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Assessing the lagged effects of R&D expenses on firm performance: Insight from BSE 100 companies

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Abstract
This research paper intends to investigate the effects of current and lag-year R&D expenditure on the financial Results of 49 listed companies in (BSE) India in the period of 2018-19 to 2022-23. Utilizing different Regression models such as Panel and Pooled OLS. The study employs ROA and ROE as proxies for financial performance, with Research and Development Intensity serving as an independent variable. According to study findings, financial performance is adversely affected by R&D intensity during the current year; and this impact turns positive and significant after two years.

Keywords: Lagged R&D, ROA, ROE, financial performance, BSE Index

Introduction

Investment activities are most important to help every business that's why every business should follow performing those activities. In this regard R&D expenditure is crucial for each company because that generates unique and better corporate performance and long-term competitive advantages (Grant, 1996) [18]. The resource-ground approach association that organizations have strategic coffers that give them a unique chance to produce (durable) competitive advantages over rivals (Barney 1991 [4]; Penrose 1959) [36].

Spending on development and exploration means investing in impalpable coffers that support the acquiring company's long-term success and expansion. Business investment in development and exploration because of boosts their capacity to grow and become more competitive than their rival in the business, also helps businesses to raise their firm value and might reduce their firm cost. (Mansfield, 1996) [29].

It plays a crucial for driving innovation, economic development, social weal, and the terrain (Cadil *et al*., 2018) [6]. R&D's most significant necessary factors for quality of life, fostering economic growth, and technology innovation (Hart and Milstein, 2003). R&D generates long-name profitable and competitive advantages and retains the request edge in terms of competitiveness. Forcing the assiduity to improve service quality and value-added products (Lee, N 2019) causes them to continuously grow the R&D practices encyclopedia (Cadil *et al*., 2018 [6]; Digar & Naskar, 2023).

There is ferocious competition in the colorful diligence due to the huge expansion in the ecosystem, when investment in R&D companies obtain greater advantages, better outcomes, and positive yields. But also has an adverse effect when spending on development is not successful consequently, Company might cease its operations. (Duqi *et al*., 2011 and Cadil *et al*., 2018) [6].

In the long run, the company's meaningful spending on development and exploration strategy may acquire good returns, and gain more market share, technological benefits, and sustainable competitive advantages over their competitors, in the request and reduce manufacturing costs through disquisition and development (Scarpello *et al*., 1986 [40]; Tiddj, J., 2003; Cadil *et al*., 2018 [6]; Erdogan & Yamaltdinova, 2019 [13]: Naskar & Digar, 2022).

When a company fails to attain satisfactory competitive advantages and sustainability the resulting risk of failure increases and affects environmental and social sustainability (Hameed *et al*., 2018). Henceforth allocation in explorations has enhanced the company's future revenue, y*et al*so considerable risk of uncertainty (Erdogan & Yamaltdinova, 2019) [13].

Nonetheless, few companies mainly focus on securing a competitive edge over their rivals and enhancing and achieving better performance that's why the company more in R&D activities and participates in innovative endeavors, infects certain companies with greater inclines, and participants towards the R&D and innovative activities (Núñez *et al*., 2018)

Literature Review and Hypothesis

In the prior literature review, the researchers gave many definitions of research and development and used definitions given by the OECD. According to this Research and development has a wide range of unique and creative activities, undertaken in these activities systematically to enhance the repository of knowledge including societal wisdom, culture, and knowledge of humanity, which is used for new applications to develop new products, processes, and services. Discover new knowledge, and enhance current offerings. OECD gives various criteria, which are important for comparison across the country and determining whether activities qualify as R&D activities. The main criteria are as follows: 1) novelty 2) uncertainty 3) systematic inquiry 4) purpose creativity 5) Utility. (OECD,2015).

In this regard, R&D Research and Development expenditures are very crucial for each company to stay competitive over others, gain a market edge, and develop new products or improve existing ones. (Wang, 2011) [47] verified that the company's degree of performance would be better served by its used resources in Development and research activities. It also helps to performance of the firm boost, and those companies who invest and allocate more R&D anticipated to yield higher relating to those who don't spend in R&D. This literature review explores the research

and development spending effect company's financial efficiency, providing insight into how every company strategically allocated its funds to innovation to enhance company performance. Number of studies investigate the association between innovation, Research and development expenditure, and firm performance as an indicator of investment activity. Existing literature reviews provide diverse outcomes of their relationship.

