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R&D, MARKET POWER, AND EXPORTS IN THE INDIAN PHARMACEUTICAL FIRMS

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Abstract
This paper analyses the impact of a firm's market power and exports on R&D activity in Indian pharmaceutical firms during the period 2014–2024. Using the inflation-adjusted financial data for the 67 publicly listed Indian R&D active pharmaceutical companies, the study provides new evidence on firm-level R&D activity of the Indian drugs and pharmaceutical industry. The Generalized Method of Movement (GMM) estimator developed by Blundell and Bond is applied in this paper. The study's empirical findings reveal that a firm's market power and export intensity are significant determinants of firm-level R&D intensity.

Keywords: India, Pharmaceutical Industry, GMM model, R&D
JEL code: A1, L1, O3

1. INTRODUCTION

The Indian pharmaceutical industry is one of the developing world's largest and most developed industries. It ranks third worldwide in production volume after the USA and Japan. The market is dominated by branded generics, constituting nearly 70 to 80 percent of the market share. Over the last four decades, it has evolved from almost non-existent to a global leader in producing high-quality generic drugs. It is the most significant global generic drugs supplier, with Indian generic drugs accounting for 20 percent of global generic exports in volume. This industry has 25 percent of the drug master filings with the US Food and Drug Administration (USFDA). It is a highly fragmented and concentrated industry with more than 24,000 firms, where the top ten companies capture more than one-third of the market.

This industry enjoys a comparative advantage over others in terms of skilled workforce, high managerial and technical competence, and shorter approval time for new drugs. This helps lower production costs, further stimulating Indian pharmaceutical firms to expand their global market base. Indian firms also have a comparative advantage in patent filings due to their high intellectual base and low-cost R&D. Public-private partnership is another critical feature in India's current trend of R&D activities. In addition to setting up their R&D base, several Indian companies are collaborating with research laboratories such as the Indian Institute of Chemical Technology (IICT), Central Drug Research Institute (CDRI), and the Centre for Cellular and Molecular Biology (CCMB). While a few leading Indian pharmaceutical firms rely on the highly regulated US and European generics and semi-regulated markets, others focus on custom manufacturing for innovative firms. From a primarily Active Pharmaceutical Ingredient (API) and formulation manufacturing base, India is moving towards an emerging hub for biopharmaceuticals, bioinformatics, contract research, clinical data management, and clinical trials.

The relationship between market power and the R&D of a firm is rooted in the Schumpeterian theory of innovation (Schumpeter, 1942), which states that larger firms enjoy more power and autonomy in the market and thus provide economies of scale in innovation and production. Larger firms tend to be more innovative, especially in a sector with high barriers to entry due to greater concentration (Blundell et al., 1999). Against this backdrop, the objective of this chapter is to empirically examine the relationship between R&D and firm power by using firm-level data from the Indian pharmaceutical industry to find out the potential of public policy related to firm power for reinforcing the Indian pharmaceutical R&D. The novelty of the study lies in the fact that it uses a dynamic estimation technique to explain innovation and firm-power linkages in the domestic pharmaceutical firms by using a more recent dataset. The rest of the paper is organized as follows: Section 2 describes data sources, methodology, and conceptual framework discussion. Section 3 discusses methodology. Section 4 focuses on results and discussion, while Section 5 concludes the study.

2. DATABASE AND CONCEPTUAL FRAMEWORK

2.1. Data Sources

The sample consists of the 67 Indian pharmaceutical firms listed on the Bombay Stock Exchange from 2014-2024. The firm's annual financial parameters data have been extracted from the Prowess Database of the Centre for Monitoring the Indian Economy (CMIE). These companies were selected based on their consistent R&D activity throughout the selected period. The final dataset forms a balanced panel for the period mentioned above.

2.2 Conceptual Framework

The R&D investment strategy is a firm's internal decision; a firm's market power plays a huge role in determining R&D and might influence a firm's innovation policy. The existing literature states that a firm's market value is positively associated with R&D, as such investments are expected to create growth opportunities for the firm. Innovation costs are increasing, yet there is a requirement for R&D activity as new strains of bacteria are viruses and surfacing, emphasizing the need to develop new drugs. The R&D investment is considered as R&D intensity, and all the variables are listed in Table 1.

