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Determinants and Impact of Corporate Research & Development Investments on Firm Performance: Evidence from India

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Abstract: Research & Development (R&D) investments have gained momentum in companies worldwide; it strengthens a firm's competitiveness and enhances its long-run performance. However, they vary among companies due to the inherent risk in generating returns. This paper explores the factors that determine the level of R&D investments in a panel data of 368 Indian listed companies over eleven years from 2011 to 2021, and examines the immediate as well as lagged effect of R&D intensity on firm performance using a dynamic GMM estimator. The results found a positive impact of firm's age on its R&D intensity but the firm's size and its debt ratio are the negative determinants of R&D investments. The findings show a higher level of R&D investments as a potential source of insecurity among investors; evident by positive impact of R&D intensity on firm's current financial performance (ROE) and negative impact on its market value (Tobin's Q). Based on the evidence obtained in the context of developing countries, the study provides useful implications for facilitating R&D investments in emerging markets.

1. Introduction

Innovation is gaining attention globally due to its significance in enhancing a company's competitiveness and sustainability in the long run. Companies are continuously evolving in the current era of competition by taking initiatives to beat the traditional way of doing things with their new ideas. For instance, Apple has changed consumer electronics; Uber has innovated the taxi business; Airbnb has evolved a new paradigm in the accommodation industry; Amazon has changed the retail segment. Companies' alertness to society's changing demands through innovation enabled them to tap the potential consumer base, thereby enhancing their performance. Innovation thus strengthens a company's position in the market; however, it is not a straightforward process. Companies innovate by undertaking research and development (R&D) expenditures; these are the building block of innovation (Becker-Blease, 2011). But, due to the long-term commitment of funds and unpredictability in outcomes, these investments

vary among companies. Companies may decide to either reduce or increase their R&D investments depending upon various internal and external factors. The study is undertaken to identify the factors determining the level of R&D investments and how these investments impact the performance of listed companies in India.

The second decade of the 21st century in India began with the buzzword 'innovation' when the President of India declared the period 2011-20 as the 'Decade of Innovation'. Since then, India has adopted policies to encourage innovative activities, such as setting up the National Innovation Council (NInC) in 2010, which exclusively focuses on innovation in every sphere of economic activity. India celebrates 11th May as 'The National Technology Day' every year to mark India's excellence in the field of technology and innovation, after it successfully tested nuclear bombs in Pokhran on 11th May 1998. ASSOCHAM, India's Apex Chamber for Commerce and Industry, organized the Third Innovation Summit cum Excellence Awards with the theme "Innovative India @ 2020" on 11th May 2015. The government has established R&D centers in different parts to foster research and achieve India's growth target under the Make in India program.

India's position in the Global Innovation Index (GII) list, 2021, has moved up two places to the 46th rank, making it the third most innovative economy among lower-middle-income countries in the world. Besides, five Indian companies, namely Hindustan Unilever, Larsen & Toubro, Bharti Airtel, Sun Pharmaceuticals, and Maruti Suzuki, made it to the Forbes' list of The World's Most Innovative Companies, 2018 which includes 100 names from across sectors and countries. The transformation in business processes powered by innovation provides India the technological edge to be at the forefront in the fiercely competitive international market.

The entry of multinational companies with large R&D centers and foreign investments has boosted India's innovative activities exponentially. The extent of R&D investments in a company however depends upon certain firm-specific and external factors, and these investments impact a company's performance too. Therefore, the study uses a sample of 368 companies listed on the Bombay Stock Exchange in India to contribute to the existing literature in several ways. Researchers have generally examined the relationship between R&D investment and firm performance in developed countries; this study will provide insight into the effect of R&D investment on companies' performance in the developing Indian economy. It would also benefit management through the identification of R&D determinants in developing strategies for allocating resources toward building the company's innovativeness.

The remainder of the paper is structured by first presenting the theoretical and literature review; after that, it develops the hypotheses followed by the research methodology used in the study. It then presents the results obtained after statistical estimations, and finally the discussion and conclusion.

