Critical Factors Determining Innovative Activities in Indian Pharmaceutical Industry

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Abstract

Technological progress through research and development (R&D) activities has been widely recognized as a key factor contributing to the overall growth of the economy. At the firm level R&D activities can be seen as a strategic tool for the firm to gain competitive advantage in the market. The literature of industrial organization considers R&D activities as an important conduct variable which shapes the structure of the market and performance of the firm. The decision to invest in R&D activities is crucial one and it competes with other investments. In pharmaceutical industry, the role of R&D is even more important as the market is highly competitive and well protected by patent laws. Using Tobit model this paper explores the critical factors that affect the decision to go for R&D activities in Indian pharmaceutical industry. The results shows that import intensity, royalty, profitability and advertisement play an important role in deciding on R&D intensity of the firm. Affiliation to group or business houses is not a significant factor with respect to R&D Intensity.

Keywords: Research and Development, Market, Pharmaceutical Industry.

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1. Introduction

The pharmaceutical industry displays several unique key characteristics that are critical to understand its challenges. It is a highly risky business with long-term payoffs and lumpy outputs. On average, it takes fourteen to fifteen years to go from discovery of a drug to approval. The odds of a compound making it through this process are around 1 in 10,000, while the cost of getting it through is around $200 million. To cover this cost and risk, the drug companies depend on a few blockbuster drugs. Even for a large firm, it is not uncommon for one drug to account for almost half of its revenue.

The past three decades has witnessed an impressive renaissance in drug innovation and R&D competition that was very broad in its scope. The pharmaceutical industry spends more on research and development, relative to its sales revenue, than almost any other industry. According to various estimates, the industry's real (inflation-adjusted) spending on drug R&D has grown between threefold and six fold over the past 25 years. In 1980, U.S. companies spent a total of $5.5 billion (in 2005 dollars) on research and development of pharmaceuticals and medicines, according to the National Science Foundation (NSF). By 2003, that figure had grown to more than $17 billion—an average increase of 5 percent per year in real terms.

The rise in research and development spending reflects an increase in the average R&D cost per drug which is attributable to a variety of factors. The scope of drug research has greatly expanded, fueled not only by growth in sales revenue for drugs but also by advances in basic science. The scientific advances have also induced a shift from "chemistry based" drug development to drug research based on molecular biology, which has led pharmaceutical firms to spend more for capital equipment and training. Basically a close relationship exists between drug firms' current R&D spending and current sales revenue for two reasons. First, successful new drugs generate large cash flows that can be invested in R&D (their manufacturing costs are usually very low

relative to their price). Second, alternative sources of investment capital—from the bond and stock markets—are not perfect substitutes for cash flow financing. Table-1 and 2 shows the R&D expenses of largest 15 pharmapharmaceuticalceutical companies and it is clear that in every company the R&D expenditure has gone up from the year 2008 to 2009.

Table 1

R&D Expenses of Largest 15 Pharmaceutical Companies in billion dollars

Company	2008	2009	2010
Pfizer	7.9	5.6.7	9.5
Johnson & Johnson	7.6	7.0	6.8
Novartis	7.2	7.5	9.1
Roche Holding	8.2	9.1	9.3
Bayer A G	3.9	3.8	4
Glaxo Smith Kline	6.5	6.2	6.2
Merck & Co	4.8	5.6	8.4
Sanofi Aventis	NA	NA	NA
Abbott Lab	2.7	2.7	3.7
Astra Zeneca	5.2	4.4	5.3
Eli Lilly	3.8	4.3	4.9
Bristol Myers Squibb	3.5	3.6	3.6
Boerhringer Ingelheim	2.4	3.1	3.1
Takeda	2.4	4.5	3.2
Teva	0.786	0.802	0.882

Source: Collated from IMAP's Pharmaceutical & Biotech Industry Global Report — 2011

Table-2

R&D Expenses of largest 50 Pharmaceutical Companies in billion $: 2008-2010

2008	2009	2010
91.59	103.86	107.40

Source: Collated from IMAP Report – 2011

2. The Pharmaceutical Industry in India

In the Post Independent period, MNCs were allowed to export drugs—mainly low-priced generics and a few high-priced specialty items. When the Indian government increased pressure against the import of finished products, MNCs developed formulation units in India and exported only bulk drugs to that country. In the early 1960s, the Indian government encouraged the indigenous manufacture of bulk drugs. In the following decade the Indian patent act prevented the granting of product patents for substances used in foods and pharmaceutical. Only process patents were allowed for five years from the date of granting a patent or seven years from the date of filing the patent. Drug price control order (DPCO) was introduced during the same period to prevent undue profiteering from essential medicines. MNCs were compelled to reduce their holdings to 40% in their Indian ventures. In the 1980s–1990s, domestic pharmaceutical companies flourished. As a result, the market share of MNCs fell to the current 35%, down from 75% in 1971.

