The Effect of Research and Development Expenditures on Corporate Financial Performance Considering the Moderating Role of Industry Type

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Abstract: A company's success can be assessed through its financial performance. The company aims to generate profits using its resources and enhance the prosperity of the company and its investors, making financial performance the company's foremost public image and a primary consideration for investors. The present study examines the effect of research and development expenditures on corporate financial performance, considering the moderating role of industry type. This relationship was investigated using data from 145 companies listed on the Tehran Stock Exchange over the period from March 2014 to March 2024. In terms of purpose, the study is applied; in terms of research design, it is ex post facto because it relies on historical information; and its inferential approach is inductive and causal. The collected data were analyzed using EViews 13. Correlation analysis, regression analysis, and pooled data methods were used to analyze the data. The hypothesis-testing results indicated a significant relationship between research and development expenditures and financial performance at the 95% confidence level. Industry type also influences the relationship between research and development expenditures and financial performance.

Keywords: research and development expenditures, corporate financial performance, industry type

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1. Introduction

Research and development (R&D) expenditures constitute an important strategic investment through which companies seek to improve their competitive position, develop organizational capabilities, and sustain financial performance. As technological change reshapes production processes and market expectations, firms face increasing pressure to renew their products, improve operational efficiency, and transform knowledge into commercially valuable outcomes. However, allocating resources to R&D involves uncertainty because expenditures occur before the technical feasibility, market acceptance, and financial returns of innovation are fully established. The broader technological environment also matters: cross-country analysis of artificial intelligence development places research capabilities alongside talent, infrastructure, and the business environment, illustrating the interconnected conditions within which technological investment occurs [1]. At the corporate level, research connecting R&D investment, financing constraints, and financial performance provides a basis for examining whether innovation expenditure generates measurable economic benefits and under what circumstances these benefits emerge [2].

The relationship between R&D expenditures and financial performance can be understood through the development and deployment of knowledge-based resources. R&D activities may improve product quality, facilitate process innovation, reduce production costs, and support differentiation from competitors. These outcomes can strengthen profitability by increasing revenues or improving the efficiency with which existing resources are used. Nevertheless, R&D expenditure represents an innovation input rather than a guaranteed innovation outcome. Projects may fail, commercialization may be delayed, and successful technologies may not generate sufficient revenues to recover their development costs. Research examining innovation success alongside R&D investment and financial leverage reinforces the importance of distinguishing expenditure commitments from realized technological achievements [3]. Consequently, the financial implications of R&D should be evaluated as a conditional relationship shaped by organizational capabilities and the circumstances surrounding investment.

The conversion of research expenditure into financial returns also depends on the coordination of financial strategy and human resources. Innovation requires employees capable of generating ideas, conducting experiments, interpreting technical information, and implementing new processes. Financial decisions therefore influence R&D through the availability of funds and through the organizational arrangements that support employee contributions. The study of financial strategy, employee performance, and the mediating role of R&D in a pharmaceutical company connects these dimensions within a specific organizational setting [4]. Similarly, research on employee earnings following R&D grants to small firms demonstrates the relevance of considering how additional financial resources are distributed within organizations [5]. Together, these research perspectives suggest that the financial consequences of innovation expenditure cannot be separated entirely from the management of the people who undertake innovative activities.

Financing conditions represent another important mechanism linking R&D expenditure to corporate outcomes. Research projects frequently involve intangible assets, uncertain repayment prospects, and information that external investors cannot readily evaluate. These characteristics may complicate access to external capital and increase reliance on internally generated cash flows. Research on R&D grants and external financing examines the relationship between public support, liquidity constraints, and innovation financing [6]. Financing arrangements may also reflect the need to protect proprietary knowledge. The investigation of single-lender financing among R&D-active firms places proprietary costs at the center of financing choice, indicating that the provision of information to capital providers can involve competitive considerations [7]. Thus, financing R&D requires firms to balance access to capital, financial risk, and the protection of commercially sensitive information.

The policy environment can further influence the availability and allocation of innovation funding. Credit policies affect the conditions under which firms obtain financing, while uncertainty can complicate decisions about projects with long development periods. Research examining R&D investment under the Green Credit Guidelines explicitly connects credit policy and uncertainty with corporate innovation decisions [8]. At the supply-chain level, the analysis of green R&D financing in platform-based arrangements with data-driven marketing illustrates how funding decisions interact with commercial structures and environmental objectives [9]. These perspectives suggest that R&D investment is embedded in relationships extending beyond the individual firm. Its financial implications may depend on the compatibility between financing arrangements, market channels, and the strategic purposes of technological development.

Developments in digital finance add another dimension to the financial context of innovation. Digital financial services may expand the range of funding channels available to enterprises and change how information is collected, assessed, and communicated. The bibliometric analysis of digital finance for small and medium-sized

enterprises and startups identifies this intersection as an established area of inquiry with continuing research needs [10]. Research examining digital finance and information transparency in relation to enterprise investment efficiency similarly directs attention to the informational conditions surrounding resource allocation [11]. For R&D-intensive companies, the relevance of these developments lies in their potential connection with project evaluation and financial access. However, the availability of financial technology alone does not establish that research expenditure will produce higher profitability; the quality of investment decisions remains essential.

