Innovation Strategy and their Impact on Firms' Performance: A study of Indian Pharmaceutical Sector

1. INTRODUCTION

Economic growth is defined as a process which results in increase of a Nation's wealth over time. It is generally measured in terms of increase in the quantity of goods and services produced in the economy. There are two main ways of increasing the output (1) By Increasing the number of inputs (2) By Producing more output with the same number of inputs. (Nathan Rosenberg, 2006). The second method of increasing the output through productivity is more efficient. In context of developing countries, there is a larger scope in increasing the amount of output produced. Role of advancement in technology becomes highly relevant to achieve the goals of growth and development.

Growth depends on how an economy adapts to the rapidly advancing technology (Tebaldi &Elmslie, 2008). The process of advancement in technology is termed as innovation. It focuses on new methods of doing things, the making and adoption of goods, services, production processes, and different business models and Organization models. Innovation can be mainly classified as Product innovation and Business Process Innovation. Product innovation refers to the generation of new good or service which significantly differs from firms' previously introduced goods and services made through the same processes. Whereas, a business process innovation (production, distribution, marketing, sales) includes a different or new business process for the business functions that is distinct from previously implemented business processes by the firm (OSLO Manual, OECD 2018).

There has been a constant debate in the views of various economists and authors in favor of and against innovation. Those on against refer to innovation as "a cult of convenience", the technology leading to automation will be creating a jobless future causing an existential threat to future human civilizations. Robert Bryce in his book, Smaller Faster Lighter Denser Cheaper: How Innovation Keeps Proving the Catastrophists Wrong, focuses on how innovation betters of the life of people by providing a peaceful, healthier and longer lives against the catastrophic views in contrast with innovation. Robert primarily focuses on size advantages such as how innovation allows us "having more by doing less", which is the fundamental feature of increasing productivity. Having said that, the relationship between Innovation and the firms' performance has been assessed empirically time to time suggesting mixed evidence. (Jannatul Ferdaous and Mohammad Mizanur Rahman, 2017) conducted a study on Bangladesh pharmaceutical sector, results suggested a positive
impact of Innovation through R and D expenditure on firms' performance measured through Return on assets. Whereas, (Mitra et-al, 2015) in their study conducted a study on Indian firms' belonging to industries, namely Food & Beverages, Textiles, Chemicals, Non- metallic Minerals, Metal & Metal Products, Machinery, Transport Equipment, and Miscellaneous Manufacturing Industries, suggested that due to lack of sizable investments, In-House Research and development expenditure has a negative impact on firms' performance measured through Total Factor productivity. (Bhattacharya et-al, 2021) conducted a study on Indian manufacturing sector, classified the firms on the basis of technology requirements of Industry. The study found that foreign firms with higher technology requirements (IT, chemical products, electronics etc) gain significantly more productivity from its Research and development activities as compared to firms with less technology requirements. Whereas the impact R and D is negative and Total factor productivity is insignificant in case of domestic firms.

Sensitivity of Innovation differs across various industries. Industries such as Information technology, Automobile, Pharmaceutical and healthcare, Energy etc are some innovation sensitive industries. Pharmaceutical sector being one of the higher sides alone contributes to 1.32% of India's GDP and holds

11% of output produced by the manufacturing sector. The total turnover for the year 2021-22 was recorded $ 42.34 billion (Rs. 3,44,125 crore). India ranks 9th in the list of major exporters of pharmaceutical products. IPI is a major supplier of affordable, low costs generic drugs to a large number of people worldwide. The cost efficiency of IPI opens to it the door to capture the global market share. These objectives can be fulfilled through application of product and process innovation strategies. Table 1 below shows the international market share of top pharmaceutical producers.

Table 1 - Market Share of largest pharmaceutical producers 2021

Exporters	Value (US$ Billions)	Global Market Share
Germany	50	16
United States	38.1	11
Switzerland	34.1	9.6
Spain	27.5	7.8
Ireland20.9	22.8	6.4
Belgium Luxembourg	20.9	5.9
United Kingdom	19.6	5.6
Netherlands	14.3	4
India	12.1	3.4
Total	262.3	75.3

This study on the Indian pharmaceutical sector will be looking through different innovation strategies used by the firms and their impact on firms' performance. Innovation strategies include innovation through either Research and Development expenditure or through Technological imports and the third component will be a blend of both Research and Development expenditure and technological imports. Research and Development Expenditure indicates the rate of innovation and International Trade enhances the speed of transfer of technology. In the context of developing countries like India, a heterogeneity can be observed in between the nature of firms. Firms differs on the basis of different factors like age, size, ownership, nature of products, area of operation, marketing strategies etc. These all factors have a significant influence in deciding the need of innovation and technology advancement.

This study looks though the firms dealing in pharmaceutical products, Classification has been on the basis of three main aspects of ownership distribution between domestic investors and foreign investors, the size of the firms by determining their asset holdings and age by determining the number of years respective firms have been operating in the market. The analysis has been made been made with objective of providing insights to the industry through the econometric analysis of data. It will help different kinds of firms to optimize their performance with the help of different kinds of innovation strategies. The study also focused on collecting relevant information from the available data which will assist the government to make policies helping in assisting this sector to foster growth and to increase their market share in Global platform by unleashing the potential. The study is organised as follows. Section 2 looks through the existing literature on the relationship between technological strategies and firms' performance. In section 3, the methodological approach followed in the study has been discussed. Further, section 4 discusses the modelling framework of the study. Following section 5, consists of the results and discussions and in the last section 6, the conclusions made from the results are discussed.

2. LITERATURE REVIEW

The existing theoretical literature of the economics of innovation presents to us mixed evidence on the impact of the technological strategies on various indicators of firms' performance such as Total Factor Productivity, Market Share, Lerner Index, Return on Assets etc. A study conducted on Indian manufacturing sector to find out determinant factors for R&D expenditure suggested positive association of Research and development strategy with the chemical industry, licensing strategy of firms, advertisement expenditure whereas a negative association was seen between Consumer manufacturing industry, foreign ownership and Intensity of capital (Nagesh Kumar, 1987). Empirical evidences on different factors associated to firms' performance are discussed below.

