A Cost Function Approach to the Estimation of Total Factor Productivity Growth in India's Rubber and Plastic Products Industry with Adjustment for Capacity Utilisation: 1981-82 to 2016-17

Pinki Bera
Ph.D. Research Scholar
Department of Economics, Vidyasagar University

Mihir Kumar Pal
Professor, Department of Economics, Vidyasagar University

Abstract

This study attempts to measure Total Factor Productivity Growth (TFPG) of Indian Rubber and Plastic Products Industry during the period 1981-82 to 2016-17. As, we have taken a long-study period, therefore, a decadal analysis of TFPG is also made in our study. We have chosen this industry on the basis of its higher share in the Gross Manufacturing Value Added. We have tried to make a comparison between the estimates of TFPG in the pre (1981-82 to 1990-1991) & post liberalisation (1991-92 to 2016-17) era. This has been done to examine the impact of liberalization on the TFPG of the selected Indian Manufacturing Industry. Most of the earlier studies show negative or very low TFP growth, though there is an increase in the rate of decline of TFPG in post-liberalisation period. In a sense, the liberalization process is found to have its adverse impact on total factor productivity growth. We may opine that if TFPG is adjusted with Capacity Utilization, it may lead to a refined measure of TFPG. Our result shows a positive and decreasing trend in TFPG (adjustment with Capacity Utilisation) in the post-reform period.

Key Words: *Productivity growth, Manufacturing Sector, Trans-log cost function, Capacity utilisation, India.*
JEL Classification: *C01, C13, C87, D24.*

1. Introduction

Productivity is obviously a fundamental element in economic progress and productivity growth is renowned as a key feature of economic dynamism. Productivity estimation is useful to assess the performance of the various industries over a period of time. The prosperity of new developed nations has been attributed mainly to the sustained growth of their total factor productivity. Low total factor productivity growth (TFPG) or negative trend TFPG is a commonly observed feature in most of the developing economies. After economic liberalisation, the industrial development programme implicitly depends on pulling TFPG out of such a dismal state. However, the management problems of TFPG are yet to draw adequate attention. The New Industrial Policy (NIP) introduced in 1991 being outward-oriented abolished licensing of capital goods, reduced number of industries in public sector, increased foreign ownerships in domestic industries, introduced deregulation in small-scale industrial units, reduced trade barriers and induced private investment in infrastructure. These elements of reform program along with others were introduced to enhance productivity and efficiency in Indian industries. The competition and new technologies generally enhance the productivity and reduce the production costs of industries with comparative advantages.

Under Rubber and Plastic Products industry, there are two sub-sectors, Manufacture of rubber products, Manufacture of plastics products. Rubber and plastics are key materials that find application in a wide range of products and applications. These industries play a key supporting role in India's overall economic development. However, both sectors are getting increasingly aligned with global market developments. These are focus sectors and the Government is actively involved in devising plans to support growth. Significant progress has been made post the Tenth Five- Year Plan since more thrust was provided on processing and marketing. Demand for rubber appears set for sustained growth, due to the strong growth projected in the automobile and consumer durables sectors. With India poised to emerge as the third largest consumer of plastics by 2010 and the industry growing at a rapid pace, the players need to gear up along with Government support, to take advantage of the new opportunities offered by the sector. Rubber and Plastic Products industries contributed 4.01% in the total value added of the manufacturing sector in India in the year 2016-17. The rubber manufacturing industry is fragmented in structure with around 6000 manufacturing units, comprising of 30 large-scale, 300 medium-scale and around 5600 small and tiny units. On the other hand, the Indian plastics industry comprises around 55,000 plastic processing units, spread over both the organised and unorganised sectors. From the above it is clear that Indian Rubber and Plastic Products industry occupies a significant position in our manufacturing sector and its productivity growth needs in depth investigation. Hence we have chosen this industry for our analysis.

This paper is concerned with the estimation of Total Factor Productivity growth (TFPG)for the Indian Rubber and Plastic Products industry and its decomposition into technical change (TC) and economies of scale components under parametric models. Here, we opt for the most general specification available- the trans-log form for the measurement of TFPG from cost function. The econometric studies on productivity change utilised either a primal approach or a dual approach. In this paper we dealt with dual approach, as there exist a dual cost function relating to output and input prices. The dual cost function contains all the information that the production function contains. Binswanger (1974) has shown that the cost function is more desirable for econometric analysis than the production function for a variety of reasons. Shephard (1953), Uzawa (1964) favored the duality approach. There are sure purposes behind thinking about the cost work, which might be bulleted as underneath: According to the essential guideline of duality in production, the cost function sums up all the economically relevant data about the way toward changing inputs into output. Therefore, the evaluated cost function permits total depiction of innovation accessible to a production unit.

