

The New IPR Regime and Indian Drug and Pharmaceutical Industry: An Empirical Analysis.

by

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The drugs and pharmaceutical industry in India has evolved through various phases over the past five decades or so. The first was the period prior to 1970, when the industry was relatively small in terms of production capacities. The second phase spanned the late 1970s to the early 1990s, a period during which the industry experienced policy-induced growth. In its third phase, during the 1990s through the new millennium, much of the regulatory structure that the Government had imposed during the previous two decades was dismantled. The third phase has been significant for India in terms of the changes in policy orientation directed at its economy. From the relatively inward looking policies in place till the end of the 1980s, the policy regime adopted in 1991 sought to break down the walls of protection behind which Indian industry had developed in the past. The biggest challenge for Indian industry posed by the new patent regime arose from the need to adopt measures that would improve its competitive strength due to globalised nature of the markets. To survive and grow in the increasingly competitive yet opportunity abundant market, a thrust on research and development became imperative.

The present study focuses on the performance of the drugs and pharmaceutical (D&P) industry, a sector that has been able to meet the challenges posed by the new policy regime with some degree of success. The success that this industry experienced in the 1990s was, however, built on a foundation that was laid in the 1970s. During this phase, the Government provided a facilitating policy environment to the industry, which was defined through a mix of instruments. The prime objective of the policy framework was to develop a viable domestic industry with adequate participation of Indian entrepreneurs. A key instrument for the realization of this objective was the policy aimed at building up the technological sinews of the industry. The performance of the industry during this deregulated regime from 1995 to 2006 is dealt with in the current paper. While the next section discusses the nexus between R&D expenditure and the growth performance of the D&P industry, the third section specifies the model to evaluate the performance of the industry particularly in the light of the patent, research and development expenditure and marketing strategy of the firms in the industry. The result of the empirical model is discussed in the fourth section and the paper concludes in the final section.

Section I: Growth performance and R&D expenditure of Indian Drug and Pharmaceutical industry

Under the regime of WTO, the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) is the most comprehensive treaty on IPR particularly aimed at strongly protecting knowledge intensive products and technologies from piracy and more so in drugs and pharmaceutical sector where R&D is highly investment intensive without any certainty of the returns. Rampant piracy in this sector was further found to be dampening R&D investment and activities. The TRIPS, for that matter, provides the needed protection and exclusive rights to commercially use the invention/innovation for a maximum period of twenty years and is perceived to be encouraging the firms in the industry to allocate more resources towards the R&D. Though India inherited her Patent and Design Act from her colonial past, a comprehensive Act on Patent was reintroduced in 1970, which exempted certain areas viz., food, chemicals, pharmaceuticals, and agro-chemicals from the product patent. **Exempted from paying for licenses and royalties, Indian companies could now access the newest molecules from across the globe and reformulate them for sale in the domestic and foreign (wherever accessible) markets at a fraction of the price charged by the inventing multinational firms. This led to an unprecedented growth of the Indian drug and pharmaceutical industry moving away from being a marginal player till 1970s to the one meeting almost 95% of India's pharmaceutical requirements by 2007.** The Indian firms (mostly public sector firms) had a less than 20% share of the market in 70s which by 2007 rose over 75%. Currently, the Indian drug and pharmaceutical industry is valued at approximately \$ 8.0 billion. Globally, the Indian industry ranks 4th in terms of volume and 13th in terms of value. Indian pharmaceuticals industry has over 20,000 units with around 260 constituting the organized sector, while others exist in the small scale sector. The prime strength of Indian pharmaceutical industry lies in manufacturing low-cost generics of the off-patented drugs and its major exports belong to the anti-infectives segment. The notable change in the stature of the Indian pharmaceutical industry is also highlighted by Table 1.

Table 1: Indian Pharmaceutical Industry: Growth Indicators (Rs.Millions)

	1965-66	1980-81	1990-91	1995-96	2000-01	2004-05
Capital Investment	1,400.0	5,000.0	N.A.	13,000.00	29,000.00	52,530.00
Production:	1680	14,400.0	45,700.0	10,9,470.0	2,28,870.0	4,09,800.0
Formulation	1,500	12,000.0	38,400.0	91,250.0	1,83,540.0	3,19,460.0
Bulk Drugs	180	2,400.0	7,300.0	18,220.0	45,330.0	90,340.0
Trade:						
Export*	30.5	463.80	7,848.0	31,777.0	82,224.0	1,66,810.0
Import**	82.0	1,125.40	6,040.0	24,050.0	37,880.0	56,300.0

R&D Expenditure	80	147.5	600.0	1,600.00	3,700.00	10,800.0
R&D as a % of Capital Investment	5.7	2.95		12.30	12.76	20.55

Note : figures do not include production from unorganized sector, which is estimated at an additional 35% of the production.

* Includes export of only bulk drugs and formulations.

**Includes Bulk Drugs, Formulations, Intermediates, Chemicals, Solvents & Others

N.A. : Not Available

Source : Bulk Drug Manufacturers Association of India.

The exports, destined to around over 150 countries including highly regulated markets of US, Europe, Japan and Australia, comprise almost 40% of the total production of pharmaceuticals in India of which formulations (processing of bulk drugs into finished dosage forms such as tablets, capsules, injections, ointments, etc.) contribute nearly 55% and the rest 45% comes from bulk drugs (Active Pharmaceutical Ingredient or API). The share of bulk drugs in total pharmaceutical exports has almost doubled from since 1985-86 precisely because with the expiry of patents on many drugs in the late 1980s, several Indian companies started filing drug master files (DMFs) to get approvals for their manufacturing facilities in the US and other international markets. While the share of bulk drugs has risen in exports, there is a fall in its share in total pharmaceutical imports (Jha 2007). India had moved from a position of net importer to that of net exporter in 1981-82, and started earning regular trade surpluses since 1987-88 (Nauriyal 2006). During this period, the Indian pharmaceutical industry has registered tremendous progress in terms of infrastructure development, technology base creation and a wide range of production. The Table 1 also reveals that in the mid sixties the R&D expenditure of the industry was merely eighty million rupees, a meagre 5.7 percent of the total capital investment of the industry. Unfortunately, it further declined to 2.95 percent during 1980-81, even though the industry kept growing during the same period. However, development of R&D base and acquisition of research capabilities later on helped them to move up the R&D value chain. As revealed by the production data from Table 1, the production of the industry during the same period went up from Rs. 1,680 million to Rs.14,400 million, almost eight and half times. This unprecedented growth can primarily be attributed to the exemption from the product patent granted to this industry. It has certainly facilitated the industry to quickly replicate and effectively market a drug soon after it was introduced by a multinationals abroad. Therefore, with such a small amount of investment in R&D, Indian firms were able to sell any drug at a price much lower than the price charged by their counterparts elsewhere. However, since 1995-96 the R&D expenditure of the industry as a percentage of total capital investment is on the rising trend (in 1995-96 it was 12.30 percent which went up to 20.55 percent in 2004-05. Such a change in the perception of the industry towards the R&D expenditure can be ascribed

to the provision of the TRIPS which had put an obligation on India to revert back to the product patent. This has resulted in a dramatic change in the structure and orientation of R&D activities, moving beyond the development of new processes for manufacturing to R&D for new chemical entities (NCEs) and modifications of existing chemical entities to develop new formulations and compositions. This implied that the Indian drug and pharmaceutical industry could no longer enjoy the freedom to reverse engineer the drugs developed and marketed abroad. The industry also made rapid strides in the domestic and foreign markets to such an extent that the growth rate of pharmaceutical exports outweighed the growth rate of overall merchandise exports. The import requirement for the bulk and formulations, on the other hand, kept receding constantly. Table 2 highlights relevant information in this regard.

Table 2: Compound Annual Growth rates (CAGR) of Pharmaceutical related and overall foreign trade of India (in percent)

Period	Pharmaceutic al Exports	Overall Merchandise Exports	Pharmaceutical Imports	Overall Merchandise Imports
1070-71 to 1980-81	26.43	17.85	15.63	22.23
1981-82 to 1994-95	26.48	17.89	18.92	13.70
1995-96 to 2005-06	20.50	14.10	12.38	14.88

Note: CAGRs have been calculated from semi-log regression model.

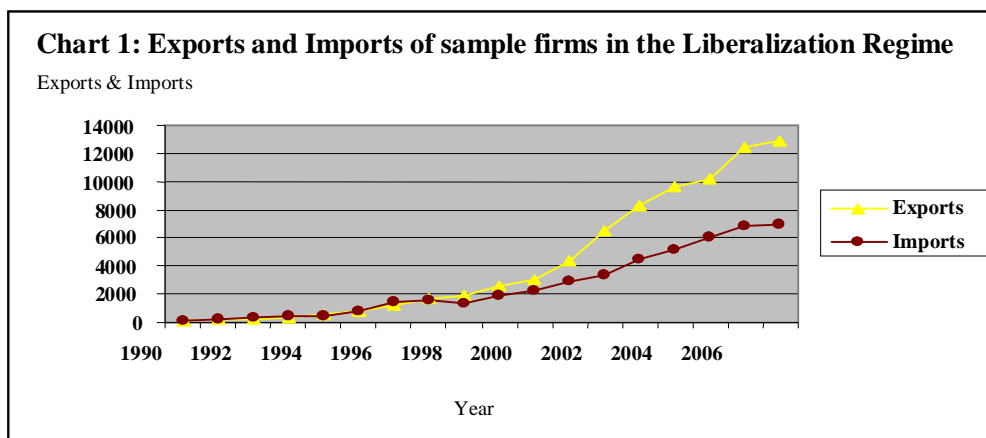
Source: Calculated from RBI's Foreign Trade Data

