FDI and R & D in the Pharmaceutical Sector in India

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Abstract

This study attempts to distinguish the determinants of R&D for domestic and FDI firms [firms with foreign capital] in the Indian pharmaceutical industry. The study employs an unbalanced panel to examine the determinants of R&D, using the firm level data form PROWESS database for a period from 1991-2005. It includes on an average of 154 domestic and 18 foreign firms. Probit and Tobit models are employed to examine the determinants of probability of undertaking R&D and R&D intensity. Probit results for domestic firms indicates that the firm size, import of capital goods intensity, Export intensity, rate of profit, Age of the firm, advertisement intensity and outward investment determines the decision of the firm to invest in R&D. Both domestic and FDI firms prefer import of technology in the form of equipments and machinery to undertake R&D compared to technology import in the form of technology know-how. In the case of foreign firms; firm size, import of capital goods intensity, rate of profit and age of the firm also turned out significant in determining the probability of undertaking R&D. Older firms appear to invest more on R&D in the case of both domestic and foreign firms. In the case of foreign firms, Tobit results remain similar to the Probit estimation. The findings of the study implies that importance of specific policies, aiming at fostering R&D through concessions in technology import for R & D purposes, special incentives for export and outward investment firms in the sector.

Keywords: FDI, Outward Investment, Pharmaceutical Industry, R&D
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1. Introduction

Technological learning and innovation play an important role in the economic growth and competitiveness of countries. Expenditure on research and development (R&D) is identified as an important source for promoting innovation and technological learning in developed as well as developing countries. However, it has been pointed out that R&D efforts in developing countries are more towards minor and incremental innovations rather than major innovations (Dosi 1988). Unlike the developed countries, the nature and direction of R&D undertaken in the developing countries are found to be different (Lall, 1992). In this regard, firm level investments in R&D not only promote innovation, but also help in adapting and absorbing technology from outside sources (Cohen and Levinthal 1989). Further, the scope of investment in R&D has increased with the progressive liberalisaion and increased flow of cross-border investment.

In this context, foreign direct investment (FDI) and its impact on R&D is one of the highly debated issues in the recent economics literature. Multinational Corporations (MNCs) are found to possess superior technology, know-how and skills compared to the domestic firms'.[1] Hence, they have enough resources at their disposal to incur R&D at the host country. Given the fact that foreign firms have access to knowledge resources of parent firms, their R&D spending primarily be towards adaptation rather than searching for any breakthrough innovations. However, a thorough comparison on the determinants of R&D in foreign and domestic firms is necessary to devise appropriate policies for domestic and foreign firms.

In the case of India, the inflow of FDI rapidly increased during the course of economic reforms[2]. The adoption of liberal FDI regime contributed positively towards this. During this period a large chunk of total FDI inflow was shifted to the manufacturing sector. From 1991-2005, total foreign direct investment India increased from 165 US $ to 3,348

[1] See Navaretti and Venables (2004), Markusen and Venables (1999) for related discussion

[2] The nature of FDI was different in the pre reform period. Most of the FDI was in the form of Greenfield investment. During the reform period the mergers & acquisition and joint ventures were also turned as major route for FDI inflows (Nayyar 2008).

US $.To understand the dynamics of R&D and its impact of domestic and foreign firms a detailed firm level investigation pertaining to a specific sector need to be undertaken.

R&D efforts of the Indian pharmaceutical industry demands special attention due to: (i) high R&D intensity compared to other industries; (ii) the contribution of R&D in building the technological capability in this sector is well accepted through the productivity growth, net value added and rapid rise of export surplus;[3] (iii) Indian pharmaceutical industry enjoys two major home-grown advantages in terms of R&D, cheaper manufacturing facilities and world-grown chemistry skills honed by years of reverse engineering (Mani, 2006); and lastly, (iv) pharmaceutical industry experienced a less regulated environment in term of patents till 2005.[4]

Few studies have already been carried out to identify the determinants of R&D in the Indian pharmaceutical sector.[5] However, these studies never differentiate between he R&D efforts of domestic and foreign firms. Our paper in this context, try to address: a) what are determinants of R&D in the case of domestic and foreign firms in the Indian pharmaceutical sector? b) What form of technology acquisition is being most preferred for conducting R&D by each group of firms?

