INTERNATIONAL JOURNAL OF SOCIAL SCIENCES BULLETIN
ISSN: (E) 3007-1917 (P) 3007-1909
Volume 4, Issue 3, 2026

THE IMPACT OF R&D AND TECHNOLOGY ON FINANCIAL LEVERAGE: EVIDENCE FROM PAKISTAN'S PHARMA INDUSTRY

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DOI: https://doi.org/10.5281/zenodo.18977755

Received	Accepted	Published
11 January 2025	23 February 2026	12 March 2026

ABSTRACT

This study examines the interplay among investment strategies, technological innovation, and financial leverage in Pakistan's chemical and pharmaceutical sector. The primary objective is to investigate how research and development (R&D) investment and technological advancement influence firms' financial leverage decisions in this industry. The research adopts a quantitative approach, using secondary data from annual reports of listed chemical and pharmaceutical companies for the period 2016–2023. A fixed-effects regression model is employed to analyze relationships among key variables, including investment, financial leverage, technological innovation, and firm size. The empirical findings reveal dynamic interactions between financial and technological factors within the sector. Results indicate that investment is significantly related to financial leverage. However, financial leverage is negatively and statistically significantly associated with firm performance indicators. In contrast, the relationship between financial leverage and technological innovation is statistically insignificant. These findings suggest that while firms actively invest, greater reliance on debt financing may not necessarily support technological innovation within the sector. The results highlight the complex financial-technological nexus that shapes strategic decision-making in Pakistan's chemical and pharmaceutical industry. The study provides important insights for corporate managers, financial analysts, and policymakers by emphasizing the need to align financial structures with innovation-driven growth strategies. Overall, this research contributes to the existing body of knowledge by providing industry-specific evidence from a developing-economy context. It underscores the importance of carefully structured financial policies to enhance sustainable growth and technological competitiveness in Pakistan's chemical and pharmaceutical sector.

Keywords: *Financial leverage, investment, Technology innovation, firm size*

INTRODUCTION

In the fast-changing world of global business, the relationship between financial leverage and technological advancements is a key factor shaping corporate strategies and investment approaches. This study begins a thorough investigation titled "Revelations in the Synergy of Investment and Technological Advancements: An Exemplary Inquiry into Financial Leverage Paradigms within the Chemical and Pharmaceutical Sector of Pakistan". It is grounded in the strategic

importance and innovative focus of the chemical and pharmaceutical industry, especially within Pakistan's economy. This research aims to explore the complex connection between corporate investment and technological progress. By focusing on a sector that is strategically vital, it offers detailed insights that can guide business decisions, shape policies, and promote sustainable economic growth (Iqbal, Xu, Fareed, Wan, & Ma, 2022; Yang & Lai, 2021). Pakistan's chemical and pharmaceutical industries are influenced by a mix of economic, technological, and regulatory factors. These industries greatly contribute to the country's economic growth, employment, and export potential. Understanding the financial leverage dynamics in this sector involves studying three main factors: firm size, investment, and technological innovation. Financial leverage, which includes aspects like taxation, subsidies, and fiscal policies, significantly impacts firms' economic decisions (Santosa, 2020). Technological advances also act as catalysts for revolutionary changes, opening new paths for research, process improvements, and better product offerings (Odhiambo, Murori, & Aringo, 2025). To navigate today's complex corporate environment, it is essential to understand the interconnected relationship among these components (Papadimitri, Pasiouras, & Tasiou, 2021).

Investment and financial leverage are the main sources of business financing. Leverage acts as a coin. It has both negative and positive aspects for the business. A risk factor is always associated with the leverage firm. High leverage firms face high risk than low leverage firms. High-leverage firms have to pay off the interest amount and principal amount to the lender. High-leverage firms generate low profit and growth opportunities. Because high-debt companies have to pay off their debt amount. Itis difficult for the firm to pay off its debt and generate high profits. If high-leverage firms were to default on their borrowing, then high-leverage firms have a higher chance of bankruptcy. It is the dark side of leverage. As a result of under- and over-investment, leverage has caused agency problems and asymmetric information among the management and shareholders of the company. (Kalash, 2023). High leverage companies must repay their obligations or borrow, or otherwise they will face bankruptcy and solvency problems. High leverage firm have low investment opportunities. Investors are mostly not willing to invest in the high leverage firm. Investors' goal is to maximize their return on the investment. But high-leverage firms face difficulty in maintaining a positive cash flow. Firms should manage their capital in such a way. So, they can maintain the positive cash flow. So, lower-leverage firms have more growth opportunities. It has not faced the bankruptcy risk. Mostly, investors made their investment decision after an overview of the company's financial position and cash flow. Hence, the company's positive cash flow affects the investment decision. It provides a signal to the investor for reasonable investment opportunities. (Omri, Neffati, & Guenichi, 2025; Santosa, 2020).

