FDI cluster, Technology and export performance of the Pharmaceutical firms in India.

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Abstract

The paper aims to investigate the impact of FDI clusters and technology, assessed by technological efforts and technological outcomes, on the export performance of pharmaceutical firms in India. Technological efforts are divided into three categories: in-house R&D efforts of the firms, capital goods imports, and raw material imports. The number of patents granted to pharmaceutical firms and the number of US FDA-approved drug files received by pharmaceutical firms have been used as an indicator of technological outcomes for the current study. FDI spillovers at the regional clusters in India are calculated as spillovers generated from the R&D activities of multinational firms. In addition to these variables, other firm-level characteristics, such as firm age, firm size, and profitability are taken from the CMIE Prowess IQ database for 318 pharmaceutical firms in India between 2005 and 2020. The econometric analysis is carried out by applying Heckman's two-stage method to account for endogeneity issues and probable bias in sample selection. The result highlights the importance of technological efforts, technological outcomes, along with other firm-specific characteristics on the decision to export and export intensity of pharmaceutical firms in India. Furthermore, the econometric exercise shows that domestic and multinational firms that are located in close proximity benefit more from the foreign R&D spillovers for exporting.

JEL: C51, F14, F23, L1, L25, M16, O31, O32

Keywords: FDI cluster, exports, Patents, Pharmaceutical sector

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1. Introduction

The export and Foreign Direct investments (FDI) have been identified as one of the most important channels for a firm's internationalization process by the empirical literature on international economics. In one of his pioneering works, Vernon (1992) developed his productlife cycle theory to help firms decide whether to export a given product or engage in the direct production of the product abroad through the route of FDI. When a product gets standardised and a firm loses its monopolistic advantage over it, it typically becomes more profitable for an innovative firm to export the product into international markets, making production abroad less desirable. Another reason why firms choose exports over FDI is the relatively low costs and risks involved with exporting compared to firms choosing to set up production facilities abroad.

The factors that affect the export performance of firms in developed and advanced economies have been the subject of numerous empirical studies, but relatively few studies have focused on the export performance of firms in developing and emerging economies. Researchers' interest in studying the exporting firms' behaviour in high-tech and knowledge-driven industries, such as chemicals, pharmaceuticals, electronics, and information technology, with an emphasis on developing and emerging markets, has grown over time. Hence, past studies on the export competitiveness of Indian industries have mostly concentrated on sectors like the information technology industry and the Basic chemical industry in the case of emerging countries like India [Aggarwal (2002); Siddharthan and Nollen (2004); Majumdar (2010)].

Indian pharmaceutical industry has become more relevant over the past two decades, with considerable domestic and global market expansion. Consequently, a plethora of empirical research has been carried out to identify the factors that are driving the exports of pharmaceutical firms in India [Bhaduri and Ray (2004) and Chaddha (2009)]. Furthermore, with the enactment of the Patent Amendment Act 2005, there has been a significant increase in the in-house R&D efforts and firms' innovation activities, making it an ideal sector to examine the exporting behaviour of pharma firms post-2005 and also analyse the role of technological efforts as well as technological outcomes in explaining the variations in the exporting strategies of the firms. Only a small number of researchers have examined how firms' innovation, measured through the number of patents granted to firms, affects export volume. [Rentala et. al (2014); Tyagi and Nauriyal (2017)]. The existing literature on the export intensity of the firms in India has mainly focussed on the role of technological efforts measured by in-house R&D efforts, import of capital goods, and raw materials, while the study on how technological outcomes affect the export performance of the manufacturing firms still needs to be explored. Therefore, this paper in addition to technological efforts also tries to analyse how technological outcomes affect pharmaceutical firms' decision to export as well the export intensities. Technological outcomes in the current study are captured through two variables, the number of patents granted to firms which is included as a catch-all variable, and the other variable used is US FDA-approved drug files which is a pharmaceutical sector-specific variable.

During the last two decades, India witnessed multinational and domestic firms co-existing in the same region, possibly forming clusters. Co-existence in the same cluster could compel the domestic firms to catch up with the multinational firms through in-house R&D efforts and the

resultant technological outcomes. Additionally, the data on the region-wise breakdown of FDI equity inflows in the Drugs and Pharmaceutical sector, also shows that between 2000 to 2018, states including Gujarat, the NCT of Delhi, Karnataka, Maharashtra, and Telangana have collectively received almost 48%[1] of FDI inflows. It can be argued that multinational firms choose to locate in these states where agglomeration economies and clusters are created at the regional level which aids multinational firms in lowering the fixed costs connected with local production as well as transportation costs connected with exporting. Further, the geographical proximity of domestic firms and multinational firms could also help domestic firms to reap benefits from R&D spillovers from multinational firms. Therefore, in the present analysis, we make an attempt to assess the role of location in the FDI cluster on both the decision to export and the export intensity of the pharmaceutical firms in India.

A brief overview of the Pharmaceutical sector in India

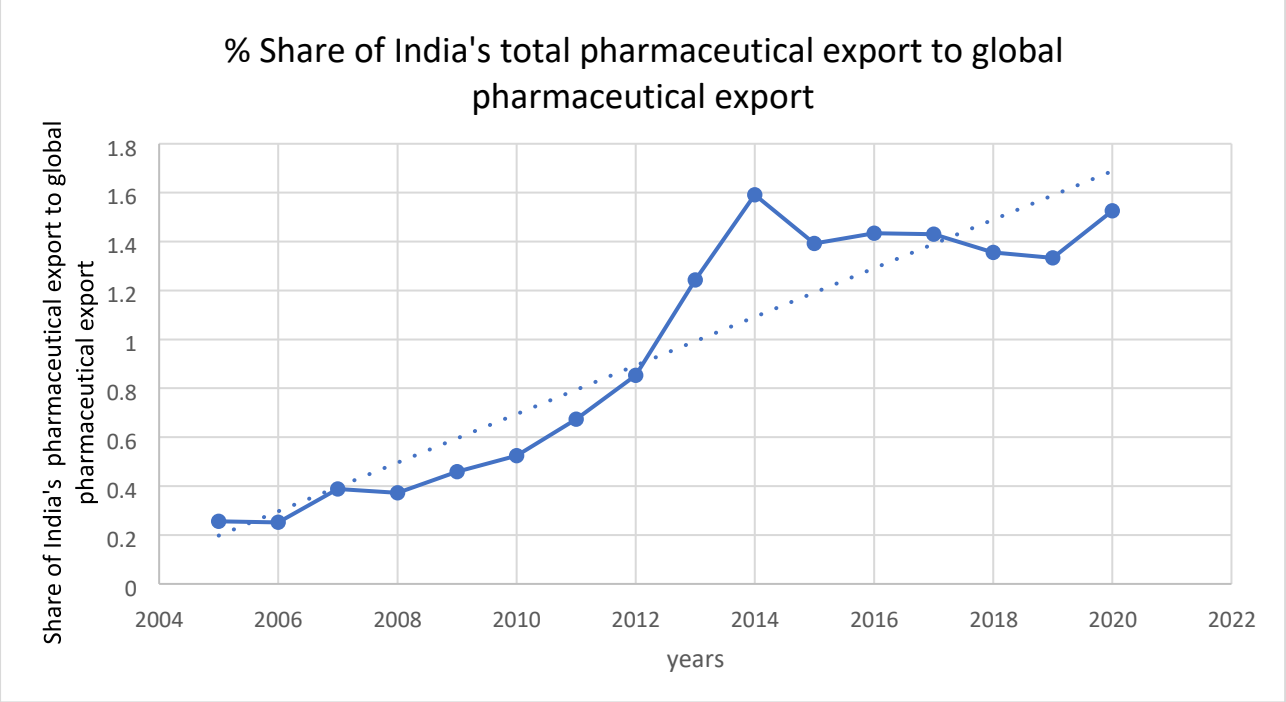
The pharmaceutical industry was largely dependent on imports up until the early 1970s, and multinational enterprises /firms from developed countries dominated the market. Following India's economic liberalisation in the 1990s, the sector has shown phenomenal growth in terms of profit margin product diversity, affordable pharmaceutical products, and growing pharmaceutical export share in India's overall export basket. Indian pharmaceutical firms have developed technological capabilities through the process of reverse engineering, which has had a significant impact on both the economic and social aspects (Bhaduri and Ray, 2004). This paved the path for the pharmaceutical sector to quickly become self-sufficient and self-reliant by lowering drug prices for the general public. Additionally, according to the annual report (2020) published by the Department for Promotion of Industries and Internal Trade (DPIIT), the sector is one of the few in India to have been successful in creating a trade surplus as pharma the exports accounted for US$20.7 billion and imports at US$ 2.31 billion in the financial year 2020, and it drew cumulative FDI inflows worth US$16.54 billion between April 2000 and June 2020. The industry has also been effective in creating jobs and now, it directly or indirectly employs approximately 2.7 million people in the country. Another factor contributing to the industry's increased innovativeness and the improved export performance of Indian pharmaceutical firms is the strategic shift from process patents to product patents that occurred with the enactment of the Patents (Amendment) Act in 2005. Due to this shift, internal R&D investment became more significant among firms, with the majority of them investing in generic drug development. All these factors led India to rose to the top of the generic drugs market globally, earning it the moniker "Pharmacy of the World" (IBEF, report 2020). The composition of drug formulations and biologicals in the total pharma export from India is around 74.72% followed by bulk drugs and drugs intermediaries which account for 20.49% (Annual report of Pharmaceutical Export Promotion Council of India, 2020). The top four major export destinations for pharma products from India are the USA, the U.K., South Africa, and Russia.