The remaining paper is organized as follows: Section 2 highlights R&D carried out in the Pharmaceutical Industry in India. Section 3 reviews Indian studies related to FDI and R&D. Section 4 gives the variable description and frames the hypothesis. Section 5 provides data description and methodology. Section 6 presents the results. Section 7 summarizes the major findings and gives the conclusion.

2. Indian pharmaceutical industry

The Indian pharmaceutical industry ranks high among developing countries, in terms of technology and quality and is today in the front rank of India's science based industries.

[3] See for example, Pradhan (2006); Dhar and Gopakumar (2006) among others for evidence on this.

[4] Pharmaceutical patents were made TRIPS compliant from 2005 onwards only.

[5] See for example, Pradhan (2005), Ray and Badhuri (2001).

Pharmaceutical products are ranked as the most high-tech and capital intensive industries of the world. Even though there is confusion regarding the total number of registered pharmaceutical units, Mashelker Committee Report acknowledges around 5,877 enterprises in the sector. It has been identified that the leading 250 pharmaceutical units control 70% of the market. Studies have notified the presence of small, medium and large size firms in the sector with the presence of MNC's, private limited, public limited and few government owned manufacturing units. Indian pharmaceutical market is composed of bulk drug,[6] formulation, large volume parenterals[7] and vaccines (Mashelkar committee report 2003). Several reports highlight that the Indian industry is dominated by formulations. Bulk drug industry resembles a perfectly competitive market with no one firm accounting for a significant share. Most of the units in this sector belong to small scale sector. On the contrary, large private sector companies, dominate the formulations market (Chaudhuri, 2005). It has been noted that the market share of MNC'S in this sector has decreased over the years. Currently 23% of market share belongs to MNC's and 77% to domestic companies. In addition to all this, structure of Indian pharmaceutical industry has undergone constant change with increased number of mergers and acquisitions in the industry (KPMG, 2006).

Investment in R&D is one of the important measures to enhance the competitiveness of the sector. In 2004, R&D spending of the organized pharmaceutical sector as a whole was nearly US $ 4,340 million, which was an increase of more than 300% from the level existing in 2000 (Dhar and Gopakumar 2006). The structure of R&D in the industry has itself undergone changes over years. In the early 1950's MNC had a considerable market share hence the R&D spending were undertaken for the production of formulation with the imported bulk drug. With the patent act of 1970 this composition underwent changes, and initiated the growth of a strong indigenous domestic sector with R&D spending for the development of generics. It has been identified that the R&D spending undertaken in

[6] Bulk drug is the active substance in the drug. Formulation is the actual produced drug, in the form of tablets or syrup, etc.

[7] Large volume parenterals means a terminally acquos drug packaged in a single dose with a capacity of 100 milli liters or more and intended to be administered or used in human beings. It includes intravenous infusions, irrigating solution etc.

Indian pharmaceutical sector is mainly for the development of generics, development of Novel Drug Delivery System (NDDS), development of new processes and the development of new chemical entities (new drugs). One of the important indicators of R&D efforts is the increased patent filings of Indian companies made in India as well as in US patent office (Dhar and Rao, 2002).

Table 1: Patents generated by Indian Pharmaceutical firms (1990-2005)

Year	No. of Patents (USPTO)	No. of patents (IPO)	Filed (IPO)	R&D Expenditure (US Million)
1990	5	87	258	36.5
1991	7	118	323	29.4
1992	13	94	234	37
1993	17	145	273	39.8
1994	6	232	629	44.6
1995	10	132	1000	45.5
1996	12	71	1124	51.5
1997	20	291	1481	56
1998	35	150	1555	61.2
1999	51	307	1000	73.6
2000	61	276	883	97.8
2001	80	320	879	130.5
2002	126	312	966	175.3
2003	142	419	2525	280
2004	109	192	2316	392.4
2005	115	457	2211	495.2
Total	**1175**	**3603**	**17657**	

Notes: US patents are based on class 424, Drug, Bio-Affecting and Body Treating Compositions (includes Class 514) and Class 532, Organic Compounds (includes Classes 532-570).

