An Application of Economic Capacity Utilization to the Measurement of TFPG from Non-Parametric Approach: Empirical Evidence from Manufacturing Sector of West Bengal: 1980-81 to 2010-11

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Abstract

This paper attempts to measure productivity performance of the manufacturing sector of West Bengal during the period 1980-81 to 2010-11. In measuring total factor productivity growth a non-parametric approach, namely, Malmquist Data Envelopment Analysis has been used to estimate different performance measure. A comparative analysis between the pre (1980-81 to 1990-1991) & post liberalisation (1991-92 to 2010-11) era has also been made in this study. The paper also seeks to adjust malmquist total factor productivity growth (MTFPG) of manufacturing sector of the state of West Bengal with economic capacity utilization (CU). Our study shows overall negative TFP growth, though there is an increase in the rate of decline of TFPG from pre to post-liberalisation period. With adjustment for variations in Capacity Utilization, TFPG shows a positive and increasing trend during the post-reform period as compared to the pre-reform period. In a sense the liberalization process is found to have its adverse impact on total factor productivity growth (unadjusted with CU), but in case of TFPG adjusted with CU the manufacturing sector of West Bengal shows a significant positive growth. In a sense, the nature of impact of liberalization boils down to the adjustment of TFPG with CU.

Key words: Manufacturing sector of West Bengal, Total Factor Productivity Growth, Malmquist Index, Data Envelopment Analysis.

JEL Classification: C14, D24, E32, L6.

1. Introcuction

Productivity is the key determinant of a nation's standard of living and an industry's competitiveness. In this regard, total factor productivity (TFP) is considered to be the better indicator than labour productivity and multi-factor productivity in order to characterize industry-level productivity performance. Despite there exists ample empirical research work regarding linkage between trade reforms and factor productivity growth, overviews on the link between liberalization and TFPG find inadequate evidence on this issue, it is as yet a controversial issue and debate is still unsettled. This controversy arises due to differing interpretations of liberalization and openness.

Theoretically, TFP is a relevant measure for technological change by measuring the real growth in production value, which cannot be explained by changes in the input of labour, capital and intermediate inputs.

Since 1991, a series of market-based reforms have been initiated by the Indian Government which was supposed to bring about noteworthy changes in industrial sector. As a result, Indian industries have been witnessing profound changes in the basic parameters governing its structure and functioning. Relaxing of licensing rule, reduction in tariff rates, removal of restriction on import of raw materials and technology, price decontrol, rationalization of customs and excise duty, enhancement of the limit of foreign equity participation etc. are among those which have been introduced at early 90s. The major objectives of such policy reforms were to make Indian industries as well as entire economy more efficient, technologically up-to-date, competitive and ready to face global challenges with a view of attain rapid growth. The proponents of liberalization believe that this policy reform will improve industrial growth and performance significantly while critics argue that total withdrawal of restrictions on several matters will have a negative effect on future growth and performance of the industry.

In 1946 West Bengal had a larger number of factories and factory employees than any other province in India. However the situation had started changing from the partition of Bengal. Two major industries, *viz.*, jute and tea had been adversely affected by the partition. Infrastructure sector, particularly loss of Chittagong port, had also got adversely affected due to this cause. Migration from erstwhile East Pakistan also created large pressure. In the process, the State lost its industrial base. It not only fell far behind some States like Gujarat, Maharashtra, Karnataka and Andhra Pradesh, but the State had to suffer a process of deindustrialisation as well. Now the State has come a long way since the pre-Independence period. But the situation does not seem to have changed; rather it appears to have become worse.

In this back drop, we consider West Bengal, to measure its industrial performance over the pre-reform & post-reform era by measuring its industrial performance through TFP growth. Here, we also consider Capacity Utilization (CU) as a measure of industrial performance. In this paper, the period under study is 1980-81 to 2010-11. This is a sufficiently large number of years that witnessed highly restricted, partially liberalized and fully liberalized regimes, with a view to compare meaningfully the growth pattern in total factor productivity(TFP) in the pre-reform period with that of the post-reform period.

