Globalization and Innovation in the Indian Pharmaceutical Industry

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Abstract: The changing global environment brings about new opportunities and new markets for domestic firms in developing countries. We examine the impacts of globalization and IPR protection on the innovation in the Indian pharmaceutical industry, using the firm-level panel data. This paper finds that there is a positive and highly significant level of foreign ownership effect on R&D activities. This indicates that there is technology spillover in the Indian pharmaceutical industry. TRIPS implementation has insignificant effects on R&D innovation. It is also found that exporting firms and firms with a higher productivity level are significantly more likely to carry out R&D activities.

Keywords: Globalization, Foreign Ownership, Innovation, R&D

1. Introduction:

It is said that, globalization will lead to dumping which could adversely affect the production and employment in other countries. The Indian pharmaceutical industry (IPI) has already been affected in to its business by none other than neighboring China. For instance, due to dumping, some bulk drugs producing units stopped manufacturing drugs in Andhra Pradesh, Gujarat and Karnataka (Lalitha, 2002). It is estimated that the Indian bulk drugs industry is losing its business amounting to Rs 2,500 crore a year due to cheap bulk drugs imports from China (Chaudhuri, 2011). The major problem for India is too much dependence on China for the import of bulk drugs. Regarding the Chinese bulk drugs production that China excelling over India, Indian Drug Manufacturers' Association (IDMA) President, S.V. Veeramani said that it is due to subsidies provided to the industry by the Chinese government. India is also planning to extend similar support to pharmaceutical industry, such as more funding, subsidies, quicker environmental clearances, etc.[1]

But the comparative advantages of these two countries are different. China's comparative advantage is in the low value end i.e. bulk drugs, and India's comparative advantage is in the high value end .i.e. generic drugs. According to Edelweiss report of Nov 2014, India has some 700 US-FDA approved facilities, and China has about 600 such US-FDA approved plants. However, India got approvals for more than 300 drug master files (DMFs) accounting for nearly a third in the US market, whereas China lagged with around 150 DMFs approved. So, Chinese pharmaceutical firms aim to move up in higher value chain in the Life Sciences sector by investing huge amount of money and scouting across the globe for talents. For example, Chinese drug firms hired senior Indian scientists to gain competence in the formulations segment by paying higher salaries. Confirming the trend, Director General of India's Pharmaceuticals Export

[1] "Drug sector needs boost to reduce dependency on China: IDMA" Economic Times, Sep 2, 2015. http://economictimes.indiatimes.com/industry/healthcare/biotech/pharmaceuticals/drug-sector-needs-boost-to-reduce-dependency-on-china-idma/articleshow/48775030.cms

Promotion Council (Pharmexcil), P.V. Appaji told the Economic Times that "*Several instances of certain leading Chinese pharmaceutical firms hiring top Indian pharmaceutical scientists have come to our notice. It could be aimed at augmenting filing of abbreviated new drug applications (ANDAS) in the US and other regulated markets as China is currently building huge capacities to produce copycat medicines. We guess this trend should over a period of time help Indian companies increase their presence in China and vice versa*" (Economic Times, 1st Sep, 2015). This strategic move can enable Chinese pharmaceutical firms to increase filings of ANDAS in the US and other regulated markets. This trend is happening at a time when India is trying to reduce its imports of raw materials from China. Chinese firms have increased significantly their R&D investments over the years. It increased from $162 million in 2000 to $3,250 million in 2011.

The IPI consists of both small and large firms. Small pharmaceutical firms are lacking in investments, skills and technologies. They are now restricted from accessing technical innovation that comes from reverse engineering. Since these firms mainly produce bulk drugs, rising imports of bulk drugs adversely affect them. Many foreign MNCs who had left during the 1970s are coming back to India. This return will gradually erode India's cost advantages as it leads to increase in drugs prices and imports of high priced finished formulations (Chaudhuri, 2011). While China moves up the value chains from manufacturing 'simple to manufacture' molecules to 'more complex to manufacture', many domestic companies are setting up their labs abroad due to lack of expertise in India in the areas necessary; and shifting their R&D activities to the western countries where there is plenty of trained personnel and good infrastructure which is lacking in India; to boost margins by producing high-value drugs due to regulatory morass at home, such as lacking of concrete regulations for clinical trials.

