Research & Development and Systematic Risk of the Firm: A Study of the Indian Industries

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This study aims at analyzing the relationship between firm R&D intensity and market risk using cross-sectional data of 333 firms of the Indian industries from 2005 to 2009. For this, a theoretical model has been developed. The results of the theoretical model show that there is an inverse relationship between firm R&D intensity and market risk. The empirical results show that after controlling for accounting variables such as growth (measured by growth rate in sales); dividend pay-out ratio (measured by equity dividend as a percentage of net profit); asset size (measured by total assets of the firm); age of the firm (measured by incorporation year of the firm); leverage (measured by debt-equity ratio); liquidity (measured by current ratio); and sales variability (measured by coefficient of variation in sales) which also influence market risk, an increase in firm R&D intensity lowers the market risk. The control variables which have come out to be significant determinants of market risk are dividend pay-out ratio and sales variability.

INTRODUCTION

In modern corporations, investing in research and development (R&D) and innovation activities is regarded as an important strategy to spur growth and/or reduce production costs. By investing in R&D, firms can either shift the demand curves of their products to the right by providing newer varieties or superior quality of their products (through product innovation) or can reduce their average costs of production by changing their production processes (through process innovation) or do both. However, it is important for innovation exercise of firms to yield positive financial returns to their companies. Modern corporations allocate huge amounts of money for their R&D activities. Expenditures are always incurred in anticipation of benefits. Thus, R&D expenditure is justifiable only if the benefits derived out of such investments are more than the amount incurred in R&D expenditure. R&D activities involve huge fixed and variable costs for firms. Judging process innovations simply by an increase in production efficiency and/or a reduction in production costs for the firm may not be sufficient since total R&D costs may still be exceeding benefits. Similarly, judging product innovations through an improvement in product quality or features which lead to higher sales for the company may not be telling the entire story since R&D costs may still not be yielding positive financial returns to the company. Much of theory in industrial economics is based on the assumption that the main objective of the firm through its various strategies is to maximize the wealth of equity shareholders. According to Srivastava and Reibstein (2005), production managers and R&D executives, today, are being encouraged to speak in the language of financial economics with their senior management and finance colleagues because the firm cannot acquire funds from different classes of investors without providing them attractive financial returns and the firm cannot implement their expensive R&D programmes without having an access to these funds. Thus, the R&D strategies of the firm should be directed towards maximising shareholders' wealth.

One of the important determinants of wealth of the shareholders of a firm is the risk that is possessed by the firm. Lower the risk that is possessed by the firm, higher the shareholders' wealth. Thus, if the R&D programs of the firm are designed in such a way that it leads to a decrease in the risk of the firm, it will result in an increase in the wealth of the shareholders of the firm. Thus, to better align the objective functions of production and R&D professionals and senior management along with finance executives, this paper attempts to analyse the impact of one of the most important elements of overall strategy of a firm, that is, research and development (R&D) on the market risk of the firm in the Indian industries. In other words, the main objective of this study is to assess whether the firms which incur more R&D expenditure in the Indian industries are able to bring a larger reduction in their market risk than the firms which incur relatively less R&D expenditure in the Indian industries or not.

Risk and returns play an important role in making any investment decision. One basic premise regarding risk and returns is that investors like returns and dislike risk. People invest in riskier assets only if they expect to receive more than average returns. Investors' decisions are governed by decision variables and non decision variables. Decision variables are those on which investors can take decisions such as deciding what product prices to charge, capital structure decisions, dividend policy decisions etc. Non-decision variables are those which are imposed on investors and on which they have no control. All macroeconomic variables such as GDP growth rate, inflation rate, unemployment rate, direct and indirect tax rates are the non-decision variables which are imposed on the investor either by policy makers or by the macroeconomic environment. However, through certain decision variables, the firm can reduce the impact of macroeconomic variables (non decision variables) on the performance of the firm.

The risk of conducting business in a sector of the economy can be divided into the following three components: (i) market risk, (ii) sector specific risk, and (iii) firm specific risk. The sector specific risk and firm specific risk, to a great extent, can be eliminated through diversification of the portfolio. Such risk is also called unsystematic risk or diversifiable risk. Such risk is assumed to be deliberately taken by the investor which can be eliminated away and therefore should not be rewarded (Sharpe,1964; Litner,1965). Market risk, according to Sharpe (1964) and Litner (1965), cannot be eliminated through diversification of the portfolio and therefore deserves to be rewarded. Market risk refers to the risk that is governed by macroeconomic factors. Market risk is also referred to as systematic risk or non diversifiable risk. Thus, returns should only be linked with market risk since market risk cannot be eliminated.

Beta which is considered as a measure of market risk has a significant influence on portfolio managers and investment analysts. Beta of the security *i* is defined as the contribution of security *i* to the variance of the market portfolio as a fraction of the total variance of the market portfolio. The capital asset pricing model (CAPM) which describes expected return-beta relationship is a very familiar expression for practitioners. Beta is used invariably by practitioners in their decision making processes. The cost of equity and thus market value of any company depends upon the beta of that company. Different models employed by analysts to value company depend upon the cost of equity and thus beta of the company. Thus, incorrect and wrong estimation of beta will lead to overvaluation or undervaluation of the company. Beta shows the sensitivity of a security's return to the market return. It simply shows how the security's returns change with a change in market returns. If the beta of a stock is greater than one, it is considered as an aggressive stock or the risk of that stock is more than the average market risk. If beta of a stock is less than one, it is considered as a defensive stock or the risk of that stock is less than the average market risk. If beta of any stock is zero, it is considered as risk-free investment. Since market value of a firm varies inversely with the market risk possessed by the firm, the firm should formulate its strategies in such a way that it should lead to a reduction in the market risk (or beta) of the firm. R&D or product innovation is considered as one of the important elements of the firm's overall strategy. This paper aims at analyzing the impact of R&D on market risk of the firms in the Indian industries.

R&D expenditure is one of the most important weapons available before firms to face and crush competition in the market. By investing in R&D, firms can either shift the demand curves of their products to the right by providing newer varieties and/or superior quality of their products or can reduce their average costs of production by changing their production processes or both. Thus, R&D expenditure will either have an effect on the demand function or on the cost function or on both.