1.1. A Brief Survey of Literature:-

The concept of technical efficiency indicates the degree of success in the utilization of productive resources. Technical efficiency is considered to be an important determinant of productivity growth and international competitiveness in any economy (Taymaz and Saatci, 1997). There are different schools of thought in estimating the technical efficiency. Technical efficiency consists of maximizing the level of production that can be obtained from a given combination of factors. In the Indian context, number of studies examined the technical efficiency of the manufacturing industry, e.g., Page (1984), Little et al. (1987), Patibandla (1998), Mitra (1999), Agarwal (2001), and Mitra et al. (2002), Bhandari et al. (2007a, 2007b) and many others. Krishna and Mitra (1998) investigate the effects on competition and productivity on the dramatic 1991 trade liberalization in case of Indian manufacturing. Using firm-level data from a variety of industries, they find some evidence of an increase in the growth rate of productivity. Driffield and Kambhampati (2003) estimate frontier production functions for six manufacturing industries. Their findings suggest an increase in overall efficiency in five out of the six manufacturing industries in the post-reform period. Mukherjee and Ray (2005) examine the efficiency dynamics of a ‘typical’ firm in individual states during the pre and post-reform years. Their findings establish no major change in the efficiency ranking for different states after the reforms was initiated. Using a panel dataset of 121 Indian manufacturing industries from 1981 to 1998, Pattnayak and Thangavelu (2005) find evidence of total factor productivity improvements for most of the industries after the reform period.

While the 1991 economic reform was radical, India adopted a gradualist approach to reform, meaning a frustratingly slow pace of implementation (Ahluwalia, 2002). It suggests that it is more appropriate to examine the effect of liberalization on manufacturing sectors' efficiency using a longer time span for both pre and post-reform period. How did this economic reform program shifted Indian manufacturing into global stage and influencing technical and scale economies of major industries? In answering this question, we employ a nonparametric approach in explaining productivity changes, technical progress and scale efficiencies of industries within the sector. In this paper, we examine the impact of liberalization on the technical efficiency of manufacturing sector of the state of West Bengal by comparing pre and post economic reform periods.

Analysis of technical efficiency of manufacturing industries in developing countries has received considerable attention in the economic literature in recent years. Recent literature includes Onder *et al.* (2003) for Turkey, Pham *et al.* (2009) for Vietnam, Margono *et al.* (2010) for Indonesia, and Mastromarco (2008) for less-developed countries among others. Technical efficiency is concerned with how closely the production unit operates to the frontier for the production possibility set. The historical roots of a rigorous approach to efficiency measurement can be traced to the works of Debreu (1951) and Farrell (1957). Over the past three decades, a variety of approaches, parametric and non-parametric, have been developed to investigate the failure of producers to achieve the same level of efficiency ,for a detailed survey on such methodologies, we may look into the work of Kalirajan and Shand (1999). In parametric models, one specifies an explicit functional form for the frontier and econometrically estimates the parameters using sample data for inputs and output, and hence the accuracy of the derived technical efficiency estimates is sensitive to the nature of the functional form specified. In contrast, the method of Data Envelopment Analysis (DEA) introduced by Charnes *et al*. (1978) and further generalized by Banker *et al*. (1984) offers a non-parametric alternative to parametric frontier production function analysis. A production frontier is empirically constructed using linear programming methods from observed input-output data of sample decision making units (DMUs). In this study, we adopt the output-oriented (OO) DEA that seeks the maximum proportional increase in output production, with input levels held fixed. The non-parametric approach entails constructing an envelope of the most productive groups to serve as the frontier for the productive performance of all manufacturing industry groups. Thus, there will be one production frontier for each year of the sample, with differences between the frontiers of any two years representing the technical change between those years. By exploiting the computational strength of DEA, the Malmquist productivity-change index may be decomposed into multiplicative factors that can be attributed to technical change (TC), technical efficiency change (TEC) and scale efficiency change (SEC). Lovell (1996) gives a clear description of how the DEA based Malmquist approach implements such decomposition.

The Paper is organized as follows: Section 1.2 deals with the main objectives of our study. Section 2 depicts methodology & database. Total Factor Productivity estimates are presented in section 3. In Section 4, we adjust TFPG with Economic Capacity Utilization. Lastly in Section 5 we present concluding remarks.

1.2. Objectives of Our Study:

Objectives of our study are as follows:

1. To estimate the total factor productivity growth (TFPG) of the manufacturing sector of West Bengal in terms of the Malmquist Productivity index (Non-parametric approach).
2. To evaluate the impact of liberalization on TFPG of the manufacturing sector of West Bengal.

