# R&D Intensity and Exports: A study of Indian Pharmaceutical Firms

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## 1. New Patent Regime, Growth, R&D and Exports

Prior to 1970, the Indian pharmaceuticals industry was relatively small in terms of production capacity. At the time of Independence in 1947, India's pharmaceuticals market was dominated by MNCs (multinational corporations) which controlled between 80 and 90 percent of the market primarily through imports (Greene, 2007). The scene changed radically with the Patent Act of 1970. Product specific patents were disregarded in favor of manufacturing process patents, which allowed Indian companies to reverse engineer or copy foreign patented drugs without paying a licensing fee. This policy initiative created a favorable environment for the domestic industry to grow and acquire technical competence. At the same time, domestic drug prices were set at very low levels under the provision of Drug Price Control Orders of 1970 and 1979. Simultaneously high import tariffs were imposed. The changed policy regime helped domestic industry to grow rapidly. The market share of MNCs declined from 68 percent in 1970 to only 23 percent in 2004 (Chaudhuri, 2005, p. 18, Table 2.2). The value of total production of bulk drugs and formulations rose from Rs. 4900 mn in 1974-75 to Rs. 14,400 mn in 1980-81 and further to Rs. 354,710 mn in 2003-04 (at current prices) due to the entry of many domestic firms along with a massive increase in the production by the older firms (Chaudhuri, 2005, p.40).

The growth rates in the value of production of bulk drugs and formulations (at constant prices) in the period 1970-71 to 1979-80 were about 14 and 17 percent per annum respectively (Jha, 2007). In the subsequent period 1980-81 to 1994-95, the growth rates were in the range of 6 to 7 percent

per annum (Jha, 2007). *Annual Survey of Industries* (Central Statistical Office, Government of India) data for the period 1970-71 to 1994-95 indicate that the average growth rate in the deflated value of output of the Indian pharmaceuticals industry was about 11 percent per annum in this period.

From 1995 began the process of establishing a new patent regime in India. Also, the price controls were substantially relaxed. At one stage there were serious concerns regarding the possible serious adverse effect that the new regime might have on Indian pharmaceuticals industry. However, there is now a wide recognition that the Indian pharmaceuticals industry has adopted strategies to meet the challenges of the new patent regime and has been successful at that. India has emerged a major supplier of cheap and quality supplier of generics in the regulated markets. The level of R&D activity in the Indian pharmaceutical firms has considerably increased and this has shown up in the application for patents in India. The Indian firms have been acquiring manufacturing facilities abroad. The firms have entered into various types in alliances. There are firms that are engaged in contract manufacturing; there are others involved in contract research and product development and in clinical trials.[1]

Despite the drastic change in the patent regime, making it a stricter regime than before, the growth of output of the domestic pharmaceutical firms continued beyond 1995. Between 1995-96 and 2004-05, the average rate of growth of deflated sales of Indian pharmaceutical firms[2] was about four percent. In the subsequent period beginning 2005, when the new patent regime became fully effective, the growth rate significantly accelerated. The growth rate in deflated sales of pharmaceutical firms in the period 2005-06 to 2010-11 was high at about 13 percent per annum.

As mentioned above, in the new patent regime, there has been a substantial increase in the R&D efforts of domestic pharmaceutical firms. The research activities have certainly increased and

[1] There has been a good deal of research on the developments in the Indian pharmaceuticals industry in the period since 1995, dealing particularly on the question how the industry has responded to the challenges of the new patent regime and on the issue of access to medicine (see Dhar and Gopakumar, 2006; FICCI, 2005; Goldar and Gupta, 2010; Gopakumar, 2010; Grace, 2004; Greene, 2007; Jha, 2007; Kiran and Mishra, 2009; Sampath, 2008; etc.).

[2] The reference here, as also later in the paper, is to the corporate sector firms. The corporate sector firms dominate in the total value of production of the pharmaceuticals industry.

large firms have started undertaking R&D after 1995 on a much larger scale not only for developing non-infringing processes and new formulations of existing and new drugs but also to develop new molecules. The ratio of R&D expenditure to sales has increased from about two percent in 1996-97 to about six percent in 2008-09 (Goldar and Gupta, 2010). This hike in R&D efforts has led to increases in number of patent applications and patents granted. The number of applications for patents made in India in the area of drugs and medicines increased from 211 in 1990-91 to 2211 in 2005-06 (Goldar and Gupta, 2010). The increase in the number of patents granted was from 87 in 1990-91 to 457 in 2005-06 (Goldar and Gupta, 2010). Similarly, there has been an increase in the number patent applications in the area of pharmaceuticals filed by the pharmaceutical firms in India and the CSIR with the US Patent and Trademark Office (USPTO). It increased from 13 in 1996 to 130 in 2008 (Goldar and Gupta, 2010). Also, there has been an increase in global patent filing by leading Indian pharmaceutical firms, from 33 in 1999 to 492 in 2005 (Dhar and Gopakumar, 2006, p.45).

