Efficiency of Indian Textile Manufacturing Sector and its Determinants: Evidence Based on Non Parametric Data Envelopment Analysis

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Abstract

This paper estimates technical efficiency (TE) of Indian textile firms (ITF) using nonparametric Data-Envelopment- Approach and exploring CMIE data for the period 1995-2016. It finds out the determinants of TE considering the effect of R&D-intensity, firms-size , export-intensity, marketing-intensity, advertising-intensity, total import-intensity and its different components like import of raw materials, stores and spares , capital goods in a panel regression framework. Whether TE improves after the withdrawal of multi-fiber-trade-agreement since 2005 is tested. The average level of TE over the sample years is 0.864, only 17% of the total sample firms are efficient, indicating prevalence of high technical-inefficiency. After 2005, the TE level increases but the TE curve became flatter, implying a decline in the rate of change of TE. Since ITF import a lot of textile-yarn and also re-export it, export and import data are correlated. Separate panel regressions are resorted with export and import as separate regressor. Considering all the factors, the impact of (i) Advertising is positive and linear,(ii) R&D, export and firm size are non-linear with positive marginal effects, (iii) total-import is positive;(iv) imports of capital goods (IMCAP) is insignificant, with significant positive and negative marginal effects of import of stores and spare (IMSTR) and raw materials (IMRAW) respectively; implying positive effect of IMSTR dominates over negative effect of IMRAW, so that on balance total import produces positive effects, (v)net export is negative implying effect of imports dominates over exports.

Key Words: *Total factor productivity growth, Manufacturing Sector, Indian Economy*
JEL Classifications: *D24, L6, O50*

1. Introduction

The 1991 economic reforms in India exposed the domestic firms to international competition. The Government of India removed all sorts of trade restriction and took a liberalized policy. The impacts of trade liberalization on the productivity and efficiency of domestic manufacturing firm are a matter of considerable debate. According to traditional infant industry arguments, the abolition of protection results in the bankruptcy of large number of domestic firms. On the other hand, many argue that the trade liberalization makes the domestic firms much more efficient and competitive to face the foreign competition by improving their performances. Numerous regulations enforced through rigid bureaucratic control created a 'permit-licence Raj' in the pre-Reform decades that effectively inhibited productivity growth and technical efficiency in Indian manufacturing. Policies like reservation of a large number of items for production by firms in the small scale sector, high customs tariffs distorting resource allocation and inhibiting the ability of Indian firms to compete in the global markets, restrictions on capacity expansion restraining firms from attaining efficient size, frictions faced in establishing and closing down of firms in response to normal competitive market dynamics, and other distortions created by domestic trade taxes and excise duties discouraged efficiency and hindered productivity growth. The earlier regulatory regime ended by the introduction of various reforms and gradual liberalization of both domestic and international trade. Also there is recognition of the urgency on the part of the Indian industries to become efficient so as to tolerate successfully the pressure of foreign competition (Government of India, 2000–01, p. 149). Over the years, several financial measures such as rationalization of excise duties, liberalization of tax laws and rates, reduction in interest rates and so on, alongside physical measures meant to remove infrastructural constraints in the power, transport and telecommunications sectors have been taken by the government of India to help domestic industries to achieve higher efficiency.

Coming to the textile industry for a long time, the global trade in textile and clothing were guided by the Multi-fiber Arrangement (MFA) of 1974, which has handled national quotas for exports of textile. India has bilateral arrangements under the MFA with developed countries such as US, Canada and countries in the European Union. Almost 70% of India's clothing exports have gone to the quota countries of the US and the European community. However WTO's Agreement on Textile and Clothing (ATC) of 1995 envisages the dismantling of the MFA over a 10-year period. The act has been dismantled since 2005. Thus, the textile industry was opened to free competition at the international level from January 1, 2005. There is a natural competitive advantage of the textile industry in terms of a strong and large multi-fibre base and abundant supply of cheap skilled labour for India. However, due to international trade and competition in the post-quota regime, prices expected to fall and hence such an advantage may not be enough. Thus efficiency and productivity of the Indian textile industries should increase in order to meet the emerging challenges of global competition. It is against this background that the performance of the Indian textile firms needs to be examined. Textiles industry in India is one of the largest in the world with a huge raw material base and manufacturing strength across all value chains. The strength of India's textiles industry lies both in the hand woven sector as well as mill sector. Traditional sectors like handloom, handicrafts and small scale power loom are the biggest source of employment for millions of people in rural and semi-urban areas. This industry contributes to 7% of industrial output in value terms, 2% of India's GDP and 15% of the country's export earnings.(Government of India, Ministry of Textile, 20 December, 2018) So far textile industry is concerned in the mid-1980s; a new textile policy was announced to enable the industry to increase the supply of good quality cloth at reasonable prices for both domestic consumption and export. To meet the modernization requirements of this industry a Textile Modernization Fund of Rs. 7.5 billion was created. The textiles industry was de-licensed in the early 1990s. Thus the requirement for a prior government approval to set up textile units including power looms was abolished. To enable the textile units to take up modernization projects, a Technology Up gradation Fund Scheme (TUFS) was also launched in 1999, by providing interest subsidy on borrowings. All of these regulatory and other policy changes were ultimately geared towards enabling the Indian textile industry to improve its competitiveness in the World market. According to the recent report of Government of India a total of 11,14,545 persons were trained under the scheme mainly in apparel and garmenting (86%) with total expenditure of Rs. 935.17 crores, of which 8,43,082 persons (75.64%) were given employment in the textile sector. Out of the persons trained in last 4 years, more than 70% were women, 22.69% were from SC category and 7.22% were from ST Category. Apart from these various policy measures were undertaken for the promotion of textile sector (Government of India, Ministry of Textile, 20 December, 2018).

Thus the question arises what is the extent of efficiency of textile firms and what are factors influencing the efficiency? The answer to this question is important given the current set up of Indian textile industry, where fostering of efficiency is needed for its very survival. The motivation of this paper steams from this observation. The paper intends to test whether the efficiency of Indian textile firms have improved or not since reform during the period 1995-2016 since ATC of 1995, especially after the removal of MFA in 2005 and also what are the factors affecting the changes in efficiency.

