R&D, Profit Persistence Impact On Profitability Of The Indian Automobile Sector

***Dinesh Jaisinghani ,** Fellow Scholar, International Management Institute, B-10 , Qutab Institutional Area New Delhi -110016 **Email : dinesh200384@gmail.com**

****Deepak Tandon**, Programme Chairperson PGDM –B&FS ,& Professor , International Management Institute (IMI) B-10 , Qutab Institutional Area , New Delhi – 111016
Email : - deepaktandon@imi.edu

Abstract

Research & Development (R&D) and human Capital are important to explain growth process of the Economy . It is pertinent to note that the processes which contribute the economic growth are new products innovations , developing new production techniques , obtaining more output and with the same input cannot be accomplished without R&D in today 's arena . The empirical purpose of the present work is to investigate the association between Research and Development (R&D) intensity and firm performance for the Automobile Industry in India. A dynamic panel methodology has been deployed. A sample of 105 listed auto firms in Indian for the period 2004 to 2013 has been considered. The results show that there exists a positive and persistent relation between profitability and R&D intensity. Also, a moderate level of persistence in the profitability was found for the sample companies. The results also indicated a possible inverted U-shape relationship between R&D intensity and profitability. The study highlights that firms may be overspend in R&D. This may yield negative returns in the long-run. Thus firms should try and find out the optimal level of R&D investments.

Key Words: Profitability; Indian Automobile Industry; Dynamic Panel; R&D Intensity; Firm Performance; Resource based view

JEL Classifications : F43; O30; O32; O40

1. . Introduction

Firm performance is the subject matter of several theories. These theories are based on work done in finance, strategy, microeconomics, and international business. The empirical studies testing such theories have looked into several firm-specific, industry-specific, and economy-specific variables (Degeorge and Zeckhauser, 1993; Anderson and Reeb, 2003; Maury, 2006; Brav *et al*., 2008). These studies are mostly dependent on the premise that the interplay between

industry structure and management efficiency determines the overall performance. The initial work on firm performance, which focused almost entirely on developed markets, is now being followed by studies from emerging markets (Khanna and Palepu, 2000a and 2000b; Kang, 2002; Nguyen and Bellalah, 2008; O'Connor, 2009). Many factors are responsible for driving the focus towards emerging markets. The chief among them is the increasing contribution of these economies towards the world GDP. The prime emerging economies are Brazil, Russia, India, China, and South Africa (also commonly referred as BRICS). A study of these economies provides useful insights in the manner in which business is conducted in emerging markets (Cheng *et al.*, 2007; Eunni and Manolova, 2012).

There has also been a shift from analyzing the entire economy to analyzing a particular industry (Roberts, 1999; Bae and Insead, 2004; Athanasoglou *et al.*, 2008; Collins *et al.*, 2011). The prime advantage of conducting an industry-wide analysis is it minimizes the variability in measurement of performance and other variables. This is because companies belonging to one particular industry face similar external environment. These companies are also subject to similar measures of profitability and other accounting ratios. The industry-wide analysis is also getting momentum in the emerging markets (Omran and Pointon, 2009; Perera *et al.*, 2012; Khilji *et al.*, 2012). However, there is much to be researched as far as analyzing industries in the emerging markets is concerned.

The foregoing discussion points at two major gaps. These are analyzing emerging markets, and understanding industry-specific determinants of firm performance in these markets. The current study is an effort to fill these gaps. The present work aims at analyzing the dynamic nature of relationship between profitability and R&D intensity for the Indian automobile companies. The study also tries to find the causality and nonlinear relationship between profitability and R&D

expenditure. Further, the nature of profit persistence among the Indian automobile firms has been analyzed. The rationale for considering automobile sector is that the sector is widely considered as one of the most crucial sectors of the Indian economy. The automobile industry contributes more than 22 percent to the country's GDP. Also, automobile firms spend a large amount of funds on R&D activities (Miotti and Sachwald, 2003). Thus the insights obtained from analyzing automobile industry can have several managerial as well as research implications.

The current work has several useful contributions to the study of firm performance. First, the present work deploys an advance methodology. The study utilizes dynamic panel methodology in which the lagged values of the dependent variables can be included among the explanatory variables. Second, the nonlinear relationship between profitability and R&D expenditure, which is generally overlooked in empirical studies, has been studied. Finally, the study has also analyzed the nature of causality between R&D intensity and profitability using causality tests. The remaining paper is organized as follows. Section 2 describes the theoretical framework and discusses the related literature. Section 3 presents the data. Section 4 discusses the empirical methods deployed. Section 5 presents the results and discussions. The final section presents the conclusion and the scope for future research.

2. Theoretical Background and Literature

Most of the research from the developed world has looked into the resource based view (RBV) as the major theory explaining firm performance. RBV suggests that firms tend to be more competitive by creating resources that are valuable, heterogeneous, and immobile (Rumelt, 1984; Barney, 1986 and 1991; Wernerfelt, 1984). These resources help an organization in creating capabilities that lead to superior performance (Grant, 1996; Danneels, 2002). These capabilities

can be created by sustained investment in tangible assets and intangible activities such as advertising, marketing, and research and development. Similarly, Rugman (2005) has contended that sustained competitive advantage is created by the interplay between firm-wide and country-wide advantages. These interactions create different outcome for different combinations of firm-specific and country-specific competencies.