Another interesting development in the period since 1995 is the marked increase in the export intensity of pharmaceutical companies. Taking together all corporate sector pharmaceutical firms, the ratio of exports to sales has increased from about 18 percent in 1996-97 to about 39 percent in 2008-09 (Goldar and Gupta, 2010). To take up some specific cases, the export intensity of Cipla Ltd. increased from about 10 percent in 1995 to about 42 percent in 2004, and that of Lupin Ltd increased from 0.2 percent in 1997 to about 47 percent in 2004 (Dhar and Gopakumar, 2006, p. 34).

A recent major development in the Indian pharmaceuticals industry is the acquisition of leading Indian firms by multinational companies. Some the acquisitions that have taken place in recent years include: Matrix lab acquired by Mylan Inc, Dabur Pharma acquired by Fresenuis Kabi, Ranbaxy acquired by Daiichi Sankyo, Santha Biotech acquired by Sanofi Aventis, Orchid Chemicals acquired by Hospira, and Piramal Healthcare's generic medicine unit acquired by US based Abbott Laboratories. With these acquisitions, the market share of multinational firms has substantially increased (by about 10 percentage points) between 2003 and 2010. The market domination of the multinational companies had eroded after 1970 because of the change in patent

policy along with other policy changes introduced. It seems that the foreign drug-makers are poised to regain to some extent their position in the Indian market.

## 2. Study objective, hypotheses and models

The main objective of this study is to examine the relationship between R&D activities in Indian pharmaceutical firms and their export performance. Since both R&D intensity and export intensity have increased significantly in the Indian pharmaceuticals industry after 1995, it would be reasonable to hypothesize that it is the R&D efforts made by Indian pharmaceutical firms that have caused improvement in their export competitiveness and hence led to increased exports.[3] This hypothesis is put to test by applying econometric models.

Some earlier studies on the Indian pharmaceuticals industry have come up with empirical evidence that suggests a positive relationship between technology and export performance among Indian pharmaceuticals firms. For instance, based on her econometric analysis, Aggarwal (2004) found R&D to be a major determinant of exports among Indian pharmaceutical firms. Similarly, a significant positive correlation between change in R&D and change in exports (both normalized by sales) among Indian pharmaceutical firms has been found in the study of Goldar and Gupta (2010). Chadha (2009) studied the product cycle and neo-technology theories of trade in the context of exports of generic pharmaceuticals from India. The study covered 131 pharmaceutical firms for the period 1989-2004. An econometric model was estimated explaining inter-firm and inter-temporal variations in exports. The results showed that technology proxied by the acquisition of foreign patents has a favorable effect on exports.

[3] Sampath (2008) observes that R&D investments in India's pharmaceuticals sector can broadly be split up into generics-related R&D and proprietary R&D for drug discovery research. The generics R&D is geared towards creating drug master files (DMFs) that are required to get approval in the US market for the sale of active pharmaceutical ingredients and to submit Abbreviated New Drug Applications (ANDAs) that are a pre-requisite to receive market approval for generic drugs. Such approvals are needed also for other regulated markets. Some of the companies that have been leading in terms of approval received by Indian firms include Dr Reddy's Laboratories, Cipla Ltd, Max laboratories Ltd, Aurobindo Pharma Ltd, and Ranbaxy Laboratories Ltd (see Dhar and Gopakumar, 2006).

The novelty of this paper is that it brings into analysis the issue of firm heterogeneity causing firms to self-select themselves into the export market. A body of literature has emerged on the link between firm heterogeneity and exports (see Malitz, 2003; Bernard et al., 2003; Melitz and Ottaviano, 2008; and a literature survey paper by Greenaway and Kneller, 2007). The main point emerging from this literature is that firms differ in productivity, and a more productive firm is more likely to self-select itself into the export market.[4]

Given that the productivity level has an influence on the propensity of a firm to enter the export market, it may be inferred that the impact of R&D intensity on the export performance of a firm will depend on the firm's level of productivity. If the firm is close to the technology frontier as reflected in its relatively high level of productivity, R&D would have a greater impact on its export performance as compared to a firm that is much below the technology frontier and thus has a low level of productivity. This is the second hypothesis put to empirical testing in this paper is respect of pharmaceutical firms in India.