Table 1: Dependent and Independent Variables

Variables	Symbol	Description
Dependent Variable		
R&D Intensity	RDI	The ratio of R&D expenditure to total sales revenue (in %)
Explanatory/Independent Variables		
Lagged R&D Intensity	RDI_{t-1}	Ratio of R&D expenditure to total sales revenue (in %) at time $_{t-1}$
The firm's lagged market share	FMS_{t-1}	The ratio of the firm's total sales to the total sales of all firms at time $_{t-1}$
Firm's size	LFSZ	Log of total assets of the firm at the time
Firm's age	FAGE	
Control Variables		
Firm's Export Intensity	XI	The ratio of the firm's exports to total sales revenue (in %)
Source: Authors' elaboration		

The description of the independent variable is given below:

Firm Size

Innovating firms tend to be larger than non-innovating firms, especially in sectors with barriers to entry and high concentration (Blundell et al., 1999). Smaller firms have less market power at their disposal and may need more support to fund R&D activities due to high start-up costs for setting up R&D infrastructure. In comparison, larger firms have better resources for attracting better talent, high internal funds availability, and more bargaining power in the credit market. Existing literature has stated a positive impact of firm size on R&D activities (Abdelmoula & Etienne, 2010; Cohen, 2010; Petruzzelli et al., 2018; Aghion et al., 2024). It is hypothesized that larger firms may allocate a larger fund for R&D activities. The variable firm size (LFSZ) is measured as a log of total assets for estimation purposes.

Firm's Market Share

The theory of a firm's market power stimulating R&D activity is rooted in the Schumpeterian theory of innovation (Schumpeter, 1942), which states that larger firms benefit from power and autonomy in the market. A firm's market power is often associated with its market share. A larger market share indicates that the firm has a vast distribution network in a large area and probably deals in many therapeutic areas, which implies that the firm should increase R&D activity to maintain its hold on the market (Tyagi et al., 2018). Thus, a firm's market share (FMS) can be used to analyze the impact of a firm's market power on R&D activity.

Firm's Age

The firm's age accounts for its' accumulated technological expertise due to past R&D and production experiences. It is also believed that the older established firms may have better R&D facilities, and they certainly attract better talent in terms of skilled staff. Age may impact a firm's R&D activity positively due to existing learning effects, as mature firms are more effective in innovative activity as they have built routines and capabilities in the past (Fan and Wang, 2021). Age also provides the experience of handling uncertainty related to innovative activity. Hence, it is hypothesized that a firm's age may positively influence R&D activity. The firm's age is measured in years as the difference between the year of establishment and the year in the specification.

Firm's Exports

A firm's exports also impact its' R&D activity as firms 'learn by exporting' due to the knowledge spillover effect. Massive exports by a firm also give the firm more power in any market as it increases the transferability of significant R&D investment across domestic and global markets. Health costs are rising globally, and Indian generic drugs provide a cheaper alternative to patented drugs working similarly, and export-oriented firms are required to undertake R&D activities seriously to meet strict global regulatory norms. Larger Indian pharmaceutical companies engage in R&D to cover the uncertainties they face in global markets. Hence, the firm's export intensity may positively impact R&D activity.

3. Methodology

Theoretical considerations hint that a dynamic model may be a more appropriate specification as lagged R&D intensity appears on the right-hand side in this model. As emphasized in earlier studies, R&D activity in the past may indicate the presence of a significant autonomous element and may be less responsive to external variables if compared with a static model (Falk, 2004; Alam et al., 2019; Nunes et al., 2019, and Tudor and Sova, 2022). The systems Generalized Method of Movements (Sys-GMM) estimator was developed by Blundell and Bond (1998). This model was suggested as an extension of the Arellano-Bond (AB) estimator, which is used for cases with few time periods and more individual units. It estimates the linear functional relationship where independent variables are not exogenous and the dependent variable is a dynamic entity. Bond and Windmejer (2002) have shown that the system GMM estimator provides more efficient results for finite samples than the standard GMM estimators because it considers first differences and eliminates unobserved firm-specific effects (Arellano & Bond, 1991).

