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Pharmaceutical Exports from India: Empirical Evidence on Innovation, FDI, and Exchange Rate Effects

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Abstract

This paper explores the connection between the growth rate of India's pharmaceutical exports over a year and various economic markers foreign direct investment (FDI) in pharmaceuticals, patent applications, and the exchange rate. With the use of annual data from 1995 to 2023, the investigation uses Ordinary Least Squares (OLS) estimation following stationarity confirmation via unit root tests. The results indicate that there is a statistically significant adverse effect of exchange rate volatility on export performance, whereas the FDI inflows and patent filings effects are statistically not significant. The results indicate that although macroeconomic stability in currency value is crucial to export growth, other variables such as FDI and innovation indicators are probably too short-term or will need complementary enabling policies to show their export contributions. The research makes a contribution to the literature by presenting empirical evidence on short-run dynamics among innovation, investment, and trade in India's pharmaceutical industry and presenting policy implications for improving global competitiveness.

Keywords: Pharmaceutical exports, Innovation, Patent filings, Foreign Direct Investment (FDI), Exchange rate volatility, Trade competitiveness.

1. Introduction

India's pharmaceutical industry ranks third in the world in volume and fourteenth in value, and is a major source of affordable, quality medicines in global supply, ordered by value, it is the largest producer of affordable and quality medicines worldwide. India exported pharmaceutical products totalling USD 25.4 billion by FY22, nearly 20% of worldwide generic drug exports (Pharmaceuticals Export Promotion Council of India [Pharmexcil], 2023). An added dimension is that the Indian pharmaceutical industry exports to over 200 countries, thus marking itself as a major contributor to global public health, particularly in its supply of affordable generics and vaccines globally. This remarkable export performance is possible based on multiple enablers of growth. Three macro-enablers or sector specific prompts stand out - patent filings; foreign direct investment (FDI); and the exchange rate (INR/USD). Patent filings, in particular, is a signal of the extent of innovation and technical advancement in the sector, a micro-enabler imperative for attracting and accelerating competitiveness in regulated markets such as the US and EU. The Intellectual Property India Annual Report (2023) indicated that the growth in pharmaceutical patent

applications in India is steady as evidenced by sustained R&D activity and innovation. Simultaneously, there was a substantial inflow of FDI in India into the pharmaceutical sector, approximately USD 21.2 billion cumulatively from April 2000 to March 2023 (Department for Promotion of Industry and Internal Trade [DPIIT], 2023). FDI is an important source of funding for R&D and innovations not only does it provide funds, but it also provides access to state-of-the-art technology, international best practices and global distribution channels, all critical to India's export capacity. It is also useful to consider the exchange rate when discussing exports. This is essential as exchange rates affect the competitiveness of a pharmaceutical product when exported. For example, if the rupee depreciates in value, Indian pharmaceutical products become cheaper, and thus more competitive, in the global market. However, although FDI and exchange rates can impact exports, fluctuating exchange rates will cause disruption in pricing, supply chains and international contract negotiations.

Recognizing the policy relevance of these variables, the study intends to conduct an empirical examination of the relationship between the growth of India's pharmaceutical exports with that of states of patent filings in pharmaceuticals, foreign direct investment (FDI) in pharmaceuticals, and the value of a unit of Asia's Indian Rupee (INR) in US dollars (USD). The study will employ time series data from 1995 - 2023 and will use statistical techniques including, stationarity testing and multiple regression analysis to discern the strength and direction of the relationships examined. Overall, the knowledge obtained from the findings will support better understanding of the relationships that connect innovation, investment, and macroeconomic policy to export performance in a knowledge intensive industry.

