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RESEARCH PAPER

Competitiveness and its impact on research and development in Indian pharmaceutical industry

Piya Das · Subhrabaran Das

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Abstract The Indian pharmaceutical industry is one of the leading industries in the world which captures a significant global market share and that attracts many investors to invest in this industry. MNCs have entered into the Indian pharmaceutical market and invest a lot of money in research and development to capture the lucrative profits. This paper attempts to examine the degree of competitiveness among the firms in Indian pharmaceutical industry and examine the persistent impact of Research and Development of the competitive pharmaceutical firms. This paper also examines the impact of market structure and market performance on Research and Development in the Indian pharmaceutical industry. The industry is highly competitive and highly competitive pharmaceutical firms have been investing more on R&D persistently. There is an increasing trend of R&D investment over the time period by the pharmaceutical firms due to significant market structure and performance of the past period.

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P. Das · S. Das (✉)
Department of Economics, Assam University, Silchar, Assam 788 011, India
e-mail: subhrabaran@hotmail.com

P. Das
e-mail: piyadas_2007@rediffmail.com

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Introduction

The Indian pharmaceutical industry is one of the leading industries not only in India but also in the world. This industry meets approximately 95 % of the country's pharmaceutical needs. The present turnover of the Indian pharmaceutical industry is US $ 9 billion of which share of exports is 40 %. Compared to the global picture, the Indian pharmaceutical industry ranks 4th position in terms of volume which is highly significant and it is growing at the compound growth rate of 13.7 % per annum (Dixit 2008).

Before the Indian Patent Act 1970, the pharmaceutical industry was developing at a slower rate. The Indian Patent Act 1970 had an enormous impact on Indian pharmaceutical industry. It explicitly excluded patents for products and only the processes required patents. The Act brought in laxity in regulations leading to the growth of the Indian pharmaceutical industry. A number of firms entered the industry, which was earlier limited to a few due to stringent norms. Reverse engineering was resorted to, which meant that the firms just copied what the patent stated. Indian firms waited for the product to be launched by a

multinational company and analyzed its molecular structure studying the copy of the patent. They brought in the same drug with a slightly different process at lower cost than the multinational company. But, after implementation of the new economic policy in 1991 the domestic pharmaceutical firms have been facing tough competition due to the entry of multinational companies. This tough competition has provided an incentive especially for large pharmaceutical firms to perform at their best, producing high-quality drugs at the cheapest price. Competition has encouraged the entrepreneurial activity and changed strategic behavior. Such competitiveness in the market has associated with the changing nature of competition, which places a premium position not only on the relationship between costs and price but also on firm-level ability to rapidly adjust to new market conditions and innovations. In this framework competitiveness refers to the ability of firms to produce drugs by upgrading technological development. The firms are trying to maintain their position through R&D strategically. In this context both incumbent firms and potential entrants have put more investment on R&D for sustaining in the market.

Achieving the promise of pharmaceutical innovation requires the maintenance of strong and predictable intellectual property rights. The social value of the pharmaceutical industry is apparent and profound. It is not only the source of cost-effective treatments that continue to increase life expectancy and bring better lives, but also a significant contributor to the strength of the economy. Innovation and R&D activities have got a boost post implementation of 'Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS)' in 1994 and strengthening of Indian patent laws by amendments made in 2005. The initiative has been made with the signing of General Agreement on Tariffs and Trade (GATT) done by the World Trade Oganization (WTO) in 1995. Soon after, the Indian pharmacy market became a sought after destination for foreign players. Foreign direct investment into the country's pharmacy industry touched US$ 172 million during 2005–2006. Indian firms have started venturing into new drug development and collaborating with multinational companies to develop competence in all aspects of drug development. After the introduction of product patent in India, small and medium pharmaceutical firms are facing tremendous challenge to sustain in the industry. Leading firms are enjoying more benefits compared to this small- and medium-scale firms. The top ten pharmacy companies reported an impressive 57 % growth in consolidated net profit at US$ 314.3 million, as against US$ 200.7 million in the same quarter of the previous year, while consolidated net sales were up to 51 % at US$ 1.7 billion.[1] Due to imposition of new product patent regime, the R&D expenditure has grown 4–6 % of their annual sales.