The following figure plot the graph of the percentage share of India’s total pharmaceutical export with the global pharmaceutical export. With the exception of 2007 and 2008, when the proportion of pharmaceutical export from India deaccelerated, the percentage share of India's

[1] Based on the Annual report of FDI inflows in India (2019), DPIIT

pharmaceutical export in the world's post-2005 pharmaceutical export saw an increasing trend in terms of export growth throughout the years 2005 to 2014. However, after reaching its pinnacle in 2014, there has been a slowdown in export growth that can be attributed to the period of the global recession as well as the reduction in overall international trade. Further, the impacts of demonetization in India in 2015, India's pharma export to global pharma the export fell, coupled with increased competition from other Asian nations and other market conditions. The export share of India in total global pharma export again in 2019 and afterward showed a steady increase, and the increase is largely driven by the shipment of generic medications to more than 200 nations (including both developed and developing markets).

Figure 1. Share of India's total pharmaceutical export to global pharmaceutical export between 2005 to 2020



Source: International Trade Statistics, UN COMTRADE

This paper is structured as follows, Section 2 briefly looks at the extant empirical literature focusing on the relationship of various firm-level characteristics, along with the role of technology, innovation, and international competitiveness in the export performance of the firms. Section 3 explains the data set, the construction of variables used in the analysis, the empirical methodology, and the estimation procedure. Followed by Section 4 which analyses trends in the exports, patents, and the FDI cluster and compares firms' performance across regions in terms of important metrics such as patenting activities, export intensity, internal R&D activities, etc. The results estimated from Heckman's two-stage model are then discussed in section 5 of the paper. Finally, Section 6 summarizes the findings and concludes the paper.

2. The extant empirical literature

In this section, we look into the empirical literature to identify the possible determinants of the exporting behaviour of the firms. In particular, we highlight some selected studies conducted on the export performance of the firms belonging to manufacturing sectors in India. We also review a few studies that attempt to evaluate the impact of FDI spillovers on local enterprises' performance in the host nations at the regional or industrial cluster levels.

The neo-technological theory of trade has started to view technology and innovation as the main driving forces in international trade, especially in high-technology-driven industries like Chemical, Information technology, and pharmaceutical. As a result of the increasing significance of technology in global trade flows. As, a result, the relationship between technology and the export performance of firms has been closely examined in a wide range of empirical studies. According to the research conducted by Bernard *et al*. (2007), United States exports are more concentrated in capital- and skill-intensive than labour-intensive industries.

Over the years, developing nations like India have evolved technologically, particularly in the pharmaceutical industry where an increasing number of firms have started producing globally competitive pharmaceutical goods at a lower cost and also boosted their in-house R&D spending. The majority of these studies identified various technology acquisition channels, either through direct technology transfer from parent firms to their subsidiaries in the host countries or through the import of technologies by domestic firms, in order to investigate its impact on the exporting behaviour of the firms. The most commonly used forms of technology in the econometric analysis of these studies are – the import of embodied and disembodied technology, payment of license fees, and in-house R&D activities of firms. One of the earlier findings by Kumar and Siddharthan (1994) demonstrates that the technological activities measured as the import of technology and in-house R&D efforts positively influence the export behaviour of the firms in the medium and high technology industries. Thus, in high technologyintensive industries, an exporting firm's in-house R&D efforts combined with the import of technology (capital goods) gives the firm a competitive edge over its rivals and subsequently has a beneficial impact on their export intensity.

Later, Bhat and Narayanan (2009) look into the factors that determine the export behaviour of the firms in the Basic chemical industry in India between 2001 to 2007. Using econometric tools like Probit and Tobit model and the Heckman-two-step model, the authors confirm the positive influence of the firm size variable on export intensity while the negative influence on the probability of the firm’s decision to export. Other factors like the import of capital, raw materials, and in-house R&D activities of the firm were also found to have a positive influence on both the decision to export and the export intensities. The authors further conclude that Heckman’s two-step model is the more appropriate method to study the export performance of firms.

Some researchers apart from the import of capital goods and the export performance also attempted to investigate the relationship between raw material imports and the exporting activities of the firms and find that importing the exporting of raw materials helps the exporting firms by giving them access to more intermediate resources so that they can improve productivity and introduce new products [Goldberg, (2010) and Aristei *et al*, (2013)].

In recent times, numerous studies have been done on the Indian pharmaceutical industry to evaluate the impact of technology on the export performance of pharma firms. In their seminal work, Bhaduri and Ray (2004) also attempt to examine the role of the technological capability of the firm and its impact on the exporting behaviour of the firms belonging to the Pharmaceutical and Electrical/Electronics industries. The authors broadly define technological capabilities as the combination of know-how-oriented technological learning (production engineering) and know-why capabilities (reverse engineering). The study apart from the technological capabilities also included various firm-level characteristics such as ownership, raw materials, size of the firm, and age of the firm in the model. The empirical findings from the study suggest that raw materials and foreign dummy positively affect the export intensity the pharmaceutical firms. While in the case of the Electrical/Electronic industry the know-how variable only turned out to be positively influencing export intensity while the coefficient of firm age showed a negative impact on export intensity.

The literature on FDI spillovers has often pointed out how the presence of multinational firms in an economy indirectly affects the performance of domestic firms through the channels of vertical spillovers (inter-industry) and horizontal spillovers (intra-industry). However, relatively few studies look at the influence of FDI spillovers on domestic firms' exporting behaviours. In one such study, Barrios *et al*., (2003) examine the effect of foreign R&D spillovers on the export performance of Spanish manufacturing industries exporting to OECD countries from 1990 to 1998. The authors conclude that the more the degree of R&D spillovers from multinational firms in R&D-intensive industries, the greater the productivity and efficiency of domestic firms, improving their positions in foreign markets as their products become of better quality and are able to compete with other products there. Over the years, a number of studies have found positive spillovers effects from the presence of multinational firms on the exporting behaviour of domestic firms in the host nations (in cases where multinational firms belong to the same industry as well as those belonging to different industries). Greenway *et al*., (2004) also observe the positive influence of R&D spillovers from MNE (multinational enterprises) on the probability of UK firms deciding to export, Pisu (2007) observe positive spillovers from MNEs on the export performance of British manufacturing firms between the period 1991-1992, Barios *et al.*, (2003) in the case of Spanish manufacturing firms between 1990-1998, and Franco and Sasidharan (2010) in the case of Indian manufacturing the exporting firms for the time period 1994 to 2006. In contrast to these findings, Kim and Choi (2019) report negative R&D spillovers from MNEs on the domestic firms' export performance in the example of South Korea. The paper contends that the R&D activities of multinational firms have two effects: the first is the positive technological spillover impact, which raises domestic firm productivity; the second is the competitive effect, or "business stealing effect," which lowers domestic firm productivity. Thus, the magnitude of these two impacts determines the direction of spillovers. Their findings suggest that negative spillovers are more pronounced for firms with lower levels of absorptive capacity compared to those with higher levels and that as a firm reaches a certain threshold level of absorptive ability, these negative spillovers from multinational firms ' R&D activities become unimportant.

The majority of the empirical studies on FDI R&D spillovers measured spillover effects at the national level and often neglected the benefits arising from spillovers to domestic firms at the

regional. Later, the advancement in communication and transportation technologies stimulated empirical research on the influence of geographical proximity on firm innovation, and also, in the past few decades, many economic geographers and regional scientists have tried to study the degree localization or concentration of FDI spillovers in the host nation [Jaffe *et al.* (1993); Fosfuri and Motta (1999); Driffield *et al.* (2014)]. This stance of the literature identified two forms of knowledge – tacit knowledge and codified knowledge. Tacit knowledge involves know-how and requires certain background to reap benefits from them and greater proximity between firms facilitates this transfer of knowledge as compared to codified knowledge which can be transferred easily. One of the key conclusions that can be drawn from these studies is the significance of domestic firms' technological and absorptive capabilities, which are necessary for enterprises to learn specifics about the market circumstances of the overseas markets by conducting market research, which necessitates significant investments. As emphasized by Aitken *et al*., (1997) when the multinational firms and domestic firms are located in the same industry then domestic may benefit from the activities of multinational firms through the transfer of knowledge from the former while examining the extent and degree of FDI spillovers on the exporting behavior of the Mexican firms. The authors conclude that the export spillovers from the export activities of multinational firms also enhance the probability of domestic firms' decision to export and export intensity. They further argue that if the export-oriented domestic and multinational firms are located in closer geographical proximity then the degree of the export spillovers is high and has a positive impact on the probability of a domestic firm's decision to export.

Another study by Behera *et al.* (2012) measure the influence of multinational firms ' activities on the overall productivity of Indian manufacturing firms situated in the industrial cluster in India. The study identified various industrial clusters belonging to the two broadly defined clusters such as the NCR and Southern region clusters. They further calculate the foreign spillovers by taking the share of the foreign firms' output share to the total industrial share output region-wise. The authors conclude that FDI spillover effects are more pronounced for domestic high-technology intensive firms that are located close to foreign firms, situated in industrial clusters than for those that are located farther away.

In the case of Chinese manufacturing industries, Wang and Wu (2016) find that the degree of knowledge spillovers from multinational firms in the host country decays with the increased geographical distance between domestic Chinese firms and multinational firms. To measure the agglomeration or cluster effect of FDI knowledge spillover on domestic firms' innovation, the author calculated FDI spillover as the share of aggregate output produced by multinational firms in the total region's output.

The following table summarises the findings from selected studies on the determinants of firms' export performance.