The Blundell-Bond estimator combines the regression in differences with the regression in levels (Tyagi & Nauriyal, 2017). The two-step estimator of the Blundell-Bond GMM estimator is employed for the present study. This model assumes no autocorrelation in the idiosyncratic errors. Moreover, it assumes that the panel-level effects are uncorrelated with the first difference of the first observation of the dependent variable. There are *T-3* restrictions in exploited levels and observations *t* in levels. The main equation of interest is written as follows:

$$\text{R\&D intensity} \sim \text{FSZ} + \text{MS} + \text{XI} \quad \ldots\ldots (1)$$

where, as per Table 1, R&D intensity represents R&D expenditure (% of GDP), and it is assumed as a function of four variables, including firm size (FSZ), firm's market share (MS), firm's age, and export intensity (XI). Given the earlier exploratory data analysis, FSZ is converted to natural logarithm form, and XI and MS are in percentage form before conducting estimations; it helps to normalize the data and give more consistent results. Thus, Equation (1) can be rewritten in a similar form and applied to panel data as follows:

$$RDI_{it} = b0 + b1FSZ_{it} + b2MS_{i,t-1} + b3XI_{it} + \varepsilon_{it} \ldots\ldots (2)$$

Consequently, the empirical model to be estimated by the Sys GMM regression model will take the final form:

$$RDI_{it} = b0 + b1RDI_{i,t-1} + b2RDI_{i,t-2} + b3RDI_{i,t-3} + b4FSZ_{it} + b5MS_{i,t-1} + b6XI_{it} + u_i + \varepsilon_{it} \ldots\ldots (3)$$

i = 1, ..., 67 and t = 2014, ..., 2024

where the dependent variable R&D intensity is explained by its own lagged values and other explanatory variables included in equation (3), while u_i stands for fixed firm effects and ε_{it} is an error term with zero mean.

4. Results and Discussions

The Arellano-Bond test for serial correlation is applied after choosing the robust standard errors as the dynamic panel data models use instrumental variables for regression technique. The Sargan test is not suitable if heteroscedastic errors are present in the estimation, which makes the Arellano-Bond test a better choice. Table 2 presents the estimates from the test.

Table 2: Arellano-Bond Test for Zero Autocorrelation in First Differenced Errors

Order	z values for the first differenced errors	z values for second differenced errors
1	-11.234**	-10.174
2	-1.851**	-2.456

Source: Author's computations
Note: *** and** indicate significance at 1% and 5%.

The results, presented in Table 2, confirm the presence of autocorrelation for the first-difference errors. Hence, it was further checked in the second difference error, where no autocorrelation was detected. The estimations, therefore, are run on second differenced errors. Vif values are also estimated, and no multicollinearity is detected.

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Next, the specified econometric model was employed to analyze the impact of market power on a firm's R&D activity using the Blundell-Bond estimator. Robust standard errors have been measured to get consistent coefficients for heteroscedasticity. Table 3 shows the relevant results.

Table 3: Results of GMM Two-step Estimator

Variables	Coefficients	Robust Standard Error
Independent variables		
RDI L1	0.41955***	0.07630
FMS_{t-1}	1.65077***	0.01368
LFSZ	-2.41487***	0.08451
LFSZSQ	0.86838***	0.58686
FAGE	0.23605	0.20182
XI	-0.00434**	0.00362
Number of observations	656	
Number of instruments	59	
Wald chi2(5)	45.75***	
Note: *** and ** indicate significance at 1% and 5% level.		
Source: Author's calculations		

The reported Wald chi-square statistics, as depicted in Table 4, highlight the statistical significance of the estimated model. The variable *RDI* $_{t-1}$ suggests a positive and significant relationship between the past R&D investment and its current R&D intensity. One probable explanation could be that an already active R&D firm is required to continue its R&D activities due to the long gestation period and several products existing in the pipeline. R&D persistence helps a firm carve a sustainable, profitable business.

The association between firm size and R&D activity is found to be nonlinear for the sample firms. *LFSZ* negatively impacts R&D intensity and is significant at 1 percent. This finding is contrary to the existing studies, which indicated that the size of the firm is positively related to R&D intensity due to scale economies and greater resource availability with the firm (Kumar & Pradhan, 2003; Cho & Lee, 2021) however Baumann & Kritikos (2016) and Tyagi et al. (2018) have found negative relative between firm size and R&D activity. One plausible reason for this could be that larger firms want to avoid uncertainty and focus on their blockbuster drugs. Some of these big companies have also opened small subsidiaries that focus on R&D to keep the firm's share prices in check in case of low R&D productivity.