It is true that Indian domestic pharmaceuticals companies become more competitive, and enable to move up to higher value chains. For instance, Nicholas Piramal is talking with Chisei

Pharmacy to bring in 'curosur' a biotech drug that can be used for the survival of premature babies. It is also entering into co-licensing and marketing deal with Roche Pharmaceuticals of the US to introduce a biotech cancer drug 'peg interferon'[2]. Another pharma major Ranbaxy had obtained exclusive marketing rights from a US firm to sell a cardiovascular drug in several Asian countries including China, South Africa and with non-exclusive rights in Mexico (Lalitha, 2002). Indian exports market share has increased from 65.2% in 1993 to 81.2% in 2013. R&D expenditures have increased from 3.88% growth rate in Pre-TRIPS period to 5.07% growth rate in the Post-TRIPS (Kiran, and Mishra, 2009b). The total R&D expenditures significantly increased from 2005 onwards, i.e. from $40.82 million in 1999 to $326.15 million in 2005 to $1,134.16 million in 2014 (Table 1). Both domestic and foreign R&D expenditures have increased significantly in absolute terms. However, in terms of percentage share, domestic R&D expenditures shares have occupy major shares of the total. The percentage share of R&D expenditures incurred by domestic firms has increased from 62.03% in 1999 to 71.59% in 2005 and to 84.27% in 2014. Foreign R&D expenditures consistently decrease from 2006 onwards. R&D expenditures incurred by foreign companies have decreased from 37.97% in 1999 to 28.41% in 2005 and to 17.22% in 2014. It indicates that after the full implementation of product patent, pharmaceutical companies have started investing huge amount in R&D activities and domestic companies take the lead.

By 2014, out of the top ten companies that had invested substantially in R&D activities, eights are Indian domestic companies (Table 2). Ranbaxy Laboratories Ltd. and Mylan Laboratories Ltd are the only two foreign companies included in the list. These eight companies' shares accounted for more than 57% of the total R&D expenditures in 2014. The first top pharmaceutical companies in term of R&D expenditure percentage share in 2014 are Dr. Reddy's

[2] 'Nicholas in Talks for Biotech Deals' The Times of India, March 13, 2002, http://timesofindia.indiatimes.com/business/india-business/Nicholas-in-talks-for-biotech-deals/articleshow/3602401.cms?

Laboratories Ltd. (15.02%), Lupin Ltd. (13.43%) and Cipla Ltd.(7.39%). It indicates that domestic pharmaceutical companies have significantly increased their R&D expenditures whereas foreign companies have incurred less R&D expenditures. By 2005, offshore outsourcing to domestic firms started to include highly advanced R&D activities. Patent activities and patent filings such as Drug Master Files (DMFs) and Abbreviated New Drug Applications (ANDAS) with US-FDA by Indian pharmaceutical firms have significantly increased. The proportion of DMF filings by India has increased more than three times in the last few years. ANDA approvals held by Indian firms as a percentage of total approvals went up sharply from 17% in 2001 to 43% in the first quarter of 2013 (Chaudhuri, 2007). Out of 4,000 pending applications at the United States Food and Drug Administration (US FDA), Indian firms had filed 1000 applications and are waiting for clearance. The approval number is expected to cross 500 if the US FDA does not ask additional details such as complete response letter. Among the highest US FDA approval Indian companies, in 2015, Lupin got 19 products approval and is followed by Aurobindo with 17 FDA approvals in the same year. Some of new companies through these products will enable to enter into new market that has so far seen limited competition, indicating a cut in profit margins. This faster US FDA nods will accelerate sales growth of Indian pharmaceutical companies.

Due to the lack of capital, many of the domestic firms go for merger and acquisitions (M&A) and consolidate their business by acquiring the manufacturing facilities or brands of other firms. For instance, Indian domestic companies such as Dr. Reddy's, Aurobindo, Cadila Healthcare, Torrent, have signed supply agreements with MNCs such as GSK, Astrazeneca and Abbot. Accordingly, Dr. Reddy's will supply about 100 branded formulations to GSK in different emerging markets such as Latin America, Africa, Middle-East and Asia-Pacific (excluding India). Likewise, Aurobindo will supply more than 100 formulations to Pfizer for the regulated markets of the US and the EU countries, and more than 50 products for about 70 non-

US/EU markets. Besides revenues sharing, Pfizer pays upfront license fees to Aurobindo (Dinar, 2005). Sun Pharmaceutical Industries Ltd has the highest M&A undertaken, having 8 mergers including Ranbaxy Laboratories. It is followed by Piramal Enterprises Ltd, having 7 mergers so far. Similar trends have also been seen in other developing countries, like Argentina, Brazil and Mexico after the regulatory policies change (Jha, 2007). The advantage of this is that many MNCs can produce drugs at lower cost as well as saving time and money and can sell drugs in both emerging and regulated markets.