2.1. Impact of Liberalization

During the period 1992–2002, the relaxation of import restrictions and foreign direct investment, along with a major change in the regulatory norms, resulted in increased competition from firms with superior resources in this industry.

The initiatives of World Trade Organization has created a dynamic environment which saw the removal or protectionism and opening up of new markets for emerging economies. The liberalization of Indian Economy in 1991 witnessed major policy changes in the Indian Pharmaceutical Industry. The major impact of these changes was reflected in the shift from an established "process patent " regime to a product patent regime. During the period 1992-2002, major policy changes for the Pharmaceutical Industry included removal of restrictions on -foreign direct investment (FDI), industrial licensing, price controls, high tariffs on technology and raw material imports. These steps led to rise in freer imports, lesser barriers to entry and higher competition. The product patent which was implemented in a phased manner during the period 1992-2005 allowed only firms with product patents to manufacture and sell the patented drugs. The change of the existing "process patent" regime, whereby firms were allowed to reverse-engineer drugs that were patented elsewhere to sell them in the domestic market and also export them to other unregulated countries as long as they use a different process to produce them. Until 1990 hardly few firms in Indian pharmaceutical firms had invested in product R&D. This regulatory change made it imperative for domestic firms to redesign their existing business model to survive and grow in the new patent regime.

During the early 1990s, markets were opened up by removing restrictions on imports and in 1994 licenses were abolished for all the bulk drugs and formulations in all the therapeutic segments. Until 1994, many Indian firms adopted the strategy of developing generic replicas of drugs that were under patent in developed countries, which were then sold in the domestic markets and exported to other unregulated markets elsewhere in the world. This generic business enabled them to compete with MNCs in India and abroad, and resulted in good revenues.

However, since the advent of the product-patent regime in 2005, firms are not allowed to reverse engineer drugs that are patented after 1995, and the revenues from this business began to decline for the domestic firms. Meanwhile, the MNC affiliates operating in

India through FDI or directly having an impressive new product portfolio (due to earlier R&D efforts) are able to command a premium for their products without the fear of competition.

The Confederation of India Industries (CII) estimates that approximately 80 percent of them are engaging in some type of contract manufacturing or outsourcing. The largest 250 companies control nearly 70 percent of the domestic market with the top 10 controlling approximately 40 percent. The domestic Indian pharmaceutical industry consists of both domestic companies and subsidiaries of MNCs. Indian pharmaceutical companies now supply nearly all the country's demand for formulations and nearly 70 percent of its demand for bulk drugs. Indian firms produce nearly 60,000 generic brands in 60 therapeutic categories and between 350 and 400 bulk drugs. Approximately 80 percent of domestic production consists of formulations, and more than 85 percent of those formulations are sold in the domestic market, whereas at least 60 percent of bulk drug production is exported. Nearly 97 percent of India's drug market consists of second-and-third generation drugs no longer subject to patent protection in the developed world.

2.2. R&D Activities in Indian Pharmaceutical Sector

The Pharmaceutical Industry in India is one of the largest and most advanced among the developing countries. India currently spends just 4.5 to 5.0 percent of its GDP on health care, and public spending accounts for just 0.9 percent, putting the nation among the 20 lowest-spending countries worldwide. Research and Development is the key to the future of pharmaceutical industry. Indian domestic pharmaceutical market has seen growth at a CAGR of about 12% in the last 5 years. About 67 Million Indians are expected to reach the age of 67 years by 2011. People of this age group spend around 3 to 4 times more on drugs than people in younger age groups.

Healthcare budget of an average Indian household is expected to grow from 7% in 2005 to 13% in 2025. By 2015, India will probably open a US$ 8 billion market for multinational pharmaceutical companies selling expensive drugs as predicted by the FICCI-Ernst & Young India study. The domestic Indian pharmaceutical market is likely to reach US$ 20 billion by 2015.