Source: USPTO (2008), Annual Reports of the Office of Controller General of Patents, Designs, Trade Marks and Geographical Indications for various years, India
Data on R&D expenditure is compiled form PROWESS database

During the reform period, especially after 1991 government of India devised specific policies to boost up the R&D activity of the sector through special subsidies and tax incentives. This gets resulted in the increase in the number of patents filed by Indian firms [as shown in Table 1].

3. Review of Literature

A large number of studies have already been undertaken to examine the relationship between FDI and R&D in the Indian context[8]. A brief review of literature is provided in this section:

Deolalikar and Evenson (1989) studied the inventive activity of Indian industries by employing the patent data. The empirical analysis was based on demand system framework. The Study employed data on 50 manufacturing firms during 1960-70. Royalty payments made by Indian enterprises were used as a proxy for import of technology and patents for domestic R&D activity. They found a complementary relationship between import of foreign technology and inventive activity.

Siddharthan (1992) examined the importance of technology transfer and its impact on the R&D intensity of the Indian private sector firms. Transaction cost framework was employed to analyse the determinants of R&D. Study used data on 69 private sector firms for a period from 1985-87. The study reported a complementary relationship between import of technology and R&D activity.

Katrak (1995) analysed the relationship between R&D and technology import and firm size. His study employed data of 200 firms as obtained from the compendium of chemical and allied industries. Using multiple regression and partial correlation the study found that the import of technology has a positive effect on the domestic R&D intensity but, not in the case of R&D based products. Further, in a later study (Katrak 1997) the author observed that imported technology is used for adapting foreign technology to local use and not for developing in-house R&D for electrical and electronic industries. The study also reported a negative relationship between R&D intensity and firm size.

Basant and Fikkert (1996) examined the role of technology purchase on local R&D activity. The study employed firm level data for a period 1974-1982 to estimate the impact of technology purchase on R&D. Study considered payments on royalties and technical fees to measure the extent of technology purchase. Contrary to previous studies study revealed a substitution relation between import of technology and R&D in the case of domestic firms.

[8] Some of the Indian studies have extended the scope of the analysis by looking at the spillover effects of FDI, linkages and R&D productivity.

Kumar and Aggarwal (2005) was the first attempt to identify the determinants of R&D in the reform period. Study used firm level data for a period from 1992-1998, and reported a complementary relationship between technology import and R&D activity of the firms. Study takes into account only those firms which report R&D data, thereby results suffering from selection bias.

Kathuria and Das (2005) considered FDI as channel to transfer the superior technology skills and know-how of the MNCs to the domestic firms. Study employed Probit and Tobit models to examine the determinants of R&D using firm level data for 1996 and 2001. The study reported a substitution relationship between import of technology and R&D.

Narayanan and Thomas (2008) studied the determinants of R&D in the case of pharmaceutical industry using firm level data of 173 firms for a period form 1991-2005. Study reported a substitution relationship between import of technology and R&D.

The present study attempts to overcome the drawbacks of the earlier studies by examining the determinants of R&D for domestic and foreign firms separately.

4. Hypothesis and Description of Variables

4.1.1 Firm size

Literature on innovation has highlighted the importance of firm size as a factor influencing the behavior of firms (Cohen and Klepper, 1992). Greater size confers two important advantages one in terms of economics of scale and other through the increased capability to mobilize resources. Since R&D cost is fixed, big firms can spread it over a large amount of output than small firms. In case of financing of R&D, large firms usually have more internal funds at their disposal and can mobilize huge amount of funds required to spend on R&D form the market. Following the previous studies on Indian industries, firm size is proxied by annual sales turnover (SIZE). We expect a non-liner relationship between firm size and R&D intensity, and a quadratic term is included to check for non-linearity.