Table 1: R&D expenditures of the Indian pharmaceutical Industry: 1999-2014 (in US$ million and in percent)

Year	Total R&D (in $million)	Domestic R&D (in $million)	Foreign R&D (in $million)	Domestic R&D (%change)	Foreign R&D (%change)
1999	40.82	25.32	15.50	62.03	37.97
2000	58.27	39.80	18.47	68.30	31.70
2001	71.60	54.17	17.43	75.66	24.34
2002	96.35	76.53	19.82	79.43	20.57
2003	134.37	91.68	42.69	68.23	31.77
2004	226.69	160.94	65.75	71.00	29.00
2005	326.15	233.48	92.67	71.59	28.41
2006	423.11	293.98	129.13	69.48	30.52
2007	547.22	422.65	124.57	77.24	22.76
2008	641.49	489.45	152.04	76.30	23.70
2009	613.83	474.66	139.17	77.33	22.67
2010	799.16	622.72	176.44	77.92	22.08
2011	959.84	773.66	186.18	80.60	19.40
2012	959.96	794.67	165.29	82.78	17.22
2013	1,045.23	869.25	175.98	83.16	16.84
2014	1,134.61	956.17	178.44	84.27	15.73

Source: Prowess database, CMIE

Table 2: Top 10 R&D Expenditure Incurred Pharmaceutical Companies in 2014 (in US$ million)

Sl. No.	Companies	2005	2010	2011	2012	2013	2014
1	Dr. Reddy'S Laboratories Ltd.	57.64	88.29	121.29	123.62	127.69	170.31
2	Lupin Ltd.	17.4	78.47	107.45	103.89	130.48	152.33
3	Ranbaxy Laboratories Ltd. [Merged]	75.35	101.26	105.86	86	82.17	86.52
4	Cipla Ltd.	20.42	55.1	57.74	60.89	66.87	83.9
5	Cadila Healthcare Ltd.	16.25	38.75	56.52	71.22	81.37	71.43
6	Mylan Laboratories Ltd.	3.65	51.2	56.32	55.08	69.74	69.12
7	Sun Pharmaceutical Inds. Ltd.	16.98	31.67	34.96	36.4	50.09	61.5
8	Aurobindo Pharma Ltd.	8.22	21.38	30.99	31.66	38.33	41.8
9	Piramal Enterprises Ltd.	11.34	7.95	9.55	36.62	43.58	39.35
10	Wockhardt Ltd.	11.53	8.77	7.4	8.88	36.94	32.53

Source: Prowess database, CMIE

All these lead to the increase in the market shares of the MNCs in the domestic formulations market, increased from less than 20% in March 2008 to 28% in December 2010 with the taking over of Ranbaxy by Daiichi Sankyo in June 2008; Dabur Pharma by Fresenius Kabi Oncology in August 2008; ShanthaBiotechs by Sanofi-Aventis in July 2009 and the domestic formulations business of Piramal Healthcare by Abbott in May 2010. Among the top 10 pharmaceutical companies in India, the number of MNCs has increased from one (i.e. GSK) in March 2008 to three (i.e. GSK, Ranbaxy and the Abbott group) in December 2010. The Abbott group, which was the 30th largest company with a market share of only 1.1% in March 2008, (comprising Abbott, Piramal Healthcare and Solvay Pharma) now, becomes the largest company in India occupying 6.2% market share followed by the Cipla (5.7%). If the MNCs have taken over some remaining major Indian companies such as Cipla (5.7% market share in 2010), Sun (4.3%), Cadila Healthcare (3.9%), Mankind (3.2%), Alkem (3%), Lupin (2.9%), their share

will exceed 50% immediately paving way to dominate the IPI. With the abolition of the Foreign Exchange Regulation Act (FERA), the MNCs listed in Indian stock exchanges have increased their equity stakes accounting for more than 50%. For instance, Novartis has increased foreign equity from 50.93% in 2005 to 76.42% in 201, Pfizer from 40% to 70.75%, Abbott from 61.7% to 68.94% and Aventis from 50.1% to 60.4% (Chaudhuri, 2011). This is not welcoming news for the domestic firms.

Since product differentiation is impossible in the pharmaceuticals industry, increasing productivity and innovation becomes very important for the survival of Indian pharmaceutical firms. This prompts domestic firms to increase their R&D investments. It is quite important to examine the effects of foreign ownership and IPR protection on the innovation in the IPI. The study investigates it by using the firm-level panel data. We find that there is a positive and highly significant level of foreign ownership effect on R&D activity and TRIPS implementation has insignificant effects on R&D innovation. This paper is arranged as follows. Section II gives the literature review. Section III shows data and empirical specification. Finally, Section IV summarizes the results and concludes.

