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[The Effect of Research and Development (R&D) Investments on the Firm Financial Performance]

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ABSTRACT

This study explores the effect of research and development (R&D) investments on the financial performance of firms listed on the Pakistan Stock Exchange (PSX) from 2005 to 2021. Using a dynamic panel dataset of 51 publicly traded companies from different industries, the research employs a two-step System Generalized Method of Moments (System GMM) estimation to tackle potential endogeneity, firm-specific differences, and dynamic feedback effects. Financial performance is measured through both accounting indicators (Return on Assets, ROA) and market indicators (Tobin's Q). The empirical findings show a dual pattern: R&D intensity negatively affects short-term profitability (measured by ROA), likely because of immediate costs and how R&D expenses are accounted for. At the same time, R&D intensity has a positive and significant impact on long-term market value (as indicated by Tobin's Q), which reflects investor optimism and the strategic importance of innovation. These results highlight the trade-off faced by R&D-active firms between short-term operational efficiency and long-term growth. The study also finds that firm size enhances the positive effects of R&D, while financial leverage decreases both operational and market performance. The findings add to academic literature (e.g., Alam et al., 2020; Khan et al., 2019; Shahbaz et al., 2021) and provide practical insights for corporate managers, investors, and policymakers seeking to align innovation strategies with sustainable financial success.

Introduction

In today's innovation-driven global economy, research and development (R&D) are central to corporate growth and competitiveness. Companies invest in R&D to create new products, improve processes, and develop unique capabilities that allow differentiation in the market. In most industries especially pharmaceuticals, information technology, and advanced manufacturing R&D has become the core of strategic decision-making (Montalvo et al., 2021; Yu & Wang, 2021).In Pakistan, R&D is viewed as a vital tool for national progress. Government incentives aim to encourage private-sector innovation and collaboration with research organizations (Khattak & Rahman, 2021). Corporations have steadily increased their R&D spending over the past two decades. However, few empirical studies have systematically analyzed the R&D-profitability relationship in PSX-listed firms, though the literature is growing (Ahmed & Waqar, 2017; Ahmed & Saleem, 2020; Hussain & Aslam, 2021). The main goal of this research is to empirically analyze how investments in R&D affect the financial performance of companies listed on the PSX. Specifically, the study aims to answer:What is the impact of R&D intensity on accounting-based financial performance (ROA)?What is the impact of R&D intensity on market-based performance (Tobin's Q)?

To address these questions, the study employs dynamic panel data methods that can handle firm-level heterogeneity, time-series dependence, and endogeneity. The findings are expected to contribute to literature in three ways:Empirical Contribution: Provides additional evidence for R&D-performance relationships in emerging markets (Ding & Ma, 2022; Rana & Javed, 2022).Methodological Contribution: Utilizes a robust econometric framework appropriate for dynamic panel data.Practical Contribution:

Offers actionable insights for stakeholders focused on innovation-led growth.

Literature Review

Research and Development (R&D) is increasingly recognized as a critical driver of innovation and competitiveness among firms in emerging economies (Gao et al., 2021). In Pakistan, R&D investment has gained traction due to increased government focus on technological upgrading and innovation (Khattak & Rahman, 2021). However, the empirical link between R&D and financial performance remains complex.

R&D as Strategic Investment in Pakistan: R&D creates intangible assets such as patents, proprietary knowledge, and skilled human capital, which enhance a firm's competitive edge (Barney, 1991). Khan et al. (2019) show that R&D-active firms in Pakistan strategically invest despite infrastructural gaps. Ahmed and Saleem (2020) add that R&D facilitates survival and differentiation in highly competitive sectors.

Financial Performance Measurement: Financial performance in Pakistan is commonly assessed through ROA, ROE, and Tobin's Q. Alam et al. (2020) found that R&D expenditure negatively affects short-run ROA but positively influences long-run Tobin's Q. Similar findings have been reported across Asian markets (Tsai & Wang, 2021; Vithessonthi & Racela, 2016).

R&D Uncertainty and Time Lag: Returns on R&D are rarely immediate. Ahmed and Waqar (2017) emphasize the delayed effect in manufacturing and IT firms. Hossain et al. (2022) and Sadiq & Ahmad (2020) confirm that time lags in innovation realization hinder short-term financial returns, especially in developing economies.

Capital Market Perception: Pakistani investors are cautious in responding to R&D disclosures. Shahbaz et al. (2021) find that positive valuation responses occur mostly when innovation is well-communicated. However, Yousaf & Rehman (2018) warn that inconsistent disclosures distort investor understanding.