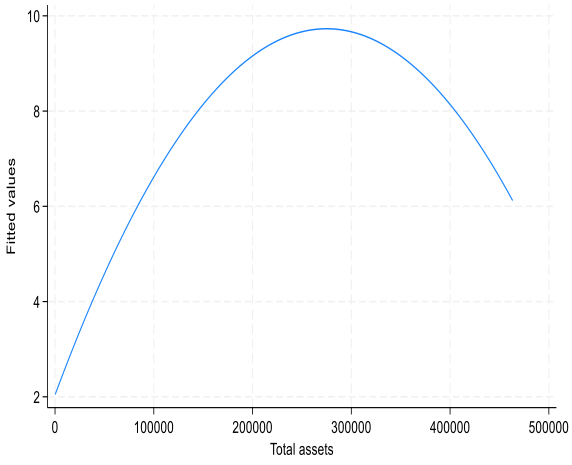

Figure 1: Total Assets and RDI (quadratic fit)

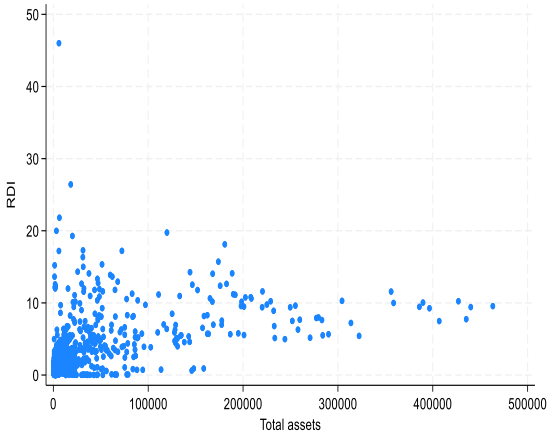

Figure 2: Total Assets and RDI (scatterplot)

The direct and significant relationship of LFSZSQ and RDI suggests that a threshold level of a firm's size makes a significant positive impact on R&D activity because of its nonlinear association with firm size. Figure 1-4 portrays the relationship between firm size and R&D activity through quadratic fit graphs.

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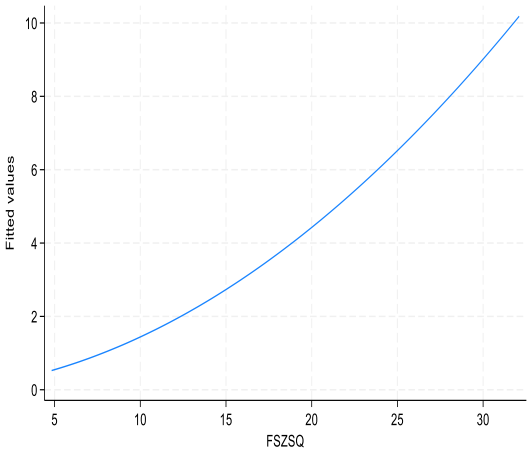

Figure 3: FSZSQ and RDI (quadratic fit)

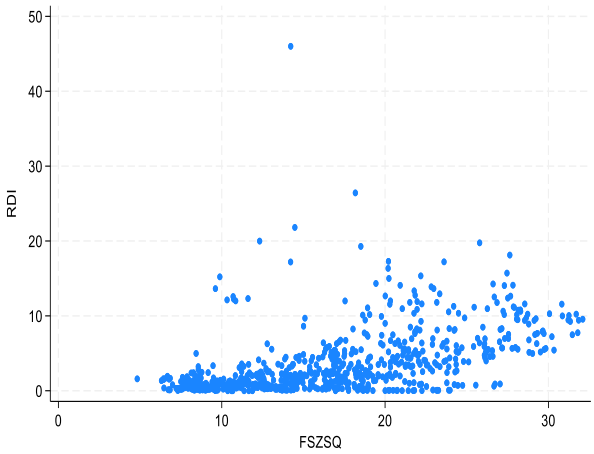

Figure 4: FSZSQ and RDI (scatterplot)

FMS_{t-1} is positively and significantly associated with R&D investment decisions for Indian pharmaceutical firms. This finding is consistent with earlier literature, concluding that R&D activity can be expected to increase with increasing market share (Schumpeter, 1942; Jeongsik & Byung-Cheol, 2013). In the pharmaceutical industry, R&D activity provides firms with a competitive advantage, which motivates firms to go for more R&D activity as their market share increases to create sustainable expansion in the market for pharmaceutical drugs. Figures 5 and 6 confirm a positive association between R&D and FMS_{t-1}.

