8. An Application of Economic Capacity Utilization to the Measurement of Total Factor Productivity Growth: Empirical Evidence from Indian Fertilizer Industry[1]

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Abstract

This paper attempts to measure the productivity performance of the Indian fertilizer industry at the aggregate level, with adjustment for variations in capacity utilization during the period from 1979-80 to 2003-04. Using a translog specification, our econometric analysis reveals a decelerating trend in total factor productivity growth resulting in negative impact of economic reforms on the Indian fertilizer industry. The study also indicates a declining trend of economic capacity utilization suggesting the adverse impact of liberalization after the mid 90's, due to slow increases in actual output; this probably results from stagnated demand and rapid expansion of capacity as a result of the abolition of the licensing rule consequent to economic reforms. Total output growth in the Indian fertilizer industry is found to be mainly as a result of input-accumulation rather than productivity driven. The analysis reveals that a correction for capacity utilization mitigates the variations in total factor productivity growth.

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1. Introduction

A great deal of intellectual exercise on total factor productivity growth (TFPG) in both developed and developing countries has been conducted since the late fifties. The study of productivity becomes unquestionably crucial in judging performance of an industry, although it is not the mere benchmark in performance evaluation. Most of the productivity studies currently undertaken are based on the assumption of fuller utilization of capacity at all points of time for all inputs.

In India, during recent times, especially after economic reforms started since 1991, productivity analysts reveal mixed results in their studies. Majumder (1996), Krishna and Mitra (1998) estimated positive impact of liberalization policies, whereas Balakrishnan, Pushpangadan and Suresh Babu (2000) and Das (2004) did not find evidence of acceleration in productivity growth as a result of economic reforms. Goldar (2004) estimated a slowdown in TFP growth in Indian manufacturing in the post-reform period. Pradhan and Barik (1999) opined that low and negative trend in TFPG is a common feature in developing countries. They also estimated a negative TFPG for the Indian chemical sector. Whether TFPG has accelerated or decelerated may be the possibility that productivity residual has been systematically underestimated or overestimated (Berndt and Fuss, 1986). Productivity accountants have identified earlier the importance of cyclical variations, such as capacity utilization in affecting TFPG. Abroad, analysts like Jorgenson and Grileches (1967) attempted to adjust the capital stock data to reflect changes in capacity utilization (CU). Denison (1979) uses variations in capital's share in income. Norsworthy, Harper (1978) etc., tried to adjust productivity by selecting time interval for which CU is believed to be nearly one. Morrison (1985) attempts to adjust productivity changes by dividing productivity growth by cost CU measure.

In India, after economic reforms introduced in 1991, economic analysts examine the industrial performance in the light of total factor productivity growth, whereas adequate intellectual attention was not given to capacity utilization in evaluating industrial performance. It may be noted that even the analysis of total factor productivity would be more meaningful if adjustment is made for fluctuations in capacity utilization (Hulten, 1986; Morrison, 1986; Berndt and Fuss, 1986). An examination of the literature reveals that conventional measures of CU have been used by most of the analysts which is not based on any explicit theoretical foundation, and very negligible attention had been paid to the possible theoretical problems. Since most of them followed the conventional engineering (installed capacity) and Wharton approaches, the principal problem underlying the interpretation of most of the existing studies is the feeble link between the underlying economic theory and the used measures of CU. Therefore, the earlier studies on capacity utilization has left several unaddressed theoretical and data problems in measuring CU.

After reviewing the literature, it can be observed that most of the studies conducted so far are on aggregate manufacturing, the coverage of which is not till 2003-2004. Until now, existing studies focus on measurement of partial and total factor productivity and entry aspect of firms. The present study is a comprehensive analysis on specific energy intensive industry – the fertilizer sector regarding total factor productivity growth with adjustment for variations in economic capacity utilization for the period 1979-‘80 to 2003-’04 at the aggregate level, dividing it into pre and post-reform period. Several unaddressed problems left in CU measurement also inspires us to inquire into the economic capacity utilization in one of the major volatile Indian manufacturing like Indian fertilizer sector using a more reliable database.