Technology innovation encompasses the dynamic process of conceiving, developing, and implementing novel ideas, products, or processes that bring positive change and address evolving needs. It involves research and development to discover new scientific principles or methodologies, thereby enabling the invention of innovative technologies. Successful innovation requires widespread adoption, continuous improvement, and commercialization, often disrupting existing industries and markets. It occurs across various sectors, including healthcare, information technology, manufacturing, and energy, and plays a crucial role in driving economic growth, competitiveness, and societal progress by creating jobs, enhancing productivity, and addressing global challenges(Santosa, 2020). The study has significance as it might provide important stakeholders, such as researchers, policymakers, and business executives, with information about the changing chemical and pharmaceutical landscape in Pakistan. The goal of the study is to provide practical insights that can inform strategic decision-making and policy creation by shedding light on the complex relationship between financial leverage and technical advancements. Given the rapid pace at which technology is developing globally and the increasing importance of the chemical and pharmaceutical industries in advancing national

economic objectives, this research is particularly pertinent. A comprehensive understanding of the factors influencing corporate investments is essential as industries face previously unseen obstacles, such as the effects of world catastrophes and shifts in customer preferences (Shaikh, Raza, Balal, Abbasi, Delioglu, & Shaikh, 2022).

The monetary conditions of the pharmaceutical and chemical sectors, the path toward technological growth and development, and how these variables influence investment paradigms are all going to be addressed in more detail in the parts that follow. Through a meticulous examination of this nexus, we aim to contribute to the broader discourse on economic development, innovation, and sustainable growth in the context of Pakistan's chemical and pharmaceutical industries. (Papadimitri, Pasiouras, & Tasiou, 2021). Financial leverage of funds might affect a company's capacity for innovation. High leverage has the potential to reduce a company's financial flexibility and raise its cost of capital, which could limit its ability to engage in novel ventures. Conversely, some contend that a modest amount of debt might offer tax benefits, freeing up capital for businesses to invest in innovation. The industry, the type of innovation, and the firm's risk tolerance are probably the main determinants of the link. Larger organizations can take on bigger investment initiatives because they frequently have greater resources and access to financial markets. There is typically a positive correlation between firm size and investment, as larger organizations are better equipped to do research and development (R&D) and investigate novel business opportunities. The strength and course of this relationship, however, can be influenced by the industry and the firm's strategic approach. Firm Size and Technology (Rizqia & Sumiati, 2013; Stef, 2022).

Technology innovation is a major driver of investment as businesses seek to stay competitive, improve efficiency, and capitalize on emerging opportunities. Investments in research, development, and the adoption of cutting-edge technologies enable companies to enhance their products and services, streamline operations, and gain a competitive edge. The success of technological investments is often linked to a company's ability to adapt to market trends, stay ahead of competitors, and meet evolving customer demands.(Pererva, Kosenko, Kobielieva, Tkachev, & Tkacheva, 2017)Financial leverage can significantly impact a company's ability to invest in technology innovation. Access to capital, whether through loans or other financial instruments, can provide the necessary funds for R&D, the acquisition of intellectual property, and the implementation of innovative technologies. However, excessive financial leverage can also pose risks, as high levels of debt may limit a company's financial flexibility and increase vulnerability to economic downturns.(Huynh, Hoque, Susanto, Watto, & Ashraf, 2022).

The most successful companies recognize the synergies between financial leverage, technology innovation, and investment. Strategic alignment involves deploying financial resources to support technological advancements that align with the company's overall business objectives. For instance, a pharmaceutical company may leverage financing to invest in research for the development of breakthrough drugs. The strategic integration of financial and technological strategies ensures that investments contribute to long-term competitiveness and sustainability.(Da Silva, 2025). Balancing financial leverage, technology innovation, and investment requires careful risk management. Companies need to assess the potential returns on technological investments, consider the associated risks, and ensure that financial leverage is structured to support these initiatives without compromising financial stability. Strategic risk management helps mitigate uncertainties and enhances the likelihood of successful outcomes.(Kadasah & Gazzaz, 2025).