2. Review of Literature

Innovation is the backbone of a company; according to Webster's dictionary, it introduces something new, a new idea, method, or device. Innovation is often also viewed as applying better solutions that meet new requirements, unarticulated needs, or existing market needs (Maranville, 1992). From airlines offering reclining seats to its high-end customers, cars equipped with airbags for safety, polarized

glasses available to protect eyes from ultraviolet (UV) rays, automation of medical processes and operations at hospitals to the transformation of cinemas and multiplexes, innovation is pervasive. According to Dalziel *et al.* (2011), "innovation is central in today's rapidly changing business environment to enhance firms' performance". Suarez and Lanzolla (2005) provided evidence on innovation's vital role in endowing a firm with a first-mover advantage that aids it in outperforming the competitors.

Companies need to think and act differently to face future challenges and embrace the change to avoid being a 'Corporate Dinosaur'. For instance, the giant company KODAK failed to foresee competition and upcoming opportunities in the digital market and ultimately disappeared despite inventing the first digital camera in 1975. Had the company acted positively to tap the potential digital market, it would have been the top company today. Similarly, Nokia, having a leading position in the smartphone market, also went out of business due to its resistance to switching to Android. Another is Xerox (who invented the first Personal Computer (PC)), who thought that the digital market was expensive and did not pay attention to demands for technological change. Blackberry failed to adopt change when more extensive touchscreen displays became a fascination in the market and so on. Innovation has thus become indispensable for companies to survive in today's competitive and constantly changing scenario.

The Investment Report of "United Nations Conference on Trade and Development (UNCTAD's Investment Report), 2005 has considered R&D as a most developed, widely available, and internationally comparable statistical indicator of industrial innovation activities." According to Griliches (1990), "R&D expenditures are considered as inputs in the process of innovation". Bhattacharya and Lal (2008) stated that organizations such as World Bank and World Economic Forum use the R&D spending of a country to measure its competitiveness.

2.1. Determinants of Research and Development Investment

R&D investments are the initial driving force in innovation, but they require the commitment of funds for an extended period with no guarantee of producing returns. Therefore, companies differ in their level of R&D investments depending upon various internal and external factors. Companies' experience and knowledge enable them to reap the benefits of innovative activities; thus, the firm's age may also relate to innovation. Firm size also determines its innovativeness; it is found to have a positive relation with R&D expenditures incurred by the company (Link, 1980; Meisel and Lin, 1983). The big-sized firms have high R&D investments (Wang, 2005), mainly due to their technical efficiency (Choi and Lee, 2018). The inherent characteristics of R&D investments make it difficult for small firms to block their limited resources in innovation activities, while it is valuable for companies with large market shares to invest in R&D (Chiang and Mensah, 2004). The company's past performance also determines the expenditure on R&D; the firm will be able to invest in R&D in the current year with more confidence if it has good performance in the previous year.

Debt is another factor that may affect R&D investments; companies with high leverage may forgo or reduce R&D investment to increase the available cash flows required to meet debt obligations (Barker and Muller, 2002). Since R&D investments carry high risk and uncertainty in generating future cash flows, companies have to curb these investments to avoid the risk of default in servicing their

debts. The debt financing thus creates pressure on sustaining profits (Myers, 1977), and is thus found to hurt R&D investments (Filatotchev and Piesse, 2009; Cumming and Macintosh, 2000; Ren, 2015). In contrast, Lee, 2012 found higher R&D investment with debt financing; hence, the empirical evidence on the impact of debt on the level of R&D investments is mixed.

2.2. Research and Development Investment and Firm Performance

The literature has well established the linkage between R&D activities and a firm's performance theoretically and empirically. Cortez *et al.* (2015) found an increase in the product portfolio of a company on account of high R&D, which enhances sales, thereby augmenting the company's financial performance. The study conducted by Bowen *et al.* (2010) proved the importance of a product or service's newness in increasing organizational performance. Zahra *et al.* (2000) found these investments to improve the company's financial performance by providing differentiated products. Grand (1991) and Izabela *et al.* (2014) are among several researchers who have confirmed that R&D investments facilitate companies in gaining market share, which boosts their sales and ultimately increases financial performance. Cockburn and Griliches (1990) and Megna and Klock (1993) found a positive impact of R&D investment on Tobin's q in the US. "R&D investments lead to increases in sales, market share, and/or profit", as reported by Ettlie (1998) & Tsai and Wang (2004). While examining whether R&D efforts are associated with future firm performance, Parcharidis and Varsakelis (2010) found positive market perceptions for firms pursuing R&D.