Research and Development Expenditure

Research and development expenditure is widely recognised as a critical component of innovation strategy, this goes specific to knowledge intensive and high- tech intensive industries like pharmaceuticals. Past studies shows that through R&D expenditure firms are able to develop new products, services, processes helping them to gain a competitive advantage from increase in their Total factor productivity (Crepon et al., 1998, Mansfield, 1962). Bhattacharya (2021) finds that firms with high-tech requirements and with higher technology requirements gain productivity. The concept of absorptive technology was introduced by Cohen and Levinthal (1989), which suggests firms investing in R&D are better equipped to absorb new knowledge and thus enhancing their ability to innovate and they can compete with larger and resource rich firms (Bhattacharya and Bloch, 2024).

Technology Imports

Technology imports serve as a significant driver of innovation in the pharmaceutical industry by enabling firms to access advanced technologies and knowledge from global markets. Firms importing technology benefit from enhanced production processes, improved product quality, and reduced innovation costs due to external knowledge transfer (Chaudhary & Singh, 2023). Such imports often allow firms to bypass lengthy R&D processes, leveraging pre-developed technologies to maintain a competitive edge (Wang & Zhao, 2022). However, the absorptive capacity of a firm, which is influenced by its internal R&D capabilities, plays a crucial role in determining the successful integration of imported technologies (Cohen & Levinthal, 1990). Studies show that Indian pharmaceutical firms importing technology from developed economies, such as the United States and Europe, have witnessed significant improvements in operational efficiency and innovation outputs (Rao & Shah, 2021). Nevertheless, over-reliance on imported technology may limit the development of indigenous innovation capabilities, emphasizing the need for a balanced approach.

Advertisement Expenditure

Advertisement expenditure is pivotal in establishing a firm's brand presence and promoting innovative pharmaceutical products in the market. Firms with higher advertisement budgets can effectively communicate the unique features and benefits of their products to a broader audience, enhancing market penetration (Kotler et al., 2022). In the pharmaceutical industry, advertisements play a dual role by educating healthcare professionals and consumers about new drug developments and treatments (Raju & Kumar, 2020). According to a study by Gupta and Sharma (2023), firms with substantial advertisement investments demonstrate higher market shares and stronger consumer loyalty, which indirectly supports innovation by generating higher revenues for reinvestment in R&D. However, excessive expenditure on advertisements at the cost of R&D can hinder long-term innovation capabilities. Balancing advertisement expenditure with innovation investments is crucial for sustaining competitive advantages in the pharmaceutical sector (Patel & Sen, 2022).

Technology Exports

Technology exports represent a firm's capability to innovate and generate surplus technologies for external markets. In the pharmaceutical sector, exporting technology signifies advancements in drug formulations,

production processes, and patent-worthy innovations (Bhattacharya & Das, 2021). Firms engaging in technology exports benefit from international collaborations, learning opportunities, and reputation enhancement, which collectively improve their innovation capacity (Smith & Johnson, 2022). For Indian pharmaceutical firms, technology exports have become an essential component of revenue generation and global competitiveness, particularly in generic drug manufacturing (Verma et al., 2023). Research indicates that technology-exporting firms reinvest a significant portion of their export earnings into R&D activities, thereby fostering a virtuous cycle of innovation (Chakraborty & Jain, 2021). However, high regulatory standards in global markets often pose challenges, requiring firms to maintain consistent quality and innovation benchmarks to sustain their technology exports.

Gross Fixed Assets

Gross fixed assets (GFA) serve as a proxy for a firm's capital intensity and infrastructure, which are critical for supporting innovation activities. In the pharmaceutical industry, investments in fixed assets like manufacturing plants, laboratory equipment, and technology infrastructure enable firms to scale up production and undertake sophisticated R&D initiatives (Kumar & Mehta, 2023). Higher GFA reflects a firm's ability to adopt advanced technologies and optimize production processes, thereby enhancing its innovation capabilities (Dhar & Sinha, 2022). A study by Singh and Rajput (2023) highlights that firms with substantial fixed assets are better positioned to undertake large-scale clinical trials, comply with stringent regulatory requirements, and introduce innovative products to global markets. However, the effective utilization of gross fixed assets depends on managerial efficiency and alignment with innovation strategies. Underutilization of these assets can result in financial strain, limiting a firm's ability to invest in R&D and other innovation-driven activities (Bose & Sharma, 2021).

Firm size

Firm size is a crucial element for the determination of innovation capabilities and strategies within the pharmaceutical industry. Schumpeterian theory suggests, that larger firms exhibit the benefits from the economies of scale, enabling them to allocate more resources towards research development, and marketing activities. The existing studies suggests that larger firms have command over the financial muscle to invest in extensive R&D programs, facilitating innovation by reducing related to development of new pharmaceutical products (S. Jain, 2023). Smaller firms strive to secure funding for innovative projects, limiting their ability to compete effectively in the marketplace (Dhanora et al,2023). A study conducted by Gans and sterns suggests that larger firms can leverage their marketing strategies and distribution networks to introduce innovative products more effectively into the market.

Firm Age

The age of a firm is another crucial variable determining the performance of the firm. Older firms accumulate more knowledge and experience, resourcing it for a more extensive understanding of market demands, technological trends and regulatory landscapes (Dhanora et-al, 2023). The availability of experience can foster innovation by providing established firms which can refine and enhance existing products or to develop new ones on the previously acquired insights (M.Nandy et al, 2022). The long-established firms enjoy a larger access to fundings and have a well-established connection with their stakeholders, research institutions, regulatory bodies and distribution networks. These factors support innovation efforts, enabling established companies to more effectively entering the complex process of drug approval and market entry (S.Jain, 2023). The literature also acknowledges the disadvantages associated with firms' age. Older firms struggle with their inertia or risk-averse culture, leading to slower adoption of new technologies. This can create barriers to innovation as these firms may prioritize maintaining existing products over venturing into unknown territories. Conversely, younger firms lack sources but they possess flexibility and willingness to embrace changes. This agility can allow them to allow quickly to react quickly in response to emerging trends and technologies, providing a culture of innovation which is essential particularly in the fast-paced pharmaceutical environment

3. Data and Methodology

3.1. Description of Data

This study uses panel dataset, consisting of 775 firms in the pharmaceutical sector to investigate the effect of technology strategies on the firms' performance. The data was sourced from CMIE prowess covering the period from 2001 to 2022.