2.Review of Literature:

Many studies have focused on the determinants of pharmaceutical exports, focusing on roles of innovation, foreign direct investment (FDI), and macroeconomic factors. Patents, as proxies for innovation, do lead to greater competitor ship with export markets by enhancing entry into regulated markets; Kumar and Pradhan (2006) and Lall (2003) found a positive relationship between R&D and patenting with export performance in high-tech sectors such as pharmaceuticals, while there is literature that demonstrates after the adoption of TRIPS in 1995 with the introduction of product patents, innovation in India increased, demonstrating continued support for increased export performance (Mani & Kumar, 2001). Foreign investment is also a contributor to export performance, as it enhances access to technology and entry into global markets. Goldar and Kumari (2003) and Chakraborty and Nunnenkamp (2008) described FDI as a positive contribution to export intensity in Indian industries, specifically pharmaceuticals. From a macroeconomic perspective, exchange rate movements have a large impact on export performance - a falling rupee increases the competitiveness of exports but excessive movements also add risk. There is empirical evidence from Ghosh (2010) and Bahmani-Oskooee and Hegerty (2007) analysing the positive link between an encouraging exchange rate to pharmaceutical exports from India. However, there have been very few studies exploring the combined effect of patent filings, FDI and exchange rate especially based on their annualised growth rates on India’s pharmaceutical exports, which the present study will do using a time-series econometric approach.

3.Database and Methodology:

This research applies a time-series econometric framework to explore the relationship between India's pharmaceutical exports and three independent variables: patent filings in pharmaceuticals, foreign direct investment (FDI) in the pharmaceutical sector, and the exchange rate of the Indian Rupee (INR) against the United States Dollar (USD); all measured in annual growth rates. The study adopts a retrospective analysis from 1995 to 2023, depending on data availability. Data on pharmaceutical exports (in USD) is collected from the Reserve Bank of India (RBI) and the Pharmaceuticals Export Promotion Council of India (Pharmexcil). The FDI data comes from the government department for Promotion of Industry and Internal Trade (DPIIT) and patent filings are drawn from the Intellectual Property India annual reports and WIPO statistics. The exchange rate (INR/USD) was gathered from the RBI Database on Indian Economy. In order to conduct a valid regression analysis, it was necessary to determine the stationarity of each variable by employing the Phillips-Perron (PP) test. As the PP test indicates that all of the variables were stationary at level [I(0)], the study proceeds with employing a Multiple Linear Regression Model utilizing the Ordinary Least Squares (OLS) method in the estimation of the relationship between the dependent and the independent variables.The functional form of the model is specified as follows:

$GR\_PH\_EXPORT = \beta 0+\beta 1 GR\_PATENT +\beta 2 GR\_FDIt +\beta 3 GR\_EXRAT+\epsilon t$

Where:

GR_PH_EXPORT = Growth rate of pharmaceutical exports

GR_PATENT = Growth rate of patents filings in Pharma

GR_FDI = Growth of Foreign Direct Investment in Pharma

GR_EXRATE = Growth rate of Exchange rate

To ensure the robustness of the regression results, the study also conducts diagnostic tests for **autocorrelation** (using the Durbin-Watson statistic) and **heteroscedasticity** (Breusch-Pagan test), All econometric analyses are performed using **EViews** software.

4.Hypothesis:

There is no strong correlation between the annual growth rate of pharmaceutical exports and the annual growth rates of patent filings, foreign direct investment in pharmaceuticals, and exchange rate in India.

5.Data analysis and interpretation:

Before running any time-series regression analysis, it is important to investigate the stationarity properties of the variables you plan to use. Stationarity means that the time series has a constant mean, constant variance, and constant auto covariance with respect to time. Non-stationary data can generate spurious regression results and can provide false inferences about the relationship among the variables analysed. This study utilized the unit root test that is, the Phillips-Perron (PP) unit root test to check for stationarity of the time series since this unit root test confirms whether the variables were stationary at level [I (0)] or needed to be differenced to obtain stationarity.