2. LITERATURE REVIEWS:

Theoretical analysis suggests that there are two major arguments for and against of tighter IPRs. One argument suggests that tighter IPRs encourage innovation thereby benefitting all regions, though many countries especially developing countries cannot totally agree with it. Another argument goes against the tighter IPRs as they only strengthen the monopoly powers of large companies of developed countries, to the detriment of the developing countries. A patent provides protection to a patentee from imitators and a country with relatively higher productivity level innovates more and can easily adopt new technology (Eaton & Kortum, 1996). Kim et al.,

(2012) also suggested that patent protection stimulates innovation and contributes in economic development only in developed countries. Implementation of patent only stimulates innovation in those countries with high level of development, education and economic freedom (Qian, 2007; Sweet & Maggio, 2015). Lai & Qiu (2003) examined the effects of strong IPRs protection in developing countries. They found that developing countries will benefit from the implementation of IPRs if they can implement the same IPRs standard of the developed countries. Stronger IPRs benefitted developing countries through technology transfer, increase in R&D activities, etc. (Dinopoulos et al., 2010) and by increasing royalty payments for technology transfers to affiliates, R&D expenditures, and foreign patent filings (Branstetter et al., 2006; Vita 2013). Branstetter et al. (2011) found that MNEs expanded their industry activities and accelerated transfer of technology to the South after IPRs reforms. They concluded that the activities of MNCs were expanded and it compensated the decrease in imitative activity in the South after the reform. Though there is temporary increase in innovation, the developing countries lose from tighter IPRs (Helpman, 1993).

Knowledge spillovers and their relation to the economic growth are empirically well established by Griliches (1979, 1992). Griliches (1986) examined the importance of R&D in enhancing productivity growth in U.S. manufacturing and found that R&D increased productivity growth. Analyzing the existence and magnitude of R&D spillovers, Griliches (1992) confirmed that R&D spillovers are both prevalent and significant. Coe and Helpman, (1995) estimated the FDI spillovers through R&D stocks. They found that returns on R&D activity were high in both output and international spillovers. Thus, a country's productivity level depends on R&D stocks. R&D enhances its productivity level (Griliches, 1986) through benefits from foreign technical advances and effective use of existing resources. Privately financed R&D expenditures were more significant than that of state financed R&D expenditures. Successful innovation required efficient assimilation of new knowledge and ideas in its innovation process

and such knowledge partly were got from foreign countries (Cassiman and Veugelers, 2002). Coe and Helpman (1995) argued that foreign R&D stimulated domestic productivity more to those economies which were more open to foreign trade and to those firms which were engaged more in their own R&D. Confirming this finding, Aw, Robert et al. (2007) found that exports and R&D were complementary for productivity growth, with R&D activities facilitating its ability to benefit from exposure to the export market.

Case studies suggest mixed evidence on the technology spillover to domestic firms. Aitken and Harrison (1999) found that there were no knowledge spillovers to domestic owned firms using the panel data on Venezuela firms. However, every OECD country other than the US benefited from foreign ideas in achieving higher its productivity growth (Eaton & Kortum, 1996). Girma et al., 2008 examined the two-way relationship between R&D and export activity using firm-level databases for the Republic of Ireland and Great Britain. They found that exporting experience increased the innovative capability of Irish firms through increasing R&D activity and no strong learning-by-exporting effects for British firms.

To examine whether stronger IPRs and implementation of TRIPS stimulate innovation for the pharmaceutical industry in the developing economies, Croix and Kawuara (1996) examined the effect of the adoption of product patents for the Korean chemical and pharmaceutical industry and found that the adoption of stronger patent laws decreased Korea's wealth. The implementation of TRIPS had increased the patenting activities and R&D investments of the domestic pharmaceutical companies (Chaudhuri, 2007; Chadha, 2009; Bedi et al., 2013) and increased sales and export performances of the companies (Kiran & Mishra, 2009a). This finding is in line with that of Guennif & Ramani (2012) that the IPI has had more success in industrial capabilities than that of Brazil due to State policy after the IPRs reform. McCalman (2001) empirically analyzed the impact of international patent harmonization as implied by the TRIPS agreement. He found that most of the developed countries benefitted and

