Institutional Reforms and Export Efficiency of Indian Pharmaceutical Industry – A Comparative Analysis of Transitory-TRIPS and Post-TRIPS Periods

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Abstract

The impact of institutional reforms on the performance of various industries in many emerging economies had been a growing area of research in the recent times. In this context, we investigate the influence of institutional reforms on the export efficiency of Indian pharmaceutical industry after India became a signatory to the provisions of World Trade Organisation (WTO) from 1st January, 1995. India had been given a transition period of 10 years till 31st December, 2004 to fully comply with Trade Related Intellectual Property Rights (TRIPS) as per the provisions of WTO agreement. Accordingly, India has completely transitioned to a product-patent regime from a process-patent regime effective from 1st January, 2005. Many researchers and industry professionals of the Indian pharmaceutical industry postulated that the institutional reforms would have a negative effect on the growth prospects of the industry. Contrary to the predictions, Indian pharmaceutical industry has capitalized on the export opportunities in various developed and emerging economies in the world. In this backdrop, we measure the export efficiency of Indian pharmaceutical industry during transitory-TRIPS (1995-2004) and post-TRIPS (2005-2014) periods using data envelopment analysis (DEA). The analysis of our research indicates that the export efficiency of the Indian pharmaceutical industry was higher in the post-TRIPS period.

Key Words: *Export efficiency, Indian pharmaceutical industry, Institutional reforms, Post-TRIPS, Transitory-TRIPS*

Introduction

The primary focus of many studies in strategic management research pertains to measuring corporate performance in terms of financial measures alone. In this process, earlier research neglected the significance of efficiency measurement in determining corporate performance (Chen, Delmas & Lieberman, 2015). Measuring efficiency using frontier methodologies like data envelopment analysis (DEA) and stochastic frontier analysis (SFA) can help to bridge this gap (Chen, Delmas & Lieberman, 2015).

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Though measuring efficiency of firms in different industries has earlier been attempted, very few studies (Pusnik, 2010; Saranga, 2007) have considered export efficiency as a measure of firm performance. In this research we attempt to contribute to this nascent area of research in the context of emerging economies by comparing the export efficiency of Indian pharmaceutical industry (IPI) in two different time periods of institutional reforms – transitory-TRIPS period (1995-2004) and post-TRIPS period (2005-2014). Some of the earlier studies have analysed the export efficiency of Indian pharmaceutical firms either during the transitory-TRIPS period (1995-2004) or during post-TRIPS period (2005-2014). The unique contribution of our research lies in the fact that it analyses and compares the export efficiency of IPI across two different periods and discusses how the export efficiency of the industry varied during transitory-TRIPS and post-TRIPS periods.

In this research, we have made an attempt to examine the export efficiency of the IPI during the transitory-TRIPS and post-TRIPS periods using Data Envelopment Analysis (DEA). Very few earlier studies examined the export efficiency of firms in the context of various nations and their constituent industries. Saranga (2007) studied the export efficiency of Indian pharmaceutical firms during the transitory-TRIPS period. Naude and Serumaga-Zake (2003) investigated the export efficiency of multiple South African industries. Pusnik (2010) examined the export efficiency of various Slovenian industries.

In view of the variables considered in the earlier studies, we measured export efficiency by taking export sales as output variable in this study. We have used R&D expenses, import of raw materials, compensation paid to employees and marketing expenses as input variables for employing DEA. We investigated export efficiency through calculation of Constant Returns to Scale Efficiency (CRSTE) and Variable Returns to Scale Efficiency (VRSTE) and Scale Efficiency (CRSTE/VRSTE) during transitory-TRIPS and post-TRIPS periods.

Export efficiency is measured by using data envelopment analysis (DEA). DEA has received increasing importance as a tool for evaluating and improving the performance of manufacturing and service operations (Talluri, 2000). It has been extensively applied in performance evaluation and benchmarking of schools, hospitals, bank branches, production plants, etc. (Charnes, Cooper, Lewin & Seiford, 1994). DEA is a multi-factor productivity analysis model for measuring the relative efficiencies of a homogenous set of decision making units (DMUs). Charnes, Cooper and Rhodes (1978) coined the term data envelopment analysis (DEA) by proposing an input orientation with constant returns to scale (CRS) model. Banker, Charnes and Cooper (1984) proposed the variable returns to scale (VRS) model.

As mentioned earlier, we measured export efficiency by taking export sales as output. Research and development (R&D) expenses, import of raw materials expenses, compensation paid to employees and marketing expenses are taken as inputs. Using data envelopment analysis, we measured export efficiency through calculation of CRSTE (constant returns to scale technical efficiency) and VRSTE (variable returns to scale technical) efficiency. Additionally Scale Efficiency (CRSTE/VRSTE) was measured for the sample firms during transitory-TRIPS and post-TRIPS periods.

Theoretical Framework, Model Specification and Review of Literature

Theoretical Framework

Data Envelopment Analysis (DEA) is a relatively new "data oriented" approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. The definition of a DMU is generic and flexible. Recent years have seen a great variety of applications of DEA for use in evaluating the performances of many different kinds of entities engaged in many different activities in many different contexts in many different countries.