The effect of R&D expenditure on the demand function depends upon the price elasticity of demand and the quality elasticity of demand. If the quality elasticity of demand is high, the firm would be aggressive in R&D. In other words, if the firm by investing in R&D, is able to provide superior quality of the product and if demand is highly quality elastic, then investment in R&D expenditure will substantially increase the quantity demanded of the product.

The second factor on which product R&D expenditure depends upon is price elasticity of demand. An increase in R&D expenditure means an increase in cost which may result in an increase in the price of the product. If the demand for the product is highly price elastic, a small increase in the price of the product will lead to a large decline in the quantity demanded of the product. Thus, from the demand function point of view, investment in R&D is profitable only when the firm's product is highly quality elastic and/or is highly price inelastic.

The effect of R&D expenditure on the cost function depends upon the market share of the firm in the total industry output. If the firm's market share is high then the firm spends more on R&D since cost reductions achieved apply to a higher output level making process R&D expenditure more effective. The second factor on which process R&D intensity depends upon is the elasticity of cost reduction with respect to R&D expenditure. Higher the absolute value of elasticity of cost reduction, more effective the R&D expenditure would be and hence higher would be the firm's equilibrium R&D expenditure.

There are a number of studies in the literature which have emphasized that the firm's R&D intensity depends upon either demand side variables or technology related variables. The demand side factors considered include market size and consumer preference for quality and price; and the technology side factors considered are effects on production costs (Lee, 2003). Griliches (1957), Schmookler (1962, 1966) and Scherer (1982), have emphasized that firm or industry R&D intensity depends upon demand-side variables whereas Scherer (1965), Phillips (1966), Parker (1972), and Rosenberg (1974) have explained that firm or industry R&D intensity depends upon technology side variables. Lee (2003), has emphasized that a firm's profit maximising R&D expenditure is determined by both demand as well as technology related variables. Lee (2003) has further emphasized that R&D intensity is independent of firm size unless consumer preference or technological competence is affected by firm size. Large Indian companies allocate huge amounts of money for their R&D budgets. Expenditures are always incurred in anticipation of benefits. Thus, R&D expenditure is justifiable only if the benefits derived out of the R&D exercise are more than the amount incurred in R&D expenditure.

The subject matter of R&D can be developed in two ways: either as an analysis of the determinants or factors which explain the quantum of R&D expenditure in different industries and firms, or developing the framework that describes the impact of R&D expenditure on costs, prices, risks and profits. This study attempts to analyse the latter, that is, analyzing the impact of R&D expenditure on market risk. In other words, this study tries to answer the question as to why firms which incur huge R&D expenditures have different market risks from the firms which incur relatively small R&D expenditures. More specifically, this study aims to assess whether the R&D intensity of firms in the Indian industries affects their market risk or not.

The empirical literature in industrial organization consists of some results as far as the relationship between R&D intensity and stock market performance is concerned. R&D intensity is measured by the ratio of R&D expenditure to sales. There have been conflicting results as far as the relationship between R&D expenditure and firm performance is concerned. According to Boulding and Staelin (1995) and Erickson and Jacobson (1992), consensus has not developed as far as the sizes of the effects of R&D investments on different performance metrics is concerned. Some researches suggest that innovating more will lead to better performance [Bayus, Erickson and Jacobson (2003); Pauwels et al (2004); Sorescu, Chandy and Prabhu (2003); Srinivasan et al (2006); Sharma and Nelson (2004)]. Lee et al (2000) have found cumulative short-term abnormal returns of around 2% as a result of each new introduction of product. Blundell, Griffth, and Reenen (1999) have found positive stock market reactions for major technological breakthroughs. Roberts (2001) has found a positive and significant relationship between

R&D investments and firm profits. Chan, Lakonishok, and Sougiannis (2001); Mizik and Jacobson (2003); and Pakes (1985) have shown that R&D investments generate high stock market returns. Jaffe (1986) has reported that firms' R&D investments have a positive and significant impact on the market value of firms. There have been a few studies which have shown that innovation leads to a marginal improvement in firm performance and that too under limited circumstances [Chaney, Divinney, and Wiener (1991); Geroski, Machin, and Reenen (1993)]. Tirole (1988) has suggested that breakthrough products will earn rents if they can be successfully differentiated from competitors' products. According to VanderWerf and Mahon (1997), firms that are first to introduce new products are not necessarily the most successful. However, there have also been studies which have reported that innovations have little or no impact on firm value [Christensen (1997); Foster and Kaplan (2001); Eddy and Saunders (1980)]. Henard and Szymanski (2001) have found that product innovativeness is not a significant driver of new product performance. As a reaction, Sorescu and Spanjol (2008) have argued that these conflicting results could have arisen from (a) difference in sample selection and definition, (b) product rather than firm-level analysis, and (c) difference in performance metrics used. They further argue that many studies have used samples of radical or otherwise important innovations, but they draw conclusions about innovation in general. They suggest that the impact of breakthrough and incremental innovations should be analysed separately as breakthroughs represent only approximately 6% of total innovation output.

Since stock market performance of a firm is influenced by market risk, we may indirectly argue that there exists a relationship between R&D intensity and market risk. McAlister, Srinivasan and Kim (2007) suggest that R&D investments create intangible market-based assets and this may help insulate the firm from the impact of stock market downturns, thus lowering the firm's systematic risk. They further suggest that "this relationship between R&D and systematic risk occurs because a firm that invests in R&D exhibits greater dynamic efficiency and greater flexibility than its competitors (which invest less in R&D) enabling it to adapt to environmental changes, including changes in input price, technologies, and customers. Miller and Bromiley (1990) also support the same argument. This efficiency and flexibility help insulate the firm from market downturns, thus lowering its systematic risk. There have been a few empirical studies which have empirically tested the relationship between market risk and R&D intensity. [Veliyath and Ferris (1997); Chaney, Devinney and Winer (1991); McAlister, Srinivasan, and Kim (2007)]. McAlister, Srinivasan, and Kim (2007) have found an inverse relationship between R&D and market risk after controlling for other factors such as firm's growth, leverage, liquidity, asset size, dividend payout, firm age and competitive intensity in the industry; factors which also influence market risk. However, there have been some studies which show direct relationship between total risk (non-systematic risk and systematic risk) and R&D [Kothari, Laguerre, and Leone (2002); Barth, Kasznik, and McNichols (2001); Chambers, Jenning, and Thompson (2002); Gatignon and Robertson (1985); Gourville (2005); Min, Kalwani and Robinson (2006); Grinblatt and Titman (1998)]. Neff (2005) has reported that breakthrough innovations have a high rate of failure. Sorescu and Spanjol (2008) too, report that breakthrough innovation is associated with an increase in the risk of the innovating firm. They further report that incremental innovation has no impact on firm risk. However, according to Lubatkin and O'Neill (1987), these kinds of firm risk are specific to a firm or an industry and can be diversified away.

