# CAPACITY UTILIZATION IN INDIAN PAPER INDUSTRY

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**Abstract:** The study estimates the rate of capacity utilization for the Indian paper industry for the period 1973-74 to 1997-98 on the basis of the theoretical framework of variable cost function. It is based on the basic premise that deviation from full utilization of capacity takes place as the levels of certain inputs, particularly capital, are fixed in the short-run and thus can be changed only in the long-run. In order to meet the increase (decrease) in demand, the industry puts the existing capital to more (less) intensive use. The study undertakes empirical estimation of a translog variable cost function by considering three variable inputs, viz., labour, energy and raw material and one quasi-fixed input, capital, on the basis of aggregate industry level data taken from annual survey of industries. It is found that under-utilization of capacity prevails in the Indian paper industry and there has been a decline in the rate of capacity utilization over time.

## 1. Introduction

The falling rate of capacity utilization (CU) in the Indian paper industry in recent years has been viewed with concern in the industry as well as the government [Government of India 1998]. Despite the rapid growth in demand for paper and paper product the profitability in the industry has been on decline. This is coupled with a declining trend in total factor productivity in the industry [Barik 2003, Srivastava 2000]. In fact, there are many instances of closure of firms in the industry due to unsustainable losses. According to a report [Economic Times, November 2000] 20 per cent production capacity remained closed during the year 1999-2000.

Although the Indian paper industry has witnessed rapid growth in level of output, number of production units and variety of paper and paper products over the years, analysis of its productivity performance has been at a rudimentary level. While the number of paper mills at the beginning of the planning era in India, i.e., 1950-51, was only 17, presently this number has gone up to 380. Simultaneously the installed capacity of the industry has increased from a meagre 0.135 million tonnes per annum (tpa) in 1950-51 to 4.6 million tpa in 1998-99. While production in the industry in the beginning was limited to a small variety of paper products in the beginning, product diversification took place over the years and by the year 1990 the paper industry was self sufficient in most varieties of paper except in newsprint.

In recent years there have been reports of declining rates of capacity utilization and profitability [see various issues of Report on Currency and Finance, RBI]. Recently the problem has reached to the extent of non-viability and closure of many firms. For example, 6 integrated units and 67 small and medium units accounting for 20 per cent of total installed capacity in the industry remained closed during 1987-88 [RBI 1988]. The problem, which started during the mid-1980s, has continued to the present [The Economic Times, May 17, 1999]. It is recognized that in a developing economy with limited availability of capital, underutilization of capacity implies waste of valuable resources and leads to decline in industrial productivity.

The paper industry is the second industry to be liberalized in India after the cement industry. Much before the liberalization euphoria of the 1990s, the paper industry was partially de-licensed in 1984-85, particularly the agro-based paper mills segment. Delicensing was extended to other segments of the industry in 1991. Thus the industry has witnessed radical policy changes starting from a command and controlled policy regime to a liberalized one. These changes have affected various fields of operations and given a more flexible approach to decision making. As a result, the industry is expected to improve upon its productivity performance under a liberalized regime compared to a command and control one.

Concern over declining CU, however, is based on the traditional engineering measure of capacity where it is defined as the maximum level of output that can be produced by a plant of given size if accompanied by appropriate levels of inputs. This approach always returns a value less than unity as the actual output produced is always less than the capacity. Moreover, its lack of foundation in the economic theory of firm makes it difficult to explain any variation in CU over time [Berndt and Morrison 1981].

It is one of the preliminary ideas in the theory of firm that depending upon changes in prevailing demand conditions and input prices a firm (industry) may decide to change its production level which is realized by changing the levels of inputs or technology. The problem arises when certain inputs, particularly capital, cannot be changed to the desired level in the short-run. In such situations the existing capital stock is either under-utilized or over-utilized.

In a theoretical perspective under-utilization of capacity is a short-run phenomenon. In response to a decrease in demand for output, the firm is not in a position to implement a simultaneous decrease in all inputs because of the fixed nature of certain inputs, particularly capital. In order to minimize cost the firm considers the variable component while the fixed cost remains unchanged. The crux of economic CU is the difference between market rental and shadow price of the fixed factors. Unexpected increase in market demand warrants expansion of capital stock so as to enhance supply of output but short-run fixity does not allow instantaneous expansion of capital stock. In such circumstances the firm perceives the intrinsic or shadow price of existing capital stock to be higher than its market rental. Thus the shadow cost of production is higher than actual cost. In the process the existing stock is more intensively utilized. On the other hand, the shadow cost is lower than actual cost when there is an unexpected decline in market demand, which results in an under-utilization of stock.

With the developments in duality theory and short-run variable cost function, the techniques of measurement of economic capacity and rate of CU have improved considerably in theory and in its application to empirical data[1].

The major objective of the present paper is to estimate CU in Indian paper industry by using the insights of a variable cost function. For this purpose Section 2, which follows, highlights the theoretical background for estimation of CU on the basis of a variable cost function. Section 3 depicts the methodology followed in the study and the database used to undertake empirical estimation. Section 4 presents the empirical results and interpretation while Section 5 summarises the study and brings out major conclusions.

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[1] See, for example, Berndt and Fuss (1986), Berndt and Hesse (1986), Hulten (1986), Lee and Kwon (1994), Morrison (1986, 1988a, 1988b, 1988c), Morrison and Berndt (1981), Park and Kwon (1995) and Slade (1986).