India has amended this Patent Act, 1970 several times, but final amendment came in March 2005 with retrospective effect from Jan, 1, 2005 (due to TRIPS obligations) that made Product patent law of the land and with that came an effective legal backing to the original inventors/innovators. This amendment made it difficult for Indian pharmaceutical firms to market the illegally reproduced products extremely difficult. In the international market, they were already facing considerable number of legal suits from the multinationals for exporting the illegally replicated products. The changed international business environment and the new provisions of the law made it imperative for the firms to undertake their own in-house R&D. It may be noted here that hitherto, 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 of the processes, besides research on formulations and known drug delivery systems. This certainly further strengthened India's R&D forte in synthetic organic chemistry and process development. In the aftermath of TRIPS, a few new drugs, using conventional screening techniques, have emerged from the Indian R&D, but none of them have been blockbusters. It may be noted that the pharmaceutical industry in India is the most research intensive industry having the highest R&D-sales

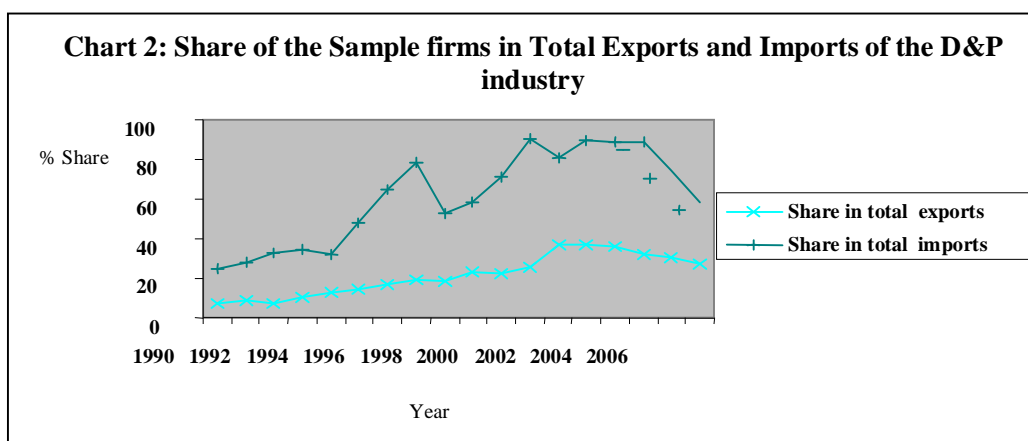
ratio (Aggarwal 2004). It is against this background that this paper attempts to explore empirically the proximate determinants of the performances of the firms in the Drugs and Pharmaceutical industry.

Section II: Sample Selection

The firms that are part of this sample have been selected from the top sixty Indian drug and pharmaceutical firms, judged by their net turnover, and exclude largely the subsidiaries of multinationals. Since the availability of the patent data was most problematic as only five out of a sample of sixty, responded to the persistent queries from the authors, the patent data for sample firms were obtained from the database of Indian, US and EU patent offices. It may be further noted that the patenting is still an area in India where only the resource rich firms venture into; therefore, the sample was narrowed down to thirty-six firms for whom the patent data were available. These firms have performed exceedingly well in the external sector in the new liberal regime. As could be judged from Chart 1, the exports and imports of these firms witnessed a phenomenal growth during 1990-91 to 2006-07. On the other hand, even though the share of these firms in the total exports and imports of the industry has some periodic fluctuations, the trend is in the upward direction (Chart 2). This justifies the dominance of these sample firms in the D&P industry.

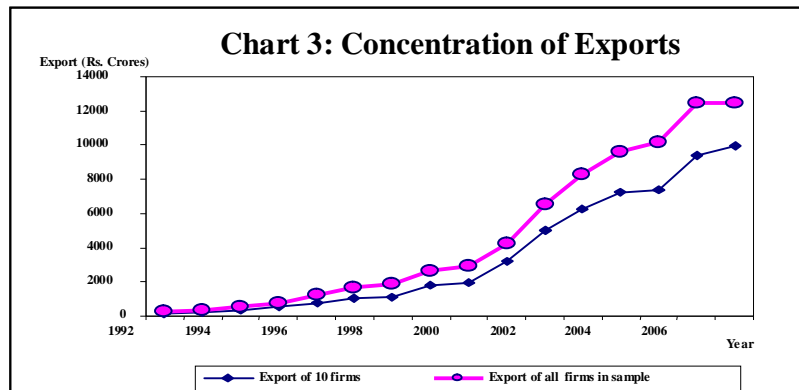


Source: Based upon the CMIE Prowess Database 2008

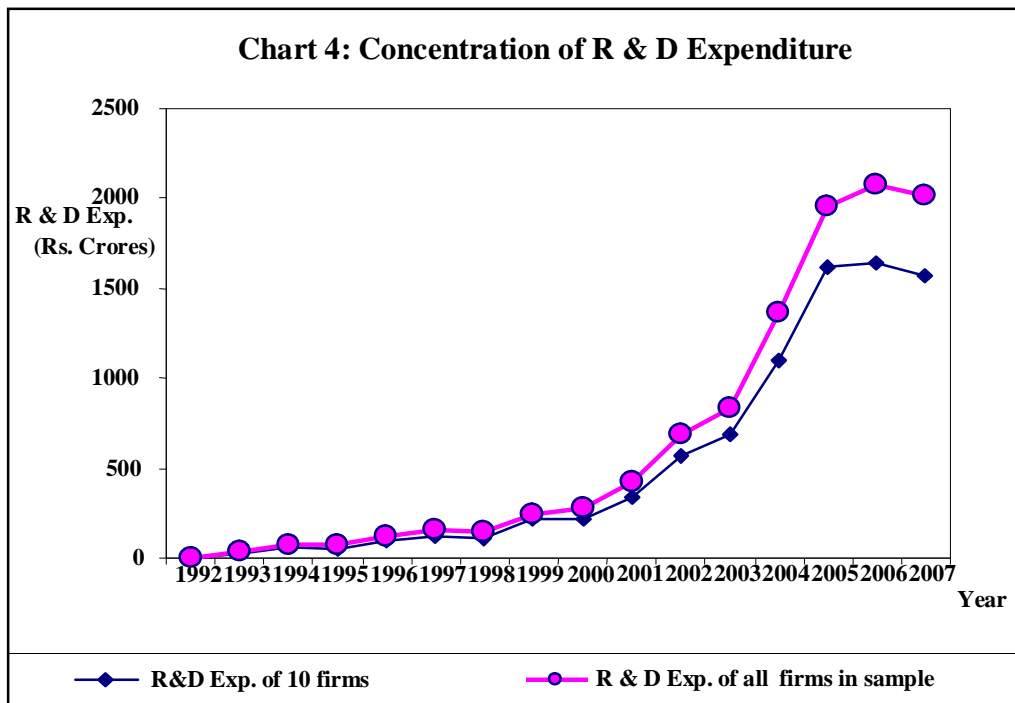


Source: Based upon the CMIE Prowess Database 2008

As can be seen from the Table 2 in the Appendix, thirteen, five and four firms, which constitute almost 63% of the sample, were found to be exporting over 50%, 40%, and 29% of their production. If the export of fine chemicals is excluded, then the share of all the sample firms put together in the total drug and pharmaceutical exports of India is well over 50%. It may, however, be noted that most of the Indian exporters operate in the commodity generics market, where entry barriers and prices are low with only a few such as Ranbaxy, DRL, Sun Pharmaceuticals, Cipla etc are targeting value added generics by challenging patents and developing non-infringing processes. They are also amongst the first ones to enter the generics market. They, at the same time, are amongst the prominent firms which are facing increasing barrage of law- suits in US and Europe for two reasons: First, their proactive role in challenging patents in order to be amongst the first ones to enter the generics market (Chaudhury 2005). Second, they themselves are being challenged by their rivals for infringing the patent rights. Since exports denote exposure of the firms to international competition, it may be interesting to find out if firms exporting more, also spend more on R&D. The data pertaining to sample firms, taken for this study, show that among the top ten Exporters viz., Ranbaxy, DRL, Cipla, Aurobindo, Lupin, Orchid, Matrix, Sun, Biocon, Ipca (sharing almost 80% of the exports by the sample firms as shown in Chart 3) and top R&D spenders viz., Ranbaxy, DRL, Sun, Cipla, Cadila, Lupin, Wockhaardt, Torrent, Nicholas, Panacea Boitech (sharing over 81% of the R&D expenditure incurred by sample firms as shown in Chart 4) there are only four firms viz., Ranbaxy, DRL, Cipla, Lupin common to both.



Source: Based upon the CMIE Prowess Database 2008



Source: Based upon the CMIE Prowess Database 2008

A perusal of Table 3 in the Appendix brings to the fore that in the early nineties, especially until 1996, there was almost marginal investment in R&D with some firms such as Ranbaxy, DRL, Lupin, Cipla, IPCA etc investing, on an average, around 2% of their sales revenue on R&D. It was only after 1996 that firms started pouring in a larger proportion of their sales revenue in R&D. By 2006, seven Indian firms viz., Sun Pharmaceuticals, Torrent, Wockhardt, Ranbaxy, USV, DRL and Panacea were investing over 10% of their net sales revenue in R&D, while nine firms were found to have invested over 5% of their net sales revenue in R&D. This is a significant departure from the past where investment in R&D

was insignificant and was fundamentally undertaken for the purpose of reverse engineering the latest patented drugs. The subsidiaries of major multinationals have, by and large, been excluded from the sample for the reason that the patents that they had filed for protection in Indian have largely originated from their US and Europe-based parents and that there is not much of the R&D originating from their Indian subsidiaries. This can be seen from the fact that except for Pfizer (3%) and Astrazeneca (Almost 1%), the ratio of R&D expenditure to sales revenue was even less than 0.4% for Abbott, Glaxosmithkline, Merck, and Novartis in 2006 as compared to Sun, Torrent, Wockhardt, Ranbaxy, DRL, Panacea and Cadila which spent over 10% of their sales revenue on R&D. In fact, the combined R&D expenditure of these six major multinationals was just 7.5% of what Ranbaxy spent on R&D in 2006. It may, however, be noted that as compared to global majors which are spending between 13-19% of their much sales turnover on R&D, Indian companies invest far less though they are increasingly devoting more resources and reorienting their strategy on R&D in order to improve their R&D output (Nauriyal 2006).