Corporate investment decisions are also situated within wider institutional and financial systems. Administrative procedures, market governance, and regional financial development may influence the costs and opportunities associated with enterprise activity. Research linking administrative approval reform, regional financial development, and corporate performance examines this connection through a market-oriented governance perspective [12]. At a broader level, the analysis of fiscal policy and financial development in Southeast European countries addresses how public financial arrangements relate to the development of financial systems [13]. Although these studies do not directly establish the effect of R&D expenditure on corporate profitability, they provide relevant context for understanding why similar investment commitments may operate under different financial conditions. Institutional circumstances can influence the environment in which firms select, fund, and implement research projects.

Institutional quality is particularly relevant when investment objectives combine financial performance with technological or environmental transformation. Research on the relationship between green financing and sustainable development explicitly considers institutional quality as part of that relationship [14]. In the Iranian context, research examining technological progress, financial market risk, and institutional quality in the relationship between natural resource revenues and financial development brings technological and financial conditions into a common analytical framework [15]. The implication for corporate R&D research is that expenditure decisions should be interpreted within their economic setting. Financial resources may provide opportunities for innovation, but their productive use depends on the conditions that support investment continuity, organizational decision-making, and the commercialization of research outcomes.

Industry-specific research further indicates that the financial and developmental consequences of strategic investment should be interpreted with attention to sectoral characteristics. Research on green transformation policies and media governance in tourism enterprises considers organizational development within a particular service industry [16]. Likewise, the study of digital finance, market position enhancement, and high-quality development in sports enterprises examines financial mechanisms within a distinct commercial setting [17]. These studies concern outcomes broader than accounting profitability, but their sectoral focus is relevant to the present argument. Industries differ in customer requirements, competitive pressures, regulatory exposure, and the resources needed to introduce change. Consequently, findings from one sector cannot automatically be assumed to describe the financial implications of R&D across all industries.

The importance of contextual differences also appears in research beyond listed corporations. The examination of digital rural development, green agricultural transformation, and digital inclusive finance connects financial access with technological change in an agricultural setting [18]. Research on fintech and urban–rural integrated development adopts a human capital perspective, placing the capabilities of economic participants within the analysis of financial technology [19]. These broader studies do not provide direct evidence about the R&D–return on equity relationship. Nevertheless, they help situate innovation financing within a wider discussion of productive capabilities and the conditions required to use financial resources effectively. For corporate analysis, this suggests

that industry characteristics may capture meaningful differences in the opportunities and capabilities associated with technological investment.

Financial evaluation additionally requires attention to the distinction between planned expenditure and realized outcomes. R&D budgets are established under uncertainty, whereas financial performance reflects the interaction of investment decisions with subsequent operational and market developments. Research on financial factors and budget forecast errors in regional governments addresses this distinction in a public-sector setting [20]. Its relevance here is conceptual: the commitment of financial resources and the achievement of intended outcomes are analytically separate. Applied to corporate R&D, this distinction supports evaluating expenditure alongside observed financial performance rather than treating larger research budgets as sufficient evidence of successful innovation. It also encourages attention to liquidity, cash generation, and other financial characteristics that may influence the sustainability of research activity.

Industry type offers a theoretically relevant basis for explaining variation in the relationship between R&D expenditure and financial performance. Industries differ in technological opportunity, product development cycles, dependence on specialized knowledge, and the ease with which competitors can imitate innovations. In some industries, R&D may be closely connected with product renewal and market differentiation, making innovation a central determinant of commercial viability. In others, research activities may primarily support incremental process improvements whose financial benefits emerge gradually. Industry conditions can therefore influence both the expected returns from R&D and the time required for those returns to appear. The moderating argument concerns whether the association between R&D expenditure and financial performance changes across industry categories, rather than merely whether industries exhibit different average levels of profitability.

The Iranian corporate setting provides an appropriate context for investigating this relationship without presuming that findings from other economies are directly transferable. Existing Iranian research connecting financial strategy with R&D at the organizational level and technological progress with financial development at the macroeconomic level establishes relevant foundations for further inquiry [4, 15]. However, these perspectives address different analytical levels and do not resolve whether industry type modifies the association between R&D expenditure and the financial performance of listed manufacturing and industrial companies. Examining this question using company-level observations can connect strategic expenditure decisions with financial outcomes while recognizing differences in the industries within which firms operate.

Financial performance must also be operationalized in a manner consistent with the study's analytical purpose. Return on equity provides an accounting-based measure of profitability relative to shareholders' equity and therefore connects corporate earnings with the capital supplied by owners. R&D expenditure relative to total assets expresses the intensity of research commitments in relation to the firm's resource base. The interpretation of their relationship nevertheless requires consideration of other financial characteristics. Firm size, return on assets, loss status, leverage, liquidity, operating cash flow, and inventory may be associated with profitability or with the capacity to sustain research investment. Incorporating these characteristics helps assess whether the observed relationship persists after accounting for relevant differences among companies, although observational associations alone cannot establish a definitive causal effect.