## 2. Theoretical Background

In terms of precepts from economic theory it was Cassels (1937) who defined capacity output as the level of output corresponding to the minimum point of long-run average cost (LRAC) curve [Berndt and Hesse 1986]. This is based on the equilibrium condition that short-run average cost (SRAC) curve is tangent to the LRAC curve in the long-run under perfect competition. However, in the short-run a 'temporary equilibrium' [Berndt and Fuss 1986] is possible at any other point on the SRAC curve, depending upon the placement of the demand curve. In this framework the industry may reap the benefits of scale economies or suffer diseconomies in short-run but in the long run there is constant returns to scale (CRTS).

The assumption of CRTS in the long-run may not be close to reality in some cases so that the LRAC curve is not U-shaped[2]. Hence monopolistic elements should be taken care of while defining equilibrium condition such that capacity output can be defined as that level of output where SRAC and LRAC curves are tangent [Klein 1960]. In this framework, the industry deviates from long-run equilibrium whenever its input-output bundle does not correspond to a point on LRAC [Berndt and Fuss 1986].

The realization of full equilibrium at the tangency between SRAC and LRAC is at a level of output where short-run marginal cost (SRMC) equals long-run marginal cost (LRMC).

For a short-run variable cost function $VC = G(Y, P_i, K, t)$, SRMC is given by

$$SRMC = \left.\frac{dG}{dY}\right|_{K=\bar{K}} = \frac{\partial G}{\partial Y} \qquad \ldots(1)$$

[2] This is more likely to occur in a restrictive policy regime where entry into the industry is determined by non-market variables. In this situation a monopolistic market condition can be sustained in an otherwise competitive industry. The Indian paper industry operated under restricted entry conditions during the sixties and seventies.

In the long-run, however, the prime concern of the firm is total cost curve $TC = C(Y, P, t)$ where all inputs, including *K*, are variable. Here $TC = VC + P_K \cdot K$ and LRMC is given by [Morrison 1988c]

$$LRMC = \frac{dC}{dY} = \frac{dG}{dY} + P_K\left(\frac{dK}{dY}\right)$$

$$= \frac{\partial G}{\partial Y} + \frac{\partial G}{\partial K} \cdot \frac{dK}{dY} + P_K\left(\frac{dK}{dY}\right) \qquad \text{...(2)}$$

On equating (1) and (2) it is found that

$$\frac{\partial G}{\partial K} \cdot \frac{dK}{dY} + P_K\left(\frac{dK}{dY}\right) = 0$$

or, $-Z_K = P_K$ ...(3)

where $Z_K = -\frac{\partial G}{\partial K}$ is the shadow price of capital which is its effective price. In Keynesian terminology it reflects the marginal efficiency of capital [Berndt and Hesse 1986]. According to Lau (1978) $Z_K$ is defined as the reduction in total variable cost resulting from a unit increase in *K*.

As per (3) above, full equilibrium is achieved when shadow price of capital is equal to its one period market rental. On the other hand, when $Z_K > P_K$ the firm perceives existing capital to be more expensive than its market value and does not utilize it to its full capacity. Consequently excess capacity exists in the industry. By similar logic a shortage of capital and over-utilization of capacity is depicted by the condition $Z_K < P_K$.

The economic capacity utilization is given by $CU_C = \frac{C^*}{C}$ where $C^* = VC + Z_K K$ is shadow total cost and $C = VC + P_K K$ is total cost. Thus

$$CU_C = \frac{C - P_K K + Z_K K}{C} = \frac{C - (P_K - Z_K)K}{C} = 1 - (P_K - Z_K)\frac{K}{C} \qquad \text{...(4)}$$

An implication of (4) is that whenever $P_K = Z_K$ there is full utilization of capacity. In case of discrepancies between $P_K$ and $Z_K$ it is inferred that $P_K > Z_K$ implies $CU_C$>1 and $P_K < Z_K$ implies $CU_C$<1. From (4) it is found that[3]

$$CU_C = 1 - (P_K - Z_K)\frac{K}{C} = 1 - \frac{\partial C}{\partial K} \cdot \frac{K}{C} = 1 - \frac{\partial \ln C}{\partial \ln K} = 1 - \varepsilon_{CK} \qquad \text{...(5)}$$

where $\varepsilon_{CK}$ is the elasticity of cost with respect to capital stock.

Equation (5) has an implication that when *K* adjusts to its equilibrium level in the long-run there is no tendency to change the capital stock and thus $\varepsilon_{CK} = 0$. Consequently, there is full utilization of capacity in the long-run and the problem of over-utilization or excess capacity is a short-run problem, a point highlighted earlier.

**3. Methodology and Database**

In the present study technology in the Indian paper industry is characterized by a translog variable cost function with four inputs, viz., capital (*K*), labour *(L)*, energy *(E)* and non-energy raw material (*M*). Out of these inputs, *K* is taken to be quasi-fixed in the sense that its level can be changed only in the long-run, not in the short-run. The other inputs are considered to be variable. The translog variable cost function takes the following form:

$$\begin{aligned}\ln VC = {} & \beta_0 + \beta_Y \ln Y + \sum_i \beta_i \ln P_i + \beta_K \ln K + \frac{1}{2}\beta_{YY}(\ln Y)^2 + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln P_i \ln P_j \\ & + \frac{1}{2}\beta_{KK}(\ln K)^2 + \sum_i \beta_{iY} \ln Y \ln P_i + \sum_i \beta_{ij} \ln K \ln P_i + \beta_{KY} \ln K \ln Y \\ & + \sum_i \beta_{it} \ln P_i\, t + \beta_{Yt} \ln Y\, t + \beta_t t + \frac{1}{2}\beta_{tt} t^2 + \beta_{Kt} \ln K\ t \quad (i = L, E, M) \qquad \text{... (6)}\end{aligned}$$