Two models are used for the econometric analysis. In the first model, export intensity is taken as the dependent variable and R&D intensity, separately and in interaction with productivity, is taken an explanatory variable. Certain other characteristics of the firms are included among the explanatory variables. Thus, the model may be written as:

$$XI = f(RD, RD*TE, Z) \quad \ldots(1)$$

where XI denotes export intensity, RD denotes R&D intensity, TE denotes technical efficiency (closeness to technology frontier or the level of productivity vis-à-vis other firms) and Z is a vector of other explanatory variables, representing firm characteristics. The effect of RD on XI

[4] Goldar and Kato (2009) have studied the export performance of Indian firms and have found empirical evidence that indicates that productivity of firms determines how import competition will impact the export intensity of firms. They conclude that while increased import competition is expected to raise the export intensity of high productivity firms, it may not have an effect or may have an adverse effect on the export intensity of low productivity firms. It should be mentioned here that there are several studies which have found evidence of self-selection of firms to export market based on their level of productivity. For Indian firms, such findings have been reported by Pattnayak and Thangavelu (2009) and Thomas and Naraynan (2012), among others.

depends on the coefficient of RD and that of the interaction term involving RD and TE. It is hypothesized that a higher level of technical efficiency (i.e. the firm is closer to the technology frontier) will raise the effect of RD on XI. Thus, the coefficient of the interaction term of RD and TE is expected to be positive.

The equation described above has first been estimated by the OLS (Ordinary Least Squares) method after introducing year dummies to allow the intercept to vary over time. The equation has then been estimated by the Tobit model with year dummies. Since export intensity is zero in a significant proportion of observations, the Tobit model has an advantage over the simple regression model estimated by the OLS method. This has been followed by the estimation of a Tobit random effects model, which has the advantage that the influence of firm-specific factors on export performance gets incorporated into the model, which is missing the simple Tobit and OLS models. In this case, the time-invariant variables have been dropped from the equation, since the influences of these factors are picked up by the firm effects.

The second model used for the analysis is directed at explaining firm entry into the export market. For this purpose, the Cox proportional hazard model has been applied. The Cox proportional hazards model may be written as:

$$h(t|x_j) = h_0(t).\exp(x_j\beta) \quad \ldots(2)$$

In this equation, $h_0(t)$ is the baseline hazard function, which is not estimated. It is assumed that the covariates $x_{j,}$ where j is the subscript for firm j, shift the baseline hazard function. The covariates for this model are taken to be the same as in the model described above. These include R&D intensity, technical efficiency and other firm characteristics. The parameters β are to be estimated from the data. It should be pointed out that survival is interpreted as the time for which the firm has not entered the export market. Failure is interpreted as entry into the export market. To separate out the marginal exporters from significant exporters, a cut-off level of one percent is used. In other words, only if the exports to sales ratio of a firm exceeds one percent, the firm is assessed to have entered the export market.

## 3. Data, variables and preliminary analysis

### 3.1 Data

The basic data for the analysis have been taken from *Capitaline* (see www.capitaline.com). Data for the period 1999-00 to 2010-11 are used for the analysis. In the *Capitaline* data-source, pharmaceutical companies have been divided into five groups: (1) Bulk drugs manufacturing domestic firms; (2) Bulk drugs and formulations manufacturing domestic firms (large); (3) Bulk drugs and formulations manufacturing domestic firms (medium and small); (4) Formulations manufacturing domestic firms; and (5) Multinational firms. Data could be obtained for about 180 to 230 firms for different years in the period under study. This is an unbalanced panel and the firms included in the dataset vary from year to year. For about 30 percent of the firms, data are available for all 12 years. On the other hand, for another 30 percent of the firms, data are available for four years or less.

The information on the group to which each firm belongs has been used for constructing two dummy variables: one for the bulk drug manufacturers (i.e. group 1 above) and the other for multinational firms (group 5 above). As described later in the paper, these two groups differ from the other firms in terms of export intensity. The bulk drug manufacturers have relatively high export intensity while multinational firms have relatively low export intensity. It was important therefore to incorporate this aspect into the econometric analysis with the help of dummy variables.