By now, the research question: “Did the economic reforms improve efficiency in Indian fertilizer industry?” has become pertinent in view of capacity utilization, as well as total factor productivity growth. The Indian fertilizer industry, by virtue of the complexity of its regulatory environment, provides economists with much more interesting questions. This study will be capable of providing adequate answers to these vital issues. In this paper, we estimate economic capacity utilization for one of the Indian manufacturing sectors, namely fertilizer sector, using a theoretically established methodology which is based on the theoretical foundation of economic theory. TFPG estimates are presented for Indian fertilizer sector at aggregate level over the period from 1980-1981 to 2003-2004, with a view to compare meaningfully the growth pattern in TFP in the pre-reform period with that of the post-reform period, assuming that all firms operating within an industry behave alike, as well as industry level characteristics are equally attributable to all the firms in an industry. Secondly, we attempted to understand the impact of policy changes owing to economic liberalization on the movements of CU and TFPG. In studying the impact of liberalization on industrial performance, we focus on one such key sector of the organized manufacturing in India for several reasons. Manufacturing is often seen as the key driver of structural changes and economic growth in discourse on economic development (Kaldor, 1967), and it was a heavily protected and regulated sector that was the largest target of liberalization reforms. Moreover, since fertilizer industry in India during recent time is particularly subject to volatile demand (coefficient of variation of output growth is very high), it has been considered to be the ideal industry for estimating how TFPG rate may be affected by the short-run variation in capacity utilization. Therefore, this paper also aims at providing an underpinning to explain how TFPG can be adjusted in a consistent manner to capture variation in CU in order to assess the effect of CU on TFPG.

In this backdrop, this paper develops an analytical framework and tests empirically whether trade reforms improve productivity growth in Indian fertilizer industry - one of the largest energy intensive industries in India. Therefore, this study is an attempt to measure the total factor productivity growth with adjustment for capacity utilization and assesses the impact of liberalization on TFPG of the said industry in order to have a clear insight into whether liberalization has significantly contributed to TFPG. Previous findings for the contribution of total factor productivity growth to total output growth yielded contradictory result. Many developing countries grew via factor accumulation instead of improved technological change via total factor productivity growth and therefore, attempt was also made to investigate into the fact whether output growth is input-driven or productivity-driven. The diverse empirical results suggest the need for further investigation into the link between trade liberalization and productivity growth and capacity utilization in the Indian fertilizer industry. An investigation of the issue on analytical front may insert to our knowledge of the issue and throw lights on the distinct set of results produced by the existing studies.

The paper is organized as follows: section 2 provides recent fertilizer policies in India and conceptual issues related to capacity, section 3 analyzes data base and methodology, section 4 depicts estimation of TFPG at aggregate level, section 5 estimates economic CU. Possible empirical application of economic CU to adjust for TFPG measurement is discussed in section 6 and section 7 presents summary and conclusion.

2. Recent Fertilizer Policy Prevailing in India

The Indian fertilizer sector has been under strict government control for most of the period since independence. A price and distribution control system was considered to be necessary not only to ensure fair prices and equal distribution all over the country but also to provide incentives for more intensive use of fertilizers. A control system of licensing and approval of collaboration aimed at standardizing technology and capacity of plants. The goal of government intervention was to improve agricultural productivity and, thus, the basic supply of food. Oil crisis in the mid-seventies led to steep increase in cost of import or production resulting in fall in consumption of fertilizer. Based on the recommendation of the Marathe Committee's report, Retention Pricing Scheme was introduced for nitrogenous fertilizer in November, 1977, for complex fertilizer in 1979, for single super phosphate in May 1982, for ammonium chloride in 1985. Under RPS, cost of production was decided on the basis of norms. It provided reasonable return on net worth to the producing companies and induces efficiency at the same time. RPS era was highly controlled, but witnessed spectacular increase in indigenous capacity built up and fertilizer consumption till 1990s.

In the wake up of economic liberalization in 1991 and rising subsidy bill, the Government explored to alternatives of RPS. Phosphatic and potassic fertilizers were decontrolled w.e.f August, 1992. Immediate impact was steep decline in the consumption of the said fertilizers. Concession scheme on phosphatic and potassic fertilizers was introduced in October, 1992 and has been operative for these fertilizers. In July 1991, price decontrol of low analysis nitrogenous fertilizers has been introduced.

August 1991 saw Dual Pricing Policy, which adopted 30% price increases of fertilizer for big farmers, no price increase for small and marginal farmers. In August 1992, Partial Decontrol of prices, distribution and movement of phosphatic and potassic fertilizer, recontrol of low analysis nitrogenous fertilizers, 10% price reduction for urea fertilizer in 1992 until March 1993 have been initiated.

For urea, RPS Continued till March, 2003 and from April, 2003, New Pricing Scheme (NPS) has come into force, which is a modification of RPS. Unit specific retention price scheme was replaced by group based concession scheme and the present NPS is valid till March, 2010.

Therefore, during post liberalization era, the fertilizer industry has been highly controlled, but reforms have taken place in both upstream and downstream sectors.

Inputs decontrolled resulted in abnormal increase in the prices of raw materials. Cost plus approach with stringent regulations and procedures have not induced any investment in the sectors. Thus, the health of the existing fertilizer industry has been adversely affected. Capacity of fertilizer remained stagnant and there is a surge in demand for fertilizer in recent years. Country resorted to high imports to meet increasing demand.

