Article

Technological Innovations and Market Power: A Study of Indian Pharmaceutical Industry

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Abstract

Technological innovations are positively associated with firms' market performance. This study aims to examine the impact of product and process innovation on the market power of 168 Indian pharmaceutical firms during 2000–2013. We generate product and process patent stock to capture firm-level innovation activities. Findings of this study suggest that both product and process innovation positively influence firms' market power. Results also reveal that MNEs enjoy more market power in the Indian pharmaceutical industry. Further, this study also highlights that there is a differential impact of firms' product group on market power. This study concludes that patenting is a positive source of firm performance in the Indian pharmaceutical industry.

Keywords

Technological innovations, MNEs, market power, Indian pharmaceutical industry

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I. Introduction

Technological activities are a source of economies of scale and efficiency (Davies & Geroski, 1997; Gruber, 2000; Mueller & Tilton, 1969; Phillips, 1966) having a direct impact on the firms' monopoly power. Technological activities leading to innovations are captured by product and process patents. Product innovation increases the firm's monopoly power through product differentiation as the firm now charges higher prices for differentiated products (Cohen & Klepper, 1996; Lunn, 1986; Vives, 2008). Process innovation positively affects firms' monopoly power through cost reduction that improves productivity and output (Crépon et al., 1998; Deolalikar & Röller, 1989; Griliches, 1980; Hall, 2011; Kamien & Schwartz, 1982). In this study, we analyse the impact of product and process innovation on firms' market power for the Indian pharmaceutical sector.

Indian pharmaceutical industry provides an interesting research context to explore the impact of product and process patent on market power. This sector witnessed many structural changes in the last 50 years like patent policy reforms that have altered the industry's competitive pressures. As until the 1970s, this industry was dominated by MNEs where both product and process patents were allowed (Duggan et al., 2016; Kale & Little, 2007). The year 1970 marked a watershed year with policy change whereby only process innovation could only be patented in the fields of food, drug and agrochemicals for 7 years. Following this, MNEs left the market, while domestic firms improved their capabilities by conducting adaptive R&D (Duggan et al., 2016; Goldar, 2013; Kale & Little, 2007). The next major change occurs with the re-introduction of product patents in 2005 to comply with the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs).[1]

The presence of MNEs significantly alters the competitive forces in the Indian pharmaceutical industry. MNEs have access to technology developed by their parent organizations that provide them competitive advantage vis-à-vis domestic firms (Buckley & Casson, 1976; Rugman & Verbeke, 1992, 2003). Empirical evidences also suggest that innovation performance of MNEs is superior to domestic firms in India (Ambrammal & Sharma, 2016; Dhanora et al., 2018; Khachoo et al., 2018). Moreover, a group of studies also find that there is a significant knowledge flow from MNEs to domestic firms (Khachoo & Sharma, 2017; Marin & Sasidharan, 2010; Sasidharan & Kathuria, 2011). MNEs are large and dominating firms due to superior technology and availability of finance. MNEs also have an edge over domestic firms in terms of investment capacity, absorption capacity, technology profile and productivity score (Cohen & Levinthal, 1989; Patel & Pavitt, 1997; Sharma, 2012).

Majority of studies in the Indian context utilized R&D expenditure to proxy firm-level innovation (Basant & Mishra, 2014; Kathuria, 2008; Narayanan, 1998; Sasidharan & Kathuria, 2011; Sharma et al., 2018) with little attention on patenting as a measure of innovation (Ambrammal & Sharma, 2016; Chadha, 2009; Deolalikar & Röller, 1989). Utilization of R&D does not represent the actual technological capabilities of a firm because many firms in the developing country do not report their R&D and also all the R&D expenditure does not convert into successful innovation. However, utilization of patent overcome these problems as it is the outcome of successful R&D. Patents are also positively associated with the commercialization of the new product and also new product sale.

Firm-level innovation activities are classified as technological and non-technological innovation activities. Technological innovations are product and process innovation whereas non-technological innovations are marketing and organizational innovations. Accordingly, while examining the impact of patenting on market power, this study utilizes different types of technological innovations, that is, product and process innovation. These innovations are changes or essential improvements in the product (product innovation) and production method (process innovation). This classification is essential because both product and process innovation influence the performance of firms through different channels. Product innovation enhances firm performance through price increasing channel whereas process innovation through cost reduction channel. In the context of developed countries, studies have incorporated types of innovation activities while analysing innovation and performance relationship (Lunn, 1986; Nemlioglu & Mallick, 2017).

In this study, we analyse the impact of MNEs presence on firms' market power. All those firms having foreign equity greater than 10 per cent are called as MNEs. This classification is based on RBI. Earlier studies such as Basant (1997), Ambrammal and Sharma (2016) and Khachoo et al. (2018) also utilize similar classification to define MNEs in India. However, there is a possibility that MNEs may have a heterogeneous impact on firms' market power. This is especially so if countries have varied corporate culture and macroeconomic fundamentals. Studies such as Xu and Sheng (2012), Monastiriotis (2014) and Ni et al. (2015) analyse the impact of technology spillover on firms' productivity by considering country origin effect of foreign direct investment (FDI). Thus, we segregate MNEs on the basis of their country of origin.

This study analyses the unilateral impact of product and process innovation on firms' market power. Extant literature[2] on innovation and market structure consider market structure as an exogenous variable, while another set[3] of literature explores a two-way relationship. Interestingly in the Indian context, empirical evidences suggest that competition is not intense to influence firm-level innovation activities due to high technology gap between the leader and followers, and unfavourable business conditions.[4] However, to address the endogeneity concerns owing to theoretical reasons, we perform a statistical test.

Based on 168 pharmaceutical firms during 2000–2013, this study analyses the impact of product and process innovation on firms' market power. This impact is also studied separately by bifurcating data on the basis of ownership structure (MNEs versus domestic). We also incorporate product group dummies (bulk drug, drug formulation and manufacturer of other pharmaceutical and botanical products) to highlight the role of product class on the relationship between innovation and market power. Findings of this study reveal that both product and process patent stocks have a positive and significant impact on firms' market power. We also find that MNEs enjoy more market power in the Indian pharmaceutical industry. Further, we find that patent policy changes positively influence firms' market performance.

The article is organized as follows: Section II discusses the key details of the Indian pharmaceutical industry, and TRIPs and its impact on the Indian pharmaceutical industry. Section III presents the role of MNEs in the Indian pharmaceutical industry. Sub-sections 'Dependent Variables', 'Independent Variables' and 'Data Source and Descriptive Statistics' in Section IV give a description of the dependent and independent variables and data sources. Section V discusses the methodology and Section VI presents the empirical findings. Section VII concludes the study.