4.1.2 Technology imports

Developing countries are characterized with limited research capability (both in terms of skill and technology) so import of technology (in the form of direct purchase) is identified as a major source to boost up the technology as well as R&D capability of domestic industries. Further, import of technology requires local R&D activity (local learning) to absorb, adapt and assimilate the imported technology to suit local technology needs. Two variables are included in the study to test the impact of technology import on the R&D activity – IMPCINT, indicating embodied technology import and IMPRPINT - disembodied technology imports.

4.1.3 Export Orientation

Exports are likely to increase the returns to investment in R&D through increase in the size of the market. Further, exports facilitate market segmentation. As a result, the firm through product differentiation could pool the profit for further R&D activity. Pharmaceutical industry has the advantage of using firm specific knowledge like innovative design, new formulations and compounds to enhance its exports which in turn can increase the R&D growth and firm level capability.

Study expects a positive relationship between R&D and exports. Export intensity is defined as a ratio of exports to sales in the study (EXPINT). In the case of domestic firms, variable indicating outward investment (OFDI) is included as an alternative strategy of outward orientation.

4.1.4 Rate of profit

One of the important sources to finance R&D expenditure of the firm is through the retained profit of the firm. Moreover, firms may be unwilling to fund R&D activity with the borrowed funds knowing the uncertain outcome of R&D activity. Profit before depreciation, interest and tax (PBDIT) is taken as rate of profit variable in the study. Following recent Indian studies a positive relationship is expected between profitability and probability to undertake R&D and R&D intensity.

4.1.5 Age of firm

By way of learning by doing and through accumulating more experience, firms could posses a greater advantage in undertaking research (Bell and Pavitt, 1997). More experienced firms may posses more stock of accumulated knowledge and hence can have

higher advantage Age of the firm (AGE) is proxied by the number of years since the incorporation of the firm. A positive impact of age on probability to undertake R&D activity is expected.

4.1.6 Advertisement intensity

Advertisement intensity helps the firm to increase the market share which in turn increases the R&D intensity. Advertisement enhances R&D only if it increases market share and thereby increases the rate of return on R&D intensity. Advertisement intensity is taken as ratio of advertisement expenditure to sales (ADVINT). A positive sign is expected.

To test these hypothesis on Indian pharmaceutical industry data has been collected on a host of firm-specific characteristics like expenditure on R&D, sales turnover, expenditure on import of capital goods, expenditure on royalty and other technical fees, profits, year of incorporation, advertisement expenditure and foreign equity participation. Table 2 gives the description of different variables.

Table 2: Description of variables

	Dependent variable	**Notation**	**Description**	**Expected sign**
	R&D Intensity	RDCINT	(R&D expenditure/Sales) * 100	
	R&D Dummy	RDINT	= 1 for R&D incurring firms = 0 for non-R&D firms	
	Independent Variables			
1	Firm Size*	SIZE	Share of *i*'th firm's sale to the median sales of the industry in *t*'th year	+
2	Export Intensity	EXPINT	Total exports as a percentage of sales turnover	+
3	Capital goods import intensity	IMPCINT	Expenditure on import of capital goods as a proportion of sales turnover	+/-
4	Disembodied technology Imports intensity	IMPRPINT	Royalties and technical fees paid as a percentage of sales turnover	+/-
5	Rate of Profit	PBDIT	Profit as a percentage of sales	+
6	Age	AGE	Number of year since the incorporation of the firm	+
7	Advertisement Intensity	ADVINT	Expenditure on advertisement as a percentage of sales turnover	+

8	Outward Investment	OFDI	= 1 if the firm has invested abroad = 0 otherwise	?

Notes: RDINT in Probit Model, RDCINT in Tobit Model.* Sales are deflated using 1993 base year prices.

4.2 Methodology

Study employs the framework of Probit and Tobit models to examine the probability and intensity of investment in R&D. Data on both R&D incurring and non R&D incurring firms are used for the model. Since the estimated coefficients of Tobit and Probit model are not the marginal effects of the explanatory variables marginal effects are also calculated and reported. In case of Tobit model, marginal effects are decomposed following Moffit and Mc Donald (1980).