There is considerable scope for collaborative R&D in India in areas of excellent scientific talents, new synthetic molecules, cost effective clinical trial research and biotechnology. The Pharmaceutical and Biotechnology industry is eligible for weight deduction for R&D expenses up to 150 per cent. These R&D companies will also enjoy tax holiday for ten years. Global competitiveness will be the key to growth and survival under the new IPR regime. Local Indian pharmaceutical manufacturers need to significantly increase their R&D expenditure. At two percent of sales these are currently far below the global level of 10 to 20 percent.

Pharmaceutical production costs are almost 50 percent lower in India than in Western nations, while overall R&D costs are about one-eighth and clinical trial expenses around one-tenth of Western levels. India's long-established manufacturing base also offers a large, well educated, English-speaking workforce. The industry provides one of the highest rates of intellectual capital per dollar worldwide.

In Indian context, R&D was largely concentrated on process development for known bulk drugs albeit through novel and innovative process routes, invariably substituting for expensive imported raw materials enhancing the productivity and efficiency. Indian companies started their drug discovery programs in the 1990s with Doctor Reddy and Ranbaxy leading as pioneers. In the early period Indian companies were involved in recognizing lead molecules and out licensing several of them at preclinical stage. Now Indian companies are conducting clinical trials of drugs of their own.

IBM Global business services report on Pharmacy mentions that research in India costs 40 per cent less than in US and developing a new drug can cost one tenth of what it does in the West. This represents a huge opportunity for India. The investments in R&D sector in pharmaceutical sector have shot up by eight times to $ 80 billion (Rupees 3, 68,000 million) since 1991. On account of India's new patent regime in the mid-1990s, domestic pharmaceutical started investing in drug discovery research. On an average, research oriented domestic pharmaceutical companies spend about one third of their R&D expenditure on drug discovery research. The rest is spent on generic R&D and new drug delivery systems

2.3. Attractiveness for Investment in India as R&D Destination

- 100% foreign equity investment is automatic in the drugs and pharmaceutical sector and over 74% is on case to case basis
- Fast Track clearance route for foreign direct investment
- Depreciation allowance on plant and machinery set up based on indigenous technology
- Customs duty exemption on goods imported for use in government funded R&D projects
- Customs and excise duty exemption to recognized scientific and industrial research organizations (SIROs)
- 150% weighted tax reduction on R&D expenditure
- Three years excise duty waiver on patented products
- 100% rebate on own R&D expenditure
- 125% rebate if research is contracted in public funded research institutions
- Joint R&D projects are provided with special fiscal benefits.

2.4. Swot Analysis of Research and Development in Pharmaceutical Sector

Strengths	Weaknesses
• Mature industry with strong manufacturing base with capacity to produce quality drugs at relatively lower costs. • A very rich base of traditional knowledge in therapeutics i.e. Ayurveda, Sidha & Unani. • Well-developed engineering base to produce wide range of pharmaceutical equipment and machinery. • Abundance of S&T talent and infrastructure. • Successful experience in innovative process chemistry. • Access to international brain bank.	• Sub-critical R&D investments. • Lack of innovative R&D culture in industry • Poor networking among constituents in the innovation chain. • Inadequate framework for clearance of new drug investigation and registration. • A policy framework for testing on animals and their import that is not facilitative. • Inadequate trained manpower in emerging areas.
Opportunities	**Threats**
• Due to rising costs of R&D overseas, greater tendency towards outsourcing and networking. • Expertise to blend knowledge of traditional medicines with modern science. • Increasing competence in molecular biology, immunology and biotechnology. • Presence of Early Pioneers like Reddy's Lab, Ranbaxy, Dabur, Shanta Biotech. • Large numbers of patients covering wide range of diseases. • Potential for clinical research and initiating clinical trials • Opportunity to improve quality standards	• Inability to cope-up with the rapidly changing new drug discovery technologies and processes at the global level. • Rapidly changing standards of quality and manufacturing at the international level. • Lack of clearly articulated and facilitative national IPR policies. • Lack of strategy to bring convergence between aspirations of the 'small' and 'big' players. • Distortion in priority and public concern on health & pharmaceutical issues. • Reducing tariff levels and dumping can be a threat to survival of products and industry.