II. TRIPs and the Indian Pharmaceutical Industry

Branded drugs and generic drugs are two important business segments of Indian pharmaceutical firms.[5] According to Greene (2007), generic drugs are 'copies of off-patent brand-name drugs that come in the same dosage, safety, strength and quality and for the same intended use. These drugs are then sold under their chemical names as both over the counter and prescription forms', whereas branded drugs are 'innovator drugs patented by MNC pharmaceutical companies to prevent them from being copied or reverse engineered by other companies' (Greene, 2007). Approximately, 22 per cent of the world's generics drugs demand is fulfilled by Indian firms. Indian pharmaceutical firms are also exporting generic drugs to developed countries such as the USA and the UK. In the production of generics, Sun Pharmaceutical, Cipla and Lupin are leading firms in the world. Sun Pharmaceutical is the fifth largest generic producer in the world. This firm specializes in the production of both generics and branded generics. Cipla is also a leading generics producer with around 1,500 products in different therapeutic categories. The business of Cipla is majorly divided into three categories: Active Pharmaceutical Ingredients (API), Respiratory and Cipla Global Access. Similarly, Lupin is also a world-class generic-producing firm which ranked fifth in the USA in 2010.[6] Pharmaceutical firms in India produce around 60,000 generic brands and 400 bulk drugs. In India, generic drugs are also classified into two categories, namely simple generics and branded generics (Bhattacharjea & Sindhwani, 2014). MNEs in India are specialized in both branded and generics drug production. Bhattacharjea and Sindhwani (2014) highlight that MNEs are also increasing the export of both patented and generic drugs to India. MNEs are expanding the business of generics in India through mergers & acquisitions with Indian generics firms. Moreover, Bhattacharjea and Sindhwani (2014) highlight that patents of many blockbuster molecules are expiring now; hence, MNEs are trying to expand the business of generics in the developing countries. Indian firms also expand their business by a vertical business model where firms control entire value chain. Vertically integrated firms are technologically superior and offer multiple products.[7]

India made many changes in its domestic patent policy to comply with the TRIPS agreements. The Patent (Amendment) Act 1999 was brought into force retrospectively from 1 January 1995. The amendment provided permission to file an application for product patent in the field of pharmaceutical, drugs and agrochemical industries. However, such applications were examined only after 31 December 2004. This amendment also provided for granting Exclusive Marketing Rights (EMRs). Second Amendment in Patent Act 1972 was made in 2002 with the Patent (Amendment) Act 2002 that also replaced the rules of Patent Act 1972. In the amended act, further changes are made such as the term of protection was extended up to 20 years, the requirement to disclose the source and geographical location of the biological material has been added, the publication of application after 18 months started and provision for pre- and post-grant opposition was also added. The third amendment to the Patent Act 1972 was made through the Patent (Amendment) Act 2004 which was implemented by 1 January 2005. This amendment introduced product patents in all fields of technology.

Since the last 20 years, there is a continuous debate on the merits of TRIPs. The basic argument which is made by the opponents of TRIPs in developing countries is that strong patent protection results in higher drug prices. Supporters of TRIPs believe that it will encourage low and middle-income countries to become innovators. However, Ramani and Maria (2005) suggest that TRIPs will encourage the racing of the first or lowest cost production of off-patented brands only. Correa (1997) also explains that developing countries are not much benefited by TRIPs as the average firm size of developing countries is small and they do not have financing capacity for new drug discovery. Moreover, Kyle and McGahan (2012) also conclude that strengthen IPRs in developing countries have not directly increased R&D expenditure for new drug discovery; however, such protections are more effective in the high-income countries. Recent empirical evidences in the Indian context suggest that TRIPs brings positive changes in firm-level R&D expenditure (Chadha, 2009; Jagadeesh & Sasidharan, 2014; Sharma et al., 2018). But the impact of this increased R&D on new drug discovery is questionable in India (Correa, 1997; Ramani & Maria, 2005).

Studies in post TRIPs era suggest that there is a greater need for strict price monitoring and control for superior category drugs (Chaudhuri et al., 2006). The compulsory licensing policy of the Amended Patent Act, 1970 can be used as a tool for healthy competition and reasonable prices in the market. However, studies challenged the compulsory licensing policy. Chatterjee et al. (2015) suggest that compulsory licensing may discourage MNEs to launch their product in India. Parallel imports from other countries can help in suppressing the drugs price in the developing countries.[8] Studies such as Basheer and Kochupillai (2009) and Bhattacharjea and Sindhwani (2014) also discuss the possibility of parallel import as a significant channel for a price reduction in India. However, as of now, we do not have strong empirical evidence on parallel import and drug prices in the Indian context.

In the context of developing countries like India, the issue of availability and affordability of drugs is very important. Patents are state-granted monopoly to innovators but they enjoy only a temporary monopoly in the market. Hence, there are short-run inefficiencies due to increased drug prices which are likely to increase consumer welfare once the patent is expired. Moreover, strong patent regime also generates long-term gains in terms of new drug discoveries (Chatterjee et al., 2015). In a weak patent regime, there is also delay in the launching of new drugs which ultimately results in loss of consumer welfare. Moreover, such delays also harm future innovations. A study by Chatterjee et al. (2015) also highlights that in a strong patent regime consumer welfare can be also increased by differential pricing and voluntary licensing strategies. Under differential pricing strategy, firms charge a lower price in the markets of developing countries in comparison to markets of developed countries.

III. MNEs and Indian Pharmaceutical Industry

MNEs dominate the markets of developing countries.[9] Berry et al. (2006) explain that MNEs can either exploit the markets of developing countries by introducing products that are new to the host country but not to the firm (known as technology exploiting activities) or explore the market with products that are new to the firm and also new to the market (known as technology exploring activities). MNEs are locating R&D centres in developing countries because of the availability of qualified personnel, low wage rate and growing market demands since the mid-1980s (Niosi, 1999; Reddy, 1997).[10] However, Mrinalini and Wakdikar (2008) show that MNEs invest in R&D to modify products using locally sourced inputs to suit local tastes and conditions. Their policy is to have little investment in high-end R&D (Mrinalini et al., 2014). Prior to the Patent Act 1970, the Indian pharmaceutical market was dominated by MNEs that controlled more than 75 per cent of the market (Duggan et al., 2016; Kale & Little, 2007). In light of the changes made as per the Patent Act 1970 (provision of only process/method patent), MNEs exit Indian pharmaceutical industry (Kale & Little, 2007). However, the introduction of TRIPs again incentivized MNEs to conduct R&D and patenting in developing countries. MNEs also file patents in the developing countries for various other strategic reasons such as protection against infringement, strengthening competitive advantage, creation of entry barriers and protection from litigation (Collinson & Narula, 2014; Setterstrom et al., 2013). In the context of India, studies such as Goldar et al. (2004), Sahu and Solarin (2014) and Banga (2004) explain that MNEs in India are superior to domestic firms in terms of their productivity score.