developing countries including India suffered a net loss from raising IPRs protection. However, as far as Indian consumer welfare is concerned, Chaudhuri et al., (2006) found that though the implementation of TRIPS resulted to some welfare loss, the TRIPS would not have much detrimental effect on the IPI, as it increased domestic firms' profits. Allred and Park (2007) examined the relationship between patent strength, firm innovation and innovation diffusion using country and firm level data. They found that patent strength reduced domestic patent filings and had insignificant effects on R&D and foreign patent filings for developing countries. For developed countries, it increased R&D and domestic patent filings, and reduced foreign patent filings. Niosi et al. (2012) for India and Jiatao (2003) for China confirmed that diffusion patterns, shaped by national policies, were critical as the process is uneven among developing countries. They identified large human capital pools, strong institutions in the national innovation system, large established firms, industrial structures, and institutional factors such as science, technology, linkages with universities, as well as public research and market size as key success factors for knowledge accumulation (Jiatao, 2003) or for diffusion in developing countries (Niosi et al.,2012). Ala (2013) also found the negative effects of TRIPS implementation on innovation in case of Bangladeshi pharmaceutical firms. The implementation of TRIPS did not improve R&D capabilities in Bangladesh and reduced competitiveness in LDCs (Ala, 2013).

Pradhan (2003) empirically examined the impact of trade liberalization on R&D investments of the IPI and found that changes in regulatory environment had forced domestic firms to increase their R&D activities in order to develop better products. Feinberg et al. (2001) also empirically examined whether knowledge spillovers from MNCs' local R&D benefits domestic firms and found that the industry experienced technology spillovers from foreign FDI, but R&D spillovers only took place among MNCs themselves. There is no technology spillover from MNCs to domestic firms. Saranga & Phani (2009) examined the role of operational

efficiencies in the survival and growth of Indian domestic firms as a result of changes in regulatory regime in the IPI. They found that the domestic (older) firms were more efficient than the MNCs (younger firms) and increased R&D investments is associated with increased operational efficiencies. Iyer (2012) also found that there was no R&D spillover effect from both foreign and domestic MNCs on domestic firms. Foreign firms didn't significantly affect domestic firms' productivities.

3. DATA

The paper uses annual census data of over 552 pharmaceutical firms, allowing us to measure the productivity effects of foreign ownership. We obtained our data from the Center for Monitoring Indian Economy's (CMIE) Prowess Database. This database has been used in many empirical studies for Indian economy such as Pradhan (2002), Saranga & Phani (2009), Iyer (2012), etc. The study covers the period from 1999 to 2014. The share of foreign equity participation for a firm in time *'t'* is a proxy for foreign ownership. Its value ranges between 0 to 100 percent. Since most of the companies in the CMIE database don't fully disclose their employment number, we use labor input from the Annual Survey of Industries (ASI) data. It is calculated by dividing total wage bill of a firm by the average industry wage rate. However, since the ASI has not provided wage rates for the last two years, labor inputs for these particular years have been obtained from Prowess database. Capital, size, exports and raw materials of the firm in time '*t'* are taken from the CMIE's Prowess Database. TRIPS compliance data comes from Kyle and Mcgahan (2008).

3.1. Specification

There are three major hypotheses regarding the major determinants of R&D investment. The patent rights protection hypothesis, which indicates that the rate of R&D investment is

positively correlated with the stronger IPRs protection. The second is the international technology transfer hypothesis, which claims that foreign R&D activities' benefits can be transmitted through trade and FDI and affect domestic R&D investment decisions. The third is the income growth hypothesis, which states that the R&D intensity is closely related to income changes (Wang, 2010).

Our focus is to analyze the evidence on the relations between foreign ownership, IPR protection and innovation. The role of technology in firm's productivity growth becomes a very important issue in the IPI, since innovation is the key factors that the Indian pharmaceuticals firms could stay competitive in the global market. There are ample of empirical studies that confirm that there is a positive role for R&D expenditure in explaining firm's productivity growth (see Griliches and Mairesse, 1990; Nadiri, 1993; Wakelin, 2001). We also try to examine whether the foreign ownership improves their technology through innovation and thereby increasing productivity. In other words, whether there are important technological spillovers in the IPI and how they affect the productivity growth of domestic firms.