Strong intellectual property protection is essential to a vital innovative pharmaceutical industry. The strength of intellectual property rights protection profoundly impacts on investment decisions. This investment is essential to enable further pharmaceutical innovation. This investment supports the constant efforts of research-based companies to develop innovative products to compete with the products of other research-based companies in a given therapeutic class. This investment also promotes competition between research-based companies and generic companies.

The generic pharmaceutical industry in India has thrived on the process patent regime and the capacity of domestic pharmaceuticals steadily advanced in conducive atmosphere. Some firms like Ranbaxy, Dr. Reddy's Laboratory, and Sun Pharma started focusing on novel drug delivery systems thus adding their own inputs and values to existing products. Pharmaceutical companies like Cipla, Lupin, Cadila, etc. established large production facilities in India and started improving their manufacturing efficiency and technology. The adoption of product patent regime made survival for small- and medium-scale enterprises and generic companies which earlier managed to exist on generic drugs or drugs in high demand manufactured by alternative non-patented processes, difficult in this competitive market (Bedi and Bedi 2013).

From the official website of Indian Patent office,[2] it is observed that the number of patent applications filled and patents granted indicates the level of inventive activity and that has been steadily increasing after TRIPS came

[1] The information has been collected from the web site: http://www.slideshare.net/keyursavalia/overview-of-the-pharma-industry. Site visited on 10 May, 2013. (See, Das and Das 2013).

[2] The information of Patent applications and granted by Indian Patent Office has been observed from the official website of Indian Patent Office www.ipindia.nic.in; site visited on 11 May, 2015.

into existence in 1995. It is also observed that more number of applications from large pharmaceutical companies is related to process patent than product patent up to the year 2004. Before 1995, only seven patents were obtained and all of them by Ranbaxy. India has revised its Patent Act in 1995, 2002, and 2005. After 2005 there has been an increase in the product patent applications filled by large companies. In this field Ranbaxy has the largest contribution which is followed by Glaxo Smithkline (GSK), Cadila, Dr. Reddy's Laboratory, Cipla, Sun Pharma, and their product patents have been approved by the competent authority. However, for small and medium companies it is found to be negligible due to limited knowledge of intellectual property system and limited resource and relative inability to absorb the cost and risk associated with enforcement and infringement issues (Bedi and Bedi 2013).

Government has taken several policy initiatives for strengthening Research & Development in Pharmaceutical sector such as fiscal incentives to R&D unit sector and streamlining of procedures concerning development of new drug molecules, clinical research, and new drug delivery systems leading to new R&D set-ups with excellent infrastructure in the field of original drug discovery. India has a large branded generics market which enables most companies to launch their version of a generic drug in the market place. Research and Development is an important aspect for development of generics that match the quality and cost targets.

India is now increasingly recognized as a strategic partner in the drug discovery value chain. Further, there are Indian companies who are investing in their R&D centers and are offering early stage discovery services as well as promising molecules. A large scientific pool in India is dedicated to Research and Development of patent non-infringing methodologies for drugs. India's rich human capital is the strongest asset for Indian pharmaceutical industry which is a knowledge-led industry.