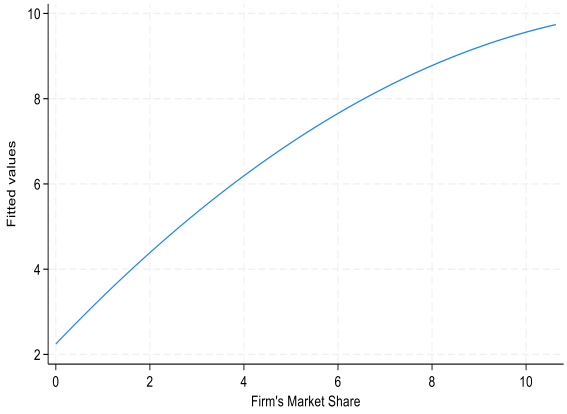

Figure 5: FMS_{t-1} and RDI (quadratic fit)

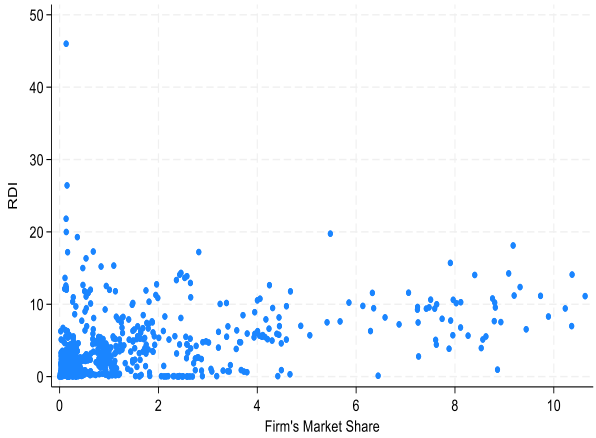

Figure 6: FMS_{t-1} and RDI (scatterplot)

FAGE is insignificantly and positively associated with RDI. The insignificance of this relationship implies that the firm's age only holds little importance when it comes to its R&D activity.

The role of XI is found to be significantly unfavorable for the sample pharmaceutical firms, contrary to the earlier studies. It may be because the Indian pharmaceutical industry is dominated by generic drugs and exports generics all over the globe, which does not require R&D in novel drugs and drug delivery systems. It may also imply that most of the R&D activity of Indian pharmaceutical companies is focused on 'developing processes and products to get regulatory approvals for entry and growth in patent-expired generic markets in developed countries' (Chaudhuri et al., 2010).

5. Conclusion and Policy Implications

The impact of a firm's market power on R&D activity was examined, and it was found that lagged market share and firm-level exports significantly and positively impacted the R&D investment across treatment categories and drug classes in the heterogeneous sample firms. Estimated results accept the hypothesis that increased export intensity, market share, and firm size are essential determinants of firm-level R&D activity, though the firm size was found to be negatively associated with RDI. These findings should logically stimulate domestic pharmaceutical firms to increase their R&D activities as a part of their survival and growth strategy in the everchanging market of drugs and pharmaceuticals. Firm size showed a negative relationship with R&D intensity, while FSZSQ showed a positive association. The negative relationship can be attributed to the loss of interest on the part of bigger firms in dedicating resources towards drug discovery due to the setbacks and constant failure so far to come up with something substantive that could provide hope. These companies have now, in effect, opened small R&D companies to eliminate the impact of low R&D productivity on the firm's market

value and to take advantage of tax benefits and other incentives. The positive impact of FSZSQ suggests a threshold level of firm size for making a positive impact on R&D investment due to its nonlinear association with the firm's market power. The positive association between the firm's market share and R&D intensity is also supported by the rising number of mergers and acquisitions internationally.

The trend and ground realities suggest that this is the appropriate time when the Indian drug and pharmaceutical industry may consolidate further through mergers and acquisitions so that many tiny units that are alleged to manufacture spurious and counterfeit drugs may grow and become relatively credible suppliers through increased R&D activity. Although such actions are generally facilitated by business considerations, public policy incentivizing it may accelerate the pace of such consolidation. Future research may also focus on including the impact of mergers and acquisitions and the type of R&D activities taken by the firm. This may help analyze R&D investment behavior better. The differences in strategic and marketing approaches of R&D active and non-R&D active firms in the Indian pharmaceutical sector may also be focused upon in future investigations.

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