Lin *et al*. (2009) have studied the consequences of partner selection on firm performance. The authors have considered sample of four US industries for a time period of 13 years. The authors found that both resources and status are important considerations in selection of a partner. They finally contend that an efficient combination of these two factors leads to higher levels of performance. Thus their findings lend support to RBV in the developed markets. Ramirez and Girdauskiene (2013) have found that there is a direct relationship between knowledge creation and prediction of reverse logistics. The authors also found a direct and positive relationship between reverse logistics and firm performance. Their study, therefore, supported the RBV as the Spanish companies were able to create valuable knowledge during the study period. Lin and Wu (2014) have analyzed the impact of creation of dynamic capabilities on performance. The authors have based their work on the premise of RBV and have argued that dynamic capabilities should improve performance. They based their study on 1,000 best performing companies that operated in Taiwan. They found that dynamic capabilities act as mediator between resources and performance. They concluded that these capabilities make the firm's resources more valuable and rare. This in turn helps the firm to outperform others.

Research in emerging markets has looked into alternate explanations of firm performance. These explanations primarily include impact of ownership structure, business-group affiliation, institutional voids, and corporate governance (Kim, 2002; Feenstra *et al*., 2003; Chacar and

Vissa, 2005; Gopalan *et al.*, 2007; Karabag and Berggren, 2014). Many studies have argued that the interplay among a few or all of these factors determine profitability for firms belonging to emerging markets (Jackling and Johl, 2009; Baghdasaryan and la-Cour, 2013). The major challenge confronting researchers studying these markets is that these factors are highly dynamic and vary widely across countries. Thus, it is very difficult to suggest a comprehensive theory that captures all aspects of firm performance. This has led to the research on emerging markets being highly fragmented and context specific. Ukaegbu (2014) has tried to find the relationship between proper management of working capital and firm profitability for African countries. The author considered several African nations such as Kenya, South Africa, Egypt, and Nigeria to discover this relationship. The time period considered was from 2005 to 2009. The author deployed a balanced panel-data methodology using fixed-effects technique. The author found a strong negative relationship between profitability and the length of cash conversion cycle. This led the author to conclude that there existed a positive relationship between proper management of working capital and performance.

Temporal dynamics of profits is a widely researched topic in advanced economies. Many authors argue that profits persist over time (Muller, 1977; Odagiri and Yamawaki, 1986; Schwalbach *et al.*, 1989; Glen *et al.*, 2001). This is due to creation of entry barriers and exploitation of economies of scale in the short-run (Kamerschen, 1969; Krugman, 1980). However, in the long run competition creeps in and drives abnormal profits away. Another reason for persistence of profitability is that consumers and producers face certain inertia (Ratchford, 1975). These factors result in profits being persistent. Mueller (1977) has analyzed profit persistence for a sample of 472 US firms. The author considered a long time frame of 24 years. The author further segregated the firms into eight subclasses based on their profits. The author found that firms

having higher initial profitability also displayed higher persistence in profitability in the subsequent periods. The author also found that competition failed to prevent firms from creating entry and exit barriers and hence did not eliminate profit persistence. Geroski and Jacquemin (1988) analyzed profit persistence among a sample of firms operating in three European countries, Germany, France, and the UK. The authors found a significant level of short run profit persistence in most UK firms. However, this persistence was much lower for French and German firms. The authors found similar results when they analyzed long run profit persistence for firms in these countries. These findings indicated a larger persistence in both short run and long run profits for the UK firms. The authors, based on these results, concluded that France and Germany were more competitive than the UK. Canarella *et al*. (2013) have analyzed industry-wide profit persistence for a sample of 1092 US firms. The authors analyzed the time period from 2001 to 2010. The authors deployed panel stationarity tests to analyze the evidence of mean reverting behavior. The authors found the profits to be stationary for most of the industries. The authors contended that the results signified evidence against profit persistence. However, the authors also found some level of persistence after bringing cross-section dependence in their dataset. Kambhampati (1995) has analyzed the persistence of profitability in several Indian industries. The author found that there is a significance presence of abnormal profits in many Indian industries. These abnormal profits also persist in the long run. The author also found that the level of persistence is much more in industries in their growth phase than in industries in their maturity phase. The author finally found that intermediation by government can control the persistence of profits in an efficient manner.

It is also generally argued that investments in R&D activities are a long-term commitment made to create intangible benefits (Gartrell, 1990; Martinez-Zarzoso and Suarez-Burguet, 2000). These

intangible benefits may be expenditure for the current period but can lead to future benefits in terms of increased profitability and value (Romer, 1990; Chauvin and Hirschey, 1993; Qian and Li, 2003; Chiao *et al.*, 2006). The proponents of RBV also argue that, in the long run, R&D is important for a firm's survival and growth (Kim and Lyn, 1990; Morbey and Reithner, 1990). Another major argument is related to the causal nature or relationship between R&D intensity and profitability. There can be a one-way or a two way causal relationship between these two variables. Branch (1974) tested these relationships for a sample of 111 firms for the time period 1950 to 1965. The author found that both R&D and profitability impact one-another. Thus, the author found evidence supporting two-way causality between R&D and profitability. A similar result was obtained by Colombo and Garrone (1996) who found bidirectional causality between R&D expenditure and inter-firm technological collaborations. The preceding discussion points at two major aspects of R&D. The first being the impact of R&D intensity on profitability and the second being the nature of causality between these two variables. The following discussion reviews some of the major studies that have tried to empirically validate the above propositions for various economies.