It may be further pointed out that there is a heavy concentration of R&D around 16 firms which share well over 90% of the total R&D expenditure incurred by all the sample firms taken for the purpose of this study. Table 3 sums up the relevant information in this regard.

Table 3: R & D Expenditure of the sample firms

Year	R&D Exp. of sample firms (Rs. Crores)	R&D Exp. of top 16 firms in the sample (Rs. Crores)	Share of top 16 R&D spenders amongst the sample firms	Annual Growth rate of R&D expenditure of sample firms	Annual Growth rate of R&D expenditure of top 16 spenders
1995	76.55	56.08	73.26	-	-
1996	124.29	99.23	79.84	62.36	76.94
1997	157.63	130.2	82.60	26.82	31.21
1998	144.45	118.87	82.29	-8.36	-8.70
1999	238.69	219.74	92.06	65.24	84.86
2000	274.69	258.89	94.25	15.08	17.82
2001	423.26	389.39	92.00	54.09	50.41
2002	686.58	627.28	91.36	62.21	61.09
2003	839.21	785.48	93.60	22.23	25.22
2004	1359.3	1281.12	94.25	61.97	63.10
2005	1952.67	1833.41	93.89	43.65	43.11
2006	2077.05	1968.6	94.78	6.37	7.37
2007	2012.06	1906.97	94.78	-3.13	-3.13

Source: CMIE Prowess Data and the Annual Reports of the Companies

Section III: The Econometric Model

Economic literature on the impact of R&D and knowledge created thereof on the growth is not scanty. There are theoretical postulations and empirical evidences to support that knowledge helps to create wealth and enhances the economic well being of a nation. Knowledge spill over and Research and Development (R&D) as the determinants of growth was first postulated by Arrow (1962) and Sheshinski (1967). In these models, each person's discoveries immediately spill over to the entire economy, an instantaneous diffusion process that might be technically feasible because knowledge is non-rival. Romer (1986) showed later that the competitive framework can be retained in this case to determine an equilibrium rate of technological advance, but the resulting growth rate would typically not be Pareto optimal. More generally, the competitive framework breaks down if discoveries depend in part on purposive R&D effort and if an individual's innovations spread only gradually to other producers. The incorporation of R&D theories and imperfect competition into the growth framework began with Romer (1987, 1990) and includes significant contributions by Aghion and Howitt (1992) and Grossman and Helpman (1991). In these models, technological advance results from purposive R&D activity, and this activity is rewarded by some form of *ex-post* monopoly power. If there is no tendency for the economy to run out of ideas, then the growth rate can remain positive in the long run, so is the case for a particular firm/industry. The rate of growth and the underlying amount of inventive activity tend, however, not to be Pareto optimal because of distortions related to the creation of the new goods and methods of production. In these frameworks, the long-term growth rate depends on governmental actions, such as taxation, maintenance of law and order, provision of infrastructure services, protection of Intellectual Property Rights (IPR) and regulations of international trade, financial markets and other aspects of the economy. Logically, such models put greater stress on the policy decisions of the government to manoeuvre the performance of the economy or a part there of.

As mentioned earlier, assigning patent (in lieu of the IPR) to a firm in the industry would push the market more towards monopoly than competition. However, this could be truer of the industry where technological obsolescence is fast and there is not much of a market for the basic products (in this case 'generic) which in this case constitutes over 80% of the medicine sales in the market. **In such a situation, the objective of the firm does not stick to mere maximization of profit. Other objectives like maximization of Revenue and/or Sales by penetrating newer markets and segments may dominate the Profit maximizing objective of the firm especially in a market which is getting global and increasingly competitive especially in the generic segments. Besides this, the firms in the industry may also decide in favour of aggressive marketing strategy in the form of higher marketing as well as advertisement**

expenditures. Such steps by the firms may raise the market share of firm at the cost of higher expenditure. Thus, cost reduction that has been one of the traditional objectives of the firms no more remains valid, rather sales revenue maximization prevail over the cost minimization objective. It may also be noted that due to global competitive pressures in the generic drugs markets and steeply escalating costs of R&D, firms are seeking mergers and acquisitions so as to have better access to the innovated technology and hitherto inaccessible markets largely of developed countries due to stringent safety requirements. The prime objective of such moves in the international and domestic markets could be to ensure sales maximization of which cost minimisation could be only one of the considerations. Thus, the pertinent objective function of the firm can be specified as:

$R = R(X, Y, \varepsilon) \dots (1)$ ¹, where R stands for the Total Sales Revenue of the firm, X is the vector of variables those are expected to raise R, Y is the vector of variables expected to drag the total revenue of the firm down and ε is the random error term that counts for any unobservable elements. Thus the coefficients of X are expected to bear a positive sign and the coefficients of Y are assumed to have negative signs. We can combine both the vectors to one (say Z) and consider Z as the vector of variables, which determine the revenue of the firm. Since, the primary objective here is to unearth the impact of IPR (Patent), R&D expenditure and the marketing strategy of the firm on the performance (as measured by revenue maximization) of the firm, vector Z would consist of the following variables²:

Total Patents achieved by the firm (TP): Patent granted may lead to increased revenue from the commercial use and licensing and may induce the firm to maintain a dynamic innovation system. It is, in fact, the uncertainty in revenue (in the absence of patents owned by the firm in a market setting that is highly competitive), that the firms are forced to undertake R&D in the hope that increased R&D and therefore, patenting may help to first stabilize and then increase the revenue (Pindyck, 1991; Dixit, 1992; Dixit, and Pindyck 1994; Dirk Czarnitzki and Andrew A. Toole, 2006). The R&D products and their licensing generate revenue. Therefore, it may be pertinent to hypothesize that the patenting activities affect revenue. In the long run, however, revenue generation may also affect the flow of funds to R&D activities, thereby, impacting patent intensities of the firm. This as an explanatory variable can be taken care of by including all the notified patents, regardless whether they were already granted or

¹ Here a general function is preferred over a specific function like C-D, CES and Trans-Log, as this would make the functional relationship between the dependent variable and independent variables quite open. However, for the estimation purpose, the specific function is stated afterwards.

² The inclusion of the variables in Z vector should be drawn from the existing theoretical as well as empirical literature and additional variables those are potentially the determinants of firm activities are also included in the empirical analysis

still pending plus disputed patents. As a passing reference, it may also be mentioned that while patents facilitates the preservation of exclusivity (thus reducing the effect of market uncertainty on the firm's investment decision), performance benchmarking and licensing revenues, it is also done for strategic reasons such as blocking cumulative innovation, defensive patenting and patents being used as bargaining chips (providing access to its own technology as well as obtain access to the technology of others) (Bekkers, Rudy and Joel West, 2006; Scotchmer, Suzanne, 199; Scotchmer, Suzanne, 2004). Thus, the effective patent will be measured as:

TP= All the notified patents (regardless whether they were already granted or still pending).

This variable is expected to have positive coefficient implying thereby: higher the total number of patents more is the revenue to the firm as it enables the firm to monopolize in more products/product versions. This variable is expected to capture the impact of patent act and hence IPR protection on revenue maximization of the firm. However, it may be noted that rise in the number of applications for patent protection also signifies patent intensity or increasing thrust of the company on the R&D although there could be other motives too. Given that Indian drug and pharmaceutical firms started undertaking serious R&D only after 1995, as displayed by Table 1 in the Appendix, when TRIPS was signed and it became impossible to escape the patent protection regime, this period of 10 to 12 years since 1995 is not adequate enough to discover, develop and market new drugs for the low base they started from and the necessity of devoting more resources and time to undertake serious R&D. Therefore, not much is expected to achieve just by resorting only to the patent granted especially when none of the patents granted to Indian pharmaceutical firms emerged as blockbuster. It may be further noted that most of the patents taken by Indian drug and pharmaceutical companies are in the bulk drug area and not in the formulations. That's why the companies who do have substantial marketing stake in the bulk drug market have gone overboard for patenting while other players which are essentially in the formulation production have not preferred that route. During 2000-06, there has been two-fold rise in the number of patents filed by the Indian drug and pharmaceutical industry as is revealed by Table 4.

Table 4: Share of sample firms in the total patents filed by Drug and Pharmaceutical Industry

Year	Patents filed by sample firms	Patents filed by the Drug and Pharmaceutical Industry	Share of sample firms in the total patents filed by Drug and Pharmaceutical Industry in (%)
2000	134	1000	13.40
2001	322	883	36.47

2002	583	879	66.33
2003	907	966	93.89
2004	1319	2525	52.24
2005	1302	2316	56.22
2006	1248	2211	56.45

Source: 1. Annual Reports of the Office of Controller General of Patents, Designs, Trade Marks and Geographical Indications for various years, and
2. www.patinfo.nic.in.

This is the reason for larger share of bigger Indian companies (as per the total turnover) in the total patents filed, as is evident from the following Table 5.

Table 5: Share of top ten firms (in terms of turnover in 2007) in the total number of patents published for all sample firms: 1990-2007

Year	Patents published for top 10 firms	Patents published by all the sample firms	Share of top 10 firms in the total patents published for all sample firms
1990	7	15	46.67
1991	13	13	100
1992	5	5	100
1993	3	14	21.43
1994	6	25	24.00
1995	7	82	8.54
1996	14	24	58.33
1997	28	97	28.87
1998	59	81	72.84
1999	41	59	69.49
2000	90	135	66.67
2001	201	323	62.23
2002	387	591	65.48
2003	699	911	76.73
2004	1021	1322	77.23
2005	1016	1302	78.03
2006	904	1253	72.15
2007	562	810	69.38

Note: Top Ten firms - Ranbaxy, DRL, Cipla, Lupin, Aurobindo, Sun, Nicholas Piramal, Cadila, Wockhardt, Ipca

Source: 1. Annual Reports of the Office of Controller General of Patents, Designs, Trade Marks and Geographical Indications for various years, and
2. www.patinfo.nic.in.

At international level too, the distribution of patent values has been found to be highly skewed, with only a small fraction of patents holding significant commercial value being owned by only few firms (Griliches, Zvi, 1990; Harhoff, Dietmar, Frederic M. Scherer and Katrin Vopel, 2003). Such a heavy concentration of patent among few firms can probably be attributed to the dependence of propensity to

invest in R&D on the resource base of the firm. Thus, it is pertinent here to explore the impact of R&D expenditure of the firm on its performance.