2.5. Research and Development Expenses

Compared to the global pharmaceuticalceutical industry, Indian R&D expenditure is still minuscule, which could have a negative effect in the long run, specially in the era of patent enforcement. Most of the Indian companies are spending 3-4% of their revenues on Research and Development compared to the global spend of 12-15 per cent of revenues. Table-3 shows top R&D spenders in Indian Pharmacy industry. It clearly shows that R&D as a percentage of sales revenue is in fact lower than most of the developed countries. Hence it is imperative to study the R&D behavior of Indian Pharmaceutical industry.

Table-3

Top Average R&D spenders in Indian pharmaceutical industry –2003-2010

Company	Ownership as per CMIE classification	R&D expenditure (Average of 2003-2010) (inclusive of current and capital account) Rs in millions	R&D as a percent of sales revenue
Ranbaxy Laboratories Ltd.	Foreign Business houses	1417.9838	2.4133
GlaxoSmithKline Pharmaceuticals Ltd.	Foreign Business houses	514.9288	2.2701
Piramal Healthcare Ltd.	Top-50 Business houses	509.1000	1.9534
Sun Pharmaceutical Inds. Ltd.	Other Business houses	489.9713	1.7010

Cadila Healthcare Ltd.	Other Business houses	443.5625	1.8279
Aventis Pharmaceutical Ltd.	Foreign Business houses	327.3000	2.3059
Orchid Chemicals & Pharmaceuticals Ltd.	Private Indian	321.0050	1.7498
Dr. Reddy's Laboratories Ltd.	Large Business houses	319.5225	0.1050
Wockhardt Ltd.	Other Business houses	299.9100	8.0416
Matrix Laboratories Ltd.	Private Foreign house	299.8600	1.9476
Hetero Drugs Ltd.	Private Indian	296.2514	7.7856

Source: Compiled from CMIE Data base

3. Literature Review

The determinants of industrial growth had been an area of keen interest for Industrial economist, management strategists and other stakeholders of a firm. In early industrial organization literature, industrial growth was studied in terms of inter-industry difference in profitability assuming homogenous firms in the industry Mason (1939) and Bain (1951). Subsequent literature however criticized the framework proposed by Bain and Mason on the grounds that firms are heterogeneous with different capabilities.

Contrary to Structure, conduct and performance (SCP) framework, the resource-based perspective analyzes competitive advantage at the firm level [Lippman and Rumelt (1982); Wernerfelt, (1984); Barney (1986, 1991); (Canibano et al., 2000)]. These studies proposed that competitive advantage emanate from firm specific factors, which the firms inherit over a long time, and are difficult to imitate.

One of the pioneering study by Schumpeter's (1943) hypothesized large firms with significant market power have far more resources than small firms with lower market power to invest in productive R&D activities. This resulted in a number of empirical studies by linking market structure especially firm size as an important determinant of R&D activities Mansfield (1963), (1964); Kamein and Schwartz (1975); Desai (1985) Acs and Audretsch (1987); Katrak (1989); Kamein (1989); Cohen and Levin (1989); Braga and Willmore (1991); Kumar and Saqib (1996); Symeonidis (1996); Basant (1997); Siddharthan and Safarian (1997); Sujit (2004). On the other hand, studies such as Symeonidis (1996); Scherer (1965); Kamien and Schwartz (1975) have seen both large and small firms to be similar in innovative activities. These studies also mentioned that substantial cash flows are necessary for effective R&D activities.

By combining both firm and industry contribution to the difference in performance was studied by Schmalensee (1985), Rumelt (1991); Roquebert et al (1996), McGahan and Porter (1997). Though the results vary across studies, the common factor is that the firm effect dominates the industry effect in explaining variations in the profitability.

Within the modified SCP framework, Caves and Porter (1977), and Nagesh (1990), have tried to introduce mobility barriers and the concept of strategic groups within an industry to explain intra-industry differences in profitability. These studies broadly followed structure, conduct and performance (SCP) as the framework for the analysis. In this approach structure and performance is linked with the behavior (innovative activities) of the firm.