Some experimental evidence suggests that immediate positive impact of R&D expenditure on company effectiveness. This study confirms that Nandy, M. (2020) [31] R&D impact on Indian forty pharma companies' performance from 1998 to 2019. For financial performance indicators, exploratory variables are used as ROA, ROE, market capitalization, and sales turnover. Findings reveal Positive effects on financial metrics due to waiting a longer time and intense effort of long-term. Similarly, Lewis and Bohumir (1993) [28] Identify a statistically favorable significant association between market worth and expenditure on development and research by the firm. (Sharma 2012) [41] Analysis of the effect on the firm operation by R&D activities by utilizing data from 1994-2006. Identified that the overall factor productivity is positive and significantly impacted by 15% by R&D intensity.

Similar outcomes were identified regarding the operating performance of the automobile industry (Mondal & Sarkar 2020) [30], showing a favorable and significant relation with EPS although it shows that negative effect on financial metrics (ROA, ROE) an increase in R&D spending by one unit leads to proportional reduce in ROA and ROE by 0.383 and 0.509 respectively and increase in EPS 0.594 unit. (Karunanithy, et. al.,2017) [24] investigate effect of development and research expenditure on the financial efficiency of Sri Lanka's large-scale Industry. In this study, 105 publicly listed top R&D firms were selected based on stratified and random sampling. Descriptive and multivariate quantitative analysis reveals those expenses of R&D negative association with the ROCE, earning price per share (EPS), and Return on Assets ratio (ROAR).

Conversely, few studies suggest that requires some time for the influence of research and development on company performance. Evidence from Slovenia (Xu *et al*.,2016) [50] The study depicts that investment in development and exploration has no significant influence on current-year operating performance. But cumulative and lag year positive effect on firm value. Similarly, evidence from Turkey, ÖZKAN, N. (2022) [34]. Studied how immediate and lag-year exploration and development expenditure impacted the firm value of 500 listed firms in Turkey. The findings of the study indicate that R&D expenditure in the current year declines firm value and one year lag of R&D positive effect while the positive effect cannot be continued and the adverse effect is seen as two-year lag period on the industry financial sector. The findings show an intricate link between development and research spending and industries' financial outcomes. Suggests that impact may depend on the timing of investment and careful planning and investment management to optimize the benefit of R&D while mitigating the potential risk. Further study in India by Sinha & Mondal, (2020) [30] suggests that initially adverse effect of lagged RDI on firm performance but after a certain period favorable coefficient of quadric term. That means generating the benefit of RDI requires a certain period, and instead of reducing the R&D budget that time managers and policymakers should consider cost management in peripheral areas alongside product and market expansion to achieve positive overall outcomes. Based on the above literature impact of research and development intensity on financial outcomes, the following hypotheses are proposed:

H_1: Current year R&D intensity has negative effect on current year financial performance

H_2: One year lag of R&D intensity has positive effect on current year financial performance

H_3: Two-year lag of R&D intensity has positive effect on current year financial performance

Data collections

Data collection from the financial year 2018-19 to 2022-2023, for the five-year time frame for this study due to the unavailability of the dataset BSE 100 companies only 49 companies were considered. The comprehensive data allows for a detailed examination of the association between research and development intensity and the performance over a substantial five-year period of multiple companies aiming to provide valuable insight within selected sample firms.