### 3.2 Variables

From the *Capitaline* database, data on sales, production cost, exports, imports, R&D expenditure, invested capital, year of incorporation, foreign equity proportion, etc for the pharmaceutical firms have been drawn (for the period 1999-00 to 2010-11). Using these data, the following variables have been constructed for the econometric analysis:

**Export intensity**: Ratio of exports to sales;

**R&D intensity**: Total expenditure on R&D as a ratio to sales;

**Technology import intensity**: Expenditure on royalty and technical fees paid in foreign exchange as a ratio to sales;

**Age of machinery**: A proxy formed by the ratio of cumulative depreciation to the gross value of fixed assets;

**Bulk drug producer firm (dummy):** dummy variable taking value one for firms engaged in the production of bulk drugs (not producing formulations) and zero otherwise; and

**Multinational firm (dummy):** dummy variable taking value one for multinational pharmaceutical firms and zero otherwise.

In addition to the variables listed above, the following variables have been constructed for the econometric analysis:

**Foreign equity participation:** The share of foreign equity out of the total equity of the firm forms this variable. There is difficulty in getting this information for each year under study. Thus, for each firm, the share of foreign equity has been computed for the latest year for which data are available, and then the ratio has been applied for all other years.

**Post-1995 firm (dummy)**: This is a dummy variable which takes value one if the firm was incorporates in 1995 or later. It takes value zero for firms that were incorporate before 1995. The firms which were set up after the new patent regime had been introduced may have a different orientation than those set up in the previous patent regime. It is to incorporate this aspect into the analysis that the dummy variable has been constructed.

**Technical efficiency:** To estimate technical efficiency, a Cobb-Douglas stochastic frontier production function has been estimated. Since panel data are used for the estimation of production function, year dummies have been introduced in the estimation of the production function allowing the intercept to change over time. Sales deflated by the wholesale price index for drugs and medicine have been taken as the measure of output. Labour cost has been converted into a measure of labour input by divided it by the wage rate. Emoluments per employee in the drugs and pharmaceuticals industry has been computed from data available in the *Annual Survey of Industries*, and this has been used to convert labour cost reported by firms into a measure of labour input. Expenditure incurred on power and fuel has been deflated by a

price index of energy to obtain a measure of energy input. Wholesale price indices for coal, oil and electricity have been combined to form a price index of energy for the drugs and pharmaceuticals industry. The weights used are based on the relative magnitude of these inputs as given in the Input-Output table for 2003-04. In a similar manner a price index for materials inputs has been formed. The reported cost of materials has been deflated by this price index to get a measure of materials input. Gross value of fixed assets deflated by the wholesale price index for machinery has been taken as the measure of capital input. When materials input was included in the estimated frontier production function, the estimates of technical efficiency showed very little variation across firms. Therefore, in the model finally applied, labour, capital and energy have been taken as three inputs, and real sales has been taken as a measure of output.

The estimate of frontier production function and the estimates of technical efficiency of firms obtained therefrom have some limitations. First, a blanket deflation procedure has been used for capital input which is inferior to the perpetual inventory method of constructing capital series. Secondly, the exclusion of materials input from the production function introduces a bias in the parameter estimate. But, it is hoped that the conclusions of the study do not get affected by these inadequacies of technical efficiency estimates. Perhaps, even if more accurate estimates of technical efficiency were used, the results of the econometric analysis would not have been much different.

### 3.3 Preliminary Analysis

Figure 1 shows the average export intensity of firms that ranked low in terms of R&D intensity, compared to the export intensity of firms that ranked high in terms of R&D intensity. The former group includes firms in which R&D to sales ratio was less than one percent. The latter group includes firms in which the ratio in question was more than five percent. It is seen from the graph that the firms which have spent relatively more on R&D are also the ones which have directed a greater portion of the sales to export markets.