3. To estimate the economic Capacity Utilization in the manufacturing sector of West Bengal.
4. To adjust the TFPG of the manufacturing sector of West Bengal by economic capacity utilization (CU).

2. Methodology Used in the Present Study:

2.1. Data Sources & Measurement of Variables:

The present study is based on industry-level time series data taken from several issues of Annual Survey of Industries, National Accounts Statistics, CMIE and Economic Survey, Statistical Abstracts (several issues), RBI bulletin etc. covering a period of 31 years commencing from 1980-81 to 2010-11. Selection of time period is largely guided by availability of data. The entire period is sub-divided into two phases as 1980-81 to 1990-91, 1991-92 to 2010-11 (Pre-reform phase and Post-reform phase). Sub-divisions of total period is being taken logically as such to assess conveniently the impact of reforms on total factor productivity growth and employment.

Now, output in this context is measured as real gross value added index. The GDP deflator has been used as the deflator of gross value added.

In this study Labour index is formed as a weighted sum of number of heads in two groups (Workers & Other employees), weights being the relative group remunerations. Relevant data is obtained from ASI & Indian Labour Statistics.

So far as capital input is concerned we have taken into account the perpetual inventory method. In our study, real gross fixed capital stock is taken as the measure of capital input. Deflator used is obtained from data on GFCF at current and constant prices. Data for the above purpose are obtained from various issues of ASI & NAS published by CSO.

In the present paper we have tried to estimate the trend in TFPG and CU for the overall manufacturing sector of West Bengal. We have also adjusted the TFPG of the manufacturing sector of West Bengal with the respective CU. Here both the entire period (1980-81 to 2010-11) and its sub periods (i.e., 1980-81 to 1990-91 & 1991-92 to 2010-11) have been taken up for analysis.

2.2. Econometric Specification:

Malmquist TFP Index:

The conventional setup of Färe *et al.* (1992) is adopted in modelling the problem as transformation of a vector of inputs $x^t \in R_+^n$ into a vector of output $y^t \in R_+^m$ .The production technology at each time period *t*, denoted S^t, is identified as the set of all technologically feasible input-output combinations at time *t* (Lovell, 1996). It is constructed from the data as:

$$S^t = \{(x^t, y^t) | x^t \text{ can produce } y^t\} \qquad (1)$$

Fare, Grosskopf, Noriss & Zhang (1994) followed Shephard (1970) to define the output distance function at time 'τ' as:

$$D_0^t (x^t, y^t) = \inf \{\theta \mid (x^t, y^t / \theta) \in S^t\} = (\sup \{ \theta \mid (x^t, \theta y^t) \in S^t\})^{-1} \qquad (2)$$

The subscript '$_0$' is used to denote the output based distance function. Note that, $D_0^t (x^t, y^t) \leq 1$; if and only if $(x^t, y^t) \in S^t$, & $D_0^t (x^t, y^t) = 1$; if and only if (x^t, y^t) is on the frontier of the technology. In the latter case, Farrell (1957) argued that the firm is technically efficient.

To define the Malamquist index, Fare et al. (1994) defined distance function with respect to two different time periods:

$$D_0^t\ (x^{t+1}, y^{t+1}) = \inf\ \{\theta \mid (x^{t+1}, y^{t+1} / \theta) \in S^t\} \qquad (3)$$

&

$$D_0^{t+1}\ (x^t, y^t) = \inf\ \{\theta \mid (x^t, y^t / \theta) \in S^{t+1}\} \qquad (4)$$

The distance function in (3) measures the maximal proportional change in output required to make (x^{t+1}, y^{t+1}) feasible in relation to technology at time 'τ'. Similarly, the distance function in (4) measures the maximal proportional change in output required to make (x^t, y^t) feasible in relation to technology at time (t+1). The output-based Malamquist TFP productivity index can then be expressed as:

$$M_0\ (x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_0^{t+1}\ (x^{t+1}, y^{t+1})}{D_0^t\ (x^t, y^t)} \left[\frac{D_0^t\ (x^{t+1}, y^{t+1})}{D_0^{t+1}\ (x^{t+1}, y^{t+1})}\ \frac{D_0^t\ (x^t, y^t)}{D_0^{t+1}\ (x^t, y^t)}\right]^{\frac{1}{2}} \qquad (5)$$