The variable cost function at (6) is linear homogeneous in input prices if the following conditions are fulfilled:

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[3] Since $C = G + P_K K$ we find that $\frac{\partial C}{\partial K} = \frac{\partial G}{\partial K} + P_K = -Z_K + P_K$.

$$\sum_i \beta_i = 1; \quad \sum_i \beta_{ij} = \sum_i \beta_{iy} = \sum_i \beta_{it} = \sum_i \beta_{ik} = 0; \quad \beta_{ij} = \beta_{ji} \qquad \text{...(7)}$$

Thus the restrictions at (7) need to be imposed while estimating (6). An alternative to the above is to normalize (6) by one of the variable input prices (Nadiri and Kim 1996). Use of raw material prices for normalization yields the following form for (6):

$$\begin{aligned}\ln VC = {} & \beta_0 + \ln P_M + \beta_L \ln(P_L/P_M) + \beta_E \ln(P_E/P_M) + \beta_Y \ln Y + \beta_K \ln K + \frac{1}{2}\beta_{YY}(\ln Y)^2 \\ & + \frac{1}{2}\beta_{LL}\ln(P_L/P_M)^2 + \frac{1}{2}\beta_{EE}\ln(P_E/P_M)^2 + \beta_{LE}\ln(P_L/P_M)\ln(P_E/P_M) + \frac{1}{2}\beta_{KK}(\ln K)^2 \\ & + \beta_{LY}\ln(P_L/P_M)\ln Y + \beta_{EY}\ln(P_E/P_M)\ln Y + \beta_{KY}\ln K \ln Y + \beta_{Lt}\ln(P_L/P_M)t \\ & + \beta_{Et}\ln(P_E/P_M)t + \beta_{Yt}\ln Y\, t + \beta_t t + \frac{1}{2}\beta_{tt}t^2 + \beta_{Kt}\ln K \qquad \text{...(8)}\end{aligned}$$

Keeping in view the fact that input demand functions have a separate identity, the factor share equations (implying factor demand) are estimated[4] together with (8). These share equations are obtained by taking the logarithmic differentiation of (8) with respect to variable input prices and applying Shephard's lemma[5] such that:

$$S_L = \beta_L + \beta_{LL}\ln(P_L/P_M) + \beta_{LE}\ln(P_E/P_M) + \beta_{LK}\ln K + \beta_{LY}\ln Y + \beta_{Lt}t \qquad \text{...(9)}$$

$$S_E = \beta_E + \beta_{LE}\ln(P_L/P_M) + \beta_{EE}\ln(P_E/P_M) + \beta_{EK}\ln K + \beta_{EY}\ln Y + \beta_{Et}t \qquad \text{...(10)}$$

$$S_M = 1 - S_L - S_E \qquad \text{...(11)}$$

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4 As the factor shares add up to unity, one of the share equations is dropped so that the error covariance matrix is non-singular (Christensen and Greene 1976).

5 Shephard (1953) has shown that under equilibrium condition $\frac{\partial C}{\partial P_i} = X_i$, where $X_i$ is the equilibrium level of $i^{th}$ input. Thus $\frac{\partial \ln VC}{\partial \ln P_i} = \frac{\partial VC}{\partial P_i}\frac{P_i}{VC} = \frac{P_i X_i}{VC} = S_i$, the $i^{th}$ factor share in variable cost.

The variable cost function specified at (8), in its estimated form, is required to be consistent with theory and fulfil the requisite regularity conditions[6].

Keeping in view the finding that the Indian paper industry does not operate under conditions stipulated by perfect competition and a mark-up over marginal cost (MC) is added for price setting[7] the study incorporates imperfect competition in the product market. For this purpose two additional equations are included in the system of equations. These are i) the inverse output demand equation[8], and ii) the market equilibrium condition, i.e., MC equals MR, marginal revenue.

The inverse output demand equation, in the present study, is specified as follows[9]:

$$\ln P_Y = \alpha_0 + \alpha_Y \ln Y + \alpha_R \ln PCI + \alpha_t t \qquad ...(12)$$

where $P_Y$ is output price, *Y* is output level, *PCI* is per capita net national product (NNP) in India, and *t* is the time variable representing tastes and preference of people.

The equilibrium condition, *MR = MC*, is specified in terms of the revenue share equation [see Barik 2003 for details] as follows:

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[6]The estimated cost function is required to be (i) non-decreasing in variable factor prices, (ii) non-increasing in quasi-fixed factors, (iii) non-decreasing in output, (iv) homogeneous of degree one in variable input prices, (v) concave in variable input prices, and (vi) convex in quasi-fixed factors (Hazilla and Kopp 1986).

[7] It has been shown in Barik (2003) that mark-up over marginal cost in the Indian paper industry, on the average, has been about 30 per cent for the period 1973-98.

[8] The need for the inclusion of the inverse demand equation in the system arises due to the fact that it provides an estimate of the price elasticity of demand, which is required in the specification of the market equilibrium condition.