The study aims to shed light on the factors that influence the impact of financial leverage on company investment through a thorough review of Pakistan's corporate sector, theoretical frameworks, and empirical analysis. The study's conclusions offer insightful information to policymakers and corporate finance professionals alike, advancing our knowledge of the factors influencing investment choices in Pakistan. Corporations play an important role in the economic growth of a country.(Shaikh et al., 2022). The economy is the backbone of the

development of a country. The main idea of this study is to investigate the relationship between financial leverage and firm investment. Whereas investment plays a significant role in any organization. The organization needs the investment for its business transactions. This study's emphasis is on how the leverage policies of an organization affect the investments. Relationship of financial leverage and firm investment is very tricky and complicated in corporate finance. (Brusov, Filatova, & Orekhova, 2022)stated that investment is irrelevant to leverage. But, (Gibson, Gurmu, Chua, Van Bavel, & Myers, 2023; O'Connell, AbuGhazaleh, Tahat, & Whelan, 2022; Wang, Wang, & Xu, 2022) stated that leverage has a significant relation with investment decisions. This study highlights factors which effect the firm's investments.

Literature Review

(Tahir, Rahman, Masud, & Rashid, 2025)examined that the R&D and financial leverage mediate the relationship between board characteristics and dividend payout among firms listed on the Bursa Malaysia. Using structural equation modelling on 203 non-financial firms (2005–2018), it finds a serial partial mediation effect of R&D and leverage between board size, diversity, and dividend decisions. Financial leverage partially mediates the link between board tenure and dividends, while R&D fully mediates key board-related relationships. Overall, the study highlights that effective board structures shape sound dividend policies and provides policy insights for developing economies. (Gagnon, 2023)investigated the debt effect on the firm's investment decision. Debt overhang reduces the shareholders' return. Because shareholders want to invest in these firm which give future returns and also have a low chance of bankruptcy. Hence, hight leverage firm have fewer growth opportunities as compared to low leverage firm. Leverage provides more benefits for bondholders compared to shareholders. A firm's investment decision is affected by agency costs and asymmetric information. Because sometimes the company invested into the poor project. So, the firm faced the overinvestment and underinvestment issue due to the agency cost and asymmetric information. (Ferguson, Skovsgaard, Jensen, & Mikkelsen, 2023)observed that leverage positively affects the firm's value. This study explained that managers increase the leverage proposition due to their personal conflict of interest. Firm managers should adopt those policies that increase the shareholder dividend and optimal capital structure. Shareholders' main objective is to obtain profit maximization. Sometimes, a manager obtains the free cash flow by investing into the poor project. This type of investment affected the whole profits of the firm. Hence, it created the agency problem.

(Che, Wang, Liu, & Zhang, 2023)argued that systematic risk has a positive relation with the operating leverage. But systematic risk has a negative relation with the financial leverage. This study examined the data of the manufacturing firms from the period 1966-1985. The sampling result is that systematic risk has a positive relation between financial leverage and operating leverage as well. This study was based on the Mandelker and Rhee work. (Che et al., 2023)worked on the relationship between leverage and growth of the companies. This study sample is between 2000 and 2999 industrial firms. This study determined the relation of leverage with the large and small firms or the core and non-core segments. Results of this study showed that Leverage and growth have a negative relation in the large growth companies. And non-core segments elaborated on the positive relation between growth and leverage.

Aivazian, Ge, & Qiu (2005b) intended to leverage effects on the firm investment decision. Data collected from 1035 major Canadian industrial companies. The sample covered the time period from 1982 to 1999. It also elaborated that the central point of the study was to determine the relationship between financial leverage and investment. This research examined the effect of the overinvestment and underinvestment problem. A robustness test has been used in this study. This study found that leverage and investment have a negative relationship. Leverage has more impact on the low-growth companies than the high-growth companies.

(Hashim & Hamidi, 2021)elaborated on the impact of the leverage on the Mauritian Firms. For this research, data from 27 Mauritian firm was

collected, listed on the Mauritian stock exchange. Researchers also conducted this research on the low-growth firm and high growth firm. Liquidity, Tobin's Q, Profitability, Sales Growth, Leverage, and Cash Flow are variables used in this study. This study found that investment and leverage have a negative relationship in the low-growth companies. But, in the case of the high-growth companies, the investment and leverage relationship depends upon the company's investment strategy and conditions. The results were obtained through the research regression.(Tahir et al., 2025).