Thus, although some empirical research suggests that R&D can increase firm's total risk, the literature mostly suggests that R&D creates strategic differentiation, efficiency and flexibility, which insulates the firm from market downturns and thus helps in lowering its market risk. We propose that higher R&D investment will lead to lower market (or systematic) risk.

The objective of this paper is to analyse the relationship between firm R&D intensity and market risk in the Indian industries. For this, a theoretical model has been developed. There is dearth of such studies in the Indian context. The present study is an attempt to fill this gap. The results of the present study, it is felt, will go a long way in helping firms in the Indian industries to gauge the impact that their R&D expenditures have on their market risk and hence on their shareholder wealth.

This paper is further divided into five sections. Section 2 deals with the theoretical framework of the study. Section 3 describes the data base of the study. Section 4 discusses the empirical model for the present study. Section 5 describes the empirical findings of the study and the implications thereof. Section 6 concludes the study with summary and conclusions.

THEORETICAL FRAMEWORK

Technical changes result in product and process innovation. Product innovations alter the range of products sold in the market, and through this they may alter the number and size distribution of the number of buyers and sellers in the market as well as the ease of new entry into the market. Process innovations change the absolute cost advantages of some or all of the existing products and may change the scale of production at which maximum economies are achieved. As far the present study is concerned, it examines the relationship between market risk and R&D intensity for the Indian industries. The relationship between market risk and R&D is determined after the firm has determined its optimal R&D budget. The study develops the model determining the optimal R&D budget from improvisations made to the Dorfman-Steiner (1954) model and Lee's (2005) model. The Dorfman-Steiner model shows that a firm's R&D intensity depends upon own R&D elasticity of demand, own price elasticity of demand, rivals R&D elasticity of demand and conjectural variation showing the degree to which the firm expects an increase in its own R & D expenditure to be matched by rivals. According to Lee (2005), consumer preference over quality and price, R & D technology, and the joint distribution of firm-specific technological competence and market share jointly determine the level of industry R & D intensity.

Let us assume that there are n firms in an industry and each firm is producing a vertically differentiated product. The objective of each firm is to maximise its profits. Assume that the market share of the ith firm (M_i) depends upon own price (P_i), own R&D expenditure (R_i) and R&D expenditure of rival firms (R_r). That is,

$$M_i = m(P_i, R_i, R_r); m_{P_i} < 0, m_{R_i} > 0, m_{R_r} < 0 \qquad (1)$$

Assume that the average cost of firm i is a function of own R&D expenditure. If the objective of incurring R&D expenditure is product innovation, we assume that to provide a superior quality of the product, the firm's average cost of production increases for a given level of output. On the other hand, if the objective of incurring R&D expenditure is process innovation, we assume that the firm's average cost of production decreases for a given level of output by bringing more efficiency in the production process. That is,

$AC_i = AC(R_i)$; $AC_{R_i} > 0$ for product innovation and $AC_{R_i} < 0$ for process innovation.

Thus, the profit function of the ith firm (Π_i) can be given as -

$$\Pi_i = P_i M_i Q - AC_i M_i Q - R_i \qquad (2)$$

Where Q is the sales in physical terms of the entire industry in which the ith firm belongs. The other terms are as already explained above. That is,

$$\Pi_i = P_i m(P_i, R_i, R_r)Q - AC(R_i) m(P_i, R_i, R_r)Q - R_i \qquad (3)$$

The decision variables for the ith firm are own R&D expenditure (R_i) and own price (P_i). We assume that each firm in an industry is a profit maximizer. Thus, to maximize profits for the ith firm, we differentiate the profit function of the ith firm with respect to P_i and R_i. That is,

$$\frac{\delta \Pi_i}{\delta P_i} = [P_i \frac{\delta M_i}{\delta P_i} + M_i - AC_i \frac{\delta M_i}{\delta P_i}]Q = 0 \quad \text{or} \qquad (4)$$

$$(P_i - AC_i)\frac{\delta M_i}{\delta P_i} + M_i = 0 \quad \text{or} \qquad (5)$$

$$(\frac{P_i - AC_i}{P_i})\frac{\delta M_i}{\delta P_i}\frac{P_i}{M_i} = -1 . \quad \text{That is,} \tag{6}$$

$$\frac{P_i - AC_i}{P_i} = -\frac{1}{\varepsilon_i^{MP}} \tag{7}$$

Where $\varepsilon_i^{MP} (= \frac{\delta M_i}{\delta P_i}\frac{P_i}{M_i})$ is the coefficient of own price elasticity of market share of firm i. ε_i^{MP} may alternatively be called as own price elasticity of demand of firm i.

Since ε_i^{MP} is always negative, we have

$$\frac{P_i - AC_i}{P_i} = \frac{1}{|\varepsilon_i^{MP}|} \tag{8}$$

Equation (8) shows that the firm will be able to earn a high price-cost margin if its product is relatively price-inelastic. High price-elastic products will yield the firm low margins. We assume that R_i and R_r are linearly independent terms in the market share function of firm i.