The cost function permits estimation when output prices are inaccessible or are not decided in a serious market.

The cost function permits a generally clear figuring of alternative cost indices for policy investigation.

The cost function approach is relevant in so far as firms are minimizing costs. It doesn't require the state of benefit boost.

Cost functions are homogeneous in prices regardless of the homogeneity properties of the production function, because a doubling of all price will double the costs but will not affect factor ratios.

In the special case of the Trans-log cost function, to which the method is applied, problems of neutral or non-neutral efficiency differences among observational units or of neutral and non-neutral economies of scale can be handled conveniently.

Again, Capacity Utilisation is a key indicator of economic performance which explains changes in investment, inflation, long-run output growth etc. Therefore, the estimation of capacity output and its utilisation will be very useful to evaluate the variations in the performance of an industry over a period of time. Recently; the economists have attempted to develop CU measures that are closely tied to the economic theory of firm behaviour. Pioneering studies in this area include the work by Klein (1960) and Hickman (1964), and more recently by Momson (1985,1986) and Berndt and Fuss (1986). These studies have defined CU using the concept of the firm's short-run cost function where one or more inputs are treated as quasi-fixed. Morrison (1985) proposes two alternative definitions, a primal measure defined in terms of the firm's output level and a dual measure defined in terms of the firm's costs. Till date, however, both the theoretical and the empirical development of these theory-based CU measures have been confined to the case of a single product firm, i.e., a firm that produces a single output.

This paper is organised as follows: Section 2 endows with the brief survey on literature related with the present study. Section 3 deals with objectives of our study. Section 4 deals with methodology used for the purpose of the study and this section contain information regarding database and variable used. Evaluation of results is summarised and discussed in Section 5. In Section 6, we comprises of summary and conclusion.

2. Literature Review

In this section, we have presented a brief review of literature on the studies on measurement and determinants of productivity in India as well as other emerging and developed economies. We also discuss the studies dealing with Capacity Utilisation (CU) of the manufacturing sector.

2.1 Studies on Total Factor Productivity Growth:

There are many studies dealings with the measurement of TFP and TFPG for the Indian manufacturing sector, and due to the different methods used and different approaches of variable construction, there are conflicting results.

Considering the data for the Indian manufacturing sector, various studies have shown that the TFP growth has declined during the early phases of the 1980s. But in the early phases of the liberalisation period, TFP growth improved due to trade openness, relaxation in the licensing policies, etc.

Murty (1986) has estimated a cost function for Indian manufacturing at an aggregate level using time series data for the period 1960-77. He has used a two-stage approach, estimating an energy and aggregate sub-model. In the energy sub-model, unit energy cost is taken as a function of the prices of coal, oil, and electricity. In the aggregate sub-model, the cost function is specified in terms of output and prices of labour, capital, materials, and energy.Vashist's study (1984) is very similar to that of Murty's (1986). One important difference is that Vashist has not included materials input in the aggregate sub-model. Also, he has assumed constant returns to scale. And interesting feature of this study is the use of the Divisia price index for labour input. For estimating the cost function, Vashist has used time-series data for 1960-71.Goldar (1984), and Kar and chakraborty (1986) have estimated only the energy sub-model, with a view to studying inter- fuel substitution. Goldar has used state-wise (aggregate) cross-sectional data for 1971, Kar and Chakraborty time-series data for seven energy intensive industries for 1959-71. Both studies find significant inter-fuel substitution possibilities. Goldar reports own price elasticity estimates of -2.5, -4.5, and -1.1, for coal, oil and electricity, respectively.In a recent study, Jha, Murty and Paul (1991) have estimated trans-log cost function for four industries, namely cement; electricity and gas; cotton textiles; and iron and steel, using time-series data for the period 1960-1 to 1982-3. The model has been so specified as to allow for non-neutral technological change. Their results indicate that technological progress has been capital saving in the iron and steel and cement industries, labour and material input (including energy) saving in cotton textiles, and biased towards saving both labour and capital in the electricity and gas industries.