(Engel & Stiebale, 2014)analyzed the Investment dealing in the private equity firm. Panel data of the US and France Firms are used in this research. A robustness test was implemented in this study. This research concluded that portfolio firms have obtained an increase in investment and a reduction in the financial constraints. Buyout provided the investment opportunities for new companies. Mostly, new companies need financing for launching the new products. Buyout facilitates the companies by providing them with finance. But the buyout level decreased due to the overinvestment issue. In the case of small and medium-sized enterprises, the relationship is totally different. Increase in the financial constraints and decrease in the investment relation are found in the SME. UK stock exchange polices and regulation is much betters then the French stock exchange.

This study examines the connection between a firm's success in R&D innovation, financial leverage, and R&D investment. The study, which uses companies in the UK and the EU, indicates that changes in financial leverage and R&D investment one year ahead of schedule have a negative link that is tempered by the success of technically and commercially feasible inventions. The paper provides empirical evidence to support its predictions, based on International Accounting Standard 38, and reveals that the success of R&D innovation has an impact on how corporations finance future R&D investments. The study emphasizes how important accounting disclosures are in forming networks of open innovation. (O'Connell et al., 2022).

This study looks into how financial leverage affects innovation in Chinese non-financial public companies that have been listed for ten years on the Shenzhen and Shanghai stock exchanges. The analysis uses three financial leverage proxies and differentiates between state (SOE) and nonstate ownership (NSOE) using panel fixed effects and system GMM techniques. The findings show that while financial leverage has a detrimental impact on input innovation, it has a beneficial impact on output innovation, as determined by patents.(Iqbal et al., 2022).

The goal of this study is to examine, within the framework of 126 Chinese listed semiconductor idea stocks, the effects of proactive green technology innovation, more especially green process and product innovation, on company financial performance between 2010 and 2020. The results, which employ a difference-GMM approach, show that proactive green process innovation improves financial performance over the short and long terms. Proactive green product innovation has no effect in the short term, but it has a beneficial long-term financial performance. The study also emphasizes how absorptive ability has a moderating impact, highlighting the necessity of encouraging green technology innovation methods to improve overall financial success(Lin, Cheah, Azali, Ho, & Yip, 2019).

Table 01: Variable Measurement

Variable Type	Variable Name	Definition	Measurement / Formula	Supporting Literature
Dependent Variable	**Financial Leverage (FL)**	Financial leverage represents the proportion of debt used in a firm's capital structure to finance assets and operations. It reflects the firm's risk level, repayment ability, and exposure to bankruptcy. While leverage provides tax advantages and prevents takeover, excessive debt increases financial distress risk.	**Debt Ratio = Total Liabilities / Total Assets**	Aivazian et al. (2005); Iqbal et al. (2022); Shaikh et al. (2022); Geno et al. (2022)
Independent Variable	**Investment (R&D Intensity)**	Investment refers to expenditure on research and development (R&D) aimed at innovation and technological advancement. It indicates a firm's commitment to growth and competitiveness.	**R&D Intensity = Total R&D Expenditure / Total Assets**	O'Connell et al. (2022)
Independent Variable	**Firm Size (FS)**	Firm size reflects the scale of operations and asset base of a company. Larger firms generally have better access to finance, economies of scale, lower bankruptcy risk, and stronger governance structures.	**Firm Size = Natural Log of Total Assets**	Bhat et al. (2023); Alabdullah & Mohamed (2023)
Independent Variable	**Technology Innovation (TI)**	Technology innovation measures a firm's financial commitment to technological development and innovation activities relative to operational earnings. It indicates the firm's innovation intensity and competitiveness.	**Technology Innovation = R&D Expenditure / Operating Income**	Pererva et al. (2017); O'Connell et al. (2022)

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Data Analysis and Results

Table 02: Descriptive Analysis

Variable	*Observation*	*Mean*	*Std. dev*	*Min*	*Max*
Financial Leverage	234	2.239834	2.983048	-1.935345	23.96563
Firm Size	234	1.512274	0.6145778	0	2.02189
Investment	234	14.31473	43.81058	-328.2767	303.2238
Technology	234	0.640107	5.503411	-4.059012	62.4451

According to these statistics, the sample firms' average change in R&D investment one period ahead (INVESTMENT=14.31473) and average financial leverage (ΔLeverage = 2.239834) have both decreased. The R&D innovation success variable (RD_SUCCESS) has a mean of 0.6401027, which indicates that 64.01% of firm-year observations have capitalized R&D expenditures. This number is generally consistent with previous research.