Now differentiating the profit function of the ith firm with respect to R_i and putting it equal to zero, we get –

$$\frac{\delta \Pi_i}{\delta R_i} = P_i[\frac{\delta M_i}{\delta R_i} + \frac{\delta M_i}{\delta R_r}\frac{\delta R_r}{\delta R_i}]Q - AC_i[\frac{\delta M_i}{\delta R_i} + \frac{\delta M_i}{\delta R_r}\frac{\delta R_r}{\delta R_i}]Q - M_i\frac{\delta AC_i}{\delta R_i}Q - 1 = 0 \quad \text{or} \tag{9}$$

$$[P_i - AC_i][\frac{\delta M_i}{\delta R_i} + \frac{\delta M_i}{\delta R_r}\frac{\delta R_r}{\delta R_i}]Q - [M_i\frac{\delta AC_i}{\delta R_i}Q + 1] = 0 \quad \text{or} \tag{10}$$

$$[P_i - AC_i][\frac{\delta M_i}{\delta R_i} + \frac{\delta M_i}{\delta R_r}\frac{\delta R_r}{\delta R_i}]Q = \Psi_i \tag{11}$$

Where $\Psi_i = M_i\frac{\delta AC_i}{\delta R_i}Q + 1$ is the total marginal cost of R&D which is the sum of one unit of R&D expenditure and production-cost effect of R&D expenditure. Equation (11) can be written as -

$$[P_i - AC_i][\frac{\delta M_i}{\delta R_i}\frac{R_i}{M_i}\frac{M_i}{R_i} + \frac{\delta M_i}{\delta R_r}\frac{R_r}{M_i}\frac{\delta R_r}{\delta R_i}\frac{R_i}{R_r}\frac{M_i}{R_i}]Q = \Psi_i \quad \text{or} \tag{12}$$

$$[P_i - AC_i][\varepsilon^{M_iR_i} + \varepsilon^{M_iR_r}\varepsilon^{R_rR_i}]\frac{M_i}{R_i}Q = \Psi_i \tag{13}$$

Where

$\varepsilon^{M_iR_i} = \frac{\delta M_i}{\delta R_i}\frac{R_i}{M_i}$ denotes the own R&D expenditure elasticity of market share of firm i.

$\varepsilon^{M_iR_r} = \frac{\delta M_i}{\delta R_r}\frac{R_r}{M_i}$ denotes the rivals' R&D expenditure elasticity of market share of firm i.

$\varepsilon^{R_rR_i} = \frac{\delta R_r}{\delta R_i}\frac{R_i}{R_r}$ denotes the elasticity of R&D expenditure of rival firms with respect to own R&D expenditure.

Equation (13) can be written as -

$$[\frac{P_i - AC_i}{P_i}][\varepsilon^{M_iR_i} + \varepsilon^{M_iR_r}\varepsilon^{R_rR_i}]M_iP_iQ = \Psi_iR_i \qquad (14)$$

From equation (8), we have

$$\frac{P_i - AC_i}{P_i} = \frac{1}{|\varepsilon_i^{MP}|}$$

Thus, equation (14) can be written as -

$$\Psi_iR_i = [\frac{\varepsilon^{M_iR_i} + \varepsilon^{M_iR_r}\varepsilon^{R_rR_i}}{|\varepsilon_i^{MP}|}]S_i \qquad (15)$$

Where $S_i = M_iP_iQ$ represents sales revenue (in monetary terms) of firm i.

Now R_i can be written as -

$$R_i = \frac{1}{\Psi_i}[\frac{\varepsilon^{M_iR_i} + \varepsilon^{M_iR_r}\varepsilon^{R_rR_i}}{|\varepsilon_i^{MP}|}]S_i \qquad (16)$$

That is,

$$\frac{R_i}{S_i} = \frac{1}{\Psi_i}[\frac{\varepsilon^{M_iR_i} + \varepsilon^{M_iR_r}\varepsilon^{R_rR_i}}{|\varepsilon_i^{MP}|}] \qquad (17)$$

If we assume that the objective of incurring R&D expenditure is product innovation, then as can be seen from equation (17), R&D intensity of the firm (R_i / S_i) depends upon marginal cost of R&D expenditure (ψ_i), own price elasticity of demand (ε_i^{MP}), own R&D expenditure elasticity of demand (ε^{MiRi}), rivals R&D expenditure elasticity of demand (ε^{MiRr}) and elasticity of R&D expenditure of rival firms with respect to own R&D expenditure (ε^{RrRi}). From equation (17) it is clear that the firm's R&D intensity varies directly with own R&D expenditure elasticity of demand and varies inversely with own price elasticity of demand.

The measure of firm R&D intensity given in equation (17) may be interpreted differently depending upon whether the objective of R&D expenditure is product innovation or process innovation.

If the objective of incurring R&D expenditure is product innovation, we expect the sign of the coefficients $\varepsilon^{M_iR_i}, \varepsilon^{M_iR_r} and \varepsilon^{R_rR_i}$ to be positive, negative and positive respectively. The sign of Ψ_i is also expected to be positive. That is, the firm's product R&D intensity varies directly with own advertising expenditure elasticity of demand and varies inversely with own price elasticity of demand. On the other hand, if the objective of incurring R&D expenditure is process innovation, we expect the sign of Ψ_i to be negative. In the case of process innovation, the effect on elasticity measures in equation (17) are expected to be relatively small. That is, the firm's process R&D intensity varies directly with the absolute value of Ψ_i.

After determining the optimal R&D budget as described in equation (16), the next step is to assess the theoretical relationship between R&D expenditure and market risk. The theoretical model as developed in the present study to find out the theoretical relationship between market risk and R&D is described below-

Assume:

$E_{i,t-1}$: the value of equity of firm i at the end of time period t-1,

$S_{i,t}$: the sales revenue of firm i during time period t,

$N_{i,t}$: the net profit of firm i during time period t,

$O_{i,t}$: the operating income of firm i during the time period,

$E_{m,t-1} = \sum_{1}^{N} E_{i,t-1}$: the value of equity of all the firms of the economy at the end of the period t-1,

$S_{m,t} = \sum_{1}^{N} S_{i,t}$: the value of sales revenue of all the firms of the economy during period t,

$N_{m,t} = \sum_{1}^{N} N_{i,t}$: the net profit earned by all the firms of the economy during time period t,

$O_{m,t} = \sum_{1}^{N} O_{i,t}$: the operating income earned by all the firms of the economy during time period t.