Some studies are available regarding the efficiency analysis for different industries including textile industry. Driffield and Kambhampati (2003) showed that the overall efficiency in the post-reform period increased in five out of their considered six manufacturing sectors. The analysis of Mazumdar and Rajeev (2009) indicated that increased export earnings did not necessarily lead to higher efficiency of Indian Pharmaceutical firms. Bhandari and Maiti (2012) presented a significant positive association between firm size and technical efficiency of Indian leather firms. Kumar and

Arora (2012) showed that a steep decline in the level of technical efficiency has been observed in post-reform period compared to the post reform period. They have also shown that the availability of skilled labour and profitability are the significant determinants of technical efficiency of Indian sugar industry. Saravanakumar and Kim (2012) revealed that the reform improved the efficiency and technological progress of heavy industries but failed to improve efficiency in light industries. Sinha (1993) showed that there was positive and significant impact of foreign equity participation on technical efficiency. Pattnayak and Thangavelu (2004) observed total factor productivity improvements in Indian manufacturing industries which in-a-way improved their economic efficiency. Bhaumik and Kumbhakar (2010) presented that there was an increase in productivity of factor inputs during 1990s but the most of the growth in value-added was explained by the growth in the use of factor inputs. The change in technical efficiency explained a very small proportion of the change in gross value added. Parameswaran (2004) estimated technical change and technical efficiency change using a stochastic frontier production function for Indian capital goods industries during 1990s. This study showed that these industries experienced a significant improvement in the rate of technological progress but decline in level of technical efficiency during the post reform period. Mazumdar, Rajeev and Ray (2012) used non- parametric approach of DEA to examine the sources of heterogeneity in the efficiency of Indian pharmaceutical firms for the period 1991-2005. They found that these firms could make efficient use of their inputs but output efficiency was declining during this period. Their analysis showed that difference in firm size and presence of economies of scale in production are the sources of firms' heterogeneity. Bhandari and Ray (2012) used data from Annual Survey of Industries (ASI) for a number of years 1985–86, 1990–91, 1996–97, 1998–99 , 1999–00, 2001–02 to measure the technical efficiency in the Indian textile industry at firm level. Their analysis suggested that the size of the firm would have a positive impact on technical efficiency, implying the consolidation of small firms into large entities might enhance efficiency.The limitation of Bhandari and Ray is that they did not consider the role of Advertising, marketing, R&D, import, export on the level of technical efficiency. However, these variables affect the technical efficiency of the firm as suggested by the literature around the globe.

For example regarding R&D it can be said that for a constant or decreasing return to scale, aggregate production function with positive spill-over effect of R&D may exhibit increasing returns to scale and thus may lead to sustained long run growth (Romer, 1986; Raut and Srinivasan (1993)).In a second line of thought Cohen and Levinthal (1989) among others argue that while knowledge from private R&D capital spills over to create social or public domain knowledge, a firm must invest in R&D to acquire the technical capability needed to make use of the public domain knowledge to enhance its productivity and or efficiency. Many of the ensuing studies in the international literature examined R&D as the determinants of efficiency at an aggregate country level, or by sector, although some research took the firm as the unit of analysis. To name a few Yang et al. (2009) , Kumbhakar et al. (2009) ,Scannell et al. (2012) . Some studies are available linking the R&D activities and efficiency of the firm for Indian industry. Mention may be made of Ferrantino, (1992), Driffed and Kambhampti (2003), Mazumder et al.(2010)among others. The studies vary with respect to the specific industries that they are considering and also with respect to the effect of R&D activity.

Regarding the role of exports an enormous amount of literature is available both at the theoretical as well as empirical level. On the theoretical front, there is a common opinion that international trade in general and export in particular enhances economic growth and improves the efficiency and or productivity of involved firms (Balassa, 1988). Economic policies under export-led growth strategy have been widely supported on the argument that exposure to international market through export helps to increase the efficiency of exporters. Similarly, advocates of endogenous growth theory believe that export plays a crucial role by improving efficiency through innovation (Grossman and Helpman, 1991) and technology transfer (Barro and Sala-i-Martin, 1995). One of the key factors in favor of the export-led hypothesis is the impact economic openness has on the efficiency with which resources are used in an economy. In theories, there are at least four explanations of how export expansion improve the efficiency and/or productivity of industry and tend to promote economic growth. (i) Export expansion *can lead to economies of scale*. An increase in exports represents an expansion of markets. International demand determines higher capacity utilization and allows the exploitation of economies of scale which tends to require and facilitate expanding of the scale of production and the achievement of economies of scale. Outward orientation may result in efficiency gains for firms, due to the exploitation of economies of scale (Clerides et al, 1998; World Bank, 1993).(ii) *Exporters might learn from their presence in international markets associated with knowledge spillovers from international contacts* (Clerides et al, 1998; World Bank, 1993). International contacts with buyers and customers are likely to foster knowledge and technology spillovers, such as access to technical expertise, including new product designs and new production methods. (iii) *Exports intensify market competition in both overseas and domestic markets, and tend to force enterprises to be more efficient through the rationalization of management and theadoption of new technologies* (Balassa, 1988; Kwon, 1986; Greenaway, 1986; Chen and Tang, 1990; Greenaway and Sapsford, 1994). (iv) *There are spill-over effects, such as technology diffusion, from export-oriented industries to non-export-oriented industries, and from foreign-invested enterprises to domestic firms* (Feder, 1983; Huallachain**,** 1984). Empirical evidence showing that firms that will become exporters have some prior advantage is very rich and unambiguous. Mention may be made of studies by Chen and Tang (1987), Sun et .al (1999), Walujadi (2004)., Mok et .al (2010) among many others. However, the studies vary with respect to the effect of export performance on efficiency of the firms.

At the same time the researchers also justified the role of imports in explaining efficiency. Import is essential to carry out R&D activity and for inputs to be used in the production process. World Bank Report (1993, 1997) talked about the firm's import for foreign technology and its positive impact on its efficiency and or productivity. Such activities enable firms to build up their internal production capabilities and competency. The removal of quantitative restrictions on imports and lowering of customs duties in the post liberalization era in India should have improved access to imported raw materials, and capital goods. Imports of materials embodying latest technologies should foster the productivity and or efficiency of the firms. In the Indian context a positive relationship between technical efficiency and imports is reported by Goldar et al. (2004) and Mazumder et al. (2010).

Advertising is used as a means to reduce scope and effectiveness of price competition by creating product differentiation among firms in the consumer goods industry. Syverson (2004) explores the influence of product substitutability in an industry on the disparity of productivity level. When consumers can easily switch between producers, relatively inefficient (high-cost) producers cannot profitably operate. Thus high-substitutability industries should exhibit less productivity dispersion and have higher average efficiency and/or productivity levels. Syverson (2004) demonstrated this mechanism in a simple industry equilibrium model and tested it empirically using producer-level data from 443 U.S. manufacturing industries and tested for the effect of higher advertising intensity on substitutability. Advertising expenditure can also affect output oriented efficiency of the industry. Goldar et al. (2004) and Carod and Blasco (2004) studied the linkages between advertising intensity and technical efficiency for the Indian Engineering goods industries and Spanish manufacturing firms respectively. Ray (2006) did not find any impact of product differentiation on technical efficiency in the Indian Manufacturing sector.