By utilizing the firms' level information on the Indian pharmaceutical industry, this study attempts to empirically verify the impact of technological innovation on firms' market power. Based on the earlier discussions, we hypothesize that there exists a positive relationship between product and process innovation, and firms' market power. Further, the available literature in the Indian context does not discuss the impact of ownership structure on market power. This study hypothesizes that MNEs have better market performance in India pharmaceutical industry as these firms are more technologically superior with better knowledge of growing pharmaceutical business. Moreover, in the context of MNEs and firms' market power, we also analyse the country origin effects of MNEs by classifying them into the US- and European-based MNEs.

IV. Description of Variables

Dependent Variables

In this study, the dependent variable is Lerner index (LI) which is a widely used measure of market power. According to Scherer and David (1990) and Connor and Peterson (1992), the price–cost margin is a reasonable approximation of the LI. Following Koetter et al. (2012), we define LI as: LIit = {(∏it + TCit – MCit Qit)/(∏it + TCit)}, where ∏it is profit, TCit is the total cost, MCit is marginal cost and Qit is the output. Data on MCit is not usually available; hence, we proxy marginal cost by average cost (ACit). When we assume MCit = ACit, than LI can be defined as: {(∏it/PitQit)}. Studies such as Aghion et al. (2005), Tingvall and Poldahl (2006) and Correa and Ornaghi (2014) also defined LI in a similar way. According to Correa and Ornaghi (2014), LI defined by firms' profitability is the best approximation to measure market structure as it reflects on the accurate competition intensity in the market.

Independent Variables

R&D expenditure, R&D stock, R&D researchers, R&D employees, simple patent count and patent stock are important measures of firm's innovation activities. Patents, an observed proxy for successful R&D expenditure, are an important measure of firm-level innovation output (Griliches, 1980; Hall et al., 2005; Park & Park, 2006). However, patent data has some limitations: First, all innovations are not patented and, second, the economic value of patents is heterogeneous due to non-commercialization.[11]

Technological knowledge is cumulative in nature. A simple series of R&D and patenting activities cannot capture the overall technological progress of a firm.[12] Hence, researchers try to capture technological progress by stock-based indicators such as R&D stock and patent stock. Porter and Stern (2000) use the term 'ideas' production function while establishing the linkages between growth and technological knowledge. They calculated stock of knowledge/ideas of a country based on historical grant of patents. Similarly, Park and Park (2006) measured citation-based patent stock and valuation-based patent stock to capture technological knowledge of a firm. According to Hall et al. (2005), knowledge stock is positively associated with future net cash flow of a firm. They calculated knowledge stock based on R&D, patent and citation data. Another study by Lanjouw and Schankerman (2004) discusses the role of knowledge stock for productivity improvement. Their calculation of knowledge stock is based on cumulative number of patents and quality-adjusted patents.

While calculating patent stock, we apply 15 per cent rate of depreciation per year. This assumption of fixed rate of depreciation is based on previous studies such as Hall et al. (2005), Porter and Stern (2000), Lanjouw and Schankerman (2004) and Park and Park (2006). Moreover, Hall et al. (2005) also explain that small change in this depreciation rate does not make any difference to the results.

However, recent studies like Li and Hall (2020) calculated industry-specific R&D depreciation rate for the developed countries. In the context of developing countries like India, Basant and Fikkert (1996), Ray and Bhaduri (2001), Goldar (2004) and Ambrammal and Sharma (2016) calculated knowledge stock based on R&D and patent data with 15 per cent rate of depreciation. Hence, we also apply 15 per cent rate of deprecation while calculating patent stock. Moreover, this 15 per cent depreciation rate for pharmaceutical firms is comparable with other studies which have calculated industry-specific R&D depreciation rate (Li & Hall, 2020). To calculate patent stock for the base year, total number of patents granted in the last five years has been utilized (Ambrammal & Sharma, 2016; Goldar, 2004). In this study, we have calculated patent stock for the period of 2000–2013. To compute patent stock for the base year, that is, 2000, we have utilized total number of patent granted during 1995–2000. Another reason for choosing the period 1995–2000 to calculate patent stock for the base year is the availability of patent data. Patenting in India is accelerated only after 1995 (due to the TRIPs agreement) before that very minimal patents were filed by Indian firms.

To analyse the impact of ownership structure on firms' market power, we create dummy variables based on MNEs and domestic firms. We assign one for MNE and zero otherwise. We utilize sets of dummy variables based on equity-based as well as origin-based definition of MNEs. First, we assign value one to those firms which have foreign promoters' equity participation greater than 10 per cent (MNES10) and zero otherwise. Second, we assign value one to those firms which are US-based MNEs (MNESUS) and zero otherwise. Third, we assign value one to those firms which are European-based MNEs (MNESEUROP) and zero otherwise.

We have discussed that patent policy change may influence firms' market power. To analyse the impact of the patent policy environment, we utilize patent policy dummy in the empirical analysis. During 2000–2013, there were two amendments to the Patent Act 1970 to comply with TRIPs: the Patent (Amendment) Act 2002 and the Patent (Amendment) Act 2004. To analyse the impact of these two amendments, we create two dummies: TRIPS2002 = 1 if >2002 and TRIPS2005 = 1 if >2005.