R&D Accounting Constraints: According to IFRS, research costs must be expensed while development costs are capitalized under strict conditions. This reduces reported earnings (Yousaf & Rehman, 2018). Firms often underreport R&D to avoid negative investor interpretation (Rahman & Akhter, 2020).

Industry and Institutional Variation: Industries like pharmaceuticals, chemicals, and IT tend to yield better R&D returns compared to traditional sectors like textiles and cement (Kiani & Khan, 2020; Li & Zheng, 2021). Firm size and institutional quality also shape R&D outcomes (Connolly & Hirschey, 2005; Alshammari & Alghababsah, 2021).

Conceptual Gaps: The Pakistani literature lacks studies on R&D efficiency and effectiveness. Scholars debate whether innovation success rates or spending intensity better reflect value creation (Kshetri, 2020). Moreover, longitudinal evidence tracking R&D lifecycle and outcomes is scarce (Hameed & Anwar, 2020).

Methodology

The sample for this research consists of an unbalanced panel of 51 PSX-listed firms from 2005 to 2021, i.e., 533 firm-year observations. Data are collected from the Compustat Global database, which collects normalized financial data on the basis of International Financial Reporting Standards (IFRS). Only those firms that reported five or more years of R&D spending in the observation period were included to maintain consistency and reliability.

The data set comprises a wide range of industries, such as Technology, Energy, Industrials, Consumer, Discretionary, and Healthcare.
This heterogeneity provides a robust sample for examining the impact of R&D expenditures on accounting profitability.

Variable Definitions

The table below summaries the major variables employed in the research, their description, and sources.

Table 1: Variables used in the Study

Variables	Definition	Calculation /Proxy
ROA	Return on Assets- a measure of operational performance	Net Income / Total Assets
Tobin's Q	Market valuation of the firm relative to its assets	(Total Assets + Market Value of Equity – Book Equity) / Total Assets
R&D Intensity	R&D spending scaled by firm size	R&D Expenditure / Revenue
Deratio	Measure of financial leverage	Total Debt / Total Equity
Size	Scale of the firm	Natural logarithm of Revenue
Year Dummies	Control for macroeconomic conditions in each year	Binary variable for each year from 2005-2021
Industry Dummies	Control for sectoral effects	Binary variable based on GICS sector classification

The table outlines the key variables used in the study, including definitions and how they are calculated. It measures firm performance using ROA and Tobin's Q, while R&D Intensity, Deratio, and Size serve as explanatory variables. Year and Industry Dummies are included to control for macroeconomic and sectoral differences across time and industries.

Econometric Challenges

Three primary econometric concerns necessitate the use of dynamic panel data techniques:

Simultaneity: Firm performance may influence R&D investment decisions, leading to reverse causality. Dynamic Endogeneity: Past performance and investment decisions can affect current outcomes. Unobserved Heterogeneity: Firm-specific factors (e.g., management quality, corporate culture) are often unobservable yet correlated with both R&D and performance. Traditional OLS and Fixed Effects models fail to address all three concerns simultaneously, making them unsuitable for this analysis.

Model Specification

We estimate two separate models for financial performance:

Performance Model – ROA

$$ROAit = \alpha_0 + \alpha_1 ROA_{it}\text{-}1 + \alpha_2 ROA_{it}\text{-}2 + \beta_1 R\&D_{it} + \beta_2 R\&D_{it}\text{-}1 + \beta_3 R\&D_{it}\text{-}2 + \gamma X_{it} + \mu_i + \epsilon_{it}$$

Performance Model – Tobin's Q

$$Q_{it} = \alpha_0 + \alpha_1 Q_{it}\text{-}1 + \alpha_2 Qit\text{-}2 + \beta_1 R\&D_{it} + \beta_2 R\&D_{it}\text{-}1 + \beta_3 R\&D_{it}\text{-}2 + \gamma X_{it} + \mu_i + \epsilon_{it}$$

Where:

$R\&D_{it}$ = R&D Intensity

X_{it} = Vector of control variables (Size, Deratio, Year & Industry dummies)

μ_i = Firm-specific fixed effect

ϵ_{it} = Error term

Empirical Results

This section presents the empirical results from estimating the impact of R&D intensity on firm performance using two-step system GMM. Results are shown separately for accounting-based performance (ROA) and market-based performance (Tobin's Q). Each table includes coefficient estimates, standard errors, and significance levels, along with diagnostic tests for the specifications.

Descriptive Statistics

To provide an overview of the data features, summary statistics were calculated for the main variables.