Table 1. Summary of selected literature review on the determinants of the export performance

Author(s)	Sector	Dependent Variable	Methodology	Main Independent Variables	Results/key findings
Kumar and Siddharthan (1994)	Indian manufacturing Industries	Export Intensity	Tobit Model	Firm size, in-house R&D activity, technology import, skill intensity, capital intensity, profitability, advertising intensity, MNE association	R&D intensity (+), Skill intensity (+), technology (+), Inverted U-shape of frim size for rubber, paper, electrical and non-electrical industry, and (-) for cement industry
Aitken *et al.* (1997)	Mexican manufacturing firms	Decision to export	Two-stage Probit Model	Plant size, MNE the export, wages, royalty payment, foreign distribution cost, Industry concentration, output tariff, and input tariff	Positive export spillovers from the presence of MNEs
Barrios *et. al.* (2003)	Spanish manufacturing firms	Export Intensity	Tobit Model	Age, firm size, wage, domestic R&D intensity, MNE R&D intensity, domestic export, MNE the export, Wage, productivity	Age (+), Productivity (+), MNE R&D intensity (+), the export (+)
Bhaduri and Ray (2004)	Indian Pharmaceutical & electrical/electronic firms	Export Intensity	Tobit Model	Age, Foreign dummy, private ownership dummy, raw material imports, capital import, R&D stock, know-how, and know-why variable	Pharma: Raw Import (+), know-how variable (+), and Foreign dummy (+) Electronic: know-how variable (+), Age (-)
Greenway *et. al.* (2004)	UK manufacturing firms	Decision to export, export Intensity	Heckman Model	Producer price index, foreign R&D spillover, employee spillover, export spillover, shareholder's fund and turnover ratio, fixed asset per employee	Foreign R&D spillovers (+), wage and turnover ratio (+), fixed asset per employees (-)
Siddharthan and Nollen (2004)	Indian information services firms	Export Intensity	Tobit Model	Technology imports, firm size, raw material imports, FDI, capital Import	Technology import (-), FDI (+), Firm size (+), capital import (-)
Kneller and Pisu (2007)	British manufacturing firms	Decision to export, export Intensity	Heckman two-step model	Technology spillovers, FDI R&D spillovers, log of employment	Technology spillovers(+), past decision of the export (+), wage (+) DFI R&D spillover (-)

Bhat and Narayanan (2009)	Basic chemical sector in India	Decision to export, export Intensity	Two-part model, Tobit Model, Heckman two-step model	Size, age of the firm, technology, advertising intensity, outsourcing intensity, R&D intensity, raw material import, import of capital goods	R&D intensity (+), import of capital goods (+), raw material imports (+), Age (-)
Chaddha (2009)	Indian Pharmaceutical firms	Export Intensity	Arellano and Bond GMM method	Profit, size, age, foreign patents granted to domestic firms, lagged the export	Lagged the export (+), Profit (+), Age (+), Foreign Patents (+), firm size (+)
Franco and Sasidharan (2010)	Indian Manufacturing firms	Decision to export, export Intensity	Heckman two-step model	Size, age, R&D intensity, wage intensity, lagged the export decision, FDI R&D spillover, the export spillover, wage spillover, Profit, royalty imports	Age (-), FDI R&D spillover (+), Wage spillover (-), royalty import (+)
Tyagi and Nauriyal (2017)	Top 91 domestic Indian Pharmaceutical firms	Export Intensity	Arellano and Bond GMM method	Age, R&D intensity, Patent count, size, import of capital	Age (+), R&D intensity (+), Patent counts (+), import of capital (+)
Kim and Choi (2019)	South Korean Manufacturing firms	Decision to export, export Intensity	Probit and Tobit Model	Age, R&D intensity, number of employees, foreign capital share, FDI R&D spillover, and productivity	Age (+), R&D intensity (+), productivity (+), FDI R&D spillover (), foreign capital share (+)

Source: Authors' own compilation

3. Data, methodology, and Estimation Procedure

This section deals with the data sources used in the study. The next subsection gives a description of the variables and the last subsection that explains the methodology used to analyse the factors that explain the export behaviour of firms in the pharmaceutical sector in India.

3.1. Data Source

The empirical investigation is carried out by firm-level data (such as net sales, export intensity, R&D expenditure, incorporation year of the firms, location of firms, Profit after Tax, etc.) from the Centre for Monitoring Indian Economy (CMIE) Prowess IQ database. The time period for the study is from 2005 to 2020 as the Patent (Amendment) Act was passed after 2005 which paved way for pharmaceutical firms to increase their patenting activities. We selected only those pharmaceutical firms for the sample that exported at least once between 2005 and 2020 out of the 904 pharmaceutical firms in the ProwessIQ database, which includes both public and unlisted firms. In the final step of the data cleaning process, all those firms that reported zero or negative net sales were deleted, leaving us with 318 pharmaceutical firms (consisting of domestic and multinational firms [2]) for the statistical analysis.

To calculate firms' innovation, the number of patents granted to pharmaceutical firms in India is taken from the Indian Patent office from the time period 2005-2020 The patent data are collected from the "inPass[3]" database. Multinational firms (in the sample) applied for patents through the PCT National Phase route. For the purpose of the present study, all patents are classified under International Patent Classification (IPC) codes A61K (Preparations for medical, dental, or toilet purposes), and C01 (Inorganic chemistry). The sample excludes those applicants which are rejected by the Indian Patent Office and also removed patents that have incomplete information on the patent characteristics and field of invention. In our sample, of the total patents granted to the pharma firms, approximately 70% of the patents are process patents and the remaining 30% are product patents. Further, data on drug files are compiled from the Approved Drug Products with Therapeutic Equivalence Evaluations database commonly known as Orange book, from the US FDA (Food and Drug Administration) website. This database identifies drug products approved on the basis of safety and effectiveness by the Food and Drug Administration (FDA) under the Federal Food, Drug, and Cosmetic Act (the FD&C Act. The approved drug products and generic medicines show therapeutic equivalence evaluations or in simpler terms, approved products must provide similar benefits as the branded medicines.

A panel data approach is employed in the analysis to control the unobserved heterogeneity of the firms. Since there are many missing data for different explanatory variables used in the study, therefore the panel data is an unbalanced panel.

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[2] Multinational firms are defined as firms having 10% or more foreign equity participation as per the RBI definition of FDI.

[3] inPass database replaced Indian Patent Information Retrieval System (IPAIRS) in 2015. Moreover, inPass database allows for a full-text search of all Indian patents and Patent Applications and patents granted in India under normal and Patent Cooperation Treaty (PCT) national Phase application

3.2. Description of Variables

Dependent Variable

ERD

This decision to export is represented by a dichotomous variable *ERD* that takes the value 1 if a firm decides to export in the current time period 't' and '0' otherwise.

Export Intensity

The firm's export intensity is calculated as the ratio of the export earnings from the export of goods and services to net sales. This variable captures the exposure of the firm in the overseas market through the export channel in the time period 't'. In this paper, export intensity is measured by the variables, *exportintensity*.

Independent Variables

Technological Efforts

The available empirical evidence indicates that firms through technological efforts try to build their technological and absorptive capabilities, which in turn helps them benefit from FDI spillovers. Therefore, in the current analysis, the technological efforts of firms are captured through three channels- in-house R&D efforts or R&D intensity of the firms, import of capital goods, and import of raw materials.

In-house R&D efforts of the firms

A firm spends more on in-house R&D activities to become innovative and technologically advanced. Therefore, more innovative and R&D-intensive firms find it profitable to expand their market by exporting to international markets. Another reason, why firms spend on inhouse R&D activities is to innovate their products in accordance with the tastes and preferences of the international market and to adapt production procedures from outside to various domestic input availability. Hence, there are many Pharma firms that have boosted their internal R&D investment to modify their products as a result of selling their goods to mature economies like the European Union and the USA, where the product quality regulations are more stringent. Similarly, Bhat and Narayanan (2009) also find evidence of the positive impact of in-house R&D activities measured as R&D intensity, as one of the important determinants to explain the exporting behaviour of firms in the Basic Chemical Industry in India. In contrast to these findings, Rentala *et al.*, (2014) observe a positive and significant impact of R&D intensity on the export intensity of pharmaceutical firms in India. The results of numerous empirical studies on in-house R&D activities and export performance have shown a causal relationship between a firm's R&D spending and export performance (Tyagi and Nauriyal, 2017). The impact of internal R&D spending on the pharmaceutical company's export performance must therefore be considered. The R&D intensity is used to capture this effect and is calculated as the proportion of R&D spending (includes both current and capital account expenditure) to the net sales of the firms. In the Heckman two-stage model, we have included the lagged value of the

R&D intensity of the firm by one year to see whether the previous year's R&D intensity has any impact on the current export decision and export intensity.

Embodied Technology

It is often observed that a large number of firms in developing nations rely on the import of capital goods or embodied technology from overseas to get a competitive advantage over rival businesses as they are less innovative and more adaptive in nature (Kumar and Siddharthan, 1994). As a result, numerous studies in this area have been carried out in India over the years to examine how the import of embodied technology affects the export capabilities of the firms. Later, Siddharthan and Nollen (2004) for information services firms evaluated the influence of capital goods imports on the export performance of the firms and noted the favourable effects of capital goods imports on export intensity. In another study, Rentala *et al*., (2014) also find evidence of the presence of a positive and significant impact of the import of capital goods on export intensity. Therefore, the variable *embodied_tech* is included in both the selection and outcome equation to study its impact on the export decision and export intensity of the pharma firms. This variable is calculated as the proportion of spending on the import of capital goods to the net sales of the firm.

Imports of raw materials

The literature on the export behaviour of the firms often pointed out the link between the import of raw materials. The availability of less expensive raw materials in the pharmaceutical sector becomes a crucial deciding factor for the firm when deciding whether or not to export. The availability of cheaper raw materials enables businesses to reduce their input costs and produce their goods more effectively. Since India's pharmaceutical firms are strongly reliant on the chemical goods that are used as raw materials to create pharmaceuticals and generic drugs, and China is a major importer of APIs (Active Productive Ingredients). As a result, the availability of less expensive raw materials may enable the product to compete in international markets.