Marketing Expenditure as a ratio to total sales and it also serves as a proxy for product differentiation. Sheth and Sisodia (2002) claimed that low productivity or efficiency is due to the sliding of marketing effectiveness. Their study suggests some changes are needed at the corporate level and the most fundamental one is that corporations should treat marketing as an investment rather than an expense. Kao et al. (2006) evaluates Technical and Allocative Efficiency in Marketing and explains the positive relation between return and marketing expenditure, which is defined as a kind of investment. The return can be in the form of increased sales, or customers, or some form of infrastructure that makes acquiring these items easier.

The perusal of the literature thus suggests that there is dearth in the literature explaining efficiency of Indian textile firms taking into account the following explanatory variable such as R&D intensity, export intensity of goods, marketing intensity, advertising intensity, total import intensity and import intensity of raw materials, stores and spares and capital goods, investment, size of the firm, capital goods intensity. The present paper contributes to the literature in this direction by using the data from CMIE for the period

1995-2016 in a panel regression framework. The technical efficiency of the firm is estimated by nonparametric Data Envelopment Approach.

The rest of the chapter unfolds as follows. Section 2 reports the methodology for measuring TE and the data source. The results of estimation TE is presented in Section 3. Section 4 explains the determinants of technical efficiency. Section 5 explains the factors that influence output oriented technical efficiency. Section 6 concludes the study.

2. Methodology and Data Source

The chapter uses two stage methodologies. In the first stage technical efficiency (TE) of the companies is obtained. After estimating technical efficiency, this chapter tries explain the variation of technical efficiency in term of other economic and strategic variables like R&D, Marketing, advertisement, export behavior, import behavior, size of the firm , capital goods intensity.

2.1. Measurement of technical efficiency (TE)

The measurement of Technical Efficiency was effectively started with the analysis of Farrell (1957). He distinguished between Technical Efficiency (TE) and Allocative Efficiency (AE). According to Farrell, in case of TE, a comparison can be made either between observed output and the maximum potential output obtainable from the given inputs (termed as 'output-oriented efficiency') or between the observed inputs and the minimum possible inputs required to produce a given level of output (termed as 'input-oriented efficiency'). In contrast, the AE is defined as the capability of a producing unit to combine inputs and outputs in optimal proportions, given their respective prices and production technology. The present paper concentrates only on TE and in particular on output-oriented efficiency measures.

Both the input and output oriented measures of technical efficiencies in case of single input and output, can be visualized from **Figure 1**

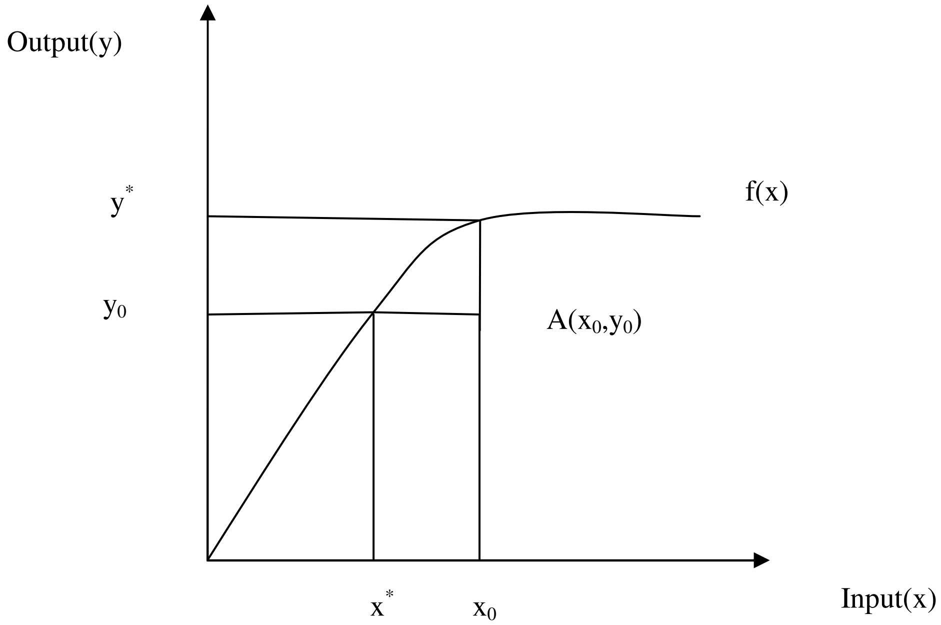


Figure 1: The input and output oriented measure of technical efficiency

In Figure 1 input x is measured along horizontal axis and output y along the vertical axis. Point A (x_0, y_0) represents the actual input-output bundle of a firm, A. Now, $y^* = f(x_0)$, where y * is the maximum output producible from input x_0. The output-oriented measure of technical efficiency of firm A = $\frac{y_0}{y^*}$ which is the comparison of actual output with the maximum producible quantity from the observed input. Now for the same output bundle y_0 , the input quantity can be reduced proportionately till the frontier is reached. So, y_0 can be produced from input x *. Thus the input-oriented technical efficiency measure for firm A = $\frac{x^*}{x_0}$.

The TE score of a firm takes a value between 0 & 1. A value of one indicates the firm is fully technically efficient.

Following Farrell's (1957) substantive theoretical and empirical literature, it can be observed that basically there are two alternative methods to measure TE scores of a producing unit – (i) non parametric Data Envelopment Analysis that involves mathematical programming procedures and (ii) parametric Stochastic Frontier Approach containing econometric methods. This paper uses nonparametric Data Envelopment Analysis.

The Data Envelopment Analysis was originally formulated by Charnes, Cooper and Rhodes [CCR (1978)]. The original CCR model was applicable only to technologies characterized by constant returns to scale globally. Later Banker, Charnes and Cooper (BCC) (1984) extended the CCR model to accommodate technologies that exhibit variable returns to scale.

In DEA, a benchmark technology is constructed from the observed input-output bundles of the firm in the sample without any assumption regarding the production frontier. The general assumptions made about the production technology are: i) All actually observed input-output combinations are feasible. ii) The production possibility set is convex. iii) Inputs are freely disposable. iv)Outputs are freely disposable. These are weak assumptions. These assumptions hold for all technologies represented by quasi-concave and weak monotonic production function

Figure 2 illustrate the basic ideas behind DEA and return to scale. Four data points (A, B, C, and D) are used here to describe the efficient frontier and the level of capacity utilization under VRS and CRS assumptions. In a simple one output and one input DEA problem, A, C and D are found to be efficient, while B is inefficient. So unit B can produce more output at point B' on the frontier (which is equal to theoretical maximum) utilizing same level of input at X_1. With constant returns to scale, the frontier is defined by point C for all points along the frontier, with all other points falling below the frontier (hence indicating capacity underutilization). With variable returns to scale, the frontier is defined by points A, C and D, and only B lies below the frontier i.e. shows capacity underutilization. So capacity output corresponding to VRS is smaller than the capacity output corresponding to CRS.