We also classify firms on the basis of their product group and estimate their impact on firms' market power. We have four types of firm that produce medicinal substances used in the manufacture of pharmaceuticals (NIC-21001), allopathic pharmaceutical preparations (NIC-21002), ayurvedic or unani preparations (NIC-21003) and other pharmaceutical and botanical products not elsewhere classified (n.e.c.) like hina powder (NIC-21009). Firms which belong to NIC-21001 are mainly bulk drug producing firms. According to Greene (2007), bulk drugs are 'the active chemical substances in powder form, the main ingredient in pharmaceuticals—chemicals having therapeutic value, used for the production of pharmaceutical formulations. Major bulk drugs include antibiotics, sulpha drugs, vitamins, steroids and analgesics'. Firms belonging to NIC-21002 and NIC-21003 are active in the production of pharmaceutical and ayurvedic preparations. These firms mainly specialize in drug formulations (drugs in finished dosages form). On the basis of these classifications, we create four dummy variables, namely

Table 1. NIC 2008, Division-21 and Its Details

NIC Code	NIC Name	Number of Firms	Average Firm Sale (₹ Millions)
21001	Manufacture of medicinal substances used in the manufacture of pharmaceuticals: antibiotics, endocrine products, basic vitamins, opium derivatives, sulpha drugs, serums and plasmas, salicylic acid, glycosides and vegetable, alkaloids and chemically pure sugar, etc.	14	463.98
21002	Manufacture of allopathic pharmaceutical preparations.	81	4,730.23
21003	Manufacture of ayurvedic or unani pharmaceutical preparation.	9	946.01
21009	Manufacture of other pharmaceutical and botanical products not elsewhere classified (n.e.c.) like hina powder.	64	1,864.51
	Total	**168**	

Source: Authors' calculations on the basis of information available in CMIE PROWESS.

NIC-21001, NIC-21002, NIC-21003 and NIC-21009 and estimate their impact on market power. Details of these NIC classifications, the number of firms under different NIC codes and average firm size (measures by sales) are presented in Table 1. In Table 1, we find that firms under NIC-21002 are bigger in size whereas firms under NIC-21001 are smaller. This statistics highlight that firms which are active in drug formulations are larger than bulk drug producing firms.

In addition to the key variables of interest, we introduce controls in the model based on the extant literature review. Exports (EXP) as a part of international activity contribute to the technological advancement of firms because of the awareness of recent developments (Vu et al., 2014; Yoon, 2004). Moreover, Bernard and Jensen (2004) show that exporting firms efficiently allocate resources to enhance their market performance and enjoy market power. The size of a firm is also an important determinant of firms' performance because large firms are innovative (Cohen & Levinthal, 1989) and productive (Sharma, 2012) in comparison to small firms. We define size by total gross fixed assets (ASSET) of a firm. The age of a firm (AGE) also influences firms' market power as it is a proxy for learning by doing. Arrow (1962) explains that experience helps firms perform in better ways. Firm technological imports (TECHIMP) also determine firms' market power. According to Tiwana and Keil (2007), external technology acquisition helps firms to concentrate their resources and capabilities for core technological competencies. Similarly, Mowery and Rosenberg (1989) suggest that firms with external technology acquisition can acquire updated technology and extend new business opportunities in both local and international markets. Advertisement intensity (ADV) that covers the product differentiation aspect of a market (Connor & Peterson, 1992) also influences firm's market power with large spending on advertising in a competitive market (Yoon, 2004).

Data Source and Descriptive Statistics

This study utilizes firm-level panel data of Indian pharmaceutical industry. The analysis is carried out at 5 digit level of NIC. Major sources of data for the study include the Centre for Monitoring Indian Economy (CMIE) prowess database and the official website of the Controller General of Patents, Designs and Trade Marks (CGPDT, Government of India). The CMIE database provides annual report data of firms listed on the Bombay Stock Exchange (BSE). This study utilizes the information on granted patents which are published under Section 43(2). CGPDT have official search engine named Indian Patent Advanced Search System (InPASS). All patent-related information is available on InPASS. However, from InPASS, we can only collect total patent data which include both product and process patent. In the Indian context, a separate list of granted product is published by CGPDT. CGPDT published product patent data only for the pharmaceutical sector. To differentiate between product and process patent, first, we have gathered total patent data (product and process patent) from InPASS and product patent data from CGPDT, then we have deducted number of product patent from total number of patent to get process patent. Moreover, we have also verified the data by visiting the abstract and claims of each patent.

To collect firm-specific patent information, we first undertook a manual search of the company name. Second, we have combined our results with the CMIE prowess database for information on other firm-specific variables. We have excluded all firms reporting zero sales. Following data cleaning, we have been able to collect the data for 168 firms with 12.5 per cent MNEs. All the variables except dummy variables are used in logarithms scale.

Table 2 includes the definition of variables and data sources. The descriptive statistics for the full sample, domestic firms and MNEs are given in Table 3. In Table 4, the correlation matrix has been constructed. In Table 3, we find that the average product and process patent stock are higher for MNEs in comparison to domestic firms. For instance, the average product and process patent stock for domestic firms are 0.29 and 1.08, respectively. The average product patent stock for MNEs (based on 10% foreign promoters' equity) is 8.51 and for process patent stock is 10.97. When we define MNEs based on country of origin, we find that US-based MNEs have average product patent stock of 11.35 whereas average process patent stock is 23.38. MNEs based on Europe have average product patent stock 22.73 and average process patent stock 17.27. We find that European-based MNEs have highest product patent stock whereas US-based MNEs have the highest process patent stock.[13]

V. Methodology

We use panel data econometric techniques to estimate the model. As we discussed that there is a possibility of feedback effect between innovation and market power while estimating the impact of innovation on market power. Additionally, market structure may influence firms' innovation decision via anticipated monopoly power

Table 2. Variables Definition and Data Source

Variables	Definition	Source of Data
Lerner index (LI)	Operational profit divided by sales.	CMIE (Prowess)
Product patent stock (PRODSTOCK)	Calculated as: $PRODSTOCK_{it} = PRD_{it} + (1 - 0.15)\ PRODSTOCK_{it-1}$, where PRD_{it} is product patent granted in year t and $PRODSTOCK_{it-1}$ is product patent stock of the previous year and 0.15 is depreciation rate.	CGPDT
Process innovation (PROCSTOCK)	Calculated as: $PROCSTOCK_{it} = PRC_{it} + (1 - 0.15)\ PROCSTOCK_{it-1}$, where PRC_{it} is product patent granted in year t and $PROCSTOCK_{it-1}$ is product patent stock of the previous year and 0.15 is depreciation rate.	CGPDT
Export intensity (EXP)	Export of goods and services divided by sales.	CMIE (Prowess)
Technology import intensity (IMBDTECH)	Sum of imports of capital (machinery and equipment) goods and royalties and technological fees divided by sale.	CMIE (Prowess)
Size of the firms (SIZE)	Gross fixed assets.	CMIE (Prowess)
Advertisement intensity (ADV)	Advertisement expenditure divided by sales.	CMIE (Prowess)
Age of the firm (AGE)	Current year minus of year of incorporation of a firm	CMIE (Prowess)
MNES10	Value 1 to those firms which have at least 10% foreign equity participation and 0 otherwise.	CMIE (Prowess)
MNESUS	Value 1 to those firms which have headquartered located in the USA and 0 otherwise.	Company website
MNESEUROP	Value 1 to those firms which have headquartered located in European countries and 0 otherwise.	Company website
NIC-21001	Value 1 to those firms which produce medicinal substances used in the manufacture of pharmaceuticals and 0 otherwise.	CMIE (Prowess)
NIC-21002	Value 1 to those firms which manufacture allopathic pharmaceutical preparations and 0 otherwise.	CMIE (Prowess)
NIC-21003	Value 1 to those firms which manufacture ayurvedic or unani preparations and 0 otherwise.	CMIE (Prowess)
NIC-21004	Value 1 to those firms which manufacture other pharmaceutical and botanical products n.e.c. like hina powder and 0 otherwise	CMIE (Prowess)