On the other hand, Baysinger *et al.* (1991) stated that R&D investments involve a significant likelihood of failure and found that the returns may only occur after many years or even not at all. Considering their long-term nature, Falk (2012) studied the impact of R&D intensity on companies' sales growth in Austria and found a significant positive impact over the subsequent two years. Similarly, Xu and Jin (2016) found lagged effects of R&D investment on profit margin and Tobin's Q, respectively. R&D investments are long-term investments that carry enormous risk and uncertainty. Driver and Guedes (2012) found R&D investments to reduce short-term earnings, which depresses performance in the near future (Wang and Thornhill, 2010), & Hoskisson *et al.* (1993) also reported that the investments might impact immediate performance negatively.

3. Objective and Hypothesis of the Study

3.1. Objective

- To identify the determinants of R&D intensity in a company and to examine the relationship between R&D intensity and firm performance.

3.2. Hypotheses

Based on the above objective, the following testable hypotheses are formulated:

H_{01}: Firm size has a positive impact on R&D intensity.

H_{02}: High leverage has a negative impact on R&D intensity.

H_{03}: Firm age has a positive impact on R&D intensity.

H_{04}: Past performance has a positive impact on R&D intensity.
H_{05}: R&D intensity has a positive impact on firm performance.
H_{06}: R&D intensity has a positive lagged effect on firm performance.

Figure 1 depicts the research model used in this study, and the above-mentioned hypotheses to investigate the relationship between R&D intensity and firm performance using ROE and Tobin's Q:

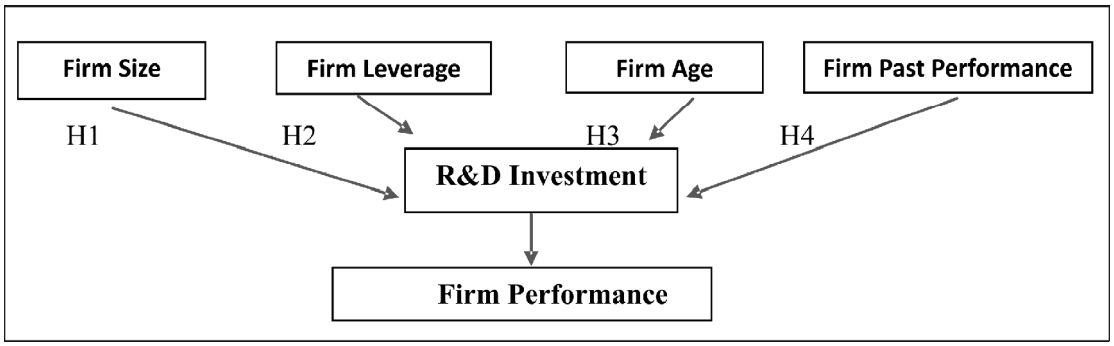

Figure 1: Research Model

Source: Author's Compilation

4. Research Methodology

4.1. Sample

The study draws a sample from 5477 companies listed on the Bombay Stock Exchange in India as of 31st March 2019. The study covers the period from 2011 to 2021 as the data for the year 2022 is yet to be uploaded by sample companies. It excludes companies that did not invest in R&D continuously during the study period and those listed after 2011 to obtain a final sample of 368 companies across 18 industries. The level of R&D investments in companies representing the pharmaceutical industry is highest with automobiles securing the second position among all. The sample companies had incurred R&D expenditure in all years and had data available on all variables of interest during the study period.

4.2. Variables and Model Specification

Consistent with previous studies (Jin *et al.*, 2018; Nivoix and Nguyen, 2012), the study employs R&D intensity as the ratio of R&D expenditure during the year divided by the company's total sales in all the models.

$$R\&D_{it} = \beta_0 + \beta_a LEV_{it} + \beta_b SIZE_{it} + +\beta_c AGE_{it} + \beta_d ROA_{it-1} + YEAR + INDUSTRY + v_{it} \quad (1)$$

$$Y_{it} = \beta_0 + \beta_a R\&D_{it} + \beta_b LEV_{it} + \beta_c SIZE_{it} + \beta_d AGE_{it} + \beta_e ROA_{it} + YEAR + INDUSTRY + v_{it} \quad (2)$$

$$Y_{it} = \beta_0 + \beta_a R\&D_{it-n} + \beta_b LEV_{it} + \beta_c SIZE_{it} + \beta_d AGE_{it} + \beta_e ROA_{it} + YEAR + INDUSTRY + v_{it} \quad (3)$$