DEA has been used in many disciplines to evaluate the performance of entities such as operations research, management control systems, organization theory, strategic management, economics, accounting & finance, human resource management and public administration including the performance of countries and regions (Rouse, 1997). Because it requires very few assumptions, DEA has also opened up possibilities for use in cases which have been resistant to other approaches because of the complex (often unknown) nature of the relations between the multiple inputs and multiple outputs involved in DMUs.

Data envelopment analysis (DEA) is a mathematical method based on production theory and the principles of linear programming. DEA was initiated in 1978 when Charnes, Cooper and Rhodes (1978) demonstrated how to change a fractional linear measure of efficiency into a linear programming (LP) format. As a result, decision- making units (DMUs) could be assessed on the basis of multiple inputs and outputs, even if the production function was unknown. It enables one to assess how efficiently a firm, organization, agency, or such other unit uses the resources available inputs to generate a set of outputs relative to other units in the dataset (Ramanathan 2003; Silkman 1986).

This non-parametric approach solves an LP formulation per DMU and the weights assigned to each linear aggregation are the results of the corresponding LP. The weights are chosen so as to show the specific DMU in as positive a light as possible, under the restriction that no other DMU, given the same weights, is more than 100% efficient.

Since DEA in its present form was first introduced in 1978, researchers in a number of fields have quickly recognized that it is an excellent and easily used methodology for modelling operational processes for performance evaluations. DEA's empirical orientation and the absence of a need for the numerous a priori assumptions that accompany other approaches (such as standard forms of statistical regression analysis) have resulted in its use in a number of studies involving efficient frontier estimation in the governmental and non-profit sector, in the regulated sector, and in the private sector.

In their originating study, Charnes, Cooper and Rhodes (1978) described DEA as a *'mathematical programming model applied to observational data [that] provides a new way of obtaining empirical estimates of relations - such as the production functions and/or efficient production possibility surfaces – that are cornerstones of modern economics'.*

Model Specification

Data envelopment analysis (DEA) is a non-parametric tool because it requires no assumption on the shape or parameters of the underlying production function. DEA is a linear programming technique based on the pioneering work of Farrell's efficiency measure (1957), to measure the different efficiency of decision-making units (DMUs). Assuming the number of DMUs is s and each DMU uses *m* inputs and produces *n* outputs. Let DMU_k be one of s decision units, 1 ≤ k≤ s. There are *m* inputs which are marked with X_i^k (i = 1, ..., m), and n outputs marked with Y_j^k (j = 1,...., n). The efficiency equals the total outputs divide by total inputs. The efficiency of DMU_k can be defined as follows:

$$\text{The efficiency of DMUk} = \frac{\sum_{j=1}^{n} u_j y_j^k}{\sum_{i=1}^{m} v_i x_i^k} \quad (1)$$

$$X_i^k, Y_j^k \geq 0, i = 1,....,m, j = 1,...,n, k = 1,...,s$$

$$u_j \; v_i \geq 0, i = 1,..., \; j = 1,...,n$$

The DEA program enables one to find the proper weights which maximise the efficiency of DMU and calculates the efficiency score and frontier. The CCR model originated by Charnes *et al*., (1978), has led to several extensions, most notably the BCC model by Banker, Charnes and Cooper (1984). The CCR and BCC models can be divided into two terms; one is the input oriented model; the other is the output oriented model. The input orientation seeks to minimize the usage of inputs given a fixed level of output while the output orientation maximizes the level of output for a given level of inputs. The CCR model assumes constant returns to scale (CRS) which means one unit input can get fixed value of output. The BCC model assumes variables returns to scale (VRS).

In this research the input oriented model had been chosen and a dual problem model was used to solve the problems. The CCR dual model is as follows:

$$Min\theta - \varepsilon \left[\sum_{i=1}^{m} S_i^- + \sum_{k=1}^{n} S_j^+ \right] \quad (2)$$

$$s.t. \sum_{i=1}^{s} \lambda_r X_i^r - \theta X_i^k + S_i^- = 0 \; i = 1,...,m$$

$$\sum_{i=1}^{s} \lambda_r Y_j^r - S_i^+ = Y_j^r \;\; j = 1,...,n$$

$$\lambda_r \geq 0 \quad r = 1,...,s$$

$$S_i^- \geq 0 \quad i = 1,...,m$$

$$S_J^+ \geq 0 \quad j = 1,...,n$$

Where

θ is the efficiency of DMU

S_i^- is the slack variable which represents the input excess value,

S_J^+ is the surplus variable represents the output shortfall value,

ε is a non-Archimedean number which represents a very small constant,

λ_r means the proportion of referencing DMUr when measure the efficiency of DMUk.