[9] There could be many other contending variables which appear to be influencing demand for paper and paper products, e.g., literacy rate, school enrolment, share of service sector in GDP, etc. However, inclusion of such variables did not improve the results and on estimation, the coefficients of these variables were found to be statistically not significant.

$$\frac{P_Y Y}{VC} = (1+\alpha_Y)^{-1}(\beta_Y + \beta_{YY}\ln Y + \beta_{LY}\ln(P_L/P_M) + \beta_{EY}\ln(P_E/P_M) + \beta_{KY}\ln K + \beta_{Yt}t) \quad \text{...(13)}$$

The system of five equations comprising (8) – (10) and (12) - (13) is estimated by non-linear maximum likelihood method. Usual error terms are added to the equations in the system and the effect of autocorrelation between successive error terms in an equation is attempted to be purged through a first order autoregressive (AR1) process, $u_t = \rho u_{t-1} + v_t$.

The derivation of a total cost function from the variable cost function requires an estimate of the equilibrium capital stock. $K^*$. In the long-run the producer minimizes total cost given the variable cost function and the price of fixed input. Thus the industry is considered to have reached equilibrium if it does not feel the need for changing its capital stock unless there is a change in variable input prices or output. By applying Hotelling's lemma [Hotelling 1932] to the long-run total cost function the optimization problem under consideration is

$$\min_K G(Y, P_i, K, t) + P_K K \quad \text{...(14)}$$

where the equilibrium capital stock, $K^*$, is given by equating the partial derivative of total cost with respect to capital to zero, that is, $\frac{\partial C}{\partial K} = \frac{\partial G}{\partial K} + P_K = 0$. For the translog specification given at (8) $K^*$ is obtained by solving the following:

$$\frac{VC}{K}(\beta_K + \beta_{KK}\ln K + \beta_{KL}\ln(P_L/P_M) + \beta_{KE}\ln(P_E/P_M) + \beta_{KY}\ln Y + \beta_{KT}t) + P_K = 0 \quad \text{...(15)}$$

It is useful to mention that closed form solution of (15) is not possible as *K* enters in both absolute and logarithmic terms. Thus $K^*$ is found out by an iterative numerical method at each observation.

The required data for estimation of the system of equations are taken from the *Annual Survey of Industries* for the period 1973-74 to 1997-98. Perpetual inventory method with a benchmark capital stock for the year 1960 (Hashim and Dadi 1973) and 4 per cent annual depreciation (Hulten and Srinivasan 1999) is taken for estimation of the capital stock. Following the practice in studies on Indian manufacturing industries (see, for example, Jha, Murty, Paul and Rao, 1993) the price of capital services is defined as $P_{Kt} = q_t(r_t + \delta)$ where $q_t$ is the price of investment good and $r_t$ is the rate of interest. The WPI of non-electrical machinery and machine tools is taken as $q_t$ and the long term lending rate of IFCI and IDBI as $r_t$. Following Pradhan and Barik (1999) the price of raw material is taken to be a weighted average of components, weights being taken from the Input-Output Table 1989-90.

**4. Empirical Results**

It may be recalled that the input demand elasticities for the Indian paper industry are derived from a short-run variable cost function. Thus it is pertinent to begin with the presentation of results on the variable cost function estimates. Of the 25 parameters estimated in the system 12 are observed to be statistically significant at the 5 per cent level. All first order coefficients of the estimated cost function, except $\beta_K$ and $\beta_L$, are statistically significant at the 5 per cent level.

TABLE 1: PARAMETER ESTIMATES OF A TRANSLOG VARIABLE COST FUNCTION

| Parameter | Estimate | t-ratio | Parameter | Estimate | t-ratio |
|---|---|---|---|---|---|
| $\beta_0$ | -1554.8 | -2.72* | $\beta_t$ | 0.9340 | 2.79* |
| $\beta_L$ | 0.2839 | 4.93* | $\beta_{tt}$ | -0.0260 | -2.55* |
| $\beta_E$ | -0.1671 | -1.51 | $\beta_{Kt}$ | -0.0104 | -0.41 |
| $\beta_Y$ | -0.8974 | -2.84* | $\beta_{Lt}$ | -0.0005 | -1.57 |
| $\beta_K$ | -1.0033 | -0.74 | $\beta_{Et}$ | 0.0016 | 0.72 |
| $\beta_{YY}$ | 0.4171 | 3.74* | $\beta_{Yt}$ | -0.0215 | -2.96* |
| $\beta_{KK}$ | 0.2619 | 0.78 | $\beta_{LY}$ | -0.0454 | -5.43* |
| $\beta_{LL}$ | 0.0501 | 3.07* | $\beta_{EY}$ | -0.0302 | -1.68 |
| $\beta_{EE}$ | 0.0566 | 2.40* | $\alpha_0$ | 63.582 | 3.56* |
| $\beta_{LE}$ | 0.0089 | 0.67 | $\alpha_Y$ | –0.1942 | -1.55 |
| $\beta_{KL}$ | -0.0064 | -0.84 | $\alpha_R$ | -0.1244 | -0.27 |
| $\beta_{KE}$ | 0.0457 | 2.55* | $\alpha_t$ | -0.2822 | -1.39 |
| $\beta_{KY}$ | -0.0398 | -0.67 | $\rho$ | 0.9957 | 291.5* |

*Notes*: The estimates pertain to equation (8) in the text.
* indicates statistical significance at the 5 per cent level.

The estimated cost function has a good fit as can be inferred from the R-squared between the actual and the estimated levels of lnVC, which turned out to be 0.99 (see Table 2). It is encouraging that both the factor share equations have a high value of R-squared in contrast to the low R-squared reported in some studies (see for example, Kim and Sachis 1986; Ramaswamy et al. 1996). However, the R-squared between the actual and estimated output share equation is comparatively low at 0.62. The inverse output demand equation, again, has a good fit in the sense that R-squared is found to be 0.99.