The reviewed literature therefore supports examining R&D and financial performance through a framework that combines investment intensity with contextual variation. Research on financing constraints and innovation success addresses conditions closely associated with R&D, whereas studies of digital finance, governance, and sectoral development expand the surrounding financial and institutional perspective [2, 3, 11]. What remains unresolved

for the present study is whether differences in industry type alter the relationship between research expenditure and shareholder-oriented profitability among companies listed on the Tehran Stock Exchange. Addressing this question can inform managerial decisions about research budgets and help investors interpret R&D expenditure in relation to the commercial environment in which it is undertaken.

The aim of this study is to examine the relationship between research and development expenditures and corporate financial performance, measured by return on equity, and to assess the moderating role of industry type using data from 145 companies listed on the Tehran Stock Exchange over the period from March 2014 to March 2024.

2. Methods and Materials

In terms of purpose, the present study is applied and quasi-experimental. Applied research uses the theories, regularities, principles, and techniques developed through basic research to address practical and real-world problems. In terms of its nature and content, the research method is correlational. The primary objective of correlational research is to determine whether a relationship exists between two or more quantitative (measurable) variables and, if so, to establish its magnitude and extent. A correlational study may aim to establish the presence or absence of a relationship and to use such relationships for prediction. Correlational research evaluates several variables presumed to be associated with a major, complex variable. This study follows a deductive–inductive reasoning framework. Accordingly, the theoretical foundations and research background were examined deductively through library research, articles, and websites, whereas data collection and hypothesis testing (confirmation or rejection) were conducted inductively.

The statistical population of this study comprises all companies listed on the Tehran Stock Exchange. The companies examined to test the research hypotheses were selected as follows: first, all companies listed on the Tehran Stock Exchange at the end of the years within the period from March 2014 to March 2023 were identified. Companies meeting all the following criteria were then selected, and listed companies that did not meet these criteria were excluded from the study population.

The companies must have been listed on the Tehran Stock Exchange before March 21, 2014.

The companies must not have suspended operations for more than three months during the study period.

The companies must have fiscal years ending in March.

The companies must not be investment companies, financial intermediaries, holding companies, insurance companies, or banks; consequently, the sample consists of manufacturing and industrial companies.

Ultimately, 145 companies remained in the research sample and were examined.

Table 1. Selection of the Companies Examined in the Study

Description	Number	Classification
Population members at the end of the year ending March 2024	678	Total
Companies whose fiscal years do not end in March	(108)	Exclusion
Companies listed on the stock exchange after March 21, 2014	(109)	Exclusion
Companies for which information was unavailable	(105)	Exclusion
Companies in the investment, banking, insurance, holding, or financial intermediation industries	(104)	Exclusion
Companies that suspended operations for more than three months during the study period	(107)	Exclusion
Total companies excluded from the population	(533)	Total exclusions
Total companies in the sample	145	Remaining

The Rahavard Novin and Tadbir Pardaz databases will be used to collect the data required to calculate the research variables. Where data in these databases are incomplete, the physical archives in the library of the Securities and Exchange Organization and the website of its Research, Development, and Islamic Studies Department (www.rdis.ir) will be consulted.

- **Dependent Variable**

Financial performance (ROE): The dependent variable in this study is financial performance, represented by profitability, which reflects a company's ability to generate profits relative to its equity capital. According to Naz et al. (2016), financial performance is the extent to which a company's financial health is measured over a specified period. This means that financial performance is a financial measure involving the management of current assets, noncurrent assets, financial assets, equity, revenues, and expense-related assets to generate sales, profitability, and corporate value for shareholders. This study uses one indicator to assess profitability: return on equity (ROE). A higher ROE indicates that corporate management is increasingly capable of generating returns for shareholders (Hery, 2015). ROE is calculated as follows:

$$\text{ROE} = \frac{\text{Net income after tax}}{\text{Total shareholders' equity}}$$

- **Independent Variable**

Research and development expenditures (R&D): This variable is calculated as the ratio of research and development expenditures to total assets. These expenditures are extracted from the notes to the companies' financial statements.

- **Moderating Variable**

Industry type (IND): In this study, industry type is measured using a dummy variable. The following ratio is used to construct the industry-type dummy variable:

$$IND_{i,t} = \frac{X_{i,t}}{\sum X_t}$$

In the above expression:

IND: The sales power coefficient of industry i in year t.

X: Sales of industry i in year t.

ΣX: Total sales across industries in year j.

The median of all coefficients is then calculated. If an industry's sales power coefficient exceeds the median, it is assigned a value of 1; if it is below the median, it is assigned a value of 0.

- **Control Variables**

Firm size (SIZE): The logarithm of total assets.

Return on assets (ROA): Net income divided by total assets.

Loss indicator (LOSS): An indicator variable equal to 1 if the company is likely to incur a loss and 0 otherwise.

Financial leverage (LEV): Total liabilities divided by total assets in year t.