Ownership structure of the firm is considered to be one of the important determinants of technological innovation. Khanna et al (2001) added this dimension especially in emerging economies by introducing business houses in explaining the performance differences among different industries. Business houses are connected though a separate legal entity, but a host of decisions are taken keeping these groups into consideration. Group members generate benefits/costs, which are shared by other members (Khanna et al, 2001). An important advantage of business group affiliation is that it gives access to the groups internal resources, such as labor and capital. From a transaction costs perspective, Coase (1937) and Williamson (1985) have argued that using internal markets may yield substantial economic benefits.

There are significant flows of synergies among its members which can help then to take risky R&D activities. Remco van der Molen (2005) finds evidence that the investment spending of stand-alone companies is more sensitive to changes in cash flow than that of business group affiliates. Dutta (1997) reconfirms that group companies are an important source of funding for new projects. Family ownership and cross-holdings of equity create strong network effects, inducing the affiliated companies to support each other with inter-corporate loans, deposits and investments. Investments in R&D involve significant risks and benefits incur to the firm only in the long run. Family owners maintain long term relationship with the firm often across generations. Hence family owners will be more willing to invest in R&D as compared to non-family firms (Chen and Hsu 2009).

Importing technology has seen widespread acceptance as an important strategy for growth after globalization wave. Royalty payment, intra-firm transfer of technology through foreign direct investment or foreign equity participation etc. are seen as options to get up-to-date technology as suggested by these studies [Link (1983); Bell and Scott-Kemmis (1985); Desai (1985); Pandit and Siddharthan (1998); Narayanan (1998); Romijn (1996); Narayanan (2004).

Studies such as Katrak, (1989), Romijn, (1996), Narayanan, (1998) used technology transfer through the supply of machinery and equipment where the technology is embodied in the imported capital good. The firm may then use internal R&D efforts to adapt, assimilate and develop imported technology. Katrak (1989) found that imported technology helped in promoting R&D activities in the firms. Similarly, Siddharthan (1992) and Rajan (2002) found it to be complementary.

Siddharthan and Pandit (1998) studied firms in Indian drugs and pharmaceutical, chemicals, and industrial machinery, post 1985 period, had to compete by creating additional capacities through investments in various technological efforts like R&D, import of capital goods, and technological imports. They found that the multi-national enterprise (MNE) affiliates too had advantage in terms of technology, brand names and other intangible assets. However, Siddharthan and Safarian (1997) found that foreign affiliates, taking advantage of deregulation, imported capital goods and undertook modernization expenditures mainly in the electrical and electronic goods, and automobile industries but not in the chemicals and pharmaceutical industries. Other important studies are as follows.

Studies	Comments
Grabowski et al (2000)	This study examines the determinants of pharmaceutical R&D using a pooled data sample of 11 major drug firms over the period 1974 to 1994. The study finds that that expected returns and cash flows are important explanatory variables of firm research intensities. The study finds that lagged returns on R&D and cash flow availability were important determinants of R&D investment.

Mahlich et al (2006)	Using a pooled data sample of the 15 publicly listed Japanese drug firms for the period 1987–1998, the study finds that expected returns to be an important determinant of R&D spending in the Japanese drug industry. The estimates on financial constraints are sensitive to model specification, indicating that Japanese drug firms face small or no financial constraints.
Saranga et al (2009)	This research paper explores the effect of managerial and strategic parameters on the degree of operational efficiency achieved by a firm in the Indian pharmaceutical industry using data envelopment analysis (DEA). The findings indicate that domestic firms, most of which are controlled by family-based governance structures, enjoy higher efficiencies than affiliates of multinational pharmaceutical majors. After controlling for firm size and initial efficiency levels, we find that firms with higher levels of innovation through higher R&D investments and older establishments are associated with higher efficiencies, when compared with their less R&D intensive and younger counterparts, respectively
Subash et al (2007)	The study based on a sample of 50 Indian pharmaceutical firms show that size; advertising expenditure, age, efficiency ratio, profitability, and research and development are statistically significant in determining the growth of firms in drugs and pharmaceutical industry.

Taewoo et al (2010)	The evidence shows that ownership structure can substantially influence the efficiency of pharmaceutical firms. Especially, institutional ownership rate affects corporate efficiencies negatively, corroborating the myopic institutional investor hypothesis. In contrast, little evidence is found on the relationship between ownership structure and R&D intensity in the American pharmaceutical industry.
Rebecca et al (96)	The study examines the relationship between firm size and research productivity in the pharmaceutical industry. Larger research efforts are more productive; not only because they enjoy economies of scale, but also because they realize economies of scope by sustaining diverse portfolios of research projects that capture internal and external knowledge spillovers.