The remaining autocorrelation problem after purging its effect at the estimation stage is not statistically significant. From Table 1 it is seen that the autocorrelation coefficient between successive error terms in the equations is estimated to be 0.9957, which is statistically significant at the 1 per cent level. The D-W statistics[10] in the estimated equations range from 1.77 for the labour share equation to 2.41 for the estimated cost function equation as can be seen from Table 5.2. Since the D-W statistics for the estimated equations in the case of the Indian paper industry are close to 2 the possibility of severe autocorrelation is unlikely.

TABLE 2: R-SQUARED AND D-W STATISTICS

| Equation | R-Squared | D-W statistic |
|---|---|---|
| lnVC | 0.996 | 2.41 |
| L -Share | 0.986 | 1.77 |
| E -Share | 0.904 | 2.07 |
| Y -Share | 0.624 | 2.40 |
| Inverse Output Demand | 0.988 | 1.78 |

*Note*: Pertains to the translog variable cost function and share equations discussed in the text.

The estimated cost function fulfils most of the requisite consistency properties. It is found to be increasing in prices and output as the estimated values are positive at all observations. Moreover, both the estimated factor share equations are found to be positive at all the data points, which fulfils the monotonicity condition required for the well-behavedness of the cost function. The first order coefficients for labour share equation $\beta_L$ and revenue share equation $\beta_Y$ are positive while that for energy, $\beta_E$, is negative as can be seen from Table 1. Prima facie it appears that variable cost is decreasing in energy price. But, by combining

[10] It is useful to note that the D-W statistic does not have the standard probability distribution when estimation is by an iterative method and residuals are calculated after adjustment for autocorrelation. Thus reliability of the D-W statistic may be reduced in the present study. However, it serves as a reasonable indicator and we expect its value to be around 2 for cases where autocorrelation is absent.

the relevant parameter estimates, the estimated share of energy is found to be positive. Secondly, the estimated cost function is increasing in output as the estimated output share is positive at all observations.

A requirement of the estimated variable cost function is that it should be decreasing in *K* which is tantamount to $\frac{\partial G}{\partial K} < 0$. On estimation, $\frac{\partial G}{\partial K}$ is found to be negative for the period 1973-74 to 1993-94 while for the remaining period, that is, for 1994-95 to 1997-98 it turned out to be positive. Thus the regularity condition $\frac{\partial G}{\partial K} < 0$ was met for 84 per cent of the observations in the study while for the remaining 16 per cent it could not be fulfilled.

An implication of the regularity condition $\frac{\partial G}{\partial K} < 0$ is that an increase in capital stock should reduce total variable cost. However, in empirical studies it has been reported that $\frac{\partial G}{\partial K} < 0$ is not met globally and violation of this condition may take place at certain observations (see for example, Bharadwaj 1994; Park and Kwon 1995). It has been argued that $\frac{\partial G}{\partial K} > 0$ is consistent with short-run equilibrium if current operating conditions are substantially different from the prevailing or expected conditions at the time of making investment decisions. It is useful to point out that the policy environment under which the Indian paper industry operated has undergone radical changes over the study period. The initial expectations under which investment took place during the seventies and eighties were totally different from the prevailing conditions during the nineties. This could partly explain non-fulfilment of the condition $\frac{\partial G}{\partial K} < 0$ during later years. The estimate of $\beta_{KK}$ is found to be positive (see Table 1) which indicates the convexity of the estimated cost function with respect to the quasi-fixed capital input. In order to test for the concavity of the estimated cost function with respect to variable input prices its Hessian matrix is evaluated for negative semi-definiteness as per the procedure suggested in Diewert and Wales (1987) and it is found that concavity condition is fulfilled at all observations.

The rate of *CU* obtained for the industry is presented in Table 3. Analysis of the CU rates given in the table on a yearly basis provides us with three major observations. First, there is gross under-utilization of capacity in the Indian paper industry over the period 1973-74 to 1997-98. It is seen from the table that Indian paper industry has never been in a position to utilize its capacity fully. In fact, rate of CU has never exceeded unity, which is a theoretical possibility as per specifications of the study discussed in the previous section. The highest rate of CU that the industry could reach is 81.86 per cent in 1973-74. Average rate of CU in the industry over the period of study is found to be 75.45 per cent. An implication of $CU < 1$, which is a prominent feature of the Indian paper industry, is that the industry has operated under excess capacity environment over the period 1973-98.

TABLE 3: RATE OF CAPACITY UTILIZATION IN PAPER INDUSTRY: 1973-74 TO 1997-98

(in per cent)

| Year | $CU_C$ | $CU_T$ | Year | $CU_C$ | $CU_T$ |
|---|---|---|---|---|---|
| 1973-74 | 81.86 | 81.10 | 1986-87 | 75.34 | 62.93 |
| 1974-75 | 79.30 | 82.29 | 1987-88 | 74.91 | 65.01 |
| 1975-76 | 78.23 | 77.08 | 1988-89 | 73.78 | 63.38 |
| 1976-77 | 78.08 | 84.07 | 1989-90 | 78.38 | 64.27 |
| 1977-78 | 78.84 | 82.23 | 1990-91 | 76.68 | 66.57 |
| 1978-79 | 77.22 | 78.76 | 1991-92 | 71.19 | 65.40 |
| 1979-80 | 78.91 | 75.26 | 1992-93 | 71.41 | 64.66 |
| 1980-81 | 74.14 | 71.94 | 1993-94 | 72.53 | 60.74 |
| 1981-82 | 75.03 | 74.68 | 1994-95 | 70.53 | 66.14 |
| 1982-83 | 73.36 | 63.86 | 1995-96 | 73.63 | 67.74 |
| 1983-84 | 72.84 | 63.26 | 1996-97 | 73.38 | 71.63 |
| 1984-85 | 72.79 | 65.51 | 1997-98 | 76.94 | |
| 1985-86 | 77.02 | 64.35 | | | |

*Notes*: $CU_C$ pertains to the dual cost capacity utilization measure estimated in the study while $CU_T$ is traditional measure. $CU_T$ for the years 1973-87 are taken from Chandhok (1990) and for the years 1988-97 are from RBI (a). $CU_T$ for the year 1997-98 is not available from this source.