If the constraint below is adjoined, the CCR dual model is known as the BCC model.

$$\sum_{i=1}^{s} \lambda_r = 1 \quad (3)$$

Equation (3) frees CRS and makes the BCC model to be VRS. For the measurement of efficiency, the CCR model measures overall technical efficiency (OTE) of a DMU and the BCC model can measure both the pure technical efficiency (PTE) and scale efficiency (SE) of the DMU. The relationship of OE, PTE and SE is as the equation (4) below.

SE = OTE/PTE (CRS technical efficiency / VRS Technical Efficiency) (4)

Accordingly in this research, export efficiency of the IPI was examined by estimating CRS technical efficiency, VRS technical efficiency and scale efficiency.

Review of Literature

Mukherjee, Nath and Pal (2003) developed a framework to measure the efficiency of Indian banking sector using 'resource-service quality-performance' triad for 27 public sector banks. Out of the 27 banks included in the study, only nine banks were found to be completely efficient. The same banks were also found to be efficient with respect to return to quality efficiency as well. It was concluded that banks that deliver better service were found to be using their resources more efficiently to deliver superior performance.

Subbanarasimha, Ahmad and Mallya (2003) investigated the technological knowledge efficiency of 29 US pharmaceutical firms for the period 1967-1972 using DEA. Return on capital (ROC) and sales growth were considered as output variables while breadth of technological knowledge and depth of technological knowledge were considered as input variables. It was found that only 6 firms were found to be efficient using ROC as output while only one firm was found be efficient using sales growth as the output.

Chen, Chien, Lin and Wang (2004) evaluated the R&D performance of 31 Taiwanese computer firms using DEA for the period 1997. Age of the firm, paid-in capital, R&D expenses and number of R&D employees were considered as input variables. Two output variables – annual sales and number of patents approved for each firm were included as output variables. 13 firms out of the total sample of 31 firms were found to be totally efficient. 17 firms were found to be technically efficient while 13 firms were concluded to be scale efficient.

Galagedera and Edirisuriya (2005) investigated the performance of Indian commercial banks for the period 1995-2002 using DEA. Total deposits and operating expenses were included as inputs while loans & other earning assets were considered as outputs. The sample included 17 public sector banks and 23 private-owned banks. The study concluded that smaller banks were found to be less efficient while highly efficient banks were found to have high equity-assets ratios and high return to average equity ratios.

Theodoridis, Psychoudakis and Christofi (2006) employed DEA to analyse the efficiency of 108 sheep-goat farms in Greece for the year 2001-2002. Gross output (in Euros) was used as the output whereas nine variables were used as inputs – number of sheep in the herd; number of goat in the herd; acreage on irrigated land; acreage on non-irrigated land; labour used in hours; machinery expenses in Euros; buildings expenses in Euros; variable cost in Euros and feed purchased in terms of tons. It was found that the mean technical efficiency was 0.944 and 67 firms in the entire sample were found to be technically efficient.

Sahoo, Sengupta and Mandal (2007) estimated the productivity performance of Indian (public & private) and foreign banks operating in India for the period 1997-98 till 2004-05. 33 banks (11 public; 8

private; 14 foreign) were included in the study. Efficiency was examined using three measures – technical efficiency; cost efficiency and scale elasticity. The study concluded that technical efficiency was found to improve among all types of banks during the period of study. Foreign banks were found to be more cost efficient in comparison to Indian public and private sector banks.

Saranga (2007) analysed the efficiency of firms belonging to IPI using multiple objective DEA for the period 1992-2002. A sample of 44 firms was considered for the study considering the continuous availability of data for the inputs and outputs included in the study. The regular inputs considered were production cost, material cost and man power cost. The regular outputs considered were net sales and profit margins. Additionally, R&D expenditure and export sales were considered as special outputs. The findings indicated that firms with higher exports as output emerged as more efficient firms in comparison to firms with lower export sales.

Afonso and Santos (2008) used DEA to measure the relative efficiency of 52 public universities in Portugal for the year 2003. The total sample of universities has been sub-divided into smaller groups depending upon the type of university and data availability. Full-time teachers to student ratio and spending per student were taken as inputs. Success rate of students and number of doctorate certificates awarded by the university were taken as outputs. It was found that only six universities were operating at full efficiency by examining the variable returns to scale technical efficiency (VRSTE) scores.

Feroz, Goel and Raab (2008) measured the performance of 26 pharmaceutical companies in USA using DEA during the period 1994-2003. In this study, the authors used an 'income efficiency' measure which considered revenues to be maximized while minimizing factors like long term debt, common equity, selling & administrative expenses, interest & tax expenses, cost of goods and firm specific risk. All the firms have been ranked every year based upon their income efficiency scores. It was found that firms like Pfizer and Allergan improved their rankings while five firms (Glaxo Smithkline; Johnson & Johnson; Schering-Plough; Genentech & Bristol-Myers-Squib) have experienced sharp decline in their rankings. The authors concluded that the results of the study can be beneficial to financial analysts to assess the performance of pharmaceutical firms. The results can help analysts to evaluate the top management teams in terms of their corporate governance practices which in turn impact the business performance of firms. Bhagavath (2009) measured the efficiency of transportation of various state-owned transport corporations in India using DEA. The author analysed the technical efficiency of 44 state-road-transport corporations in India for the period 2000-2001. Fleet size, average distance travelled by a bus per day and cost of running the bus per day were considered as the input variables while revenue generated per day per bus was considered as the output variable. It was found that only eight out of the 44 transport corporations included in the study were found to be technically efficient. (ASRTU and CRT)

Ozbek, Garza and Triantis (2009) analysed the efficiency of six departments of transportation (DOT) in six states of USA using DEA. Cost of highway maintenance was included as input whereas level of service score and timeliness-of-response score were considered as outputs. The results obtained using Charnes-Cooper-Rhodes Model (CCR Model) concluded that only three out of the six state departments of transportation considered for the study were efficient.