The Department of Pharmaceuticals, Government of India was created on the 1st of July in the year 2008 in the Ministry of Chemicals and Fertilizers so as to provide greater focus for the growth of the high potential pharmaceutical industry. The basic objective of this department is to make India the Largest Global Provider of Quality Medicines at Reasonable Prices; to promote Public–Private Partnership for the development of pharmaceutical industry; to promote environmentally sustainable development of pharmaceutical industry; to promote Pharma Brand India through International Cooperation and to enable availability, accessibility, and affordability of drugs.[3]

The Indian policy regime has succeeded in bringing out its pharmaceutical sector as among the fastest growing in the world, but it has also created its own limitations in pushing forward its productivity and technological activities. The fragmented nature of policy that had encouraged a large number of small- and medium-sized pharmaceutical firms appears to have placed a constraint on the scale of production and capabilities to further upgrade the technological strength (Pradhan 2006). These large numbers of small- and medium-sized firms can sustain in the market through encouraging merger policy otherwise they will not sustain due to the presence of large-scale firms as well as MNCs.

Multinationals from all over the world are accelerating the pace of their direct investments in overseas R&D and strategic alliances. Previously, companies expanded their R&D operations overseas primarily to support local manufacturing and marketing operations. But now, companies are making overseas investments to complement their domestic research, technology, and product portfolios. They are integrating their domestic and overseas R&D facilities into global R&D networks thereby achieving cost reductions and price advantages (Saji 2004).

Mansfield (1986) concerns with two most important aspects viz; the patent system and its effects. In pharmaceutical and chemical industries, the effects of the patent system are found to be very substantial. The large Indian pharmaceutical companies are the major R&D spenders, and they have been focusing on the larger and the more lucratively developed country markets, particularly that of the United States. In this regard, the primary incentive to invest in R&D, whether for new chemical entities (NCEs), modifications, or development of generics, has not been the new TRIPS-compliant product patent regime in India but the product patent regime in developed countries that was in place well before TRIPS. TRIPS may have accelerated the trend towards such R&D because of the anticipated shrinkage of domestic opportunities. For major spenders, R&D expenditure has increased steadily from 1.78 % of sales in 1992–1993 to 3.86 % in 2001–2002, and then sharply

[3] Report on Indian Pharmaceutical Industry published by Department of Pharmaceuticals, Ministry of Chemicals & Fertilizer, Govt. of India (2008); collected from the web site: www.pharmaceuticals.gov.in; site visited on 8 April, 2015.

to 7.83 % in 2004–2005 and 8.79 % in 2005–2006 (Chaudhuri 2007). As a result of this, competitiveness comes in the industry due to leading firms.

Competitiveness is basically a function of two factors. Firstly, it is determined by the value dimensions which are basically for their customer's satisfaction. The second factor of firm competitiveness is the sum of resources and capabilities that make a firm capable to create and deliver the identified important value dimensions for the customer (Gelei 2003). Dasgupta and Stiglitz (1980) argue that in the model of cost-reducing R&D with non-exclusive property rights, increase in the number of competitors reduces the amount of cost reduction. The effect of competition is also monotonic in this model, although in the opposite direction. There is an intuitive argument that moderate levels of competition should be most effective in promoting innovation. In highly competitive markets, the incentive to innovate may be low because the innovator's small scale of operations may limit its benefit from a new technology. To the extent that market concentration is a reasonable proxy for the degree of competition, this suggests that intermediate levels of market concentration are the most fertile environments for innovative activity. However, the models that rely solely on the pursuit of profit maximization generate innovation incentives that peak at moderate levels of competition. There is an inverted-U relationship between market concentration and R&D spending in manufacturing industry (Scott 1984). This shows the degree of competitiveness at which R&D spending is maximum.

Research and development is highly associated with the market structure and performance. Competition is a stimulus to innovation. Firms in more competitive markets invest more in research and development in search of profit (Lunn and Martin 1986; Lunn 1986). There is a clear distinction between R&D inputs and R&D outputs in a research production function framework to understand the process of technology generation. Ray and Bhaduri (2001) find that the conventional determinants of R&D, like firm size, technology import, or ownership, appear significant only in explaining R&D effort in line with existing empirical studies. In fact, learning both experience based as well as interaction (or spill over) based, proved to be the only important determinant of the research production process. Therefore, technological learning has been the most important determinant of technology generation in Indian industry.