4.2.1 Probit Model

Probit model explains the probability of undertaking R&D activity taking into account the host of firm specific factors. The dependent variable in the case of Probit model is binary type, i.e.,0,1 type depending upon whether the firm spends on R&D or not.

$$RDINT^{*}_{it} = \alpha + \beta_1 SIZE_{it} + \beta_2 SIZE^2_{it} + \beta_3 EXPINT_{it} + \beta_4 IMPCINT_{it} + \beta_5 IMPRPINT_{it} + \beta_6 PBDIT_{it} + \beta_7 AGE_{it} + \beta_8 ADVINT_{it} + \beta_9 OFDI_{it} + \mu_{it}$$

$$RDINT = 1 \quad \text{if} \quad RDINT^* > 0, \text{ and}$$
$$= 0 \quad \text{otherwise} \ldots\ldots\ldots (1)$$

Where the subscript i stands for particular observation, RDINT* is the latent variable and RDINT is a binary variable that takes the value 1 whenever RDINT* is greater than zero else RDINT* is zero.

Probit analysis, does not provide explanation for the intensity to undertake R&D activity hence, Tobit model is employed.

4.2.2 Tobit model

Tobit model explains the intensity of R&D activity where large number of firms reports no R&D activity. Moreover, in such cases where the information on the regressand is not

available for some observation, the coefficients obtained using the OLS technique is biased towards the censoring point (zero in the current study). Tobit estimation is employed in numerous studies dealing with censored data. In addition it has been argued that the maximum likelihood estimation (MLE) based Tobit model could take care of the problems associated with the censored data (Green, 2000; Wooldridge, 2002). Statistically, the functional form of Tobit model could be expressed as

$$RDCINT^{*}_{it} = \alpha + \beta_1 SIZE_{it} + \beta_2 SIZE2_{it} + \beta_3 EXPINT_{it} + \beta_4 IMPCINT_{it} + \beta_5 IMPRPINT_{it} + \beta_6 PBDIT_{it} + \beta_7 AGE_{it} + \beta_8 ADVINT_{it} + \beta_9 OFDI_{it} + \mu_{it}$$

5. Data Source and Descriptive Statistics

The study uses firm level data, PROWESS, provided by the centre for monitoring Indian economy (CMIE) for a period of 16 years from 1990 to 2005[9]. A number of truncation rules are followed to arrive at the final data set for empirical analysis. First, those firms which report zero sales or negative net value added is deleted from the initial data set. Second, study includes only those firms which reported continuous data for at least four years. The sample includes those firms which produce Bulk drug, Formulation or both on the basis of the end product classification. FDI firms are considered as those firms which have foreign promoters share greater than or equal to 10%.[10] The sample firms include an average of 154 domestic and 18 foreign firms. Table 2 gives the distribution of firms and R&D intensive firms over the years.

Table 3: Distribution of Firms

Year	Sample firms	Number of R&D Incurring firms	Domestic firms	Foreign firms	R&D Incurring Foreign firms	Domestic firms Incurring R&D
1990	77	5	63	14	2	3
1991	82	10	68	14	2	8
1992	86	19	72	14	3	16

[9] PROWESS provides Annual Report Data for nearly 5000 manufacturing firms listed in the Bombay Stock Exchange. Of these 5000 firms, 338 firms belong to Pharmaceutical sector.

[10] This is based on the RBI definition of foreign firms.

1993	107	42	92	15	10	32
1994	146	56	129	17	8	48
1995	191	69	173	18	9	60
1996	209	77	189	20	12	65
1997	191	83	171	20	12	71
1998	200	80	181	19	13	67
1999	209	84	189	20	13	71
2000	215	86	194	21	11	75
2001	215	86	193	22	14	72
2002	208	98	185	23	15	83
2003	226	97	205	21	14	83
2004	223	109	201	22	15	94
2005*	183	99	165	18	14	85

Note: * - Data is till March 2005

Table 4 giving the descriptive statistics over the entire sample indicates that the mean R&D intensity of the sample firms is nearly 0.6 with a maximum R&D spending of around 50% of sales. The sample firms are fairly experienced with the mean age being approximately 23 years. The mean expenditure for advertisement intensity is 0.9% with a maximum advertising expenditure of 45% of sales turnover. The sample includes 100% export oriented firms as well as those cater to the domestic market only. It is evident that import of technology in the form of machinery and equipment is the favorite means of obtaining technology compared to disembodied technology imports.