Saranga (2009) estimated the operational efficiency of India auto components industry using DEA. A set of 50 firms was included in the study for the year 2003. Raw material costs, labour costs, cost of capital and sundry cost were included as input variables while gross income was considered as the output variable. It was found that out of the 50 sample firms, 14 firms were found to be efficient while 36 firms were reported to be inefficient using constant returns to scale (CRS) model. Similarly, 21 firms were found to be efficient and 29 firms were concluded to be inefficient using variable returns to scale (VRS) model. The author has further used the efficiency scores as the dependent variable and investigated the determinants of efficiency by considering capital employed, average inventory, net working capital cycle and royalty payments as independent variables. Multiple regression analysis method was employed to examine the determinants of efficiency of auto components industry.

Saranga and Phani (2009) investigated the determinants of operational efficiencies of 44 Indian pharmaceutical firms using DEA for the period 1992-2002. Cost of production & selling, raw material cost and wages & salaries were considered as inputs whereas net sales were considered as the output variable. The study found that out of 44 sample firms, only 8 firms were found to be efficient during the period considered for the study. The eight firms were identified as those firms which were found to be efficient in at least five or more years out of the eleven year period considered for the study. The remaining 36 firms were found to be efficient only in four years or less during the entire period of study.

Tahir and Memon (2011) examined the efficiency of 14 top manufacturing firms in Pakistan using DEA for a five year period (2006-2010). Total expenses and total assets were included as input variables while sales and profit before tax were considered as output variables. Only one firm was found to be technically efficient in all the five years using the constant returns to scale (CRS) model.

Hoque and Rayhan (2012) estimated the efficiency of 24 banks in Bangladesh using DEA for the year 2010. Operating profit was included as the output variable while operation income, operation cost, total assets and deposits were considered as input variables. It was concluded that out of the 24 banks included in the study only three banks were found to be efficient using constant returns to scale technical efficiency (CRSTE) while 12 banks were efficient using variable returns to scale technical efficiency (VRSTE). Three banks were found to be scale efficient among all the banks considered for the study.

Kumar and Kumar (2012) investigated the efficiency of 27 Indian public sector banks for the period 2008-2009 using Reserve Bank of India (RBI) data base. CCR Model and BCC Model of DEA were used for the study. Interest expended and operating expenses were considered as inputs whereas net interest income and non-interest income were taken as output measures. Out of the total sample of 27 banks, 10 banks were found to be efficient using BCC Model (VRS) while only 6 banks were found to be efficient using CCR Model (CRS).

In another study on the Indian banking industry, Singh, Kedia and Singh (2012) have examined the efficiency of 18 public and private sector banks over a ten year period (2001-2011) using DEA. The study included deposits, assets and profits as output measures and various factors related to employees, factors related to each branch, issues related to operations, factors impacting liquidity and profitability of the banks as input measures. The study concluded that out of all the 18 banks considered for the study, only four banks were found to be highly efficient (SBI; Canara Bank; IDBI and ICICI).

Memon and Tahir (2012) compared the efficiency scores of 49 Pakistani firms belonging to various industries. The efficiency scores were calculated using DEA for a three-year period (2008-2011). Cost of raw materials, salary and wages, plant & machinery and cost of goods sold were included as inputs while net sales and earnings after tax were considered as output variables. The research concluded that only eight firms were efficient during the period of study. Further, 13 firms were concluded to be star performers when all the sample firms have been analysed with the help of performance-efficiency matrix.

Minh, Long and Hung (2013) estimated the efficiency of 32 commercial banks in Vietnam using DEA during the period 2001-2005. In this study - received income, other operating income and total loans were included as outputs whereas personnel expenses, net total assets, all deposits and labour were included as inputs. It was found that 12 banks were efficient in 2001, 11 banks were efficient in 2002, 10 banks were efficient in 2003, 12 banks were efficient in 2004 while 11 banks were efficient in 2005 using the Banker, Charnes and Cooper Model (BCC Model).