The term outside the brackets shows the change in technical efficiency while the geometric mean of the two ratios inside the brackets measures the shift in technology between the two period 't' & 't+1'; this could be called technological progress. So:

$$\text{Efficiency change} = \frac{D_0^{t+1}\ (x^{t+1}, y^{t+1})}{D_0^t\ (x^t, y^t)} \qquad (6)$$

$$\text{Technical change} = \left[\frac{D_0^t\ (x^{t+1}, y^{t+1})}{D_0^{t+1}\ (x^{t+1}, y^{t+1})}\ \frac{D_0^t\ (x^t, y^t)}{D_0^{t+1}\ (x^t, y^t)}\right]^{\frac{1}{2}} \qquad (7)$$

In each of the formulas i.e., equation(6) & (7) , a value greater than one indicates a positive growth of TFP (an improvement) from a period 't' to 't+1' and a value smaller than one represents deteriorations in performance over time.

We can decompose the total factor productivity growth in following way as well:

MTFPI = Technical Efficiency change X Technical Change
(Catching up effect) (Frontier effect)

MTFPI is the product of measure of efficiency change (catching up effect) at current period 't' and previous period 's' (average geometrically) and a technical change (frontier effect) as measured by shift in a frontier over the same period. The catching up effect measures that a firm is how much close to the frontier by capturing extent of diffusion of technology or knowledge of technology use. On the other side frontier effect measures the movement of frontier between two periods with regards to rate of technology adoption. In DEA-Malmquist TFP Index does not assume all the firms or sectors are efficient so therefore any firm or sector can be performing less than the efficient frontier. In this methodology we will use the output oriented analysis because most of the firms and sectors have their objective to maximize output in the form of revenue or profit. It is also assumed that there is constant return to scale (CRS) technology to estimate distance function for calculating Malmquist TFP index and if technology exhibits constant return to scale (CRS), the input based and output based Malmquist TFP Index will provide the same measure of productivity change.

2.3. Model of Capacity Utilization:

Simply, capacity output is defined as the maximum feasible level of output of the firm. An economically more meaningful definition of capacity output originated by Cassel (1937) is the level of production where the firms long run average cost curve reaches a minimum. As we consider the long run average cost, no input is held fixed. For a firm with the typical 'U' shaped average cost curve, at this capacity level of output, economies of scale have been exhausted but diseconomies have not set in. The physical limit defines the capacity of one or more quasi-fixed input. Klein (1960) defined capacity as the maximum sustainable level of output an industry can attain within a very short time, when not constrained by the demand for product and the industry is operating its existing stock of capital at its customary level of intensity. Klein (1960) argued that long run average cost curve may not have a minimum and proposed the output level where the short run average cost curve is tangent to the long run average cost curve as an alternative measure of capacity output. This is also the approach adopted by Berndt and Morrison (1981).

In view of variations in CU as a short-run phenomenon caused by the quasi-fixed nature of capital, an econometrically tractable short-run variable cost function that assumes capital as a quasi-fixed input has been used to estimate CU.

Considering a single output and three input framework (K, L, E) in estimating CU, we assume that firms produce output within the technological constraint of a well-behaved production function.

Y = f (K, L, E) where K, L and E are capital input, labor input and energy input respectively.

Since capacity output is a short run notion, the fundamental concept behind it is that firm faces short run constraint like stock of capital. Firms operate at full capacity where their existing capital stock is at the long run optimal level. Capacity output is that level of output, which would make existing short run capital stock optimal.

Rate of CU is given as:

$$CU = Y/Y^* \ldots\ldots\ldots \qquad (1)$$

Y is actual output and Y* is capacity output.

In association with variable profit function, there exists a variable cost function, which can be expressed as

$$VC = f\,(P_L, P_E, K, Y)\ldots \qquad (2)$$

Short run total cost function is expressed as

$$STC = f\,(P_L, P_E, K, Y) + P_K.K\ldots\ldots \qquad (3)$$

P_K is the rental price of Capital.