Table 3. Descriptive Statistics

Variables	Full Sample	Domestic Firms	MNEs Based on 10% Foreign Promoters' Equity	US-based MNEs	European-based MNEs
LI	0.23129	0.22765	0.25679	0.243451	0.24080
	(1.31332)	(1.35913)	(0.93299)	(0.10823)	(0.09361)
PRODSTOCK	1.31967	0.29228	8.51141	11.35995	22.73142
	(7.83583)	(1.40052)	(20.48384)	(16.94518)	(33.62706)
PROCSTOCK	2.31872	1.08234	10.97341	23.38515	17.27077
	(9.88086)	(4.61318)	(23.41114)	(35.6537)	(24.23261)
EXP	0.20095	0.20038	0.20495	0.13917	0.07140
	(0.25857)	(0.25602)	(0.27614)	(0.25069)	(0.06967)
ADV	0.00899	0.00775	0.01765	0.02484	0.02511
	(0.02416)	(0.02415)	(0.02244)	(0.02275)	(0.02617)
TECHIMP	0.01008	0.00972	0.01262	0.00899	0.00532
	(0.04851)	(0.04815)	(0.05097)	(0.00971)	(0.01227)
AGE	27.97024	26.57483	37.7381	47.9000	51.9000
	(17.85367)	(16.87192)	(21.20780)	(16.05529)	(19.25056)
ASSET	5.60089	5.46565	6.54757	7.16157	6.81790
	(2.13002)	(2.14390)	(1.76297)	(0.92319)	(1.17326)
OBS.	**2,352**	**2,058**	**294**	**70**	**70**

Source: Authors' calculations on the basis of information available in CMIE Prowess and CGPDT.
Note: Standard deviations are shown in parenthesis.

Table 4. Correlation matrix

	LI	MS	MVS	PRODSTOCK	PROCSTOCK	EXP	ADV	TECHIMP	AGE	ASSET
LI	1.0000									
PRODSTOCK	0.0054	0.1228***	0.1673***	1.0000						
PROCSTOCK	0.0113	0.2892***	0.2322***	0.7738***	1.0000					
EXP	0.0122	0.2795***	0.2589***	–0.0284	0.0576***	1.0000				
ADV	0.0088	0.1089***	0.0780***	0.1640***	0.1416***	–0.1114***	1.0000			
TECHIMP	–0.0027	0.0341*	0.0267	0.0037	0.0259	0.1200***	–0.0234	1.0000		
AGE	–0.0227	0.2740***	0.0256	0.2034***	0.2340***	–0.1111***	0.2910***	–0.0132	1.0000	
ASSET	–0.0317	0.5676***	0.4626***	0.1387***	0.2650***	0.4345***	0.1314***	0.0933***	0.2741***	1.0000

Note: Table contains pairwise correlation coefficients. ***, ** and * denote that correlation coefficients are statistically significant at 1%, 5% and 10%, respectively.

Table 5. Durbin–Wu–Hausman (DWH) Test

Dependent Variable: LI	DWH Test
PRODSTOCK (Ho: PRODSTOCK is exogenous)	$\chi^2 = 0.48923$ ($p = 0.48430$)
PROCSTOCK (Ho: PROCSTOCK is exogenous)	$\chi^2 = 0.26472$ ($p = 0.60690$)

Note: The DWH test does not reject the null hypothesis that PRODSTOCK and PROCSTOCK are exogenous variables at any conventional significance levels.

(Geroski, 1990; Kamien & Schwartz, 1982; Levin, 1978). Thus, it is important for us to test the endogeneity of independent variables in an innovation and market power relationship. For this purpose, we conduct the Durbin–Wu–Hausman (DWH) test for endogeneity that follows a Chi-square distribution. The null hypothesis is that endogenous regressors can be treated as exogenous. The instrumental variables used for the test are one-year lagged differences of independent variables (Nguyen et al., 2014; Schultz et al., 2010). The results of the DWH test statistics are reported in Table 5. In Table 5, we find that the null hypothesis cannot be rejected at any conventional level of significance which indicates that our specified model does not suffer from the endogeneity problem. The result though surprising has been corroborated by other studies in the Indian context. For instance, Kumar and Saqib (1996), Subodh (2002), Mishra (2007), Basant and Mishra (2014) and Jagadeesh and Sasidharan (2014) report the insignificant impact of market structure on innovation. One probable explanation for this is due to higher technological gap and unfavourable business conditions for Indian firms (Bas & Paunov, 2018). As a result, insignificant competition emerges in the industry which does not drive innovation activities.

Fixed effect and random effect estimation techniques are preferred for panel data analysis. We estimate the model by fixed effect using least square dummy variable model (LSDV). Torres-Reyna (2007) states that LSDV estimates the pure impact of independent variable by controlling for the unobserved heterogeneity and it also tackles the endogeneity bias. There might be another exogenous factor (year effect and/or other firm-specific effects) which can influence the relationship. Hence, we have incorporated both year effects (dummies for each of the years in our data set) and firm-specific fixed effect (dummies for each of the firms in our data set) in the model. Year effects capture the influence of aggregate (time-series) trends in the data set. Fixed effects LSDV estimator is consistent under both the null and alternative hypothesis of the Hausman specification test.[14] Studies such as Liu et al. (2000), Amess (2002), Vaona and Pianta (2008) and Lee (2009) also employ similar estimation technique for firm-level analysis.