Model 1 in equation (1) finds the determinants of R&D investment using leverage, firm size, firm age and past performance as explanatory variables. These variables are then used as control variables in

other two equations along with industry and year dummies. A series of year dummies are included to control the time effect because R&D investment levels in companies may change over time depending on general market and economic conditions (Katila and Ahuja, 2002). The dummy variables for each industry account for unobserved heterogeneity in R&D spending across industries (Breschi *et al.*, 2000; Malerba, 2002; Shapiro *et al.*, 2015).

Models in equation (2) and (3) tests the immediate and lagged effect of R&D investment on firm performance (Y_{it}) respectively. Firm performance is measured through two indicators, namely financial performance Return on Equity (ROE) and firm value (Tobin's Q). ROE measures management's efficiency in utilizing shareholders' funds to maximize their returns, and Tobin's Q is a long-term measure of performance that indicates the firm's future growth potential. Besides, 'n' in equation (3) takes the value of 1 and 2 for one-year lag and two-year lag respectively, i and t represent the firm and year respectively, and v_{it} denotes theerror term. The data for variables is extracted from Prowess IQ, the corporate database maintained by the Centre for Monitoring of the Indian Economy (CMIE). The measurement of variables is described in detail in Table 1.

Table 1: Description of Variables

S. No	*Variable*	*Description*	*Symbol*
1.	R&D intensity	Ratio of R&D expenditure incurred during the year to total sales.	R&D Intensity
2.	Return on Equity	Logarithm of {Ratio of (Profits after Tax (PAT)-Dividend to Preference shareholders) to (Paid-up equity capital Reserves and Funds – Revaluation Reserve)}	ROE
3.	Tobin's Q	Logarithm of {Ratio of (Market Value of common stock + Book Value (BV) of preference stock + BV of borrowings + BV of Current Liabilities) to the BV of assets denoted by (Fixed Assets + Investments + Current Assets)}	TBQ
4.	Size	Logarithm of total assets	SIZE
5.	Leverage	Ratio of the total book value of debts to total assets	LEV
6.	Age	Number of years since the company was incorporated	AGE
7.	Past Performance	Logarithm of (Ratio of profit before interest and tax to average total assets)	Lag ROA
8.	Year Dummies	Dummy variable 1 for test year, otherwise 0	YEAR
9.	Industry Dummies	Dummy variable 1 for test industry, otherwise 0	INDUSTRY

Source: Author's Compilation

4.3. Data Diagnostics and Techniques

The multicollinearity in all the regression models used in the study is detected by computing the correlation between variables and the variance inflation factor (VIF). The consistency of estimation

results with fixed effects and random effects models in panel data estimation assessed through the Hausman test gave statistically significant chi-square (Probability> chi2 = 0.000), and therefore fixed-effect method (FEM) is employed for all the models. Although this method acts as a powerful tool to address the problem of endogeneity, the dynamic Generalized Method of Moments (GMM) estimator is used to ensure consistent regression estimates for Model 2 by taking the lag of the performance indicator as an explanatory variable. Also, there may be simultaneity bias between R&D and performance variables; it is resolved by taking ROA lagged by one year in Model 1.It ensures that the direction of causality runs from independent variable to dependent variable when impact of performance on R&D is examined. Similarly, Model 3 and 4 takes lagged values of R&D while examining the impact of R&D investments on performance indicators. Due to heteroscedasticity and autocorrelation present in the data, clustering is applied to obtain robust standard errors (Wooldridge, 2010) as regression estimates in all models. The study thus overcomes the issues of heteroscedasticity, autocorrelation, endogeneity, and simultaneity to ensure the highest precision in estimations.

5. Data Analysis

The R&D expenditure incurred by sample companies is analyzed over 11 years from 2011 to 2021 through a graphical representation of data before identifying the factors affecting the investment decisions. Finally, it investigates the impact of R&D intensity on firm performance in panel data through the fixed regression method.