Research and Development Expenditure of the firm (RD): This would include expenditure of the firm on addition to or creation of R&D infrastructure and the wages and salaries of scientists and engineers, who create ideally profitable new knowledge (This knowledge is specialized, sunk and intangible, and its value, hence, may be difficult to determine). This variable is expected to bear positive coefficient for the reason that it may help the firm to move up the value chain by investing in improved/new products, which in turn might create a niche market/ strong brand loyalty. However, no linear relationship between the R&D Expenditure and innovations/inventions can be presumed priori for the reason that a firm, with relatively smaller R&D expenditure, could prove to be far more productive if it is able to zero-in on a right molecule at the right time. Similarly, in this industry a firm can invest a good sum of capital on imitating and adapting the drugs that are going off-patent soon rather than discovering a new drug. Thus R&D activity may not always result in acquisition of patents for putting a novel method/product into commercial use but could result in the replication of products viz., generic drugs, already in the market- – high degree of competence which Indian pharmaceutical firms have acquired and substantially further developed during the pre-TRIPS period. This is further corroborated by the fact that while Indian pharmaceutical firms have filed maximum DMFs and ANDAs in the US, there is a virtual dearth of NDA filings (Grace 2004). Yet this cannot be generalised for all the Indian pharmaceutical firms as the larger Indian firms such as Ranbaxy, DRL, Cipla etc are focusing on new chemical entities (NCE), the proprietary drugs, new drug delivery systems and developing NCEs. At present, the R&D activities of the Indian drug and pharmaceutical industry centre around: Novel Drug Delivery System (NDDS), Contrast media API and Formulations, Import Substitution, Quality Improvement, Process Improvement and Cost Reduction, Development of API and Intermediates, and Contract Research and Manufacturing Services (CRAMS). The contract manufacturing comprising Contract Manufacturing for Patented Drugs, Custom Synthesis & Scale Ups, Specialized Generics and Old Generics/ Old Molecules are being undertaken by even by large players such as Dishman, Divi's Laboratories, Nicholas Piramal, Shasun, Matrix, IPCA, Jubilant, Torrent and Morepen Laboratories.

Given that the propensity to invest in R&D is proportional to the resource base of the company in a dynamically competitive environment, it is likely that small firms may be focusing on the areas where relatively smaller investment might help them to reap larger benefits. And one such area could be the replication of the off-patent drugs rather than developing, testing and altogether new molecules. That is the reason for the concentration of over 77% of the R&D expenditure during 1992-2007

(incurred by the sample firms) among ten firms namely Ranbaxy, DRL, Sun Pharmaceutical, Cipla, Wockhardt, Cadila, Lupin, Nicholas Piramal, Torrent, and Aurobindo. These are the firms which are using the revenue generated from the production and world-wide marketing of off-patent drugs for financing the development of new chemical entities (NCEs). Nevertheless, it may be more interesting to find out the percentage of total sales revenue that a firm is devoting to the R&D (Table 3 in the Appendix). The top ten firms which are devoting over 7% of their sales revenue (as on 2006) are not necessarily the top ten largest firms. For instance firms such as Torrent, USV, Panacea, Matrix and Orchid, which are dedicating over 7% of their sales revenue on R&D, do not figure in the list of top ten largest firms. It appears that R&D expenditure is more reflective of firm's commitment to stay competitive in the dynamic market setting than to its resource base.

Expenditure of the firm on advertisement and marketing (AME): This would include the expenditure of the firm on marketing. It would include wages and salaries of their marketing executives and sales representatives, who are largely in the charge of promoting sales of the firm in the market. This should ideally include the advertisement expenditure of the firm in promoting the product in the market. However, In India prescription drugs comprising all antibiotics and specific pain-killers cannot be advertised in the general media. They, at best, can be advertised through trade journals, medical megazines, distribution of free samples and other materials. The avenues for advertising are therefore restricted. These costs are substantial and firms incurring such expenses may be expected to compete in the markets for additional profits. It may be interesting to note that there is virtually no difference in the AME of the Indian and foreign firms operating in India. In fact, the AME of eight Indian firms included in the sample was found to be higher (over 8% of their sales revenue) than the multinationals' subsidiaries in India. It may be further noted that only four firms viz., Torrent, Ranbaxy, USV and Cadila, out of the top ten, which are devoting highest proportion of their sales revenue to the AME, were also found to be spending much more on the R&D. Remaining six firms were found to be spending more on AME than the R&D (Table 4 in the Appendix). Incidentally, except for Ranbaxy, USV, and Cadila, other firms viz., Lupin, Alembic, Ipca, JB Chem. & Pharma, Albert David and TTK are not even among the top ten firms (of the sample) with highest export intensity (Table 2 in the Appendix). These are also not amongst the top ten firms in terms of sales revenue. However, as the major objective of investing in AME is to maximise the revenue, this variable is relevant for this study. This variable is expected to bear positive coefficient, i.e., higher the AME more is the revenue to the firm as it enables the firm to improve its sales in the market. This is expected to capture the impact of marketing strategy of the firm on its revenue maximization.

In the literature of business economics, mergers and acquisition is supposed to be a widely accepted business and marketing strategy of the firm to raise the revenue. This should ideally include number of takeovers/acquisitions a firm goes for in the industry. Since, the merging of two firms would make it easier to gain monopolistic power in the market and higher economies of scale, this variable can be a proxy for the marketing strategy of the firm. Another hypothesis regarding this could be that mergers would improve the economies of scale of the firm due to larger operations. Thus, the coefficient of this variable is expected to have a positive sign. However, in the drugs and pharmaceutical industry of India, the takeovers/acquisitions are confined to top 5-6 companies and is not a common phenomenon, therefore, this variable is dropped from the final analysis. Furthermore, the revenue of the firm can also be dependent upon the ownership structure, the presence of foreign interest in the firms and expenditure incurred on meeting the new regulatory demands. For instance, presence of foreign interest in a firm can help it to have access to the package of better 'managerial resources' (Cardoso and Dornbusch 1989). The package of 'managerial resources' may include specialized and technological knowledge in the areas of patents, know-how, sales techniques, managerial expertise, and ability to obtain funds and credit. Since the productivity of transferred managerial resources can be very high in the recipient firm, they can make a big contribution to the development of the domestic firm to which they are made available. However, in the drugs and pharmaceutical industry of India, the firms are either Indian or foreign and are certainly not of the collaborative nature. Therefore, it mergers and acquisitions as an explanatory variable to the sales revenue of the firms may not be pertinent in India.

Furthermore, the impact of the introduction of environmental changes (TRIPS-compliant amendment in the Indian pharmaceutical regulations) on the revenue of the firm can be explained with the expenditures of the firm on this head. This would include the abatement cost of the firm towards the wastages and any other expenditure incurred by it to meet the environmental regulations of the governments. More regulations are expected to reduce the output, sales and the revenue of the firm. Higher expenditures on this head by the firm can be an indication of higher regulations and thus should reduce the revenue of the firm. However, the data on this head in the drugs and pharmaceutical industry are not available. Therefore, even though, we recognize this as an important explanatory variable for the performance of the firm, we are left with no alternative but to drop the variable from further analysis.

With the above-mentioned explanatory variables (with some omitted variables like, mergers, presence of MNCs and the expenditure of the firm to meet the environmental norms of the government) and the dependent variable R, the functional relation of (1) can be restated as:

$R = A(TP)^{\beta_1}(RD)^{\beta_2}(AME)^{\beta_3}\varepsilon$(2)³, where A stands for the efficiency parameter of the firm, β_s ' are the partial elasticities of R with respect to the concerned explanatory variable and all other variables are as explained earlier. However, since there are more numbers of firms within the Drugs and Pharmaceutical industry and the impact of the explanatory variables would be assessed over a period of time, equation 2 can be restated as:

$R_{it} = A(TP_{it})^{\beta_1}(RD_{it})^{\beta_2}(AME_{it})^{\beta_3}\varepsilon_{it}$(2a), where the subscripts 'i' refer to the particular firm in the industry and 't' refers to the time period. So, R_{it} would mean the revenue of the ith firm at time period 't'. Similar would be the interpretation of the explanatory variables. The coefficients of the equation 2a can be estimated with any non-linear estimation technique. However, for the purpose of empirical estimation, equation 2a can be transformed into a double logarithm model as follows:

$$\text{Log}R_{it} = \text{Log}A + \beta_1\text{Log}(TP_{it}) + \beta_2\text{Log}(RD_{it}) + \beta_3\text{Log}(AME_{it}) + \text{Log}\varepsilon_{it}$$
.....(3)

Since A is a constant, LogA would also be constant, and $\text{Log}\varepsilon_{it}$ would also be the random error term which would satisfy the assumption of IID⁴ (0, σ^2). Thus, the equation 3 can be estimated by any of the panel regression technique. However, some of the issues relating to the estimation of equation 3 are worth mentioning here. The issue arises from the desirability of some dynamic structure in the estimation. There is likely to be lag between the R&D expenditures and the actual output derived from them. For this reason, Hall, Griliches and Hausman, (1986) investigate the existence of a lag structure in the patents-R&D relationship. Although they argue that there is no evidence of a long lag between R&D and patenting, past R&D history seem to add to the current year's patent applications, although the effects may be small. In such a scenario, it is pertinent to find out the gestation period of the R&D expenditure on patent in the Drugs and Pharmaceutical industry of India. This could be done with the help of a distributed lag model as follows:

$\text{Log}TP_t = \alpha + \sum_{i=0}^n \beta_{t-i}\text{Log}RD_{t-i} + e_t$(4), where TP_t is the Total number of Patent application of the Drugs and Pharmaceutical industry at time period 't', RD_{t-i} is the aggregate R&D expenditure of the Drugs and Pharmaceutical industry at time period 't-i', 'i' would measure the lag-length, 'n' is the optimum lag and e_t is the random error term that satisfies the assumptions of the Classical Linear Regression. The optimum lag length can be decided with the test-statistics like Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC) and Hannan-Quinn Criterion (HQC). Thus, the explanatory variable RD would appear as the lagged variable, after establishing the optimum lag. In

³ A C-D type of Revenue function.