Quick ratio (LIQ): Current assets divided by current liabilities in year t.

Operating cash flow (CFO): Cash flow from operating activities divided by total assets in year t.

Inventory (INV): Inventory divided by total assets in year t.

- **Regression Models for the Research Hypotheses**

$$\text{ROE}_{i,t} = \alpha_0 + \beta_1 \text{R\&D}_{i,t} + \beta_2 \text{SIZE} + \beta_3 \text{ROA}_{i,t} + \beta_4 \text{LOSS}_{i,t}$$

$$+ \beta_5 LEV_{i,t} + \beta_6 LIQ_{i,t} + \beta_7 CFO_{i,t} + \beta_8 INV_{i,t} + \varepsilon_{i,t}$$

$$ROE_{i,t} = \alpha_0 + \beta_1 R\&D_{i,t} + \beta_2 IND + \beta_3 R\&D \times IND + \beta_4 ROA_{i,t}$$

$$+ \beta_5 LOSS_{i,t} + \beta_6 LEV_{i,t} + \beta_7 LIQ_{i,t} + \beta_8 CFO_{i,t} + \beta_9 INV_{i,t} + \varepsilon_{i,t}$$

- **Data Analysis Methods**

Initially, the Jarque–Bera test is used to examine the normality of the data distribution. The Durbin–Watson test is then used to determine whether the sample observations are independent and whether the sample is random. A Durbin–Watson statistic close to 2 (approximately 2 ± 0.5) indicates that the sample is random and that autocorrelation is absent. Pearson correlation coefficients among the research variables are also examined. The coefficients of the variables in the regression model are tested using Student's t test. In this study, the overall significance of the fitted regression model is assessed using Fisher's F statistic at the 95% confidence level, and the Durbin–Watson test is used to test for the absence of correlation among model errors. Finally, the distribution of the regression model's error terms is plotted to examine their normality. The hypotheses are tested using linear regression. Multiple regression is employed as the statistical method in this study. The primary objective of regression analysis is to determine whether a relationship exists between the dependent and independent research variables. Descriptive data analysis will begin with the calculation of measures of central tendency, including the mean and median, and distributional measures, including the standard deviation, skewness, and kurtosis. These measures will be calculated separately for different industries and for the sample as a whole. Combined cross-sectional and time-series data will be used to test the hypotheses. In the combined-data approach, the F-Limer test is used to choose between panel and pooled estimation. If panel estimation is selected, the Hausman test is performed to choose between fixed-effects and random-effects models. After the necessary corrections and classification according to the variables under investigation in Excel, the collected data will be entered into EViews 7 for the final analyses. Ultimately, the research hypotheses will be confirmed or rejected based on the results obtained from the relevant software.

- **Regression Tests**

Reliance on statistical results without considering the assumptions of the regression model has limited validity and cannot provide a sound basis for decision-making. Therefore, before interpreting any regression results, the model assumptions must be examined to verify the validity of the results.

- **Descriptive Methods**

Frequency distribution tables and statistical measures, including the mean, standard deviation, standardized skewness coefficient, standardized kurtosis coefficient, minimum, and maximum, were used in this study to describe the sample and the findings.

- **Inferential Methods**

Because this study uses multiple linear regression with combined data, or panel data, the following methods will be used to analyze the assumptions:

1. The Jarque–Bera test to determine whether the variables are normally distributed.

2. The Durbin–Watson test to examine error independence and the differences between actual and predicted values.

3. Evaluation of the coefficient of determination (R^2) to assess whether the assumption of a linear relationship between the variables is satisfied.

4. Pearson's correlation test to assess the linear independence of the independent variables.

5. A multicollinearity test indicates whether an independent variable is a linear function of the other independent variables. This issue can be examined using an appropriate diagnostic measure.

3. Findings and Results

In this study, ordinary least squares (OLS) is used to estimate the model parameters. The ordinary least squares method is based on the assumption that the research variables are normally distributed; a nonnormal distribution violates the assumptions of this parameter-estimation method. It is therefore necessary to test the normality of the research variables. In this study, this issue is examined using the Jarque–Bera statistic. If the significance level of this test exceeds .05 ($p \geq .05$), the hypothesis that the variable is normally distributed is accepted.

The Durbin–Watson test will be conducted to examine error independence and the differences between actual and predicted values.

The corresponding statistical hypotheses are as follows:

H_0: There is no significant correlation among the errors.

H_1: There is significant correlation among the errors.

If the hypothesis of error independence is rejected and the errors are correlated, regression cannot be used. The test statistic is calculated using the following expression:

$$D_w = \sum \frac{(e_t - e_t - 1)^2}{\sum e_t^2}$$

In this expression, e_t denotes the error or disturbance in period t, and e_{t-1} denotes the error or disturbance in the preceding year. If the correlation among errors is denoted by ϱ, the Durbin–Watson statistic is calculated using the following expression:

$$D_w = Z(1 - P)$$

The value of this test statistic lies within the range $0 < D_w < 4$ because:

If $\varrho = 0$, then $D_w = 2$, indicating that the errors are independent (no autocorrelation).