Figure 2 visualizes the R&D expenditure undertaken by 368 R&D intensive companies listed in India from 2011 to 2021 in a bar diagram, along with the change in performance indicators (ROE and

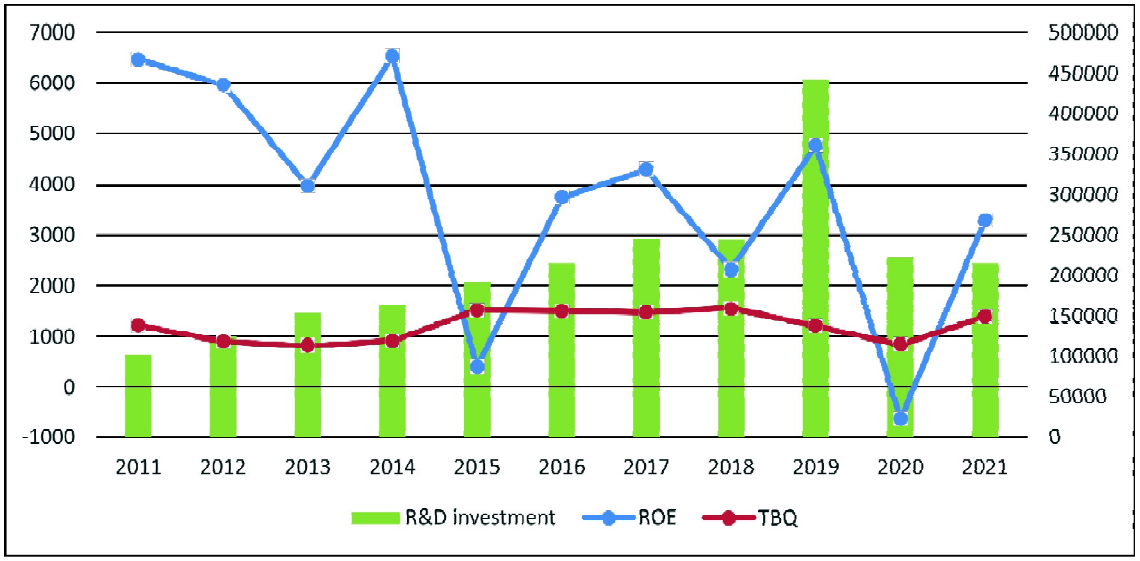

Figure 2: R&D expenditure and Performance Indicators for Sample Companies from 2011- 2021

Source: Author's Compilation (based on data obtained from PROWESS)

Tobin's Q). It shows a steady increase in R&D investments from 2011 to 2021; the investments have more than doubled by 2016, but there is little change until 2018. The year 2019 observed a significant jump in investments with a 181.11 percent increase over last year, which dropped by 48.50 percent in 2021. Regarding firm performance, both ROE and Tobin's Q have declined in the initial years signifying pressure on company's returns.

However, a difference in the movement of these indicators is observed in recent years. Tobin's Q came down by 22.13 percent despite a considerable spike in R&D investments in 2019, while ROE gained more than 200 percent in the same year. Interestingly, in 2020, the decline in R&D investments is accompanied by a steep fall in both performance indicators. However, it soon got corrected with the maintenance of steady R&D levels in companies. Thus, there exists a relationship between R&D investments and the performance of companies that need to be further examined.

Out of 368 companies, Table 2 lists the names of the top 10 companies that have incurred the highest aggregate expenditure on R&D investments in the last 11 years. The percentage increase in the R&D spending of companies in 2021 over the amount spent in 2011 shows a multifold increase in the R&D expenditure at all companies. While Tata Motors Ltd. has incurred the highest expenditure on R&D during 2011-2021, Sun pharmaceuticals Industries Ltd. had made a huge jump with a 667 percent rise towards its investments in R&D in Financial Year (FY) 21 over FY11. The data shows vast variation in the level of R&D investments undertaken by companies over time, as well as in the allocation of resources amongst them.