Table 4 Summary Statistics (Full sample)

	Variable	Mean	Std. Dev.	Min	Max
1	**SIZE**	1.02	1.97	0.00	24.96
2	**RDCINT**	0.60	2.51	0.00	50.00
3	**EXPINT**	14.81	22.06	0.00	100.00
4	**IMPCINT**	0.57	3.89	0.00	100.00
5	**IMPRPINT**	0.08	0.83	0.00	34.26
6	**PBDIT**	8.62	90.38	-390.00	660.00
7	**AGE**	22.62	19.29	1.00	104.00
8	**ADVINT**	0.95	2.49	0.00	45.10

Note: Number of observations 2766.

Given the objective of present study, table 5 compares the two groups of firms with respect to a number of indicators. From the table it is clear that on an average, foreign

firms are larger than the domestic firms. Further, foreign firms are more profitable[11] than local firms. The significance test for difference in mean indicate that the average age of foreign firms is higher than that of domestic firms, pointing that foreign firms have more experience and might have accumulated more knowledge.

Table 5: Comparison between the two groups – Domestic vs. Foreign firms and R&D expenditure incurring and non-incurring firms

Variables	Mean			
	Domestic	**Foreign**	**R&D Incurring firms**	**Non R&D Incurring firms**
SIZE	0.88* (1.83)	2.22* (2.56)	1.92* (2.67)	.43* (1.89)
RDCINT	0.59 (2.43)	0.68 (3.07)	4.16 (17.26)	-
EXPINT	15.34* (22.36)	10.39* (18.84)	19.64* (23.4)	11.61* (20.51)
IMPCINT	0.54 (3.45)	0.82 (6.50)	.92 (4.59)	.33 (3.32)
IMPRPINT	0.04* (0.48)	0.34* (2.10)	.08 (.32)	.07 (1.03)
PBDIT	8.17* (95.55)	12.40* (13.84)	13.46* (16.21)	-2.12* (43.03)
AGE	20.92* (18.26)	36.65* (21.72)	30.08* (21.07)	17.69* (16.24)
ADVINT	0.92* (2.59)	1.18* (1.48)	2.03* (8.14)	1.76* (4.48)

Notes: Std. dev. in parenthesis; * indicates difference in the mean is statistically significant at 5% level based on the t-test with unequal variances. Total number of foreign (FDI) observations = 298. Total number of observations with firms incurring R&D expenditure = 243. Total number of observation for column 3 and 4 = 2766 (includes all the firms)

Columns 3 and 4 show the significant difference in the mean of firm size for R&D incurring and non R&D incurring firms. In addition, the export performance of R&D incurring firms is significantly better than that of the non R&D firms. This implies that firms incurring R&D expenditure tends to be more outward oriented. Again, R&D firms are better in terms of experience and profitability. However there is no systematic difference between R&D and non R&D firms in terms of import of technology (both embodied and disembodied technology).

[11] Here one should note that the number of foreign firms in the sample is comparatively less than that of the domestic ones and those foreign firms which entered the market during the liberalization period might have faced even a small gestation period to reap returns.

6. Results and Interpretation

6.1 Explanation for Probability of undertaking R&D

Table 6 gives the results for the probit estimations for each group separately. The variable (Size) indicating the size of the firm and its quadratic term (SIZE2) turns out significant with positive and negative coefficient. This indicates an inverted 'U' shaped relationship between the firm size and the probability to undertake R&D activity (holds both for domestic as well as foreign firms). This indicates that the firm size has a positive influence on the decision of the firm to undertake R&D to a threshold limit and then starts decreasing. One striking difference between the results of domestic and foreign firms R&D activity is its relationship between exports.