The specification of the estimate is given by:

$$Logit\ (R\&D_{it} = 1) = f(lagged\ ownership, lagged\ export, lagged\ TFP, lagged\ TRIPS, lagged\ firm\ attributes) \quad (1)$$

R&D is a dummy equal to one if it has any positive R&D expenditure in time, *'t'* and zero otherwise (i = 552 companies, t = 1999-2014). Foreign ownership (indicated by ownership) is the share of foreign equity participation at the firm level in the previous year, which varies between 0 and 100 percent. If foreign ownership in a firm increases that firm's productivity, the coefficient of ownership will be positive. Export is a dummy, 1 indicates a firm exports in time, '*t-1'* and 0 otherwise. It is expected that exports should have positive coefficient if exports increase firm's productivity. Lagged TFP indicates a firm's productivity in the previous year. We estimate TFP using Levinsohn-Petrin (LP) semi-parametric. Size represents market size and

capabilities of a firm. The coefficient of TFP is expected to be positive sign, as higher productivity firms will invest more on R&D activities. TRIPS is a dummy, 1 indicates that the years after which India fully implement 'product patent' in 2005, and 0 indicates the year before 2005. We expect the coefficient of TRIPS will be positive on R&D activities since undertaking R&D activities are necessary to fight tough competition with many foreign competitive firms for their survival. By protecting IPRs, TRIPS allows technology transfer and diffusion, and relates to a set of administrative and market-organizing regulated rules. They enable agents to use or transfer resources among each other, and allow governments to achieve economic efficiency which is one goal observed in IPRs regulations, or product liability and safety regulations. The firm attributes include firm size and it is a control variable. We expect a positive sign of its coefficient as firm size represents market power and capabilities. Large firms have higher market access and higher capabilities than small firms. It is expected that size will increase productivity growth of firms.

3.2. Empirical Results

Table 3 gives the different estimated results of equation (1). In column (1) and (2), it is calculated by using the logit model. Column (2) differs from column (1) in that lagged size is added in column (2). In column (1) and (2), the coefficients of foreign ownership are positive and highly significant at 1 percent level, which are 0.035 and 0.026 respectively. The coefficients of export dummy are positive and highly significant. The coefficient of TFP is also positive and significant (p=0.000) in column (1) and is positive and insignificant in column (2). The coefficient of TRIPS, in both columns, is negative and insignificant. The coefficient of size, in column (2), is also positive and significant (p=0.000). However, these estimated coefficients are likely to be biased due to ignoring unobserved heterogeneity.

To check biasness, we re-estimate the equation (1) using logit fixed effects model in column (3) and (4). We run Hausman test and the result indicates rejection of the null hypothesis

of uncorrelated time-invariant unobserved heterogeneity with the regressors, only fixed effect is consistent. In column (3), the coefficient of ownership is positive and significant at 5 percent level. It indicates that foreign-owned firms are more likely to undertake R&D activities. It also suggests that there is international technology spillover in India. Some of the possible reasons are discussed herewith. Since foreign MNCs have been losing their market shares and profits, due to drop of sales and expiry of patent for blockbuster drugs, rising costs and declining R&D revenues, they found India a profitable place to reallocate their R&D activities in India because, India is becoming a global hub of offshore outsourcing for R&D activities. Besides, India has the largest number of US-FDA approved facilities outside the United States with large pool of cheap and skilled manpower. Thus, foreign firms invest and relocate their R&D activities in India. They want to discover more new products. Once a new drug has been developed, its marginal cost of production becomes lower. Formula of the drugs needs not to be improved. The same formula can be applied to produce at different locations. Given India's comparative advantages, foreign MNCs invest in R&D in order to get monopoly rents from new varieties of drugs.

As far as domestic pharmaceutical firms are concerned, most of them produce generic drugs. The quality of such drugs must be high. In order to produce such high quality products, firms should be more innovative. Domestic pharmaceutical firms are more focused on developing innovations for regulated markets, particularly for the US markets. They must invest more on R&D activities to increase their productivity levels. Patents activities and filings by domestic companies registered the highest increase during the study period. Pharmaceutical products are knowledge-based products. These products are non-excludable (Grossman and Helpman, 1991). It implies that the patentees of new product might not get full compensation from all the agents that make use of it. They only get benefits from the patents on their new products.

Table 3: Impact of foreign ownership and IPR Protection on the Innovation of firms in the Indian Pharmaceutical Industry:

	R&D Dummy			
	Logit		Fixed Effects	
	(1)	(2)	(3)	(4)
Lagged Ownership	0.035	0.026	0.048	0.038
	(0.005)***	(0.005)***	(0.023)**	(0.024)
Lagged Export	2.405	2.214	1.497	1.498
	(0.180)***	(0.186)***	(0.421)***	(0.426)***
Lagged TPF	0.000	0.000	0.000	0.000
	(2.01e-07)***	(3.01e-07)	(6.03e-07)**	(9.07e-07)
Lagged TRIPS	-0.041	-0.078	-1.712	-1.922
	(0.541)	(0.559)	(1.116)	(1.187)
Lagged Size		0.000		0.000
		(2.61e-09)***		(1.15e-08)*
Year fixed effects	YES	YES	YES	YES
Constant	-2.255	-2.093		
	(0.266)***	(0.272)***		
N	1717	1676	468	448
Log likelihood	-808.39	-756.93	-169.95	-159.24
Prob>Chi2	0.0000	0.0000	0.0003	0.000
	LR Chi2(15)	LR Chi2(16)	LR Chi2(15)	LR Chi2(16)
	= 742.19	=779.54	=40.96	=48.21
Pseudo R^2	0.3146	0.3399		