The literature on measurement of TFP is quite extensive; which is discussed in the following:
Das et al. (2010) have examined the relative contributions of factor accumulation and productivity growth in the different sectors of the Indian economy.
According to Kathuria et al. (2013), growth in productivity is the only plausible route to increase standard of living and therefore, it is considered as a measure of welfare.
TFP and labor productivity have been studied by Harris and Moffat (2016) in the UK. The significant decline post-2008 did not recover before 2012. Therefore, they concluded that the loss in productivity is likely to be permanent rather than cyclical.
Recently, Kapelko et al. (2017) investigated the impact on dynamic productivity growth in the Spanish food manufacturing industry. Negative impacts on productivity were found. However, diverse effects are observed between different sub-industries and firm-sizes.

2.2 Studies on capacity utilization:
An examination of the literature on capacity utilization (CU) of the Indian manufacturing industries reveals that most of the studies have used conventional measures of capacity utilization (CU) and have paid inadequate attention to the possible theoretical problems. There are several studies such as Goldar and Ranganathan (1991), Srinivasan (1992a), Azeez.E. Abdul (2001), Danish.A.Hashim (2003) etc.
Vishwanathan and Mukhopadhyay (1991) have presented economic measure of capacity utilization for Indian cement industry for a period of 1960-61 to 1984-85. Their study suggests that, for some years, CU is found to be more than one, on the basis of which the authors conclude that the firms could have reduced their production cost by moving to the minimum point of short-run and average cost curve. The first study of Srinivasan (1992a) examines the determinants of capacity utilization in Indian industries. Data on full capacity and utilisation levels or different industrial sectors is taken from CMIE (1987). Time series data on capacity utilization from 1970 to 1984 has been collected from World Bank (1989) for selected industries from four broad sectors: basic, capital, intermediate and consumer goods. Azeez.E. Abdul (2001) estimates a consistent series for the economic capacity utilization of the Indian non-electrical machinery manufacturing sector. The optimal or economic capacity is defined as the output where short-run average total cost is minimized. Danish. A. Hashim (2003) makes an attempt to measure the extent of capacity utilization in Indian airlines industry and its impact on unit cost of production. Using data from 1964-65 to 1999-2000 and applying a trans-log variable cost function, the capacity utilization has been estimated with respect to two alternative measures of potential output : (i) where short-run average cost is minimum and (ii) where short-run and long-run average cost curves are tangent. However, Cesaroni et al. (2017) presented the input-oriented CU measures. The "economic" strand of literature on CU considers the minimum level of the short- or long-run average costs when identifying the capacity level.

2.3 Relevance and Importance of Our Work:

In our work, we have tried to estimate the total factor productivity growth (TFPG) for the Indian Rubber and Plastic Products industry using cost function approach. The available studies on Indian manufacturing have focused on the use production function approach to measure TFP, but studies on the use cost function approach in determining productivity are limited. The methodology used in that study takes into account the multivariate nature of the industry and takes up a cost function approach. Again, another value addition of our study is that, it takes energy as an input in the production function. In recent climate change negotiations and debates, energy cannot be overlooked and there is a necessity to focus on productivity and energy use in Indian industries, more specifically in the manufacturing industries. Here in lies the relevance and importance of our study.

3. Objectives:

The major objectives of our study can be presented as:

A. To estimate Total Factor Productivity Growth (TFPG) of Indian Rubber and Plastic Products industry using cost function approach.
B. To estimate the economic Capacity Utilization (CU) in the select manufacturing industry.
C. To make a decadal analysis of TFPG & CU for Indian Rubber and Plastic Products industry.
D. To adjust the TFPG of the select Indian manufacturing industry by Capacity Utilization (CU).
E. To make a comparative analysis between pre and post reform period.

4. Database and Methodology

4.1 Database:

This paper covers a period of 36 years from 1981-82 to 2016-17. The entire period is divided into two phases, the pre-reform (1981-82 to 1990-91) and post-reform period (1991-92 to 2016-17). This was done to incorporate the impact of liberalisation on total factor productivity growth (TFPG) obtained by cost function approach. .As, we have taken a long-study period; therefore, a decadal analysis of TFPG is also made in our present study.

The present study is based on industry level time series data taken from: Several issues of Annual Survey of Industries (ASI), Energy statistics published by Central Statistical Organization (CSO), Economic Survey, Statistical Abstracts (several issues), RBI Handbook of statistics on Indian Economy published by Reserve Bank of India (RBI).