In a very unique and interesting study, Tripathy, Yadav and Sharma (2013) compared the efficiency and productivity of IPI during the process patent (2001-02 to 2004-05) and product patent (2005-06 to 2008-09) regimes. A sample of 81 large Indian pharmaceutical firms was included in the study. Efficiency of the industry was measured using DEA and productivity was measured using Malmquist Productivity Index (MPI). Domestic sales values and export sales of the firms were considered as output variable while cost of materials, cost of energy, wages & salaries and advertising costs were included as inputs. Using VRSTE method, 28 firms were found to be efficient in the process patent regime in comparison to 19 firms in the product patent regime. In terms of scale efficiency, 14 firms were found to be scale efficient in the process patent era in comparison to 20 firms in the product patent era. It was finally concluded that technical efficiency and productivity of IPI has increased had comparatively increased in the product patent regime than in the process patent regime.

Mahajan, Nauriyal and Singh (2014a) presented an analysis of the technical efficiency of IPI using DEA. The authors investigated a sample of 50 Indian pharmaceutical firms for the period 2010-2011. Net sales revenue was included as the output variable while raw material cost, salaries & wages, advertising & marketing cost and capital usage cost were considered as the inputs. The results indicated that out of the 50 sample firms, only 9 firms were found to scale efficient while the remaining 41 firms were reported to be scale inefficient.

Mahajan, Nauriyal and Singh (2014b) examined whether type of ownership has an impact on the efficiency of the top 50 Indian pharmaceutical firms using DEA for the period 2010-2011. Raw material costs, salaries & wages paid, advertising and marketing expenses and capital usage cost were included as input variables. Net sales value has been considered as the output variable. Out of the 50 firms investigated, only 9 firms were found to be overall technically efficient while 19 firms were found to be pure technically efficient. In terms of ownership, out of the nine overall technically efficient firms, four firms were reported to be privately-held Indian firms and three firms were privately-held foreign firms while the remaining two firms belonged to group-owned Indian firms. In terms of scale efficiency measurement, only nine firms in the entire sample were found to be scale-efficient.

Chen, Delmas and Lieberman (2015) investigated the efficiency of 11 automobile firms in USA and Japan during the period 1977-1997 by comparing the results from DEA, stochastic frontier analysis and profitability returns. Value-added was included as the output variable while capital and number of employees were included as input variables. It was concluded that the Japanese automobile firms were found to be significantly higher in efficiency scores in comparison to their financial returns while the opposite was true for the automobile firms in USA.

Data and Methods

Data Source and Variables

In this research we extracted data from Centre for Monitoring Indian Economy (CMIE) Prowess database. Since the results of DEA analysis are affected by sample size, we applied two rules of thumb – a) the number of decision making units (DMUs) should be higher than the number of variables taken as inputs and outputs and b) the number of DMUs need to be at least three times the addition of number of inputs and outputs (Mahajan, Nauriyal & Singh, 2014a). Additionally, continuous availability of data is required to perform DEA. There are 615 pharmaceutical firms listed in Prowess database. We have observed that among all these firms only in case of 40 firms, continuous data was available for all the inputs and output variables in the transitory-TRIPS period (1995-2004). Similarly, during the post-TRIPS period (2005-2014), continuous data was available for only 59 firms. The sample size is in accordance with the two rules of thumb mentioned above.

Table 1 and Table 2 give a Summary of the Descriptive Statistics of the Sample Considered for this Research During Transitory-TRIPS and Post-TRIPS Periods Respectively

Table 1: Descriptive Statistics (Sample=40 firms) for Output and Inputs during Transitory-TRIPS period (1995-2004) – values in Rs. millions

	Minimum	**Maximum**	**SD**	**Mean**	**Best Firm**
Output Variable					
Export Sales	9.07	8775.3	248.8	775.8	Ranbaxy
Input Variables					
R&D Expenses	0.32	724.2	22.5	67.4	Ranbaxy
Import of Raw Materials	1.836	3111.8	92.7	356.7	Ranbaxy
Marketing Expenses	0.79	2109.6	58.5	248.8	Ranbaxy
Compensation	9.38	1242.2	46.7	286.5	Ranbaxy

Source: Authors' compilation based on CMIE data

Table 2: Descriptive Statistics (Sample=59 firms) for Output and Inputs during post-TRIPS period (2005-2014) – values in Rs. millions

	Minimum	**Maximum**	**SD**	**Mean**	**Best Firm**
Output Variable					
Export Sales	8.2	35143.69	8049.9	4830.2	Dr. Reddy's
Input Variables					
R&D Expenses	0.1	4901.3	1050.2	541.9	Dr. Reddy's
Import of Raw Materials	4.3	12291.0	2310.6	1470.8	Aurobindo
Marketing Expenses	1.3	7741.1	1312.5	825.1	Ranbaxy
Compensation	3.6	6438.9	1371.6	1074.0	Ranbaxy

Source: Authors' compilation based on CMIE data

We investigated the export efficiency of the IPI using data envelopment analysis. We have used the following variables for the analysis.

1) Output Variable:
   Export Sales
2) Input Variables:
   a) R&D Expenses
   b) Import of Raw Materials Expenses
   c) Compensation Paid to Employees
   d) Marketing Expenses (Advertising + Distribution + Promotional Expenses)

Results and Discussion

The figures in Table 3 and Table 4 represent the number of years in which a firm is efficient using either CRSTE or VRSTE scores during the transitory-TRIPS and post-TRIPS periods respectively.