In one of the previous studies on the Indian pharmaceutical industry, Bhaduri and Ray (2004) observe that the import of raw materials has a positive influence on the export intensity of pharmaceutical firms in India. To examine the impact of raw materials on the firm's likelihood to participate in the export and on export intensity, the variable *RawImport* is included as an independent variable in both the selection equation and outcome equation. The variable *RawImport* is calculated as a ratio of payment made by the firm to import raw materials upon net sales of the firm. We expect the sign of the raw materials import coefficient to be positive.

Technological Outcomes

The present study apart from technological efforts also attempt to examine the role of technological outcomes on the export performance of pharmaceutical firms. For this, firm innovation is measured as the number of patents granted to pharmaceutical firms and US FDAapproved drug files received by pharmaceutical are calculated.

Drug files

Since 55% of India's total pharma products are exported to highly regulated markets like the USA, and the European Union, therefore drug approvals from regulatory authorities like US

FDA can be a good measure to examine its impact on the exporting behavior of the pharma firms in India. Since firms are able to sell their generic drugs and other pharma products in the US market only after successfully obtaining approval from the US FDA, therefore, in the present study, we have also included the approved number of drug files received by pharma firms in India from the US FDA. Filing for drug approvals is both a time-consuming and costly affair, therefore there are a relatively smaller number of firms that file for drug approval applications and hence there are many firms in our sample that have zero drug files over the span of 16 years. We expect the sign of the variable to be positive for both the selection equation as well as on the export intensity.

Firm's innovation

The impact of innovation on a company's ability to export goods has been highlighted through empirical studies on firm innovation. Numerous studies have taken patent count as an explanatory variable to explain the exporting behaviour of corporations and view patent count as a measure of innovation. Van Beveren and Vandenbussche (2010) examine how the number of patents affects Belgian manufacturing firms' propensity to export and found a positive relationship between patents received by the firms and their export performance.

In the Indian context, Rentala *et al*., (2014) and later Tyagi and Nauriyal, (2017) introduced patent counts obtained by the firms in the pharmaceutical industry in India to explain the extent of export intensity. Both the study obtained positive and significant results indicating Patents have a positive influence on the export intensity of pharmaceutical firms in India.

In the current analysis, to assess the impact of the firm's innovation measured as the number of patent grants to the pharma firms from both product and process innovations by the Office of the Controller General of Patents, Designs and Trade Marks on the exporting behaviour of pharma firms in India. Since the benefits/ revenues generated by the patents received by a firm are more pronounced after a certain time period, and thus firms with an innovative product are able to capture more market share and earn higher profits, therefore, one year lag of the patent is taken as to measure firm's past innovation and is represented by a dummy variable that takes the value '1' if a firm is granted patent(s) in the previous year and '0' otherwise. Based on the earlier findings, we expect to find a positive relationship between the two.

FDI Spillover effect at clusters

In the present study, apart from firms' spending on in-house R&D activities as discussed above, we have included R&D spillovers from multinational firms to examine the potential imitation effect of foreign firms' R&D activities on other firms in the pharmaceutical sector. Therefore, to measure the extent and degree of localisation of FDI R&D spillover effects, we have calculated the FDI R&D spillovers for the firms located in India's pharmaceutical hub. Based on our sample, we identified 7 states with the maximum number of foreign-owned and domestic pharma firms located in and are, Gujarat, Kerala, Karnataka, Maharashtra, New Delhi, Punjab and Telangana. We further clubbed together these states to form 3 different pharmaceutical regions, the North region comprising New Delhi and Punjab, and the South region comprising Kerala, Karnataka, and Telangana. The third region is the west region consisting of Gujarat and

Maharashtra. Foreign R&D spillovers are calculated as the share of the total foreign firm's R&D expenditure to the total R&D expenditure of all the firms belonging to these regions.

Although there isn't a lot of agreement among the earlier findings on the agglomeration effect of FDI spillovers as some researchers observed a positive impact of localisation of spillovers from MNEs on the performance of the domestic firms, others didn't find any significant results. However, in the present analysis, we hypothesize that firms located in these regions will experience a greater degree of R&D spillovers from multinational firms because of the closer geographical proximity of firms.

R&D spillover from multinational firms is measured as the share of multinational firms' R&D expenditures on total R&D expenditure of the firms in the pharmaceutical industry in a given year 't' and operating in a specific region 'c'.

Mathematically it is calculated as:

$$\text{Foreign R\&D spillover}_{ct} = \frac{\sum \text{fi Total R\&D expenditure of foreign firms}}{\sum \text{Total R\&D expenditure by all firms in the sector firms}} * 100$$

Where, f_i: foreign firm, t: year, c: regions (North, South and West)

Control Variables and other firm-level characteristics

Age of the firm

Another important firm-level characteristic identified by the empirical studies on the determinants of a firm's export behavior is its age. A firm often requires time and effort to learn new cultures, languages, and foreign market distribution channels before entering foreign markets. As a result, a firm may need to invest several years in creating specialised procedures, abilities, and legitimacy to acquire a minimum economic scale. The empirical literature, however, found mixed results in explaining the relationship between firm's age and export performance. Some studies found evidence of a negative relationship between the age of the firm and the export performance of the firm [Bhat and Narayanan (2009) in the case of firms belonging to the Basic Chemical industry in India; Franco and Sasidharan (2010) in case of manufacturing firms from India; Tyagi and Nauriyal (2017)] in the case of top 91 domestic pharmaceutical firms in India]. Other studies noted a positive impact of the age of the firm on both probability of the firm to export and as well as on export intensity [Kim and Choi (2019) for manufacturing firms in South- Korea].

In the current analysis, the firm age is calculated as the difference between the incorporation year of the firm and the current year of study. It is reasonable to argue that older pharmaceutical firms may have the upper hand in recognising the demand and market conditions in international countries and adapting their goods accordingly to fit into the foreign market because they have amassed stronger technological capabilities over the years than newer firms. Therefore, in the current analysis, we expect the sign of the age variable, *Age* to be positively related to both the probability of the firm deciding to export and the export intensity of the firm.

Size of the firm

The literature on export intensity has extensively analysed the relationship between the firm size and the firm's export performance. In this case, findings are also inconclusive as some researchers found a positive relationship between the firm size and the exporting behaviour while others observed a negative relationship between them. While Hymer, (1976), Ray and Bhadhuri (2004), Narayanan (2006), Bhat and Narayanan (2009), and Dunning (2015) conclude that firm size has a greater and more positive influence on its capability to export abroad. These studies highlight that large-size firms are better able to take advantage of both home and foreign markets than small-size firms because they have more market power, better access to resources, and cheaper project finance costs. Other researchers observe that firm size and export intensity are inversely related. Bonaccorsi (1992) demonstrates that there exists a negative relationship between firm size and the export intensity of a firm as smaller firms are found to be more export intensive.

To analyse the influence of firm size on both decisions to the export and export intensity, we have taken the natural logarithm of real net sales of the firm in the current time period 't' as a measure of the firm size. To measure the size of the firm, the firm's net sales data is deflated using the Wholesale Price Index (WPI), with 2011 as the base year to measure the real net sales. Further to capture the magnitude and direction of the relationship between firm size and the firm's decision to export and export intensity, we have introduced the quadratic term of the firm size. To account for the problem of multicollinearity between firm size and the quadratic term of firm size, we first demeaned the firm size and then took the square term of firm size to calculate the firm size square.

Profitability

It is assumed that high-profit-earning firms will be better able to manage the significant sunk expenses associated with exporting operations. Numerous studies have discovered a correlation between a company's profitability and its decision to export as well as its success at exporting [Kneller and Pisu (2007); Franco and Sasidharan (2010).

Contrary to these findings, Zhao and Li (1997) found the coefficient of profitability variable negative representing a negative relationship between the profitability and export intensity of the Chinese manufacturing firms. Their findings suggest that the exporting firms in China find it less profitable to export their products because the sunk cost of the exporting process exceeds the benefits (revenues earned) from the exports for the domestic firm, making it more challenging for them to turn a profit. In the current analysis, profitability is also identified as one of the possible determinants of the export performance of pharma firms in India. The variable *profitability* is calculated as the ratio of profit before tax divided by the firm's net sales.

The export decision of the firms

Numerous studies on the export performance of the firms have found that the firms' prior exporting experience influences the firms' current export activity favourably. Kneller and Pisu (2007) and Franco and Sasidharan (2011) observe that if a firm has exported in the previous

year, then there is a greater probability of them participating in the export in the present. Both studies introduced a dummy for the firm's previous export decision in Heckman's two-stage method in the selection equation. Therefore, based on the empirical findings, we have also looked at the past experiences of pharma firms' export decisions, however, instead of taking a dichotomous variable for the firm's previous year's decision to export, we have looked at the firm's consistent decision to export over the time period, i.e., from 2005 to 2019 and if a firm has shown a continuous pattern in deciding to export, then it is accorded a higher numerical value. In other words, a firm that has consistently decided to export in all the years between 2005 to 2019 is given the highest numerical value of 15. We measure this by the variable *'exportdecision'*. Thus, a firm that has been consistently deciding to export in past will have more likelihood of deciding to export in the present as well. Also, to account for the exclusion restriction principle of Heckman's two-stage method which states that the selection equation should include at least one variable that doesn't influence the outcome equation, we have introduced *exportdecision* variable in the selection equation and we expect it to have a positive influence on firm's decision to export at the current time period 't'.

Against this backdrop, we have included the factors discussed above in the Heckman two-stage model to understand the exporting behavior of the firms in the pharmaceutical sector in India. We have further classified the sample into two sub-samples: multinational firms and domestic firms to see and compare how different factors affect the export decision and the extent of export intensity of all firms versus domestic and multinational firms. The following table summarizes the definition of variables used in the econometric analysis.