We have made the data comparable keeping in mind the composition of the above mentioned manufacturing industry for several periods in our study. Though we have taken up 2-digit level industry, but for making data comparable, we have gone on to the 3-digit and 4-digit level industries under the 2-digit level industry classification of ASI data.

Table-1: Coverage of the Industry and Industry Codes

	NIC 2008	NIC 2004	NIC 1998	NIC 1987	NIC 1970
Rubber and Plastic Products	**2211+2219+2220**	**2511+2519+2520**	**2511+2519+2520**	**310+312+313**	**300+302+303**

Source: Annual Survey of Industries (several issues)

4.2 Description of Variables

Table 2: Variables Definitions and it's measure in our work

VARIABLES	ABBREVIATION	MEASURE
OUTPUT	Y	Real Gross Value Added
CAPITAL	K	Real Gross Fixed Capital Formation
LABOUR	L	segregated total employees as workers and persons other than workers and made an weighted index
ENERGY	E	Fuel consumed
TIME	T	proxy for technological progress
PRICE OF LABOUR	P_L	total emoluments / total number of persons engaged
PRICE OF CAPITAL	P_K	Interest paid/ capital invested
PRICE OF ENERGY	P_E	Weighted aggregative average price index of fuel
TOTAL COST	TC	sum of the expenditure on all inputs
VARIABLE COST	VC	sum of expenditure on variable inputs

Source: Author's own measurement

4.3 Methodology:

4.3.1 Cost Function Approach to the Measurement of TFPG:

We estimate TFP by using cost function approach and decompose the TFP change in to two components: one part due to technical change and other returns to scale.

Technical change is reflected through shift in cost function. Returns to scale is represented by the cost/output elasticity. Productivity growth is linked to key parameters relating to the cost/output elasticities of a specific cost function. When the cost elasticities are known, the inter-temporal shifts in the cost function and scale effects can be separated.

The growth rate of TFP is defined as: $T\dot{F}P=\dot{Q}-\dot{F}$

Where, rate of change of output is $\dot{Q}$, $\dot{F}$ is rate of change of total factor inputs; it is the proportionate change in the variables over time. In other words TFPG is the unexplained part of output growth which is not explained by the growth of inputs taken together.

Let us represent the cost function in three explanatory variables, by

$$C= F(Q,P_L,P_K,P_E,T) \text{ ---------------------(1)}$$

Where P_L is the price of labour, P_K is the price of capital, T the index of technology, which is a simple time function, and Q is the output.

The cost function specified in the study is of the Trans-log form, which is more flexible, compared to the alternative functional forms and Trans-log specification of this generalised cost function as given in equation (1) as:

$$\ln C(Q,P_L,P_K,P_E,T)= \beta_0+\beta_Q\ln Q+\beta_L\ln P_L+\beta_K\ln P_K+\beta_E\ln P_E+\beta_T\ln T+\beta_{QL}\ln Q.\ln P_L+\beta_{QK}\ln Q.\ln P_K+\beta_{QE}\ln Q.\ln P_E+\beta_{QT}\ln Q.\ln T+\beta_{LK}\ln P_L.\ln P_K+\beta_{LE}\ln P_L.\ln P_E+\beta_{LT}\ln P_L.\ln T+\beta_{KE}\ln P_K.\ln P_E+\beta_{KT}\ln P_K.\ln T+\beta_{ET}\ln P_E.\ln T+1/2\beta_Q(\ln Q)^2+1/2\beta_L(\ln P_L)^2+1/2\beta_K(\ln P_K)^2+1/2\beta_E(\ln P_E)^2+1/2\beta_T(\ln T)^2$$

Now, differentiating (1) totally with respect to T , we get,

$$\dot{TFP} = -\dot{\theta}+ (1- \eta_{CQ})\dot{Q}$$

Where, $\dot{\theta}=\frac{1}{C}\frac{dC}{dT}$ is the proportionate shift in the cost function due to technology, the cost/output elasticity denoted by, $\eta_{CQ}=\frac{\partial C}{\partial Q}\frac{Q}{C}$ and $\dot{Q}$ is the proportionate change in output.

4.3.2 Method for measuring Capacity Utilisation:

Let us consider a cost-minimizing firm that produces an output level Qusing three variable inputs Capital (K), Labour (L) and Energy (E) and the input K, that is quasi-fixed, i.e., fixed in the short run but variable in the long run.