Table 2: Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
ROA	-0.0154	0.1231	-1.321	0.301
Tobin's Q	2.3366	2.7843	0.162	18.114
R&D Intensity	0.1486	0.2527	0.001	2.192
Deratio	1.6403	3.9833	0.012	51.373
Size (ln Revenue)	8.7989	1.6904	3.914	13.251

The Table presents descriptive statistics for the key variables used in the analysis. The average firm has a negative ROA (-0.0154), a Tobin's Q of 2.34, and R&D intensity of 0.15. The wide standard deviations and ranges suggest substantial variation across firms in profitability, valuation, leverage, and size.

The average ROA is slightly negative, indicating that, on average, these firms face operating losses. The average Tobin's Q greater than 1 shows that the market values these firms above their book value, aligning with expectations for innovation-driven companies. R&D intensity varies widely among firms, with some exceeding 200% of revenue, showing high levels of investment by certain firms.The high standard deviation of Deratio indicates significant variation in capital structures among firms.

Correlation Matrix

To assess potential multicollinearity and explore initial relationships, a Pearson correlation matrix was generated for the core variables.

Table 3: Correlation Matrix

Variable	ROA	Tobin's Q	R&D Intensity	Deratio	Size
ROA	1.000	0.321	-0.291	-0.336	0.287
Tobin's Q	0.321	1.000	0.341	-0.212	0.394
R&D Intensity	-0.291	0.341	1.000	-0.174	0.102
Deratio	-0.336	-0.212	-0.174	1.000	-0.084
Size	0.287	0.394	0.102	-0.084	1.000

The table shows the correlation relationships between the main variables of the study. ROA is positively correlated with Tobin's Q and Size, but negatively with R&D Intensity and Deratio. Tobin's Q shows a strong positive relationship with Size and R&D Intensity, indicating that larger and more R&D-intensive firms tend to have higher market valuation. ROA is negatively correlated with R&D Intensity and Deratio, indicating that firms investing more in R&D or using higher leverage may have lower short-term profitability. Tobin's Q is positively correlated with R&D Intensity and Size, showing that the market values innovation and scale. The correlations are moderate, so multicollinearity is unlikely to bias the regressions.

Table 4: ROA Model–Operational Performance

Variable	Coefficient	Std. Error	Significance
R&D Intensity	-0.0753	0.023	***
R&D Intensity (Lag 1)	0.0391	0.021	*
R&D Intensity (Lag 2)	-0.0184	0.010	**
Lagged ROA (L1)	0.2814	0.067	***
Lagged ROA (L2)	-0.0561	0.028	**
Deratio	-0.0142	0.007	**
Size (ln Revenue)	0.0216	0.011	*
Year Dummies	Included		
Industry Dummies	Included		
AR(1) p-value	0.038		
AR(2) p-value	0.694		
Hansen test p-value	0.943		

Significance levels:
*** p < 0.01
** p < 0.05
p < 0.10

The Table shows Current R&D intensity significantly reduces ROA (-0.0753, ***), while the one-year lag increases it (0.0391, *) and the two-year lag decreases it (-0.0184, **). Lagged ROA (L1) strongly improves current ROA (0.2814, ***), but L2 has a slight negative effect (-0.0561, **); debt ratio also lowers ROA (-0.0142, **), whereas firm size improves it (0.0216, *). The model passes diagnostic tests (AR(1) p = 0.038, AR(2) p = 0.694, Hansen p = 0.943), indicating valid instruments and no serial correlation.

The negative and significant coefficient of current R&D intensity (-0.0753) indicates that R&D spending reduces short-term operational profitability, as expected. Lagged ROA variables further confirm the dynamic nature of profitability. The second lag of R&D also shows a negative effect, possibly capturing longer-term spillovers or failures. Control variables behave as expected: leverage (Deratio) reduces ROA, while firm size enhances it. Diagnostic tests (Hansen and AR (2)) confirm no over-identification or second-order serial correlation.

Table 5: Tobin's Q Model – Performance

Variable	Coefficient	Std. Error	Significance
R&D Intensity	1.0857	0.437	**
R&D Intensity (Lag 1)	0.3121	0.175	*
R&D Intensity (Lag 2)	-0.3732	0.146	**
Lagged Tobin's Q (L1)	0.4173	0.125	***
Lagged Tobin's Q (L2)	-0.2038	0.097	**
Deratio	-0.0314	0.016	*
Size (ln Revenue)	0.1635	0.042	***
Year Dummies	Included		
Industry Dummies	Included		
AR(1) p-value	0.038		
AR(2) p-value	0.874		
Hansen test p-value	0.997		

Significance Levels:

***** p < 0.01**

**** p < 0.05**

p < 0.10

The Table shows Current R&D intensity significantly increases Tobin's Q (1.0857, **), while the one-year lag has a smaller positive effect (0.3121, *) and the two-year lag turns negative (-0.3732, **). Lagged Tobin's Q (L1) positively affects current value (0.4173, ***), but L2 negatively impacts it (-0.2038, **); debt ratio lowers Tobin's Q (-0.0314, *), and firm size boosts it (0.1635, ***). The model is statistically valid with AR(1) p = 0.038, AR(2) p = 0.874, and Hansen p=0.997, confirming no serial correlation and valid instruments.