Focusing the attention towards nature of causality between R&D and performance, Rouvinen (2002) found evidence supporting one way causality between R&D and performance. The author, analyzing data from 12 OECD economies, found that R&D causes productivity and not the other way round. The author also found that increase in productivity considerably lags R&D expenditure. Frantzen (2003) has studied the nature of causality between R&D expenditure and factor productivity for 14 different countries. The author has considered a time frame from 1972 to 1994. The author found that, for a majority of cases, R&D had an impact on factor

productivity. Thus the findings by the author confirm presence of unidirectional causality from R&D to performance.

3. Data

3.1. Sample

The dataset for the present work includes firm specific factors for 105 firms operating in the Indian automobile industry. These firms include large and medium-sized companies, and therefore are a good representation of the automobile industry. The source for collecting the data is Prowess database that is maintained by Center for Monitoring of Indian Economy. The time frame considered is from 2004 to 2013.

The initial search yielded data for 523 companies that operated in the Indian automobile sector. To get the final dataset several filters were applied. First, all the companies having negative value of equity capital, sales, or total assets were deleted. Second, all companies having total assets of less than Rs 500 million were deleted. The rationale is to avoid including very small firms that may act as outliers and deteriorate the results. These firms also suffered from the missing data problem. Finally, all unlisted firms, government owned firms, and foreign firms were deleted. This resulted in a final sample of 105 firms. These firms represented around 70% of total assets of the initial 523 companies. Thus, not much information was lost while applying these filters.

3.2. Dependent Variables

In order to measure firm performance, three different measures of profitability were considered. These measures included Return on Assets (ROA), Return on Sales (ROS), and Return on Equity

(ROE). ROA is defined as profit before interest, tax, depreciation, and amortization (PBDITA) scaled by total assets. Similarly, ROS is measured as PBDITA scaled by total sales. Finally, ROE is measured as net-profit after tax scaled by net-worth. These three measures of profitability make the analysis robust and increase the validity of the results.

3.3. Explanatory and Control Variables

In the present work R&D intensity (RNDI) is the main explanatory variable. RNDI is defined as total outlay on R&D scaled by total sales. This term conveys what portion of total sales is dedicated to research activities of a firm. Earlier works that have considered similar measure for R&D intensity include Yeh *et al*. (2010), Asthana and Zhang (2006), Hitt *et al*. (1997) and Peng and Luo (2000).

Apart from R&D intensity, five other control variables have been considered. These include firm size, marketing intensity, capital structure, export intensity, and manpower ratio. Firm size (SIZE) is measured as the natural log of total assets. Taking the natural log reduces the scale factor and hence the heterogeneity is avoided to a large extent. Authors who have considered similar measure for firm size include Ettlie (1998), Chan *et al*. (2001) and Asthana and Zhang (2006). Capital Structure (CS) is calculated as long-term debt scaled by total assets. Earlier works having defined capital structure in similar manner include the work done by McDonald (2002) and Tongkong (2012). Export intensity (EXPI) is measured as export sales scaled by total sales. This ratio signifies the level of geographical diversification. Other studies having similar measure for export intensity include work done by Pradhan (2002) and Barber and Alegre (2007). Marketing Intensity (MI) is calculated as sum of advertisement and marketing expenditure scaled by total sales. Other studies having similar measure for marketing intensity

include work done by Chauvin and Hirschey (1993) and Kashmiri and Mahajan (2014). Manpower Ratio (MR) is calculated as sum of salaries, wages, and other benefits scaled by total sales. This ratio signifies the labor intensity in the total production. Prior studies having considered similar variable include the works of Glaum (2009), Aboody *et al.* (2010) and Schiemann and Guenther (2013).

3.4. Descriptive Statistics and Correlation

Table 1 presents the descriptive analysis for the entire sample. The table shows that the mean (median) ROA for the entire sample is 15.7% (14.9%). Similarly, the mean (median) values of ROS and ROE are respectively 13.2% (12.4%) and 27.8% (15.3%). The table further shows that the spending on R&D activities is around 0.4% of the total sales. The median value is considerably lesser than the mean and stands at 0.1% of the sales. This fact highlights that there are many small firms that cannot afford to invest large amounts in research activities. The average long-term debt is around 30% of total assets. This shows that Indian automobile firms are moderately levered. The overall spending on employees is under 10% of total sales. This is mostly because the automobile firms are highly capital-intensive and spend a high proportion of their sales in creating fixed assets.

[Insert table 1 here]

Table 2 presents the coefficient of correlation among the various variables. The table shows that there is a negative correlation between current R&D and various measures of profitability. This is because R&D for the current period is an expense and usually generates positive benefits in the long run. The correlation analysis shows that none of the correlations between any two

explanatory variables is greater than 0.4. Thus the dataset does not suffer from problem of severe multicollinearity.

[Insert table 2 here]

4. Method

The current study deploys dynamic panel methodology. Dynamic panel methods help in identifying the dependence of a particular variable on its past values apart from its dependence on other variables. Dynamic panel designs are becoming increasingly prominent in empirical studies (see Guha-Khasnobis and Bhaduri, 2002; Goddard *et al.*, 2006; Hughes, 2008; Serrasqueiro and Rogao, 2009; Dang *et al.*, 2012; Flannery and Hankins, 2013). These methods are helpful in analyzing variables that display a tendency to persist overtime. There is a strong theoretical reason to assume that current profitability will depend on past profitability. This is because firms cannot change their production and marketing strategies in a short span of time. Also, consumers cannot instantly shift to a competitive product even if it is more attractive.