Empirical Model

Model 1: Examine the Correlation Between Present Year Research and Development investment and Present-year ROA

$$\mathbf{ROA_{it} = \alpha + \beta_1 RDI_{it} + \beta_2 LEV_{it} + \beta_3 SIZE_{it} + \epsilon_{it}}$$

Model 2: Examine the Correlation Between Present Year Research and Development Investment and Present Year ROE

$$\mathbf{ROE_{it} = \alpha + \beta_1 RDI_{it} + \beta_2 LEV_{it} + \beta_3 SIZE_{it} + \epsilon_{it}}$$

Model 3: Examine Lagged Effect of Research and Development Investment and ROA.

$$\mathbf{ROA_{it} = \alpha + \beta_1 RDI_{it} + \beta_2 RDI_{(it-1)} + \beta_3 RDI_{(it-2)} + \beta_4 LEV_{it} + \beta_5 SIZE_{it} + \epsilon_{it}}$$

Model 4: Examine Lagged Effect of Research and Development and ROE.

$$\mathbf{ROE_{it} = \alpha + \beta_1 RDI_{it} + \beta_2 RDI_{(it-1)} + \beta_3 RDI_{(it-2)} + \beta_4 LEV_{it} + \beta_5 SIZE_{it} + \epsilon_{it}}$$

Wherein, ROA_{it} = Return on Assets, ROE_{it} = Return on Equity, RDI_{it}=Present Year Research and Development Investment, $RDI_{(t-1)}$= Previous Year Lag of Research and Development Investment, $RDI_{(t-2)}$=Previous Two Year Lag of Research and Development Investment, $SIZE_{it}$ = Firm Size, LEV_{it} = Leverage, ϵ_{it}= Error Term.

Table 1: Variable Description

Variable	Measurement	Acronym	Variable
Return on Asset	(EBIT +Depreciation) / Total Asset	ROA	Dependent Variable
Return on Equitys	Equity / Total Assets	ROE	Dependent Variable
R & D Intensity	Research & Development Expenditure / Net Sales	RDI	Independent Variable

One-Year-Lag of R&D Intensity	Research & Development Expenditure (Previous Year) / Net Sales	$RDI_{(t-1)}$	Independent Variable
Two-Year-Lag of R&D Intensity	Research & Development Expenditure (Two Years Prior) / Net Sales	$RDI_{(t-2)}$	Independent Variable
Firm Size	Natural Log of Assets	SIZE	Control Variable
Leverage	Total Debt/Equity	LEV	Control Variable

We visualize different types of Independent, Dependent, and Control variables. it will use to create link between R&D activities and financial performance in panel regression analysis concerning BSE 100 companies. The dependent variable is return on equity (ROE), and return on assets (ROA), in that order. Research & Development Intensity (RDI) is regarded as predictor variable. Leverage and Firm Size are the additional control variables that help to how other influence factors affect financial performance.

In this study we estimate two model related to panel data analysis, as outlined below: Random and Fixed effect model. The Hausman specification test was used final stage based on this result choose which model appropriate.

Table 2: Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum	VIF	1/VIF
ROA	12.1832	9.3833	-0.43	64.54		
ROE	20.5693	14.6833	-1.16	89.54		
RDI	2.3395	4.6205	0.01	44.79	2.37	0.421396
RDI(t-1)	2.3205	4.5360	0.01	44.79	1.58	0.631531
RDI(t-2)	2.4356	4.8624	0.01	44.79	2.53	0.395459
LEV	0.3603	0.4167	0.01	3.1	1.12	0.888916
SIZE	10.3897	1.2724	8.1290	13.7942	1.12	0.890665
				Mean VIF	1.75	

Table 2 represents the result of descriptive statistics summary shows the average, minimum, maximum values, and SD of different factors used in this work. exploratory variables are ROA, and ROE. Research and Development Intensity has been denoted by RDI and considered an independent variable. Here control variable includes Leverage and Firm Size whereas Firm Size takes into account the Natural log of total assets. mean values of ROE, and ROA are 20.5693 and 12.1832. The minimum values of ROA and ROE -0.43 and -1.16 respectively. The mean value of R&D Intensity and its Lag periods are 2.3395, 2.3205, and 2.4356 respectively. the variations of R&D expenditure, minimum value 0.01 and maximum value 44.79. the dispersion is also supported by SD of 4.6205 to 4.8624.

VIF values are calculated to check the existence of multicollinearity among the independent and control variables. VIF value above 5 or 10 is problematic because it indicates multicollinearity. The VIF value below that level indicates little multicollinearity between the variables. The mean VIF is 1.75 which is below the maximum acceptance level i.e., 5. So, multicollinearity between the variable is absent.