Second, capacity utilization in the industry has not remained at the same level over the period of study. It is seen from Table 3 that $CU_C$ has varied between 81.86 per cent in 1973-74 to 70.53 per cent in 1994-95. The variation in rate of CU becomes prominent if plotted against time (see Fig. 1).

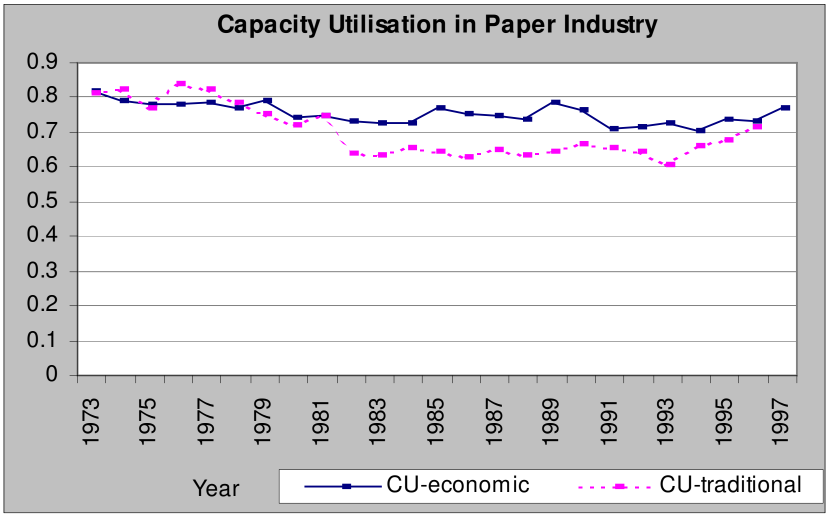


**Fig. 1**

Third, rate of capacity utilization in the industry has undergone a general decline over time. It is seen from Table 3 that $CU_C$ has declined from 81.86 per cent in 1973-74 to 76.94 per cent in 1997-98. However, decline in the rate of CU has not been at a uniform rate and the industry has witnessed fluctuations in CU over the period of study.

In Table 3 the traditional capacity utilization rate ($CU_T$) is presented along with $CU_C$. It is observed from the table that $CU_T$, like $CU_C$, exhibits a declining trend. Secondly, $CU_C$ returns a higher value than $CU_T$ except for 1974-75 and 1976-79. Earlier researchers also have reported higher values for $CU_C$ than $CU_T$ [see for example, Morrison and Berndt 1981; Nelson 1989]. Thirdly, there is a close relationship between both the CU measures as the correlation coefficient between $CU_T$ and $CU_C$ for the period 1973-74 to 1996-97 was found to be 0.71. In fact, turning points in the traditional CU measure are captured to a fair extent by the economic measure as can be observed from Fig. 1.

The inference on under-utilisation of capacity gets reinforced when we compare the level of equilibrium capital stock with the actual level. It may be recalled that the equilibrium level of capital stock is obtained by applying Hotelling's lemma to the long-run total cost function and solving it numerically. Three observations can be made on the basis of the ratio of equilibrium capital stock to its observed value, which are presented in Table 4. First, the estimated levels of the equilibrium capital have been less than the actual capital throughout the period of study. The equilibrium capital as a percentage of actual capital ranged from 50.72 per cent in 1974-75 to 33.13 per cent in 1992-93. Thus there is an under-utilisation of capital input, which supports our earlier observation of under-utilisation of capacity. Second, there is a discrepancy between the range of capacity utilisation and the utilisation of capital input. The CU ranged from 81.86 per cent in 1973-74 to 70.53 per cent in 1994-95 (see Table 3), which is higher than the range of equilibrium capital as a percentage of the actual capital. The discrepancy could be because of the fact that $CU_C \ (= C^*/C)$ is obtained by adding the variable costs to both the numerator and denominator in $P_K K^*/P_K K$. Thus $K^*/K$ will assume lower values than $C^*/C$. Third, the equilibrium capital as percentage of actual capital stock declined from 48.30 per cent in 1973-74 to 38.19 per cent in 1997-98.