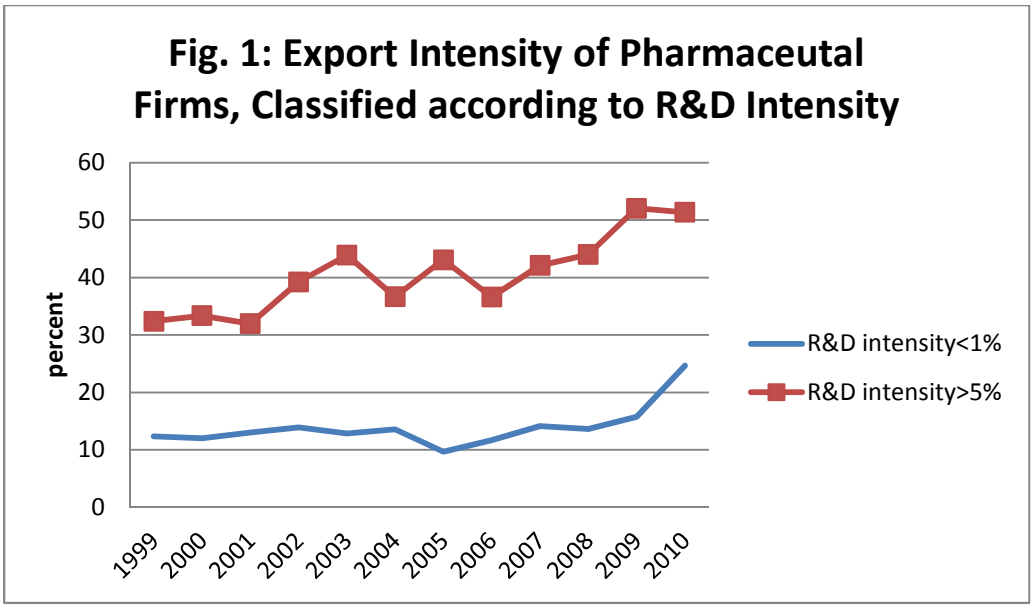



Figure 2 shows average export intensity of firms, classified into four categories: firms engaged in the production of bulk drugs, firms engaged in the production of bulk drugs and formulations, firms engaged in the production of formulations only, and firms set up in India by multinational companies. It is evident that average export intensity is the highest for the first group and lowest for the last group. Also, it is interesting to observe that the average export intensity of bulk drug manufacturers has increase over time, whereas that for MNCs had a slight fall.

Let us consider now the distribution of pharmaceutical firms according to the proportion of output they export. In 1999, about 10 percent of the pharmaceutical firms directed more than 50% of their sales to export markets. This proportion rose to about 20 percent of firms in 2010 (Figure 3). On the other hand, the proportion of firms that exported less than one percent of their output (including those that do not export at all) has gone down between 1999 and 2010. The proportion was a little over 40 percent in 1999. It came down to a little over 30 percent in2010.

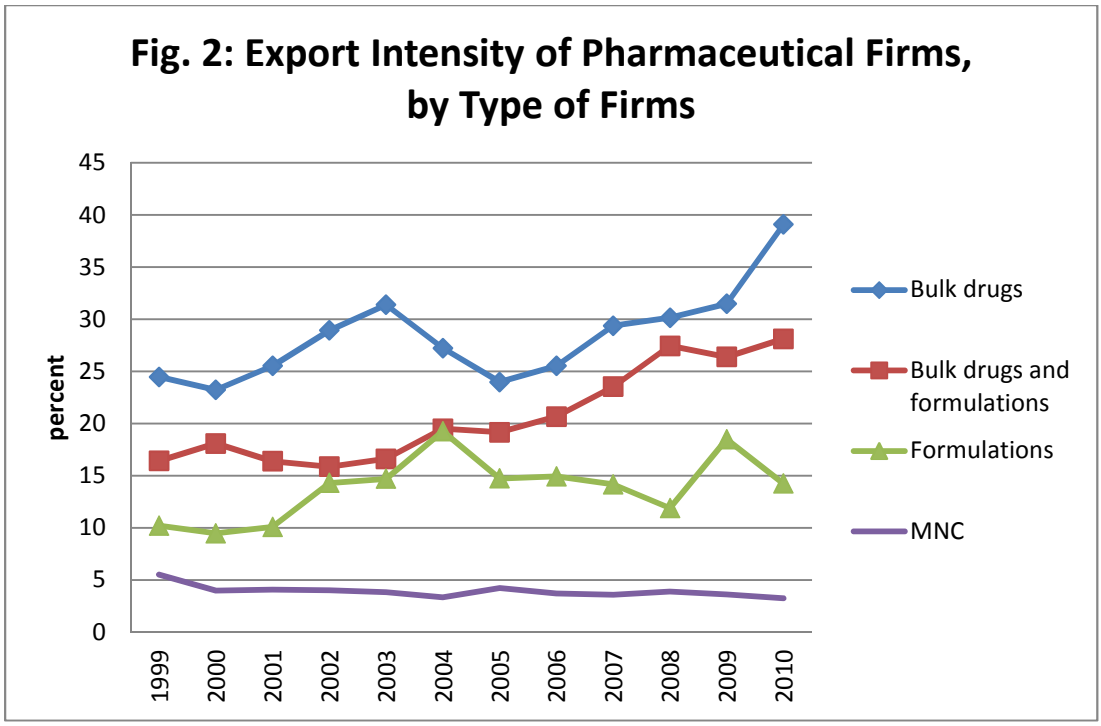


Fig. 2: Export Intensity of Pharmaceutical Firms, by Type of Firms
percent
45
40
35
30
25
20
15
10
5
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Bulk drugs
Bulk drugs and formulations
Formulations
MNC