Table 2: List of Top 10 Companies in India Based on their R&D Spending During 2011-2021

Rank	*Name of the Company*	*Percent increase in R&D investments over the last 11 years*
1.	Tata Motors Ltd.	235%
2.	I T C Ltd.	114%
3.	Mahindra & Mahindra Ltd.	115%
4.	Reliance Industries Ltd.	224%
5.	Lupin Ltd.	206%
6.	Dr. Reddy's Laboratories Ltd.	200%
7.	Bharat Heavy Electricals Ltd.	73%
8.	Cipla Ltd.	335%
9.	Sun Pharmaceutical Industries. Ltd.	667%
10.	Bharat Electronics Ltd.	232%

Source: Author's Compilation (based on data obtained from PROWESS)

5.1. Descriptive Statistics and Correlation Analysis

Table 3 provides the descriptive statistics and correlation analysis for the sample before conducting regression. The mean and standard deviation values reveal a huge difference in the R&D intensity and

ROE of companies. The average size and age show that the sample constitutes big and experienced companies; it appears that companies prefer the debt component in their capital structure, with average leverage of 0.868.

Table 3: Descriptive Statistics and Correlation Analysis

Variables	*Mean*	*Std. Dev.*	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
1. R&D Intensity	61.22	704.21	1.000						
2. TBQ	3.39	7.41	-0.075*	1.000					
3. ROE	10.39	101.78	0.0002	0.0273	1.000				
4. LEV	.86	4.14	-0.0037	0.0645*	-0.161*	1.000			
5. SIZE	64082.34	312601	-0.054*	-0.0144	-0.0002	-0.0036	1.000		
6. AGE	44.261	21.066	0.0611*	0.0054	0.0295	-0.032*	0.055*	1.000	
7. Lagged ROA	6.170	9.105	0.0047	0.1074*	0.2639*	-0.213*	0.0051	0.0067	1.000
VIF			1.67	1.02	1.13	1.06	1.02	1.01	1.15

* shows significance at the .05 level

Source: Author's Compilation (STATA output)

The correlation matrix reports a negative correlation between firm size and R&D intensity, while the firm's age has a positive correlation with the level of R&D investments. The higher R&D expenditures tend to decrease the firm value, indicated by a weak negative correlation (-0.075*) between Tobin's Q and R&D intensity. The correlations among independent variables are less than 0.70, and variance inflation factors (VIFs) are less than 10; hence, multicollinearity is not an issue in the study's data. The opposite signs for a firm's size and age with R&D intensity in the correlation matrix and the significant negative correlation between Tobin's Q and R&D intensity are further examined by regression analysis.

5.2. Determinants of Research and Development Investment

The relationship between R&D intensity and individual explanatory variables is examined through Model 1 presented in Table 4.

The value of the R^2 statistic shows that the model is statistically significant in explaining the relationship between the variables; the explanatory variable explains approximately 76 percent variation in R&D intensity. The results show a significant negative impact of firm size on R&D intensity in contrast to hypothesis H_{01}, while the significant negative impact of the financing variable, leverage, supports H_{02}. With the positive impact of firm age on the level of R&D investments undertaken by companies, the third hypothesis H_{03} is also validated. Finally, H_{04} is rejected because of the insignificant impact of the company's past performance on R&D investments. Thus, R&D expenditures largely depend upon firm size (ASSETS), its age, and leverage (debt-equity ratio) in the capital structure.

Table 4: Regression Results for Determinants of R&D Intensity

Variables	*R&D Intensity (Model 1)*
LEV	-99.93**
	(71.91)
SIZE	-165.08***
	(29.90)
AGE	21.89***
	(5.07)
Lagged ROA	-2.28
	(7.96)
Constant	551.29***
	(235.77)
Observations	3172
R-squared	.76
Adj R^2	.77
F-stat	8.011
Industry Dummies	Yes
Year Dummies	Yes

Robust Standard errors are in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's Compilation (STATA output)

5.3. Impact of Research and Development Investment on Firm Performance

Table 5 presents the regression results of Model 2 (immediate effect), Model 3 (one-year lagged effect), and Model 4 (two-year lagged effect) where Model 2A, 3A, and 4A examine the impact of R&D investments on Tobin's Q and Model 2B, 3B and 4B examines the relationship of R&D investments with ROE.