Table 1: Philips-Perron Test Results

Variable	Test statistics (P Value)		Integration
	At Level		
	Intercept	Trend & Intercept	
GR_IN_PH_EX	0.0136	0.0349	**I(0)**
GR_FDI_PHARMA	0.0000	0.0001	**I(0)**
GR_PATENTS	0.0000	0.0001	**I(0)**
GR_R_E	0.0000	0.0000	**I(0)**

Using Phillips-Perron (PP) procedures, the results of the stationarity test shows that all variables within the study are stationary at level i.e., they are in a level or integrated of order zero [I(0)]. For example, the p-values for the test statistic (both intercept and trend & intercept) are all below the 5% significance level for all the variables indicating the null hypothesis of a unit root is rejected. The annual growth rate of pharmaceutical exports (GR_IN_PH_EX) exhibits p-values of 0.0136 and 0.0349, respectively. This shows that stationarity is achieved. Likewise, the annual growth of Foreign Direct Investment in pharmaceuticals (GR_FDI_PHARMA), growth of patents in the pharma sector (GR_PATENTS) and growth of the value of INR/USD (GR_R_E) all have p-values of 0.0000 or 0.0001 in untook both tests for the tests specifications indicating strong evidence of stationarity at level. The results suggest that Ordinary Least Squares (OLS) regression analysis of the variables will be appropriate.

6.Ordinary Least Square Methods:

Since all variables are stationary at level [I (0)], it is appropriate to apply Ordinary Least Squares (OLS) for estimation (Gujarati & Porter, 2009).

Table 2: Results of Ordinary Least Square Test

Variable	Coefficient	Std. Error	t-Statistic	p-Value
C (Constant)	15.0404	2.1480	7.0019	0.0000
AGR_FDI (Growth Rate of FDI)	0.0094	0.0056	1.6756	0.1068
AGR_R_E (Growth Rate of Exchange Rate)	-0.5721	0.2220	-2.5769	0.0165
AGR_PATENTS (Growth Rate of Patent Filings)	0.0027	0.0321	0.0843	0.9335

It estimates how foreign direct investment (AGR_FDI), exchange rate (AGR_R_E), and patent filings (AGR_PATENTS) are affecting the annual growth rate of pharmaceutical exports (dependent variable: GR_IN_PH_EX) in India. The overall model is statistically significant, with the F-statistics of 3.858 and p-value of 0.0219 implying that the independent variables together have statistically significant effects on pharmaceutical export growth at 5% level of significance. The constant term is 15.04 and statistically significant ($p < 0.01$). This means that when all independent variables are zero, the baseline (and only other factors, which may reflect other unobserved factors or an industry-wide structural growth trend) growth rate of pharmaceutical exports is 15.04%. The estimate of the AGR_FDI variable in the model is 0.0094, suggesting a positive relationship between FDI and export growth. However, the p-value is 0.1068, suggesting that this variable plays an insignificant role at the 5% level. Yet, the p-value indicates that it is minimally insignificant with some evidence at the 10% level. This means that there may be an effect of FDI on export growth, but this variable does not produce a strong signal in this model. The estimate of INR is –0.5721 and statistically significant ($p = 0.0165$) suggesting that an increase in the exchange rate (i.e., INR depreciation) leads to a decline in pharmaceutical export growth. This is counterintuitive, because it is expected that a weaker rupee would likely benefit exports. Therefore, the estimated negative relationship could suggest that volatility in the exchange rate or high levels of import dependency (e.g., APIs) appears to negatively impact export performance. The p-value suggests a relationship exists, with a coefficient of 0.0027, although this variable has a p-value of .9335, which indicates a statistically insignificant relationship between application filings (patents) and export growth. This indicates that patent filing developments do not have any substantiate effects on export performance in the short term as it relates to growth or performance.