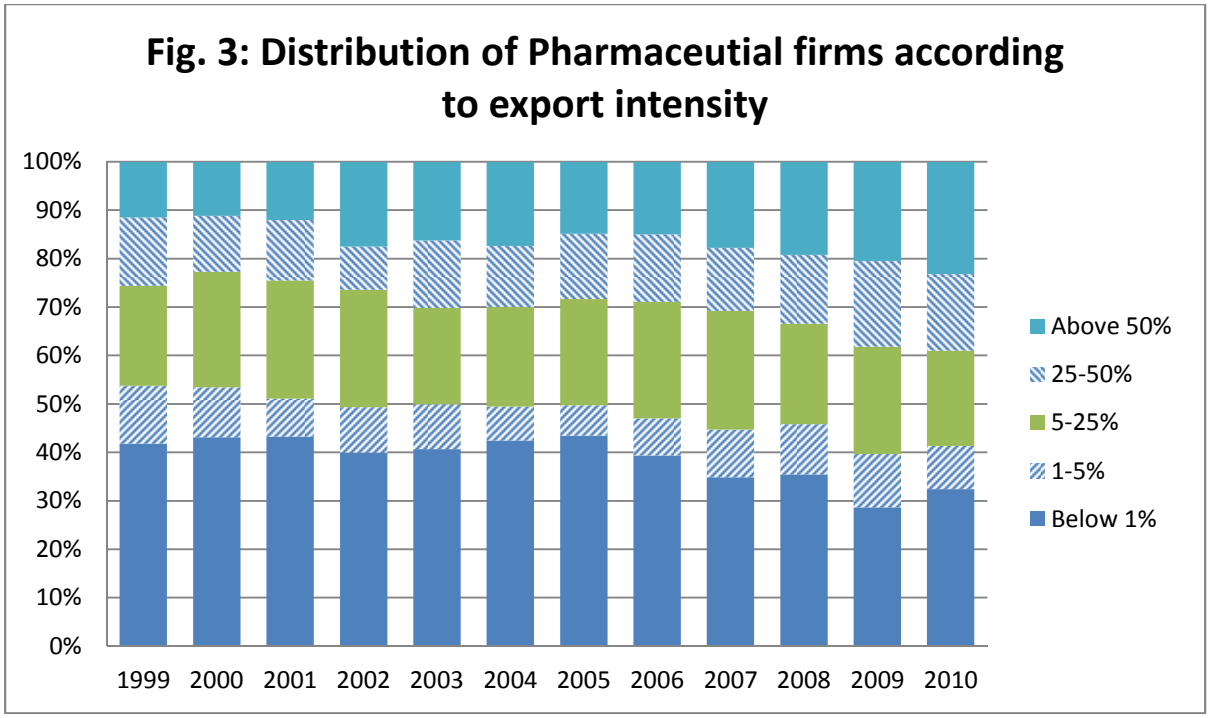
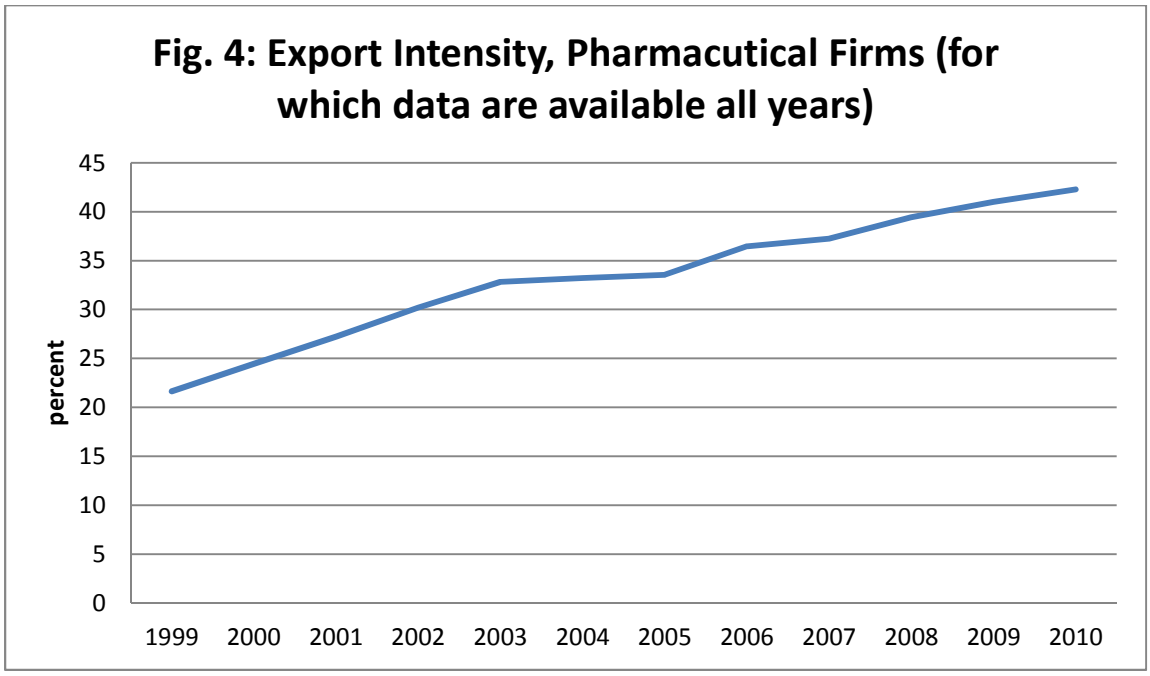