The value of R^2 statistics in all models proves their statistical significance in explaining the relationship between variables. The explanatory variable, R&D intensity, explains approximately 75 percent variation in Tobin's Q and about 93 percent variation in ROE. Model 2 examines the immediate impact of R&D intensity on two performance indicators; and found a significant positive impact on a firm's financial performance measure, ROE, but a negative impact on the company's market value, Tobin's Q. The results confirm the presence of a dynamic model by rejecting the null hypothesis of AR (1) when GMM is used in Model 2. Also, it does not reject the null hypothesis of AR (2) and the Sargan Test confirming the existence of no further autocorrelation after introducing the lag of the dependent variable and validity of instruments used in each model respectively. Model 3 and 4 test the lagged effect of R&D intensity on firm performance with one-year and two-year lag periods respectively; and reports a significant negative impact of R&D intensity on Tobin's Q. The results thus, supports

both hypotheses, H5 and H6, partially. Besides, the company's past performance and age act as contributors to the improvement of ROE in R&D intensive companies, while leverage and firm size have adverse effects on Tobin's Q.

Table 5: Regression Results for Effect of R&D Intensity on Firm Performance

Variables	*Model 2A*		*Model 3A*	*Model 4A*	*Model 2B*		*Model 3B*	*Model 4B*
	TBQ		*TBQ*	*TBQ*	*ROE*		*ROE*	*ROE*
	No lag		*One year lag*	*Two-year lag*	*No lag*		*One year lag*	*Two-year lag*
	FEM	GMM	FEM	FEM	FEM	GMM	FEM	FEM
$R\&D_{(t-1)}$		.0873				.3584		
		(.011)				(.047)		
R&D	-.0005*	-.0002***	-.0007**	-.0003*	4.674*	5.341*	6.254	5.742
	(.0002)	(.0001)	(.0002)	(.0001)	(6.325)	(2.634)	(4.043)	(3.211)
LEV	-.0546***	-.0280**	-.044***	-.032***	-0.213	-0.213	-.206	-.192
	(.030)	(.012)	(.035)	(.047)	(.027)	(.052)	(.028)	(.036)
SIZE	-.0958**	-.0193***	-.100***	-.108**	-.002	-.012	-.003	-.003
	(.014)	(.003)	(.014)	(.014)	(.004)	(.017)	(.004)	(.007)
AGE	-.0412	-.0023	-.042	-.034	.0185***	.001**	.020***	.023***
	(.002)	(.007)	(.003)	(.004)	(.0012)	(.0029)	(.0014)	(.0017)
Lagged ROA	.251	1.015	.236	.222	0.976***	.167**	.973***	.976***
	(.017)	(.011)	(.018)	(.020)	(.0049)	(.0490)	(.0050)	(.0060)
Constant	2.686	.750	-.680	-.1697	1.476	.239	1.580	1.702
	(2.195)	(.042)	(.215)	(.251)	(0.083)	(.1679)	(0.085)	(0.098)
Observations	3456	3105	3116	2806	3473	2971	3130	2818
AR (1)		9.21				-9.05		
		(0.00)				(0.01)		
AR (2)		-1.89				-6.68		
		(0.58)				(0.34)		
Sargan Test		40.17				41.41		
		(0.418)				(0.825)		
R-squared	.78		.78	.79	.92		.97	.98
Adj R^2	.75		.75	.76	.93		.97	.97
F-stat	93.25		82.29	58.53	8.542		7.89	8.142
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust Standard errors are in parenthesis. AR(1) and AR(2) show the statistics for first and second-order serial correlation in the residuals under the null of no serial correlation obtained through the GMM estimator. The Sargan tests for over-identifying restrictions under the null of instrument validity.

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's Compilation (STATA output)

6. Results and Discussion

The empirical analysis of determinants of R&D intensity of a company and investigation into the relationship between R&D intensity and firm performance using a panel dataset of 368 Indian listed firms actively involved in R&D over 11 years provides intriguing observations. First, firm size has a significant negative impact on the R&D intensity of listed companies in India, indicating the active involvement of small and medium firms. It appears that large firms prefer to maintain stability rather than making investments in high-risk uncertain R&D activities. Conversely, small-sized firms consider investment in R&D as an opportunity to help them gain market share through the development of new products. Moreover, intense competition in the market builds pressure upon small companies to engage in R&D activities for survival in the long term. In this direction, India's favorable policies to boost R&D investments have been a prominent source in contributing to the overall economy's development.