Objectives of the study

This paper attempts to examine the following objectives

- To examine whether the market in the Indian pharmaceutical industry is highly competitive or not.
- To examine the persistent impact of past R&D on its current period.
- To examine the impact of industrial performance and market structure on R&D expenditure in the Indian pharmaceutical industry.

Hypotheses of the study

In order to address the above-mentioned objectives, the following hypotheses can be framed:

- Highly competitive Indian pharmaceutical firms have been investing more on R&D persistently.
- Market performance and market structural variables of different size of firms have an impact on their future R&D intensity.

Methodology of the study

The present study is based mainly on secondary data collected from Centre for Monitoring Indian Economy (CMIE) firm-level data sources for the period 1991–2008. The firm-level data are divided into three categories on the basis of firm's annual sales and profit viz; small scale, medium scale, and large scale. The companies having two-digit annual sales and almost negative profit for all time periods consistently have been considered as small-scale firm. The companies having three-digit annual sales and mixed profit have been considered as medium-scale firm and companies having four-digit annual sales and almost positive profit have been considered as large-scale firm. In the present study, 43 drugs and pharmaceutical firms have been considered. Out of these firms five are large-scale firms, 13 are medium-scale firms, and 25 are small-scale firms in the industry. For the proposed study,

advanced econometric techniques viz; Panel regression and Vector Auto Regression have been used.

The study focuses on the market structure to examine the competitiveness. Market concentration ratio has been considered as a proxy of market structure. In most of the empirical literature, market concentration of the four firms has been considered. Market concentration ratio of four firms is defined by

$$\mathrm{CR}_{4t} = \frac{\text{Four largest firm's sales of } t-\text{th period}}{\text{Total sales of the industry of } t\text{-th period}}$$

The present study has also focused the Schumpeterian inverted-U hypothesis between R&D intensity (R&D/Sales) and market concentration ratio in the pharmaceutical industry to show the nature of R&D intensity according to market concentration.

For showing the inverted-U relationship, the following equation can be framed which will be quadratic in nature.

$$\mathrm{RDS}_{it} = \alpha + \beta_1 \mathrm{CR}_{4t} + \beta_2 \mathrm{CR}_{4t}^2 + u_{it}, \quad (1)$$

where RDS_{it} is research and development intensity of the of ith firm at the tth period which is defined as research and development per unit of sales; α, β_1, β_2 are the parameters; $\beta_1 > 0$ and $\beta_2 < 0$ (for showing the inverted-U hypothesis)

$\mathrm{CR}_{4t} =$ Four firm concentration ratio for tth period,

where u_{it} is the classical error that follows the normal distribution with zero mean and constant variances.

This relationship has been examined for the small scale, medium scale, and large scale and for the industry as a whole. The relationship will be inverted if and only if the sign of β_1 is positive and sign of β_2 is negative. The optimum value of market concentration ratio for which R&D intensity will be maximum can be derived from the first-order condition (first-order differentiation equals to zero) of maximization. For maximization, second-order differentiation will be negative.

For dealing time series data, it is mandatory to check whether each variable has an impact on itself or not. R&D expenditure depends on itself and up to which lag is examined here by using vector auto regression (VAR).

$$\mathrm{RD}_{it} = \gamma + \sum_{i=1}^{k} \delta_i \ \mathrm{RD}_{i(t-1)} + u_{it}, \quad (2)$$

where RD_{it} is research and development expenditure of ith firm for tth time period and k is the lag length. Research and Development is a dynamic and continuous process. Once a firm spends on R&D, then it spends in the next period and so on because it is a continuous process which takes longer period of time for its success.

It has been found that R&D expenditure of the firms as well as of the Indian pharmaceutical industry depends up to one period lag only. For other variables like, profit margin (PM), concentration ratio (CR_4), cost margin (CM), and gross fixed asset (GFA) the same exercise has been done using VAR in similar way and it has also been found that these variables are also stationary up to one period lag only.

