RD in Indian public enterprises: An assessment

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Abstract

Using data on a large sample of public companies in India for 1987-2005, the findings indicate that increases in firm size are likely to be associated with increase in R&D up to a threshold. The evidence is also supportive of the fact that both the intensity of R&D as well as innovation activity is lower for leveraged firms. Finally, the findings fail to discern any significant improvement in R&D intensity in the post-reform period; although there is a noticeable decline in innovation activity after reforms. Privatization does not seem to have exerted any perceptible influence on R&D behaviour of public firms.

JEL Classification: E22, E44

Key words: R&D intensity, innovation activity, leverage ratio, Tobit model, privatization, India

I. Introduction

In an increasingly globalised economy, the technological capacity is viewed as an important influence on a country's international competitiveness and growth prospects. In view of its critical role for growth and competitiveness, technology has received significant attention among researchers and policymakers (Cohen *et al.*, 1987; Cohen and Levin, 1989; Cohen, 1995). This renewed focus on technology stems from three main reasons. Firstly, there has been increased competition from fast followers, which has subjected advanced nations to competition *via* imitation by firms in hitherto less innovative countries. Secondly, there has been a more rapid diffusion of intellectual capital, aided by the revolution in communications technology. Thirdly, competition for investments by multinational enterprises (MNEs) has meant that these companies have increasingly relocated investments wherever circumstances offer the greatest opportunity, including their R&D activities.

Against this background, the aim of this article is to provide empirical evidence on the determinants of R&D investment in public enterprises (PSEs) in India for the period 1987-2005. An analysis of this sort assumes relevance for an economy such as India for several reasons. First, India is rapidly emerging as a knowledge society; a significant number of multinational companies have already set up R&D centers in the country, leading to the deepening of technological and innovative capabilities of Indian firms. Leading Indian companies have also begun forging alliances with global firms. Such collaboration presents several benefits for Indian

[1] The views expressed and the approach pursued in the paper expresses the personal opinion of the author.

industry, because the linkages among firms, universities and research institutes and the worldwide R&D network further integrate Indian into global technology development. Second, India's emergence as a major economic power is poised to have wide-ranging implications. These include effects on trade, investment, employment, the environment and trajectories for national industrial and technological developments. Furthermore, the continued and rapid growth of information technology (IT) and IT-enabled services, including business process outsourcing, including higher-end knowledge process industry niches such as finance, accounting and insurance will demand substantial step-up of its R&D capabilities. The findings so obtained may be representative of the factors influencing R&D in other emerging markets.

The remainder of the paper proceeds as follows. Section 2 provides an overview of the relevant literature. The Indian experience with R&D is summarized in Section 3. The empirical model is delineated in Section 4, followed by a discussion of the results in the subsequent section. The final section concludes.

II. Related literature

The factors driving firms' decision to invest in R&D activities have been under scrutiny since the pioneering work of Schumpeter. A significant body of theoretical and empirical literature has focused on the determinants of the innovativeness of firms. Within the broad strand of this literature, a number of different lines of research have been pursued. Several studies have analyzed a research production function using R&D expenses as a measure of inputs and the number of patents as the relevant output measure (Hall, 2002). Other studies have investigated the factors driving the output side of the innovation process, such as the number of product or process innovations (Baldwin *et al*., 2002), or the number of patents introduced by firms (Pakes and Grilliches, 1984). The final set of studies explore the input side of the innovation process, such as the amount of R&D expenditures by firms (Levine and Ross, 1984) or the decision of firms to undertake R&D activities at the country level (Czarnitzki and Kraft, 2004).