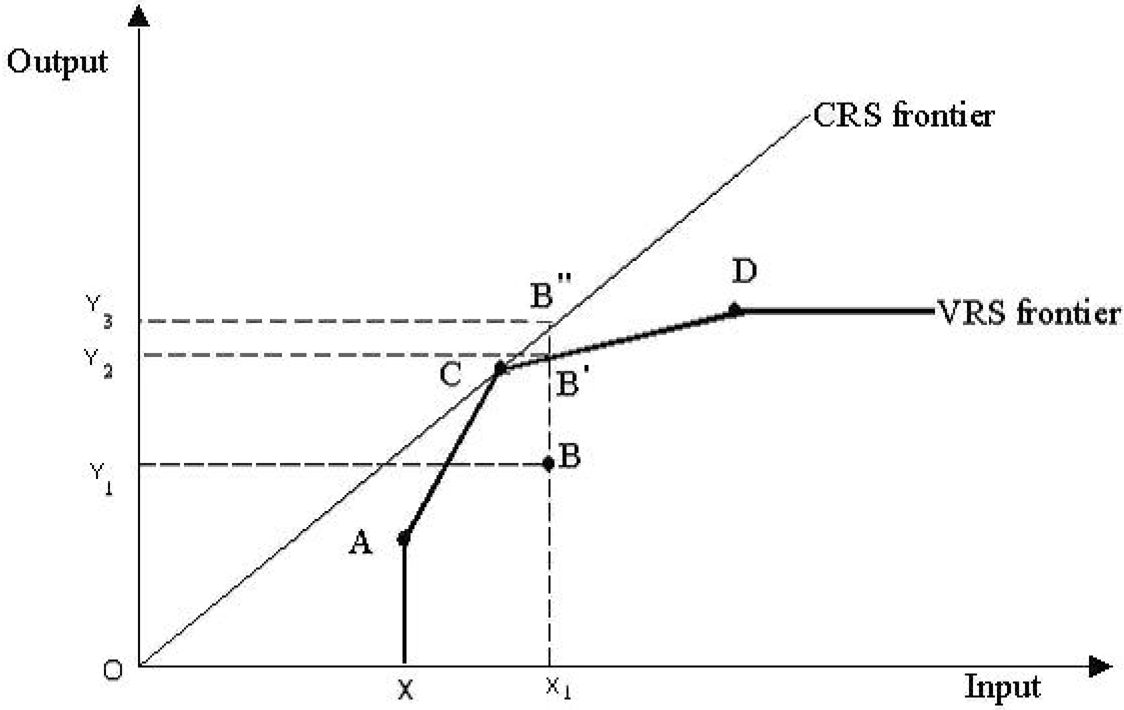


Figure2: The Production Frontier and Returns to scale

The present chapter measure technical efficiency of the textile companies assuming variable return to scale(VRS) using nonparametric method of Data Envelopment Analysis (DEA) and rests on output oriented measure of TE.

Output Oriented TE

It is supposed that there are *N* firms. Each of them is producing 'g' outputs using 'h' inputs. The firm t uses input bundle $x^t = (x_{1t,} x_{2t,\dots\dots\dots} x_{ht})$ and produces the output bundle $y^t = (y_{1t,} y_{2t,\dots\dots\dots} y_{gt})$. Technology can either follow constant returns to scale (CRS) or variable returns to scale (VRS).

The production possibility set corresponding to CRS can be defined as

$$T^{CRS} = \left\{ (x, y) : x \geq \sum_{j=1}^{N} \lambda_j x^t ; y \leq \sum_{j=1}^{N} \lambda_j y^t ; \lambda_j \geq 0; (j = 1,2,\dots\dots.N) \right\} \quad \cdots 1$$

The specific production possibility set under VRS is given by

$$T^{VRS} = \left\{ (x, y) : x \geq \sum_{j=1}^{N} \lambda_j x^t ; y \leq \sum_{j=1}^{N} \lambda_j y^t ; \sum_{j=1}^{N} \lambda_j = 1; \lambda_j \geq 0; (j = 1,2\dots.N) \right\} \quad \dots..2$$

The output oriented measure of TE of any firm t under *CRS technology* requires the solution of the following LP problem

$\max \phi$

Subject to $\sum_{j=1}^{N} \lambda_j y_{rj} \geq \phi y_{rt}$; $(r = 1,2,....g)$;

$\sum_{j=1}^{N} \lambda_j x_{ij} \leq x_{it}$; $(i = 1,2,.....h)$;

ϕ free $\lambda_j \geq 0;,$ $(j = 1,2........N)$ ….3

Output oriented TE of firm t can be determined by using equation (5.4).

$$TE_o^{ct} = TE_o^{ct}(x^t, y^t) = \frac{1}{\phi^*} \quad .... \ 4$$

Where ϕ^* is the solution of equation (5.3) showing the maximum value of ϕ . y* is the maximum output bundle producible from input bundle x^t and is defined as $y^* = \phi^* y^t$. Under VRS, $\max \phi, \phi^\bullet$, can be determined by solving equation (5.3) along with the constraint $\sum_{j=1}^{N} \lambda_j = 1$, taking into account the VRS frontier (equation 5. 2) .Knowing $\phi^\bullet$, technical efficiency of the firm can be solved using similar methodology corresponding to CRS.

2.2. The Data

Firm-level textile companies' data was collected from Centre for Monitoring of Indian Economy (CMIE) Prowess database. The time period for the study is from 1995-1996 to 2015-2016. The reason for taking 1995 as the starting year is that it gives a clear picture of the textile industry in the post-liberalisation scenario. During this period, the maximum amount of information on firm-specific characteristics could be obtained from CMIE Prowess database. A sample of 125 textile firms was chosen.

The study conceptualizes a 1-output and 5-inputs production technology. The output in the model is the real output defined as the total sales of the firm. The value of output was deflated by the wholesale price index for textile sector. The inputs in the model are: (i) Raw Material inputs (measured in terms of the companies' expenditure on raw materials, stores and spares), (ii) Energy and water Input (measured in terms of the expenditure of the companies for power, fuel and water), (iii)Labour (measured in terms of wages and salaries of the workers), (iv) Land (measured in terms of rent & lease rent paid) and (v) Capital (measured in terms of value of the net fixed assets).