Table 2. Definition of variables

Variables	Description/ Measurement	Symbol
Dependent Variables		
Decision to export	Captures whether a firm decides to export or not. (Takes value 0,1)	**ERD**
Export intensity	Share of total export to net sales of the firms (%)	**Exportintensity**
Independent variable		
Technological Efforts Variables		
R&D intensity (lagged by one year)	Proportion of R&D expenditure to net sales (%)	**RDintensity**
Embodied technology	Proportion of the import of capital goods to net sales of the firms (%)	**embodied_tech**
Raw Imports	Proportion of the import of raw materials to net sales of the firms (%)	**RawImport**
Technological Outcomes Variables		
Past innovation	Dummy variable that takes value 1 if a firm has been granted patents in the previous year otherwise '0'	**Patentcount**
Drug Files	Number of Drug applications of a firm approved by the US FDA	**drugfiles**

Foreign R&D spillovers measured at cluster		
FDI cluster effect	Foreign R&D spillover calculated at the regions: North, South & West	**FDIR&Dclusterspill**
Other firm-level Variables		
Profitability	Profit before tax divided by net sales (%)	**Profitability**
Age of the firm	Year of incorporation – year of study	**Age**
Firm size	Natural Logarithm of real net sales of the firms	**Firmsize**
Firms size square	Quadratic term of firm size	**Firmsizesq**
Export decision of the firm	A discrete variable that takes the maximum value of 15 if a firm has consistently decided to export between 2005 to 2019	**exportdecision**

3.2. Estimation Procedure

Empirical studies on the factors influencing a firm's exporting behaviour have mostly used censored data estimation techniques such as Tobit Model as well as binary choice models such as Probit and Logit models in their econometric analysis [Kumar and Siddharthan (1994); Siddharthan and Nollen (2004); Bhaduri and Ray (2004)]. The binary choice models, however, do come with certain shortcomings, as they consistently assume the value "1" in all situations when the dependant variable takes non-zero values and the dummy variable doesn't consider the extreme values the variables can take. There is also a problem of endogeneity of the independent variables due to the self-selection bias in the sample because only the final decision of the firms is observed while some factors influencing their final decision remain unobserved. Therefore, applying the Tobit model will not give the correct representation as in the Tobit model, the regressors included in the outcome model (that explains the level of export intensity) are exactly the same that are used in the model which explains the factors affecting the decision or selection model analysed by the Probit Model.

Hence, to account for these issues, many researchers and empirical studies have instead applied Heckman's two-stage model, especially in the case of innovation research where some firms strategically self-select themselves into the sample and a subset of the population remains unobserved [Arikan & Capron, (2010); Clougherty *et al.* (2016), and Bendig and Hoke, (2022)]. A vast growing empirical literature on the export performance of the firms has applied Heckman's two-step sample selection method to study the firm's exporting behavior [Barrios *et al.*, (2003); Kneller and Pisu (2007); Bhat and Narayanan (2009); Chuang and Lin (2010); Franco and Sasidharan, (2010); Anwar and Nguyen, (2011); Sasidharan and Kathuria, (2011)].

Model Specification

Due to the significantly high sunk costs associated with exporting, all firms in the sample do not participate in the export. These high sunk costs include the price of finding a prospective distribution and networking infrastructure abroad as well as the expense of gathering data regarding foreign market circumstances. As a result, there are many firms for which data on the exports are missing or not reported. Therefore, a two-step decision-making process is

employed to analyse the firm's exporting behaviour. The first stage decides whether to export or not, and the second stage decides how much to export. There is also the problem of self-selection of pharma firms in the export market as more innovative and R&D-intensive pharma firms have a higher likelihood to enter into the foreign markets as their products are of higher quality and better able to compete in the foreign markets which causes the issue of endogeneity in the sample. Therefore, for the purpose of the present study, we have applied Heckman's two-stage method which is similar to the Tobit model as it deals with truncated or censored variable (export intensity) which is only observable for some parts and at the same time also accounts for the endogeneity problem arising because of the censoring or truncation (Kneller and Pisu, 2007).

Stage I: Selection Equation (Decision to export)

In the first stage, a firm's decision to export is explained by a latent variable nonlinear model, represented as:

$$z_{it}^{*} = \alpha + \gamma a_{it} + \varepsilon_{it} \quad (1)$$

Where i : firms, t : year
a: 1 x K row vector of observations on K explanatory variables
γ: coefficient of explanatory variables of K x 1 vector

z_{it}^{*} : are called as a latent variable which is an unobserved variable that generates the observed binary variable z_{it} that takes the value `0' and 1'.

Thus, the link between observed binary variable z_{it} and latent variable z_{it}^{*} is given by:

$z_{it} = 1 \;\; if \;\; z_{it}^{*} > 0$; Firm decided to export
$z_{it} = 0 \;\; if \; z_{it}^{*} \leq 0$; Firm do not the export

Here, the error term ε_{it} is assumed to be normally distributed with 0 mean and Var $(\varepsilon) = 1$.

This gives us binary Probit model. In our study, $z_{it} = ERD_{it}$ which explains the firm's decision whether to export or not. Similarly, ERD_{it} is observed when $z_{it}^{*} = ERD_{it}^{*} = 1$, or firm decided to the export while $z_{it}^{*} = ERD_{it} = 0$ means firm do not the export. The explanatory variables are continuous except for the Dummy Variable for the firms that received Patents in the previous year while *drugfiles* variable is a discrete variable. In addition, because of the exclusion restriction, we have also included the instrument variable, *exportdecision* which shows a firm's consistent decision to export over 15 years (between 2005-2019). This instrument variable fulfils the criteria of the exclusion restriction as it only affects the likelihood of the firm's decision to export (selection stage) and has no influence on the amount firms choose to export (outcome stage). Stage I is estimated using the Maximum Likelihood estimation (MLE) method on the Probit model. Thus stage 1 or decision equation is given by:

$$ERD_{it} = f\,(Patent\_count_{it-1},\ FDIRDclusterspill_{ct},\ RDintensity_{it-1}\ Firmsize_{it},\ Firmsizesq_{it},\ Age_{it},\ embodied\_tech_{it},\ Profitability_{it},\ RawImport_{it},\ drugfiles_{it},\ Exportdecision_{it})$$

Where , i: individual firms t: year

c: Region (North, South, and West)

Stage II: Outcome Equation

After the decision to export is taken by firms, the outcome equation then explains the variation in the export activities (measured as export intensity) when it is observed. So, the outcome equation, or export intensity of a firm is zero when firm do not the export and it takes positive value only when firm decides to the export. Therefore, to analyse the factors determining the degree of export intensity of the pharmaceutical firms, the dependent variable, *exportintensity* is regressed on firms' characteristics discussed above.

The second stage is modelled as:

$$y_{it}^{*} = \alpha + \beta x_{it} + \mu_{it} \quad (3)$$

Where, $y_{it} = y_{it}^{*}$ when $z_{it}^{*} = 1$

Or $y_{it} = 0$ when $z_{it}^{*} = 0$

x_{it} : 1 x K row vector of observations on K explanatory variables

Here, the regressand y_{it} , is an observed variable that represents the export intensity of a firm, $x_{it,}$is the set of explanatory variables and μ_{it} is the random error term representing, unobserved disturbances influencing, y_{it} . The dependent variable, y_{it} is a truncated or censored variable that is observable only when $z_{it}^{*} = 1$. The error terms in both stages, $_{it}$ & μ_{it} are assumed to follow a bivariate normal distribution with a correlation 'ρ[4]'. The second stage apart from the explanatory variables from the selection stage (except for the instrument variable) also consists of the selection parameter, Inverse mills ratio[5], or Lambda (λ) estimated from the first stage. The second stage is modeled as:

Exportintensity$_{it}$ = f (Patent_count$_{it-1}$, FDIRDclusterspill$_{ct}$, RDintensity$_{it-1,}$ Firmsize$_{it}$, Firmsizesq$_{it,}$ Age$_{it}$, embodied_tech$_{it}$, Profitability$_{it}$, RawImport$_{it,}$ drugfiles$_{it}$, Inverse Mills ratio)

4. Trends in the exports, Patents & FDI cluster

In this section, we compare the mean and standard deviation of the firms based on ownership and also look at the average export intensity of firms based on ownership. For this purpose, the sample is further categorised into two sub-categories- domestic firms and multinational firms- to see how the mean of the variables differs across the sample.

[4] The two equations from both stages are related if ρ ≠0 and estimation of only stage II equation in that case will give spurious results.

[5] Inverse Mills ratio estimated from the stage I Probit method is a selection parameter that estimates the unobserved and unmeasurable information of the sample and represents the covariance of the error terms from two stages. The Mills ratio thus connects the two stages.

Table 3 summarises the mean and standard deviation of the variables used in the analysis. The domestic firms have higher mean export intensity compared to both all firms and multinational firms which are in accordance with expectations given that fewer multinational firms are exporting pharmaceutical products while more domestic pharma firms are becoming more the export-intensive. Variables such as, R&D intensity, raw imports, and profitability of domestic firms are higher than those of multinational firms, which again can be explained by the existing literature that multinational firms conduct less in-house R&D activities in the host country and find it more convenient to import technology from their parent firms. The variable for the export decision is greater for multinational firms, demonstrating that despite their smaller number, they have consistently and persistently chosen to the export over the years (between 2005 to 2019). One potential explanation for this could be that there is a problem with product compliance, where the exporting firms must meet a specific product quality requirement of the importing firms, particularly in the case of the USA, where the exporting businesses must adhere to the FDA's (Food and Regulation Authority) minimum standards before they can sell their goods there. In such a situation, foreign firms or MNEs that are a part of the global production system find it simpler to incur the large sunk costs involved with the export. Hence, multinational firms who have consistently exported over the years have a higher likelihood of entering the export market in the current year as well.