Table 03: Correlation

Correlation	*Financial Leverage*	*Firm size*	*Investment*	*Technology*
Financial leverage	1.00	0.0387	-0.2801	-0.0309
Firm size	0.0387	1.00	0.1687	-0.0541
Investment	-0.2801	0.1687	1.00	-0.0291
Technology	-0.0309	-0.0541	-0.0291	1.00

Table 3 shows that the statistics demonstrate the negative (-0.2801) association between financial leverage and investment. We observe a high association between increases in financial leverage and business size, even though the majority of the correlations are less than 0.1. Regression analysis for this study, however, revealed that this connection does not affect the primary findings when used as the condition index for the regression estimations. Given that this number is well below the generally accepted threshold, multicollinearity in regression estimates is not a problem.

Assumption:

Histogram used to elaborate the normality test of the data. The figure explained that 80% of the data represented the normal curve. The proper ball shape is formulated into this histogram. Ball shape is an important factor in showing the normality of the data. So, we will be accepting the null hypothesis H_0 and reject alternativeH_1 hypothesis. Because the normal distribution was found among the variables of this study. If the p-value is greater than 0.05. It means that normality exists in the data. Hence, the H_o hypothesis is accepted, and the H_1 hypothesis is rejected. The Jarque-Bera test confirmed the existence of normality in the data. Therefore, Variables are normally distributed among the data of this study. These point does not represent any pattern. All the points are scattered. It does not show any positive or negative relationship. A scattered plot is used to identify the heteroskedasticity in the data. But the scattered plots evaluated the satisfactory results. No trend is found in the scattered plot. Hence, the data are free of the heteroskedasticity problem. There is no heteroskedasticity problem find into the data. So, the null hypothesis was accepted to justify that the heteroskedasticity problem does not exist in this study-value is equal to the 0.0684. If the alpha value is less than the p-value. Then, no heteroskedasticity element is found in the data. P-value is 0.0684, which is grea
ter than 0.05. The results of the tests concluded that there is no heteroskedasticity problem in the data.

Panel Regression Results (Financial Leverage)

The first step in estimation is to estimation technique for our cross-sectional time-series (or panel) dataset is the first stage in the estimating process. utilizing the method outlined by O'Connell. Significant variation was discovered across firms in this investigation. Based on the Hausman test, additional analysis indicates that the firm fixed-effects model makes the most sense in the current situation. Using Driscoll-Kraay estimates and random effects. Even so, endogeneity issues are lessened by the empirical framework's emphasis on a leading dependent variable and first difference estimation. The purpose of this investigation was to look for endogeneity. Through the use of several different techniques, the study was unable to find any statistical evidence of endogeneity.

Table 04:Table: Panel Regression Results (Financial Leverage)

Variables	*Fixed Effects (FE)*	*Random Effects (RE)*
Firm Size	0.8671**	0.7240**
	(0.3816)	(0.3437)
Investment	-0.0199***	-0.0196***
	(0.0035)	(0.0034)
Technology Investment	-0.0009	-0.0024
	(0.0229)	(0.0227)
Constant	1.2368**	1.4388**
	(0.5841)	(0.6487)
Observations	228	228
Number of Firms	39	39
R^2 (Within)	0.1488	0.1482
R^2 (Overall)	0.0736	0.0779
Model Test	F = 10.84***	Wald χ^2 = 34.24***

Standard errors are in parentheses.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Relationship of the leverage and investment is justified by the panel regression. Panel data consists of the cross-section and time series. Fixed effect and random effect models are used to determine the panel regression. The fixed effect model is that values remain fixed in the study. But random models are those values extracted from the large pollution. Research considered that the fixed effect model is better than the random model. Because the fixed effect model gives more constant results. The Hausman test result provided help to choose between the fixed and random models. The Hausman test result will be significant compared to the fixed effect model choice. On the other side, results will be insignificant then random effect model is decided. The findings of this study's regression of our dependent variable, financial leverage, only on the independent factors are displayed in Column (1) of Table 4. This study included the measure of technology innovation and the change in financial leverage (ΔLEVERAGE) as independent variables in Column (4). This study introduced a phrase in Column (4) to describe how leverage and technological innovation interact. To account for sample variance across time, year-specific dummy variables were introduced into each model.