3. Results of Estimation of Technical Efficiency

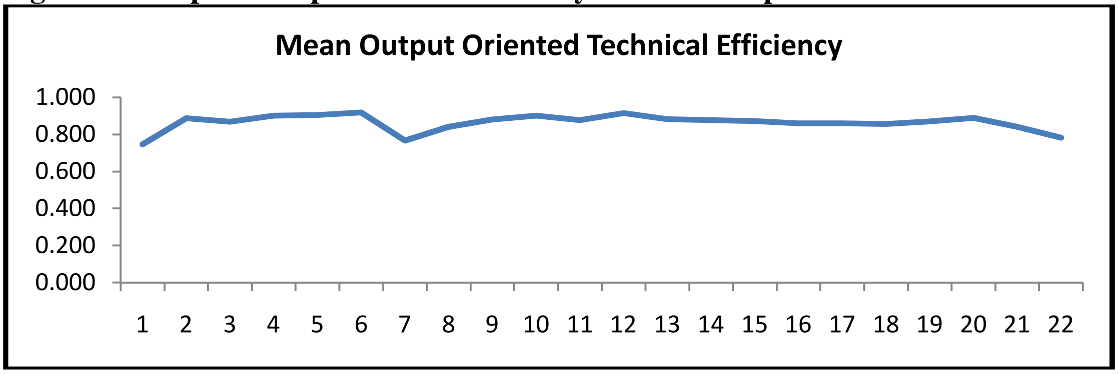
Year wise mean values of output oriented measure of technical efficiency for different companies within the sample are presented in **Table 1**. The graphical representation of the year wise Output oriented measure of TE is presented in **Figure 3.**

Table 1: Mean Output Oriented Technical Efficiency of the Textile Companies

Year	Mean Output Oriented Technical Efficiency
1995	0.746
1996	0.887
1997	0.868
1998	0.901
1999	0.906
2000	0.919
2001	0.766
2002	0.841
2003	0.881
2004	0.901
2005	0.877
2006	0.916
2007	0.883
2008	0.878
2009	0.872
2010	0.860
2011	0.860
2012	0.856
2013	0.871
2014	0.890
2015	0.841
2016	0.783
Mean	0.864

The graphical representation of the technical efficiency is presented in Figure 3

Figure 3: Graphical representation of the year wise Output oriented measure of TE



The average level of the output oriented technical efficiency over the sample years is 0.864. This indicates that the scarce resources have been inefficiently used during the study period. If the inputs are efficiently used, then the additional 13.6% output can be produced by utilizing the same level of inputs. The mean output oriented technical efficiency was highest (i.e. 0.919) in 2000 and lowest (i.e. 0.746) in 1995. The mean output oriented technical efficiency score was not one for any of the years but has been increased from 0.746 in 1995 to 0.783 in 2016.

The percentage of sample firms which are efficient in each year is calculated. The results are presented in **Table 2**. Figures presented in **Table 2** suggest that, on an average, only 17% of the total sample firms were producing efficiently. This means that the efficiency score of these 17% sample firms is equal to 1 and others are producing below the production frontier, indicating that the prevalence of technical inefficiency is very high.

Table 2: The percentage of efficient sample firms in each year

Output oriented Technical efficiency	
Year	**Efficient**
1995	10.4
1996	10.4
1997	12.0
1998	20.0
1999	15.2
2000	23.2
2001	19.2
2002	21.6
2003	21.6
2004	20.8
2005	20.8
2006	22.4
2007	19.2

2008	18.4
2009	16.0
2010	20.8
2011	14.4
2012	16.0
2013	19.2
2014	20.0
2015	16.8
2016	12.8
Mean	17.8

In order to test whether there is a change in technical efficiency after dismantling of Multifibre Arrangement (MFA) in the year **2005, the dummy variable is estimated having the following form:** Output Efficiency $= \alpha + \beta t + \gamma D_t + \delta t D_t + u_t$ …………………. (5)

Where D_t = Intercept dummy ($D_t = 0$ for all the years <2005 and

$D_t = 1$ for all the year > or = 2005) , t = Time period

The result of estimation of estimation of equation (5) is presented in **Table 3**

Table 3: Estimation of Dummy Variable model of Output Oriented Technical Efficiency

Output Efficiency	**Coefficient**	**Std. Err.**	**t**
t	.0049893***	.0015108	3.30
D_t	.1317895***	.0214953	6.13
tD_t	-.0110799***	.0018971	-5.84
Constant	.8343061***	.009374	89.00

Source	SS	df	MS	
Model	.93	3	.31	Number of observations = 2750 F(3, 2746) = 13.17 Prob > F = 0.0000
Residual	64.63	2746	.02	R-squared = 0.0142
Total	65.56	2749	.02	Adj R-squared = 0.0131 Root MSE = .15342

Note: ***: Significant at 1% level.

The results presented in Table 3 show that there was a rise in the level of output efficiency of Indian textile firms after 2005 due to the increase in the intercept of the output efficiency function and it is statistically significant. But the output efficiency curve has become flatter due to a fall in slope of the output efficiency function, implying a decline in the rate of change of technical efficiency after 2005.

4. The Determinants of Technical Efficiency

To relate technical efficiency with the strategic variables perused by firms as well as firm's characteristics, the following variables are taken into account:

Export Intensity (EX): Role of exports in determining the technical efficiency has already been elaborated. Export intensity is defined as exports of goods and services by sales in real term.

Import intensity(IMP): The imports of raw materials, stores and spares and capital goods may play significant role in determining the technical efficiency of the firms as already been explained. In this paper we have tested the effect of total imports (the sum of imports of raw materials, stores and spare parts and capital goods) as well as the separate effect of each of the components of import. The total import intensity can be defined as the ratio of imports of raw materials, stores and spares and capital goods to sales of the firm. To test whether the relationship is nonlinear in nature, total import intensity and the square of total import intensity have been incorporated, implying that the relationship may be either U-shaped or, inverted U shaped depending on the sign condition of the estimated coefficients. The non- linear effect of each components of total import intensity (import of raw materials, imports of capital goods and import of stores and spares) in determining the technical efficiency is also tested.

R&D Intensity (RD): As argued above, R&D Intensity can be a significant determinant of technical efficiency as the individual firms invest in R&D for private knowledge which enhances the efficiency of the firms. R&D intensity is calculated as the ratio of R&D expenditure to sales of the firm. Here also the possibility of the existence of nonlinear relationship is tested by incorporating R&D intensity and the square of R&D intensity astwo separate explanatory variables.

Marketing Intensity (MKT): Marketing expenditure is also a major determinant of technical efficiency as it is also a proxy for product differentiation. Marketing intensity is defined as the ratio of marketing expenditure to sales of the firm. Apart from testing the individual effect of the export and R&D and marketing, the interaction effect of R&D and export has also been incorporated because engaging in R&D activities will increase the firm's probability of engaging in export activities. Additionally, engaging in export activities will also increase the probability of engaging in R&D. More productive firms self-select into exporting activities and also provide support for the learning-by-exporting hypothesis (Neves, Teixeira and Silva 2016). The interaction effect of R&D and marketing has also been incorporated. It has generally been accepted that tight integration between R&D and marketing successfully influences the development of an innovative (Lin and Saggi 2002).