Variable cost equation which is variant of general quadratic form for (2) that provide a closed form expression for Y* is specified as:

$$VC = \alpha_0 + K_{-1}\left(\alpha_K + \tfrac{1}{2}\beta_{KK} \left[\frac{K_{-1}}{Y}\right] + \beta_{KL}.P_L + \beta_{KE}.P_E \right)$$
$$+\ P_L\left(\alpha_L + \tfrac{1}{2}\beta_{LL}.P_L + \beta_{LE}.P_E + \beta_{LY}.Y \right)$$
$$+\ P_E\left(\alpha_E + \tfrac{1}{2}\beta_{EE}.P_E + \beta_{EY}.Y \right) + Y\left(\alpha_Y + \tfrac{1}{2}\beta_{YY}.Y \right) \ldots\ldots\ldots \qquad (4)$$

K_{-1} is the capital stock at the beginning of the year, which implies that a firm makes output decisions constrained by the capital stock at the beginning of the year.

Capacity output (Y*) for a given level of quasi-fixed factor is defined as that level of output, which minimizes STC. So, the optimal capacity output level, for a given level of quasi-fixed factors, is defined as that level of output, which minimizes short-run total cost (STC). So, at the optimal capacity output level, the envelop theorem implies that the following relation must exist. Capacity output (Y*) for a given level of quasi-fixed factor is defined as that level of output, which minimizes STC. So, the optimal capacity output level, for a given level of quasi-fixed factors, is defined as that level of output, which minimizes STC. So, at the optimal capacity output level, the envelop theorem implies that the following relation must exist.

$$\frac{\partial STC}{\partial K} = \frac{\partial VC}{\partial K} + P_K = 0 \ldots\ldots\ldots \qquad (5)$$

In estimating Y*, we differentiate VC equation (4) w.r.t K_{-1} and substitute expression in equation (5)

$$Y^* = \frac{-\beta_{KK.}K_{-1}}{(\alpha_K + \beta_{KL}P_L + \beta_{KE}P_E + P_K)} \qquad (6)$$

The estimates of CU can be obtained by combining equation (6) and (1).

Now to estimate capacity utilization (CU), output is measured as real value added produced by manufacturers ($Y = P_L L + P_K K_{-1} + P_E . E$) suitably deflated by SDP deflator for the manufacturing sector of West Bengal. Total number of persons engaged in manufacturing industries is used as a measure of labor inputs. Price of labor (P_L) is the total emolument divided by number of laborers which includes both production and non-production workers (Goldar & others 2004).Deflated cost of fuel has been taken as measure of energy inputs. Due to unavailability of data regarding periodic price series of energy in India, some approximation becomes necessary. We have taken weighted aggregative average price index of fuel (considering coal, petroleum and electricity price index, suitably weighted, from statistical abstract) as proxy price of energy. Deflated gross fixed capital stock at 1991-1992 (of manufacturing sector of West Bengal) prices is taken as the measure of capital input. The estimates are based on perpetual inventory method. Rental price of capital is assumed to be the price of capital (P_K) which can be estimated following Jorgenson and Griliches (1967): P_K= (Interest paid/Capital investment).

3. Empirical Results of MTFP Growth:

In this section, we have calculated total factor productivity growth and its component using Malmquist Productivity Index under two inputs- labour & capital and one output framework. Estimates of annual TFP growth rate for overall manufacturing sector of West Bengal for the pre as well as post-reform period at aggregate level are presented in Table: 1 & Table: 2 respectively.

Table: 1 – Malmquist Index Summary of Annual Means for Pre-reform Period

Year	EFFCH	TECHCH	PECH	SECH	TFPCH
1980-81	-	-	-	-	-
1981-82	1.000	1.098	1.000	1.000	1.098
1982-83	1.000	0.916	1.000	1.000	0.916
1983-84	1.000	0.711	1.000	1.000	0.711
1984-85	1.000	0.882	1.000	1.000	0.882
1985-86	1.000	1.401	1.000	1.000	1.401
1986-87	1.000	0.846	1.000	1.000	0.846
1987-88	1.000	0.908	1.000	1.000	0.908
1988-89	1.000	0.713	1.000	1.000	0.713
1989-90	1.000	1.014	1.000	1.000	1.014
1990-91	1.000	1.179	1.000	1.000	1.179
Mean	**1.000**	**0.947**	**1.000**	**1.000**	**0.947**