Fig. 3: Distribution of Pharmaceutial firms according to export intensity
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Above 50%
25-50%
5-25%
1-5%
Below 1%

Data on sales and exports obtained for the pharmaceutical firms reveal that export intensity increased from about 19 percent in 1999 to about 41 percent in 2010. Since the computed export intensity is affected by the entry and exit of firms, it is would be useful to examine the export intensity of firms for which data could be found for all 12 years under study. The export intensity computed for these firms is shown in Figure 4. The export intensity of this group of firms increased from about 22 percent in 1999 to about 42 percent in2010. Within this group, about 18 percent firms exported more than 50 percent of their output in 1999. This proportion rose to 26 percent of firms in 2010.




**4. Results of Econometric Analysis**

The results of the regression analysis are presented in Table 1. As mentioned earlier, the data used for regression analysis relate to the period 1999-00 to 2010-11. Data for 319 firms are used. For only about 30 percent of the firms, data are available for the full period under study. This explains why the number of observations is 2273 when the number of firms considered is 319 and the period covered is 12 years.

The interaction term between R&D and technical efficiency has a positive and statistically significant coefficient in all four regressions. This support the hypothesis that R&D has a positive effect on export intensity and the effect goes up as the level of productivity of firm increases.

**Table 1: Regression Results, Model Explaining Export Intensity of Pharmaceutical Firms (No. of observations= 2273, No. of firms=319, Period 1999-00 to 2010-11)**

| **Explanatory variable** | **OLS** | **Tobit** | **Tobit –random effects** | **Tobit –random effects** |
|---|---|---|---|---|
| R&D intensity | -0.083 (-0.29) | 0.333 (0.85) | -0.595(-2.04)** | -- |
| R&D intensity * technical efficiency | 1.646 (3.40)*** | 1.258 (1.89)* | 1.233(2.53)** | 0.329 (2.39)** |
| Technology import intensity | 0.819 (2.22)** | 1.065(2.24)** | 0.916(2.30)** | 0.894 (2.29)** |
| Firm size | 0.030 (10.39)*** | 0.066 (15.48)*** | 0.050(13.09)*** | 0.050 (12.54)*** |
| Incorporated in or after 1995 (dummy) | -0.063(-3.95)*** | -0.128 (-5.58)*** | -- | -- |
| Firm engaged in the production of bulk drugs (dummy) | 0.090 (8.08)*** | 0.129 (8.50)*** | -- | -- |
| Multinational firm (dummy) | -0.179(-7.74)*** | -0.202 (-6.52)*** | -- | -- |
| Age of machinery | -0.062(-2.00)** | -0.116 (-2.66)*** | -0.177(-3.33)*** | -0.179 (-3.25)*** |
| Foreign equity proportion | 0.300 (5.21)*** | 0.211 (2.76)*** | -- | -- |
| Year effects | Yes | Yes | Yes | Yes |
| Firm effects | No | No | Yes | Yes |
| R-squared | 0.21 | | | |
| Pseudo R-squared | | 0.30 | | |
| LR (chi-squared) | | 679.6 (d.f.=20) | | |
| Wald chi-squared | | | 296.5 (d.f.=16) | 360.3 (d.f.=15) |

Turning to other firm characteristics included in the model as explanatory variables, a significant positive effect of firm size on export intensity is indicated by the regression results. A significant positive effect is found also for foreign equity participation and technology import intensity. The age of machinery variable has a significant negative coefficient, which indicates that *ceteris*