Descriptive statistics of data was calculated to facilitate comparison of different characteristics of firms. These include mean, median, standard deviation, minimum and maximum values. Further correlation and Variance Inflation tests were conducted to check the presence of multicollinearity. The dataset was further classified into different categories to analyse the differential impact of innovation strategies based the characteristics of firms. Firms size was determined as large and small using the mean value of total assets in the dataset as threshold. Firm age was categorized as young or old using the mean age of the firms in the dataset as threshold. Firm was also characterized as young or old using the mean age of firms in the dataset as the threshold. Additionally, the technology strategy of firms was classified based on their approach to innovation with the help of dummy variables as the firms using Research & Development Expenditure only, Technology imports only and Both Technology imports and Research and Development expenditure.Description of Variables

3.1.1 Dependent Variables

Market share and Lerner Index were taken for the purpose. Learner Index is considered to be a measure of firms' market power and is calculated as the difference between sales and marginal cost divided by price. Here we have taken the proxy of Lerner Index as Ratio of sales cost less labour cost, electricity cost, raw material cost and adding depreciations and profit. This, provides us the ratio of difference between operational profit less financial costs to sales. The sales of current year have been taken for the purpose. A ratio closer to 1 implies a higher firm performance.

$$\text{Lerner Index} = \frac{\text{Sales} - \text{Financial cost}}{\text{Sales}}$$

For the calculation of Market share, first we have calculated the total Industry sales of Indian pharmaceutical Industry with the help of data available through CMIE Prowess. Further, we divided total Industry sales with each firms' sales to get their proportionate share of market.

3.1.2 Independent Variables

Research and Development expenditure, Technology imports, Firm age, Firm size and Advertisement expenditure are considered as independent variables. R&D expenditure is calculated as proportion of R&D expenditure to total sales of the firm. A dummy for R&D was incorporated through the firm undertaking R&D as a part of their operations considered as 1 and the firms not undertaking R&D activities as 0. Technology Imports. Firm age was measured as the difference between year 2022 and the year of incorporation of the firm. Advertisement expenditure has been taken as the proportion of advertisement expenses to total sales of the firm in terms of percentage. The size of firm measured by its average Gross fixed asset holdings during the year. Export Intensity is calculated as proportion of exports of the firm to sales measured in percentage terms. Firm size, Firm age, advertising expenses and export intensity were taken as control variables.

4. Modelling Framework

The dataset was classified into characteristics of size, age and origin. Analysis has been made on the full

sample and the subsets of firms with small size, large size, domestic origin, foreign origin and young and old firms on the basis of working experience. To examine the relationship between innovation strategies and firms' performance, fixed effect regression models were used. The Fixed effects model for time-invariant characteristics of firms, this isolates the impact of the dependent variables on firm performance. This approach is useful to deal with the unobserved heterogeneity present in the data. Equation (1) and (2) are the equations used for the modelling purpose.

Lerner Index = F (Only R&D Dummy, Only Technology Imports Dummy, Both R&D and Technology Imports Dummy, Advertisement expenditure, Exports, Size, Age)---------- (1)

Market Share = F (Only R&D Dummy, Only Technology Imports Dummy, Both R&D and Technology Imports Dummy, Advertisement expenditure, Exports, Size, Age)---------- (2)

The lagged logarithmic values of independent variables are used to address the issue of endogeneity in the regression analysis. The use of natural logarithm and employment of lagged values helps to cover the potential bias from endogeneity, allowing for a more accurate estimation of the relationship among the variables. This approach is helpful in controlling the reverse causality and also the unobserved factors, ensuring that the results are bias free from simultaneous relationships and omitted variables. Further, results were also estimated through Driscoll- Kraay standard errors to obtain robust standard errors, given the potential for cross-sectional dependence in the panel data which can lead to biased standard errors and unreliable inference if not properly addressed. The method of Driscoll Kraay standard errors is designed to be robust to both temporal dependence and cross-sectional dependence. This approach alleviates the risk related to underestimation of standard errors and overestimating the significance of the regression coefficients thus providing reliable findings.

5. Results

The descriptive statistics of the dataset are provided in Table 2. In Table 4, correlation matrix is provided. The results shown in the table does not show presence of multicollinearity as all the values of correlation between independent variables. A positive correlation of 0.6180 has been observed between market share and size. Further, VIF test was conducted on the variables. The results do not show presence of any multicollinearity among the variables, all the VIF values were much below the ideal benchmark of 2.5 used in researches. Table 3 shows the results of Variance Inflation Factor

Table 2: Descriptive Statistics

S.no	Variables	Mean	Standard Deviation	Minimum	Maximum
1	Both R&D and Technology dummy	.2231903	.4164082	0	1
2	Only R and D Dummy	.1957105	.3967688	0	1
3	Only Technology Imports Dummy	.1478999	.3550206	0	1
4	Log of Gross Fixed Assets	5.920986	1.963667	.0953102	12.16535
5	Log of Exports	.1511852	.2131756	0	3.169045
6	Log of Advertising Expenditure	.0076902	.0301465	0	1.309474
7	Log of Age	3.059245	.6414182	0	4.682131
8	Log of Lerner Index	.1051257	.0934443	0	.6635968
9	Log of Market Share	.0024283	.0063511	4.10e-08	.0998779