Source: Authors own estimate by using DEAP software, version 2.1

From Table 1, it is seen that, during the pre-reform period, the overall manufacturing sector of West Bengal experienced an overall negative TFP growth of 5.3%. During the post reform period, from Table 2, we can clearly see that the overall growth of TFP is negative and it is 7.2% indicating that the rate of decline increase form pre to post reform period. This results reveals that decline in the industry's TFPG is due to its productivity based frontier capability. On the other side, it can be said that as the technical change is less than unity and has a negative effect on the overall TFP growth for both in the pre & post-reform era. Pradhan & Barik (1999) opined that low and negative trend in the TFPG is a common feature in most of the developing countries.

Table: 2 – Malmquist Index Summary of Annual Means for Post-reform Period

Year	EFFCH	TECHCH	PECH	SECH	MTFPCH
1991-92	1.000	1.135	1.000	1.000	1.135
1992-93	1.000	0.777	1.000	1.000	0.777
1993-94	1.000	1.197	1.000	1.000	1.197
1994-95	1.000	0.601	1.000	1.000	0.601
1995-96	1.000	0.741	1.000	1.000	0.741
1996-97	1.000	1.237	1.000	1.000	1.237
1997-98	1.000	0.999	1.000	1.000	0.999
1998-99	1.000	0.599	1.000	1.000	0.599
1999-2000	1.000	0.347	1.000	1.000	0.347
2000-01	1.000	1.844	1.000	1.000	1.844
2001-02	1.000	0.985	1.000	1.000	0.985
2002-03	1.000	0.892	1.000	1.000	0.892
2003-04	1.000	0.835	1.000	1.000	0.835
2004-05	1.000	1.634	1.000	1.000	1.634
2005-06	1.000	0.907	1.000	1.000	0.907
2006-07	1.000	1.171	1.000	1.000	1.171
2007-08	1.000	1.132	1.000	1.000	1.132
2008-09	1.000	0.767	1.000	1.000	0.767
2009-10	1.000	1.560	1.000	1.000	1.560
2010-11	1.000	0.591	1.000	1.000	0.591
Mean	**1.000**	**0.928**	**1.000**	**1.000**	**0.928**

Source: Authors own estimate by using DEAP software, version 2.1

The zero efficiency change index (EFFCH) indicates that the negative total factor productivity in manufacturing sector of West Bengal caused from the non-upgradation in innovation of technology. This may be due to the reason that some of the industries within the manufacturing sector of the state of West Bengal still have the problem of excessive labour utilization in producing output.

4. Trend in Malamquist Total Factor Productivity Growth After Removal of Short-run Variation in CU:

An increase in TFP is generally interpreted as improvement in technical efficiency. The crucial problem is that this interpretation holds only in cases where long run equilibrium is realized in production. Long run equilibrium in production is the condition where inefficient firm exit and only firms that efficiently utilize resources are left operating. In other words, the theory is that production always takes place along the production function. In short-run, production does not always take place along the production function due to the presence of adjustment cost. In such cases, the shirt run change in capacity utilization exerts an influence on the estimated value of MTFP.

Here, we estimate how, in short run, TFPG measure may be changed with the variation in capacity utilization. We regress the measured productivity growth on the capacity utilization rate which is a proxy for business cycle. Subsequently, we have adjusted the average of the regression error term so that it equals the original productivity measure when the productivity measure is adjusted for cyclical factor.

$$MTFP_t = a + b\ CU_t$$

$$MTFP = 22.742 - 31.092\ CU$$
$$(-2.364)^{**}$$

Where CU is economic capacity utilization (derived from optimization procedure as shown in methodology concerning CU measurement) and t-statistics are given in the parenthesis. R^2 = 0.166.

Our regression result shows that effect of CU on measured productivity growth is significant at 0.05 level of significance.