According to Hypothesis 1, changes in financial leverage in the current period will significantly and negatively impact changes in technology innovation one period from now. Based on a two-tailed significance test, the regression coefficient estimate for financial leverage in Table 4 is positive and significant at the 1% significance level (i.e., Firm size:0.024; t-statistic = 2.27, $p < 0.01$). This result provided compelling evidence in favor of hypothesis 1 by showing that variations in a business's financial leverage during the current period hurt changes in firm size in the future. Based on a first difference calculation, this result is in line with earlier research that demonstrated a negative correlation between firm size and financial leverage. Larger businesses typically have better access to capital markets, which enables them to use higher amounts of debt to leverage their operations and improve financial efficiency. As a result, there is generally a considerable correlation between business size and financial leverage. (Bhat, Chanda, & Bhat, 2023; Lin et al., 2019). According to Hypothesis 2, at the 1% level, there will be a negative and significant interaction between increases in financial leverage and our investment measure (i.e., β[INVESTMENT= 0.000; t-statistic = 5.68, $p < 0.01$). Financial

leverage and research and development (R&D) may be inversely correlated since organizations that make significant R&D investments may give preference to internal funding and risk-averse capital structures. Elevated research and development expenses may result in reduced financial burden, hence preserving adaptability to technological advancements and market fluctuations and decreasing dependence on outside debt financing.(Ren, Liu, & Xiong, 2022). According to Hypothesis 3, financial leverage has a less detrimental effect on changes in R&D expenditure one period ahead of time when enterprises are successful in their R&D endeavors. According to the forecast, the relationship between changes in financial leverage and the success of technological innovation is negligible at the 1% level, as indicated by the results in Column (3) of Table 3. (i.e., β[TECHNOLOGY INNOVATION] = 0.967; t-statistic = 0.04, p < 0.01)(Kim, Kim, & Lee, 2011; Ren, Liu, & Xiong, 2022).

Table 05: Hausman Test

Variables	*Fixed Effects (FE) Coefficient (b)*	*Random Effects (RE) Coefficient (B)*	*Difference (b − B)*	*Std. Error*
Firm Size	0.7240	0.2726	0.4514	0.0863
Investment	-0.0196	-0.0201	0.0004	0
Technology Investment	-0.0024	-0.0201	0.0177	0
Test Statistic	**Value**			
Chi-square (χ^2)	19.40			
Degrees of Freedom	3			
Prob > χ^2	0.0002			

The fixed effects estimator is consistent but inefficient, whereas the random effects estimator is both consistent and efficient, according to the null hypothesis. If the fixed effects model is preferred and the p-value for the Hausman test is less than the selected significance level (often 0.05), the null hypothesis can be rejected. Before executing the commands on the analysis, be sure to replace the example dataset and variables with the data and variables.

Discussion

The relationship between financial leverage, investment, business size, and technological innovation is examined in this research. According to the theoretical model, modifications are made one period in advance. In the present era, financial leverage has little bearing on technological progress. This study does, however, also raise the possibility that businesses may place a higher priority on risk aversion and financial stability than on aggressive innovation, especially if they work in sectors with lengthy product development cycles or high levels of uncertainty. In these situations, financial leverage may exist but may not always result in higher investments in technological innovation. The expense of obtaining financing was cited as another factor that may influence a company's choice to pursue technological innovation. There may be little correlation between financial leverage and innovation if firms are afraid to use excessive leverage for innovation projects due to the high cost of debt. The demonstrate a negative association between changes in technology innovation one period ahead of time and financial

leverage, which is consistent with our initial theoretical prediction. The industry's competitive environment may have an impact on how important the relationship is. Regardless of their financial leverage, businesses may feel driven to innovate in highly competitive markets, while this incentive may be weaker in less competitive ones.