The positive and significant effect of current R&D intensity (1.0857) supports the hypothesis that markets reward innovative firms. Lagged Tobin's Q values confirm market valuation persistence. The second lag of R&D intensity turns negative, perhaps reflecting investor skepticism over unproductive R&D or signaling effect fatigue. Firm size has a significant positive effect on Tobin's Q, aligning with economies of scale and investor confidence. All diagnostic tests are within acceptable limits, indicating a well-specified model.

Discussion

The results support the dual effect of R&D on financial performance. The short-term ROA decline echoes findings by Vithessonthi & Racela (2016), while long-term Tobin's Q gains align with studies such as Yu & Wang (2021) and Rana & Javed (2022). The negative second-year lag, found in both models, suggests either inefficiencies or investor fatigue with prolonged R&D cycles (Ding & Ma, 2022).

Short-Term Performance: Negative Impact on ROA. The negative and statistically significant impact of R&D intensity on Return on Assets (ROA) confirms the first hypothesis (H1) and aligns with earlier research findings (e.g., Vithessonthi & Racela, 2016; Alam et al., 2020). Several reasons explain why R&D investment may decrease ROA in the

short term: Immediate Cost Effect: R&D activities raise operating expenses, while returns are realized only over time. Intangible Output: Many R&D results do not generate revenue in the same year they occur. Project Failure or Delays: Some R&D projects do not succeed commercially, which lowers performance metrics like ROA. Accounting Treatment: Under IFRS, many R&D expenses are charged immediately, reducing earnings. Despite the negative short-term impact, the weakly positive effect with a one-year lag suggests some R&D projects start to show operational benefits after one year.

Long-Term Performance: Positive Effect on Tobin's Q. The Tobin's Q model supports H2: R&D investments significantly boost long-term market value. A current-period coefficient of +1.0857 and a positive one-year lag show that markets perceive R&D-intensive firms as more valuable. Explanations include: Investor optimism, as R&D serves as a signal of innovation potential and long-term competitiveness; Brand and product differentiation, since successful R&D improves firm reputation and pricing power, which the market factors into valuation; Strategic signaling, where high R&D spending indicates commitment to growth and future profitability; and scale effects, as larger firms with higher R&D intensity benefit from better absorption and utilization of innovation. However, the negative second lag in both models suggests that persistent R&D without tangible results may cause concern among investors or point to inefficiencies.

Role of Firm Size and Leverage. Firm size consistently shows a positive and significant effect in both models. Larger firms benefit from economies of scale, better access to capital, and more efficient R&D commercialization. Deratio (leverage) has a negative impact on both ROA and Tobin's Q. High leverage may limit innovation flexibility and raise investor concerns about financial risk.

Table 6: Summary Comparison of Findings

Dimension	ROA Model	Tobin's Q Model	Interpretation
R&D Intensity (current)	Negative and significant	Positive and significant	Short-term cost burden vs. long-term market optimism
R&D Intensity (lag 1)	Weakly positive	Positive	Some benefits appear with a one-year delay
R&D Intensity (lag 2)	Negative	Negative	Diminishing or failed project effects
Deratio	Negative	Negative	Leverage weakens operational and market performance
Size (ln Revenue)	Positive	Strong positive	Larger firms extract more value from R&D
AR(2) & Hansen tests	Passed	Passed	Models are statistically valid

The ROA model shows short-term negative effects of R&D, while the Tobin's Q model reflects positive market expectations, highlighting a cost benefit contrast. Both models indicate that R&D benefits may appear after a year but tend to decline by the second year. Firm size enhances performance in both models, and statistical tests confirm model validity.