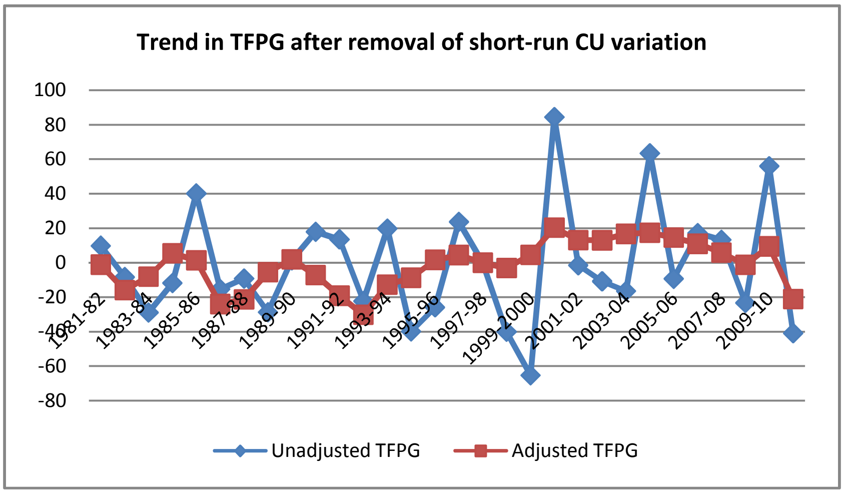

Figure 1

From our study, it is found that rate of change in CU of the manufacturing sector of the state of West Bengal has a negative impact over MTFP growth rate. This implies that among many other factors like growth in output, import of capital goods, advanced technology, trade policy etc., that affect MTFPG, CU may have a resultant negative effect on TFPG rate. With the removal effect of CU in short-run, it is found that the growth rate of TFP increases from 0.10% in pre-reform period to 1.10% in the post-reform period.

Table 3: TFP Growth Rate After Adjusting Capacity Utilization

Time Interval	TFP Growth rate (in %)	
	Unadjusted TFPG (before removing CU effect)	Adjusted TFPG (after removing CU effect)
Pre-reform period i.e. 1980-81 to 1990-91	-5.3%	0.10%

Post-reform period i.e. 1991-92 to 2010-11	-7.2%	1.10%
Entire Period i.e. 1980-81 to 2010-11	-6.6%	0.70%

Authors own estimates

On the contrary, it is found from the comparison between pre & post-reform period of the manufacturing sector of West Bengal that after incorporating the effect of CU into MTFP growth, the growth rate increases from 0.10% in pre-reform period to 1.10% in post reform period. Again, unadjusted MTFPG measure implies a sharp fall of -1.9% (-7.2% minus -5.3%). Further, capacity adjusted MTFPG measures suggest a net improvement of 1.00% (1.10% minus 0.10%) following trade reform. In a nut shell, inspection of entries in Table 3 reveals that removal of cyclical effect from the estimated MTFP growth affect its overall movement & remarkably mitigates its variation because variations between sub periods are significantly changed after adjusting capacity utilization as a cyclical factor.

5. Summary & Conclusion:

In this study we have tried to estimate the technical efficiency, total factor productivity growth & capacity utilisation adjusted total factor productivity growth for manufacturing sector of the state of West Bengal. We have tried to make a comparative analysis between the pre & post-reform era with respect to the above mentioned economic variables. In this study, total factor productivity growth (TFPG) has been obtained by non-parametric Data Envelopment Analysis approach through Malmquist TFP index (as discussed under methodology). This study also seeks to analyse the picture when total factor productivity growth (TFPG) is adjusted with economic capacity utilisation (CU).

From our study, we may reach at the following conclusions:

- ❖ TFPG (unadjusted with CU) shows an overall negative growth for the entire period (1980-81 to 2010-11) and it is -6.6%. There is a sharp increase in the rate of decline in TFPG from pre to post reform period by -1.9% for the manufacturing sector of West Bengal.
- ❖ When TFPG is adjusted with CU, we notice a positive and increasing trend from the pre-reform period to post-reform period.
- ❖ There is a need for technological up gradation in the production process for overall manufacturing sector of West Bengal.
- ❖ From our study on unadjusted TFPG, it seems that, in West Bengal, the industrial growth is mainly input driven.
- ❖ Further it may be concluded that liberalization process had its adverse impact on total factor productivity growth (CU-unadjusted) for the manufacturing sector of the state of West Bengal. Some sort of a different picture is observed when TFPG is adjusted with CU.
- ❖ From our study, it seems that, the difference in the results is due to the process of estimation of CU and the adjustment of TFPG with economic CU.

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