Table 3: Number of Efficient Firms using CRS and VRS Models during Transitory-TRIPS Period

Company Name	CRS Model	VRS Model
Alpha Drug	2	8
Ambalal Sarabhai	2	3
Brabourne Enterprises	1	1
Capsugel Healthcare	6	10
Cipla	1	3
Dr. Reddy's	0	4
F D C Ltd.	2	2
Glenmark	2	2
Ipca Laboratories	2	9
Krebs Biochemicals	10	10
Lyka Labs	0	3
Natco Pharma	5	6
Orchid Pharmaceuticals	10	10
Ranbaxy	0	10
Raptakos, Brett & Co.	0	1
Resonance Specialties	3	9
Shasun Pharmaceuticals	2	6
Span Diagnostics	0	1
Suven Life Sciences	9	9
Themis Medicare	0	1
Twilight Litaka Pharma	0	2
Unichem Laboratories	0	1
Wintac Ltd.	1	5
Total Firms	**15**	**23**

***Source**:* Authors' analysis based on DEA results

Table 4: Number of Efficient Firms using CRS and VRS Models during post-TRIPS Period (2005-2014)

Company Name	CRS Model	VRS Model
Aarti Drugs	5	5
Ajanta Pharma	5	7
Arch Pharmalabs	2	2
Aurobindo	0	10
Avon Organics	6	6
Biocon	0	1
Cipla	0	8
Claris Lifesciences	3	3
Dishman Pharma.	8	9
Divi's Laboratories	9	10
Dr. Reddy's Laboratories	1	9
Emami	4	5
Fermenta Biotech	2	2
Fresenius Kabi Oncology	2	5
Glenmark	2	3
Ind-Swift Laboratories	7	8
Ipca Laboratories	0	1
Ishita Drugs	3	10
J B Chem. & Pharma.	4	10
Lupin	0	1
Morepen Laboratories	1	1
Mylan Laboratories	6	6
N G L Fine-Chem	9	10
Natco Pharma	4	9
Orchid Pharmaceuticals	0	3
Ranbaxy Laboratories	0	4
S M S Pharmaceuticals	1	1
Sanofi India	0	1
Sequent Scientific	1	1
Shasun Pharmaceuticals	1	3
Smruthi Organics	2	2
Strides Arcolab	2	3
Sun Pharmaceuticals	1	1
Suven Life Sciences	6	6
T T K Healthcare	0	1
Themis Medicare	1	1
Unichem Laboratories	1	1
Total Firms	**28**	**37**

Source: Authors' analysis based on DEA results

We can observe from Table 3 that out of 40 firms, only 15 firms were found to be efficient in at least one year during transitory-TRIPS period using CRSTE scores. Similarly, it can be noted from Table 4 that only 23 firms were found to be efficient in at least one year during the same period using VRSTE scores. It can be seen that only two firms – Krebs Biochemicals and Orchid Chemicals and Pharmaceuticals - were found to be efficient in all the ten years on the basis of both CRSTE and VRSTE scores.

Using CRSTE scores alone it is observed that Krebs Biochemicals and Orchid Pharmaceuticals were found to be efficient during the entire period of research. On the basis of VRSTE scores alone, only four firms (Capsugel Healthcare; Krebs Biochemicals; Orchid Pharmaceuticals and Ranbaxy) were found to be efficient during the transitory-TRIPS period. Overall it is noted that more firms were efficient on the basis of VRSTE scores.The figures in Table 4 represent the number of years in which a firm is efficient using either CRSTE or VRSTE scores during the post-TRIPS period.

It is seen that out of 59 firms, only 28 firms were found to be efficient in at one at least one year during post-TRIPS period using CRSTE scores. Similarly, only 37 firms were found to be efficient during the same period using VRSTE scores. It can be seen that none of the firms were found to be efficient in all the ten years on the basis of both CRSTE and VRSTE scores.

Using CRSTE scores alone it is observed none of the firms were found to be efficient during the entire post-TRIPS period. On the basis of VRSTE scores alone, only five firms – Aurobindo, Divi's, Ishita Drugs, JB Chem & Pharma & NGL Fine Chem. - were found to be efficient during the entire post-TRIPS period. Overall it is noted that more firms were efficient on the basis of VRSTE scores.

Table 5 presents the list of firms that were efficient for all 10 years; more than 5 years; less than 5 years and none of the years using CRS model during the transitory-TRIPS period. It is seen that only five firms were efficient for more than 5 years during transitory-TRIPS period. 24 firms were found to be inefficient during the entire period of research.