For checking the impact of performance and market structure on R&D, market concentration ratio of previous years, profitability of the previous periods, and gross fixed asset of the previous periods have been considered as explanatory variables. Current R&D depends not only on the above-mentioned explanatory variables but also on previous R&D expenditures. So, the lag-dependent variable is now treated as regressor. As a result of this, the model is dynamic in nature. To get a consistent estimator, covariance between regressors and the error term should be equal to zero. But, the covariance between lag-dependent variable and error term is not zero because lag-dependent variable itself is a function of the stochastic component (i.e., function of error term) and as a result of this the estimator is inconsistent. So, ordinary least square estimation (OLS) or generalized least square (GLS) estimation is the appropriate estimation technique. For the dynamic panel regression specification, generalized method of moments (GMM) is the appropriate estimation technique. The dynamic model specification can be framed by taking several explanatory variables based on the VAR analysis in the following:

$$\begin{aligned}\mathrm{RDS}_{it} = {} & \alpha + \beta_1 \mathrm{CR}_{4(t-1)} + \beta_2 \mathrm{PM}_{i(t-1)} \\ & + \beta_3 \mathrm{GFAS}_{i(t-1)} + \beta_4 \mathrm{RDS}_{i(t-1)} + u_{it}\end{aligned} \quad (3)$$

All variables are normalized by dividing sales to avoid money illusion. The equation is framed as per the Neo-Classical theory of structure–conduct–performance (SCP) paradigm. The above equation indicates that the conduct (R&D intensity is treated as conduct variable) depends on market structure and

market performance. The justifications of the above explanatory variables are given in the following.

Concentration ratio (CR_4) is used to assess how the concentration ratio affects R&D investment of the firms in the industry. But, the decision on R&D spending depends on firm's size. Profit margin (PM) of the last period is considered as an explanatory variable because decision of R&D spending of the firm depends on the last period's performance. One of the basic motives of R&D spending is to minimize the future cost of production of the firms. If cost of production increases then the firms are forced to reduce it in future through current R&D expenditure. So, the decision of more R&D spending depends on the cost margin of the firms. Gross fixed asset–sales ratio (GFAS) is used as an explanatory variable because firm's R&D expenditure depends on the firm's last period's financial strength. Gross Fixed Asset is used as a proxy for the financial strength. R&D is a dynamic process, and from VAR analysis, it is observed that current R&D is reflected by last year's R&D spending.

Results and discussions

The growth rate of market concentration is negligible and negatively significant in the Indian pharmaceutical industry. The smaller value of market concentration is due to large number of firms (413 firms) in the industry. In the pharmaceutical industry, different firms have different patents over their products. So, there is large heterogeneity in the market. There are different types of medicines produced for different types of diseases. So, the total sales of all types of medicines are very high compared to four leading firms' sales. This negative growth of market concentration (CR_4) implies that total sales of the industry increases. Though growth rate of leading firms' sales increase, the growth of CR_4 will be negative only when total sales increase either due to entry of more firms or more sales of existing firms. Competitiveness in the pharmaceutical industry is very high. In the pharmaceutical industry, the large-scale firms have already captured the market. So, the new entrants are not able to compete in the market as they are faced with tough challenge from the incumbent firms.

There is a significant inverted-U relationship between R&D intensity and market concentration in Indian pharmaceutical industry as a whole (Table 1). It has also been found that inverted-U relationship is established for all size of firms in the industry which supports Schumpeterian inverted-U hypothesis. It has been estimated from the result that R&D intensity is maximum when concentration ratio is 0.21 for all firm's size and for the whole industry also. So, firms spend more expenditure on research and development even at the lower market share or lower concentration and that indicates very high degree of competitiveness. Though the competitiveness aspect in pharmaceutical industry is a very difficult task due to their heterogeneous production characteristics, it is observed that 96 firms exited from the market from 2004 onwards as they are not able to sustain in the market due to very high competition.