TABLE 4

EQUILIBRIUM LEVEL OF CAPITAL IN INDIAN PAPER INDUSTRY

(as percentage of actual capital stock)

| Year | Equilibrium Capital stock | Year | Equilibrium Capital stock |
|---|---|---|---|
| 1973-74 | 48.30 | 1986-87 | 41.45 |
| 1974-75 | 50.72 | 1987-88 | 40.31 |
| 1975-76 | 48.78 | 1988-89 | 39.74 |
| 1976-77 | 49.46 | 1989-90 | 41.47 |
| 1977-78 | 49.89 | 1990-91 | 40.30 |
| 1978-79 | 44.41 | 1991-92 | 34.54 |
| 1979-80 | 47.95 | 1992-93 | 33.13 |
| 1980-81 | 42.75 | 1993-94 | 34.13 |
| 1981-82 | 43.36 | 1994-95 | 34.79 |
| 1982-83 | 39.60 | 1995-96 | 34.43 |
| 1983-84 | 40.95 | 1996-97 | 35.23 |
| 1984-85 | 40.99 | 1997-98 | 38.19 |
| 1985-86 | 41.92 | | |

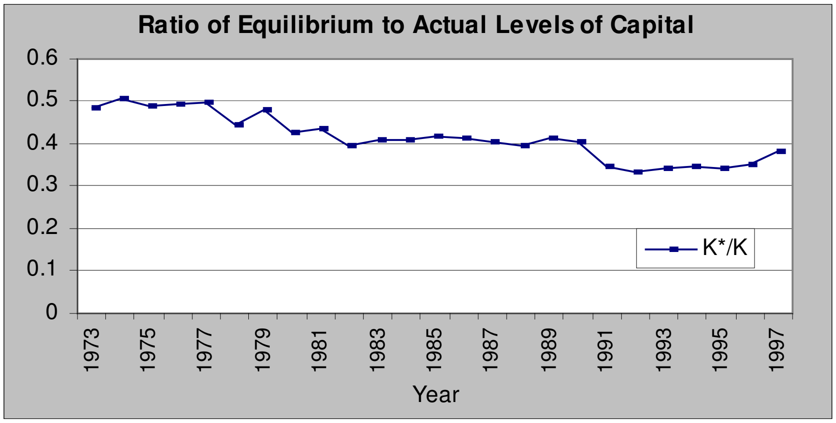


**Fig. 2**

An implication of $CU_C < 1$ that is obtained in the present case has several implications. First, there has been excess capacity in the industry throughout. Thus scarce resources are not being utilized optimally. Second, traditional TFP measure that we obtained through Divisia-Tornquist approximation is an under-estimate of true technical change. Third, shadow price of capital, which the industry perceives to be the real cost existing capital, is lower than prevailing market price at which the industry procures capital. Fourth, as CU is measured along the short-run average cost curve, a value of $CU_C < 1$ indicates that production in the paper industry takes place to the left of the minimum point of SRAC curve and induces the industry to reduce its capital stock through dis-investment in the long-run.

Growth rate in capital stock over the period of study has been 7.49 per cent per annum. Logically under-utilization of capacity should induce the industry to reduce capital stock. However, the industry has experienced negative net investment during 4 years, viz., 1985-86, 1989-90, 1995-96 and 1997-98. In these years the book value of fixed capital has declined over that of the previous year[11]. This assumes importance in view of the fact that there have been reports on closure of unviable units. Thus the industry could have found a route to dis-investment through closure of such units.

[11] The difference in book values of fixed capital for successive years is taken as a measure of net investment.

## 5. Summary and Conclusions

A correct measure of CU is important for an industry so as to examine the efficiency with which resources are utilized. The under-utilization of capacity, in a developing country such as India, tantamount to waste of scarce resources. Traditionally CU is seen through the engineering approach where it is measured as the maximum capacity a firm can produce given the accompanying inputs. A major lacuna in this approach is that it does not explain the variations in CU over time mainly due to the lack of any economic foundation. With the developments in duality theory and short-run variable cost function, the techniques of measurement of economic capacity and rate of CU have improved considerably in theory and in its application to empirical data.

On the basis of aggregate industry data of the Indian paper industry for the period 1973-74 to 1997-98 the study estimated a translog variable cost function. By considering capital input to be quasi-fixed in the sense that its level can be changed only in the long-run, the study finds considerable under-utilization of capacity in the industry. In fact, the industry could never reach the level of full utilization of capacity. The highest rate CU that the industry could be realized is 81.86 per cent in 1973-74, while average over the period under consideration is found to be 75.45 per cent. Rather, there has been a general decline in the rate of CU over time. The inference on underutilzation of capacity is reinforced when the level of equilibrium capital stock is compared with the actual capital stock. The under-utilzation of capacity in the Indian paper industry implies presence of excess capacity in the industry which tantamount to wastage of valuable resources.

Under-utilization capacity has a tendency to reduce the level of actual capital stock. However, rigidities in Indian industrial policy place certain restrictions on exit of firms. This could have prompted unviable plants to shut down operations.

The present study suffers from certain limitations, which should be taken into account while interpreting the results. It is a major limitation of the study that it assumes capital to be homogeneous in nature while it has distinct identifiable components. Aggregating these components at historical prices, deflating by a single index number and assuming all components to follow a uniform rate of depreciation and longevity may induce some amount of bias into the level of capital input. The labour variable used in the study, total persons engaged, is a concept of stock whereas its flow counterpart is man-hours used in the production process. However, the ASI does not provide data on man-hours. The deflator used for estimation of material input at constant prices also has certain limitations. The input-output table, which is used for the construction of material input deflator, is for both the registered and unregistered sector, even though the study covers the registered sector only. Moreover, the limitation that structural change is not allowed when a single input-output table is used is applicable to the present study as well. The output variable used in the study is at ex-factory prices, that is, exclusive of taxes while the WPI used as deflator of output is inclusive of taxes and subsidies.

## References


Ahuja, S. P. 1992, *Paper Industry in India*, Institute of Economic and Market Research, New Delhi.

Barik, K., 2003, *Paper Industry in India: Production Structure and Productivity Growth*, Abhijeet Publications, New Delhi.

Berndt, E. R. and M. A. Fuss, 1986, 'Productivity Measurement with Adjustments for Variations in Capacity Utilisation and other forms of Temporary Equilibrium', *Journal of Econometrics*, vol. 33, 7-29.