Let the firm's variable cost function be given by VC = f (P_L, P_E, K, Q) and the explicit form of the variable cost function is:

$$VC = \alpha_0 + K_0 [\alpha_K+ ½ \alpha_{KK} (K_0/Q) + \alpha_{KL} P_L + \alpha_{KE} P_E]$$

$$+ P_L (\alpha_L + ½ \alpha_{LL} P_L + \alpha_{LE} P_E + \alpha_{LQ}Q)$$

$$+ P_E (\alpha_E + ½\alpha_{EE} P_E + \alpha_{EQ}Q) + Q (\alpha_Q+ ½\alpha_{QQ}Q)$$

Where, K_0 is the capital stocks at the current year which implies that a firm makes output decisions constrained by the capital stocks available during current year.

Short-run total costs, STC = f (P_L, P_E, K, Q) + P_K K, where P_K, P_L and P_E are the price of K, L and E.

Given K, the capacity level Q* is defined to be the output level at which the short-run average cost (SRAC) curve is tangent to the long-run average cost (LRAC) curve. This can be found by differentiating STC with respect to K and solving for Q*i.e., Q* solves $\delta STC/\delta K = \delta VC/\delta K + P_K = 0$ and we get, $Q^* = - \alpha_{KK}\ K_0/ (\alpha_K+ \alpha_{KL} P_L + \alpha_{KE} P_E + P_K)$

Given this capacity output level Q*, the primal CU measure is then defined to be CU= Q/Q*. If CU > 1, then Q>Q* and there is pressure to increase investment in K. Likewise, CU< 1 implies disinvestment incentives. When CU = 1, K is the cost-minimizing level of capital for producing Q and the firm has no incentive to change the level of K. The primal CU measure captures the output gap that exists when actual output differs from capacity output.

5. Results and Discussion

In this section, we have calculated total factor productivity growth and its components using dual cost function approach under three inputs- labour, capital& energy and one output framework. Estimates of annual TFP growth rate for Indian Rubber and Plastic Products Industry for the pre-reform as well as post-reform period are presented in Table: 3. we have also adjusted TFPG with Capacity Utilization, which may lead to a refined measure of TFPG.

Table: 3 Total Factor Productivity Growth (TFPG) and its Components

DECADE	PERIOD	Shift of the Cost Function ($-\dot{\theta}$)	Cost- Output Elasticity (η_{CQ})	Non-constant Returns to scale $(1-\eta_{CQ})\dot{Q}$	TFPG $[-\dot{\theta}+(1-\eta_{CQ})\dot{Q}]$
	ENTIRE (1981-82 TO 2016-17)	**-0.0186**	**0.3278**	**0.0657**	**0.0471**
FIRST	**PRE-REFORM (1981-82 TO 1990-91)**	**0.0360**	**0.2988**	**0.0848**	**0.1208**
	POST-REFORM (1991-92 TO 2016-17)	**-0.0396**	**0.3390**	**0.0584**	**0.0188**
SECOND	1991-92 TO 2000-01	-0.0419	0.3269	0.0838	0.0418
THIED	2001-02 TO 2010-11	-0.0393	0.3404	0.0456	0.0063
FOURTH	2011-12 TO 2016-17	-0.0363	0.3568	0.0376	0.0013

Source: Author's own estimation

From Table-3, we find that the TFP growth for the Indian Rubber and Plastic Products Industry for the entire period (1981-82 to 2016-17) is positive and it is 4.71%. We also observe that rate of growth of TFP has declined over decades. This result may be obtained due to technological progress or scale effect.

Technological progress in production is best reflected through a shift down in cost function. The negative (positive) sign associated with the parameter implies a shift down (up) in the cost of production. From the above table we may conclude that cost function is shifted down over the decades and technology is rapidly growing in the last period (2011-12 to 2016-17) compare to other three decades. Hence, Technology is progressing over time.