The R&D spillovers from overseas firms are greater for multinational firms than for domestic firms, demonstrating that multinational firms have a technological advantage over domestic firms and are therefore better positioned to capitalize from the R&D spillovers than their domestic counterparts. Along the same lines, domestic firms also have a greater mean FDI R&D spillover cluster effect located in the west region relative to other firms located in the other two regions. The average drug approvals received by domestic firms are higher compared to multinational firms which is on the expected lines as export intensity of domestic firms are higher compared to multinational firms and thus, domestic firms find it more profitable to sell generic drugs in the foreign market.

Table 3. Comparison of mean of the variables based on the ownership of the firm (2005-2020)

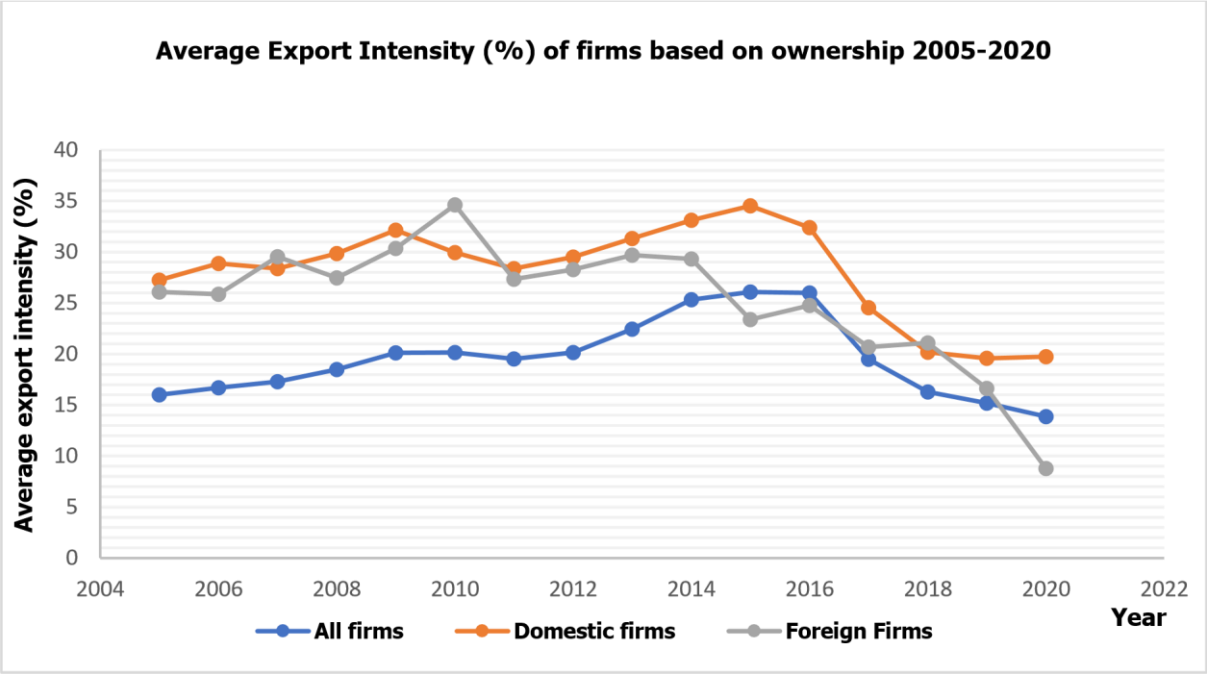
Variables	All firms sample		Domestic firms' sample		Foreign firms' sample	
	mean	sd	mean	sd	mean	sd
Exportintensity	19.73	27.96	20.28	29.24	11.64	24.28
RDintensity	7.12	172.7	7.35	178.56	3.73	8.17
Age	27.79	16.85	26.20	17.90	44.00	22.36
Patentcount	0.16	0.36	0.14	0.35	0.36	0.48
embodied_tech	1.48	13.65	1.74	17.28	1.94	8.00
Raw Import	9.90	19.98	10.54	14.81	8.39	8.88
Firmsize	2.82	1.46	2.78	1.73	3.43	1.94
Firmsizesq	0.27	0.54	0.28	0.55	0.15	0.26
Profitability	-14.86	398.40	-13.58	396.63	-33.38	423.17
FDIR&Dnorthclusterspill	1.19	4.05	1.21	4.03	0.99	4.31
FDIR&Dsouthclusterspill	3.47	6.36	3.43	6.34	3.99	6.73
FDIR&Dwestclusterspill	6.04	7.42	5.87	7.35	8.54	7.98
export decision	3.66	3.94	3.72	3.96	2.72	3.57
drugfiles	0.57	2.59	0.59	2.63	0.42	1.81

Observations	3768	3524	244

Source: Authors' own calculation

Figure 2. plots the average export intensity of domestic firms and multinational firms along with all firms. export intensity of domestic firms is shown by the orange line, the grey line is for multinational firms while the blue line represents all firms including both domestic and foreign between 2005 to 2020. The average export intensity of all firms as well as for subsample firms follows similar paths. Since the enactment of the Patent (Amendment) Act of 2005, both domestic and multinational firms have experienced an increase in their average export intensity. However, following 2015, domestic and multinational firms have experienced a decline in their average export intensity. This shows that pharmaceutical firms in India have turned their attention more toward serving the domestic consumer base. Another reason for the decline in export intensity of the pharma firms can be attributed to the low sales growth of Indian pharma firms (in recent years) in the USA market. The domestic pharmaceutical market grew at a compound annual growth rate (CAGR) of about 11% between 2014 and 2020, while the export revenue growth rate of the exporting firms fell by about 5% over the same time period, according to the most recent report on the Indian pharmaceutical industry by Macquarie Research (2022).

Figure 2. Average export intensity (%) of pharmaceutical firms based on the ownership (20052020)



Source: CMIE, ProwessIQ database

Region Wise comparison of firms' performance located in the 3 regions

The distribution of domestic and multinational firms in the states that constitute the three regions is summarised in Table 4. The west region, which includes Gujarat and Maharashtra,

has the majority of domestic and multinational firms located there, followed by South region which consists of Karnataka, Kerala and Telangana.

Table 4. Number of foreign and domestic firms located in the 3 regions between 2005-2020

States	Total number of multinational firms located in regions	Total number of domestic firms located in regions
North Region		
NCT of Delhi	2	25
Punjab	1	5
South Region		
Karnataka	2	22
Kerala	1	6
Telangana	4	59
West Region		
Gujarat	3	40
Maharashtra	9	101
Total	**22**	**258**

Source: Authors' own calculations based on CMIE, ProwessIQ database

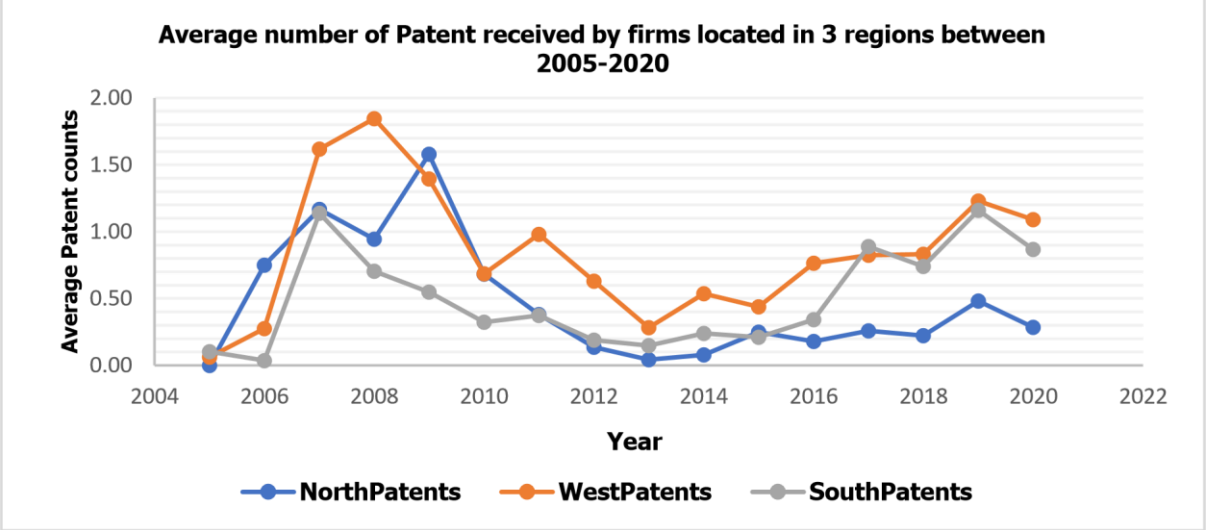
Further, table 5 tabulates a region-wise comparison of average Patents counts received by the firms, average R&D intensity of the firms, average export intensity, and the average number of drug files received by the firms from by US FDA between 2005-20220. Out of the three regions, firms located in the west region have received the maximum number of patents over the span of 16 years. (i.e. from 2005 to 2020) followed by the firms located in the south region. Hence, the firms located in the west region are more involved in manufacturing novel drugs. Similarly, to this firms in the west region are more R&D intensive than firms in the other two regions. Between 2005 and 2020, firms in the west region invested an average of the most in R&D, at around 11.28%, followed by businesses in the south region. This explains why firms in the south region and west region have also received high average number of drugs files that were approved by the US FDA. The region wise comparison of export intensity of firms belonging to three regions again shows that average export intensity of the firms located in the west region is highest. export intensity of the firms located in three regions are plotted in the figure 4. As discussed earlier, export intensity has declined post 2016, however, export intensity of firms located in the Maharashtra region have shown an upward tick and is on average higher compared to the firms located in the other two regions till 2016 and declined afterwards. Over the year, export intensity of firms located in the north region have increased due to increasing internal R&D efforts and the presence of foreign businesses.