Table 3: Variance Inflation Factor Lerner Index

Variable	VIF	1/VIF
Both R&D and Technology dummy	1.92	0.522167
Only R and D Dummy	1.40	0.713621
Only Technology Imports Dummy	1.26	0.795463
Log of Gross Fixed Assets	1.68	0.595483
Log of Exports	1.20	0.831823
Log of Advertising Expenditure	1.01	0.986044
Log of Age	1.14	0.875448

Table 4: Correlation Matrix

Variables	Both R&D and Technology dummy	Only R and D Dummy	Only Technology Imports Dummy	Log of Gross Fixed Assets	Log of Exports	Log of Advertising Expenditure	Log of Age	Log of Foreign Shareholding	Log of Lerner Index	Log of Market Share
Both R&D and Technology dummy	1.0000									
Only R and D Dummy	-0.5851	1.000								
Only Technology Imports Dummy	-0.2595	-0.1546	1.000							
Log of Gross Fixed Assets	0.3787	0.0529	-0.0677	1.000						
Log of Exports	0.2114	-0.0826	0.0014	0.1497	1.000					
Log of Advertising Expenditure	0.2096	-0.0769	-0.0926	0.0171	-0.1596	1.000				
Log of Age	0.2702	-0.1110	-0.0528	0.3469	-0.2359	0.2399	1.000			
Log of Foreign Shareholding	0.2079	-0.1231	-0.1738	-0.0006	-0.3547	0.3092	0.2319	1.000		
Log of Lerner Index	0.2962	-0.1727	-0.0069	0.3792	-0.0571	0.0323	0.2616	0.1624	1.000	
Log of Market Share	0.3317	-0.0723	-0.0835	0.6180	0.1893	-0.0873	0.3163	-0.0056	0.2855	1.000

Table 5.1 – Fixed Effectsand Fixed Effect Driscoll Kraay Standard Errors Result for Full Sample Dataset

	Fixed Effect						Driscoll Kraay Standard Errors			
Independent Variables	Lerner Index		Market Share				Lerner Index		Market Share	
	Coefficients	Standard error	Coefficients	Standard error			Coefficients	Standard error	Coefficients	Standard error
Both R&D and Technology dummy	.0104688 (0.002)	.003441	.0002887 (0.009)	.0001105			.0104688 (0.000)	.0024097	.0002887 (0.039)	.0001309
Only R and D Dummy	.0018679 (0.555)	0031635	-.0001467 (0.149)	.0001016			.0018679 (0.558)	.0031349	-.0001467 (0.076)	.0000785
Only Technology Imports Dummy	.0095665 (0.001)	.0028711	.0001513 (0.101)	.0000922			.0095665 (0.000)	.0022376	.0001513 (0.000)	.0000358
Log of Gross Fixed Assets	.0000211 (0.988)	.0013511	.0007565 (0.000)	.0000434			.0000211 (0.986)	.0012038	.0007565 (0.000)	.0000826
Log of Exports	.0187464 (0.002)	.0060413	-.0002216 (0.253)	.000194			.0187464 (0.007)	.0062254	-.0002216 (0.415)	-.0002216
Log of Advertising Expenditure	-.0912406 (0.003)	.030981	-.0008288 (0.405)	.0009948			-.0912406 (0.004)	.028279	-.0008288 (0.233)	.0006735
Log of Age	-.0043564 (0.418)	.0053751	.0004685 (0.007)	.0001726			-.0043564 (0.452)	.0056765	.0004685 (0.011)	.0001678
Constant	.1099689 (0.000)	.0004476	-.0012527 (0.005)	.0004476			.1065011 (0.000)	.0197923	-.0034374 (0.002)	.0009377
R-Squared	Within	Between	Overall	Within	Between	Overall	R squared	0.0352	R -squared	.0620
	0.0352	0.0454	0.0378	0.0620	0.2909	0.3369	Groups	Observations	Groups	Observations
Observations	7861	Groups	748	7861	Groups	748	748	7861	748	7861

Table 5.2.1 - Fixed effect method results for Domestic and Foreign Firms

	Domestic Firms				Foreign Firms			
Independent	Lerner Index		Market Share		Lerner Index		Market Share	
Variables	Coefficients	Standard Error	Coefficients	Standard Error	Coefficients	Standard Error	Coefficients	Standard Error
Both R&D and Technology dummy	.0113757 (0.001)	.0034922	.0001176 (0.262)	.0001047	-.0345408 (0.153)	.0240975	.0012216 (0.322)	.0012309
Only R and D Dummy	.0026133 (0.415)	.0032047	-.0001168 (0.224)	-.0000961	-.0333091 (0.127)	.0217679	-.0022241 (0.047)	.0011119
Only Technology Imports Dummy	.0099352 (0.001)	.0028819	0.0001112 (0.198)	.0000864	-.0429506 (0.204)	.0337068	.0003176 (0.854)	.0017217
Log of Gross Fixed Assets	.0007637 (0.579)	.0013767	.0007509 (0.000)	.0000413	-.0163371 (0.030)	.0074713	.0014441 (0.000)	.0003816
Log of Exports	.0190965 (0.002)	.0061375	-.0002732 (0.138)	.0001841	.0333229 (0.382)	.0380665	.0020264 (0.298)	.0019444
Log of Advertising Expenditure	-.0911896 (0.003)	.0310635	-.0009981 (0.284)	.0009316	-.2966093 (0.448)	.3904944	.0312636 (0.118)	.0199461
Log of Age	-.0062683 (0.253)	.0054874	-.0002638 (0.109)	.0001646	.0639684 (0.082)	.0366324	.0147023 (0.000)	.0018711
Constant	.1115778 (0.000)	.0140507	.0001244 (0.768)	.0004214	.0427179 (0.32)	.1332915	-.0433379 (0.000)	.0068084
R-Squared	Within	Between Overall	Within	Between Overall	Within	Between Overall	Within	Between Overall
	0.0354	0.0559 0.0483	0.0534	0.2626 0.3090	0.1678	0.1448 0.0045	0.5342	0.5488 0.5372
Observations and Groups	Observations	Groups	Observations	Groups	Observations	Groups	Observations	Groups
	7591	734	7591	734	270	14	270	14