2.1. Concept of Capacity

The concept of capacity has played an important role in economic analysis. Unlike many well defined concepts, capacity has been subjected to alternative definition and misconceptions. The economists' a definition differs from the engineers' idea of capacity, since what is technically possible may not be economically desirable. 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 inputs. Klein 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). If technology exhibits constant return to scale, long run average cost curve is horizontal and the capacity level output is not defined. In this case, at the minimum point, the short run average cost curve is tangent to the long run average cost curve. This helps to determine the economic capacity output in the short run.

We prefer choice theoretic model[4], because it is firmly based in the behavioural concept of economic theory. The choice theoretic approach defines capacity output as the long run desired level of output given capital stock and input prices.

The Indian fertilizer industry comprising the nitrogenenous, phosphatic and potassic segments has played a pivotal role in facilitating the required increase in the use of

[4] *Cassel (1937) first suggests that a firm's capacity output is the minimum of the long run average cost curve. Klein and Friedman suggest capacity output as that output level at which long run and short run average cost curves are tangent. Economic capacity is a short run concept. The fixed nature of some inputs like capital characterizes short run. For any amount of fixed input like capital, the output which can be obtained with the minimum long run cost method is capacity output which will require a higher cost method of production and therefore short run average cost of output is above the long run average cost curve except at the capacity output level. In the short run, higher cost methods are required to obtain additional output since only variable inputs may be increased. Therefore, a firm with fixed capital may choose to operate in the short run at a level of output that differs from the long run desired level and variation in CU is viewed as a short run phenomenon due to quasi-fixity of capital.*

plant nutrients for achieving the goal of self sufficiency in food grain production, on one hand, and sustained agricultural growth, on the other. With the current level of performance the industry ranks 3rd in the world in production and consumption of fertilizer. This industry occupies 3.25% a share in GVA, 5.58% a share in fuel consumption, the energy intensity (measured as fuel consumption / GVA) is 0.55 and foreign exchange earning growth from export enhanced from 21.2% in 1991-1992 to 55.9% in 2005-2006.

3. Database and Methodology

This paper covers a period of 25 years, from 1979 –1980 to 2003 –2004. The entire period is sub-divided into two phases, as pre-reform period (1980 –1981 to 1990 – 1991) and post-reform period (1991- 1992 to 2003-2004) on the basis of changes in macroeconomic policy governing the Indian economy, sub-division of period being taken logically as such to assess conveniently the impact of liberalization on TFPG and CU.

3.1. Description of Data and 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, Whole sale price in India prepared by the Index no of office of Economic Advisor, Ministry of Industry etc., covering a period of 25 years commencing from 1979-1980 to 2003-2004. Selection of time period is largely guided by availability of data[5]. In capacity utilization (CU) estimate, output is measured as real value added produced by manufacturers *(*$Y = P_L L + P_K K_{-1} + P_E . E$*)* suitably deflated by WIP index for manufactured. In order to avoid over estimation due to ignoring contribution of material input on TFP, a third variable of intermediate input (material including energy input)[6] has been incorporated in the value-added function as such to obtain gross output while estimating TFPG. Pradhan and Barik (1999) argued that the gross output, instead of value added, appears to be the appropriate choice of TFPG estimation in India. Generally, TFP growth estimates based on value added terms are over estimated since they ignore the contribution of intermediate inputs on productivity growth (Sharma, 1999). Therefore, modified gross value of output so calculated has been used as a measure of output suitably deflated by wholesale price index of manufactured.

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[5] *Until 1988-1989, the classification of industries followed in ASI was based on the National Industrial classification 1970 (NIC 1970). The switch to the NIC-1987 from 1989-1990 and also switch to NIC1998 requires some matching. Considering NIC1987 as base and further NIC 1998 as base, fertilizer industry has been merged accordingly. For price correction of variable, wholesale price indices taken from official publication of CMIE have been used to construct deflators.*

[6] *Earlier studies that have not treated material including energy as separate factor of production, has failed to pick-up significant economies that are likely to generate in the use of such input. Jorgenson (1988) has observed that in a three input production framework, the contribution of intermediate inputs like material, energy etc. are significant sources of output growth.*

Total number of persons engaged in Indian fertilizer sector 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[7] (Goldar *et al.*, 2004). Deflated cost of fuel (Appendix 1) 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[8]. Deflated gross fixed capital stock at 1981-'82 prices is taken as the measure of capital input. The estimates are based on perpetual inventory method (Appendix 2). Following the same line as adopted in deflating energy input, the reported series on materials has been deflated to obtain material inputs at constant prices. Rental price of capital is assumed to be the price of capital (P_K) which can be estimated following Jorgenson and Griliches (1967):

$$P^t_K = r_t + d_t - \frac{P^{\bullet}_k}{P_k}$$

where: r_t is the rate of return on capital in year t, d_t is the rate of depreciation of capital in the year t and $\frac{P^{\bullet}_k}{P_k}$ is the rate of appreciation of capital .Rate of return is taken as the rate of interest on long term government bonds and securities [9] which is collected from RBI bulletin(various issues). The rate of depreciation is estimated from the reported figures on depreciation and fixed capital as available in ASI which Murty (1986) had done earlier. However, we have not tried corrections for the appreciation of value of capital [10] in the estimates of price of capital services.