Advertising Intensity (ADV): Advertising is also a major determinant of technical efficiency as it is a mean to reduce the scope and effectiveness of price competition by creating product differentiation among the firms in the manufacturing industries. Advertising intensity is defined as the ratio of advertisement expenditure to sales of the firm.

Firm size (FS): The efficiency of the firms also differs due to difference in their relative size. A large firm may have an easier access to cheaper and superior quality of inputs which helps to enhance its productivity. Moreover, it is easier for such firms to exploit economies of scale, widen scope of production and obtain the necessary approvals. All these aspects, by making its operation more effective, allow it to perform better, relative to smaller firms (Penrose, 1959). Studies are available in the literature with respect to the firm size and efficiency. The studies vary both with respect to the measure of firm size as well as conclusions. Different measure of firm size that are available in the literature are number of worker (Mukherjee, 1963), capital stock per factory (Ahluwalia, 1991), log value of sales (Majumder, 1997), amount of intermediate inputs (Lundvall and Battese, 2000), asset of firms (Biesebroeck, 2005; Palangkaraya, Stierwald and Yong, 2009; Palangkaraya, Stierwald and Yong, 2005; Urata and Kawai, 2002).In the present study, firm size is measured as the value of sales of the firm in real term. The possibility of the existence of nonlinear relationship is tested by incorporating size and its square astwo separate explanatory variables.

A joint interaction term of the firm size and export intensity has been incorporated. The vast number of studies in this area confirms a positive and statistically significant relationship among them, while some studies found no significant relationship and others suggest a negative association between firm size and export performance.

Capital goods Intensity (CAP): Capital goods intensity is defined as the ratio of total capital goods (total of domestic capital goods and imported capital goods) It serves as a technological variable and gives an idea about the relative degree of mechanization. The possibility of the existence of nonlinear relationship of this variable is tested by incorporating capital goods intensity and its square astwo separate explanatory variables.

Net Export Intensity (NEX): If one accepts the possibility that both exports and imports affect TE, the question remains what is the relative role of exportsagainst imports. In order to test these phenomenon net exports was taken as an explanatory variable.It is measured by the difference between export intensity and import intensity. The possibility of the existence of nonlinear relationship is tested by incorporating net export intensity and its square astwo separate explanatory variables.

5. The results of estimation of the determinants of Output oriented Technical efficiency

The determinants analysis is carried out using panel regression model. To test for appropriateness of the assumption of fixed effect *vis á vis* the random effect model, Hausman's specification test is performed for each of the regression which strongly rejects the assumption of fixed effect model and supports the assumption of random effect model. Different alternative specification is tried out and the best specification is reported. The important aspects for this textile industry is that Indian textile firms reengineer the imported items and then re-export the product in which case the export and import data are likely to be correlated. For example in 2014 total imports of textile fiber including manmade staple fiber, raw wool, cotton raw including waste amounts to 65.99 Million US $ and the exports of these three items in terms of Million US $ are 21.93, 26,83 and 17.2 respectively(Farhan Ullah biag(2017)).Thus the export and import data are not kept in the same regression and separate regressions are tried out: the one with export and the other with import as explanatory variables. The Tables 4.1 and 4.2 represent panel regression results taking into account exports and total imports as explanatory variables. Total imports consist of imports of stores and spareparts, raw materials and capital goods. In our sample, total import comprises of 58% of raw materials, 34% of capital goods and 8% of stores and spares. To analyses this effect more vividly, the impacts of different components of imports on technical efficiency are estimated. The estimated results are presented in Table 4.3.

Table 4.1: The results of panel regression showing determinants of output oriented technical efficiency taking exports as determinant

Output Oriented Technical Efficiency	Coefficient	Std. Err.	z	P>|z|
FS	-9.73e-08***	1.27e-08	-7.63	0.000
$(FS)^2$	4.59e-12***	6.45e-13	7.12	0.000
ADV	0.6817329*	0.487727	1.40	0.162
MKT	-0.0875116	0.2830634	-0.31	0.757
RD	-4.410314**	1.743517	-2.53	0.011
$(RD)^2$	5.518394**	2.585124	2.13	0.033
EX	-0.099940***	0.0325665	-3.07	0.002
EX*FS	9.94e-09*	8.98e-09	1.11	0.268
RD*EX	3.224151**	1.480983	2.18	0.029
RD*MKT	22.04256	32.37603	0.68	0.496
Constant	0.9790714***	0.031559	31.02	0.000

Note: ***, **,*: Significant at 1%, 5% and 10% level respectively.

The figures presented in **Table 4.1** containing export as a determinant of TE suggest the following: **(i)** There is positive and significant effect of firm size, advertising, R&D and exports on TE The effect of Advertising is positive and linear in nature. With the increase in advertising intensity, the firm becomes more competitive in the product market which will in turn increase the technical efficiency. **(ii)** But for R&D, export and firm size the effect is nonlinear in nature.**(iii)**For example, sole effect of R&D is negative but the effect of the square term of R&D is positive implying that initially the effect of R&D is negative and there is a threshold level after which the positive effect on R&D is felt. There is also some positive interaction effect of R&D and export. We have also incorporated the interaction effect of R&D and marketing intensity. However, the effect is not statistically significant. The marginal effect of RD taking into account all the effects and evaluated at the mean value is positive.**(iv)**Similarly, for export the sole effect of export is negative. However, there are some positive interaction effects of export intensity and firm size apart from the interaction effect of R&D and export as mentioned above. If the interaction effect of R&D and export is considered, the marginal effect of export evaluated at mean is positive and statistically significant. This in turn implies there is a threshold level of R&D after which the positive effect of export is felt. If all of these effects are taken together, one can find that the marginal impact of the export intensity on output oriented technical efficiency is positive and significant. These results therefore support the fact that as the firm goes on increasing the investment in R&D, new technique of production will be invented which may enhance the product quality and the product competitiveness in the international market may be higher which will in turn increase the export and hence technical efficiency.**(vi)** For firm size, the sole effect of firm size is negative but the effect of the square term of firm size is positive, implying that there is a threshold level after which the positive effect of firm size is realized. There is also some positive interaction effect of firm size and export. But if all the effects are considered, the marginal effect of firm size is positive and statistically significant. Since the sole effect of firm size is negative, this in turn implies there is a threshold level of firm size after which the positive effect of export is felt. This result suggests that the technical efficiency increases when the firm becomes large sized. The large sized firms are more technically efficient due to economies of large scale production. (vii) The sole effect of marketing intensity also turned out to be insignificant.

Table 4.2: The results of panel regression showing determinants of output oriented technical efficiency taking totalimports as determinant

Output Oriented Technical Efficiency	Coefficient	Std. Err.	z	P>|z|
FS	-9.71e-08***	8.47e-09	-11.46	0.000
$(FS)^2$	4.65e-12***	4.93e-13	9.44	0.000
ADV	0.7622359*	0.4213164	1.81	0.070
IMP	0.0404461*	0.0370123	1.09	0.274
(IMP)2	-0.0128072*	0.007014	-1.83	0.068
Constant	0.9098737***	0.0211005	43.12	0.000

Note: ***, **,*: Significant at 1%, 5% and 10% level respectively.