A growing body of literature in India has focused on various facets of R&D activities. Focusing on R&D efforts and technology imports, Kartak (1989) regressed R&D efforts on technology imports with other explanatory variables. Subsequent evidence Kartak (1997) contended that there existed a two-way relationship between R&D efforts and technology imports, since on the one hand, technology imports influenced firms' in-house R&D efforts, while on the other hand, the intensity of technology imports was, in itself, influenced by initial R&D efforts. Exploiting this argument, using data on 48 industries for the period 1981-1990, Aggarwal (2000) found that while technology imports were weakly related with past R&D efforts, whereas post-liberalization, the impact of R&D efforts on technology imports increased significantly. More recent work (Kumar and Aggarwal, 2005) offers evidence to suggest that over the period of liberalization, increased competition has pushed local firms to rationalize their R&D activity and make it more efficient. More importantly, the analysis indicates that R&D activities of local firms are primarily directed towards imbibing imported technology, whereas foreign firms essentially exploit the locational advantages to provide R&D backup service for their parent companies.

None of the studies however, focused exclusively on the R&D activity of public sector enterprises. This assumes relevance in view of several considerations. First, the share of public enterprises in total industrial sector R&D has been rising moderately from an average of 0.09 percent in the first half of the 1990s to roughly 0.11 percent in the second half, suggestive of a pro-active focus on R&D by these enterprises. Second, the share of R&D of the sample firms in total public sector R&D has been on average around 70 percent, pointing to the representative of our sample. Finally, post initiation of economic reforms, the Federal government has been expending a substantial amount of its resources on R&D.

III. Data and methods

The analysis employs data drawn from the *Public Enterprise Survey* (hereafter, *Survey*), Government of India. The *Survey* covers Federal PSEs established by the Government under the Companies Act or as statutory corporations under specific statutes of Parliament in which the Central Government holding in paid-up share capital is not less than 51% (excluding banks and other financial institutions).

III.1 The database

The basic data for the *Survey* is compiled from the annual reports and accounts furnished by individual PSEs to the Government. The data is compiled, analyzed and presented in three volumes. The first volume presents a consolidated analysis of the performance of the PSEs in terms of physical and financial parameters. Volume II provides an analysis of its performance over the last three years including the present year and Volume III presents the enterprise-wise analytical data comprising of summarized balance sheet information and profit and loss accounts.

The enterprises covered in the *Survey* are classified under two heads: those producing and manufacturing goods and those rendering services. Given our focus on manufacturing entities, we base our analysis on the former category. As at end-March 2005, there were a total of 229 PSEs, of which 147 were manufacturing sector companies. These manufacturing companies accounted for, on average three-fourths of total turnover and nearly 80% of the total assets of central PSEs.

We started off with all the 147 entities, but subsequently delete several firms. First, we delete firms which witnessed transfer of majority equity to strategic partners, since subsequent to this process, data on such entities are not included in the *Survey*. In addition, we delete firms with extremely misrecorded data or those with missing information on key financial variables. These exclusions reduce the final sample to 100 firms. These firms comprise, on average, about 65% of total asset and over 80% of the total turnover of these Federal PSEs. Table 1 provides the sample description. We base our analysis on this data and collate information on the relevant variables of interest to our study using this database.[2]

Table 1. Sample firms

Industry	No. of firms	Per cent to total
Agro-based products	2	2
Chemicals & pharmaceuticals	6	6
Coal & Lignite	1	1
Construction	3	3
Consumer goods	13	13
Fertilizers	7	7
Heavy Engineering	4	4
Medium & Light Engineering	24	24
Minerals & Metals	6	6
Petroleum	8	8
Power	3	3
Steel	7	7
Textiles	10	10
Transportation equipment	6	6
Total	100	100

Table 2 sets out the definitions and summary statistics of all firm characteristics based on the sample of manufacturing entities employed in the regression analysis. A common proxy

[2] R&D expenses often accounts for less than 1% of turnover. Accordingly, companies often do not separately report such expenditures. This lack of a mandatory disclosure of R&D expenditures in accounts, could be a source of bias, because it is not evident whether the firm does not incur any expense on R&D or alternately, whether it does, but chooses not to report. Owing to this fact, even if a company reports zero R&D expenses, we retain it in our sample.

for innovation is R&D intensity, the ratio of the firm's R&D expenditure to sales. We also use a measure *innovation activity*, defined as the logarithm of R&D expenses per 1000 employees, as an alternate dependent variable. Using data on 91 of the top 100 US companies that invested in R&D during 2003 and 2004, Smith (2006) shows that smaller companies have much higher per employee R&D level.