3.2. Econometric Specification

3.2.1. TFPG Estimation Procedure

In this paper, TFPG is estimated under three input framework applying Tran slog index of TFP as below:

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[7] *One serious limitation of this assumption is that this does not take into account variations in quality and the composition of labour force.*

[8] *To compute the price of energy inputs, some studies have aggregated quantities of different energy inputs using some conversion factors (say British Thermal units or coal replacement etc.) and then take the ratio of expenditure on energy to the aggregate quantity of energy. This method is criticized because it assumes different types of energy inputs to be perfect substitutes.*

[9] *Prime lending rate is generally viewed as an opportunity cost of capital, but problem is that there is no unique lending rate available for use.So, we have used rate of interest on long term government bond and securities as rate of return on capital [as previously used by Jha, Murty and Paul (1991)].Alternatively, one can use the gross yield on preferential industrial shares, if available, as Murty(1986) has done.*

[10] *As Jorgenson and Griliches note capital gains should be deducted from (r_t +d_t) but several studies have not done so and adjustment for capital gains does not seem to make such difference to the result.*

$$\Delta LnTFP(t) = \Delta LnQ(t) - \left[\frac{S_L(t) + S_L(t-1)}{2} x \Delta LnL(t) \right] -$$
$$- \left[\frac{S_K(t) + S_K(t-1)}{2} x \Delta LnK(t) \right] - \left[\frac{S_M(t) + S_M(t-1)}{2} x \Delta LnM(t) \right]$$

Q denotes gross value added, *L* Labour, *K* Capital, *M* material including energy input.

$$\Delta Ln\ Q(t) = Ln\ Q(t) - Ln\ Q(t-1)$$
$$\Delta Ln\ L(t) = Ln\ L(t) - Ln\ L(t-1)$$
$$\Delta Ln\ M(t) = Ln\ M(t) - Ln\ M(t-1)$$
$$\Delta Ln\ L\ (t) = Ln\ L(t) - Ln\ L(t-1)$$

S_K, S_L *and* S_M being income share of capital, labor and material respectively and these factors add up to unity. *TFP* is the rate of technological change.

3.2.2. Capacity Utilization Estimation Procedure

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[11] production function *Y = f (K, L, E),* where: *K, L* and *E* are capital, labor and energy 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

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

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

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

Short run total cost function is expressed as

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

P_K is the rental price of Capital.

Variable cost equation[12] which is variant of general quadratic form for (2) that provide a closed form expression for *Y** is specified as

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[11] *A production function is considered to be well-behaved if it has positive marginal product for each input and it is quasi- concave and also satisfies the conditions of monotonocity. Quasi-concavity required that the bordered Hessian matrix of first and second partial derivatives of the production function be negative semi-definite.*

[12] *Similar functional form has been previously estimated by Denny et al (1981). The variable cost function is based on the assumption that some input like capital cannot be adjusted to*

$$VC = \alpha_0 + K_{-1}\ (\ \alpha_K\ + ½\ \beta_{KK} \left[\frac{K_{-1}}{Y}\right] + \beta_{KL.} P_L\ + \beta_{KE.} P_E\ ) +$$
$$+\ P_L\ (\ \alpha_L + ½\beta_{LL.} P_L\ + \beta_{LE.} P_E + \ \beta_{LY.} Y\ ) + \tag{4}$$
$$+\ P_E\ (\ \alpha_E + ½\beta_{EE.} P_E\ + \beta_{EY.} Y\ ) + Y(\ \ \alpha_Y + ½\ \beta_{YY.} Y$$

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 the level of output that minimizes STC. Thus, 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.

$$\frac{\partial STC}{\partial K} = \frac{\partial VC}{\partial K} + PK = 0 \tag{5}$$

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

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

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

4. Empirical Estimation of TFP Growth

Estimation of annual TFP growth rate of Indian fertilizer Industry at aggregate level are presented in Table 1.