VI. Empirical Findings

In Table 6, we analyse the impact of technological innovations of firms' market power. In Table 4, we find that there is a significantly high correlation between

Table 6. Technological Innovation and Market Power (Dependent Variable: LI)

	I	II	III	IV	V	VI
PRODSTOCK	0.01878***	0.01889***	0.01889***			
	(0.00433)	(0.00417)	(0.00417)			
PROCSTOCK				0.01738***	0.01622***	0.01622***
				(0.00557)	(0.00519)	(0.00519)
EXP		0.07367	0.07367		0.07102	0.07102
		(0.05099)	(0.05099)		(0.05039)	(0.05039)
ADV		0.24018	0.24018		0.24114	0.24114
		(0.19443)	(0.19443)		(0.18896)	(0.18896)
TECHIMP		–0.03559	–0.03559		–0.03309	–0.03309
		(0.11950)	(0.11950)		(0.11979)	(0.11979)
SIZE		0.00671*	0.00671*		0.00630*	0.00630*
		(0.00390)	(0.00390)		(0.00389)	(0.00389)
AGE		–0.41103*	–0.41103*		–0.41090**	–0.41090**
		(0.18277)	(0.18277)		(0.18260)	(0.18260)
TRIPS2002		2.03450**	2.03450**		2.03294**	2.03294**
		(0.90433)	(0.90433)		(0.90339)	(0.90339)
TRIPS2005		3.25459**	3.25459**		3.25293**	3.25293**
		(1.46442)	(1.46442)		(1.46279)	(1.46279)
MNES10		17.37623**			17.37643**	
		(7.68088)			(7.67337)	
MNESUS			17.37623**			17.37643**
			(7.68088)			(7.67337)
MNESEUROP			13.60535**			13.61513**
			(6.03757)			(6.03188)

(Table 6 continued)

(Table 6 continued)

	I	II	III	IV	V	VI
NIC-21001		–0.81265**	–0.81265**		–0.81226**	–0.81226**
		(0.36148)	(0.36148)		(0.36115)	(0.36115)
NIC-21002		1.13937**	1.13937**		1.13670**	1.13670**
		(0.56010)	(0.56010)		(0.55939)	(0.55939)
NIC-21003		18.00021**	18.00021**		17.99023**	17.99023**
		(8.05131)	(8.05131)		(8.04341)	(8.04341)
CONSTANT	0.18288***	3.45197**	3.45197**	0.18454***	3.45346**	3.45346**
	(0.06186)	(1.46545)	(1.46545)	(0.06175)	(1.46435)	(1.46435)
Year effect	YES	YES	YES	YES	YES	YES
Firm fixed effect	YES	YES	YES	YES	YES	YES
OBS.	2,352	2,352	2,352	2,352	2,352	2,352

Notes: Robust standard errors are shown in parenthesis. Here, ***, ** and * denote that coefficients are statistically significant at 1%, 5% and 10%, respectively. Time and firm-specific dummies have been incorporated in the models.

PRODSTOCK and PROCSTOCK. Utilization of both the variables together in the regression analysis may lead to the problem of multicollinearity. Hence, we estimate the impact of PRODSTOCK and PROCSTOCK separately. Columns I–III present the estimated coefficients of PRODSTOCK whereas the estimated coefficients PROCSTOCK are reported in Columns IV–VI. In Columns I–III, we find that the impact of PRODSTOCK is positive and significant. This result indicates that pharmaceutical firms' which are active in product innovation are more profitable; hence, enjoy the monopoly. Similarly, the impact of process innovation is also positive and significant as the coefficients of PROCSTOCK are positive and significant in Columns IV–VI. Patenting is an important in-house technology creation activity which leads to sustainable competitive advantage for firms. This finding also corroborates with other studies such as Raut (1995), Sharma (2012), Ambrammal & Sharma (2016) and Khachoo et al. (2018) on innovation and firm performance relationship in the Indian context.

With respect to patent policy change, we find that TRIPs have a positive and significant impact on firms' market power. Both the coefficients of TRIPS2002 and TRIPS2005 are positive and significant which highlight that the Patent (Amendment) Act 1999 and the Patent (Amendment) Act 2002 are beneficial for Indian pharmaceutical firms. Changes in the policy positively influence firms' incentive to engage in innovation activities. With the implementation of TRIPs, R&D and patenting activities in the developing countries have been increased. Firms have become competitive in the new patent regime (Bhattacharjea & Sindhwani, 2014). A study by Sharma et al. (2018) suggests that TRIPs brings positive changes in innovation performance of Indian firms through an increase in the protection duration, enforcement mechanism and membership into the international convention. This result corroborates the finding of Chadha (2009), Haley and Haley (2012) and Jagadeesh and Sasidharan (2014).

While analysing the impact of MNEs on market power, we find that the coefficient of MNES10 is positive and significant in Columns II and V which suggests that MNEs based on 10 per cent foreign promoters' equity participation are dominating the drug market and enjoying more profits. In Columns III and VI, we have classified MNEs on the basis of their country of origin. Both the coefficients of MNESUS and MNESEUROP are positive and significant. This result suggests that the US and European MNEs are more profitable and have a leading position in the market. Moreover, we also note that the coefficient of MNESUS is higher than MNESEUROP which means US-based MNEs are enjoying more monopoly than European MNEs. MNEs utilize updated technology to dominate the market by conducting both technology exploring and technology exploiting activities in the developing countries. Under product patent regime, MNEs have re-gained their market dominance and secured leading positions in the market. A study by Chaudhuri (2012) also shows that after TRIPs compliant changes, 50 per cent of the products patented after 1995 were marketed by MNEs. These accounted for 20 per cent of total patented products in 2010.

While analysing the impact of product group dummies on firms' market power, we find that the coefficient of NIC-21001 is negative and significant in Columns II, III, V and VI. The negative coefficient of NIC-21001 suggests that firms which

Table 7. Technological Innovation and Market Power (Result Based on Interaction Terms)

	I	II	III	IV	V	VI
PRODSTOCK* MNES10	0.013851***	0.01530***				
	(0.00393)	(0.00416)				
PROCSTOCK* MNES10				0.00937**	0.01014***	
				(0.00362)	(0.00388)	
PRODSTOCK* MNESUS			0.02264***			
			(0.00696)			
PROCSTOCK* MNESUS						0.01396**
						(0.00615)
PRODSTOCK* MNESEUROP			0.01207***			
			(0.00427)			
PROCSTOCK* MNESEUROP						0.01363***
						(0.00466)
EXP		0.00416	0.07749		0.07612	0.07697
		(0.05098)	(0.05095)		(0.05105)	(0.05095)
ADV		0.25149	0.24918		0.26181	0.25772
		(0.19835)	(0.19817)		(0.19853)	(0.19804)
TECHIMP		–0.03480	–0.03512		–0.03554	–0.03544
		(0.11986)	(0.11983)		(0.12004)	(0.11998)
SIZE		0.00672*	0.00676*		0.00644*	0.00664*
		(0.00395)	(0.00396)		(0.00395)	(0.00396)
AGE		–0.41084**	–0.41083**		–0.41066**	–0.41075**
		(0.18300)	(0.18306)		(0.18302)	(0.18308)
TRIPS2002		2.03349**	2.03337**		2.03260**	2.03291**
		(0.90547)	(0.90577)		(0.90557)	(0.90587)