Beta of the security i is defined as the sensitivity of the security i's return to the market return. Here, return on equity of the firm is taken as the measurement of the firm's security return. Return on equity earned by all the firms of the economy together is taken as the measurement of the market return. That is, beta of the firm i, $\beta_{i,t}$, is defined as follows:

$$\beta_{i,t} = \frac{Cov(ER_{i,t}, ER_{m,t})}{Var(ER_{m,t})}$$

Where

$ER_{i,t} = \frac{N_{i,t}}{E_{i,t-1}}$: the return on equity earned by firm i during time period t,

$ER_{m,t} = \frac{N_{m,t}}{E_{m,t-1}}$: the return on equity of the market during time period t.

That is,

$$\beta_{i,t} = \frac{Cov(\frac{N_{i,t}}{E_{i,t-1}}, \frac{N_{m,t}}{E_{m,t-1}})}{Var(\frac{N_{m,t}}{E_{m,t-1}})} = \frac{\frac{1}{E_{i,t-1}E_{m,t-1}} Cov(N_{i,t}, N_{m,t})}{\frac{1}{E_{m,t-1}^{\ 2}} Var(N_{m,t})} = \frac{E_{m,t-1} Cov(N_{i,t}, N_{m,t})}{E_{i,t-1} Var(N_{m,t})}$$

Now,

$$Cov(N_{i,t}, N_{m,t}) = Cov[\{(P_{it} - AC_{it})Q_{it} - R_{it}\}(1-T)\}, N_{m,t}] \quad \text{or}$$

$$Cov(N_{i,t}, N_{m,t}) = Cov[\{(\frac{P_{it} - AC_{it}}{P_{it}})P_{it}Q_{it} - R_{it}\}(1-T)\}, N_{m,t}] \tag{18}$$

Substituting (8) and (16) into (18), we have

$$Cov(N_{it}, N_{mt}) = Cov[\{\frac{1}{|\varepsilon_i^{MP}|} S_{it} - \frac{1}{\Psi_i}[\frac{\varepsilon^{M_iR_i} + \varepsilon^{M_iR_r}\varepsilon^{R_rR_i}}{|\varepsilon_i^{MP}|}]S_i\}(1-T), N_{mt}] \quad \text{or}$$

$$Cov(N_{it}, N_{mt}) = \frac{\Psi_i - \varepsilon^{M_iR_i} - \varepsilon^{M_iR_r}\varepsilon^{R_rR_i}}{\Psi_i |\varepsilon_i^{MP}|}(1-T)Cov(S_{it}, N_{mt}]$$

We know that

$$\beta_{i,t} = \frac{E_{m,t-1} Cov(N_{i,t}, N_{m,t})}{E_{i,t-1} Var(N_{m,t})}$$

Since $\varepsilon^{M_i R_r}$ is always negative, we have

$$\beta_{it} = \frac{\Psi_i - \varepsilon^{M_i R_i} + |\varepsilon^{M_i R_r}| \varepsilon^{R_r R_i}}{\Psi_i |\varepsilon_i^{MP}|}(1-T)\frac{E_{mt-1}}{E_{it-1}}\frac{Cov(S_{it}, N_{mt}]}{Var(N_{mt})} \tag{19}$$

Thus from equation (19), it is clear that beta (market risk) of the firm depends upon own price elasticity of demand, own R&D expenditure elasticity of demand, rivals R&D expenditure elasticity of demand, elasticity of R&D expenditure of rival firms with respect to own R&D expenditure and the marginal cost of R&D. $\varepsilon^{M_i R_i}$ may be taken as a measure of the firm's technological competence. Higher the size of the coefficient of $\varepsilon^{M_i R_i}$, more technologically competent the firm i is. $\varepsilon^{M_i R_r}$ may be taken as the measure of the technological competence of rival firms. Higher the absolute value of $\varepsilon^{M_i R_r}$, more technological competent the rival firms are. Thus, if the objective of incurring R&D expenditure is product innovation (i.e. $\Psi_i > 0$), other things remaining the same, the firm's beta varies inversely with own R&D expenditure elasticity of demand ($\varepsilon^{M_i R_i}$) and varies directly with rivals advertising expenditure elasticity of demand ($\varepsilon^{M_i R_r}$). From equation (17), we have seen that if the objective of incurring R&D expenditure is product innovation, the firm's R&D intensity varies directly with own R&D expenditure elasticity of demand ($\varepsilon^{M_i R_i}$) and varies inversely with rivals R&D expenditure elasticity of demand ($\varepsilon^{M_i R_r}$). Thus, from the above, we can say that the firm's beta varies inversely with its product R&D intensity.

However, if the objective of incurring R&D expenditure is process innovation (i.e $\Psi_i < 0$), other things remaining the same, the firm's beta varies inversely with marginal cost of R&D. From equation (17), we have seen that if the objective of incurring R&D expenditure is process innovation, the firm's R&D intensity varies directly with absolute marginal cost of R&D. Thus, the firm's beta varies inversely with its process R&D intensity also.

THE DATA

The basic data for the study has been collected from *prowess*, a corporate database of Centre for Monitoring Indian Economy (CMIE). CMIE data base disaggregates the data base to the five-digit level which is desirable due to narrower and thus better-defined classification of industries. The data set includes the Indian industries and contains useful information on R&D expenditure, sales, profits etc. To analyse the relationship between firm R&D intensity and market risk for the firms belonging to the Indian industries, a time period of five years from 2005 to 2009 has been chosen. The sample covers 333 firms belonging to the Indian industries.

CMIE database does not provide the value of beta (market risk) for the different firms of the Indian industries. Beta for the different firms of the Indian industries has been computed using the following regression model-

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \tag{20}$$

Where

$R_{it} = \ln(\frac{D_{it} + P_{it}}{P_{it-1}})$ is the ex-post rate return earned by stock i during time period t.

$R_{mt} = \ln(\frac{P_{mt}}{P_{mt-1}})$ is the ex-post rate return earned by BSE-sensex (broad stock market index of Bombay Stock Exchange) during time period t.

α_i is the intercept of the regression line of R_{it} on R_{mt}.