5. Results and Discussion

The first step involved testing the stationarity of various variables considered. Regression analysis performed on nonstationary data can yield misleading results. The unit-root tests for stationarity were performed and it was observed that all the variables were stationary in their base form. Also, a stepwise regression analysis was performed to find the significance of the variables considered. The base model is as described in equation (7). In equation (7) performance is represented by three different measures of profitability, as represented by ROA, ROS, and

ROE. These measures are described earlier in the data section. It was observed that all the variables considered as well as the overall model was significant [2].

$$Performance_{it} = \alpha + \beta_1 RNDI_i + \beta_2 SIZE_i + \beta_3 CS_i + \beta_4 EXPI_i + \beta_5 MI_i + \beta_6 MR_i + u_i \quad (7)$$

Dynamic panel regression helps in finding the impact of past values of the dependent variable and other explanatory variables on performance. However, the base model as described in equation (7) has two major limitations. First, it does not consider the presence of nonlinear relationship between profitability and R&D intensity. Several authors have argued for testing nonlinear relationships between accounting measures and performance (Amir and Wooders, 1998; Omran and Ragab, 2004). Second, there can be endogeneity bias among variables as all the variables are considered for the current year. To avoid the first problem a squared R&D term is introduced and to avoid the second issue one period lag values of all the variables is considered. This yields the modified regression model as described by equation (8).

$$Performance_{it} = \alpha + \delta ROA_{it-1} + \beta_1 RNDI_{i,t-1} + \beta_2 SIZE_{i,t-1} + \beta_3 CS_{i,t-1} + \beta_4 EXPI_{i,t-1} + \beta_5 MI_{i,t-1} + \beta_6 MR_{i,t-1} + \phi RNDI^2_{i,t-1} + u_{it} \quad (8)$$

Arellano and Bond (1991) estimation, which is a robust technique in the absence of endogeneity, bias has been applied. This technique can handle several types of dynamic panels. The estimation technique assumes presence of first order autocorrelation but absence of second order autocorrelation. This method also yields robust results even in the presence of endogeneity (Flannery and Hankins, 2013).

Panel A of table 3 displays the results of the dynamic panel estimation with ROA as the dependent variable. The table clearly indicates that R&D intensity has a positive impact on profitability. The coefficient is positive and also significant at 5% level. This shows that firms can increase their profitability by investing in R&D activities. Although the benefits of these investments accrue in the long run, firms must invest in R&D activities in order to become sustainable. The findings suggest that automobile firms should focus on creating a long-term R&D project so they can bring out new products and innovative processes in frequent intervals. The findings are similar to those obtained by Chauvin and Hirschey (1993) and Martinez-Zarzoso and Suarez-Burguet (2000). The findings support the resource based view (RBV), which claims that creating valuable resources helps firms to attain long-term competitive advantage. The results are in contrast to those obtained by Kumaraswamy *et al*. (2012) who found no significant relationship between profitability and R&D expenditure for Indian auto component firms. The difference in results may be due to different methodology considered and different time frame. Kumaraswamy *et al*. (2012) considered the sample period from 1992 to 2002. The current study considers the sample period from 2004 to 2013. This also highlights that Indian firms have started focusing on internal R&D for creating organizational competencies.

There are certain other interesting findings. The coefficient of lagged term of the dependent variable, that is, ROA is positive and significant. The coefficient of 0.37 suggests a moderate level of persistence in the profitability as indicated by ROA. This is also very intuitive as automobile firms generally have some loyal consumer base such as industrial houses, and government agencies. The repeat orders and the existence of long-term contracts with these organizations bring repeat sales for the automobile firms. This causes certain level of persistence in profitability. The coefficient value of 0.37 also suggests that the persistence is around one-

third of profitability and hence the firms constantly have to look for new customer base to expand its sales. This is also intuitive as automobiles are capital goods and the same users don't buy automobiles frequently. Also there is a large market for resale of automobiles in India. This resale or secondhand market also weakens the persistence in the profitability as this market provides an alternative to the buyers. The findings also support the entry and exit barrier argument (Kamerschen, 1969; Gschwandtner, 2012). The findings reveal that automobile industry in India is characterized by certain entry barriers that enable the incumbent firms to earn abnormal profits. The results justify the benefits of dynamic panel methodology over other techniques such as OLS and two-stage least squares (2SLS) that are common in empirical studies. The findings are similar to those obtained by Mueller (1977) and Geroski and Jacquemin (1988) who found moderate to high profit persistence in various industries.

The analyses of other factors also reveal several interesting findings. The squared term of R&D intensity is negative and significant. This implies that there can be a threshold level of R&D intensity beyond which it starts yielding negative returns. This means that there can be companies investing beyond the threshold level. These firms need to cut down their R&D spending as some part of these investments are not yielding positive returns. Unproductive and inefficient utilization of R&D outlay can also be a factor behind such results. This generally happens when firms are not able to maintain a balance between investments in explorative activities and investments in exploitative activities (O'Reilly and Tushman, 2008). This also signifies that there is a tremendous scope for the automobile firms to streamline their R&D expenditures to get the most out of it.