7.Model Statistics Results:

Table 3: Models Statistics Results

Statistic	Value
R-squared	0.3254
Adjusted R-squared	0.2410
F-statistic	3.8583
Prob(F-statistic)	0.0220
Durbin-Watson statistic	1.3699
S.E. of regression	8.7061
Mean dependent variable	13.9703
S.D. dependent variable	9.9934

The regression model captures 32.5% of the variation in the annual growth rate of pharmaceutical exports in India as measured by the R-squared value of 0.3254. Since the Adjusted R-squared value was also reported (0.2410), which accounts for the number of predictors in the model, that model can be interpreted as having a modest fit. The F-Statistic of 3.8583 and a p-value of 0.0220 tell us that the independent variables provide a statistically significant aggregate relationship with export growth at the 5% level. The standard error of regression (8.71), reflects the average dispersion of the actual data from predicted values

which means that '8.71' is the average absolute deviation of the model in the prediction of export growth. The Durbin Watson stat at 1.37 implies that the residuals are likely to have positive autocorrelation, which means additional diagnostics or modification of the model will be needed.

8.Diagnostic Tests:

Table 4: Serial Auto-correlation

Variable	Coefficient	Std. Error	t-Statistic	p-Value	Interpretation
C (Constant)	0.2345	2.0905	0.1122	0.9117	Not statistically significant.
AGR_FDI	-0.0008	0.0055	-0.1506	0.8816	No significant effect.
AGR_R_E	0.0041	0.2155	0.0189	0.9850	Not significant.
AGR_PATENTS	-0.0090	0.0317	-0.2852	0.7781	Not significant.
RESID(-1) (Lagged Residual)	**0.3223**	0.2051	1.5716	**0.1297**	Not statistically significant at 5% level. Suggests **no strong evidence of autocorrelation**.

The outcomes of the regression included the lagged residual term (RESID (-1)) and showed no first order autocorrelation in the model. The coefficient of RESID (-1) was 0.3223 with a p-value of 0.1297, which is well above the 5% significance level, not suggesting any concern about whether the residuals correlated over time. The other independent variables AGR_FDI, AGR_R_E and AGR_PATENTS also had high p-values (all above 0.77) and were not statistically significant predictors in this test either. Based on these outcomes there appears to be insufficient reason for concern about serious serial correlation in the model. Nonetheless, in support of these results I recommend corroborating the regression findings with a formal test, such as the Breusch-Godfrey LM test or the Durbin-Watson statistic.

Table 5: Heteroscedasticity Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C (Constant)	76.4209	17.1851	4.4469	0.0002
AGR_FDI	-0.0384	0.0451	-0.8526	0.4023
AGR_R_E	-2.4720	1.7763	-1.3916	0.1768
AGR_PATENTS	0.0689	0.2566	0.2683	0.7907

In order to verify whether the regression model had heteroscedasticity, the Breusch-Pagan test was executed. The test indicated that the F-statistic's p-value of 0.5179 is far greater than the conventional threshold of 0.05, providing no evidence against the null hypothesis of homoscedasticity (constant residual variance). Furthermore, the low R-squared (0.0886) and negative Adjusted R-squared (-0.0253) from the auxiliary regression add to the conclusion that the independent variables explain little of the change in the squared residuals. Therefore, we conclude that there is little evidence of heteroscedasticity, and the assumption of constant variance is met.

Conclusion:

This study investigated the relationship between annual growth rates in pharmaceutical exports and key variables influencing that growth: growth rates for FDI#s into pharmaceuticals, patents filed, and the exchange rate in India. The results of the OLS regression indicate that the overall model was statistically significant but that only the exchange rate has a statistically significant impact on annual pharmaceutical export growth, and in an interesting negative relationship. The growth rate associated with FDI had a weak positive effect while patents filed, did not have a statistically significant effect pointing towards a longer term or indirect relationship. The model explained about 32.5% of variability in export growth while mild positive autocorrelation was detected. The study showed the importance of exchange rate stability and FDI effectivity mechanisms to sustain pharmaceutical export performance. Ongoing studies may also include lag effects or other variables such as R&D spending, and global demand trends.

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