Present exercise exhibits an overall negative growth rate in TFP. It is evident from Table 1 that the estimated growth rate of TFP for the period 1980-1981 to 1991-1992 is 0.44% p.a., which signifies a positive rate of growth in TFP, whereas post-reform period covering 1991-1992 to 2003-2004 in our study witnessed a sharp negative growth of -1.12% p.a., a steeper fall from growth rate as revealed in the pre-reform period. This decline is due to reduced capacity utilization caused by downfall in production rather than being a consequence of lack of technical progress. The growth rate of TFP in Indian fertilizer sector is assessed to be –0.055% p.a., implying average overall annual deceleration for the entire period 1980-1981 to 2003-2004. On the whole, the impact of economic reforms on TFPG at aggregate level was poor as the positive average rate of TFPG estimated in the pre-reform period declined to negative growth in post-reform period. Moreover, difference between mean TFPG of two periods is statistically significant at 0.05 levels thereby indicating that average TFPG between two periods are statistically different.

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their equilibrium level. Therefore, the firm minimizes variable cost given the output and the quasi-fixed inputs.

Table 1

Trend in Growth Rate of TFP at Aggregate Level

Pre-reform Period (1979-1980 to 1991-1992)			Post-reform Period (1991-1992 to 2003-2004)		
Year	TFP Indices	Growth rate in TFP (%)	Year	TFP Indices	Growth rate in TFP (%)
1979-80	1	-	1991-92	0.9739	-8.05
80-81	1.0344	3.44	92-93	1.0643	9.28
81-82	0.9648	-6.73	93-94	0.9581	-9.98
82-83	1.0063	4.30	94-95	0.9388	-2.01
83-84	1.0154	0.90	95-96	1.0348	10.23
84-85	1.0213	0.59	96-97	1.0392	0.43
85-86	0.9784	-4.20	97-98	0.9356	-9.97
86-87	1.0081	3.04	98-99	0.999	6.78
87-88	1.0149	0.67	99-‘00	1.0457	4.67
88-89	0.8796	-13.33	00-01	1.0208	-2.38
89-90	1.2	36.43	01-02	0.9735	-4.63
90-91	1.0592	-11.73	02-03	1.0518	8.04
91-92	0.9739	-8.05	03-04	0.8729	-17.01
Average		0.44			-1.12

Source: Estimated by authors.

Output growth – either input accumulation or productivity driven:

Theoretically, sources of economic growth are composed of factor accumulation and productivity growth. The first source may lead to high growth rates, but only for a limited period of time. Thereafter, the law of diminishing returns inevitably occurs. Consequently, sustained growth can only be achieved through productivity growth, that is, the ability to produce more and more output with the same amount of input. Some researchers argued that the Soviet Union of the 1950s and the 1960s, and the growth of the Asian ‘Tigers’ are examples of growth through factor accumulation (e.g. Krugman, 1994). On the other hand, growth in the industrialized countries appears to be as the result of improved productivity (e.g. Fare *et al*, 1994).

Traditionally (owing to Solow), the sources of output growth are decomposed into two components: a component that is accounted for by the increase in factors of production and a component that is not accounted for by the increase in factors of production which is the residual after calculating the first component. The latter component actually represents the contribution of TFP growth.

Table 2 shows the relative contribution of TFP growth and factor input growth for the growth of output during 1979-1980 to 2003-2004. Observing the growth path, it is apparent that TFP growth contribution is either negative or insignificant across the entire time frame. Therefore, it is true that increase in factor input is responsible for observed output growth and TFP contribution plays negligible role in enhancing output growth. Consequently, growth in Indian fertilizer industry was fundamentally dominated by factor accumulation resulting in input-driven growth.

Table 2

Contribution of TFPG to Output Growth under Liberalized Trade Regime

Period	Output growth	Contribution of Input growth	Contribution of TFPG
Phase 1 (1979-80 to85-86)	3.67	3.95(107.63%)	-0.28 (-7.63%)
Phase 2 (1986-87 to91-92)	26.99	25.82(95.66%)	1.17(4.34%)
Phase 3 (1992-93 to97-98)	7.09	7.43(100.46%)	-0.34(-0.46%)
Phase 4 (98-99 to2003-04)	-2.05	-1.30(63.41%)	-0.75(36.59%)
Entire Pre-reform period (1979-80 to 1991-92)	15.33	14.89(97.13%)	0.44(2.87%)
Entire Post-reform period (1991-92 to 2003-04)	3.74	4.86(127.08%)	-1.12(-27.08%)
Entire period (1979-80 to03-04)	8.93	8.98(127.63%)	-0.05(-27.63%)

**Figures in the parenthesis are contribution of factor inputs and productivity in percentage term to the respective phase.*

5. Economic Measure of Capacity Utilization

In Table 3 below, in view of overriding importance of capacity utilization as one of the determinants of productivity, we present economic CU estimation and its trend during the study period by adopting OLS technique.