P_{it} is the closing price of stock i at the end of period t.

P_{it-1} is the adjusted closing price (adjusted for stock split, bonus shares, if required) of stock i at the end of period t-1.

D_{it} is the equity dividend paid by stock i during time period t.

P_{mt} is the closing value of BSE-Sensex at the end of period t.

P_{mt-1} is the closing value of BSE-Sensex at the end of period t-1.

The slope of the estimated regression model (20), $\hat{\beta}_i$, is taken as the measurement of market risk of firm i.

Ordinary least squares approach has been used to estimate the regression model (20). The regression model has been estimated using the monthly stock returns and BSE-Sensex returns for each firm *i* covering the time period from 2005 to 2009. There were total 60 observations on the monthly stock returns of firm *i* and 60 observations on the BSE-Sensex returns which were used to estimate the regression model (20). To avoid confusion, observations on 51 firms were eliminated for which the firm's estimated beta was negative. Further, only those firms which had minimum sales turnover of Rs. 5000 million in 2009 were included in the final sample, since data pertaining to smaller firms was missing for many of the years under consideration in the present study.

R&D intensity has been defined as the ratio of R&D expenditure to sales expressed as a percentage of sales. R&D intensity of the different firms of the Indian industries has been computed using the following formula-

$$RI_i = \frac{RE_i}{S_i} x100$$

Where

RI_i : R&D intensity of firm i.

RE_i : R&D expenditure of firm i.

S_i : Sales revenue of firm i.

The data on R&D expenditures and sales revenue from 2005 to 2009 for the firms belonging to the Indian industries are reported in Prowess, a corporate data base of CMIE.

To study the impact of a firm's R&D intensity on its market risk, seven other variables which also influence market risk have been included as control variables in the proposed regression model. The seven control variables included in the model are - growth rate in sales; dividend pay-out ratio; leverage; asset size; age of the firm; variability in sales revenue and liquidity.

Growth rate in sales of a firm has been measured as the average annual growth rate of the firm from 2005 to 2009. Average annual dividends from 2005 to 2009 as a percentage of average annual sales from 2005 to 2009 has been taken as the measure of firm's dividend pay-out ratio. The ratio of average closing debt from 2005 to 2009 to average closing net worth from 2005 to 2009 (debt-equity ratio) has been taken as the measurement of firm's leverage. The average closing total assets value from 2005 to 2009 has been taken as the measurement of firm's asset size. The incorporation year of a firm has been taken as the measurement of age of the firm. Coefficient of variation in sales has been taken as the measurement of variability in sales. The ratio of average closing current assets from 2005 to 2009 to average closing current liabilities (current ratio) has been taken as the measurement of liquidity of firm.

The complete data on market risk, R&D intensity and the control variables were available for 333 firms belonging to the Indian industries and finally these 333 firms were used as a sample to assess the relationship between R&D intensity and market risk for the firms belonging to the Indian industries.

EMPIRICAL MODEL

The objective of this paper is to analyse the relationship between a firm's R&D intensity and its market risk for the firms belonging to different Indian industries after controlling for variables such as growth rate in sales, dividend pay-out ratio, size, age of the firm, leverage, variability in sales and liquidity. Here, beta has been taken as the measure of market risk. To analyse the relationship between a firm's R&D intensity and its market risk, the following regression model is proposed-

$$\beta_i = \alpha_0 + \alpha_1 RI_i + \alpha_2 GRS_i + \alpha_3 POR_i + \alpha_4 SIZ_i + \alpha_5 AGE_i + \alpha_6 LEV_i + \alpha_7 LIQ_i + \alpha_8 SV_i + U_i$$

where

β_i : Beta of firm i estimated by regressing stock returns of firm i on BSE-Sensex returns using the monthly return from 2005 to 2009. Here beta has been taken as the measure of market risk.

RI_i : Average annual R&D intensity of firm i from 2005 to 2009. Here R&D intensity has been defined as R&D expenditure expressed as a percentage of sales.

GRS_i: Average annual growth rate in sales of firm i from 2005 to 2009. Growth rate in sales has been taken as a control variable.

POR_i: Average annual dividend pay-out ratio of firm i from 2005 to 2009. Here dividend pay-out ratio has been taken as a measure of the dividend policy of the firm. Pay-out ratio has also been taken as a control variable.

SIZ_i : Average size of firm i in terms of total investment from 2005 to 2009 which has also been taken as a control variable. Total assets of the firm has been taken as the measure of size.

AGE_i : Age of firm i. Incorporation year of the firm has been taken as the measure of age of the firm. Age of the firm has also been included as a control variable.

LEV_i : Average leverage of firm i from 2005 to 2009. Here debt-equity ratio has been taken as the measure of leverage of the firm. Leverage of the firm has also been taken as a control variable.

LIQ_i : Average liquidity enjoyed by firm i from 2005 to 2009. Here current ratio has been taken as the measure of liquidity of the firm. Liquidity of the firm, too, has been taken as a control variable.

SV_i : Average annual variability in sales of firm i from 2005 to 2009. Here coefficient of variation in sales has been taken as the measure of sales variability of the firm. Sales variability of the firm has also been included as a control variable.

U_i : Random disturbance term

$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_8$: regression coefficients to be estimated

The direction of the relationship between firm R&D intensity and market risk depends upon the estimated value of the coefficient α_1. If estimated coefficient α_1 comes out to be negative and significant, it means that the firms which rigorously involve themselves in innovations are having lower market risk than firms which have relatively low R&D intensity. From the theoretical model developed in section 2, we expect negative and significant value of coefficient α_1.

The direction of the relationship between the six control variables and market risk depends upon the estimated values of the coefficients $\alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_8$. If estimated coefficient α_2 comes out to be negative (positive) and significant, it means that firms which enjoy high average annual growth rate in sales are having lower (higher) market risk than the firms which have relatively low average annual growth rate in sales.

If estimated coefficient α_3 comes out to be negative (positive) and significant, it means that firms which pay relatively high dividends as a percentage of net profits are having lower (higher) market risk than the firms which pay relatively low dividends as a percentage of net profits.