Table 2 reveals that in case of large-scale firms, CR_4 of the last period and R&D intensity is positively related and significant at 5 % level of significance. In the pharmaceutical industry, the value of CR_4 is very low as many firms exist in the industry and produce

Table 1 Inverted-U relationship between R&D intensity and market concentration ratio in pharmaceutical industry

Firm's size	Constant	CR_4	CR_4^2	Model[a]
All firms	−0.13* (−3.78)	1.38* (4.23)	−3.31* (−4.32)	Random effect model
Large scale	−0.38*** (−1.87)	3.92** (2.03)	−9.21** (−2.03)	Random effect model
Medium scale	−0.15* (−2.73)	1.58* (3.06)	−3.78* (−3.11)	Random effect model
Small scale	−0.69** (−2.19)	0.76* (2.52)	−1.88* (−2.64)	Random effect model

Source Calculated from the CMIE data sources for the period 1990–2008

Parentheses shows the *t* values for the coefficient

* Denotes the level of significance at 1 % or <1 % level of significance

** Denotes the level of significance at 5 % or <5 % level of significance

*** Denotes the level of significance at 10 % or <10 % level of significance

Table 2 Determinants of R&D intensity in pharmaceutical industry

Variables	All firms	Large-size firms	Medium-size firms	Small-size firms
Constant	−0.004 (−1.17)	−0.032** (−2.28)	−0.004 (−0.84)	−0.0008 (−0.23)
$CR_{4,\ t-1}$	0.042** (2.16)	0.171** (2.06)	0.0001 (0.00)	−0.039*** (−1.78)
$PM_{i,\ t-1}$	0.00002 (0.34)	0.147* (3.21)	0.028** (1.92)	−0.00001 (−0.32)
$GFAS_{i,\ t-1}$	0.00001 (0.32)	−0.01 (−0.34)	−0.003* (−4.3)	−0.00005 (−1.4)
$RDS_{i,\ t-1}$	0.759* (30.11)	0.79* (27.86)	0.623* (13.33)	0.57* (16.0)

Source calculated from the CMIE data sources for the period 1991–2008

Parentheses shows the *t* values for the coefficient

* Denotes the level of significance at 1 % or <1 % level of significance

** Denotes the level of significance at 5 % or <5 % level of significance

Table 3 Growth rate of sales, profit, R&D, and cost margin of the large-scale firms in pharmaceutical industry

Company name	Sales	Profit	R&D	GFA	CM
Cipla Ltd	0.21*	0.29*	9.85*	0.21*	−0.006**
Dr. Reddy's Laboratories Ltd	0.25*	0.32*	19.28*	0.29*	0.002
Glaxo Smith Kline pharmaceuticals Ltd	0.08*	0.23*	0.02*	0.04*	−0.02*
Piramal Healthcare Ltd	0.22*	0.23*	5.07*	0.21*	0.01*
Ranbaxy Laboratories Ltd	0.16*	0.22*	0.29*	0.20*	0.007**

Source calculated from the CMIE data sources for the period 1991–2008

* Denotes the level of significance at 1 % or <1 % level of significance

** Denotes the level of significance at 5 % or <5 % level of significance

*** Denotes the level of significance at 10 % or <10 % level of significance

Table 4 Growth rate of sales, profit, R&D, and cost margin of the medium-scale firms in pharmaceutical industry