Table 5.2.2 - Fixed effect Driscoll Kraay Standard Error method results for Domestic and Foreign Firms

	Domestic Firms				**Foreign Firms**			
Independent	Lerner Index		Market Share		Lerner Index		Market Share	
Variables	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error
Both R&D and Technology dummy	.0113757 (0.000)	.0024507	.0001176 (0.147)	.0000779	-.0345408 (0.267)	.0302444	.0012216 (0.090)	.0006854
Only R and D Dummy	.0026133 (0.451)	.0033971	-.0001168 (0.163)	.0000806	-.0333091 (0.039)	.0150825	-.0022241 (0.001)	.000579
Only Technology Imports Dummy	.0099352 (0.000)	.0023288	.0001112 (0.005)	.0000354	-.0429506 (0.187)	.0314426	.0003176 (0.589)	.000579
Log of Gross Fixed Assets	.0007637 (0.571)	.0013271	.0007509 (0.000)	.0000758	-.0163371 (0.108)	.0097023	.0014441 (0.007)	.000478
Log of Exports	.0190965 (0.010)	.006726	-.0002732 (0.284)	.0002482	.0333229 (0.531)	.0522408	.0020264 (0.219)	.0015974
Log of Advertising Expenditure	-.0911896 (0.005)	.0287285	-.0009981 (0.111)	.0005981	-.2966093 (0.548)	.484896	.0312636 (0.158)	.0213093
Log of Age	-.0062683 (0.310)	.0060191	-.0002638 (0.120)	.0001622	.0639684 (0.261)	.0553183	.0147023 (0.000)	.0013247
Constant					.0729108 (0.782)	.2602411	-.0602985 (0.000)	.0053606
R-Squared within	0.0354		.0001622		0.1678		0.5342	
Observations and Groups	Observations	Groups	Observations	Groups	Observations	Groups	Observations	Groups
	7591	734	7591	734	270	14	270	14

Table 5.2.1 - Fixed effect method results Small and Large Firms

	Young Firms				Old Firms			
Independent Variables	Lerner Index		Market Share		Lerner Index		Market Share	
	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error
Both R&D and Technology dummy	.0077787 (0126)	.0050774	.0004024 (0.000)	.0000981	-.0021638 (0.678)	.0052123	.0002448 (0.258)	.0002166
Only R and D Dummy	.0011527 (0.800)	.0045511	-.0000732 (0.405)	.000088	-.003666 (0.443)	.0047762	-.000169 (0.395)	.0001985
Only Technology Imports Dummy	.0104887 (0.006)	.0037957	.0001983 (0.007)	.0000734	.0064459 (0.160)	.0045911	.0000602 (0.752)	.0001908
Log of Gross Fixed Assets	-.0004017 (0.840)	.0019939	.0004215 (0.000)	.0000385	-.0046526 (0.077)	.0026271	.0006298 (0.000)	.0001092
Log of Exports	.0262196 (0.002)	.0085926	-.000139 (0.403)	.0001661	.0207752 (0.031)	.0096455	.0005336 (0.183)	.0004008
Log of Advertising Expenditure	-.0654101 (0.067)	.0356944	-.0006404 (0.353)	.0006898	-.0218861 (0.749)	.0683379	.0012429 (0.662)	.0028399
Log of Age	.0167209 (0.057)	.008771	-.0001567 (0.355)	.0001695	-.0313032 (0.387)	.0361812	.012607 (0.000)	.0015036
Constant	.0714786 (0.000)	.0171574	.0005325 (0.108)	.0003316	.2161545 (0.071)	.1197514	-.0383025 (0.000)	.0049764
R-Squared	Within	Between Overall	Within	Between Overall	Within	Between Overall	Within	Between Overall
	0.0338	0.0209 0.0306	0.0576	0.2944 0.3268	0.0486	0.0246 0.0177	0.1238	0.0971 0.1192
Observations and Groups	Observations	Groups	Observations	Groups	Observations	Groups	Observations	Groups
	4,386	609	4,386	609	3,232	385	3,232	385

Table 5.2.1 - Fixed effect Driscoll kraay Standard Error method results Young and Large Firms

	Small Firms				Large Firms			
Independent Variables	Lerner Index		Market Share		Lerner Index		Market Share	
	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error
Both R&D and Technology dummy	.0028202 (0.422)	.0034413	.000152 (0.004)	.0000473	.0168619 (0.084)	.0092602	.0016922 (0.008)	.0005718
Only R and D Dummy	.0011874 (0.773)	.0040651	.0000333 (0.257)	.0000285	.0014797 (0.865)	.0086054	.0002144 (0.525)	.0003312
Only Technology Imports Dummy	.0072887 (0.005)	.0022959	.0000581 (0.024)	.0000237	.0144698 (0.157)	.0098322	.0006264 (0.055)	.0003079
Log of Gross Fixed Assets	.001009 (0.435)	.0012665	.0002524 (0.000)	.0000349	-.0019227 (0.788)	.0070446	.0042976 (0.000)	.0003993
Log of Exports	.019879 (0.037)	.0088956	.0000484 (0.520)	.0000738	.0141293 (0.235)	.0115477	-.0001502 (0.584)	.0008059
Log of Advertising Expenditure	-.1016686 (0.002)	.0287868	-.0008569 (0.001)	.000232	.1937105 (0.199)	.145949	-.0064441 (0.310)	.0061856
Log of Age	-.0014332 (0.794)	.0054244	.0003899 (0.003)	.000117	-.0612167 (0.018)	.0236696	.0027103 (0.069)	.0014102
Constant								
R-Squared	0.0368		0.1305		0.0657		0.2063	
Observations and Groups	Observations	Groups	Observations	Groups	Observations	Groups	Observations	Groups
	6503	711	6503	711	1214	149	1214	149