Table 3

Trend in Capacity Utilization, 1979-1980 to 2003-2004

Year	Economic CU = Y/Y*	Capacity Growth (%)	Output Growth (%)	Growth in CU (%)	Year	Economic CU = Y/Y*	Capacity Growth (%)	Output Growth (%)	Growth in CU (%)
79-80	0.5425	-	-	-	1991-92	1.005	9.15	11.12	1.81
80-81	0.6270	4.82	21.15	15.57	92-93	0.9447	28.25	20.54	-6.01
81-82	0.5604	2.40	-8.47	-10.61	93-94	0.7767	11.78	-8.10	-17.78
82-83	0.5458	2.31	-0.36	-2.61	94-95	0.8319	15.16	23.34	7.10
83-84	0.5972	4.54	14.40	9.42	95-96	0.7863	30.40	23.25	-5.48
84-85	0.6267	5.27	10.46	4.93	96-97	0.7417	7.68	1.57	-5.67
85-86	0.6854	1.39	10.89	9.37	97-98	0.6831	5.13	-3.18	-7.90
86-87	0.8609	9.34	37.34	25.61	98-99	0.6052	12.68	-0.18	-11.41
87-88	0.7121	6.05	-12.28	-17.28	99-00	0.7269	5.07	26.21	20.12
88-89	0.8372	8.27	21.33	17.56	00-01	0.6719	11.73	3.27	-7.57
89-90	0.7963	6.46	20.01	-4.89	01-02	0.6017	1.98	-8.68	-10.45
90-91	0.9873	16.23	17.01	23.99	02-03	0.5597	2.01	-5.10	-6.97
91-92	1.005	9.15	11.12	1.81	03-04	0.5859	-6.61	-2.25	4.67
Average	0.7218	6.35	11.88	5.61		0.7324	10.34	6.29	-3.50

Source: Estimated by authors.

It was noticed that if capacity output is taken to be the economic capacity derived from optimization process, the CU could exceed one in some cases. This implies that production is to the right of minimum point of short-run average total cost curve which induces cost reducing net investment. The estimate in Table 3 shows that industry's average *CU* ratio rose from 0.7218 to 0.7324 during post-reform period and similar trends have been noticed in the average growth rate of capacity and actual output during these two time frames shows declining trend. Wide variations in the magnitude of *CU* are found in the estimation, which ranges from about 0.5425 to 1.005 within these two-time periods.

In investigating the issue of whether there exist any impact of economic reforms on CU or not, piecewise linear regression (Spline function) is used as follows.

$$Ln\ CU_t = \alpha + \beta t + \beta'(t - t_0)\ D\ t$$

Result of the regression equation is as follows:

$$Ln\ CU_t = -\ 0.719 \quad +\ 0.054 -\ 0.0925\ D\ t$$
$$(-\ 14.96) \quad (9.54) \quad (-\ 9.98)$$

Adjusted R^2 = 0.804, Durbin-Watson value = 1.96

Here, β gives the slope of the regression line in pre-reform period which is positive and significant implying that growth in *CU* shows positive trend immediately before liberalization starts. But as coefficient of the difference between two time periods is significant at 0.01 level and negative (coefficient being - 0.0925), it can be concluded that liberalization has its significant negative impact on *CU* during post- reform period.

It is also evidently supported by our empirical estimation of average growth rate in capacity utilization as shown in Table 3 that there is a significant drop in average growth rate of capacity utilization, from 5.61% in pre-reform period to -3.50 % in post-reform period.

Trend in capacity expansion reflects that capacity expanded more rapidly in post-reform period than pre-reform period due to abolition of licensing rules which might have encouraged entrepreneurs to invest more and expand plant capacity. Gross output at 1981-1982 prices had grown constantly during 1980s and its growth rate accelerated in the first half of 1990s. Output growth may take place because the size of the overall market is expanding. A rapid growth of gross output in an industry generates expectation that the industry will grow in future, investment in industry might increase. Abolition of industrial licensing might have encouraged investment. It is noteworthy that growth rate of output of Indian fertilizer sector stagnated or slowed down after 1995-1996. The slow growth rate of gross output might be due to deficient demand which is supported from declining sales growth rate after1995-96 as shown in Table-4, increase of import probably (5.75% import growth during'95-'04period) affecting domestic production, high cost of capital over-burdening manufacturers which resulted due to tight monetary policy of Reserve Bank of India adopted in 1995-'96. Apart from this, withdrawal of price and distribution control for potassic, phosphatic and nitrogenous fertilizers coupled wtith introduction of dual pricing probability of further decrease in subsidies reflected immediate effect on production, but capacity expanded rapidly as a result of abolition of licensing restriction consequent to economic reforms. Moreover, the regulation of fertilizer prices and the Retention Price Scheme (RPS) compensates the negative margins faced by fertilizer manufacturers. This scheme, introduced in 1977, ensures that, in principle, fertilizer manufacturers do not make losses (Venkateshwarlu and Sen, 2002). The reforms of the early 1990s brought a delisting of several items (i.e. several items were no longer the subject of RPS), which meant that manufacturers producing these items were suddenly exposed to losses. It is not surprising that this change in regulatory environment led to decline in growth rate of capacity utilization.