NOTES: Robust standard errors are in parenthesis. *** indicates significance at 1% level, ** at 5% level and * at 10%. Standard errors in parentheses.

The export coefficient is highly positive and significant, which is 1.497. It suggests that exporting firms are more likely to invest in R&D. It is consistent with Girma et al., 2008. They found that previous year exporting activities increase the innovative capacities of Irish firms through increase in R&D activity. In other words, Indian pharmaceutical firms increase its probability to undertake R&D activities when they enter into export markets. After entering into export markets, firms face a tough competition from many MNCs. They must learn to get new

skills and knowledge in order to be more competitive so that they can produce niche products. It necessitates domestic firms improving their product qualities, designs, production processes so that they can meet the demands of domestic and foreign markets. For such a task, their managerial and operational efficiencies must increase and undertaking exports activities help them achieved such efficiencies through interaction and collaboration with foreign agents. These activities lead to increase in firm's innovative capabilities. Such kind of export competitiveness is only possible when firms invest huge amount in R&D activities (Pradhan, 2002), as investments in innovation are required to increase firm's capabilities.

The coefficient of TFP is positive and significant. But its coefficient is very minimal. It indicates that firms with a higher productivity level are more likely to perform R&D activities. Thus, productivity plays an important role in undertaking innovative activities. Productive firms are generally large in size and have more financial flexibilities. They can invest a large amount of money for innovative activities, thereby enhancing their innovative capabilities. Surprisingly, the coefficient of TRIPS is negative but insignificant. It is quite opposite to our expectation. Allred and Park (2007) also found similar results. They found that patent protection insignificantly affect R&D activities in developing economies. The negative coefficient suggests that TRIPS implementation does not encourage R&D activities.

In column (4), firm attributes i.e. lagged size is added to the baseline model. The coefficient of ownership becomes positive but insignificant. The export coefficient have similar pattern, positive and significant. However, the TFP coefficient becomes positive and insignificant. The effect of TRIPS is still negative and insignificant. The coefficient of firms' size is positive and significant. Its effect is very small. It suggests that there is a positive relationship between firm size and innovation, indicating that larger firms have higher possibility to undertake R&D activities. Large firms have higher market access and can appropriate economic rent from innovative activities. Since R&D undertaking requires a large amount of

investment and also involves risks, large firms can undertake such kind of activities, given their resource base and economies of scale. Thus, larger the firm size higher its probability to do R&D activities.

Table 4: Impact of foreign ownership and IPR Protection on the Innovation of firms in the Indian Pharmaceutical Industry:

	R&D Dummy	
	Random Effects	
	(1)	(2)
Lagged Ownership	0.073	0.054
	(0.017)***	(0.018)***
Lagged Export	2.843	2.623
	(0.452)***	(0.451)***
Lagged TPF	0.000	0.000
	(5.86e-07)***	(8.25e-07)
Lagged TRIPS	-1.652	-2.018
	(0.969)*	(1.013)**
Lagged Size		0.000
		(8.10e-09)***
Year fixed effects	YES	YES
Constant	-2.993	3.026
	(0.595)***	(0.607)***
N	1717	1676
Log likelihood	-445.19	-417.48
Prob>Chi2	0.0000	0.0000
	WALD Chi2(15)	WALD Chi2(17)
	=111.71	=108.13

NOTES: Robust standard errors are in parenthesis. *** indicates significance at 1% level, ** at 5% level and * at 10%. Standard errors in parentheses.