The coefficient of size is negative and significant. This implies that there is an optimal firm size and smaller sized automobile firms are generating higher profit margins. The findings also have

practical implications since in recent times there have been several demergers in the Indian automobile industry. For instance, Hero-Honda, which operated as a joint-venture enterprise since 1984, split into two separate firms in 2010. Similarly, Bajaj and Kawasaki discontinued their partnership in India. The coefficient of capital structure is positive and significant. This means that more profitable firms are better able to utilize the use of debt. This is in accordance with the pecking order theory as well as the signaling theory of capital structure that claim that profitable and established firms rely more on borrowings and less on equity (Ross, 1977; Myers, 1984). This is because markets discount equity more than debt.

Export intensity is having a negative coefficient but is not significant at the 10% level. This implies that domestic markets are fetching higher margins compared to foreign markets. One reason for this finding can be the dumping policy followed by Indian automobile firms. This may be done in order to penetrate into these markets so that they can be exploited in future. Similarly, the coefficient of marketing intensity is also negative. One reason can be that for automobile firms alternate forms of promotions, such as winning the car of the year award may be more beneficial than spending heavily on advertisements. Finally, the manpower ratio is having a positive and significant impact on performance. This highlights that firms that spend a lot in developing and training their employees are more efficiently utilizing their workforce in creating economic value addition.

Further, in order to test the applicability of Arellano and Bond (1991) model, it is important to analyze the residuals for a possible presence of second order autocorrelation. The model provides robust results when the error terms follow an AR(1) scheme but not an AR(2) scheme. Panel B of table 3 presents these results. As is clear from the table, the error terms follow an AR(1)

scheme but not an AR(2) scheme. This provides with sufficient proof of the validity of the results.

[Insert table 3 here]

The next analysis involved testing for the second period persistence of profitability. Table 4 presents the results of this analysis. Panel A of table 4 reports the dynamic-panel regression results with the second-period lagged values of ROA included among the regressors. From the table, it is quite clear that the second-period lagged term of ROA is also positive and significant. This implies that profits persist for more than one period. These results are similar to those obtained for many advanced economies, characterized by higher level of competition and well-developed economic institutions (Goddard *et al.*, 2005; Collins *et al.*, 2011). Panel B of table 4 presents the results of residual diagnosis tests. The results confirm the significance of firs-order autocorrelation term and the insignificance of the second-order autocorrelation term. The results obtained fulfill the assumptions of Arellano and Bond (1991) estimation technique. Thus the results obtained are robust and can be utilized while taking managerial decisions.

[Insert table 4 here]

In order to be certain about the results obtained, two alternative measures of profitability were subjected to similar analyses. These measures included ROS and ROE. Whereas the former indicates the gross-profitability per unit of sales, the latter describes net-profit belonging to the shareholders. Thus, it would be useful to analyze whether these measures are providing similar outcomes. Table 5 and table 6 report the results with ROS as the dependent variable. Table 5 reports the results with one-period lagged term of ROS included among the regressors. Table 6

reports the results with one and two-period lagged terms of ROS included among the regressors. Panel B of both these tables display the results of the residual diagnosis tests.

Table 5 clearly indicates that results for ROS are quite similar to those obtained for ROA. However, the persistence level is much smaller for ROS compared to ROA. One reason for this finding may be that assets are more stable in the short run than sales. The coefficient of the R&D term is positive and significant. These results further highlight the usefulness of investing in R&D activities. Similar to the findings for ROA, the coefficient of the squared R&D term is negative and significant. The magnitude and signs of other coefficients are qualitatively similar to those found for ROA. Panel B of table 5 reports the results of the residual diagnosis tests. The results confirm that the model is robust and the residuals behave as per the assumptions of the model.

[Insert table 5 here]

Table 6 reports the results by considering one and two-period lagged terms of ROS among the regressors. The second period coefficient of ROS is very small but significant. This shows that profits persist in multiple periods. The findings are similar to those obtained for ROA. The conclusions about R&D intensity are qualitatively the same. The squared R&D intensity term is negative and significant. The results support the earlier conclusions drawn. Panel B of table 6 reports the results of residual analysis. The table clearly points out that the residuals behave as per the assumptions of the model.

[Insert table 6 here]

Table 7 and table 8 present similar analyses with ROE as the dependent variable. The results are qualitatively the same as observed for ROA and ROS. The persistence level of ROE is the least

among the three measures of profitability. The second-period lagged term of ROE shows negligible persistence. Thus, it is evident that ROA has the highest persistence and ROE has the lowest persistence. The residual diagnosis analyses of the two tables clearly highlight that the models are robust and the residuals behave as per the expectations.

[Insert table 7 here]

[Insert table 8 here]

In many applied studies it is often argued that there can be bidirectional causality between the accounting variables. If this is the case then the results have to be considered in newer lights [3]. Profitability and R&D intensity are the two main variables considered in the current study. Understanding the nature of causality between these two parameters is vital before concluding anything about the impact of one variable on the other. This can be accomplished by performing causality tests. The most prominent causality test is proposed by Granger (1969). In the current study the Granger-based causality test for panel-data is performed to find the causality between R&D intensity and the three measures of profitability.

The final analysis involved testing the main cause of the negative coefficient of the squared R&D intensity term. This is achieved by introducing a new dummy variable HRND (to represent firms spending very heavily on R&D intensity). HRND takes the value of 1 if the firm in question is among the top 25% of the firms in terms of R&D intensity and 0 otherwise. The coefficient of HRND should be negative for firms having high R&D intensity and not managing their research activities efficiently. Also, a negative coefficient of HRND can hint at a possible inverted U-shape relationship between R&D intensity and profitability.