If $\varrho = 1$, then $D_w = 0$, indicating that the errors exhibit positive autocorrelation.

If $\varrho = -1$, then $D_w = 4$, indicating that the errors exhibit negative autocorrelation.

If the test statistic falls within the interval from 1.5 to 2.5, H_0 is accepted, indicating that the errors are independent and that autocorrelation is absent.

The coefficient of determination (R^2) is evaluated to assess whether the assumption of a linear relationship between the variables is satisfied, and Pearson's correlation test is used to assess the linear independence of the independent variables.

The coefficient of determination is the most important criterion for explaining the relationship between two variables. Its value ranges from 0 to 1. The larger its value, the more the variation in the dependent variable depends on the independent variable. Thus, a coefficient of determination of 1 means that all variation in the dependent variable is explained by the independent variable. A coefficient of determination of 0 indicates no dependence on the independent variable. The following formula shows how the coefficient of determination is calculated:

$$r^2 = \frac{a\sum y + b\sum xy - x\bar{y}^2}{\sum y^2 - x\bar{y}_2}$$

Taking the square root of the coefficient of determination yields the correlation coefficient, denoted by R. The correlation coefficient indicates both the strength and the direction of the relationship (positive or negative).

Because the coefficient of determination always lies between 0 and 1, its square root, r, also always lies between −1 and 1. The coefficient of determination is more informative than the correlation coefficient. The formula for calculating the correlation coefficient is as follows:

$$r = \frac{\sum xy - n\bar{x}\bar{y}}{\sqrt{y^2 - n\bar{y}^2}\sqrt{\sum x^2 - n\bar{x}^2}}$$

To test whether two random variables, x and y, are correlated, or equivalently whether the population correlation coefficient equals zero, the appropriate statistic for testing a zero population correlation coefficient is as follows:

$$t = \frac{r - p}{\sqrt{\frac{1 - r^2}{n - 2}}}$$

This statistic follows Student's t distribution with n − 2 degrees of freedom. The critical values at the specified significance level (α = 5%) are then obtained from Student's t table.

Heteroskedasticity is an important issue in econometrics. It means that the error terms have unequal variances when estimating a regression model. When estimating a regression using ordinary least squares, it is initially assumed that all error terms have equal variances. After the model has been estimated, various methods and techniques are used to examine this assumption and determine whether homoskedasticity is indeed absent from the model. In practical econometric work, however, researchers consistently encounter two issues: (1) because the error terms in the underlying population are unobservable, how can heteroskedasticity in the model be detected? (2) In practice, it is highly unlikely that all error-term variances are exactly equal, and the variances generally differ to some extent. A natural question is therefore whether a statistical criterion exists that measures the degree of inequality among variances, allowing researchers to conclude that a model suffers from heteroskedasticity if that inequality exceeds a certain threshold. In response, economists use various methods, including the Breusch–Pagan test, White's test, and the Park test. White's test is among the most widely used methods.

Fisher's F statistic can readily be used to determine whether the model exhibits heteroskedasticity. If the probability associated with the F statistic, Prob(F-statistic), exceeds the significance level (alpha), H_0 is not rejected and homoskedasticity is accepted. If this condition is not satisfied and the model exhibits heteroskedasticity, generalized least squares (GLS) can be used to address it.

H_0: Homoskedasticity.

H_1: Heteroskedasticity.

The F-Limer statistic is used to choose between panel-data and pooled-data methods. In other words, this statistic determines whether a separate intercept exists for each company. If heterogeneity or individual differences exist among observations, the panel-data method is used; otherwise, the pooled-data method is used, because the data are simply pooled and differences among them are not considered.

H_0: Pooled data.

H_1: Panel data.

If the null hypothesis is rejected in the F-Limer test, the question arises as to whether the relationships should be examined using a fixed-effects or a random-effects model. The Hausman test determines this choice. The null hypothesis (the random-effects method) states that the disturbance component associated with the intercept is unrelated to the explanatory variables and is independent of them. The alternative hypothesis (the fixed-effects

method) states that the disturbance component is correlated with the explanatory variable. Therefore, the fixed-effects method is used if the null hypothesis is rejected; otherwise, the random-effects method is used.

H_0: Random-effects method.

H_1: Fixed-effects method.

The stationarity of the model variables must be examined before estimation. A variable is stationary when its mean, variance, and covariance remain constant over time. In general, if a change in a variable's time origin does not change its mean, variance, or covariance, the variable is stationary; otherwise, it is nonstationary. The hypotheses concerning variable stationarity are as follows:

H_0: The variable is nonstationary.

H_1: The variable is stationary.

Stationarity can be examined at three stages: in levels, in first differences, and in second differences. For variables whose test probability in levels is below 5%, the null hypothesis is rejected and the variable is stationary in levels; if the probability exceeds 5%, the variable is nonstationary. The stationarity test results are presented in Table 2. According to the Levin–Lin–Chu test, because the probability for every variable was below 5%, all independent, dependent, and control variables were stationary in levels during the study period. Stationarity means that the means and variances of the research variables remained constant over time and that their covariances remained constant across different years. As shown in Table 2, all variables are stationary, and no cointegration test is required. Accordingly, spurious regression will not affect the estimated coefficients; in a spurious regression, coefficient significance is artificial.