Table 5 : Transitory-TRIPS Period - List of Efficient Firms – CRS Model

	All 10 Years	**≥ 5 Years**	**< 5 Years**	**None of the Years**
CRSTE (40)	**2**	**3**	**11**	**24**
List of Firms	1) Kreb's 2) Orchid	1) Capsugel 2) Natco 3) Suven	1) Alpha 2) Ambalal 3) Brabourne 4) Cipla 5) FDC 6) Glenmark 7) Ipca 8) Lyka 9) Resonance 10) Shasun 11) Wintac	1) Abbot 2) Albert David 3) Amrutanjan 4) Anglo-French 5) Cadila 6) Dr. Reddy's 7) GlaxoSmithKline 8) Lupin 9) Merck 10) Novartis 11) Panacea 12) Pfizer 13) Piramal Ent. 14) Ranbaxy 15) Raptokas Brett 16) Sanofi 17) Span Diagnostics 18) Sun Pharma. 19) TTK Healthcare 20) Themis 21) Twilight Litaka 22) Unichem 23) Wockhardt 24) Wyeth

Source: Authors' analysis based on DEA results

Table 6 presents the list of firms that were efficient for all 10 years; more than 5 years; less than 5 years and none of the years using VRS model during the transitory-TRIPS period.

Table 6: Transitory-TRIPS Period - List of Efficient Firms – VRS Model

	All 10 Years	≥ 5 Years	< 5 Years	None of the Years
VRSTE (40)	**4**	**7**	**12**	**17**
List of Firms	1) Capsugel 2) Kreb's 3) Orchid 4) Ranbaxy	1) Alpha 2) Ipca 3) Natco 4)Resonance 5) Shasun 6) Suven 7) Wintac	1) Ambalal 2) Brabourne 3) Cipla 4) Dr. Reddy's 5) FDC 6) Glenmark 7) Lyka 8) Raptokas Brett 9) Span 10) Themis 11) Twilight 12) Unichem	1) Abbott 2) Albert David 3) Amrutanjan 4) Anglo-French 5) Cadila 6)GlaxoSmithKline 7) Lupin 8) Merck 9) Novartis 10) Panacea 11) Pfizer 12) Piramal Ent. 13) Sanofi 14) Sun Pharma. 15) TTK Healthcare 16) Wockhardt 17) Wyeth

Source: Authors' analysis based on DEA results

It is seen that only 11 firms were efficient in more than 5 years. 17 firms were found to be inefficient during the entire transitory-TRIPS period. Table 7 presents the list of firms that were efficient for all 10 years; more than 5 years; less than 5 years and none of the years using CRS model during the post-TRIPS period.

Table 7: Post-TRIPS Period - Number of Efficient Firms – CRS Model

	All 10 Years	≥ 5 Years	< 5 Years	None of the Years
CRSTE (59)	**0**	**9**	**19**	**31**
List of Firms		1) Aarthi Drugs 2) Ajantha 3) Avon Organics 4) Dishman 5) Divi's Labs 6) Ind-Swift Labs 7) Mylan 8) NGL 9) Suven	1) Arch Pharma 2) Claris 3) Dr. Reddy's 4) Emami 5) Fermenta 6) Fresenius 7) Glenmark 8) Ishitha 9) J B Chem 10) Morepen 11) Natco 12) SMS 13) Sequent 14) Shasun 15) Smruthi 16) Strides 17) Sun 18) Themis 19) Unichem	1) Albert David 2) Amrutanjan 3) Anglo-French 4) Aurobindo 5) Bal Pharma 6) Biocon 7) Cadila 8) Cipla 9) Elder 10) FDC 11) GlaxoSmithKline 12) Ind-Swift Ltd. 13) Indoco 14) Ipca 15) Jagsonpal 16) Lupin 17) Merck 18) Neuland 19) Novartis 20) Orchid 21) Panacea 22) Pfizer 23) Piramal Ent. 24) Ranbaxy 25) Sanofi 26) Span 27) TTK Healthcare 28) Torrent 29) Wanbury 30) Wockhardt 31) Wyeth

Source: Authors' analysis based on DEA results

It is seen that only nine firms were efficient for more than 5 years during post-TRIPS period. 31 firms were found to be inefficient during the entire period of research.

Table 8 presents the list of firms that were efficient for all 10 years; more than 5 years; less than 5 years and none of the years using VRS model during the post-TRIPS period

Table 8: Post-TRIPS Period - Number of Efficient Firms – VRS Model				
	All 10 Years	**≥ 5 Years**	**< 5 Years**	**None of the Years**
VRSTE (59)	**5**	**12**	**20**	**22**
List of Firms	1) Aurobindo 2) Divi's Labs 3) Ishitha 4) JB Chem. 5) NGL	1) Aarti 2) Ajantha 3) Avon 4) Cipla 5) Dishman 6) Dr. Reddy's 7) Emami 8) Fresenious 9) Indswift Labs 10) Mylan 11) Natco 12) Suven	1) Arch 2) Biocon 3) Claris 4) Fermenta 5) Glenmark 6) Ipca 7) Lupin 8) Morepen 9) Orchid 10) Ranbaxy 11) SMS 12) Sanofi 13) Sequent 14) Shashun 15) Smruthi 16) Strides 17) Sun 18) TTK 19) Themis 20) Unichem	1) Albert David 2) Amrutanjan 3) Anglo-French 4) Bal Pharma 5) Cadila 6) Elder 7) FDC 8) GlaxoSmithKline 9) Indswift Ltd. 10) Indoco 11) Jagsonpal 12) Merck 13) Neuland 14) Novartis 15) Panacea 16) Pfizer 17) Piramal 18) Span 19) Torrent 20) Wanbury 21) Wockhardt 22) Wyeth

Source: Authors' analysis based on DEA results

It is seen that only 17 firms were efficient for more than 5 years during post-TRIPS period. 22 firms were found to be inefficient during the entire period of research.