4. Data and Methodology

Most of the data for this study was collected from Centre for Monitoring Indian Economy (CMIE) data bases. The time period taken for this study was from 2003-2010. The total sample size for this study was 387 firms as seen in table-5. As R&D expenses is a continuous one the study has taken the average of this period to include continuity. For the information on groups and business houses the study used the classification as given Prowess database from CMIE, Mumbai. The classification of business houses into the "top fifty", "large houses other than the top fifty" "other business houses" "foreign business houses" "private foreign" and "Private Indian."

Table-4

Descriptive Statistics

	RD	ADVT	IMPORT CAP	MS	PROFIT	ROYALTY
Mean	10.888	10.483	5.347	0.003	4.188	8.693
Median	2.103	0.175	1.349	0.000	0.874	0.128
Maximum	800.000	3609.667	573.000	0.163	714.000	3107.667
Minimum	0.000	-174.000	-0.255	0.000	-1.488	-50.000
Std. Dev.	67.298	184.005	35.184	0.013	41.678	158.073
Skewness	9.155	19.413	13.513	8.107	15.052	19.546
Kurtosis	89.636	380.228	200.578	84.079	239.768	383.684
Jarque-Bera	126435.7	2318916.0	641246.9	110242.8	918563.3	2361479.0
Probability	0	0	0	0	0	0
Observa-tions	387	387	387	387	387	387

Table 5

Data segregation: Ownership and R&D expenses

Ownership type	Number of firms	Average R&D expenses in millions (2003-2010)
Top-50 Business Houses	7	82.92
Private Indian	287	26.94
Private foreign business	18	83.47
Other business Houses	49	64.62
Large Business Houses	19	45.78
Foreign business Houses	7	326.68*
Total	387	630.41

** Ranbaxy was also included among foreign business houses since it has been taken over by Daiichi (F) Sankyo Group. The R&D expenditure of this company was 1417.98 millions during this period, this contributed to a very high average R&D for this group.*

The underlying methodology in estimation of Tobit model is the maximum likelihood estimation technique and not the least-square estimation technique. So the technique is free from many of the necessary conditions of the least square estimation technique. As many firms in this industry report zero R&D intensity as a result this tobit model is more suitable than any other model. Statistically, a Tobit model can be expressed as:

$$y_i = x_i\beta + \sigma\varepsilon_i$$

Where σ is a scale parameter which is identified and estimated along with the β. In the canonical censored regression model, known as the tobit, the observed data y are given by

combinations of dummy variables. Error distribution is significant in all the four models estimated as seen in table-6.

It is clear from the models that except for private Indian pharmaceutical companies all other groups have similar R&D intensities. Group which includes business houses such as Indian business houses (top-50 business houses plus other Indian business houses) and foreign companies do not significantly differ on R&D Intensity. During the last three decades the large private Indian pharmaceutical firms focused their efforts on reverse engineering oriented process R&D, and activity was limited to applying known knowledge, or to making small adjustments in the contents Wendt, R. A. (2000).

In literature, advertizement is always seen as a competitor to R&D investments. In pharmaceutical industry however it is complementary and it moves in the same direction.

Several studies have mentioned that import of capital goods as a strategy to import inbuilt technology for adaptation turned out to be negative suggesting it to be substitute not complementary as found by Siddhartha (1992) and Rajan (2002). But, royalty payment as a means to transfer technology is positive and significant which suggests that technology transfers instigate Indian pharmaceutical industry to invest more on R&D activities.

Market share as a proxy for size variable is not significant in any model suggesting market size is not a crucial determinant of R&D activities in Indian pharmaceutical industry.

Profitability turned out to positive and significant as expected and it is clear from this study that higher profitability promotes R&D activities. R&D being risky it is always comfortable to fund through retained earnings.

$$y_i = \begin{cases} 0 & \text{if } y_i < 0 \\ y_i & \text{if } y_i > 0 \end{cases}$$

In other words, all negative values of are coded as a single value 0. Note that this situation differs from a truncated regression model where all negative values of are simply dropped from the sample. The parameters σ , ß are estimated by maximizing the log likelihood function.