⁴ Independently Identically Distributed.

addition to this, the established optimum lag period can also be the guideline for the age of the firm. If a firm is already in the industry for a period equal to or higher than the determined lag period, the firm can be viewed as a more established firm (which in turn is a proxy for the age of the firm). An established firm with more years of business in the industry is expected to have more market share and thus more revenue. Therefore, in order to incorporate this attribute of the firms, a Dummy (D) variable will be used. Thus, equation 3 can be restated as:

$$\text{Log}(R_{it}) = \text{Log}A + \alpha_1 D_i + \beta_1 (EP_{it}) + \sum_{i=0}^n \theta_{t-i} \text{Log}(RD_{it-i}) + \beta_3 \text{Log}(AME_{it}) + u_{1it} \dots \dots \dots (4a)$$

Where ‘D’ is the dummy variable that accounts for the age of the firm. The value of ‘D’ will be one (1), if the firm has more than or equal to ‘n’⁵ number of years of existence in the industry and zero ‘0’ otherwise. However, it could be possible that all the sample firms are more than or equal to ‘n’ number of years of existence in the industry. In such a case, use of dummy variable may be futile. Therefore, a multiple of ‘n’ can be used to determine the age of the firm in the industry, if the circumstances requires. ‘u_{1it}’ is equal to Logε_{it} and thus satisfies all the assumptions of the random error term.

Additionally, Blundell Griffith and Windmeijer (2002) argue that there may be a feedback effect between R&D expenditures and the patents generated by those expenditures. They developed an estimator which explicitly models the dynamics of the count process in the panel data taking into account the feedback relation between patents and R&D. Furthermore, since Patents achieved may vary with firm size, while marketing and R&D expenses (even as a share of expenses) would be driven by output and ultimately revenue of the firms, most of the explanatory variables can also be the function of the dependent variable, i.e. ‘R’. All these interdependent of variables in the model may lead to the endogeneity/simultaneity problem. Here in the present case, the relation between patents and the R&D expenditure, marketing expenditure and the revenue of the firms can be expressed as follows:

$$TP_{it} = \alpha_2 + \sum_{i=0}^n \delta_{t-i} \text{Log}(RD_{t-i}) + \pi_1 \text{Log}(AME_{it}) + \gamma_1 \text{Log}(R_{it}) + u_{2it} \dots \dots \dots (4b)$$

This makes the model a simultaneous model where it requires to identify the endogenous and exogenous variables to test the identification of the model and for the ultimate estimation of the model. But, the detection of endogenous and exogenous variables can be quite a tricky task. Neither, the theoretical nor the empirical literature assigns exogeneity to any of the variables and thus, the feedback relation among the variables exists, confirming the endogeneity of most of the variables. Thus, in order to examine the dynamic interrelationships among these variables the empirical literature advocates for

⁵ ‘n’ is determined from equation 4

a Vector Autoregressive (VAR) technique. However, since the sample data here are in panel form, we need to resort to a Panel VAR (PVAR) model. The VAR model is based on an atheoretical framework and contains simultaneous equations in which all the variables are considered to be endogenous. However, each endogenous variable is explained by its lagged or past values and the lagged values of the other endogenous variables included in the system. Within the PVAR framework, one can estimate the co-integrating relation among the variables without compromising the endogeneity of any variable. In order to estimate the co-integrating relationship among the firm specific variables within the PVAR framework, the Panel co-integration (PCONT) model can be described as follows:

The standard equation to be estimated in the present study is:

$$\text{Log}(R_{it}) = \text{Log}A + \alpha_1 D_i + \beta_1 (EP_{it}) + \sum_{i=0}^n \theta_{t-i} \text{Log}(RD_{it-i}) + \beta_3 \text{Log}(AME_{it}) + u_{1it} \dots \dots \dots (4c)$$

This can be represented in a more general way as:

$$R_{it} = \alpha_i + \beta_i X_{it} + V_{it}$$

Where,

R_{it} = Dependent variable;

X_{it} = vector of independent variables;

β_i = Vector of Coefficients; and

V_{it} = error vector.

In the above equation, ‘ R_{it} ’ and ‘ X_{it} ’ are co-integrated with slopes β ’s, which may or may not be homogeneous across ‘ i ’. However, there is a need for the verification of the stationary properties of the variables in the analysis of a PCONT model and for the present study it can be done for all the pooled variables by the unit root tests as prescribed by Pedroni (1999)⁶. The usual tests for the unit root for a panel set of data are Levin-Lin, Augmented Dickey-Fuller (ADF) test. The test would cover the most general specification for all the pooled variables, which include a constant, a trend and lags. If the variables are found to be non-stationary, then they can be made stationary by taking the differences. Additionally, the test of unit root of the error term of equation 4c can be performed to check the presence of co-integrating relation among the variables (Pedroni, 2004; Kao, 1999). If the error term is stationary, then we can conclude that there exists a co-integrating relation among the variables (provided that the variables are stationary at first difference). Such a technique can help us to estimate the performances of the firms in Drugs and Pharmaceutical industry of India without confronting the problem of endogeneity/simultaneity.

⁶ For details, see, Pedroni 1999

Section IV: Results and Discussion

With the implementation of the patent laws in India, the firms primarily with an eye on the current and newly emerging areas, as a result of some of the drugs going off-patent, went for substantially raising their R&D expenditure in order to develop NDDS, Contrast Media API and Formulations, Process Improvement and Cost Reduction, Development of API and Intermediates, and Contract Research and Manufacturing Services (CRAMS). Various policy incentives provided by the Govt. of India (viz., incremental deductions allowed for R&D expenses) to firms for setting up in-house R&D units have also contributed towards encouraging the firms to invest in the R&D. Consequently, the number of patents filed and acquired in the industry went up rapidly during the 1990s'. As could be seen from Table 6, the exponential growth rate of the patent achieved and patent filed in the D&P industry is 1.15 and 1.10 percent respectively during 1991 to 2006. During the same period the R&D expenditure of the industry also increased at an exponential rate of 1.19 percent. This could be because of the policy-induced increase in R&D by the firms. Additionally, the correlation coefficient between patent filed and the R&D expenses of the industry is 0.79, and the correlation coefficient between patent granted and the R&D expenses of the industry is 0.65 during the above-mentioned period. This implies that the policy-induced R&D expenses of the firms have helped the firms to innovate product or processes that are so crucial for the growth of the firms.

Table 6: R&D Expenditure and Patents of the D&P industry in India since 1990-91

Year	Patents Granted	Patents Filed	R&D Expenditure (US Million \$)
1990-91	87	258	36.5
1991-92	118	323	29.4
1992-93	94	234	37.0
1993-94	145	273	39.8
1994-95	232	629	44.6
1995-96	132	1000	45.5
1996-97	71	1124	51.5
1997-98	291	1481	56.0
1998-99	150	1555	61.2
1999-00	307	1000	73.6
2000-01	276	883	97.8
2001-02	320	879	130.5
2002-03	312	966	175.3

2003-04	419	2525	280.0
2004-05	192	2316	392.4
2005-06	457	2211	495.2
EGR	1.10	1.15	1.19

Source: Annual Reports of the Office of Controller General of Patents, Designs, Trade Marks and Geographical Indications for various years.

However, as mentioned in section III, there is a lag between R&D and the patent filed by the firms. Though this gestation period would be different for different firms, the trend in the industry can be the guideline for the lag-length of the R&D expenditure. The estimation of equation 4 establishes that the optimum lag length of R&D expenditure in the D&P industry is four years. These four years can be taken as the lag length in the PCONT estimation. A review of the existing literature suggests that the gestation period of R&D turning into productive patents and consequently commercial products is considered to be ranging between eight to fourteen years. However, it applies to the breakthrough research. In case of the incremental research for off-patent drugs, as is largely true of the Indian pharmaceutical firms, four years appear to be a plausible proposition.

Furthermore, couple of observations need special attention before discussing the result of the PCONT results. First, the number of firms included in the current model is 36 as against the initial proposed 50 firms. This is because while only 39 firms were found to be active in R&D and the patenting activities during the study period, the data relating to other variables were not found to be available for three firms for the study period. Secondly, since all the firms are there in the industry over a period of four years, using the dummy variable to trace the age of the firm becomes futile (In fact using a multiple of four also does not change the result). Therefore, in the final estimation, age of the firm is not considered. Additionally, the data relating to the expenditure incurred by them to meet the environmental regulations of the governments are also not available. Therefore, these variables are omitted from the final analysis. Thirdly, patenting activity being of very recent origin for the Indian drug and pharmaceutical firms, it is not uncommon to find a situation of ‘no patent’ for some years for some firms. Since, the model is proposed to be estimated in its logarithm form, logarithm of one will be zero and logarithm of zero becomes in-deterministic. In order to avoid this problem, 100 is added to all the patent data of all the firms. This would make the zero value as 100 and one value as 101.

Additionally, there is a need for the verification of the stationary properties of all the variables in the analysis of a PCONT model and for the present study it has been carried out for all the variables

by the unit root tests as prescribed by Pedroni (1999)⁷. The usual tests for the unit root for a panel set of data are Levin-Lin, Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) test. The test covers the most general specification for all the variables, which include a constant and trend. It is also necessary to determine the lag length of the variables in the PCONT model. The Akaike Information Criterion (AIC) and Schwarz Criterion (SC) are the common test-criterion to fix the lag length in such models. However, in the current PCONT model, though the test statistics confirmed for a lag length of one, the present study settled for lag length four, as already determined by equation four. The results of the panel unit root test are given in Table 7. The unit root tests show that all the four variables, i.e. Patent, Sales revenue, R&D expenditure, Marketing and Advertisement expenditure of the firms are non-stationary at their log level (though the test statistics Levin-Lin and PP show that two variables, i.e. sales revenue and Marketing and Advertisement expenditure are stationary at their level, ADF test does not confirm such a result). However, all the variables are stationary at their first difference (Δ) and are integrated of order one i.e. I (1). Thus, in order to carry out the PCONT analysis, all the variables are made stationary by differentiating once. Such transformation will also reduce the co-linearity of the variables. Furthermore, if the variables are not stationary, there can be upward bias of the estimated coefficients giving rise to spurious results.