If the estimated coefficient α_4 comes out to be negative (positive) and significant, it would mean that the relatively large-sized firms in terms of total investment are having lower (higher) market risk than the relatively small sized firms.

If the estimated coefficient α_5 comes out to be negative (positive) and significant, it would mean that the relatively old-aged firms are having lower (higher) market risk than the relatively new firms.

If the coefficient α_6 comes out to be positive (negative) and significant, it would mean that the firms that are having relatively low leverage are having lower (higher) market risk than the firms which have relatively high leverage.

If the coefficient α_7 comes out to be negative (positive) and significant, it would mean that the firms which enjoy relatively high liquidity are having lower (higher) market risk than the firms which have relatively low liquidity.

If the coefficient α_8 comes out to be positive (negative) and significant, it would mean that the firms which have relatively low variability in sales revenue are having lower (higher) market risk than the firms which have relatively high sales variability.

EMPIRICAL RESULTS

As discussed earlier, the objective of this paper is to analyse the relationship between R&D intensity and market risk for the Indian industries using cross-sectional data of 333 firms covering almost every industry of the Indian economy from 2005 to 2009. The dependent variable used for the study is firm market risk which is measured by beta of the firm. The main explanatory variable included in the model is firm R&D intensity which is measured by the ratio of firm R&D expenditure to the sales of the firm. A few control variables have been included in the model also. For example, a variable for firm leverage measured by debt-equity ratio has been included to judge whether leverage of firms affects their market risk. The other control variables included in the model are growth (measured by growth rate in sales); dividend pay-out ratio (measured by equity dividend as a percentage of net profit); asset size (measured by total assets of the firm); age of the firm (measured by incorporation year of the firm); liquidity (measured by current ratio of the firm); and sales variability (measured by coefficient of variation in sales). The brief statistics for all the variables included in the regression model is shown in Table 1.

An analysis of the statistics of the key variables shown in Table 1 show that, on an average, the firms of the Indian industries have beta of around 1.00. The results further show that there is large variation in market risk of firms in the Indian industries. There are a few firms in the Indian industries which have a beta of around 1.72 while there are some which have a beta of only 0.21. The standard deviation of beta of firms of the Indian industries is 0.30.

An analysis of the figures of R&D intensity (RI) show that, on an average, the firms of the Indian industries spend 0.60% of their total sales on advertising. The results further show that there is large variation in R&D intensity of firms in the Indian industries. There are a few firms in the Indian industries which spend around 13.39% of their total sales on R&D while there are some which do not incur any expenditure on R&D. The standard deviation of R&D intensity of firms of the Indian industries is 1.69%.

TABLE 1
STATISTICS FOR THE KEY VARIABLES

Variables	Mean	Maximum	Minimum	Standard Deviation
Beta	0.998919	1.72	0.21	0.30474
R&D Intensity (%)	0.596353	13.38625	0	1.692878
Growth Rate in Sales (%)	15.89664	150.2257	-100	21.24672
Pay-out Ratio (%)	21.24379	97.24567	0	58.08696
Total Assets (Rs. Million)	51147.44	1375847.00	96.96	136739.60
Age (Years)	40.90	131	8	22.67089
Debt-Equity Ratio	0.968185	23.0325	0	2.619975
Current Ratio	1.519047	8.624	0.264	0.85652
Sales Variability (%)	31.17724	205.7902	6.060922	20.02437

An analysis of the figures of growth rate in sales (GRS) show that the mean value of GRS is 15.90% which indicates that, on an average, firms in the Indian industries have reasonably high average annual growth rate in sales. However, there is large variation in growth rate in sales of firms in the Indian industries too. Some firms in the Indian industries have as high a growth rate in sales of 150% while there are a few firms which have a negative growth rate in sales of around 100%. The standard deviation of GRS works out to be 21.25%.

An analysis of the figures of pay-out ratio (POR) show that, on an average, the firms of the Indian industries pay around 21% of their net profits as dividends. The results further show that there is large variation in pay-out ratios of firms in the Indian industries. There are a few firms in the Indian industries which pay around 97% of their total net profits as equity dividends while there are some which do not pay any dividends. The standard deviation of pay-out ratio of firms of the Indian industries is around 58%.

An analysis of figures of investment size (total assets) from Table 1 also shows that there is a large variation in the Indian industries as regards the same. The total asset size of firms belonging to the Indian industries varies from a minimum of around Rs. 97 million to a maximum of Rs. 1375847 million, with the mean being Rs. 51147 million.

An analysis of figures of age of the firms show that firms in the Indian industries have an average age of around 41 years. In case of age of the firm too, there is large variation in the firms of the Indian industries. There are some firms which are 131 years old while there are some which are only 8 years old.

An analysis of the figures of debt-equity ratio show that the mean value of debt-equity ratio is 0.97 which indicates that, on an average, firms in the Indian industries have moderate degree of leverage. However, there is large variation in debt-equity ratio in the Indian industries, the standard deviation being equal to 2.62. Some firms in the Indian industries have very high degree of leverage (debt-equity ratio of around 23.03) while there are some firms which are unlevered.

An analysis of the figures of current ratio show that the mean value of current ratio is 1.52 which indicates that, on an average, firms in the Indian industries enjoy moderate level of liquidity. However, there is large variation in the liquidity position of firms also in the Indian industries. Some firms in the

Indian industries enjoy very high degree of liquidity (current ratio of around 9) while there are some firms which have very low level of liquidity (current ratio of 0.26 only). The standard deviation pertaining to this variable works out to be 0.86.

Finally, an analysis of figures of sales variability from Table 1 also shows that, on an average, there is large variability in sales of the firms in the Indian industries. The coefficient of variation in sales of firms belonging to the Indian industries varies from a minimum of around 6% to a maximum of around 206%, with the mean being 31%.