Table 5. Region wise comparison of R&D intensity, export intensity, patenting activities and US FDA approved drug files received by firms, 2005-2020

Region	Average R&D Intensity	Average export intensity	Average Patent count	Average Drug files
North Region	2.74	19.79	0.42	0.05
West Region	11.28	21.35	0.84	0.71
South Region	3.75	18.86	0.52	0.80
All regions	5.923	20.00	0.59	0.52

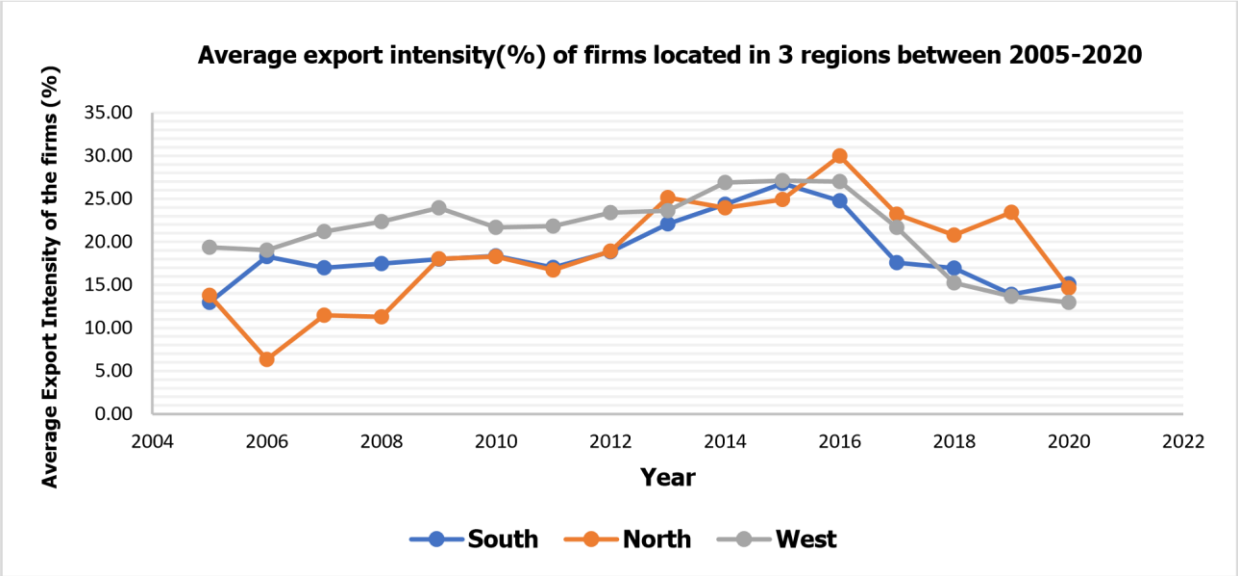
Source: Authors' own calculation

Figure 3. Region wise comparison of average Patents counts received by the firms between 20052020



Source: inPass search database, Indian Patent Office

Figure 4. Region-wise comparison of the average export intensity of the firms between 2005-2020.



Source: CMIE, ProwessIQ database

5. Results and Discussions

This section discusses the results obtained from estimating Heckman's two-stage model. To obtain consistent and unbiased results from the statistical analysis, we tested for the stationarity of variables before initiating empirical analysis of the model. As the current study uses unbalanced panel data, therefore we have used the Phillips-Perron test to check for the stationarity of the variables. All the variables are found to be stationary at 1% and 5% levels of significance. The results for the same are reported in Appendix Table A1. To check for the problem of multicollinearity, we have also calculated the Variance Inflator factor (VIF) and from Appendix Table A2., we can see that none of the variables suffer from the problem of high multicollinearity.

The results are reported in Table 6. The Heckman model for both all firms (consisting of both foreign and domestic firms) and sub-group consisting of only domestic firms[6] are estimated and reported. The value of Lambda or inverse Mills ratio for both samples is coming out to be negative and significant at 5 % indicating the presence of negative sample selection problem. Also, the value of rho or 'ρ' is also turning out to be significant at 5 % measured by the Likelihood ratio test for both all firms sample (7.87) and domestic firms' sample (7.08). This implies that both the selection equation and outcome equation are interrelated to each other and there exists sample selection bias and ignoring this would result in biased estimates from the OLS method. Thus, applying Heckman's two-stage method is more appropriate in this case.

Decision to export

The econometric analysis shows, out of the three measures of technological efforts, the variable on import of disembodied technology is found to positively affect the firm's decision to export and that too for only domestic firms' sample. This indicates that rigorous prior in-house R&D efforts by firms can help them to produce higher-quality or even unique products to compete with other products in the foreign market. Thus, a firm's past or previous in-house R&D efforts increases its prospect of participating in the export in the current. While other two variables of technological efforts turned out insignificant for both all firms' and domestic firms' sample

In the case of technological outcomes variable, *Patent_count*, with a one-year lag is coming out to be significant only in the selection equation for all firms' sample only. The negative sign of the coefficient of *Patent_count* shows that firms that have obtained patents in the previous year have less likelihood to export. The most likely explanation for this is that firms that have acquired patents find it more profitable to sell their patented goods domestically rather than exporting. Since patents are granted to pharmaceutical firms either for the discovery of novel drugs or for the development of new manufacturing processes that aid in the manufacture of the drugs. In other words, a patented product might be more appealing to domestic consumers, generating more profits for the firms than exporting to international markets, where there is considerably more competition than in the domestic market. Hence, the patenting firm believes that appropriating benefits from patented products can be more successfully done in the domestic markets than in foreign markets as pharma firms in India export more generic drugs compared to novel drugs.

Another interesting insight coming out from the econometric analysis is the FDI cluster, *FDIR&Dnorthclusterspill* coefficient, which come out to be positive and significant in the selection equation or decision to export equation for both samples. The positive sign shows that competing or rival firms that are located in the north region along with multinational, due to positive R&D spillovers from multinational firms, increases their probability to export. If we compare the extent of R&D spillovers from multinational to rival firms located in north region between two samples, we find that for domestic firms, the degree of foreign R&D spillovers is higher for domestic firms' sample.

[6] To investigate the exporting behavior of foreign-owned firms in India, we separately estimated Heckman's model for the sub-sample that only included multinational firms. However, because fewer multinational firms participate in exporting activities, the inverse mills ratio was found to be statistically insignificant, indicating the absence of sample selection bias.

In addition, the variable *Age* is emerging as a statistically significant with the negative sign in the selection equation for both samples. The negative relationship between age of the firm and it's likelihood to participate in export highlights that that younger firms, in contrast to older ones, are frequently able to offset the disadvantage of a lack of market experience due to their inherent dynamism and greater technology possession. Other firm-level characteristics such as size of the firm and profitability of the firm didn't appear to have any significant influence on the firm's decision to export for either the two samples.

Lastly for the "all firms" sample, the variable *exportdecision* in the selection equation which is of interest as it is introduced as an instrument variable according to the principle of exclusion restriction in Heckman's two-stage method is turning out to be significant and positive for both samples. Thus a 1 unit change in *the exportdecision* increases the probability of the firm's decision to export by 19.5%. For domestic firms' sample, the variable *exportdecision* in the selection equation is also significant and positive at 1 percent and indicating that 1 unit change in *exportdecision* increases the probability of the domestic firm's decision to export in the current year by 19.2% showing firms that have been persistently deciding to export have a greater probability of exporting in the current period.

Export Intensity

For the export intensity equation, all three variables of technological efforts are found to be statistically significant. The variable on import of raw material is found to have a significant and positive impact on the export intensity of both domestic firms' sample and for all firms' sample. After the introduction of the policy of import liberalisation in 1991, the import of raw materials became cheaper, and the availability of raw materials such as chemical products (which are essential ingredients in the production of drugs and medicines) makes exporting firms profitable because they are able to cut input costs and increase the quantity of export. Hence the variable is showing a favourable impact on export intensity. The other technological effort variables which turned out significant for all firms' sample is the coefficient of import of capital goods or embodied technology for both the samples and the direction of the variable is also same. The *embodied_tech* variable is statistically significant at 5% in both samples. The computed coefficient's negative value indicates that firms are using more imported technology to produce pharma products for the domestic market than for the export. The conclusions align with those of Siddharthan and Nollen (2004), who discovered a similar negative effect of capital imports on the export intensity of Indian enterprises in the information technology industry. Similarly, in the case of domestic firm samples, we find a positive and significant impact of a firm's past in-house R&D efforts on its current export intensity. Thus, one can say a firm's previous year's in-house R&D activities have a positive influence not only on the decision to export but also on the export intensity which indicates how in-house R&D activities are important, especially for the pharma firms who need to produce goods of the standard quality to meet the regulatory standards like that in the USA. This result is similar to Tyagi and Nauriyal (2017) findings in case of Indian pharmaceutical firms.

In the case of technological outcomes variable measured through the *drugfiles* variable and past patent counts received by firms, we find only *drugfiles* variable to have a positive impact on the export intensity for both the samples. This indicate that firms that have received drug

approvals from US FDA are more export intensive. As firms with a maximum number of US FDA-approved drug licenses find it easier to penetrate highly regulated markets like the US; India's pharma export, which primarily consists of generic medications and drugs.