Berndt E. R. and D. M. Hesse, 1986, 'Measuring and Assessing Capacity Utilisation in the Manufacturing Sector', *European Economic Review*, vol. 30, 961-89.

Bharadwaj, R. N. 1994, *Some Economic Aspects of India's Iron and Steel Industry*, Ph. D. Thesis submitted to the University of Delhi.

Cassels, J. H., 1937, 'Excess Capacity and Monopolistic Competition', *Quarterly Journal of Economics*, vol. 51, pp. 426-43.

Christensen, L. R. and W. H. Greene, 1976, `Economies of Scale in U. S. Electric Power Generation', *Journal of Political Economy*, vol. 84, no. 1.

Diewert, W. E. and T. J. Wales, 1987, 'Flexible Functional Forms and Global Curvature Conditions', *Econometrica*, 55, 1, pp. 43-68.

Hashim, S. R. and M. M. Dadi, 1973, *Capital-Output Relations in Indian Manufacturing*, M. S. University, Baroda.

Hazilla, M. and R. J. Kopp, 1986, Testing For Separable Functional Structure using Temporal equilibrium Models, *Journal of Econometrics*, vol. 33, pp. 119-141.

Hotelling, H., 1932, 'Edgeworth's Taxation Paradox and the Nature of Demand and Supply Function', *Political Economy*, vol. 40, pp. 577-616.

Hulten, C R, 1986, Productivity Change, Capacity Utilisation and the Source of Efficiency Growth, Journal of Econometrics, vol. 33, Oct-Nov, 31-50.

Hulten, C. R. and S. Srinivasan, 1999, 'Indian Manufacturing Industry: Elephant or Tiger?', *NBER Working Paper* 7441, NBER.

Jha, R., M. N. Murty, S. Paul and B. B. Rao, 1993, An Analysis of Technological change, Factor Sustitution and Economies of Scale in Manufacturing Industries in India, *Applied Econometrics*, 25, 1337-1343.

Kim, M. and A. Sachis, 1986, 'The Structure of Production, Technological Change and Productivity in a Port', *Journal of Industrial Economics*, vol. XXXV, no. 2, pp. 209-23.

Klein, L. R., 1960, Some Theoretical Issues in the Measurement of Capacity, *Econometrica*, vol. 28, pp. 272-86.

Lau, L. J., 1978, 'Applications Profit Functions', in Fuss and McFadden (eds.), *Production Economics: A Dual Approach to Theory and Applications*, vol. 1, North-Holland.

Lee, L J and J K Kwon, 1994, Interpretaion and Measurement of Capacity Utilisation: The Case of Korean Manufacturing, *Applied Economics*, 26, 981-990

Morrison, C. J., 1986a, 'Productivity Measurement with Non-Static Expectations and Varying Capacity Utilization: An Integrated Approach, *Journal of Econometrics*, 33, 51-74.

Morrison, C. J., 1988a, 'Quasi-Fixed Inputs in U. S. and Japanese Manufacturing: A Generalized Leontief Restricted Cost Function Approach', *Review of Economics and Statistics*, vol. LXX, no. 2, pp. 275-87.

Morrison, C. J., 1988b, 'Subequilibrium in the North American Steel Industries: A Study of Short-run Biases from Regulation and Utilization Fluctuation, *Economic Journal*, June, pp. 390-411.

Morrison, C. J., 1988c, 'Capacity Utilization and Productivity Measurement: An Application to the U. S. Automobile Industry', in Dogramaci and Fare (eds.), *Applications of Modern Production Theory: Efficiency and Productivity*, Kluwer Academic Publishers.

Morrison C J and E R Berndt, 1981, Short-run Labour productivity in a Dynamic Model, *Journal of Econometrics*, vol. 16, pp. 339-365.

Nadiri, M. I. and S. Kim, 1996, *Production Structure and Productivity Growth: A Comparison of U. S., Japanese and Korean Manufacturing Sectors*, National Bureau of Economic Research (NBER) Working Paper 5506, National Bureau of Economic Research.

Nelson, R. A., 1989, 'On the Measurement of Capacity Utilisation, The Journal of Industrial Economics, vol. XXXVII, no. 3, pp.273-86.

Park, S. R. and J. K. Kwon, 1995, 'Rapid Economic Growth with Increasing Returns to Scale Little or No Productivity growth', *Review of Economics and Statistics*, Vol. LXXVII.

Pradhan, G. and K. Barik, 1999, 'Total Factor Productivity Growth in Developing Economies: A Study of Selected Industries in India ', *Economic and Political Weekly*, July 31, 1999, pp. M92-M97.

Ramaswamy, K. V., R. R. Vaidya, R. J. Bennis and J. G. M. Hoogeveen, 1996, 'Input Substitution in the Indian Paper Industry: a Variable Cost Function Approach', *CREED Working Paper No. 7*, International Institute of Environment and Development (ILED).

Reserve bank of India (RBI) (a), *Report on Currency and Finance, vol. I*, (various issues), Mumbai.

Srivastava, V., 2000, *Impact of Economic Reforms on Industrial Productivity, Efficiency and Competitiveness: A Panel Study of Indian Companies*, National Council of Applied Economic Research, New Delhi.

Shephard, R. W., 1953, *Cost and Production Functions*, Princeton University Press, Princeton.

Slade, M E, 1986, TFP Measurement when Equilibrium is Temporary, *Journal of Econometrics*, 33, 75-95.