The results of this analysis are reported in table 9. The explanatory variables are the same as considered earlier in the dynamic- panel analyses. The only exception is that this time static-panel estimation is performed. This is because dynamic-panels cannot handle variables that are completely time invariant (the dummy variable HRND in the current case). Therefore a static-panel is considered. The table has three panels. These three panels report results by considering ROA, ROS, and ROE as the dependent variable. The table clearly highlights that the dummy variable is negative and significant for ROA and ROE. For ROS, the coefficient of the dummy variable is negative but is not significant at the conventional levels. These results highlight that firms having high R&D intensity are unable to efficiently leverage on their research activities. The results also hint at a possible presence of a threshold level of R&D intensity beyond which it is unprofitable to keep investing further. The results are quite surprising considering the low level of R&D spending by Indian firms compared to the R&D spending of firms from advanced countries. One reason for this may be inappropriate allocation of research budget between the explorative activities and exploitative activities by the Indian automobile firms. The coefficients and signs of other explanatory variables are qualitatively the same as obtained in dynamic-panel estimation.

[Insert table 9 here]

6. Conclusions

In the current work an effort has been made to analyze the impact of R&D investment on the profitability of firms operating in the Indian automobile sector. Dynamic panel methodology has been deployed to estimate the results. The estimation technique deployed is the one developed by Arellano and Bond (1991) that utilizes a GMM technique to estimate the coefficients and their

error structures. The sample consisted of 105 companies that operated in the Indian automobile sector for the period 2004 to 2013.

The results obtained highlighted certain interesting findings. It was confirmed that investment in R&D and profitability are positively related. However, it was also found that there can be a possible nonlinear relationship between R&D intensity and profitability. The results suggested an inverted U-shape relationship between these two variables. It was also found that size as well as export intensity were having a negative impact on performance. It was further found that manpower ratio and debt were having positive impact on performance for the sample firms. The tests of causality indicated unidirectional causality flowing from R&D intensity to profitability.

The current study offers several managerial implications. Automobile firms should consider expenditure in R&D as investments done for bringing future benefits. However, they should abstain from investing too much into R&D activities. Also the firms must try to find an appropriate balance between explorative and exploitative activities. The automobile firms in India should try to streamline their operations according to their size as it was found that bigger firms are underperforming compared to smaller firms. Finally, the management of automobile firms must consider having highly skilled workforce so that they can leverage their capabilities in creating superior value for their firms.

The study has two major limitations. First, the current study has analyzed only a single country and a single industry. Second, the current study did not attempted to find out the exact threshold level beyond which it is not profitable to invest in R&D activities. These limitations can also become scope for future research. It will be interesting to find out whether similar results are

obtained for other countries such as China, Brazil, Russia, and South Africa. It will also be interesting to find out the exact threshold level of R&D intensity for various industries.

Table 1: Descriptive Analysis

	Mean	Median	Maximum	Minimum	Std. Dev.
ROA	0.157	0.149	0.575	-0.068	0.073
ROS	0.132	0.124	0.532	-0.206	0.067
ROE	0.278	0.153	152.50	-13.447	4.734
RNDI	0.004	0.001	0.116	0.000	0.007
SIZE	7.648	7.560	13.226	4.228	1.600
LEV	0.304	0.312	0.962	0.000	0.161
MI	0.021	0.009	0.208	0.000	0.026
ECI	0.097	0.082	0.686	0.008	0.063
EXPI	0.121	0.056	0.888	0.000	0.166

Notes: The sample consists of 105 firms and the time period studied is from 2004 till 2013. ROA is measured as PBDITA scaled by total assets. ROS is measured as PBDITA scaled by total sales. ROE is measured as net-profit scaled by net-worth. RDNI is calculated as R&D expenditure scaled by total sales. SIZE is measured as natural log of total assets. CS is measured as total debt scaled by total assets. EXPI is measured as total exports scaled by total sales. MI is measured as total marketing and advertisement expenditure scaled by total sales. MR is measured as total compensation to employees scaled by total sales. The data has been collected from Prowess database which is maintained by CMIE.

Table 2: Correlations

	ROA	ROS	ROE	RNDI	SIZE	LEV	MI	EXPI	ECI
ROA	1.00	0.55	-0.03	-0.08	0.04	-0.37	-0.15	-0.10	-0.28
ROS	0.55	1.00	-0.03	-0.01	0.14	-0.11	-0.12	0.14	-0.09
ROE	-0.03	-0.03	1.00	-0.02	-0.02	0.05	0.04	0.04	-0.03
RNDI	-0.08	-0.01	-0.02	1.00	0.26	-0.06	0.15	-0.03	0.11
SIZE	0.04	0.14	-0.02	0.26	1.00	0.02	0.07	-0.01	-0.35
LEV	-0.37	-0.11	0.05	-0.06	0.02	1.00	0.04	-0.03	0.19
MI	-0.15	-0.12	0.04	0.15	0.07	0.04	1.00	-0.02	0.10
EXPI	-0.10	0.14	0.04	-0.03	-0.01	-0.03	-0.02	1.00	0.11
ECI	-0.28	-0.09	-0.03	0.11	-0.35	0.19	0.10	0.11	1.00

Notes: The sample consists of 1050 firm-year observations. ROA is measured as PBDITA scaled by total assets. ROS is measured as PBDITA scaled by total sales. ROE is measured as net-profit scaled by net-worth. RDNI is calculated as R&D expenditure scaled by total sales. SIZE is measured as natural log of total assets. CS is measured as total debt scaled by total assets. EXPI is measured as total exports scaled by total sales. MI is measured as total marketing and advertisement expenditure scaled by total sales. MR is measured as total compensation to employees scaled by total sales. The data has been collected from Prowess database which is maintained by CMIE.