Table 2. Stationarity Test Results for the Research Variables

Variable	Symbol	Levin–Lin–Chu statistic	p	Result
Financial performance	ROE	-16.8877	0.0000	Stationary
Research and development expenditures	R&D	-11.4572	0.0000	Stationary
Industry type	IND	-5.7668	0.0000	Stationary
Firm size	SIZE	-90.3723	0.0000	Stationary
Return on assets	ROA	-10.4862	0.0000	Stationary
Loss indicator	LOSS	-2.9256	0.0017	Stationary
Financial leverage	LEV	-10.4529	0.0000	Stationary
Quick ratio	LIQ	-8.9782	0.0000	Stationary
Operating cash flow	CFO	-26.2192	0.0000	Stationary
Inventory	INV	-18.1530	0.0000	Stationary

For the reasons discussed in Chapter 3, this study uses combined cross-sectional and time-series data. Before estimating the models, however, the estimation method (pooled or panel) must be determined. The F-Limer test is used for this purpose. For observations whose test probability exceeds 5%, or equivalently whose test statistic is below the tabulated critical value, the pooled method is used. For observations whose test probability is below 5%, the panel method is used to estimate the model. Panel estimation can be performed using either random-effects or fixed-effects models. The Hausman test is used to determine which model should be employed. Observations with a test probability below 5% are estimated using the fixed-effects model, whereas those with a test probability above 5% are estimated using the random-effects model.

As reported in Table 3, the F-Limer test probabilities for both research models exceed 5%; therefore, the pooled method is used to estimate both models. Because both models are estimated using the pooled method, the Hausman test is unnecessary.

Table 3. Results of the F Limer and Hausman Tests

Model	Test	Statistic	p	Result
First	F-Limer	1.4463	0.1631	Pooled estimation
First	Hausman	—	—	The Hausman test is unnecessary.
Second	F-Limer	1.2453	0.2628	Pooled estimation
Second	Hausman	—	—	The Hausman test is unnecessary.

A set of assumptions, known as the classical assumptions, applies to the residual term (or model error). For the regression coefficient estimators in a linear regression model to be the best linear unbiased estimators, these assumptions must be examined and tested. The procedures used to test these assumptions are described below, followed by an explanation of the estimation results.

Another assumption of linear regression is that all residual terms have equal variances. In practice, this assumption may not hold, and heteroskedasticity may arise for various reasons, including an incorrectly specified functional form, outliers, or structural breaks in the statistical population. Economists have introduced various tests to investigate this issue. In this study, the assumption of homoskedastic residuals was examined using White's test. The results in Table 4 indicate that the null hypothesis of homoskedasticity is rejected for both models. Therefore, generalized least squares (GLS) regression is used to address heteroskedasticity.

Table 4. Test Results for Constant Variance of the Error Term

Model	F statistic	p	Result
First	24.4578	0.0000	Heteroskedastic error term
Second	18.5842	0.0000	Heteroskedastic error term

This assumption of the classical linear regression model states that the regression residuals must not be correlated. The Breusch–Godfrey serial correlation test was used to examine residual independence. In this test, the null hypothesis indicates the absence of autocorrelation, whereas the alternative hypothesis indicates serial correlation among the errors. The test results show that, at the 95% confidence level, the probability associated with the F statistic exceeds 5% in both models. Therefore, the null hypothesis of no autocorrelation in the error term is accepted for both models. In other words, the assumption of no error-term autocorrelation holds in both models.

Table 5. Test Results for the Absence of Error Term Autocorrelation

Model	F statistic	p	Result
First	1.3077	0.2723	No error-term autocorrelation
Second	1.5536	0.2157	No error-term autocorrelation

Multicollinearity refers to a strong relationship among the independent and control variables in the model. In the presence of multicollinearity, the estimated model coefficients have large standard errors, which consequently reduces the number of significant variables in the equation. The variance inflation factor (VIF) was used to examine the absence of multicollinearity in this equation. A VIF below 10 indicates the absence of multicollinearity. As shown in Tables 6 and 7, the test results indicate that the variance inflation factors for the independent and control variables in the research models are within acceptable limits; therefore, no problem exists in this regard.

Table 6. Test Results for the Absence of Multicollinearity in the First Research Model

Variable	Symbol	Coefficient variance	Variance inflation factor
Research and development expenditures	R&D	0.026886	1.265932
Firm size	SIZE	0.000461	1.159204
Return on assets	ROA	0.001187	2.450275

Loss indicator	LOSS	0.000131	1.238741
Financial leverage	LEV	0.000660	3.125037
Quick ratio	LIQ	0.000353	2.829346
Operating cash flow	CFO	0.000795	1.324449
Inventory	INV	0.000589	1.224227

Table 7. Test Results for the Absence of Multicollinearity in the Second Research Model

Variable	Symbol	Coefficient variance	Variance inflation factor
Research and development expenditures	R&D	0.037437	1.891545
Industry type	IND	0.000175	3.658818
Research and development expenditures × Industry type	R&D × IND	0.085842	3.696464
Firm size	SIZE	0.000433	1.169565
Return on assets	ROA	0.001659	3.674332
Loss indicator	LOSS	0.000125	1.261545
Financial leverage	LEV	0.000636	3.229647
Quick ratio	LIQ	0.000333	2.864257
Operating cash flow	CFO	0.000745	1.332357
Inventory	INV	0.000561	1.250536

Hypothesis: There is a significant relationship between research and development expenditures and financial performance.