Second, the R&D intensity of a firm increases with its age; it signifies greater confidence among experienced firms to undertake R&D investment decisions. Younger firms are relatively hesitant to take these investments to avoid an impact on their immediate returns. The company's capital structure also determines the R&D expenditures; more precisely, high debt hurts the R&D intensity of companies. The results indicate a lower level of R&D investments in companies mainly due to the liquidity crunch created by debt, especially short-term debt, which may require payment of the entire amount at short notice. To avoid the challenges of meeting debt obligations, it is better to employ equity capital for financing R&D investments (Giudici and Paleari, 2000; Müller and Zimmermann, 2009). The commitment to pay timely interest and principal thus plays a significant role in deciding the allocation of funds towards R&D investments.

Regarding the effect of R&D intensity on firm performance, it has a positive impact on a firm's financial performance, measured by ROE but a negative immediate as well as the time-lag effect on the firm's market value, i.e., Tobin's Q in both the first as well as second lag phase. It indicates insecurity among investors due to firms' higher exposure to R&D investments. Since returns from R&D investments are neither immediate nor certain, long-term commitment of funds in R&D investments enhances investors' risk. Thus, information asymmetry and sensitivity associated with R&D investments affect a firm's market valuation adversely. Moreover, the non-significant impact of lagged R&D intensity on ROE suggests the difficulties in sustaining success in hyper-competitive markets. Hence, the high risks and uncertainties associated with generating returns from R&D investments are confirmed by the empirical analysis.

7. Conclusion

The analysis of determinants of R&D intensity and examination of whether R&D intensity affects firm performance in panel data of 368 R&D intensive companies listed in India gives exciting results. Age is the positive determinant of R&D intensity, while leverage and firm size restrict the level of R&D investments in companies. Regarding the effect of R&D intensity on firm performance, the results show a positive impact of R&D investment on a company's financial performance but not with the lag period. Thus, a company can be successful with its thoughtful business strategy; however,

maintaining it is difficult. Additionally, the negative immediate, as well as the time-lag effect of R&D investment on the firm's market value, signifies investors' failure to recognize the economic effectiveness of R&D investments in the long run due to their preference for immediate returns. Therefore, strict vigilance and feasibility tests before making investments in R&D projects become crucial for successful innovation. Thus, a well-planned R&D investment strategy that mitigates the associated high risks is necessary to enhance long-term firm performance.

The growing importance of innovation coupled with associated risks has key implications for companies and policymakers. While R&D activities need to be accelerated to keep pace with other emerging economies, the management should recognize that efficient and optimal R&D investments on a moderate scale would help companies achieve sustainable growth. Management should drive strategic thinking, initiate creative sessions to develop new ideas and embrace experimentation to enhance innovativeness. The results imply using long-term debt in the capital structure to alleviate the burden of debt; the managers are therefore recommended to employ either equity capital or long-term debt for financing the R&D investments. It will reduce the pressure of meeting fixed obligations timely, and enable management to enhance the level of R&D investments in the company. Furthermore, efforts should be made to capitalize the R&D expenditures. This would help in reducing the perceived risk signaling value to investors. Apart from improving the market perception, it will improve the company's net income, which is otherwise burdened by entering R&D expenditures as expenses in the income statement. Companies need to organize management development programs and workshops at regular intervals to upgrade knowledge about tools used for big data analytics, essential for undertaking risk assessment of complex investments.

Policymakers in India have created a cohesive environment for higher innovative activities by providing substantial tax incentives and R&D subsidies to facilitate R&D activities at newly formed companies particularly the small enterprises. The companies should take advantage of these legislative and support mechanisms to develop new innovative products and services. The implementation of the New Education Policy by the government in India is a step in the right direction; it aims to overhaul India's entire education system. Aiming at children's holistic development, its focus on building analytical and reasoning skills among children would produce creative minds. Government should also consider providing higher research grants to educational institutions and encourage collaborative research between academia and industry to produce spillover effects of R&D investments in the economy.

The study has certain limitations; it focused on a few determinants of R&D investment and thus guides future researchers to consider other factors such as liquidity, and sales growth while analyzing the factors affecting the R&D investment strategy of companies. Furthermore, the comparison of determinants of R&D investment in India with those in other emerging countries and that of developed economies would also bring fruitful observations. Besides, industry-wise analysis can also be taken for examining the impact of R&D investments on firm performance to gain insight into characteristics of innovation in emerging markets.

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