Table 4

Growth of Real Sales and Cost of Capital (%)

Year	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04
Real Growth in sales %	10.5	6.9	22.9	12.1	13.7	1.6	-2.1	1.2	5.4
Growth of cost of capital % (interest etc.)	22.12	20.82	17.62	19.04	18.66	17.96	16.31	8.01	14.79

Source: ASI & CMIE data (several issues) (Compiled).

6. Empirical CU Economic Application to Adjust for TFPG in Indian Fertilizer Industry

Now, focus can be directed towards a vital application of the aforesaid economic CU measure to the adjustment of productivity measures in Indian fertilizer industry due to cyclical variation in utilization. Such adjustment to productivity measure is of crucial importance in order to account for the effect of variation in capacity utilization on TFPG. This section estimates how TFPG measure may be distorted with the variation in capacity utilization .We regress the log difference of the measured productivity growth on the log difference of 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 factors.

$$\Delta\ Log\ TFP_t = a + b\Delta\ Log\ CU_t$$

$$\Delta\ Log\ TFP = -0.0023 - 0.121\Delta\ Log\ CU_t$$
$$(-0.252)\quad (-0.692)$$

where: *CU* is capacity utilization and *t* statistics are given in the parenthesis. Durbin-Watson = 2.74, $R^2 = 0.21$.

Table 5

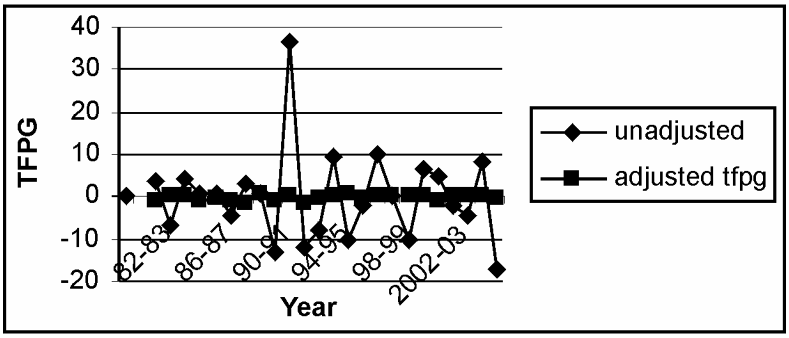
TFP Growth rate with adjustment for capacity utilization, 1980-1981 to 2003-2004

Time interval	TFP growth rate (% per annum).	
	Unadjusted TFPG	TFPG adjusted for capacity utilization
Pre-reform period i.e. 1980 -81 to 1991 – 92	0.44	-0.50
‘80-81 to84-85	0.5	-0.38
‘84-85-to 88-89	-2.65	-0.58
‘88-89 to 91-92	0.83	0.68
Post- reform period i.e. 1991 –92 to 2003 –04	-1.12	-0.019
‘91-92 to 97-98	-1.44	0.047
‘97-98 to 03-04	-2.07	-0.053
Entire period i.e. 1980-81 to 2003 – 04	-0.055	-0.25

 # Growth rates for the entire periods are obtained from the semi log trend.

Figure 1

Graphical presentation of Total factor productivity growth with adjustment for capacity utilization



Rate of changes in CU are found to be negatively correlated with TFP growth rate. This implies that among many other factors like growth in output, import of capital goods, advanced technology, trade policy etc. that affect TFPG, CU may have a resultant negative effect on TFPG rate. After adjustment of capacity utilization, positive growth rate of TFP (0.44%) in '80s vanishes, rather displays a very noticeable decelerated growth rate in TFP(-0.50%) and in '90s, TFPG rate is negative but improvement is noticed inspite of negative trend existed as compared to pre-reform period resulting a net improvement of 0.48% (-0.019 % minus -0.50%) following trade reform.

Difference in average annual growth rate between pre-reform (1980-1981 to1990-1991) and post-reform period (1991-1992 to 2003-2004) is lower when effect of CU is incorporated into TFP growth calculation; while unadjusted tran slog measure implies a slowdown of 1.56% (0.44 minus - 1.12%), despite showing negative inclination, capacity adjusted TFPG measure suggest a net improvement of 0.48% (-0.019 % minus -0.50%) following trade reform.