The estimation results reported in Table 7 were used to test Hypothesis 1. The probability (or significance level) associated with F is 0.0000. Because this value is below .05, the null hypothesis is rejected at the 95% confidence level, indicating that the model is significant. The Durbin–Watson statistic is 1.974, indicating the absence of error autocorrelation. The adjusted coefficient of determination indicates that approximately 64.7% of the variation in the dependent variable is explained by the model's independent and control variables. The results for the control variables show that, based on the t statistic at the 95% confidence level, firm size, return on assets, the quick ratio, operating cash flow, and inventory have positive and significant relationships with financial performance. In contrast, the loss indicator and financial leverage have negative and significant relationships with financial performance.

Overall, the results indicate that the coefficient for research and development expenditures is 0.126016, indicating a positive relationship between research and development expenditures and financial performance. Based on the t statistic, the coefficient for research and development expenditures is significant at the 95% confidence level. Accordingly, Hypothesis can be supported at the 95% confidence level. This indicates a positive and significant relationship between research and development expenditures and financial performance. In other words, financial performance increases as research and development expenditures increase.

4. Discussion and Conclusion

The findings indicate a positive and statistically significant relationship between research and development (R&D) expenditures and corporate financial performance among the companies examined. The estimated coefficient for R&D expenditures was 0.126016 and was significant at the 95% confidence level, supporting the first research hypothesis. Because R&D expenditure was measured relative to total assets and financial performance was measured using return on equity (ROE), the coefficient represents an association between research intensity and shareholder-oriented profitability, conditional on the other variables included in the model. The overall

regression was statistically significant, and its adjusted coefficient of determination indicated that approximately 64.7% of the variation in financial performance was explained by the explanatory variables. These findings suggest that R&D investment is relevant to corporate profitability, although the observational design does not establish that increasing research expenditure necessarily causes an improvement in ROE.

The positive association is consistent with research examining R&D investment, financing constraints, and corporate financial performance in China, which reported that R&D investment was positively related to performance and that this relationship was stronger under lower financing constraints [2]. A plausible explanation is that research activities help companies develop products, improve production processes, and use their resources more efficiently. These improvements can support profitability through higher sales, lower operating costs, or stronger market differentiation. Nevertheless, these mechanisms were not directly measured in the present study and should therefore be interpreted as possible explanations. The results establish an association between expenditure intensity and financial performance rather than identifying which technological or commercial outcomes account for that association.

The findings also support distinguishing research expenditure from successful innovation. Although the positive coefficient suggests that companies with greater R&D intensity tended to report higher financial performance, expenditure alone does not demonstrate that individual research projects achieved their objectives. Research on innovation success, R&D investment, and financial leverage places realized innovation outcomes within the analysis of corporate financing decisions [3]. This perspective suggests that the observed relationship may reflect companies' ability to convert research commitments into commercially useful developments. Organizational coordination may contribute to this conversion. The study of financial strategy, employee performance, and the mediating role of R&D in a pharmaceutical company provides a related organizational perspective, connecting financial decisions with the research activities undertaken by employees [4].

Financing capacity offers another explanation for the association between R&D expenditures and profitability. Research projects require continuing financial support, while their returns may be delayed and uncertain. Firms capable of maintaining research activity through development and commercialization may therefore obtain greater benefits than firms forced to interrupt projects. Research on R&D grants and external financing examines how public support relates to liquidity constraints and innovation funding [6]. Similarly, research on wages following R&D grants demonstrates that additional financial resources can affect internal organizational allocations as well as investment activity [5]. These studies do not directly establish the mechanism underlying the present findings, but they support interpreting R&D expenditure within a broader framework of financing continuity and organizational resource allocation.

The negative relationship between financial leverage and financial performance is compatible with the possibility that debt commitments constrain financial flexibility. Interest expenses and repayment obligations may reduce earnings available to shareholders and limit the resources that companies can allocate to uncertain research projects. However, the present results do not show that borrowing is inherently detrimental to innovation or that leverage necessarily reduces performance in every financial setting. Research connecting R&D investment, innovation success, and leverage indicates that these relationships require consideration of innovation outcomes [3]. Moreover, the study of single-lender financing among R&D-active firms highlights the importance of proprietary information in financing choices [7]. Thus, financing suitability may depend on repayment conditions, information requirements, and the protection of research knowledge.