The figures presented in Table 4.2 suggest the following:

- The impacts of size of the firm and advertising intensity on output oriented technical efficiency is same as that have been already discussed in Table 4.1, with export as determinant.
- This table 4.2 is mainly used to represent the effect oftotal import intensity on output oriented technical efficiency. The import intensity is the positive and significant determinant of technical efficiency. The Indian textile firms usually imports the raw materials, capital goods and stores and spares to produce their output. Thus, import plays a very significant role in determining the technical efficiency. For output production the import of raw materials, capital goods and stores and spares are required. With the increase in imports, the output production expands and the firms become large sized and start enjoying the benefits of large scale production. This in return increases technical efficiency.

Having accepted the fact that there is a positive significant effect of import on TE, the next question arises what happens to the effect of different components of imports? Total imports consist of imports of capital goods (**IMCAP**), raw materials(**IMRAW**), store and spares(**IMSTR**)Different regression are tried out and best fit is reported. Table 4.3 reports such regressions.

Table 4.3: The results of panel regression showing determinants of output oriented technical efficiency taking different component of imports as determinants

Regression	Determinants											Goodness of fit
	FS	$(FS)^2$	ADV	CAP	$(\mathbf{CAP})^2$	IMRAW	$(\mathbf{IMRAW})^2$	IMSTR	$(\mathbf{IMSTR})^2$	IMCAP	$(\mathbf{IMCAP})^2$	Wald chi2
Reg1	-9.95e-08***	4.73e-15***	1.11***	0.001	-0.000015	.091***	-.0204***	-	-	-	-	269.98
	(-13.36)	(-10.15)	(-3.23)	(-0.96)	(-0.94)	(-2.66)	(-2.94)					(0.00)
Reg2	-	-	-	.007***	-00006***	-0.0269	-	-	-	-	-	13.98
	-	-		(-3.56)	(-3.12)	(-0.88)						(-0.003)
Reg3	-9.73e-08***	4.65e-15***	.752*	-	-	.0785*	-.0185**	-	-	0.097	-0.093	174.42
	(-11.55)	(-9.42)	(-1.79)			(-1.72)	(-2.26)			(-1.01)	(-1.44)	(0.00)
Reg4	-	-	-	-	-	-0.025	-	-	-	.326***	-.207***	10.06
						(-1.03)				-2.95	(-2.80)	(-0.02)
Reg5	-9.74e-08***	4.67e-15***	.925**	-	-	.072*	-.017**	-0.671	1.958	-	-	184.77
	(-11.80)	(-9.6)	(-2.28)			(-1.66)	(-2.10)	(-1.34)	(-1.54)			(0.00)
Reg6	-9.46e-08***	4.54e-15***	.8372*	-	-	-	-	-.896*	2.469*	-	-	155.82
	(-11.04)	(-9.17)	(-					(-1.72)	(-1.89)			(0.00)

			1.94)									
Reg7	-	-	-	-	-	-	-	-0019***	3.75e-36***			36.39
								(-5.81)	(-4.63)			(0.00)

Note: ***, **,*: Significant at 1%, 5% and 10% respectively. Figures in the parenthesis are z values

The regression 1 shows effect of import of raw materials (IMRAW) and capital goods intensity (CAP) on TE. Since capital goods comprise of domestic capital and imported capital goods, the imported capital goods (IMCAP), and the imports of spares parts (IMSTR) are not taken into account as separate explanatory variables in the regression with CAP as explanatory variables. Different regressions are tried out and best fit is reported. Among the different components of imports the effect of IMRAW is statistically significant in all the regressions (Regression 1,3 and 5) having nonlinear inverted U-shaped relation, implying TE increases with IMRAW but up to a limit and falls after that. Also, the marginal effect of IMRAW at mean value of IMRAW is negative, suggesting that the level of IMRAW has already reached the limit after which its negative effect will be felt.

The effect of IMSTR is also nonlinear having U-shaped relation suggesting initially TE falls with increase in IMSTR but upto a limit and TE increases after that (Regressions 5 &6).But the effect of IMSTR is significant without the IMRAW variable (Regression 6) and the effect is not significant if IMRAW variable is taken into account(Regression 5) . The regression showing significant relation between IMSTR and TE reports a positive marginal effect, implying that we are in the zone where TE increases with the use of IMSTR. The individual effect of IMSTR is also nonlinear U-shaped type having positive marginal effect (Regression 7)

Coming to the effect of CAP or IMCAP it can be mentioned that, although the individual effect of CAP or IMCAP is statistically significant having inverted U-shaped relation (Regressions 2and 4), the effect turned out to be insignificant if the effect of the other explanatory variables are taken into account. (Regressions 1 and 3)

Apart from the different import components the other significant variables are firm size and advertising intensity as can be seen from all the regressions with this variables. The effect of advertisement intensity is linear and positive, while the effect of firm size is nonlinear U-shaped type, implying that TE initially falls with size but up to a point and increases after that.

Thus it can be found that among 3 components of imports IMCAP is insignificant while taking into account other variables. The effect of IMSTR and IMRAW are significant with positive and negative marginal effect respectively. Also the effect of total import is positive and statistically significant (as reported in Table 4.2). Therefore, it in turn implies positive effect of IMSTR dominates over negative effect of IMRAW, so that on balance total import produces positive effect.

Since both the exports and imports have positive effect, it will be interesting to see whether effect of exports dominates over imports. To answer this question net export **(NEX)** (exports minus imports) was taken as an explanatory variable along with the other significant variables like size and advertisement intensity. The results of such regression are presented in **Table 4.4.**

Table 4.4: The results of panel regression showing determinants of output oriented technical efficiency taking net exports as determinant

Output Oriented Technical Efficiency	Coefficient	Std. Err.	z	P>|z|
FS	-8.81e-08***	8.95e-09	-9.84	0.000
(FS)^2	4.09e-15***	5.27e-16	7.76	0.000
ADV	.7712585*	.4148774	1.86	0.063
NEX	-.0362834**	.015257	-2.38	0.017
(NEX)^2	-.0123425***	.0037177	-3.32	0.001
Constant	.9243581***	.0186837	49.47	0.000

Note: ***,**,*: Significant at 1%, 5% and 10% respectively.

The figures presented in **Table 4.4** suggests that the effect of size and advertising intensity is same as before as in the case of **Tables 4.2 and 4.3** . The effect of net export (**NEX**) is negative and statistically significant implying that the effect of imports dominates over exports.