Conclusion

This study contributes to the expanding body of literature on R&D in emerging markets, particularly Pakistan (Alam et al., 2020; Hussain & Aslam, 2021). It highlights the importance of scale, capital structure, and timing in leveraging R&D for financial gains. The dynamic panel analysis affirms that while R&D may depress short-term returns, it enhances long-term valuation. This study aimed to examine the impact of R&D investments on the financial performance of companies listed on the Pakistan Stock Exchange. Using a solid econometric approach, two-step system GMM, on a 17-year unbalanced panel of 51 firms, it assessed how R&D intensity influences both short-term operational results (measured by ROA) and long-term market value (measured by Tobin's Q). The results reveal a dual dynamic: in the short term, R&D intensity negatively affects ROA, likely due to immediate costs, accounting treatments, and uncertainty in returns. In the long term, R&D intensity has a significant positive impact on Tobin's Q, suggesting that capital markets favor firms with innovation potential and prospects for growth.

The evidence also underscores the importance of firm size larger firms tend to achieve more favorable outcomes from R&D, both operationally and in the eyes of investors. Meanwhile, financial leverage (Deratio) negatively affects both performance measures, suggesting that over-reliance on debt may hinder a firm's ability to invest in or benefit from R&D effectively.

Implications

The results of this paper show that R&D expenditures of firms listed on the Pakistan Stock Exchange between 2005 and 2021 have a negative impact on short-run accounting performance (ROA) but decidedly boost long-run market valuation (Tobin's Q). For managers of these firms, this implies that innovation efforts should be pursued with a long-term strategic vision, even if they temporarily depress profitability. Firms should prioritize aligning R&D investments with clear commercialization pathways and ensure that shareholders and stakeholders are informed about the expected time lag in returns. The results also suggest that firm size enhances the effectiveness of R&D, indicating that larger firms in Pakistan are better positioned to extract value from innovation. Conversely, high financial leverage always lowers both operational and market performance, highlighting the necessity for wise capital structure management in undertaking innovation-led growth. For the policymakers in Pakistan, the research recommends an urgent requirement to establish a favorable context for long-term R&D investment. The policies must aim to alleviate fiscal tightness for small and medium-sized enterprises via tax benefits, grants for innovation, and subsidized funding instruments. Further, public–private partnerships and joint R&D facilities with academia and industry may enhance the innovation performance and decrease the time-to-market for research results.

This paper contributes to the existing body of literature by offering dynamic panel data

evidence from an under-researched emerging market context. Unlike many prior studies focused on developed economies, it employs a robust two-step system GMM approach to address endogeneity and firm-level heterogeneity, revealing the dual impact of R&D on firm performance. It also provides nuanced insights into how firm characteristics like size and leverage condition the financial outcomes of R&D, thus expanding theoretical understanding and empirical validation of the innovation-performance relationship in Pakistan's Capital market.

Limitation

The study excludes non-listed firms and lacks output-based innovation metrics. It also doesn't capture sector-specific dynamics (Rahman & Akhter, 2020; Montalvo et al., 2021). This study, while offering valuable insights into the relationship between R&D intensity and firm financial performance in Pakistan, has certain limitations that should be acknowledged. Firstly, the sample is restricted to firms listed on the Pakistan Stock Exchange that reported R&D expenditures for at least five years between 2005 and 2021. This could introduce selection bias in that it leaves out small or less transparent companies, or companies operating in sectors where R&D reporting is irregular or non-existent. Second, the research only measures R&D input (i.e., expenditure) without taking into account R&D output metrics like patents, new product launches, or rates of innovation success. Consequently, it fails to measure the productivity or efficacy of R&D endeavors in producing concrete innovation output. Thirdly, applying Tobin's Q and ROA as measures of performance, although conventional in the literature, might fail to capture the multi-dimensional effect of R&D, especially in sectors where non-financial performance measures (e.g., sustainability, social contribution, or digitalization) are ever more pertinent. In addition, the research fails to examine sectoral dynamics in industries in detail, potentially concealing sectoral differences in the R&D performance link.

Future Research Directions

Future research may involve SMEs, patent information, or cross-industry comparisons (Li & Zheng, 2021; Gao et al., 2021). Cross-country comparisons or mixed-methods designs may provide more comprehensive insights. Researchers may also examine sectoral effects by performing industry-level analysis (e.g., pharma, tech, manufacturing) to establish differences in how the R&D performance relationship varies across different innovation contexts. The moderating influence of other firm traits like the quality of corporate governance, managerial competence, ownership structure, or organizational culture can also be examined to sharpen the explanation of R&D effectiveness. Longitudinal case studies or mixed-method designs integrating quantitative and qualitative data could further advance the knowledge on how firms balance R&D trade-offs over time. Lastly, comparative studies between emerging markets or developed and developing economies may frame the results against larger trends in global innovation.

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