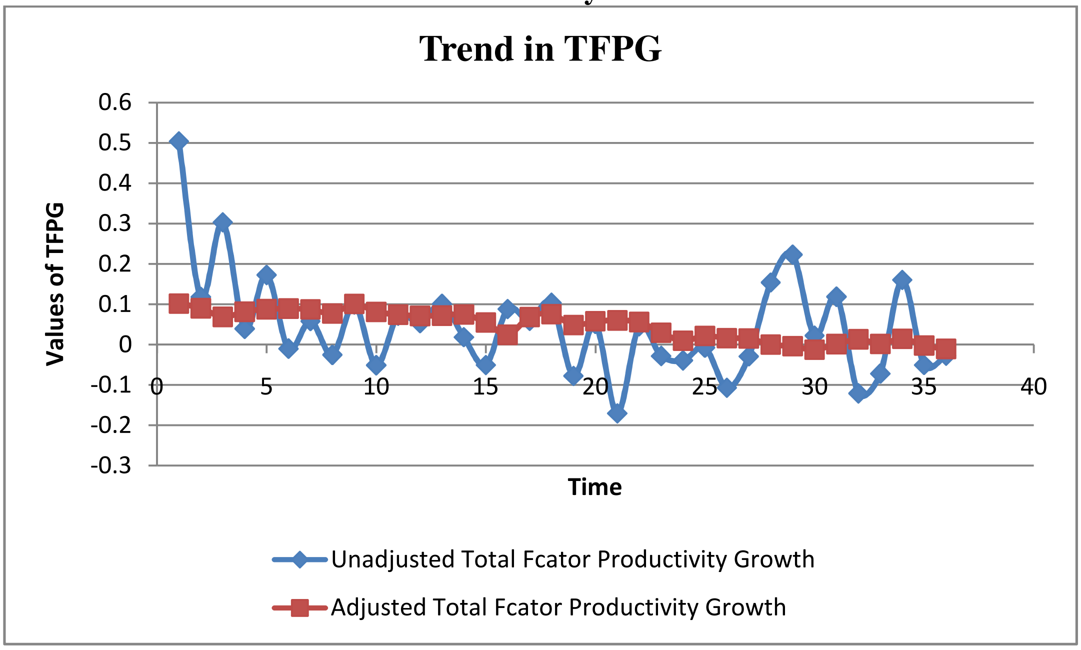
Returns to scale parameter indicates the proportionate increase in output for a proportionate increase in all inputs. When the parameter is numerically less than one, it is suggestive of the operation of diminishing returns to scale. We find a decreasing return to scale in each and every decade and also in the entire as well as pre and Post- reform period.

The above analysis exhibited that, when diminishing returns to scale operates the growth rate of TFP decreases and technological progress is also present over the decades. Another contradictory result also observed for the estimates of total factor productivity growth. In our considered time period, in most of the cases, annual TFPG is negative. So we may think that if we adjust TFPG with capacity utilisation, we may get refined measures of TFPG. An adjustment of TFP measure is of vital importance in order to capture the effect of variation in capacity utilisation on TFPG. To estimates how TFPG measure may be changed with the variation in capacity utilisation, we regress the log difference of the measured TFPG on the log difference of the capacity utilisation rate which is proxy for business cycle. The regression equation is:

$$\Delta \log(TFP_t) = \alpha + \beta \Delta \log{(CU_t)} + U_t \text{ ; And}$$

$$\text{Adjusted TFP} = \hat{\alpha} \ + \ \hat{\beta} \text{ CU}$$

Diagram-1: Trend in Total Factor Productivity Growth (TFPG) Before and After Adjustment by Capacity Utilisation (CU) for Indian Rubber and Plastic Products Industry



Source: Author's own estimation

From the above line diagram, we observe that total factor productivity growth is negative and diminishing in most of the cases .Some sort of a different picture is observed when TFPG is adjusted with CU. The growth rate of TFP decreases over the year but not negative and technological is also progressing over the years.

Table-4: TFP Growth Rate (in %)

Time Period	Unadjusted TFPG	Adjusted TFPG
Entire	**4.71**	**4.73**
Pre-reform	**12.08**	**8.67**
Post-reform	**1.88**	**3.21**

Source: Author's own estimation

On the contrary, it is found from the comparison between pre & post-reform period of the Indian Rubber and Plastic Products industry that after incorporating the effect of CU into TFP growth, the growth rate increases slightly from 4.71% to 4.73% for the entire period. Basically, there is not much significant difference between these two estimates, as because; both, TFPG and CU are estimated from the cost function approach. Again, unadjusted TFPG measure implies a high growth rate in the pre-reform period, in reality which is not observed. After adjustment of TFPG with CU which gives economically significant estimates in the pre-reform period. We also observe that total factor productivity growth has decreased in the post-reform period compared to the pre-reform period for adjusted and unadjusted TFPG.