Table 2. Variable definitions and summary statistics

Variable	Empirical definition	N.firms	Mean	SD
R&D intensity	R&D expenses/Sales	99	0.005	0.037
Innovation activity	R&D expenses/1000 employees	72	3.181	0.844
Size	Log(total sales)	99	2.149	1.047
Age	Log (number of years since firm incorporation)	100	1.409	0.314
Borrowings	Government borrowings/Total borrowings	100	0.259	0.402
Reservation	Dummy=1, if a firm was reserved for the public sector till 1991	100	0.058	0.234
Monopoly	Dummy=1, if a firm is operating in a monopoly environment	100	0.090	0.286
Ministry	Dummy=1, depending on the ministry to which a PSE reports	100	0.007	0.086

The descriptive statistics shows that, on average, the R&D expenditure is 0.5 percent. The innovation activity is Rs.4086 (US $100). The leverage ratios of the firms were also modest, with an average of just over 55 percent. The sample firms had high levels of asset tangibility and are, therefore, informationally less opaque. The average firm size was Rs.22360 million (US $540 million) and the average age was roughly 30 years. These figures indicate that the firms have been in existence for a significant time span. Out of the 100 firms, 27 were operating in a monopoly environment.

III.2 Decision making in PSEs

The decision making process of PSEs also deserves a mention in this context. In the first round of disinvestment in 1992, the government offered 'bundles' of shares of various PSEs, distinguished on the basis of financial performance, each bundle carrying a notional reserve price, to government-owned financial institutions. Later in 1995, the bidding process was opened to foreign institutional investors and the public at large. The overwhelming chunk of funds raised through disinvestment (Rs.9.9 billion or US $0.25 billion) has been through the auction route. The method of disinvestment was widened in 1997 when disinvestment was effected through both the GDR (global depository receipts) route and public issues in the domestic market.

The outcome of the initial phase of divestment was encouraging, with receipts amounting to about 0.5% of GDP. Thereafter, while budget targets of revenue realization expanded continuously, the realized receipts dwindled. On an annual average basis, receipts amounted to less than one quarter of one percent of GDP per year over 1992-96, lower than the average amounts realized in other developing countries in the 1990s (Davis *et al*., 2000).

After the initial round of disinvestment in 1991-92, the process was guided by recommendations made by a Committee on Disinvestment established in 1993. Later, the government constituted the Disinvestment Commission, an independent body in 1996 (subsequently reconstituted in 2001) to draw up a comprehensive program of disinvestment over the medium-term for PSEs referred to the Commission (Government of India, 1998). The Commission formulated a broad approach to disinvestment and also made specific recommendations in respect of 58 out of 72 PSEs referred to it by August 1999.[3] The Commission broadly distinguished between a 'core' and 'non-core' group of industries. In the 'non-core' category, the Commission advocated sale of up to 74% of government equity.

In the past, PSEs remained highly regulated, with over 500 guidelines governing the behaviour of enterprises. During the second phase of reforms, the government, on the basis of the Vittal Committee Report (Tandon, 1999) retained around 100 guidelines 100 guidelines and modified another 25 of them. This initiative to an extent liberated PSEs and provided them with flexibility in decision-making.

III.3 Empirical Strategy

For the empirical model, we first employ a Tobit model with the R&D intensity as the dependent variable. It takes into account the fact that many companies report zero values of R&D expenditure. In the Tobit model, regressors have the same influence on the probability of conducting a positive amount of R&D as on the R&D intensity itself.