Table 3: Dynamic Panel Regression Results

Panel A: Regression Estimates				
Variable	**Coefficient**	**S.E.**	**t-statistic**	**p-value**
ROA_{it-1}	0.370	0.038	9.791	0.000
$RNDI_{i,t-1}$	3.753	1.472	2.549	0.011
$RNDI^2_{i,t-1}$	-184.510	53.745	-3.433	0.001
$SIZE_{i,t-1}$	-0.019	0.008	-2.268	0.024
$CS_{i,t-1}$	0.203	0.023	8.907	0.000
$EXPI_{i,t-1}$	-0.051	0.031	-1.641	0.101
$MI_{i,t-1}$	-0.307	0.171	-1.799	0.072
$MR_{i,t-1}$	0.364	0.076	4.769	0.000
Panel B: Residual Diagnosis				
Test order	**m-statistic**	**Rho**	**SE(rho)**	**p-value**
AR(1)	-3.730	-1.509	0.405	0.000
AR(2)	-0.910	-0.214	0.235	0.363

Notes: The above table presents the results of the dynamic panel regression. The dependent variable is return on assets (ROA). One-period lagged value of ROA is included among the explanatory variables. Arellano and Bond (1991) two step procedure has been deployed to estimate the results. The estimation technique is based on Generalized Method of Moment (GMM) using Instrumental Variables (IV). Panel A of the table presents the dynamic-panel regression results. Panel B presents the results of residual diagnosis tests.

Table 4: Dynamic Panel Regression Results

Panel A: Regression Estimates				
Variable	**Coefficient**	**S.E.**	**t-statistic**	**p-value**
ROA_{it-1}	0.340	0.040	8.528	0.000
ROA_{it-2}	0.041	0.024	1.713	0.087
$RNDI_{i,t-1}$	5.483	1.592	3.444	0.001
$RNDI^2_{i,t-1}$	-225.792	58.637	-3.851	0.000
$SIZE_{i,t-1}$	-0.021	0.009	-2.395	0.017
$CS_{i,t-1}$	0.185	0.025	7.291	0.000
$EXPI_{i,t-1}$	-0.013	0.039	-0.326	0.745
$MI_{i,t-1}$	-0.475	0.215	-2.204	0.028
$MR_{i,t-1}$	0.371	0.084	4.423	0.000
Panel B: Residual Diagnosis				
Test order	**m-statistic**	**Rho**	**SE(rho)**	**p-value**
AR(1)	-3.440	-1.184	0.344	0.001
AR(2)	-1.165	-0.235	0.202	0.244

Notes: The above table presents the results of the dynamic panel regression. The dependent variable is return on assets (ROA). One-period and two-period lagged values of ROA are included among the explanatory variables. Arellano and Bond (1991) two step procedure has been deployed to estimate the results. The estimation technique is based on Generalized Method of Moment (GMM) using Instrumental Variables (IV). Panel A of the table presents the dynamic-panel regression results. Panel B presents the results of residual diagnosis tests.

Table 5: Dynamic Panel Regression Results

Panel A: Regression Estimates				
Variable	**Coefficient**	**S.E.**	**t-statistic**	**p-value**
ROS_{it-1}	0.143	0.030	4.738	0.000
$RNDI_{i,t-1}$	2.298	1.240	1.853	0.064
$RNDI^2_{i,t-1}$	-131.550	50.144	-2.623	0.009
$SIZE_{i,t-1}$	-0.027	0.005	-5.651	0.000
$CS_{i,t-1}$	0.091	0.016	5.683	0.000
$EXPI_{i,t-1}$	-0.024	0.023	-1.041	0.298
$MI_{i,t-1}$	-0.663	0.146	-4.543	0.000
$MR_{i,t-1}$	0.391	0.048	8.063	0.000
Panel B: Residual Diagnosis				
Test order	**m-statistic**	**Rho**	**SE(rho)**	**p-value**
AR(1)	-2.345	-1.061	0.452	0.019
AR(2)	0.263	0.058	0.220	0.792

Notes: The above table presents the results of the dynamic panel regression. The dependent variable is return on sales (ROS). One-period lagged value of ROS is included among the explanatory variables. Arellano and Bond (1991) two step procedure has been deployed to estimate the results. The estimation technique is based on Generalized Method of Moment (GMM) using Instrumental Variables (IV). Panel A of the table presents the dynamic-panel regression results. Panel B presents the results of residual diagnosis tests.