Table 7: Unit-root Test Results for Patent, Sales revenue, R&D expenditure, Advertisement and Marketing expenditure

Test.	Levin-Lin		PP		ADF	
	Level	First Difference	Level	First Difference	Level	First Difference
Patent	1.42	-2.91*	8.31	183.05*	5.24	65.67*
Revenue	-4.11*	-5.41*	52.17*	134.51*	7.91	69.98*
R&D	1.31	-7.23*	15.29	149.26*	10.78	91.23*
AME	-3.61*	-4.81*	61.18*	142.94*	12.06	59.62*
The unit root test regressions include the intercept and trend						
* implies that the test statistic is significant at one per cent level						

The lag lengths of the variables, as mentioned earlier, are decided by taking into the equation four. Confirming the variables are stationary at their first difference, the PCONT model is estimated with the first difference (Δ) of all variables. The analysis included computation of Panel Co integration

⁷ for details, see, Pedroni 1999

result, and the Levin-Lin Statistics of the error term. A rejection of the null hypothesis of the unit root would indicate that the variables in equation 4c are co-integrated and that the estimated relationship represents an equilibrium long-term relationship. The technique depicts and focuses on a unique co-integration equation although there might exist multiple co-integrating equations.

The results of the empirical investigation are displayed in Table 8. Three specifications are examined: the first is a specification without any firm dummy or time dummy; the second, a specification with a dummy variable for the firms; and the third, a specification with dummy variables for both firms and time. The alternative specification of the model would help to test the sensitivity of the explanatory variables to different specifications. The results of the panel co-integration test are given under the Levin and Lin statistic displayed at the bottom of each specification. The null hypothesis of the existence of a unit root in the residuals is rejected for all three specifications. Hence, we can conclude that the variables are co-integrated. The estimated equations, particularly the third specification, represent the long-run equilibrium relationship between sales revenue of the firm and the related potential determinants. This specification allows us to make the following assessments.

Table 8: Elasticity of Sales Revenue, Panel Co integration Result

Specifications	I	II (The Coefficients of the individual firms are given in Table 7 of the Appendix)	III
Explanatory Variables			
Constant	4.66 (107.15)*	--	4.61 (54.89)*
Patents	-0.03 (-1.85)*****	-0.01 (-0.51)	-0.03 (-1.28)
R&D	0.30 (14.59)*	0.23 (10.25)*	0.24 (11-44)*
AME	0.39 (14.80)*	0.40 (15.50)*	0.40 (15-56)*
Adjusted R ²	0.71	0.79	0.81
F-Statistics	305.49	42.98	33.79
Levin-Lin Statistics	3.56 [0.001]	3.49 [0.001]	3.91 [0.001]

As evidenced from the Levin-Lin statistics for panel co integration, the explanatory variables like Patent, R&D expenditure, Advertisement and Marketing expenditure have a co-integrating relation with the Sales revenue of the firms in all the alternative models. The alternative model specifications also show a good fit as supported by the relatively higher adjusted R-square and significant F-statistics.

Both the R&D and Advertisement and marketing expenditures appear as strong determining forces of the sales revenue of the firms. The elasticity of R&D expenditure seems to be sensitive to the model specification whereas the same for the advertisement and marketing expenditure is more or less stable across alternative models. The positive and significant elasticity of sales revenue with respect to R&D expenditure is an encouraging sign for the firm. This implies that the firms those invest more on R&D reap the benefit in the form of higher revenue. This expenditure may help the firms to innovate new and low-cost products/product variations that, in turn, will raise their sales revenue in the long run. This finding is further corroborated by the fact that R&D expenditure has a lag period in its realization into patent. As mentioned in the theoretical model earlier, R&D conducted by Indian companies in this sector primarily concentrates around generics and incrementally modified drugs and significant R&D efforts are being directed towards developing processes and products to get regulatory approvals for entry and growth in off-patent generic markets in developed countries. This trend is probably induced by increasing export orientation of Indian pharmaceutical companies and diversification to the regulated markets as these markets are now showing a definite shift towards generic drugs amid increasing health-care related expenditure leading to strident public demand for less expensive medicines. Provision of several fiscal incentives, by Govt. of India, to the drug and pharmaceutical exporters viz., direct and indirect subsidies and cash compensatory support, replenishment import licence, tax exemption of export income, subsidised export credit and export credit insurance, bonded warehouses, support for export marketing have also encouraged the firms to increase their export orientation.

Similarly, the expenditure of the firm on advertisement and marketing, has a positive effect on the sales revenue of the firm (the elasticity of sale revenue of the firms with respect to AME is around 0.40 in all the models implying there by one percent increase in AME brings 0.40 percent growth in the sales revenue of the firms). This implies that marketing and advertisement expenditure of the firm has a very strong impact on the sales of the firm, as the influence of such expenses is immediate on the consumer's mind. This also shows that the marketing expenditure of the firm helps to spur the demand growth or their product which, in turn, raises their revenue well in the long run. The result of our analysis reveals the fact that expenditure of the firms on the advertisement and marketing is more effective than the expenditure of the firm on R&D, primarily because of the fact that the latter has some gestation period which can potentially offset the beneficial effects in the short run. However, the analysis reveals the fact that both the expenditure policies can be employed by the firms to enhance their sales revenue.

However, one surprising but interesting finding comes out from the current analysis, i.e. the elasticity of sales revenue with respect to patent is negative in model I and it is also significant at 6 percent level (elasticity is -0.03). Though the robustness of this elasticity sensitive to alternative model specifications, still the direction remains negative. Given the fact that this coefficient is not significant in two models, nothing can be interpreted with authority, though it gives an impression that most of the patents achieved by the firms may not have been used for commercial purpose yet.

Section V: Concluding Remarks

Has the new IPR regime helped the firms of the D&P industry to perform better? Yes, if the performance is measured in terms of their sales revenue. The study confirms that even though the R&D expenditure of the firm is less effective than the advertisement and marketing expenditure, expenditure of the firm on this head in the long run can be more productive in the form of more commercial patent patents and higher revenue. Furthermore, the study also calls for more marketing and advertisement expenditure on the part of the firms to create a '*niche market*' for their product with '*brand loyalty*' among the consumers.

The data presented in this study also highlighted that major thrust on R&D began since 1996 as from this year onward, firms substantially pegged up their R&D expenditure and that there is heavy concentration of R&D expenditure around 16 firms which share over 90% of R&D expenditure incurred by all the sample firms. It further brought to the fore that there is no close connection between high export performance and R&D expenditure. It was found that only four (Ranbaxy, DRL, Cipla, Lupin) out of top ten exporters were also among the top ten firms with maximum R&D intensity. However, it would be too early to infer from this trend that the firms with high export intensity may not have high R&D intensity as the increased expenditure on R&D is a recent phenomenon and this period is not long enough to infer conclusively as there is a considerable time lag between R&D expenditure and its impact on the exports and other parameters. The data presented in this study showed that bigger Indian drug and pharmaceutical firms also share majority of patents filed by the sample firms. It further demonstrated that relatively smaller firms are spending more on advertising and marketing than on R&D.

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APPENDIX

Table1: Share of sample firms in the total exports and imports of the drug and pharmaceutical sector

Years	Exports of Basic chemicals, Pharmaceuticals & cosmetics	Exports of 36 firms	Share of 36 firms in total exports	Import of Basic chemicals, Pharmaceuticals & cosmetics	Imports of 36 firms	Share of 36 firms in total imports
1990	1878.9	128.96	6.86	618.2	152.2	24.62
1991	2216.1	194.09	8.76	754.4	208.99	27.70
1992	3453.0	260.63	7.55	896.8	297.65	33.19
1993	3324.8	345.38	10.39	1304	446.15	34.21
1994	4306.8	544.7	12.65	1332.5	431.57	32.39
1995	5535.3	781.76	14.12	1571.0	748.11	47.62
1996	7255.9	1224.86	16.88	2179.1	1420.71	65.20
1997	8865.7	1672.86	18.87	2024.9	1591.51	78.60
1998	10487.1	1948.36	18.58	2557.6	1355.08	52.98
1999	11168.1	2628.8	23.54	3255.0	1888.33	58.01
2000	13381.8	2975.48	22.24	3179.5	2261.87	71.14
2001	16738.7	4327.1	25.85	3240.2	2934.76	90.57
2002	17631.8	6550.43	37.15	4146.2	3334.41	80.42
2003	22544.6	8300.96	36.82	5052.6	4507.42	89.21
2004	26861.6	9671.5	36.00	5860.3	5205.88	88.83
2005	32076.9	10148.66	31.64	6850.8	6057.59	88.42
2006	40408.9	12442.9	30.79	9210.6	6856.54	74.44
2007	47266.6	12913.07	27.32	11872.7	6907.41	58.18

Source: Calculated from CMIE Prowess Database 2008 and Handbook of Indian Statistics, RBI.