Company name	Sales	Profit	R&D	GFA	CM
Abbott India Ltd.	0.10*	0.18*	0.12*	0.06*	0.01
Alembic Ltd	0.11*	0.26*	0.21*	0.15*	−0.003
Astrazeneca Pharma India Ltd	0.14*	0.21*	0.15*	0.15*	−0.01***
Aventis Pharma Ltd.	0.07*	0.21*	−0.07	0.04*	−0.01*
Brabourne Enterprises Ltd.	−0.07	−0.79	0.19*	0.03	−0.03**
F D C Ltd.	0.13*	0.23*	0.001**	0.35*	0.00
Ipca Laboratories Ltd.	0.25*	0.006**	0.002*	0.02*	0.007
JB Chemicals Pharmaceutical Ltd.	0.13*	0.16*	0.002*	0.17*	−0.005
Merck Ltd.	0.10*	0.01*	0.06*	0.07*	−0.02*
Novartis India Ltd.	0.03***	0.12*	−0.007	-0.07**	−0.005**
Pfizer Ltd	0.11*	0.22*	0.002*	0.09*	−0.008**
U S V Ltd.	0.18*	0.28*	0.005*	0.24*	−0.007**
Unichem Laboratories Ltd	0.13*	0.008*	0.003*	0.19*	−0.01***

Source calculated from the CMIE data sources for the period 1991–2008

* Denotes the level of significance at 1 % or <1 % level of significance

** Denotes the level of significance at 5 % or <5 % level of significance

*** Denotes the level of significance at 10 % or <10 % level of significance

Table 5 Growth rate of sales, profit, R&D, and cost margin of the small-scale firms in pharmaceutical industry

Company name	Sales	Profit	R&D	GFA	CM
Albert David Ltd.	0.08*	0.003**	0.01*	0.09*	−0.002
Ambalal Sarabhai Enterprises Ltd	−0.03**	−0.7	0.04***	0.02*	0.01*
Amrutanjan Health Care Ltd	0.09*	0.15*	0.002**	0.05*	−0.007**
Apte Amalgamations Ltd	−0.39*	0.20	0.00	−0.01	0.07*
Core Healthcare Ltd.	0.05	−1.44	−0.02	0.07	0.02***
D I L Ltd	−0.18*	0.02	0.06***	0.00	0.06**
Dey'S Medical Stores Mfg. Ltd.	0.03*	0.05*	0.03	0.05*	−0.002
East India Pharmaceutical Works Ltd.	0.05*	0.06**	0.08*	0.009*	−0.002
Fulford (India) Ltd.	0.06*	0.004**	0.00	0.09*	−0.002
Gufic Biosciences Ltd.	0.17**	0.13**	0.00	−0.3	−0.003
Gujarat Themis Biosyn Ltd	0.15**	−0.1	0.002	0.12**	−0.04
Kopran Ltd.	0.05***	0.15**	−0.08	0.20*	−0.002
Kothari Phytochemicals & Inds. Ltd.	−0.02***	−0.04	0.00	0.01	0.001
Lyka Labs Ltd.	0.01	−0.08	−0.003	−0.08**	0.002
Makers Laboratories Ltd.	0.25*	0.03**	0.004**	0.003	0.06*
Medi-Caps Ltd.	0.13*	0.01***	0.00	0.09*	0.02*
Morepen Laboratories Ltd	0.25*	−0.04**	0.15	0.12*	0.02**
Organon (India) Ltd	0.08*	0.14*	−0.01	0.07*	−0.009*
Resonance Specialties Ltd	0.23*	0.01***	0.01	−0.02	0.03***
Siris Ltd.	0.05*	−0.04*	−0.04	0.06*	−0.004
T T K Healthcare Ltd.	0.09*	0.11	0.01*	0.09*	0.009
Themis Medicare Ltd.	0.05	0.20*	0.10*	0.07*	0.009
Twilight Litaka Pharma Ltd	0.23*	0.03	0.008**	0.15*	0.01
Wyeth Ltd	0.09*	0.16*	0.03	0.09*	−0.02*
Zandu Pharmaceutical Works Ltd	0.09*	0.12*	0.09*	0.12*	−0.01*

Source calculated from the CMIE data sources for the period 1991–2008

* Denotes the level of significance at 1 % or less than 1 % level of significance