TRIPS2005		3.25716**	3.25721**		3.25698**	3.25733**
		(1.46651)	(1.46702)		(1.46664)	(1.46718)
NIC-21001		–0.81244**	–0.81245**		–0.81207**	–0.81229**
		(0.36190)	(0.36201)		(0.36193)	(0.36205)
NIC-21002		1.13847**	1.13842**		1.13813**	1.13828**
		(0.56089)	(0.56108)		(0.56099)	(0.56117)
NIC-21003		17.99209**	17.99158**		17.98398**	17.98806**
		(8.06147)	(8.06410)		(8.06245)	(8.06505)
CONSTANT	0.18071***	3.44856**	3.44825***	0.18034***	3.44754**	3.44771**
	(0.06213)	(1.46711)	(1.46758)	(0.06220)	(1.46728)	(1.46775)
Year effect	YES	YES	YES	YES	YES	YES
Firm fixed effect	YES	YES	YES	YES	YES	YES
OBS.	2,352	2,352	2,352	2,352	2,352	2,352

Notes: Robust standard errors are shown in parenthesis. Here ***, ** and * denote that coefficients are statistically significant at 1%, 5% and 10%, respectively. Time and firm-specific dummies have been incorporated in the models.

are active in bulk drug production are less profitable (around 0.81% lower profitable) in comparison to reference category firms (NIC-21009). Further, the coefficients of dummy variables NIC-21002 and NIC-21003 are positive and significant which means firms which are operating in drug formulation categories are dominating the market.

With respect to control variables, we find that the coefficient of SIZE is positive and significant. This reveals that large firms enjoy more monopoly due to availability of resources and stability, in line with the results of Cohen and Levinthal (1989) and Katrak (1990). The coefficient of AGE is negative and significant which reveals that younger firms are more profitable.[15] We find that the coefficients of EXP, ADV and TECHIMP are insignificant.

Results presented in Table 6 show the aggregate impact of patenting on firms' monopoly power. However, in the Indian context, large numbers of studies show that the innovation performance of MNEs is superior to Indian domestic firms. Moreover, empirical results presented in Table 6 also highlight that MNEs are enjoying more monopoly power in the Indian market. The descriptive statistics of this study also highlight that MNEs are patenting more. Hence, it is important for us to analyse the impact of patenting on monopoly power for MNEs. For this purpose, we interact patent stock variables with MNEs dummies. First, we interact product patent stock with MNEs, that is, PRODSTOCK*MNES10, PRODSTOCK*MNESUS and PRODSTOCK*MNESEUROP. Second, the process patent stock is interacted with MNEs, that is, PROCSTOCK*MNES10, PROCSTOCK*MNESUS and PROCSTOCK*MNESEUROP. Results of these interaction terms are presented in Table 7. In Columns I and II, the coefficient of PRODSTOCK*MNES10 is positive and significant at 1 per cent level. This result highlights that MNEs are significantly enjoying monopoly power through product innovation. Similarly, the coefficients of PRODSTOCK*MNESUS and PRODSTOCK*MNESEUROP are also positive and significant which reveal that both the US- and European-based MNEs are also dominating the Indian pharmaceutical market by product-based innovations. In Columns IV and V, the impact of PROCSTOCK*MNES10 is positive and significant. In Column VI also, the coefficients of PROCSTOCK*MNESUS and PROCSTOCK*MNESEUROP are positive and significant.

VII. Conclusion

This study analyses the impact of technological innovations (product and process) on the market power of Indian pharmaceutical firms. Granted product and process patents are utilized to generate patent stocks, a firm-level proxy for innovation. Primarily, this study concludes that both product and process innovations are the potential sources of market power under the TRIPs regime. The empirical findings also reveal that there is a positive and significant influence of MNEs on firms' market power. MNEs from US and European countries are dominating the drug market. The results also reveal that firms which are active in the drug formulation business hold a strong position in the drug market. We also find a significant impact of size, export and age on firms' market power.

We believe that our results have significant policy implications. Under the TRIPs regime, there is a debate on conduct and performance of firms in the developing countries. In this study, we find a strong positive relationship between patenting and market power; hence, firms in the developing countries should focus on in-house technology creation (R&D & patenting) to improve their market performance. This study also highlights that MNEs enjoy more market power. Thus, there is a need to devise appropriate incentive mechanisms for domestic firms so that they can become more competitive. For example, the R&D tax credit scheme in India was introduced in 2001 (and further amended in 2011). However, such schemes are horizontal in nature as the eligibility conditions only consist of Department of Scientific and Industrial Research affiliation and the availability of an in-house R&D centre. As we know, the market is dominated by large firms which are already innovation-intensive firms. Hence, there is a need to develop separate innovation incentive schemes/policies for small and laggard firms. Other measures such as compulsory licensing and parallel imports can be used to maintain a healthy competition in the market. Compulsory licensing can maintain imitation dynamics of domestic firms which were present during the process patent regime.

A limitation of this study is to utilize patent as a measure of innovation output that does not adjust for the patent quality. The focus of the current study is the Indian pharmaceutical industry only. Further research can be conducted by incorporating the whole manufacturing sector to provide more thorough picture of MNEs behaviour in different industrial segments. A cross country analysis is also possible to check whether the conduct of MNEs is different emerging economies. The main objective of this article has been to analyse the impact of technological innovations, that is, product and process innovations of firms monopoly power. Technological innovations are directly linked with firms' monopoly power as they are directly associated with pricing and cost structure of a firm. However, non-technological aspects of innovation, that is, organizational and marketing innovations can be also explored in the future.

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Appendix A

Table A1. Variance Inflation Factor (VIF)

Variables	VIF	VIF	VIF
PRODSTOCK	3.38	1.15	–
PROCSTOCK	3.89	–	1.33
EXP	1.42	1.40	1.40
ADV	1.13	1.13	1.12
TECHIMP	1.02	1.02	1.02
SIZE	1.68	1.56	1.66
AGE	1.29	1.27	1.29
Mean VIF	1.97	1.26	1.31

Note: Low values of VIF indicate that there is no serious multicollinearity among the independent variables.