Accordingly, we estimate the following reduced form specification of R&D intensity for firm *s* at time *t* given by expression (1)[4]

$$R\&D_{s,t} = \alpha_o + \alpha_1[Controls]_{s,t} + D\_GDP_t + ID_t + MD_t + \lambda_t + \eta_i + \xi_{s,t} \qquad \textbf{(1)}$$

where *Controls* is the set of control variables, including firm size, age and government borrowings. We control for the business cycle by including real GDP growth. To moderate the influence of noise, instead of the continuous measure - real GDP growth - we employ a dummy variable (*D_GDP*) that equals one if the GDP growth exceeds the median for the sample period.

[3] Out of the 58, the recommendations involved change in ownership in respect of 41, no change in ownership for 5, no divestment in case of 8 and closure and sale of assets in case of 4 PSEs.

[4] Although in theory, a two-limit Tobit model could be used to allow for censoring at a maximum R&D to sales ratio of one, R&D intensities in practice rarely come near this threshold. Right limit censoring thus, ceases to be relevant.

Lastly, industry dummies (*ID*, not reported) and Ministry dummies (*MD,* not reported) are included to control for idiosyncratic industry features not explicitly factored into the analysis.

We control for firm size because in general, larger firms have the technology to seize opportunities. They also have more resources to invest in these activities and have the ability to benefit from the returns on their innovative activity (Nelson and Winter, 1982). In the Indian context, earlier studies have reported a positive effect of firm size on R&D (Kartak, 1985), although other studies for developed economies report a U-shaped relationship (Acs, 1988; Audretsch and Acs, 1991). To take account of this fact, we include, in addition to size, its squared term to account for possible non-linearities.

The (presence) age of the firm, measured as the number of years since its incorporation, captures firm experience and knowledge accumulation and it usually proxies for efficiency differences (Ericson and Pakes, 1995). Age increases the skill and managerial capabilities (i.e., the stock of knowledge), leading to a concomitant increase in skill and managerial capabilities of the firm as well. We also include the squared of the age variable to account for any non-linearities in the relation between age and R&D.

It has been argued that government policy plays an important role in influencing R&D, especially in public firms. Several public firms have incurred losses over a continuous stretch of time and in spite of this fact, have been undertaking R&D, since they have been receiving government support. Both Indian (Gupta, 2005) and international (Bartel and Harrison, 2005) evidence indicates that government support is an important factor influencing the behaviour of state-owned firms. Accordingly, we control for potential changes in government involvement by including as an explanatory variable the share of government financing (loans and borrowings) in total borrowings.

IV. Results and discussion

Table 3 exhibits the results of the estimation of the factors influencing R&D intensity. Unlike in OLS model where the coefficients indicate the impact of an explanatory variable on the dependent variable, in the Tobit specification, they represent their effects on the latent dependent variable. As a result, we report (instead of the coefficients) the marginal effects. Following the decomposition framework advanced by McDonald and Moffitt (1980), we disaggregate the total marginal effect into the weighted sum of two types of marginal effect that reveal the impact of explanatory variables on (a) changes in the probability of the dependent variable (*y*) being above zero and (b) changes in the value of the dependent variable if it is already above zero.

The overall significance of the Tobit model was tested using the Wald test, which has a Chi-Square distribution under the null hypothesis that all explanatory variables equal to zero. The values of the Chi-square statistic are associated with a p-value of zero. These results suggest that the explanatory power of both models is statistically significant at the 1% level. In Cols.(1) and (2), we have, on average data for 15.3 years, hence the maximum number of firm-years is 1471. In case of the alternate model with innovation activity as dependent variable, the number of firm-years is 729 with to data on 71 firms at an average of 10.3 years of data per firm.