For the outcome equation or export intensity, only *FDIR&Dwestclusterspill* variable turned out to be statistically significant for both all firms' and domestic firms' samples. The export performance of competing pharma firms located in closer proximity to multinational firms in the west region, gain from the imitation effect from multinational firms' R&D activities, and to become more competitive in the foreign markets, they try to increase their technological knowledge base by increasing their R&D spending. This confirms the similar results obtained by the previous study by Wang and Wu (2016), which reports a favourable agglomeration effect of FDI knowledge spillovers in the case of Chinese manufacturing industries. Therefore, foreign R&D spillover effects are higher when firms are located in a close cluster with multinational firms or spillovers from FDI decay with the increase in the geographical distance. Another explanation for why *FDIR&Dwestcluster*spill turned out to be positive for export intensity is the high absorptive capacity indicated by the in-house R&D efforts of the firms in the west region. As noted in Table 4, the firms belonging to the west region are almost four times R&D intensive on average compared to firms located in the north and south regions, and hence, pharma firms located in the west region due to higher absorptive capacity[7] are better able to capture the knowledge spillovers from the R&D activities of the multinational firms. Therefore, firms located in the west region appear to be feeling the pressure of competition due to the presence of multinational firms in the same cluster.

Another firm level characteristic which is found to significantly influence the export intensity is *Age* variable, with a negative sign in both samples, demonstrating that younger firms, equipped with latest technology and due to its inherent dynamism, find it easier to enter foreign markets through export channels in contrast to older ones. These findings are similar to the earlier findings of many empirical studies on export intensity of firms in India [Bhaduri and Ray, (2004); Franco and Sasidharan (2010)]. Similar to this finding, for the firm size variable, the econometric analysis shows significant and negative sign for export intensity equation in both samples both samples. This shows that smaller firm are more export intensive compared to large firms. The quadratic term of firm size on the other hand, is significant and positive U-shape, demonstrating that smaller firms with experience are able to offset the disadvantages they confront and, over time, become more export-intensive. Furthermore, past empirical evidences on the learning-through-exporting theory has shown that exporting firms become more effective as a result of the knowledge they gain from overseas markets, which further boosts their productivity and innovative ability. This gives them an advantage over rivals in foreign markets and raises their potential for future exports. While other variables like *Profitability* did not turn significant for export intensity in either of the two samples.

[7] As highlighted in the study by Cohen and Levinthal, (1990) who argues that in-house R&D intensity is an indicator of a firm's absorptive capacity.

Table 6. Result obtained from Heckman Sample selection method

Variables	*All firms' sample*		*Domestic Firms's sample*	
	Selection Equation	***Outcome Equation***	***Selection Equation***	***Outcome Equation***
	Decision to Export ERD	***Export intensity***	***Decision to Export ERD***	***Export intensity***
Technological efforts variables				
RDintensitylag$_{it}$	0.00111	0.0298	0.00158*	0.0284**
	(0.0154)	(0.0317)	(0.000832)	(0.0123)
embodied_int$_{it}$	-0.00371	-0.441***	0.00396	-0.423**
	(0.00582)	(0.111)	(0.00418)	(0.115)
RawImport$_{it}$	0.00158	0.151***	0.00140	0.173***
	(0.00191)	(0.0457)	(0.00174)	(0.0449)
Technological outcome variables				
Patentcount_lag$_{it}$	-0.114*	-0.425	-0.0741	-1.773
	(0.0684)	(2.154)	(0.0933)	(2.358)
drugfiles$_{it}$	-0.000351	0.824***	-0.00218	0.923***
	(0.0110)	(0.205)	(0.0126)	(0.217)
FDI cluster effects				
FDIR&Dnorthclusterspill$_{t}$	0.0288***	-0.140	0.0328***	-0.215
	(0.00603)	(0.137)	(0.00769)	(0.177)
FDIR&Dwestclusterspill$_{t}$	0.00255	0.533***	0.00285	0.562***
	(0.00452)	(0.130)	(0.00368)	(0.137)
FDIR&Dsouthclusterspill$_{t}$	0.00477	0.122	0.00428	0.00457
	(0.00524)	(0.142)	(0.00427)	(0.160)
Other variables				
profitability$_{it}$	0.000237	0.00415	0.000354	0.000355
	(0.000348)	(0.00911)	(0.000302)	(0.00877)
Firmsize$_{it}$	-0.0106	-1.732***	-0.0203	-1.601***
	(0.0228)	(0.619)	(0.0259)	(0.566)
Firmsizesq$_{it}$	-0.113	3.881**	-0.0920	3.230**
	(0.0806)	(1.884)	(0.0604)	(1.628)
Age$_{it}$	-0.00288*	-0.211***	-0.00218*	-0.182***
	(0.00170)	(0.0286)	(0.00105)	(0.0361)
exportdecision	0.195***		0.192***	
	(0.00683)		(0.00781)	
Constant	-0.205*	39.48***	-0.274**	37.61***
	(0.118)	(3.504)	(0.110)	(4.930)
Year dummy	Yes	Yes	Yes	Yes
Lambda	-5.86		-5.88	
Rho	-0.192		-0.191	
LR test (ρ=0)	7.87(1)**		7.08(1)**	
Log likelihood	-10953.0		-11704.45	
Wald Chi2(df)	340.23***		224.92***	
Observations	3,363	3,363	3,134	3,134

Note: Bootstrap standard errors in parentheses, ***, ** & * means 0.01%, 0.05%, 0.1% level of significance

6. Summary and conclusion

The current paper tried to look deeper into how technology measured as technological efforts and technological outcomes along with various firm-level factors identified on the basis of the existing empirical literature affect the export performance of pharmaceutical firms in India. Further, we also attempted to analyse the impact of FDI clusters on the export performance of the firms located in closer geographical proximity to multinational firms. FDI cluster is measured as FDR R&D spillovers at the regional level or at the cluster level. For this purpose, the two-stage model was used in which the first stage consists of the decision equation and the second stage consisted of the outcome or export intensity equation. To account for the possible endogeneity arising from the self-selection of firms to the export and to obtain consistent and unbiased estimates, we applied Heckman's two-stage sample selection method. The inverse mill's ratio from the econometric analysis confirmed the presence of sample selection bias and the Heckman two-stage method was the correct way to tackle this problem. We further examined the role of the aforementioned explanatory variables on export intensity and the decision to export separately for domestic firms. The results obtained for all firms including foreign and domestic firms did not differ substantially from that the results obtained in the case of domestic firms. The reason behind this is that the number of domestic firms in the all-firms sample is much higher as compared to the multinational firms.

The findings from the econometric exercise suggest technological efforts through import of raw materials, import of capital R&D intensity lagged by one year, and import of capital are the important factors in explaining the export performance of the pharmaceutical firms in India. Another interesting result obtained from the analysis is the importance of technological variable measured as drug file received by pharma the exporting firms from US FDA approvals is one of the crucial factors that can explain the differences in the export performance of the firms. Therefore, potential exporting firms that conduct some internal R&D and through raw material imports acquire technological capabilities which increase the competitiveness of their products in foreign markets. This further improves their chances of receiving more drug approvals from the US FDA regulations since the US is the largest export destination of India's generic drugs the export.

Additionally, the inclusion of the cluster effect of foreign R&D spillovers in the model offers some intriguing insights into the exporting behaviour of competing firms located in pharmaceutical hubs/regions that are categorized according to the highest concentration of both domestic as well as multinational firms. According to econometric analysis and descriptive statistics, firms in the west region, which includes states like Gujarat and Maharashtra, not only invest more in R&D but also patent more inventions than firms located in other regions. Because of this, domestic firms in these states are better equipped to reap the benefits of knowledge (R&D spillover) generated by the presence of multinational firms there. Thus, the government can create a more conducive atmosphere by building modern infrastructure for better knowledge sharing between domestic firms and multinational firms located in other pharmaceutical clusters. Furthermore, results from the econometric exercise also highlights the importance in-house R&D efforts of the firms in stimulating benefits from multinational firms. Hence, domestic pharma firms need to build their innovative capacity by investing more in-house R&D efforts in order to increase their competiivness in the foreign markets.

Apart from this, a firm's persisting exporting behaviour over the years also influences the firm's decision to export in the current time period. Most of the explanatory variables on the other firm-level characteristics such as firm size and age of the firms are found to follow the results obtained from the previous empirical studies in the Indian context.

Our paper contributes to the literature by highlighting the role of both technological efforts and outcomes in the form of patents and US FDA-approved drug filing, along with the co-location of domestic firms and multinationals in a cluster in determining the decision to export as well as interfirm differences in the export intensity.

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APPENDIX

A.1. Unit root test of the variables

	Phillips Perron test statistics	
Variables	**Inverse normal (Z)**	**Inverse chi-square (P)**
RDintensity	-17.1***	2062.28***
embodied_tech	-26.92***	2096.97***
Profitability	-19.20 ***	2461.11***
Exportintensity	-6.99***	1105.61***
Firmsize	-2.80**	1255.48 ***
Firmsizesq	-30.19 ***	3732.89 ***
FDIclusterspillnorth	-14.32***	908.46***
FDIclusterspillssouth	-7.31***	895.14**
FDIclusterspillwest	-11.99***	912.71***
Patent_count	-15.99***	681.08***
RawImport	-8.39***	1332.10***
drugfiles	-25.51***	983.72***

Note: *** & ** means 0.01%, and 0.05% level of significance.

A.2. Test for Collinearity

Variable	**VIF**	**1/VIF**
embodied_tech	7.00	0.143
RDintensity	6.96	0.144
Firmsizes	5.64	0.177
Age	3.55	0.282
FDIR&Dwestclusterspill	2.02	0.495
FDIR&Dsouthclusterspill	1.45	0.689
Patentcount	1.43	0.697
Firmsizesq	1.31	0.765
drugfiles	1.28	0.783
RawImport	1.28	0.784
FDIR&Dnorthclusterspill	1.17	0.851
Profitability	1.05	0.950
Mean VIF	**2.45**	