Table 2: Export Intensity (Ratio of Exports to Sales Revenue) of the Sample Drug and Pharmaceutical Firms (Ranked in Descending Order According to Their Rank in 2006)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Divis	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	89.26	88.10	85.68	82.92	84.89	81.62	84.00	85.99	91.13
Strides Arco.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	64.39	56.48	63.82	75.07	90.12	90.91	94.52	85.01	N.A.
Orchid	N.A.	N.A.	98.42	95.87	97.65	94.32	88.75	87.70	80.85	85.66	83.19	83.16	74.86	75.65	75.22	78.19
Ranbaxy	23.34	24.92	32.12	38.42	43.37	45.27	34.57	43.12	39.89	45.95	58.24	60.31	58.80	63.48	65.79	N.A..
Neuland	43.25	40.92	42.00	49.17	34.36	47.04	60.18	45.29	52.88	43.77	54.52	55.12	56.47	69.91	60.80	55.13
Morepen	7.25	5.88	6.13	12.33	28.74	29.75	13.84	11.00	9.71	9.93	12.49	32.34	N.A.	66.44	58.40	N.A.
Aurobindo	0	7.81	26.61	29.18	39.63	40.81	31.78	39.18	49.26	54.48	46.89	47.38	48.08	48.43	56.44	58.33
Ajanta	0	0	0	0	0	30.07	53.49	35.30	35.77	37.97	49.34	56.44	55.83	75.44	54.82	40.09
Matrix	N.A.	N.A.	10.29	14.55	23.36	10.55	6.10	3.85	0.93	6.72	9.25	67.63	53.39	51.25	52.90	67.84
DRL	14.84	18.75	23.74	32.07	31.91	28.03	33.68	28.04	26.69	43.47	57.03	54.27	53.58	52.89	51.68	70.23
Shasun	-	29.43	30.34	40.71	41.59	38.22	46.41	48.25	60.58	56.67	59.01	62.16	65.95	71.87	68.21	58.78
JB	24.90	16.11	25.81	20.86	30.60	40.56	38.78	31.41	34.06	42.86	44.14	46.89	49.14	52.47	50.88	52.59
Cipla	11.73	10.04	9.81	10.36	11.17	13.81	14.24	19.05	18.58	25.01	35.46	36.42	42.36	45.73	50.45	51.00
Biocon	-	-	-	-	-	-	-	-	-	22.15	29.26	39.10	56.02	54.84	49.26	54.00
Ind-Swift	0	0	0	0	0	0	9.67	26.14	26.47	32.29	27.73	28.84	40.24	46.97	47.69	N.A
Ipca	25.46	31.56	31.70	32.87	37.50	42.83	47.59	44.31	46.94	41.43	48.00	51.23	51.77	53.29	47.02	47.44
Natco	N.A.	N.A.	31.81	32.20	44.27	19.49	N.A.	20.50	0	54.33	47.51	51.65	42.57	53.53	46.39	40.57
Lupin	N.A.	0	0	0	0	0.15	0.38	0	18.49	25.52	32.18	37.96	48.14	45.80	45.96	53.32
Glenmark	-	-	-	-	8.34	6.33	1.59	0.03	0.01	5.2	4.16	5.45	12.83	24.18	24.54	38.05
Wockhardt	10.84	9.79	N.A.	N.A.	10.57	21.49	20.04	15.89	21.10	25.68	31.12	36.93	37.15	38.65	37.92	N.A.
Sun	N.A	N.A	4.68	5.04	4.89	4.97	13.11	17.26	11.52	18.52	17.90	16.34	21.73	27.41	29.90	30.37
RPG	17.31	14.54	8.87	8.00	12.08	12.10	9.24	7.79	11.39	15.17	N.A.	25.82	21.66	29.03	31.60	29.21
SMS	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A	N.A	N.A	N.A	51.83	27.79	34.48	28.93	25.99
Aventies	11.44	4.11	8.53	12.72	16.15	20.14	20.11	12.28	10.50	17.09	19.08	21.18	26.06	27.14	24.30	N.A.
Alembic	10.67	13.68	12.07	17.05	14.74	15.76	17.94	19.23	20.62	N.A.	18.56	20.79	20.24	18.63	19.74	20.84
Torrent	0	0	0	0	0	2.27	29.17	8.54	25.49	6.95	7.11	9.09	9.61	18.49	18.57	19.40
Cadila	N.A.	N.A.	N.A.	N.A.	11.85	8.82	9.19	8.50	8.03	11.84	14.42	10.09	15.12	12.05	16.36	20.13
Nicholas Pir.	0.86	0.54	2.60	5.88	3.53	8.62	5.92	1.33	0.87	0.59	1.06	3.85	7.00	16.96	14.89	16.89
FDC	6.70	4.55	5.74	7.39	13.82	15.59	16.51	14.98	16.09	14.77	14.84	14.14	14.86	22.57	11.07	8.70

Albert David	0.03	2.32	3.29	1.29	0.88	1.69	3.47	4.15	6.06	7.66	9.99	17.53	12.57	11.64	10.85	8.55
Panacea				4.08	7.50	6.55	11.62	9.19	37.07	7.11	2.47	4.74	5.37	4.20	8.33	20.65
Raptakos	0.86	1.20	1.85	3.81	6.52	N.A.	5.18	3.80	4.35	5.42	6.44	5.65	5.11	5.96	6.11	N.A.
Elder					11.46	7.12	N.A.	2.67	2.77	3.22	10.69	6.42	6.23	2.24	2.02	2.47
TTK	4.34	1.44	4.30	3.87	2.26	4.04	0.98	0.68	1.83	1.62	1.30	1.54	0.78	0.78	1.01	0.84
Core	21.25	49.36	51.30	41.18	23.52	25.67	30.99	17.81	9.96	3.19	0.39	1.54	0.95	2.06	0	N.A.
USV	N.A.	0.03	0.05	0.04	6.80	6.35	4.71	4.57	2.96	7.02	16.73	24.30	31.20	0	0	N.A.

Source: Calculated from CMIE Prowess Database 2008

Table3: Ratio of R&D to Net Sales Revenue of the Sample Drug and Pharmaceutical Firms (Ranked in Descending Order According to Their Rank in 2006)

S.N.	Company	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	Panacea	0	0	0	0	5.86	6.23	7.81	6.97	6.76	0.30	3.21	0.39	5.58	6.01	10.08	12.79
2	Torrent	0	0	1.49	3.04	5.12	N.A.	N.A.	11.25	N.A.	6.27	5.98	8.33	8.69	13.74	12.60	12.67
3	Neuland	0	0	0	0	0	0.44	0.46	1.88	1.31	1.63	0.81	0.69	0.85	2.87	2.66	12.35
4	Matrix	0	0	0	0	0	0	0	0	0	0.52	1.91	1.37	3.08	4.27	7.75	12.17
5	Sun	0	0	9.20	4.54	4.18	4.50	4.70	3.01	4.37	4.61	5.04	8.67	12.60	12.14	12.91	11.69
6	Wockhardt	1.94	1.90	N. A.	N. A.	6.92	8.90	3.99	4.32	7.73	6.59	6.60	8.28	8.19	9.26	12.22	N. A.
7	Ranbaxy	0	2.99	5.35	4.92	4.94	4.58	3.81	3.10	3.91	3.40	5.71	6.64	9.58	17.78	11.78	N. A.
8	USV	N.A.	0	1.91	0.81	0	0.59	N.A.	N.A.	6.31	4.29	3.42	3.91	4.51	5.52	11.44	N. A.
9	DRL	1.55	2.47	2.20	2.20	2.74	3.47	2.37	2.49	3.04	4.53	6.25	10.11	12.86	17.95	11.35	6.79
10	Cadila	0	0	0	0	1.67	1.10	1.58	3.70	4.75	8.94	7.88	4.09	8.09	9.51	9.30	10.76
11	Orchid	0	0	9.50	3.42	3.20	2.43	1.84	1.05	1.32	3.91	4.27	5.27	5.72	7.71	7.08	6.90
12	Strides Arco	0	0	0	0	0	0	0	0	0	0	0	0.15	5.58	12.20	6.79	N. A.
13	Lupin	0	18.90	0.53	0	1.10	0.26	0.41	2.87	0.85	5.46	6.18	3.50	4.04	7.22	6.55	7.17
14	Nicholas Pir.	0	0	0.26	0.27	0.12	1.36	0	6.58	2.25	2.12	2.53	1.91	4.43	8.80	6.55	6.73
15	Biocon	0	0	0	0	0	0	0	0	0	3.18	4.70	4.45	4.61	3.70	5.80	5.62
16	Glenmark	-	-	-	-	0.24	0.26	0.99	3.64	3.58	11.98	4.66	9.17	9.75	9.05	5.32	5.16
17	Shasun	-	0.52	1.02	1.86	1.46	0.71	0.99	0.91	1.27	3.51	4.08	4.49	3.97	9.27	7.14	5.14
18	Aurobindo	0	0	0	0	0	0	0	0	2.06	0.91	1.32	1.98	3.91	5.01	4.64	5.14
19	Cipla	0	0.04	3.49	0.03	0	3.83	4.26	4.02	4.26	4.17	3.64	0	2.94	4.37	5.23	4.94
20	Ipca	0.49	0.67	1.23	1.64	1.52	1.26	0.74	0.76	1.93	2.37	2.00	2.73	4.04	4.91	5.02	3.56
21	Alembic	0	0	0	1.04	1.11	1.15	1.89	N.A.	N.A.	N.A.	2.58	3.91	3.54	6.01	4.24	4.99
22	JB	0	0	0	0	0	0	0	0	0	0	1.64	2.11	2.25	1.84	2.64	2.33
23	Divis	0	0	0	0	0	0	0	3.61	2.81	0.70	2.44	2.68	2.40	2.62	2.60	1.40
24	SMS	0	0	0	0	0	0	0	0	0	0	0	0	2.59	2.85	2.52	3.02
25	RPG Life	0	0.66	0.79	0.88	0.01	2.32	1.19	0.82	1.67	1.56	N. A.	3.40	2.12	2.09	2.20	3.49
26	FDC	0	1.59	1.64	1.73	1.90	2.22	1.59	1.64	1.66	1.48	1.23	1.47	1.93	1.65	1.89	1.48
27	Raptakos	1.11	0	0.86	0.95	1.14	N. A.	0.87	0.56	0.99	0.63	1.84	1.52	1.37	1.34	1.32	N. A.
28	Ind-Swift	2.76	2.57	N.A.	4.68	0.70	0.39	0.58	1.14	1.02	1.76	0.98	0.77	1.71	1.39	1.25	0.84
29	Elder	0	0	0	0	0.20	0.82	N.A.	N.A.	0.53	0.81	0.74	0.74	0.94	0.36	0.68	0.76

30	Aventies	0	3.18	2.75	3.28	3.98	3.13	2.35	0.98	0.39	0.53	0.74	0.59	0.53	0.40	0.36	N. A.
31	Albert Dav.	0	0.18	0.12	0.17	0	0	0	0	0	0	0	0	0	0	0.31	0.27
32	TTK	0.42	0.30	0.21	0.26	0.17	0.23	0.18	0.17	0.21	0.20	0.14	0.14	0.16	0.16	0.20	0.17
33	Natco	0	0	1.49	5.77	1.29	0.74	0	N. A.	0.06	N.A.	0.72	1.16	1.19	3.24	N.A.	N.A.
34	Ajanta	0	0	0	0	0	0	0	0	0	21.0	17.0	0.92	0.97	0.43	0	0
35	Morepen	0	0	0	0.70	2.52	1.19	0.95	1.08	N.A.	N.A.	2.01	N.A.	N. A.	N.A.	N.A.	N. A.
36	Core	0	0	0	1.22	0.58	0.56	0.14	0.04	0.08	0	0	0	0	0	0	N. A.