Tobit Model

$$R\&D_i = a + bGroup_i + b_1\, Adv_i + b_2\, profit_i + b_3\, Royalty_i + b_4\, Import_i + b_5\, MS_i + \varepsilon_i$$

$$\text{Where} \quad R\&D_i = \begin{cases} 0 & \text{if } R\&D_i < 0 \\ R\&D_i & \text{if } R\&D_i > 0 \end{cases}$$

Independent Variables are as follows:

- **Adv.** = Advertizement intensity (Advertizement expenses as a percentage of sales revenue)
- **Profit** = Profitability (Profit after tax as a percentage of sales revenue)
- **Royalty**$_i$ = Royalty expenses as a percentage of sales revenue
- **Import**$_i$ = Import of capital goods as a percentage of sales revenue.
- **Group**$_i$ = Group dummy $\begin{cases} 0 = \textit{if it does not belong to the category} \\ 1 = \textit{if it belongs to the category} \end{cases}$

5. Empirical Result

The descriptive statistics, in table-4, shows that the mean R&D intensity in this industry is 10.88 with high standard deviation. The calculated Jarque-Bera statistics for all the variables is very high and p-value suggests that the sample is not normally distributed.

For this study, four models have been estimated using Tobit model by taking different

Table-6

Tobit model (Maximum Likelihood - Censored Extreme Value)

Independent variable	Model-1	Model-2	Model-3	Model--4
Constant	-7.041(-0.379)	4.897 (0.594)	18.338 (3.670)*	17.63 (3.420)*
Group Dummy	5.254 (1.298)			
Indian Business Houses (IBH)				0.661 (-0.600)
Private Indian		15.68(1.664)***		
Advertizement	0.672(3.078)*	0.682 (3.1354)*	0.661 (3.025)*	0.661(3.030)*
Import of capital	-1.517(-6.81)*	-1.490(-6.694)*	-1.583 (-7.12)*	-1.528 (-6.669)*
Market share	-244.7(-0.868)	-224.06 (-0.79)	-287.05 (-1.01)	-248.39 (-0.871)
Profitability	4.531(9.187)*	4.499(9.095)*	4.573 (9.370)*	4.578(9.319)*
Royalty	2.115(6.636)*	2.095 (6.569)*	2.139(6.753)*	2.141 (6.733)*
R^2	-40.575	-40.406	-40.769495	-41.191
Adj R^2	-41.343	-41.171	-41.540963	-41.970
Error distribution	76.00 (20.38)*	75.92 (6.569)*	75.90 (20.39)*	76.005(20.375)*

** represents significant z statistics at 1%*
*** represents significant z statistics at 5%*
**** represents significant z statistics at 10%*

6. Conclusion of the Study

The pharmaceutical industry spends more on research and development, relative to its sales revenue, than any other industry. The rise in research and development spending

reflects an increase in the average R&D cost per drug that is attributable to a variety of factors. The scope of drug research has greatly expanded, fueled not only by growth in sales revenue for drugs but also by advances in basic science. The decision to invest on R&D competes with all other investments. In this context it is imperative to explore critical factors determining R&D activities in Indian pharmaceutical industry. The study was conducted for the time period 2003-2010 using tobit model. The result shows that Indian pharmaceutical industry is not sensitive to group affiliation and R&D activities are sensitive to factors like advertisement intensity, profitability, import of capital good intensity and royalty intensity. All the variables are positively related except import of capital goods. It was expected as import of capital goods already has technology embodied in to it and hence lower R&D intensity.

Market share turned out to be insignificant in affecting R&D intensity of the firm. This could be due to the fact that Indian pharmaceutical industry is characterized by a low degree of concentration; a large number of firms with similar market shares, a low level of R&D intensity ratios. The need and incentive for innovation was undermined by low purchasing capability of the domestic market along with the ease of imitation and horizontal product differentiation D'Este, P (2001).

6.1. Implications

The results of this research could be useful to practitioners in identifying the critical factors associated with the decision to invest in R&D activities. The import of capital goods could be identified as a factor that motivates managers to implement more indigenous R&D based strategies for innovation. Higher the royalty payment, greater would be the urge for the manager to enhance R&D funds for the pharmaceutical firms. This could be interpreted as the trend of growing realization among the mangers of the need for more investment in R&D activities for technology up gradation to save the cost of increased royalty payments.

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