Table 3: Person Correlation Coefficient

Variable	ROA	ROE	RDI	RDI(t-1)	RDI(t-2)	LEV	SIZE
ROA	1.0000						
ROE	0.8670	1.0000					
RDI	0.1874	0.1320	1.0000				
RDI(t-1)	0.1708	0.0989	0.6013	1.0000			
RDI(t-2)	0.3231	0.2016	0.7484	0.5818	1.0000		
LEV	-0.2897	-0.1481	-0.1208	-0.1220	-0.1266	1.0000	
SIZE	-0.3086	-0.3210	-0.1018	-0.1120	-0.1239	0.3640	1.0000

Table 3: In this table correlation between ROE and ROA is 0.8670 Point out there exists Highly strong favourable relationship. Correlation between RDI and Financial metrics (ROA and ROE) is positive but relatively weak correlations, however, slightly higher positive relation with a two period Lag of R&D, because benefit of expenses in R&D is not reflected in short-term and persistent over the time. also, there is a negative weak correlation between leverage and size with the other variable. suggest that higher leverage is associated with a lower return on assets and equity, and large firms invest proportionally less in R&D.

Table 4: Static Panel Regression (Dependent Variable – ROA)

	Pooled-OLS	Random Effect	Fixed Effect	Lagrangian	Hausman	Acceptance
RDI	-.0711704 (0.727)	-.2557646 (0.014)	-.2876542 (0.198)			
RDI(t-1)	-.0428879 (0.812)	.0493518 (0.650)	.0369666 (0.889)			
RDI(t-2)	.6118233 (0.008)	.7146446 (0.000)	.7037402 (0.001)	0.0000	0.1120	REM Accepted
LEV	-2.064863 (0.229)	-3.629548 (0.041)	-4.330868 (0.051)			
SIZE	-1.646329 (0.006)	-.8824806 (0.278)	5.171499 (0.029)			
CONS	28.9229 (0.000)	21.43265 (0.012)	-41.72818 (0.093)			

For Panel Data analysis use Pooled OLS, Random and Fixed Effect Model. The Lagrangian Multiplier Test between OLS and REM to select which model is best. Hausman Test also conduct to determine which model i.e. FEM or REM suitable for the data.

Table 4: LM test applied to choose Between OLS and FEM, values of Lagrangian fall below 5% significance level, leading to reject null hypothesis. So, REM accepts. Thereafter we conduct Hausman Test between REM and FEM to determine which model is appropriate based on the result the REM model accepts because the Hausman result (0.1120) is greater than the 5% level of significance and fails to reject the null hypothesis. Finally, REM is most appropriate to test the effectiveness of ROA. In this regard RDI serves as the independent variable shows statistically negative significant impact on ROA in current year, it is not significant in one year lagged period. However, notably, two year lagged period of RDI significant positive impact on ROA, with a coefficient estimate of 0.7146. suggest that for each unit increase in RDI two years ago, ROA increase by approximately 0.7146, other variable constant. Control variable LEV negative statistically significant association with ROA, suggest that for every additional unit increase in Leverage, there is an approximately reduction of 4 units in ROE. while Firm size is no significant relation with ROA

Table 5: Static Panel Regression (Dependent Variable – ROE)

	Pooled-OLS	Random Effect	Fixed Effect	Lagrangian	Hausman	Acceptance
RDI	-.0527274 (0.882)	-.4238728 (0.046)	-.4871114 (0.343)			
RDI(t-1)	-.1625774 (0.607)	-.0490566 (0.818)	-.044156 (0.942)			
RDI(t-2)	.6914008 (0.084)	.9309842 (0.000)	.9554107 (0.044)	0.0000	0.0376	FEM Accepted
LEV	2.971704 (0.328)	-3.05773 (0.384)	-12.11311 (0.018)			
SIZE	-3.742672 (0.000)	-2.472041 (0.092)	7.978178 (0.139)			
CONS	58.13956 (0.000)	46.9495 (0.002)	-59.47587 (0.296)			