Table A2. Year-wise Average Granted Patents of MNEs and Domestic Firms

Year	Full Sample	Domestic Firms	MNEs Based on 10% Foreign Promoters' Equity	US-based MNEs	European-based MNEs
2000	0.059	0.013	0.380	1.600	0.000
2001	0.059	0.013	0.380	1.600	0.000
2002	0.059	0.027	0.285	1.200	0.000
2003	0.130	0.054	0.666	2.800	0.000
2004	0.136	0.047	0.761	3.200	0.000
2005	0.601	0.156	3.714	15.200	0.000
2006	1.107	0.312	6.666	19.200	4.600
2007	2.154	0.843	11.333	22.000	19.600
2008	2.113	0.850	10.952	19.600	22.200
2009	1.904	0.612	10.952	22.600	20.400
2010	1.416	0.612	7.047	16.600	10.200
2011	1.345	0.612	6.476	15.000	10.800
2012	1.214	0.421	6.761	15.800	8.800
2013	1.160	0.639	4.809	9.800	7.600
OBS.	2,352	2,058	294	70	70

Source: Authors' calculations on the basis of information available in CMIE Prowess and CGPDT.

Table A3. Technological Innovation and Market Power (Estimating Nonlinear Impact of Age)

	I	II
PRODSTOCK	0.00917**	
	(0.00377)	
PROCSTOCK		0.00629
		(0.00405)
EXP	0.07496	0.07421
	(0.05089)	(0.05039)
ADV	0.15831	0.16212
	(0.18318)	(0.18037)
TECHIMP	–0.03459	–0.03372
	(0.11882)	(0.11898)
SIZE	0.00803**	0.00782**
	(0.00375)	(0.00374)
AGE	–0.41499**	–0.41490**
	(0.18172)	(0.18167)
AGE^2	0.00011***	0.00011***
	(0.00002)	(0.00002)
TRIPS2002	2.02690**	2.02597**
	(0.89676)	(0.89658)
TRIPS2005	3.23519**	3.23464**
	(1.45160)	(1.45122)
NIC-21001	–0.81460**	–0.81435**
	(0.35927)	(0.35918)
NIC-21002	1.14032**	1.13911**
	(0.55524)	(0.55507)
NIC-21003	17.82189**	17.81411**
	(7.97439)	(7.97337)
CONSTANT	3.49005**	3.49021**
	(1.45815)	(1.45780)
Year effect	YES	YES
Firm fixed effect	YES	YES
OBS.	2,352	2,352

Notes: Robust standard errors are shown in parenthesis. Here, ***, ** and * denote that coefficients are statistically significant at 1%, 5% and 10%, respectively. Time and firm-specific dummies have been incorporated in the models.

Notes

1. Patents rights are territorial in nature; hence, patents granted by Indian Patent Office (IPO) are effective only in India. To seek patent protection in other countries, a separate patent application can be filed in the patent offices of respective countries. There are also other ways like Patent Cooperation Treaty (PCT) through which a patent can be filed in multiple countries (known as international patent application). International patent application can be filed through national patent office or directly through WIPO.
2. See for instance, Aghion et al. (2005), Tingvall and Poldahl (2006), Correa (2012), Polder and Veldhuizen (2012), Inui et al. (2012), Hashmi (2013), Correa and Ornaghi (2014), Beneito et al. (2017) and Negassi et al. (2018) for one-way relationship between innovation and market structure.
3. Studies such as Lunn (1986), Albert (1995) and Koeller (1995), discuss a two-way relationship between innovation and market structure.
4. See for instance, Kumar and Saqib (1996), Subodh (2002), Mishra (2007), Basant and Mishra (2014), Jagadeesh and Sasidharan (2014) and Bas and Paunov (2018). These studies provide the potential reasons for not finding significant impact of competition on innovation.
5. In India, drug approval process is controlled by the Central Drugs Standard Control Organization (CDSCO) under Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India. The functions of CDSCO are parallel to the Food and Drug Administration of the USA (USA–FDA). Similarly, labelling of drugs is also uniquely defined in India under the Drugs and Cosmetics Act, 1940 and the Drugs and Cosmetics Rules, 1945.
6. This discussion is based on 2019 report of India Brand Equity Foundation.
7. Firms such as NPIL, Sun Pharma, Lupin and Cipla follow vertical integration model.
8. As per Section 107 A(b) of the Patent (Amendment) Act 2005, 'importation of patented products by any person from a person who is duly authorized under the law to produce and sell or distribute the product' is not an infringement.
9. According to transaction cost theory, international operations of MNEs depend upon firm-specific advantages (FSAs), country-specific advantages (CSAs) and international advantages (Dunning, 1988; Rugman & Verbeke, 1992, 2003; Patra & Krishna, 2015). FSAs are ownership-specific advantages which include R&D, patenting, firm size, experience and marketing knowledge. CSAs refer to government regulations and infrastructure related advantages which MNEs enjoy by locating their economic activities in a particular country. International advantages are associated with export, import, FDI, joint ventures and licensing activities.
10. MNEs perform three types of R&D: adaptive R&D, product development for the local market; and, product and process development for the global market (Reddy, 1997). Moreover, high-end R&D that requires a specialized workforce usually in limited supply in developing countries can also be acquired by employing home country innovators to train local innovators (Branstetter et al., 2018).
11. Given these limitations, researchers measure the quality of patents by using citation weighted count to resolve the heterogeneity problem (Hall et al., 2005). Indian Patent Office (IPO) does not require applicants to cite thus the present study relies on the number of granted patents to calculate patent stock.
12. In this study, we construct stock of product patent (PRODSTOCK) and process patent (PROCSTOCK) based on granted patent to measure firm-level innovation activity. Patent stock is calculated by employing perpetual inventory method. We calculate patent stock as: $PATSTOCKit = PATENTit + (1 - \delta)\ PATSTOCKt-1$, where

PATSTOCKit is the stock of patent, PATENTit is the number of patent granted to firm, δ is the depreciation rate which is 15 per cent in our case, PATSTOCKt−1 is the previous year patent stock.

13. We find that certain firms such as Astrazeneca, Novartis and Sanofi have more patent grant; hence, both average patent stock and variance for European-based MNEs are higher in comparison to other MNEs.
14. The null hypothesis of the Hausman test is that that there is no systematic difference in random effects and fixed effects coefficients (Greene, 2003).
15. We have also estimated nonlinear impact of age on the monopoly power and reported results in Table A3.

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