The fruits of the policies of the liberalized regime was not obtained for this industry due to the fact that the agricultural growth rate was stagnant in the post-reform period and again the low level of capacity utilisation

6. Summary Conclusion and Policy Implications:

In this study we have tried to estimate total factor productivity growth and its components for Indian Rubber and Plastic Products Industry over the year 1981-82 to 2016-17. We have tried to make a comparative analysis between the pre& post-reform era with respect to the above mentioned economic variables and we also try to make a decadal analysis between the estimates of TFPG. In this study, total factor productivity growth (TFPG) has been obtained by dual cost function approach. This paper also seeks to analyse the scenario when total factor productivity growth (TFPG) is adjusted with economic capacity utilisation (CU).
From our study, we may reach at the following conclusions:

Firstly, unadjusted TFPG with CU shows negative growth for most of the year but positive growth rate in the entire period (1981-82 to 2016-17) and it is 4.71%. There is a haphazard picture over the year but sharp decrease in the rate of decline in TFPG from pre to post reform period.

Secondly, when TFPG is adjusted with CU; we notice a positive and decreasing trend over the year and also from the pre-reform period to post-reform period.

Thirdly, there is technological up gradation in the production process over the time.

Last but not the least, further it may be concluded that liberalization process had its adverse impact on total factor productivity growth with CU-unadjusted and adjusted for the select industry.

Policy Implication:

The results have vital policy implications. One specific implication is, proper policy formulation should be taken by the government to encourage the rubber and plastic products industry. Agricultural growth rate should be increased. Again, for that industry Capacity Utilisation should be increased. Another implication is that, if cost of raw materials is less, which is used to produce the products of rubber and plastic, the price of the finished products would be less and demand may increase to a great extent in the international market. So our government should take specific policies to increase the export of Rubber and Plastic Products industry and to produce that rubber and plastic products even in India at a low cost. So that price can be kept low in the international market and in a sense we can capture the international market and earn huge foreign exchange. Keeping this in mind, if we can increase export earnings, then overall economic growth may increase further.

References

Berndt, Ernst and Melvyn Fuss., (1986).“Productivity measurement with adjustments for variations in capacity utilization and other forms of temporary equilibrium”, Journal of Econometrics 33,7-29.

Cesaroni, Giovanni; Kerstens, Kristiaan and Van De Woestyne, Ignace.,(2017). “A New Input-Oriented Plant Capacity Notion: Definition and Empirical Comparison.” Pacific Economic Review, Wiley Blackwell 22(4). 720-739.

Das, Deb Kusum; Erumban, Abdul Azeez; Aggarwal, Suresh and Wadhwa, Deepika.,(2010), "Total Factor Productivity Growth in India in the Reform Period: A Disaggregated Sectoral Analysis". 1st World Klems Conference, Harvard University..

Erumban, Abdul Azeez.(2001)."Utilization of Optimal Capacity in Indian Manufacturing, 1974-96." Applied Economic Letters 8, no. 9. 623-628.

Goldar, Bishwanath and Ranganathan, V.S. (1991). "Capacity Utilization in Indian Industries." Indian Economic Journal 39, no. 2. 82-92.

Harris, Richard and Moffat, John.(2017). "The UK Productivity Puzzle, 2008–2012: Evidence Using Plant-Level Estimates of Total Factor Productivity." *Oxford Economic Papers* 69, no. 3. 529–549.

Hashim, Danish A. (2003). "Capacity Utilozation in Indian Airlines." Working Paper, Institute of Economic Growth, Delhi.

Hickman, Bert G..(1964). "On a new method of capacity estimation", Journal of the American Statistical Association 59. 529-549.

Kapelko, Magdalena; Oude Lansink, Alfons and Stefanou Spiro E. (2017)."The Impact of the 2008 Financial Crisis on Dynamic Productivity Growth of the Spanish Food Manufacturing Industry. An Impulse Response Analysis." Agricultural Economics48, no. 5. 561–571.

Kathuria, Vinish; Raj, S.N. Rajesh and Sen, Kunal.(2013). "Productivity Measuring in Indian Manufacturing: A Comparison of Alternate Methods." Journal of Quantitative Economics 11, no. ½. 148–179.

Klein, Lawrence R., (1960)."Some theoretical issues in the measurement of capacity", Econometrica28, 272-286.

Morrison. Catherine,(1985). "Primal and dual capacity utilization: An application to productivity measurement in the U.S. automobile industry", Journal of Business and Economic Statistics 3, 312-324.

Ray, S and Pal, M. K, (2010). "Trade reform and Total Factor Productivity Growth in India's Aluminium Industry, which Adjusted for Capacity Utilisation." ArthaVijnana, Vol.L, III, No. 1, 7-26.