Table 5: Lagrangian test conducted to choose model between OLS and REM. The result reveals that the calculated value of the LM test is 0.0000 is indeed less than 0.005, thus indicating that null hypothesis is rejected, favouring the result REM. Thereafter Hausman test was applied to select which model was appropriate, as per result the Hausman (0.0376) which is significant at the 5% level and reject the null Hypothesis. So, table 5 finally based on the Hausman test authors select FEM as appropriate model to test the effectiveness of RDI with ROE. Display that RDI negative effect on ROE current year and proceeding with one year lag. However, it is noteworthy that RDI demonstrates positive and statistically significant impact of ROE in the two-year lagged period, with a coefficient value of 0.9554107. The coefficient of Leverage -12.11311 with P value of 0.018, which indicates leverage has a negative significant effect on ROE suggests that each unit increase in leverage there is an approximately 12.1131 units decrease in ROE. While Firm size does not demonstrate statistically significant, with a coefficient 7.978178 and P value of 0.139.

Findings and Conclusion:

Based on prior literature review the aim of this study is to explore the link between current and time lagged effect of R&D Investment and their impact on financial outcome. The main Findings and conclusion are as follows:

Firstly, the Current Year coefficient of RDI is negatively associated with financial performance metrics such as ROA and ROE. Another way, increased level of R&D expenditure corresponding decrease in ROA and ROE. In essence advantage of development and research expenditure is not performed short term and is persistent over time. This finding is consistent with Rao *et al*., (2013) [38], (Ravšelj & Aristovnik, 2020) [39], who suggest that the short-term performance impact of R&D may not be always positive. Therefore, H_1 is supported.

Secondly, based on the Model and Data used, The Coefficient Indicates the consequence of Lagged R&D on ROA and ROE in previous year's period $RDI_{(t-1)}$ not being statistically significant. There is insufficient evidence to suggest that $RDI_{(t-1)}$ and Financial Metrics (ROA, ROE). RDI from the previous year might not accurately predict how profitable a company is in the current year. Implies that relying slowly on lagged R&D Investment as the predictor of current performance may not be sufficient. So, Faill to accept H_2.

Finally, the Coefficient of $RDI_{(t-2)}$ shows positive and statistically significant relationship exist with financial metrics in two-year lagged Period. Suggests influence of R&D expenditure on financial health may be delayed, requiring several periods or waiting time before it has positive impact on return. The results similar with Sinha & Mondal (2021), and Holzl (2009). So, H_3 is Accepted.

There exist detrimental and statistically significant correlation between Leverage and performance metrics indicates that higher level of leverage is correlated with decreased profitability and return on equity. suggest that firms face increased financial risk and may struggle to generate returns for their shareholders. While Firm Size is not statistically significant.

Overall study suggest current year firm performance is negatively affected by R&D intensity while future after two-year firm performance shows positive influence from it. Initially negative performed due to high investment costs which are not recovering immediately, require some effort to translate in intangible assets and generate sufficient profit over cost, supported by analysis and align with prior literature review Ravšelj & Aristovnik (2020) [39], Rao *et al*., (2013) [38], Sinha & Mondal (2021), and Holzl (2009).

Practical Implication, Limitation, and Future Research

The study has several significant practical consequences, overall findings suggest that minimum two year necessary to observe positive impact on financial performance resulting from R&D investment. This statement especially helpful manager, policymaker because they should aware that spending on R&D may not significantly benefit in short term or immediately on financial efficiency but can lead to positive return in future. So, the manager advice to have some patience when distribution of the resource in the R&D activities and take appropriate decision based on the this.

Further, this study beneficial for policymaker because impact of R&D investment may not materialize immediately. Policymaker should consider take into account advantage that arise in long-term.

While this study offering valuable insight and ideas, it essential to acknowledge its limitations and consider them as guidance for future research endeavour first, period of analysis relatively short for the sample of forty-nine listed companies is restricted to the financial year 2018-19 to 2022-23. So, the one direction should extent the research period for future research. Secondly, small sample size encompasses 49 companies may restrict generalizability of the findings to a boarder population, so the future prospective researcher uses large sample size. Additionally due to shortage period of time challenges arise to apply sophisticate econometric model.

JL Classification: C23; O3; D25; F21

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