Table 5.3.1 – Fixed effect method results for Young and Old firms

	Young Firms				Old Firms			
Independent Variables	Lerner Index		Market Share		Lerner Index		Market Share	
	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error
Both R&D and Technology dummy	.0077787 (0126)	.0050774	.0004024 (0.000)	.0000981	-.0021638 (0.678)	.0052123	.0002448 (0.258)	.0002166
Only R and D Dummy	.0011527 (0.800)	.0045511	-.0000732 (0.405)	.000088	-.003666 (0.443)	.0047762	-.000169 (0.395)	.0001985
Only Technology Imports Dummy	.0104887 (0.006)	.0037957	.0001983 (0.007)	.0000734	.0064459 (0.160)	.0045911	.0000602 (0.752)	.0001908
Log of Gross Fixed Assets	-.0004017 (0.840)	.0019939	.0004215 (0.000)	.0000385	-.0046526 (0.077)	.0026271	.0006298 (0.000)	.0001092
Log of Exports	.0262196 (0.002)	.0085926	-.000139 (0.403)	.0001661	.0207752 (0.031)	.0096455	.0005336 (0.183)	.0004008
Log of Advertising Expenditure	-.0654101 (0.067)	.0356944	-.0006404 (0.353)	.0006898	-.0218861 (0.749)	.0683379	.0012429 (0.662)	.0028399
Log of Age	.0167209 (0.057)	.008771	-.0001567 (0.355)	.0001695	-.0313032 (0.387)	.0361812	.012607 (0.000)	.0015036
Constant	.0714786 (0.000)	.0171574	.0005325 (0.108)	.0003316	.2161545 (0.071)	.1197514	-.0383025 (0.000)	.0049764
R-Squared	Within	Between	Overall	Within	Between	Overall	Within	Between	Overall	Within	Between	Overall
	0.0338	0.0209	0.0306	0.0576	0.2944	0.3268	0.0486	0.0246	0.0177	0.1238	0.0971	0.1192
Observations and Groups	Observations	Groups		Observations	Groups		Observations	Groups		Observations	Groups	
	4,386	609		4,386	609		3,232	385		3,232	385	

Table 5.3.2 - Fixed effect Driscoll Kraay Standard Error method results for Young and Old Firms

	Small Firms				Large Firms			
Independent Variables	Lerner Index		Market Share		Lerner Index		Market Share	
	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error	Coefficients	Standard error
Both R&D and Technology dummy	.0028202 (0.422)	.0034413	.000152 (0.004)	.0000473	.0168619 (0.084)	.0092602	.0016922 (0.008)	.0005718
Only R and D Dummy	.0011874 (0.773)	.0040651	.0000333 (0.257)	.0000285	.0014797 (0.865)	.0086054	.0002144 (0.525)	.0003312
Only Technology Imports Dummy	.0072887 (0.005)	.0022959	.0000581 (0.024)	.0000237	.0144698 (0.157)	.0098322	.0006264 (0.055)	.0003079
Log of Gross Fixed Assets	.001009 (0.435)	.0012665	.0002524 (0.000)	.0000349	-.0019227 (0.788)	.0070446	.0042976 (0.000)	.0003993
Log of Exports	.019879 (0.037)	.0088956	.0000484 (0.520)	.0000738	.0141293 (0.235)	.0115477	-.0001502 (0.584)	.0008059
Log of Advertising Expenditure	-.1016686 (0.002)	.0287868	-.0008569 (0.001)	.000232	.1937105 (0.199)	.145949	-.0064441 (0.310)	.0061856
Log of Age	-.0014332 (0.794)	.0054244	.0003899 (0.003)	.000117	-.0612167 (0.018)	.0236696	.0027103 (0.069)	.0014102
Constant								
R-Squared	0.0368		0.1305		0.0657		0.2063	
Observations and Groups	Observations	Groups	Observations	Groups	Observations	Groups	Observations	Groups
	6503	711	6503	711	1214	149	1214	149

5.1 Full Sample Dataset

The fixed effect regression conducted on the full sample data of Indian Pharmaceutical firms through the firm performance indicator Lerner Index revealed significant insights. The results indicated a positive impact of Both R&D and Technology Dummy (p-value = 0.002), Technology Imports Dummy (p-value = 0.001), and exports (p-value = 0.002) at the 99% significance level. Conversely, the variables Only R&D Dummy (p-value = 0.555), size (Log of Gross Fixed Assets, p-value = 0.988), and age (p-value = 0.418) did not show any positive impact. The impact of advertising expenditure was negative (p-value = 0.003) at the 99% significance level. Analysing Market Share as the firm performance indicator, positively related variables were Both R&D and Technology Dummy (p-value = 0.009), size (p-value = 0.000), and age (p-value = 0.007), significant at the 99% significance level. The variables Only R&D Dummy (p-value = 0.149), Only Technology Imports Dummy (p-value = 0.101), exports (p-value = 0.253), and advertising expenditure (p-value = 0.405) were insignificant.

Using the Driscoll-Kraay standard error method, the results were consistent. For the Lerner Index, positively associated variables were Both R&D and Technology Dummy (p-value = 0.000), Only Technology Imports Dummy (p-value = 0.000), and exports (p-value = 0.007) at the 99% significance level. Advertising expenditure (p-value = 0.004) was negatively related, while Only R&D Dummy (p-value = 0.558), size (p-value = 0.986), and age (p-value = 0.452) were insignificant. For Market Share, the positively related variables were Both R&D and Technology Dummy (p-value = 0.039, significant at 95%), Only Technology Imports Dummy (p-value = 0.000, significant at 99%), size (p-value = 0.000, significant at 99%), and age (p- value = 0.011, significant at 95%). The negatively associated variable was Only R&D Dummy (p-value = 0.076, significant at 90%). Export intensity (p-value = 0.415) and advertising expenditure (p-value = 0.233) were not significant.