Source: Calculated from CMIE Prowess Database 2008

Table 4: Ratio of Advertising and Marketing Expenditure to Sales Revenue, 1995, 2000-2007

Sl. No.	Name of the firm	1995	2000	2001	2002	2003	2004	2005	2006	2007
1	Ranbaxy Laboratories Ltd.	6.97	8.78	10.30	9.37	9.74	9.28	13.28	11.65	-
2	J B Chem.& Pharm. Ltd.	3.49	6.00	6.77	7.77	8.45	8.04	11.63	12.05	11.63
3	Albert David Ltd.	17.77	13.41	13.73	20.50	20.05	11.50	10.75	9.65	9.52
4	Torrent Pharm. Ltd.	4.64	6.66	9.46	8.60	8.78	9.59	11.53	9.37	9.35
5	Cadila Healthcare Ltd.*	9.22	7.64	7.32	9.27	8.34	8.56	9.75	9.30	9.39
6	U S V Ltd.	6.45	8.28	12.24	9.96	9.25	7.49	8.13	9.22	-
7	T T K Healthcare Ltd.	6.75	5.36	5.70	5.56	5.68	7.52	7.53	8.28	8.90
8	Lupin Ltd.	0.08	1.07	5.45	6.21	6.13	5.31	7.65	8.39	8.28
9	Alembic Ltd.	9.07	8.61	-	8.74	9.26	9.20	7.22	6.87	6.84
10	Ipsa Laboratories Ltd.	2.76	5.36	5.34	4.76	5.04	5.79	5.18	5.58	6.11
11	Glenmark	9.95	3.21	3.65	2.91	2.30	1.54	1.02	1.01	0.69
12	F D C Ltd.	1.76	2.95	3.34	3.61	4.44	4.05	3.87	5.42	5.59
13	Dr. Reddy'S Laboratories	14.59	11.40	9.55	7.36	8.65	9.44	7.40	7.62	5.43
14	Elder Pharm. Ltd.*	8.71	6.16	5.86	3.85	3.53	4.06	4.88	5.30	5.41
15	Cipla Ltd.	5.52	5.80	6.97	7.50	6.62	6.10	6.58	5.31	5.41
16	Ajanta Pharma Ltd.**	3.92	5.11	9.58	11.71	11.40	9.56	7.53	6.14	5.20
17	Core Healthcare Ltd.	2.39	43.25	26.49	10.42	12.32	3.90	5.55	5.17	-
18	Nicholas Piramal India	0.85	0.91	1.07	3.10	4.10	4.30	5.61	4.54	3.89
19	Wockhardt Ltd.	5.76	5.54	4.75	4.75	3.89	3.44	3.18	3.66	-
20	Raptakos, Brett & Co.	1.66	9.08	4.50	4.71	4.82	5.77	5.39	3.64	-
21	Ind-Swift Laboratories	1.52	0.68	0.53	1.13	1.35	2.72	3.05	3.40	3.55
22	Aventis Pharma Ltd.	4.28	4.58	5.94	6.06	6.02	4.91	2.77	3.27	-
23	Panacea Biotec Ltd.	1.79	3.11	3.50	3.22	3.23	4.57	4.94	4.00	3.13
24	R P G Life Sciences Ltd.	1.99	1.45	1.61	-	2.62	2.36	3.92	2.82	2.61
25	Strides Arcolab Ltd.	-	3.44	0.24	1.18	2.67	2.38	2.75	2.43	-
26	Orchid Chem. & Pharm.	0.27	1.25	1.43	1.65	2.76	3.47	4.53	1.91	2.34
27	Morepen Laboratories Ltd.	0.48	2.12	2.51	4.59	-	8.81	10.90	2.09	-
28	Biocon Ltd.	-	-	1.10	0.92	1.25	1.12	1.23	1.59	1.66
29	Neuland Laboratories Ltd.	2.53	0.06	2.53	3.11	2.17	2.85	2.92	1.66	1.59
30	Matrix Laboratories Ltd.	0.98	0.77	1.15	0.81	6.16	3.21	1.65	1.66	1.54
31	Natco Pharma Ltd.	3.90	1.26	2.14	1.69	2.34	2.66	2.33	1.75	1.53
32	Sun Pharmaceutical Inds.	8.48	7.52	5.46	5.35	4.75	0.95	1.52	1.23	1.18
33	S M S Pharmaceuticals	-	-	-	-	1.16	0.81	1.24	0.86	1.01
34	Divi'S Laboratories Ltd.	0.25	0.29	0.34	0.21	0.42	0.57	0.78	0.66	0.29
35	Aurobindo Pharma Ltd.	1.10	1.03	1.06	1.03	0.77	1.22	1.70	0.84	0.79
36	Shasun	3.12	0.83	1.01	0.99	0.76	1.09	1.06	0.99	0.57

Note: * Data are given for 1996 as the data for 1995 were not available.

** Data are given for 1997 as the data for 1995 were not available.

Source: Calculated from CMIE Prowess Database, India, 2008

Table 5: Data for Figure 3: Share of top 10 firms in the total exports of drug and pharmaceutical products from India

Year	Value of Export by 10 firms	Total Value of Export of drug and pharmaceutical products from India	Share of 10 firms in the total drug and pharmaceutical firms from India
1992	153.51	260.48	58.93
1993	224.19	345.38	64.91
1994	350.97	531.38	66.05
1995	537.77	768.44	69.98
1996	781.56	1224.86	63.81
1997	1057.07	1668.03	63.37
1998	1113.03	1890.96	58.86
1999	1777.2	2628.43	67.61
2000	1965.39	2956.25	66.48
2001	3187.4	4228.71	75.38
2002	5049.22	6550.43	77.08
2003	6285.22	8300.96	75.72
2004	7271.66	9584.62	75.87
2005	7413.73	10148.66	73.05
2006	9384.81	12442.9	75.42
2007	9940.09	12455.41	79.81

Top Ten firms: Ranbaxy, DRL, Cipla, Aurobindo, Lupin, Orchid, Matrix, Sun, Biocon, Ipca,
Source: Calculated from CMIE Prowess Database, India, 2008

Table 6: Data for Figure 4: Share of top 10 firms in the total R&D Expenditure of sample firms

Year	R&D Expenditure by top 10 firms in the sample	R&D Expenditure by 35 sample firms	Share of 10 firms in the R&D Expenditure of the sample firms
1992	3.32	4.73	70.19
1993	21.65	33.62	64.4
1994	54.5	70.44	77.37
1995	50.67	76.55	66.19
1996	92.45	124.29	74.38
1997	121.55	157.63	77.11
1998	112.48	144.45	77.87
1999	213.94	238.69	89.63
2000	219.34	274.69	79.85
2001	342.09	423.26	80.82
2002	567.42	686.58	82.64
2003	690.81	839.21	82.32
2004	1103.71	1359.3	81.2
2005	1615.08	1952.67	82.71
2006	1642.13	2077.05	79.06
2007	1574.49	2012.06	78.25

Source: Calculated from CMIE Prowess Database 2008

Table 7: Intercept of the individual firms (For Model II)

Name of the firm	Coefficient of the Dummy	T- Values
Ranbaxy Laboratories Ltd.	3.99	21.36
J B Chem.& Pharm. Ltd.	3.79	21.13
Albert David Ltd.	4.50	25.42
Torrent Pharm. Ltd.	5.19	25.89
Cadila Healthcare Ltd.	4.91	23.67
U S V Ltd.	5.11	21.54
T T K Healthcare Ltd.	4.42	24.09
Lupin Ltd.	4.23	24.08
Alembic Ltd.	4.73	23.71
Ipca Laboratories Ltd.	4.42	25.64
F D C Ltd.	4.39	26.13
Dr. Reddy'S Laboratories	4.43	25.34
Elder Pharm. Ltd.	4.44	21.91
Cipla Ltd.	4.98	17.46
Ajanta Pharma Ltd.	4.68	22.19
Core Healthcare Ltd.	5.21	23.54
Nicholas Piramal India	4.52	21.12
Wockhardt Ltd.	4.34	22.97
Raptakos, Brett & Co.	4.24	21.34
Ind-Swift Laboratories	3.98	17.79
Aventis Pharma Ltd.	4.15	19.85
Panacea Biotec Ltd.	5.21	21.03
R P G Life Sciences Ltd.	3.87	22.43
Strides Arcolab Ltd.	4.51	21.13
Orchid Chem. & Pharm.	4.72	25.67
Morepen Laboratories Ltd.	4.23	18.78
Biocon Ltd.	4.41	21.98
Neuland Laboratories Ltd.	5.19	22.13
Matrix Laboratories Ltd.	3.87	24.41
Natco Pharma Ltd.	4.61	21.13
Sun Pharmaceutical Inds.	4.12	26.13
S M S Pharmaceuticals	4.53	19.51
Divi'S Laboratories Ltd.	4.32	25.19
Aurobindo Pharma Ltd.	4.19	26.84
Glenmark Pharmaceuticals Ltd.	4.16	22.15
Shasun Chemicals & Drugs Ltd.	5.18	26.84
Note: All the coefficients are significant at zero per cent level		