Table 9 presents a summary of the number of firms that were efficient for different years during transitory-TRIPS and post-TRIPS periods.

Table 9: Number of Efficient Firms – CRS and VRS Models				
	All 10 Years	**≥ 5 Years**	**< 5 Years**	**None of the Years**
Transitory-TRIPS Period				
CRS Model (40)	2	3	11	24
VRS Model (40)	4	7	12	17
Post-TRIPS Period				
CRS Model (59)	0	9	19	31
VRS Model (59)	5	12	20	22

Source: Authors' analysis based on DEA results

It is seen that more firms were efficient in export performance during the post-TRIPS period in comparison to the transitory-TRIPS period using CRS and VRS models.

Table 10: Mean CRSTE and Mean VRSTE Scores – Transitory-TRIPS and Post-TRIPS Periods										
Transitory-TRIPS Period (1995-2004)										
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Mean CRSTE	0.35	0.40	0.37	0.35	0.39	0.38	0.32	0.34	0.48	0.51
No. of Firms	6	6	6	5	7	5	6	4	7	7
Mean VRSTE	0.49	0.58	0.54	0.54	0.57	0.52	0.56	0.51	0.61	0.68
No. of Firms	9	12	9	9	12	14	14	11	14	13
Post-TRIPS Period (2005-2014)										
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Mean CRSTE	0.47	0.58	0.60	0.54	0.53	0.56	0.54	0.56	0.57	0.54
No. of Firms	5	16	13	7	9	11	9	9	11	9
Mean VRSTE	0.59	0.63	0.63	0.59	0.60	0.65	0.64	0.65	0.68	0.63
No. of Firms	17	24	18	14	13	17	17	18	19	14

Source: Authors' analysis based on DEA results

Table 10 presents a summary of the mean CRSTE scores and mean VRSTE scores during transitory-TRIPS and post-TRIPS periods.

Overall, it is seen that the export efficiency of Indian pharmaceutical industry was better in the post-TRIPS period in comparison to transitory-TRIPS period using both CRS and VRS models.

Table 11 presents a summary of the scale efficiency (SE) scores of the sample firms during transitory-TRIPS and post-TRIPS periods.

Table 11: Scale Efficiency Scores – Transitory-TRIPS Period and Post-TRIPS Period										
Transitory-TRIPS Period										
	199	**199**	**199**	**199**	**199**	**200**	**200**	**200**	**200**	**200**
Mean of Scale Efficient	0.75	0.66	0.65	0.59	0.63	0.69	0.53	0.66	0.78	0.72
No. of Scale Efficient Firms	9	6	6	5	7	5	6	4	7	7
Post-TRIPS Period										
	200	**200**	**200**	**200**	**200**	**201**	**201**	**201**	**201**	**201**
Mean of Scale Efficient	0.81	0.90	0.94	0.86	0.86	0.85	0.82	0.84	0.82	0.85
No. of Scale Efficient Firms	6	19	15	10	10	11	9	10	12	10

Source: Authors' analysis based on DEA results

It is seen that the SE scores were comparatively better during the post-TRIPS period. It is observed that the mean of scale efficient firms decreased during transitory-TRIPS period while it increased during post-TRIPS period.

The results of the analysis highlight that the export efficiency of the Indian pharmaceutical industry was higher in the post-TRIPS period in comparison to the transitory-TRIPS period.

Conclusions

The Indian pharmaceutical industry has experienced a rapid growth in exports after India became a member of WTO on 1st January, 1995. The growth of the exports has been marginally lower in the transitory-TRIPS period (1995-2004) in comparison to the post-TRIPS period (2005-2014). We attribute this phenomenon to the uncertainty that prevailed over the future in the Indian pharmaceutical industry during the period immediately after India became a signatory to WTO agreement. Despite the initial apprehensions, the industry has gradually captured a growth trajectory, largely due to exploitation of export opportunities in global markets.

This had been possible due to the fact that the industry was able to offer high-quality products at competitive prices. In this research, we examined the efficiency of Indian pharmaceutical exports during the transitory-TRIPS and post-TRIPs periods. Our research was aimed to investigate whether the industry was able to increase its export efficiency while it aggressively exploited global export opportunities.

The results of our research indicate that the export efficiency of Indian pharmaceutical industry has increased progressively after India became a member of WTO. We also conclude that the efficiency of the industry was higher in the post-TRIPS period. Future researchers can use this approach to understand the export efficiency of other Indian industries in the back drop in institutional reforms in India.

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