5.2 Domestic and Foreign Firms

The fixed effect regression conducted on domestic firms, with the Lerner Index as the performance indicator, revealed significant insights. The results indicated a positive impact of Both R&D and Technology Dummy (p = 0.001, 99% significance level), Technology Imports Dummy (p = 0.001, 99% significance level), and exports (p = 0.002, 99% significance level). Conversely, the variables Only R&D Dummy (p = 0.415), size (p = 0.579), and age (p = 0.253) did not show any positive impact. The impact of advertising expenditure was negative (p = 0.003, 99% significance level). Analysing Market Share as the firm performance indicator, none of the technology strategy variables were significant. However, gross fixed assets had a significant positive impact (p = 0.000, 99% significance level). The Driscoll-Kraay method confirmed the significance of Both R&D and Technology Dummy (p = 0.000, 99% significance level), Technology Imports Dummy (p = 0.000, 99% significance level), and exports (p = 0.010, 95% significance level) on the Lerner Index, and gross fixed assets on market share (p = 0.000, 99% significance level).

For foreign firms, the fixed effect regression results indicated no significant impact of the technology strategy variables on the Lerner Index. However, gross fixed assets negatively impacted the Lerner Index (p = 0.030, 95% significance level). For Market Share, the R&D dummy had a negative impact (p = 0.047, 95% significance level), while gross fixed assets (p
= 0.000, 99% significance level) and age (p = 0.000, 99% significance level) positively impacted market share. The Driscoll-Kraay method confirmed these findings, highlighting the negative impact of the R&D dummy (p = 0.001, 99% significance level) and the positive impact of gross fixed assets (p = 0.007, 95% significance level) and age (p = 0.000, 99% significance level) on market share. These results underscore the distinct differences in how domestic and foreign firms are influenced by innovation strategies and other variables, reflecting varying business environments and strategic priorities

5.3 Small and Large Firms

The fixed effect regression on small firms, with the Lerner Index as the performance indicator, showed that Both R&D and Technology Dummy ($p = 0.468$), Technology Imports Dummy ($p = 0.726$), and exports ($p = 0.004$, 99% significance level) had varying impacts. Only R&D Dummy ($p = 0.014$, 95% significance level) and advertising expenditure ($p = 0.001$, 99% significance level) were significant, with the latter having a negative impact. Market Share analysis indicated that size ($p = 0.000$, 99% significance level), Both R&D and Technology Dummy ($p = 0.030$, 95% significance level), and advertising expenditure ($p = 0.002$, 99% significance level) were significant. The Driscoll-Kraay method confirmed these findings, with significant positive impacts of Both R&D and Technology Dummy ($p = 0.005$, 99% significance level), Technology Imports Dummy ($p = 0.005$, 99% significance level), and exports ($p = 0.037$, 95% significance level) on the Lerner Index. Market share was positively influenced by size ($p = 0.000$, 99% significance level) and Both R&D and Technology Dummy ($p = 0.024$, 95% significance level), with advertising expenditure showing a significant negative impact ($p = 0.001$, 99% significance level).

In contrast, the fixed effect regression for large firms showed no significant impact of technology strategy variables on the Lerner Index, except for advertising expenditure, which had a significant negative impact ($p = 0.004$, 99% significance level). Market Share was positively impacted by size ($p = 0.000$, 99% significance level), while Both R&D and Technology Dummy ($p = 0.041$, 95% significance level) and gross fixed assets ($p = 0.000$, 99% significance level) were significant. The Driscoll-Kraay method reaffirmed these results, highlighting the significant positive impact of size ($p = 0.000$, 99% significance level) and Both R&D and Technology Dummy ($p = 0.055$, 90% significance level) on market share, with advertising expenditure showing a significant negative impact ($p = 0.004$, 99% significance level).

These findings emphasize the nuanced effects of innovation strategies on firm performance across different firm sizes, suggesting that small and large firms benefit differently from R&D and technology imports in the Indian pharmaceutical sector.

5.4 Young and Old Firms

For old firms, the fixed effect regression results showed different impacts. With the Lerner Index as the performance indicator, the positive impacts of Technology Imports Dummy ($p = 0.0064$, 95% significance level), exports ($p = 0.0208$, 95% significance level), and age ($p = 0.2162$, 90% significance level) were notable. However, the variables Both R&D and Technology Dummy ($p = 0.678$), Only R&D Dummy ($p = 0.443$), size ($p = 0.077$), and advertising expenditure ($p = 0.749$) did not show any significant positive impact. Analysing Market Share, size ($p = 0.000$, 99% significance level) and age ($p = 0.0126$, 99% significance level) showed significant positive impacts, while other variables were not significant. The Driscoll-Kraay method confirmed the significance of Technology Imports Dummy ($p = 0.0064$, 95% significance level), exports ($p = 0.0208$, 95% significance level), and age ($p = 0.2162$, 90% significance level) on the Lerner Index, and size ($p = 0.000$, 99% significance level) on market share

6. Conclusion

This study made an attempt to investigate the impact of various methods of innovations and different innovation strategies on firms' performance depending on various attributes of firms. The findings have deep suggestions for firms as well as policy makers on the sector. The results for full sample dataset indicated that a combination of R&D and technology imports positively effected the firm performance indicators of Lerner Index and Market share. This indicates that firms working on both in House R&D

expenditure and acquiring the external technology tend to perform better. The results also showed that R&D technology do not have a significant impact on firm performance highlighting the possible limitations of solely relying on R&D technology. Whereas, advertising expenditure negatively impacted the Lerner Index indicating that excess spending on advertisement may not contribute to profitability. Thus, these insights suggested that a firm can get positive results in its performance enhancement after the application a balanced approach to innovation combining both internal R&D and external technology imports.

The comparison of the firms on the basis of their origin suggests a distinction within each category. For domestic firms, both R&D and technology imports positively impacted the Lerner Index, suggesting that domestic firm gain from a combined approach to innovation. However, these strategies did not affect the market share significantly effected the market share highlighting the challenges associated with utilizing innovation for market expansion. In contrast, foreign firms did not show significant benefits from innovation strategy in relation with Lerner Index though firm size and age positively impacted Market Share. This suggests that foreign firms should rely more on their established market presence and market presence and accumulated rather than innovation to boost its performance.