Table 6: Probit Results (Domestic Vs Foreign Firms)

Variables	Domestic Firms		Domestic Vs Foreign Firms	Foreign Firms	
	Coefficient	**Marginal effects**		**Coefficient**	**Marginal effects**
SIZE	0.613*** (0.055)	0.232		0.340*** (0.107)	0.124
$SIZE^2$	-0.025*** (0.003)	-0.010		-0.024*** (0.008)	-0.009
EXPINT	0.012*** (0.001)	0.005		0.006 (0.004)	0.002
IMPCINT	0.012* (0.007)	0.005		0.432** (0.204)	0.157
IMPRPINT	0.071 (0.063)	0.027		-0.179 (0.125)	-0.065
PBDIT	0.001* (0.001)	0.000		0.014** (0.007)	0.005
AGE	0.013*** (0.002)	0.005		0.031*** (0.007)	0.011
ADVINT	0.033*** (0.011)	0.012		0.088 (0.067)	0.032
OFDI	-0.328*** (0.097)	-0.118		–	–
_cons	-1.216 (0.053)			-1.819 (0.238)	
Wald chi2(9)	336.130			117.520	
Prob > chi2	0.000			0.000	
Log pseudo-likelihood	-1303.937			-133.730	
Pseudo R2	0.203			0.346	
Number of obs	**2468**			**298**	

Notes: *Indicates significance at 10% level;** significance at 5%, ***significance at 1%; [a]marginal effects are for the discrete change of the dummy variable from 0 to 1

The coefficient of export intensity turns out positive and significant in the case of domestic firms (for foreign firms the results are insignificant). Further, domestic firms which foray into foreign markets through outward investment have less probability of undertaking R&D in the home country, especially if they try to locate their R & D units in those foreign locations. The firms which internationalise into the foreign markets can mobilize resources for R&D in the host country. Further, Outward direct investment provides additional advantages like location, internationalization, ownership and access to the capital markets to mobilize resources for innovation. Import of technology in the form of capital goods import appears to be the preferred means of technology acquisition by domestic as well as foreign firms. The positive sign of variable (IMPCINT) indicates a complementary relationship between import of technology and the decision of the firm to invest in R&D. Profit, age of the firm and advertisement intensity also determines the probability of under taking R&D by domestic firms. This is in contrast with the findings reported by Basant and Fikkert (1996) in the case of Indian manufacturing industry.

Table 7: Tobit Results (Domestic Vs Foreign Firms)

Variables	Domestic Firms		Domestic Vs Foreign Firms	Foreign Firms	
	Coef.	Marginal effects		Coef.	Marginal effects
SIZE	1.121*** (0.117)	1.121		0.305*** (0.085)	0.305
$SIZE^2$	-0.045*** (0.007)	-0.045		-0.022*** (0.007)	-0.022
EXPINT	0.043*** (0.005)	0.043		0.007 (0.005)	0.007
IMPCINT	0.012 (0.031)	0.012		0.473*** (0.010)	0.473
IMPRPINT	0.286 (0.210)	0.286		-0.008 (0.060)	-0.008
PBDIT	0.004 (0.004)	0.004		0.017** (0.007)	0.017
AGE	0.034*** (0.006)	0.034		0.012** (0.004)	0.012
ADVINT	0.082*** (0.040)	0.082		0.092 (0.052)	0.092
OFDI	-0.097 (0.325)	-0.097		-	-

_cons	-4.752 (0.242)			-1.458 (0.221)	
Wald chi2(9)	369.040			488.930	
Prob > chi2	0.000			0.000	
Log pseudo-likelihood	-3302.250			-315.910	
Pseudo R2	0.053			0.436	
Number of obs	**2468**			**298**	

Notes: *Indicates significance at 10% level;** significance at 5%, ***significance at 1%; [a]marginal effects are for the discrete change of the dummy variable from 0 to 1.

6.2 Explanation for R&D intensity

The Tobit results indicate that firm size of the Domestic as well as foreign firms exerts non liner relationship with R&D intensity. Kumar and Saquib (1996) reported similar results in the case of Indian manufacturing industry. Like the Probit results the coefficient of import of capital goods (IMPCINT) intensity has a positive sign in the case of foreign firms. This indicate that the R&D intensity of the foreign firms depend on the imported technology and shows the complementarity between import of technology and R&D intensity. Comparing with the Probit results (Table 6), coefficient of variables indicating rate of profit, capital good import intensity and outward investment is insignificant in the Tobit results which represents R&D intensity (Domestic firms). In the case of foreign firms the Probit and Tobit results turned out similar.