The reported moderating role of industry type further indicates that the relationship between R&D expenditures and financial performance varies across industry categories. This finding supports a conditional interpretation of innovation investment: the financial implications of research expenditure depend partly on the commercial environment in which companies operate. Industries differ in product development cycles, technological opportunities, customer requirements, and competitive pressures. These differences can affect whether research outcomes generate revenues quickly, produce gradual efficiency gains, or remain difficult to commercialize. However, because the supplied findings do not report the interaction coefficient or its direction, the moderation result cannot establish which industry category benefits more from R&D expenditure. The evidence supports variation in the relationship without specifying the magnitude or direction of that variation.

Previous studies provide relevant support for considering such contextual differences. Research on credit policy, uncertainty, and R&D investment examines how innovation decisions respond to the financing and policy environment [8]. The analysis of green R&D financing in platform supply chains similarly demonstrates the relevance of commercial arrangements and financing channels to research decisions [9]. Sector-specific studies examining tourism enterprises and sports enterprises also place financial and developmental relationships within distinct industry settings [16, 17]. Although these studies do not directly test the present interaction between industry type and R&D intensity, they support the underlying argument that strategic investment should be interpreted in relation to the characteristics of the sector in which it occurs.

The positive associations of firm size, liquidity, and operating cash flow with financial performance suggest that organizational scale and financial capacity accompany stronger profitability. Larger firms may possess broader resource bases, while liquidity and operating cash generation can support routine operations and investment continuity. These explanations remain tentative because the regression does not directly test the pathways connecting these characteristics with performance. Research on digital finance and information transparency in relation to investment efficiency provides a complementary perspective on the conditions surrounding resource allocation [11]. The bibliometric analysis of digital finance for small and medium-sized enterprises and startups likewise identifies financing access as an important research domain [10]. Together, these perspectives reinforce the relevance of examining research expenditure alongside firms' financial circumstances.

The positive relationship between return on assets and ROE requires particular interpretive caution because both measures incorporate net income. Their association may therefore reflect shared accounting components as well as differences in operating profitability. Likewise, the negative coefficient for the loss indicator is consistent with weaker financial performance among loss-associated observations, but this relationship is closely connected to the construction of profitability measures. Inventory exhibited a positive association with financial performance, which may reflect the operating requirements of the manufacturing and industrial companies studied; it does not demonstrate that increasing inventory improves profitability. These findings underscore the importance of interpreting control variables according to their measurement and accounting relationships rather than assigning each coefficient a separate causal explanation.

The diagnostic results strengthen confidence in some aspects of the estimated relationships while leaving other methodological questions unresolved. The F-Limer tests supported pooled estimation, the variance inflation factors were below the stated threshold, and the serial correlation tests did not identify significant residual autocorrelation. White's tests nevertheless indicated heteroskedasticity in both models, leading to the use of generalized least squares. These procedures address specified statistical concerns but cannot eliminate omitted-variable bias or reverse causality. More profitable firms may have greater capacity to finance research, just as research activity may

contribute to subsequent profitability. Broader studies of governance, institutional quality, and financial development further suggest that corporate outcomes occur within conditions extending beyond the firm-level variables included here [12, 14, 15].

Several limitations should be considered when interpreting the findings. The sample comprises 145 listed manufacturing and industrial companies meeting specific eligibility criteria, limiting generalization to unlisted firms and excluded sectors. R&D intensity measures expenditure rather than research quality, commercialization success, or accumulated knowledge. ROE is sensitive to equity structure and may not capture longer-term innovation benefits. The industry indicator is based on relative industry sales and should not be interpreted as a direct measure of technological intensity. In addition, the incomplete reporting of the moderation coefficient prevents assessment of its direction and practical magnitude. Inconsistencies in the stated study period, software versions, and second-model specification also require clarification before the empirical findings can be fully evaluated.

Future research should examine the temporal relationship between R&D expenditure and financial performance using lagged investment measures and longer observation periods. Alternative outcomes, including market valuation, productivity, sales growth, and operating profitability, would help determine whether the relationship extends beyond ROE. Industry comparisons should distinguish technological intensity, competitive conditions, and commercialization cycles rather than relying exclusively on relative sales. Researchers should also investigate financing constraints, innovation success, and organizational capabilities as possible explanatory mechanisms. Designs addressing reverse causality and unobserved firm characteristics would strengthen interpretation. Reporting complete interaction estimates, conditional effects, confidence intervals, and sensitivity analyses would make the moderating role of industry type more transparent and assessable.

In practice, managers should evaluate R&D budgets in relation to project feasibility, expected commercialization periods, and available financial resources. Research expenditure should be accompanied by clear milestones and measures of technical and commercial progress. Companies should maintain sufficient liquidity and operating cash flow to support projects whose returns emerge gradually, while assessing whether debt repayment commitments are compatible with research timelines. Industry characteristics should inform investment decisions, but the present results do not justify prescribing higher R&D expenditure for a particular industry category. Investors should similarly interpret research intensity alongside profitability, financing structure, and evidence of innovation outcomes. Better disclosure of research objectives, expenditure composition, and project progress would improve the assessment of corporate innovation commitments.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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