On the whole, inspection of entries in table 5 reveals that removal of cyclical effect from the estimated TFP growth does not affect its overall movement but remarkably mitigates its variation because variation between subperiods are reduced after adjusting capacity utilization as cyclical factors. This implies that since average CU rates fell during post-reform period, the magnitude of the post liberalization (1991-1992 to 2003-2004) TFPG slowdown was over-estimated by failing to take into account the effect of capacity utilization on TFPG.

7. Summary and Conclusion

Our study examines the trend in TFPG, adjusted for capacity utilization in the context of Indian fertilizer industry during 1980s and 1990s. The analysis reveals in a nut shell that during 90's, there was a deceleration in TFP growth supporting the findings of many earlier studies.

Our findings also exhibit that:

a) Traditionally measured TFP growth without adjustment for CU, showing positive average growth during ‘80s and negative average growth during ‘90s, appears to be considerably over-estimated because it is evident that capacity adjusted measure suggests a noticeable improvement in TFP growth (0.48%) over pre-reformTFPG compared to unadjusted traditional Tran slog measure (a slowdown of 1.56%).

b) Total output growth in the Indian fertilizer industry is found to be mainly input-accumulated rather than productivity driven.

c) Economic reforms have a significant negative impact on TFPG as well as on capacity utilization in Indian fertilizer industry.

d) Our result shows that a declining trend of CU is noticed after mid ‘90s due to slow increase in actual output resulting from stagnated demand and rapid expansion of capacity output as a result of abolition of licensing rule consequent to economic reforms.

e) Capacity utilization was a crucial factor that affects productivity growth in this industry.

In conclusion, it should be noted that economic reforms were undertaken to make Indian industry more efficient, technologically updated and competitive which are supposed to increase the level of productivity as well as capacity utilization. But our analysis does not support this contention.

In summary, while assessing performance of an industry, application of CU framework econometrically indicates the importance and usefulness of economic CU measure and offers a comfortable basis for future applied economic research in the context of emerging as well as rapidly developing economies like India. It is also suggested that while making policy decisions on the basis of aggregate, the consideration of intra-sectoral analysis may be attempted in order to have more valuable results because generalization based on aggregative analysis sometimes fails to pave the way for improved decision making.

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Appendix 1

Energy Inputs: - Industry level time series data on cost of fuel of Indian fertilizer sector have been deflated by suitable deflator (base 1981-1982 = 100) to get real energy inputs. An input output table provides the purchase made by manufacturing industry from input output sectors. These transactions are used as the basis to construct weight and then weighted average of price index of different sectors is taken. Taking into consideration 115 sector input-output table (98-99) prepared by CSO, the energy deflator is formed as a weighted average of price indices for various input-output sectors which considers the expenses incurred by manufacturing industries on coal, petroleum products and electricity as given in I-O table for 1998-99. The WIP indices (based 1981-1982) of Coal, Petroleum and Electricity have been used for these three categories of energy inputs. The columns in the absorption matrix for 66 sectors belonging to manufacturing (33-98) have been added together and the sum so obtained is the price of energy made by the manufacturing industries from various sectors. The column for the relevant sector in the absorption matrix provides the weights used.

Appendix 2

Capital Stock: - The procedure for the arriving at capital stock series is depicted as follows:

First, an implicit deflator for capital stock is formed on NFCS at current and constant prices given in NAS. The base is shifted to 1981-82 to be consistent with the price of inputs and output.

Second, an estimate of net fixed capital stock (NFCS) for the registered manufacturing sector for 1970-1971 (benchmark) is taken from National Accounts Statistics. It is multiplied by a gross-net factor to get an estimate of gross fixed capital stock (GFCS) for the year 1970-1971. The rate of gross to net fixed asset available from RBI bulletin was 1.86 in 1970-1971 for medium and large public Ltd. companies. Therefore, the NFCS for the registered manufacturing for the benchmark year (1970-1971) as reported in NAS is multiplied by 1.86 to get an estimate of GFCS which is deflated by implicit deflator at 1981-1982 prices to get it in real figure. In order to obtain benchmark estimate of gross real fixed capital stock made for registered manufacturing, it is distributed among various two digit industries (in our study, fertilizer industry) in proportion of its fixed capital stock reported in ASI, 1970-1971)

Third, from ASI data, gross investment in fixed capital in fertilizer industries is computed for each year by subtracting the book value of fixed assets in previous year from that in the current year and adding to that figure the reported depreciation on fixed asset in current year (Symbolically, $I_t = (\beta_t - \beta_{t-1} + D_t)/Pt$) and subsequently it is deflated by the implicit deflator to get real gross investment.

Fourth, the post benchmark real gross fixed capital stock is arrived at by the following procedure. Real gross fixed capital stock (t) = real gross fixed capital stock (t – 1) + real gross investment (t). The annual rate of discarding of capital stock (D_{st}) is assumed to be zero due to difficulty in obtaining data regarding $D_{st.}$