** Denotes the level of significance at 5 % or less than 5 % level of significance

*** Denotes the level of significance at 10 % or less than 10 % level of significance

heterogeneous medicines. If the concentration ratio increases then large firms capture more market share due to high demand for their product and as a result they spend more R&D in the next period. There is a positive and significant relationship between R&D intensity and profit margin of the last period as last period's profit encourages R&D spending in the large-scale firms. From Table 3, it is observed that for all firms of the large scale, growth rate of profit and R&D is positive and highly significant. More specifically, Dr. Reddy Labratories Ltd., Cipla Ltd. and Piramal Healthcare Ltd. spend more money on R&D. Dr. Reddy's Group is the first domestic company to file the first two product patent applications for anti-cancer and anti-diabetes substances. All these leading Indian companies are pursuing the strategy of R&D collaborations to lower their costs and risk factors. Companies like Ranbaxy, Dr. Reddy's Laboratory, and Glenmark are all following the out-licensing route. Dr. Reddy's Laboratory has tried a deal with Novratis for further work on an anti-diabetic compound DRF 4158. Ranbaxy has entered into a deal with Bayer for Cipro NDDS and RBx 2258 (BPH). Ranbaxy is also shaking hands with Eli Lilly and Schwartz Pharma AG; Cipla is undertaking custom synthesis and is collaborating with Japanese and Swiss firms. Glenmark has tried a deal with Forest of North America and Tejin of Japan for compounds that could provide treatment for asthma (Abrol 2014). These firms also maintain healthy profit margin. From Table 2, it is also

found that current R&D spending increased 79 % over last period's R&D because large-size firms spent more on R&D for dominating the market.

The results of the medium-scale pharmaceutical industry reveals that there is a positive and significant relationship between profit margin of the last period and R&D intensity as last period's profit encourages current period's R&D spending in the medium-scale firms. The growth rate of GFA of the medium-scale firms is positive (Table 4), though their financial strength is not so good compared to large-scale firms. The growth rate of R&D is not impressive for medium-scale firms compared to large-scale firms. There is a negative relation between GFAS of the last period and R&D intensity. But it is clear that medium-size firms are emphasizing on R&D spending and it is found that current R&D spending increases 62.3 % over last period's R&D.

Table 2 reveals that the relationship between R&D and CR_4 is negative for small-scale firms because the size of the market captured by small-scale firms is very less. To sustain in the market the small-scale firms have to spend more on R&D. In case of small-scale firms in the pharmaceutical industry it is observed that absolute value of R&D spending for small-scale firms are very poor; only nine firms have significant R&D growth. Though in most of the firms the growth rate of R&D is very poor (Table 5), the current period R&D increases 57 % over the last period's spending on R&D. This is statistically significant at one per cent level of significance.

It has been found that for the pharmaceutical industry as a whole, CR_4 of the last period and R&D intensity is positively related and significant at 5 % level of significance. It is found that current R&D spending increases by 75.9 % over the last period in the pharmaceutical industry.

Conclusion

Competitiveness in the pharmaceutical industry is very high. In the pharmaceutical industry, the large-scale firms have already captured the market. Though the competitiveness aspect in case of pharmaceuticals industry is very much difficult task due to their heterogeneous production characteristics but the pharmaceutical firms are spending very good R&D expenditure to sustain in the market.

It is concluded that past R&D has a persistent impact on the next period's R&D. The firms in pharmaceutical industry spent more over the last period as it is a continuous process to compete in the market. Spending on R&D is important for the development of the industry. It is concluded that concentration ratio, gross fixed asset, cost margin, and profit margin of the last period are the significant determinants of R&D. R&D is affected by market structure viz; concentration ratio and gross fixed asset of the last period. R&D intensity is positively related to the last period's cost margin. R&D intensity is affected by market performance and the relationship depends on the firms' size.

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