6. Conclusions

The present paper examined whether the technical efficiency (TE) of Indian textile firms have improved after the withdrawal of multi fiber trade agreement since 2005, and explains efficiency of Indian textile firms after taking into account the effect of R&D intensity, size of the firm, export intensity of goods, marketing intensity, advertising intensity, total import intensity as well as import intensity of different component of imports like import of raw materials, stores and spares and capital goods , using the data from CMIE for the period 1995-2016 in a panel regression framework. The technical efficiency of the firm is estimated by nonparametric Data Envelopment Approach. The present paper uses output oriented measure of TE. In case of output oriented measure the TE of a firm can be computed by comparing its actual output with the maximum producible quantity from its observed inputs i.e. by how much can output quantities be proportionally expanded without altering the inputs quantities used. In order to find out what happens to the extent of TE after the withdrawal of multi fiber trade agreement since 2005, the paper uses dummy variable model.

The results of estimation suggest that: (i) the average level of TE over the sample years is 0.864, indicating inefficiency of output which in turn indicates inefficiency of input utilization. If the inputs are efficiently used, then the additional 14% output can be produced can be produced with the help of same level of input uses. (ii)The mean TE has been increased from 0.746 in 1995 to 0.783 in 2016. The results of dummy variable analysis show that there was a rise in the level of TE of Indian textile firms after 2005 as revealed by the statistically significant increase in the intercept of the TE function But the TE curve has become flatter as depicted by the statistically significant fall in slope of TE function, implying a decline in the rate of change of TE after 2005.

Coming to the determinant analysis it can be said that the textile firm imports a significant amount of textile yarn and also re exports it. Thus export and import data are likely to be correlated. Therefore separate panel regressions are resorted to after taking into account export and import as separate explanatory variables. Regarding imports, the effect of its different components on TE is also tested.

The results of the regression taking export as explanatory variable along with the other determinants supports positive and significant effect of firm size, advertising, R&D and exports. The effect of Advertising is linear in nature. But for R&D, export and firmsize the effect is nonlinear in nature. For example sole effect of R&D is negative but the effect of the square term of R&D is positive implying there is a threshold level after which the positive effect on R&D is felt. There is also some positive interaction effect of R&D and export. The sole effect of export is negative. But if the interaction effect of R&D and export is considered, the combined effect of export is positive. This in turn implies there is a threshold level of R&D after which the positive effect of export is felt. Similar explanation holds for firm size. The sole effect of firm size is negative but the effect of the square term of firm size is positive, implying there is a threshold level after which the positive effect of firm size is felt. There is also some positive interaction effect of firm size and export. But if the interaction effect of firm size and export is considered, the combined effect of export is positive. Since the sole effect of export is negative, this in turn implies there is a threshold level of firm size after which the positive effect of export is felt. The effect of marketing intensity turned out to be insignificant.

The results of the panel regression taking total import as determinant suggest that the total import intensity is the positive and significant determinant of TE of textile firms. The Indian textile firms usually imports the raw materials, capital goods, stores and spares to produce their output. Thus the import of the raw materials, capital goods, stores and spares facilitates the output production. With the increase in these imports, the output production expands and the firms become large sized and start enjoying the benefits of large scale production. This in return increases technical efficiency.

Coming to the different component of imports, it can be said that the effect of imports of stores and spares (IMSTR) on technical efficiency is also nonlinear in nature, having U-shaped relation with positive marginal effect, as can be visualized from regression 5 and 6. The regression 5 contains both imports of raw materials and IMSTR, where the level of significance of IMSTR is relatively low. The regression 6 suggests if one drop IMRAW from the set of explanatory variables then IMSTR becomes significant at 10% level. The sole effect of IMSTR is statistically significant.

The effect of IMCAP on TE can be seen from regression 3 and regression 4. The marginal effect of IMCAP is negative. The sole effect of IMCAP is statistically significant as 1% level. (regression 4) However, the level of significance falls if the other variables are taken into account.(regression 3)

The effect of IMRAW is also nonlinear having inverted U shaped relation, as can be visualized from regressions 1, 3 and 5. The marginal effect is negative and is statistically significant.

Thus it can be found that among three components of imports IMCAP is not significant while taking into account other variables. The effect of IMSTR and IMRAW are significant with positive and negative marginal effect respectively. Also, the effect of total import is positive and statistically significant (as reported in Table 4.2). Therefore it in turn implies positive effect of INSTR dominates over negative effect of IMRAW, so that on balance total import produces positive effect.

Since both the exports and imports have positive effect, it will be interesting to see whether effect of exports dominates over imports. To answer these question net exports (exports minus imports) was taken as an explanatory variable along with the other significant variables like size and advertisement intensity. The effect of net export is negative and statistically significant implying that the effect of imports dominates over exports.

Regarding policy measures for promoting technical efficiency it can be said that, since R&D has a positive impact on TE, in order to boost up TE, promotion of R&D measures is important. For promotion of R&D, the reduction of R&D cost is very important. Tax incentives to key sectors have played a central role in R&D. Since R&D activity is mainly dependent on imported inputs, facilitated imports will also boost up the R&D activity which in turn will improve TE of the firms. But since import of the goods is not a permanent solution for the sustained growth of the firms and hence of industries, at the same time indigenous measures of development should be generated to develop R&D skill of the firm, so that in the long run one can minimize the import requirements for R&D activity. The fiscal incentives and support measures presently available include exemption of import duties on key R&D expenditure, customs duty exemption on capital equipment, spares, accessories and consumables imported for Research and Development by approved institutions, weighted tax deduction for sponsored research and on in-house Research and Development expenditure, custom duty exemption on imports for R&D projects supported by Government, an excise duty waiver on indigenous items purchased by approved institution for Research and Development. These measures be carried out and strengthened. The Government should promote R&D activities and at the same time Government should facilitate import activities of the firms which basically foster R&D.

The firms on their part have to invest more on R&D and at the same time they have to carry on their export activity, keeping in mind that R&D and export activity have joint positive interaction effect on TE. At the same time the firm should try to improve the quality of export, because the empirical evidences suggest that the quality of exports is one of the main determinants of exports. This in turn suggests greater role of R&D because sustained increase in R&D will in turn help to improve the quality of the product. The effect of total imports and of IMSTR is significant with positive marginal effect. Thus different type of incentives must be continued so that the firm can continue their import needed for production and R&D activity at a lower cost.

The discussions suggest that advertisement activity has a favourable effect on TE. Thus it is recommended that the firm should carry on their advertisement activity. The size of the firms is the significant determinant of output efficiency. The output efficiency has a U-relationship with size of the firms. Initially, with the increase in the size of the firm, output efficiency of the firms deceases. But, as the firms start producing at a large scale for enjoying economies of scale, the output efficiency starts increasing. The marginal effect of firm size is positive. Thus, different measures of the government which in turn favourably affect firm size will also have positive effect on TE.

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