The main objective of this paper is to assess the relationship between firm R&D intensity and market risk in the Indian industries. The model specified in section 4 has been used to analyse the relationship between R&D intensity and market risk of firms in Indian industries. The dependent variable used in the regression model is beta which has been taken as the measure of market risk. The main independent variable used in the model is R&D intensity which has been defined as the ratio of R&D expenditure expressed as a percentage of sales. In addition to R&D intensity, seven control variables have also been included as independent variables in the regression model. These additional independent variables used in the regression model are: growth (measured by growth rate in sales); dividend pay-out ratio (measured by equity dividend as a percentage of net profit); asset size (measured by total assets of the firm); age of the firm (measured by incorporation year of the firm); leverage (measured by debt-equity ratio); liquidity (measured by current ratio); sales variability (measured by coefficient of variation in sales revenue). The regression model has been estimated using the ordinary least squares approach (OLS). The estimated regression model using the ordinary least squares approach has been shown in Table 2.

TABLE 2
REGRESSION RESULTS

$$\beta_i = \alpha_0 + \alpha_1 RI_i + \alpha_2 GRS_i + \alpha_3 POR_i + \alpha_4 SIZ_i + \alpha_5 AGE_i + \alpha_6 LEV_i + \alpha_7 LIQ_i + \alpha_8 SV_i + U_i$$

Parameters	Coefficient	t-value	P-value
α_0	0.539490858	0.383417036	0.70166203
α_1	-0.041002998 *	-4.324227647	2.04024×10^{-05}
α_2	0.000775879	0.998596317	0.318735484
α_3	-0.000568754 **	-2.422403499	0.015966325
α_4	5.07579×10^{-07}	0.435390859	0.66356864
α_5	0.000216064	0.300931832	0.763659499
α_6	0.007103423	1.166235328	0.24437704
α_7	-0.016805151	-0.893666974	0.372163422
α_8	0.002380958 *	2.869781899	0.004377462
F	5.6366224 *		1.04263×10^{-06}
Adj. R^2	0.100497656		

* significant at 1% level. ** significant at 5% level. *** significant at 10% level.

The results of the regression model show that the proposed model is significant at 1% level (F = 5.64) and the adjusted coefficient of determination for the proposed model is 10%.

The results of the estimated regression model show that only three independent variables out of eight variables included in the model have come out to be significant at least at 5% level. The three variables which have come out to be significant are: R&D intensity; dividend pay-out ratio and sales variability. The coefficient of leverage has t-value of greater than and thus it is making some contribution in increasing the explanatory power of the model although coefficient of leverage has come out to be significant only at 24% level. The coefficient of R&D intensity has come out to be negative and significant (at 1% level). The coefficient of dividend pay-out ratio has come out to be negative and significant (at 5% level) whereas the coefficient of sales variability has come out to be positive and highly significant (at 1% level). The coefficients of growth rate in sales; age of the firm (measured by incorporation year of the firm); and asset size of the firm have come out to be positive but insignificant whereas the coefficient of liquidity of the firm has come out to be negative but insignificant.

If we measure R&D intensity on the horizontal axis (X-axis) and market risk (beta) on the vertical axis, the results of the estimated regression model show that there is an inverse relationship between firm R&D intensity and market risk in the Indian industries. That is, those firms in the Indian industries which engage themselves more intensively in innovative activity have lower market risk than the firms which believe relatively less in R&D competition.

The negative and significant coefficient α_3 shows that for a given level of R&D intensity, firms which pay relatively high equity dividend as percentage of net profit have lower market risk than those firms which have relatively low dividend pay-out ratios.

The positive and significant coefficient α_8 shows that the firms which are having relatively low variability in sales have lower market risk than the firms which have relatively high variability in sales.

The positive and moderately significant coefficient α_6 (t-value > 1) shows that the firms which are having relatively low degree of leverage have lower market risk than the firms which have relatively high degree of leverage.

The results further show that there is a positive but insignificant relationship between growth rate in sales and market risk as also between age of the firm and market risk and between asset size and market risk. The control variable which has negative but insignificant impact on market risk is liquidity.

Thus, the results of regression model show that after controlling for the accounting variables which influence market risk, an increase in firm R&D intensity lowers the firm's market risk. That is, those firms of Indian industries which invest heavily in R&D, other things remaining the same, are ones who are able to reduce their market risk substantially and thus bring about a larger increase in the wealth of their shareholders as compared to firms which invest less in R&D.

CONCLUSION

The objective of this paper is to analyse the relationship between firm R&D intensity and market risk of firms in the Indian industries. For this a theoretical model has been developed. There is dearth of such studies in the Indian context. The present study is an attempt to fill this gap. The results of the present study, it is felt, will go a long way in helping firms in the Indian industries to optimally decide their R&D expenditures and to link their innovation programmes with shareholder value. The results of the theoretical model show that the market risk of a firm varies inversely with its R&D intensity.

The theoretical model has been tested using cross sectional data of 333 firms belonging to different Indian industries from 2005 to 2009. The results of the empirical model show that if we measure R&D intensity on the horizontal axis (X-axis) and market risk on the vertical axis, there is an inverse relationship between firm R&D intensity and market risk in the Indian industries after controlling for other accounting variables such as growth (measured by growth rate in sales); dividend pay-out ratio (measured by equity dividend as a percentage of net profit); asset size (measured by total assets of the firm); age of the firm (measured by incorporation year of the firm); leverage (measured by debt-equity ratio); liquidity (measured by current ratio); and sales variability (measured by coefficient of variation in sales) which also influence market risk. When the impact of control variables on market risk is analysed, the results further show that for a given level of R&D intensity, those firms which pay relatively high equity dividend as a percentage of their net profits have lower market risk than the firms which have relatively low dividend pay-out ratios. The results further show that the firms which have relatively low variability in sales have lower market risk than the firms which have relatively high variability in sales. The coefficient of degree of leverage has come out to be positive but moderately significant (t-value > 1) indicating that the firms which have relatively low degree of leverage have lower market risk than the firms which have relatively high degree of leverage. The other control variables such as asset size, age of the firm, growth rate in sales and liquidity are not significant determinants of market risk of the firms in the Indian industries.

Thus, it may be concluded that after controlling for accounting variables which influence market risk, an increase in firm R&D intensity lowers the market risk of the firms in the different Indian industries. That is, those firms of Indian industries which invest heavily in R&D, other things remaining the same, are ones who are able to reduce their market risk substantially and thus bring about a larger increase in the wealth of their shareholders as compared to firms which invest less in R&D.

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