Table 3. Regression results for determinants of R&D

Variable	Dependent variable = R&D/Sales	Dependent variable = log(R&D/ 1000 employees)
	Tobit model	RE model
Size	0.049 (0.012)***	0.037 (0.201)
Size squared	-0.004 (0.002)**	0.054 (0.031)**
Age	0.173 (0.060)***	-0.216 (0.349)
Age squared	-0.051 (0.032)	0.502 (0.343)
Borrowings	0.019 (0.007)***	0.121 (0.051)**
Dummies		
Real GDP growth	0.003 (0.002)	-0.071 (0.033)**
Monopoly	-0.049 (0.012)***	0.108 (0.311)
Constant	-0.102 (0.044)***	0.967 (0.403)**
Industry dummies	Included	Included
Ministry dummies	Included	
No. of firms, Obs.	96, 1471	71, 729
Time period	1987-2005	1987-2005
McFadden R^2	0.303	
R^2		0.271
LR Chi squared (p-Value)	422.14 (0.00)	
Wald Chi squared (p-value)		451.19 (0.00)

Standard errors within parentheses
For dummy variables, marginal effects are for discrete changes from 0 to 1
*, ** and *** indicates statistical significance at 1, 5 and 10%, respectively

In (1), the coefficient on *Size* is positive and significant. This is consistent with studies that report a positive effect of firm size on R&D intensity (Bah and Dumontier, 2001; Aghion *et al.*, 2004). More specifically, increases in firm size are likely to be associated with increase in R&D up to a threshold. Beyond this threshold, R&D declines with size. This concave quadratic relationship suggests that firms increase their R&D efforts up to a defined limit; subsequently, the cost of additional unit of R&D outweighs the benefits, leading them to scale down their R&D expenses. Besides the statistical significance, the effect is also economically important. According to the calculated marginal effect, when *Size* increases by Rs. 10 million (US $0.25

million), the probability of R&D increases by 0.021, and the amount of R&D would, on average, increase by Rs. 0.343 million, when R&D is already above zero.[5]

The coefficient on *Age*, wherever significant is positive, consistent with the fact that older firms tend to be more efficient and therefore, more inclined to undertake R&D activity. *Age squared* is however negative, indicating that although the intensity of R&D initially rises for older firms, it subsequently declines. The variable could be capturing the life cycle of the firm product, such that the technological opportunities facing older firms gradually diminishes, leaving them with lower incentives to invest in R&D.

It is of interest to note that the coefficient on *borrowings* is positive and significant at the 0.01 level. This supports the fact that firms which receive government support are more likely to exhibit higher R&D intensity.

The analysis indirectly controls for the pricing policy of PSEs by introducing a dummy for monopoly. The evidence clearly indicates that such firms tend to have lower incentives to engage in R&D as compared to their competitive counterparts.

In Col. (4) where the dependent variable is *innovation activity*, we utilize a RE model. The result is broadly in line with those obtained under the earlier specification. S*ize squared* exhibits an observed positive sign: in other words, increase in size beyond a threshold raises R&D expenses proportionately more than employment. Importantly, as in the previous specification, *borrowings* display a positive sign, consistent with the fact that government support plays an important role in influencing the R&D behaviour of public firms in India.

V. Concluding observations

A growing body of research in India has explored the technological capabilities of firms. Limited research has, however, been forthcoming as to the factors influencing R&D intensity, especially of public sector firms. Using data on a sample of 100 public sector manufacturing companies for the period 1987-2005 the evidence presented in the paper suggests that a whole host of factors have a significant influence on R&D. First, increases in firm size are likely to be associated with increase in R&D up to a threshold, beyond which, R&D is observed to decline with size. The evidence is supportive of the fact that both the intensity of R&D as well as innovation activity is lower for leveraged firms. Finally, the findings fail to discern any significant improvement in R&D intensity in the post-reform period; although there is a noticeable decline

[5] *Size* is defined as logarithm of total sales and therefore, an increase by one translates into an increase in sales by 10.

in innovation activity after reforms. Privatization does not seem to have exerted any perceptible influence on R&D behaviour of public firms.

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