*paribus* a firm with relatively old plant and machinery would have lower export orientation. Such a relationship between export intensity and age of plant and machinery is expected. Interestingly, the results seem to suggest that a firm incorporated in the period since 1995 have lower export intensity than a firm incorporated earlier. To check the robustness of this result, the cut-off date has been changed and the regressions re-estimated. When the cut-off is changed to 1997 or to 2000, the coefficient remains negative but becomes statistically insignificant. Hence, not much importance should be assigned to the finding of a significant negative coefficient for this variable. But, there is evidence to suggest that after controlling for other factors, the firms which were set up after the new patent regime was introduced were not more export oriented than those set up during 1970-1994.

The dummy variable for bulk drugs manufacturers has a significant positive coefficient while the dummy variable for multinational firms has a significant negative coefficient. This is consistent with the pattern observed in Figure 2. The results suggest that while multinational pharmaceutical firms operating in India are not interested in exporting their products from India, the domestic firms with foreign equity participation are more export oriented than the domestic firm not having foreign equity participation.

The results of the Cox proportional hazard model are presented in Table 2. The results are by and large similar to those in Table 1. The results suggest that the probability of entering export market goes up with firm size. The probability is relatively higher for bulk drug producers and relatively lower for multinational firms as compared to other categories of pharmaceutical firms. These findings are in agreement with the results reported in Table 1. For technology import intensity and foreign equity participation, no significant effect is found in the Cox proportional hazard model. This is at variance with the results reported in Table 1. This might mean that technology imports and foreign equity participation do not have a strong impact on the firms' decision to enter the export market, but once a firm has entered the export market, these factors significantly influence the level of export intensity the firm is like to reach.

**Table 2: Estimates of the Cox Proportional Hazard Model, Indian Pharmaceutical Firms**

| **Explanatory variable** | **Model-1** | | **Model-2** | | **Model-3** | |
|---|---|---|---|---|---|---|
| | Hazard ratio | z-value | Hazard ratio | z-value | Hazard ratio | z-value |
| R&D intensity | 31.586* | 1.64 | | | 4.188*** | 3.22 |
| R&D intensity * technical efficiency | 0.034 | -0.98 | 8.248*** | 2.73 | | |
| Technology import intensity | 0.326 | -0.18 | 0.280 | -0.20 | 0.021 | -0.64 |
| Firm size | 1.195*** | 8.76 | 1.187*** | 8.67 | 1.204*** | 10.03 |
| Incorporated in or after 1995 (dummy) | 0.709*** | -3.03 | 0.700*** | -3.14 | 0.729*** | -2.91 |
| Firm engaged in the production of bulk drugs (dummy) | 1.203*** | 2.81 | 1.202*** | 2.80 | 1.216*** | 3.04 |
| Multinational firm (dummy) | 0.715** | -2.44 | 0.725** | -2.34 | 0.635*** | -3.53 |
| Age of machinery | 0.647** | -2.12 | 0.632** | -2.24 | 1.036 | 1.01 |
| Foreign equity proportion | 0.997 | -0.85 | 0.997 | -0.86 | 0.998 | -0.73 |
| LR (chi-squared) | 157.2 (d.f.=9) | | 155.0 (d.f.=8) | | 169.9 (d.f.=8) | |

From the results of Cox proportional hazard model obtained, it appears that a higher level of R&D intensity tends to raise the probability of entering the export market. The interaction variable between R&D intensity and technical efficiency is also found to a have significant positive effect on the probability of entering export market. This is consistent with the regression results reported in Table 1, and lend support to the hypothesis that R&D efforts enhance export competitiveness, and the effect is greater for the firms that are closer to the technology frontier.

## 5. Conclusion

The export intensity of Indian pharmaceutical firms has increased substantially in the period after 1995 when the new, more restrictive patent regime was introduced in India. The hike in export intensity has been accompanied by an increase in R&D intensity of Indian pharmaceutical firms. The results of the analysis presented in the paper provide support to the hypothesis that increased R&D efforts of pharmaceutical firms was one of the important factors responsible for the observed increase in export intensity.

A second hypothesis put to econometric test is that the impact of R&D on exports depends on the level of productivity already reached by the firm. To put it differently, if a firm is close to the technology frontier, its R&D efforts will have a greater impact on its export competitiveness in comparison with a firm which is much below the technology frontier as reflected in its low level of productivity or technical efficiency. The econometric results presented in the paper provide support to this hypothesis.

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