Table 6: Dynamic Panel Regression Results

Panel A: Regression Estimates				
Variable	**Coefficient**	**S.E.**	**t-statistic**	**p-value**
ROS_{it-1}	0.134	0.035	3.819	0.000
ROS_{it-2}	0.095	0.019	5.055	0.000
$RNDI_{i,t-1}$	2.893	1.262	2.293	0.022
$RNDI^2_{i,t-1}$	-155.029	50.903	-3.046	0.002
$SIZE_{i,t-1}$	-0.030	0.005	-5.882	0.000
$CS_{i,t-1}$	0.093	0.016	5.718	0.000
$EXPI_{i,t-1}$	-0.001	0.026	-0.032	0.975
$MI_{i,t-1}$	-0.694	0.184	-3.776	0.000
$MR_{i,t-1}$	0.394	0.049	7.996	0.000
Panel B: Residual Diagnosis				
Test order	**m-statistic**	**rho**	**SE(rho)**	**p-value**
AR(1)	-2.615	-0.956	0.366	0.009
AR(2)	-0.224	-0.034	0.153	0.823

Notes: The above table presents the results of the dynamic panel regression. The dependent variable is return on sales (ROS). One-period and two-period lagged values of ROS are included among the explanatory variables. Arellano and Bond (1991) two step procedure has been deployed to estimate the results. The estimation technique is based on Generalized Method of Moment (GMM) using Instrumental Variables (IV). Panel A of the table presents the dynamic-panel regression results. Panel B presents the results of residual diagnosis tests.

Table 7: Dynamic Panel Regression Results

Panel A: Regression Estimates				
Variable	**Coefficient**	**S.E.**	**t-statistic**	**p-value**
ROE_{it-1}	0.011	0.000	29.549	0.000
$RNDI_{i,t-1}$	626.197	13.276	47.169	0.000
$RNDI^2_{i,t-1}$	-16253.780	387.089	-41.990	0.000
$SIZE_{i,t-1}$	-0.755	0.089	-8.488	0.000
$CS_{i,t-1}$	0.139	0.121	1.152	0.250
$EXPI_{i,t-1}$	-1.952	0.186	-10.494	0.000
$MI_{i,t-1}$	-29.914	1.902	-15.730	0.000
$MR_{i,t-1}$	15.377	0.286	53.744	0.000
Panel B: Residual Diagnosis				
Test order	**m-statistic**	**rho**	**SE(rho)**	**p-value**
AR(1)	-2.281	-361.914	158.671	0.023
AR(2)	0.822	88.894	108.132	0.411

Notes: The above table presents the results of the dynamic panel regression. The dependent variable is return on equity (ROE). One-period lagged value of ROE is included among the explanatory variables. Arellano and Bond (1991) two step procedure has been deployed to estimate the results. The estimation technique is based on Generalized Method of Moment (GMM) using Instrumental Variables (IV). Panel A of the table presents the dynamic-panel regression results. Panel B presents the results of residual diagnosis tests.

Table 8: Dynamic Panel Regression Results

Panel A: Regression Estimates				
Variable	**Coefficient**	**S.E.**	**t-statistic**	**p-value**
ROE_{it-1}	0.002	0.000	12.738	0.000
ROE_{it-2}	0.000	0.000	-5.012	0.000
$RNDI_{i,t-1}$	66.209	2.648	25.005	0.000
$RNDI^2_{i,t-1}$	-3004.430	114.152	-26.319	0.000
$SIZE_{i,t-1}$	0.069	0.019	3.547	0.000
$CS_{i,t-1}$	0.214	0.042	5.102	0.000
$EXPI_{i,t-1}$	-0.499	0.055	-9.037	0.000
$MI_{i,t-1}$	-5.570	0.445	-12.511	0.000
$MR_{i,t-1}$	2.541	0.120	21.145	0.000
Panel B: Residual Diagnosis				
Test order	**m-statistic**	**rho**	**SE(rho)**	**p-value**
AR(1)	-1.781	-30.363	17.052	0.075
AR(2)	-0.421	-6.910	16.400	0.674

Notes: The above table presents the results of the dynamic panel regression. The dependent variable is return on equity (ROE). One-period and two-period lagged values of ROE are included among the explanatory variables. Arellano and Bond (1991) two step procedure has been deployed to estimate the results. The estimation technique is based on Generalized Method of Moment (GMM) using Instrumental Variables (IV). Panel A of the table presents the dynamic-panel regression results. Panel B presents the results of residual diagnosis tests.

Table 9: Panel Regression Results

	Dependent Variable					
	ROA		ROS		ROE	
Variable	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**	**Coefficient**	**t-Statistic**
C	0.22	9.06***	0.09	3.64***	-0.47	-0.32
$RNDI_{i,t-1}$	3.06	2.18**	2.44	2.09**	331.86	2.82***
$RNDI^2_{i,t-1}$	-105.98	-2.37**	-87.56	-2.29**	-9385.30	-2.46**
$SIZE_{i,t-1}$	0.00	-0.62	0.01	2.17**	-0.11	-0.62
$CS_{i,t-1}$	-0.04	-2.32**	-0.02	-1.06	3.55	2.69***
$EXPI_{i,t-1}$	-0.04	-1.91*	0.02	0.82	2.33	1.72*
$MI_{i,t-1}$	-0.52	-4.06***	-0.64	-5.77***	12.89	1.53
$MR_{i,t-1}$	-0.20	-3.39***	0.09	1.59	-3.22	-0.77
$HRND$	-0.02	-1.73*	-0.02	-1.16	-1.72	-2.00**
Adj. R-sqr.	0.088		0.067		0.016	
f-statistic	6.692***		5.213***		1.973**	
p-value	0.000		0.000		0.012	

Notes: The above table presents the results of the static-panel regression. The three panels respectively present the results with ROA, ROS, and ROE as the dependent variable. ***, **, and * indicate significant at 1%, 5%, and 10% respectively.

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