Also, purely domestic firms with higher exports intensity, who have been in business for a longer period and introduce product differentiation, are likely to be spending more on R & D than their counterparts. In the case of FDI firms, imports of capital machinery [embodied technology], and age of the firm turned out significant in explaining R & D intensity. This implies that FDI firms are using imported capital goods for technology acquisition, and in order to cater to the local demand conditions are using their R & D to complement the import of technology. Moreover, older FDI firms are spending more on R & D than their younger counterparts. Higher profit margins are also driving the R & D intensity of foreign firms in this sector in India.

7. Summary and conclusion

The present study attempts to examine the determinants of R&D in the Indian Pharmaceutical industry. Many studies have already been conducted to identify the

determinants of innovative efforts in the Indian manufacturing. This study tries to overcome the short coming of the previous studies by analyzing the determinants of R&D for both domestic and the foreign firms. Study employs the firm level data obtained from PROWESS database for a period from 1991-2005 to examine the determinants of R&D. An unbalanced panel has been constructed with an average of 154 domestic and 18 foreign firms. The sample includes firms which undertake R&D as well as non-R&D firms. Since there are significant differences in the determinants of probability of undertaking R&D and R&D intensity, study employed Probit and Tobit model to distinguish between the two.

Descriptive statistics reveals that the R&D intensity of domestic firms is greater than that of the foreign firms. In addition to this, there is also significant difference in the means of import of technology, export intensity, profit, age and advertisement intensity between domestic and foreign firms. On average foreign firms are older than the domestic firms. Domestic firms are more export intensive compared to the foreign firms. Hence, the comparisons of several indicators indicate notable difference in the performance of the domestic and foreign firms.

Probit results indicate that firm size, exports, import of technology, age of the firm and rate of profit determines the probability of undertaking R&D. Like earlier studies the relationship between firm size and probability of undertaking R&D is inverted 'U' shaped. This indicates a non- linear relationship between decision to spend on R&D and firm size, implying that both very small and very large firms are unlikely to spend more on R & D. It is the medium sized firms, to gain higher market share, and explore avenues in international markets which are likely to be more active in doing R & D. Exports and outward investment influence the decision of the domestic firms to invest in R&D. Further, it is noted that accumulated knowledge and experience of the domestic firms also influence the decision of the firms to invest in domestic R&D. In the case of foreign firms, the determinant of probability of undertaking R&D slightly varies from the domestic firms. Firm size, exports intensity, import of capital good intensity and age of the firm influence the R&D decision of foreign firms. Like the domestic firms that foreign firms also depend on the imported technology in the form of capital goods import to undertake R&D in the host country.

Tobit model estimates the relationship between determinants of R&D and R&D intensity. In the case of domestic firms' firm size, export intensity, age and advertisement intensity turned significant determinant of R&D intensity. Similar to the Probit, the relationship between firms size and R&D intensity is inverted 'U shaped'. Pradhan (2006) estimated the threshold R&D intensity for firms in the pharmaceutical sector and reported the presence of firms with very low R&D intensity in the sector. He concluded that firms in the Indian pharmaceutical industry have not yet reached the threshold level of R&D intensity. Since majority of observation in our sample belongs to small firm size, it may be applicable to the present study also. Comparing Probit and Tobit results in the case of domestic firms it is evident that import of technology and profit determines the probability of undertaking but does not influence R&D intensity. In the case of foreign firm Tobit result remain similar to the Probit, where, firm size, import of capital goods intensity, age of the firm and rate of profit determines R&D intensity.

The findings of the study have several implications for R&D, technology and FDI related policies in the pharmaceutical sector. The results indicate that the import of technology complements R&D activity in the sector. Hence, concessions can be provided to those units which import technology for undertaking R&D. Appropriate incentives can also enhance the export and outward orientation of R&D intensive domestic firms in the sector. Since domestic firms are more R&D intensive compared to FDI firms separate policies can be devised to foster innovative activities of the domestic firms.

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