For robustness checking, we re-estimate the equation (1) using random logit model. Table 4 gives the results. In column (2) firm's size is added. The results are consistent with different methods. The coefficients of ownership and export are all positive and significant in both columns. The coefficient of TFP is positive and significant in column (1) but positive and

insignificant in column (2) when firm size is added. The only different is the coefficient of TRIPS. The coefficient of TRIPS, in both column, is negative but significant (p=0.088; p=0.46). It suggests that trade liberalization and TRIPS implementation don't go in favor of increasing R&D activities in the IPI. One of the possible reasons is that patent systems restrict imitation and copycat of patented technologies (Alfred & Park, 2007).It also increases transaction costs for technological exchange. Stronger patent protections increase the cost of technological inputs. This reduced technology transfers among countries. Due to stricter patent protection, local agents must pay for access to technological inputs and knowledge that used to be free. Since most of the Indian pharmaceutical firms are small firms, only large firms can undertake R&D activities. It implies that the small firms could not undertake R&D activities due to financial and resource constraints. These reduce the chances of local agents to increase innovative capabilities through imitation or learning by doing, reducing innovation.

Patent holders are suspicious of domestic pharmaceutical companies doing reverse-engineering and imitation of their patented drugs. They try to restrict them from accessing their technologies. Stronger patents protection may not provide the incentives to patent holders to upgrade or develop new technologies if they face less competition. Increased market power increases monopoly power of foreign MNCs and they exploit more opportunities from existing technologies. They gain economic rents longer with fewer introductions of new technologies, leading to a slower rate of innovation activities. As far as the benefits from the TRIPS agreement are concerned, McCalman (2001) also found that stronger patent protection resulted in significant loss to India. Unless patent reforms have a significant impact on developing-country's R&D, they could have largely negative impacts on domestic patenting. As expected the firm's size is positive and significant.

4. Conclusions

The literature on the R&D spillovers suggests that the role of R&D spillover effects is mixed in the case of developing countries. Product innovation mainly depends on R&D resources and the costs of R&D (Grossman & Helpman, 1990b). We have presented an overview of the preferences that MNCs in locating their R&D activities in India. It is cost considerations and the availability of a vast pool of human resources that brings MNCs to India. Our main concern was to investigate the impacts of R&D and IPR protection on the innovation in the IPI. What emerges is foreign firms encourage domestic pharmaceutical firms to undertake R&D activities and increase their innovative activities. It will in turn make the industry more competitive in the long run through this technology spillover. This technology spillover might be due to India's comparative advantage. Besides, foreign MNCs have lost its market share and profits, due to drop of sales and expiry of patent for blockbuster drugs, rising costs and declining R&D revenue.

Foreign MNCs might come and invest in R&D activities in order to get monopoly rents from new varieties of drugs. Since most of domestic pharmaceutical companies produce generic drugs, the quality of such drugs must be high to meet demand from domestic and foreign consumers. In order to produce such high quality products, domestic firms should be more innovative. They must invest more on R&D activities to increase their productivity levels. All these factors compel them to enter R&D agreement with leading domestic firms. The government incentive such as tax benefits, grants and soft loans for promoting R&D may contribute in attracting more R&D activities. TRIPS may have provided incentives and confidence to MNCs to take advantage of country's strength in manufacturing and to look for location for R&D in India. It indicates that firms incur more R&D expenditure inducing high innovative activity and more patents by domestic firms in India. It prompts that most of the developing countries introduce patent protection for new drug products and lead to do more research on innovation.

Exporting firms are more likely to invest in R&D activities. Since pharmaceutical is a knowledge-intensive industry, entry into export markets depends on firm-specific knowledge like better qualities, innovative design and marketing. Otherwise they cannot compete with the global peers. Such kind of export competitiveness is only possible when firms invest huge amount in R&D activities. Regarding TFP, firms with a higher productivity level are significantly more likely to do R&D activities. However, the coefficient of TRIPS is negative and insignificant. But it is negative and significant when we estimate it using random effects model. It is quite interesting that trade liberalization and TRIPS implementation don't stimulate R&D activities in the IPI. It is against our expectation. It suggests that trade liberalization and TRIPS implementation don't go in favor of increasing R&D activities at least for this industry. The outcome may be due to increasing monopoly powers of foreign MNCs, increasing transaction costs and restriction of imitation and reverse-engineering of foreign technologies as a result of TRIPS implementation. As expected, the firm's size is positive and significant. It implies that large firms have higher market access and can appropriate economic rent from innovative activities, for R&D undertaking requires a large amount of investment and also involves risks. Large firms can undertake such kind of activity, given their resource base and economies of scale. Thus, larger the firm size higher its probability to do R&D activity.

It is recommended to add more variables such as location, FDI, etc. Whether location and FDI play significant role in technology spillovers will be an interesting issue. Other variables like compulsory licensing and parallel imports may have impact on pharmaceutical exports and innovation. Such variables can be included in future study. Since our analysis is based on only one industry i.e. pharmaceutical industry, it is highly recommended to examine the effect of foreign ownership on more disaggregated data.

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