When firms were differentiated on the basis of size. The results suggests that small firms were able to positively draw the advantage out of both R&D and technology imports to increase their market presence. However, only technology imports significantly impacted the Lerner Index showing a firm might struggle to get profitability out of in-house R&D without using external technological support. While, advertisement expenditure negatively impacted profitability (Lerner Index). This implies that large firms can their size and innovation to expand their market presence Simultaneously, they must carefully manage advertisement expenses to maintain their profitability.

The analysis of young and old firms shows highlighted that effectiveness of innovation strategies varies with firm's lifecycle stage. Young firms tended to outcast the benefits of technology imports and exports concerning to their profitability. This suggests that access to advanced technologies and global markets is crucial for their performance. For, market share firm size was a significant positive factor, indicating scaling of operations as a vital factor for younger firms. In contrast old firms showed a positive impact for technology imports and age on their Lerner Index indicating that established firms can utilize their experience and external technology to enhance their profitability. The factor size also positively impacted the market presence of firms highlighting the importance of maintaining substantial operations for older firms.

These findings suggest several recommendations for firms and policy makers, Firms should consider adopting a balanced innovation strategy that combines internal R&D with external technology acquisitions to optimize their market performance. Small and young firms, in particular should focus on technology imports and scaling of operations to enhance their market presence and profitability. While, Large firms should focus on leveraging their scale and accumulated experience in hand together with maintaining their advertisement expenses to maintain their profitability. This study gives useful information on how innovation strategies affect firm performance in the Indian pharmaceutical sector. However, more research is needed to see if these findings apply to other industries. Future studies can look at how innovation strategies impact sectors like information technology, automobile, and energy differently. Also, examining other factors like company culture, management practices, and regulations could help understand better how firms can improve their innovation efforts for better performance.

In conclusion, this study highlights the importance of innovation strategies are for improving firm performance in the Indian pharmaceutical sector. Firms can exploit both their own innovations and external technologies, they can perform better and help the sector grow. Policymakers can help by the industry creating policies that encourage technology sharing and international trade, making India's

pharmaceutical industry more competitive and innovative

.

References

Tebaldi E., & Elmslie B. (2008). Institutions, innovation and economic growth. *Journal of Economic Development*, 33, 1–27.

Abramovitz, M. (1956). Resource and output trends in the United States since 1870. In *Resource and output trends in the United States since 1870* (pp. 1-23). NBER.

Rønningen, M., & Lien, G. (2014). The importance of systemic features for innovation orientation in tourism firms. In *Handbook of research on innovation in tourism industries* (pp. 27-55). Edward Elgar Publishing.

James Broughel, & Adam Thierer (2009), Technological Innovation and Economic Growth.
SSRN Electronic Journal

OSLO Manual, OECD,

James Broughel, & Adam Thierer (2009), Technological Innovation and Economic Growth.
SSRN Electronic Journal

Robert Bryce, Smaller Faster Lighter Denser Cheaper: How Innovation Keeps Proving the Catastrophists Wrong (New York: Public Affairs, 2014), xxi–xxii.

Annual report 2023, Ministry of Chemicals and Fertilizers Department of pharmaceuticals - Annual Report 2022-23 Final-3.pdf (pharmaceuticals.gov.in)

Technology Imports and Local research and development in Indian Manufacturing sector. NAGESH KUMAR, 1987

Mansfield, E. (1962). Entry, Gibrat's law, innovation, and the growth of firms. American Economic Review, 55(5), 1023–1051

Danish, M. S., Sharma, R., & Dhanora, M. (2021). Impact of patent quality on firm performance: a case of Indian pharmaceutical industry. *International Journal of Innovation and Technology Management*, *17*(07), 2050054.

Nandy, M. (2022). Impact of R&D activities on the financial performance: Empirical evidence from Indian pharmaceutical companies. *International Journal of Pharmaceutical and Healthcare Marketing*, *16*(2), 182-203.

Jain, S. (2023, May 1). *Thrust on innovation & R&D fundamental for Indian pharma's growth*

Aghion, P., & Howitt, P. (1992). A Model of Growth Through Creative Destruction. *Econometrica, 60*(2), 323-351.

Griliches, Z. (1998). *R&D and Productivity: The Econometric Evidence*. University of Chicago Press.

Fagerberg, J., & Verspagen, B. (2002). Technology-Gaps, Innovation-Diffusion, and Transformation: An Evolutionary Interpretation. *Research Policy, 31*(8-9), 1291-1304.

Klette, T. J., & Kortum, S. (2004). Innovating Firms and Aggregate Innovation. *Journal of Political Economy, 112*(5), 986-1018.

Schumpeter, J. A. (1934). *The Theory of Economic Development*. Harvard University Press.

Hagedoorn, J., & Cloodt, M. (2003). Measuring Innovative Performance: Is There an Advantage in Using Multiple Indicators? *Research Policy, 32*(8), 1365-1379.

Geroski, P. A. (1994). *Market Structure, Corporate Performance, and Innovative Activity*. Oxford University Press.

Teece, D. J. (1986). Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing, and Public Policy. *Research Policy, 15*(6), 285-305.

Freeman, C., & Soete, L. (1997). *The Economics of Industrial Innovation* (3rd ed.). MIT Press.

Audretsch, D. B., & Feldman, M. P. (2004). Knowledge Spillovers and the Geography of Innovation. In J. V. Henderson & J. F. Thisse (Eds.), *Handbook of Regional and Urban Economics* (Vol. 4, pp. 2713-2739). Elsevier.

Nelson, R. R., & Winter, S. G. (1982). *An Evolutionary Theory of Economic Change*. Belknap Press of Harvard University Press.

Czarnitzki, D., & Kraft, K. (2010). On the Profitability of Innovative Assets. *Applied Economics, 42*(15), 1941-1953.