Srinivasan, Pagalthivarthi.(1992a). "Determinants of Capacity Utilization in Indian Industries." Journal of Quantitative Economics 8, no. 1139-156.

APPENDIXA-1

- CAPITALSTOCK: ASI data, gross investment in fixed capital in Indian iron and steel industry computed for each year by subtracting the book value of fixed capital in previous year from that in the current year and adding to that figure the reported depreciation fixed asset in current year and subsequently it is deflated by the implicit deflator to get real gross investment.
- FIXED CAPITAL: represents the depreciated value of fixed assets owned by the factory as on the closing day of the accounting year. Fixed capital includes land including leasehold land, buildings, plant and machinery, furniture and fixtures, transport equipment, water system and roadways and other fixed assets such as hospitals, schools etc. used for the benefit of factory personnel.
- RENT PAID: represents the amount of royalty paid in the nature of rent for the use of the fixed assets in the factory.
- INTEREST PAID: includes all interest paid on factory account on loans, whether short term or long term, irrespective of the duration and the nature of agency from which the loan was taken. Interest paid to partners and proprietors on capital or loan are excluded.
- TOTAL PERSONS ENGAGED: include the employees as defined above and all working proprietors and their family members who are actively engaged in the work of the factory even without any pay and the unpaid members of the co-operative societies who worked in or for the factory in any direct and productive capacity. The number of workers or employees is an average number obtained by dividing man days worked by the number of days the factory had worked during the reference year.
- TOTAL EMOLUMENTS: is defined as the sum of wages and salaries, employer's contribution as provident fund and other funds and workmen and staff welfare expenses as defined above.
- FUELS CONSUMED: represent total purchase value of all items of fuels such as coal, liquefied petroleum gas, petrol, diesel, electricity, lubricants, water etc. consumed by the factory during the accounting year but excluding the items which directly enter into the manufacturing process.
- OUTPUT: is measured by real gross value added. To get real, deflated GVA by the ratio of GDP at current to constant prices GDP deflator. We measured GDP deflator by considering a single base year (1990-91).

APPENDIX A-2

Year	Total Factor Productivity Growth	Capacity Utilisation	Adjusted Total Factor Productivity Growth
1981-82	0.5037	0.6286	0.1016
1982-83	0.118	0.6581	0.0903
1983-84	0.3031	0.714	0.0688
1984-85	0.0393	0.6807	0.0816
1985-86	0.1727	0.664	0.088
1986-87	-0.0099	0.6601	0.0895
1987-88	0.0582	0.6656	0.0874
1988-89	-0.0255	0.6922	0.0772
1989-90	0.0992	0.6307	0.1008
1990-91	-0.0511	0.6814	0.0813
1991-92	0.0718	0.6997	0.0743
1992-93	0.0537	0.7075	0.0713
1993-94	0.101	0.7059	0.0719
1994-95	0.0185	0.6983	0.0748
1995-96	-0.0506	0.7503	0.0549
1996-97	0.088	0.8292	0.0246
1997-98	0.0592	0.7143	0.0687
1998-99	0.1035	0.6959	0.0758
1999-2000	-0.0776	0.7666	0.0486
2000-01	0.0509	0.7421	0.058
2001-02	-0.1703	0.7364	0.0602
2002-03	0.0454	0.7466	0.0563
2003-04	-0.0282	0.8163	0.0295
2004-05	-0.0391	0.868	0.0097
2005-06	-0.0074	0.8366	0.0218
2006-07	-0.1069	0.8514	0.016
2007-08	-0.0292	0.8534	0.0153
2008-09	0.154	0.8919	0.0005
2009-10	0.2229	0.9029	-0.0037
2010-11	0.0221	0.9251	-0.0122
2011-12	0.1186	0.8894	0.0015
2012-13	-0.1209	0.8586	0.0133
2013-14	-0.0719	0.8877	0.0021
2014-15	0.1603	0.8553	0.0146
2015-16	-0.0505	0.8984	-0.002
2016-17	-0.0278	0.9204	-0.0104
Entire Time Period	0.0471	0.7701	0.0473
Pre-Reform	0.1208	0.6675	0.0867
Post-Reform	0.0188	0.8095	0.0321
Post-Reform: I	0.0418	0.731	0.0623
Post-Reform: II	0.0063	0.8429	0.0193
Post-Reform: III	0.0013	0.885	0.0032