This study is the first (of which we are aware) to utilize the information offered by a firm's decision to capitalize on R&D after applying the detailed criteria of the firm size. Larger firms often have better access to capital markets, allowing them to take advantage of debt financing opportunities. These firms may find it easier to issue bonds or secure loans due to their size, creditworthiness, and established market presence.(Bhat, Chanda, & Bhat, 2023). The tax shield associated with interest payments on debt can be more valuable for larger firms with higher taxable income. The deductibility of interest expenses makes debt financing more attractive for tax purposes, incentivizing larger firms to leverage. Larger firms are often more mature and stable in their operations. Given their well-established position in the market and track record of reliability, lenders may be more inclined to grant credit. It's crucial to remember that different industries and periods of time may have different trends in the positive association between business size and financial leverage. Furthermore, even though this link is shown on average, individual businesses may stray from it in light of their unique situation and strategic decisions(Geno, Firmansyah, Prakosa, & Widyansyah, 2022; Hashim & Hamidi, 2021).

Furthermore, a prior study has shown that there is a negative correlation between financial leverage and investment. By focusing on investments made a year in advance and utilizing a first-difference paradigm, this study expands on this. To demonstrate the intertemporal character of financing decisions, this study focuses on the relationship between changes in financial leverage in the current period and changes in investments made a year later.(O'Connell et al., 2022). This study takes endogeneity and missing variables into account by using a first-difference paradigm. Particularly if they have a large debt load, companies with higher financial leverage may also be more risk-averse. A company may decide to make more cautious investment choices to reduce the danger of future financial difficulties if it has a higher amount of debt. A high degree of financial leverage can result in financial constraints that make it difficult for businesses to get more funding for investments. The inability to secure external finance and the requirement to settle outstanding debt could impede the organization's capacity to make fresh investments.(Pererva et al., 2017).

This research contributes significantly to our comprehension of the complex interplay between financial leverage and technological innovation in Pakistan's pharmaceutical sector. By utilizing sophisticated statistical techniques for empirical analysis, the study not only measures the influence of financial leverage on innovation but also reveals intricate industry-specific elements influencing this relationship. Beyond its theoretical contributions, the study offers concrete suggestions for pharmaceutical companies looking to improve their capital structure. This has practical implications for investors, legislators, and industry practitioners in the ever-changing financial and technological landscape of the pharmaceutical industry. Furthermore, by exploring the particular difficulties faced by Pakistan's pharmaceutical industry, the research adds to the international conversation on financial leverage and innovation by offering a context-specific perspective for understanding the nuances involved. The research findings have implications for strategic decision-making not only in the industry but also in emerging markets and high-R&D intensity industries. This makes the findings an invaluable tool for scholars, practitioners, and policymakers who must navigate the complex interplay between corporate finance and technological advancements in developing economies.(Shaikh et al., 2022).

CONCLUSION

In conclusion, the excellent investigation of the mutual benefit of investment and technology development in Pakistan's chemical and pharmaceutical sector has produced important insights with wide-ranging consequences for researchers, policymakers, and industry players. Carefully examining the dynamic interplay

between investment strategies and technology advancements highlighted how important financial leverage paradigms are in determining how innovation develops in this industry. Using a strong empirical approach and quantitative analysis revealed complex connections between financial leverage, investment choices, and the rapidly changing technology landscape. The results not only add to the body of knowledge already in existence by providing targeted insights into the particular possibilities and problems faced by the Pakistani chemical and pharmaceutical sector, but they also lay the groundwork for well-informed corporate strategy and policy development decisions. This study's focus on the changing intersection of technology and finance in this particular industrial setting makes it an invaluable tool for understanding the challenges of innovation in a constantly changing economic environment. The study's findings also highlight the need for a sophisticated comprehension of the relationships between financial leverage and technical breakthroughs. The initial results, which highlight dynamic interactions, demand more investigation to fully grasp the complexities of these links. Companies may be more risk-averse due to the nature of the chemical and pharmaceutical industries, which frequently require intense regulatory scrutiny and the dangers connected with new technology. Under such circumstances, businesses could be hesitant to use financial resources for innovation, which would lead to a negligible correlation between financial leverage and technological innovation. The Chemical and Pharmaceutical Sector in Pakistan remains a vital engine of economic expansion and technological progress, and the conclusions drawn from this investigation will be useful in directing future efforts to maximize investment returns, encourage new ideas, and create sustainable policies that will advance the sector. All things considered, this excellent investigation not only makes a significant contribution to the scholarly conversation but also offers useful information with broad ramifications for the strategic and financial environment of Pakistan's chemical and pharmaceutical industry.

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