CHAPTER XI
ECONOMIC EFFICIENCY: REVIEW OF LITERATURE

This chapter deals with the concept and criteria of economic efficiency and the actual indicators of economic efficiency adopted in the present study. Various methods that are used to measure these indicators have been discussed. Various studies that have made use of these methods have also been reviewed.

Economic efficiency in microeconomic theory is defined, with reference to the allocative efficiency, market efficiency and productive efficiency. Allocative efficiency refers to the allocation of factors of production in different uses and the optimum allocation of goods produced among the consumers, so that social welfare is maximised. If it is assumed that firms operate on an outer-bound production possibility surface consistent with their resources, a situation which Leibenstein (1966) describes as X-efficiency, then allocative efficiency of the resources in the economy is the centre of attention. Market efficiency measures the dexterity of the firm in manufacturing products demanded by the public and making them available at prices equal to the marginal social cost of these products. This efficiency is concerned with market structure, that is, degree of concentration, size and entry conditions in the market; the conduct

of market enterprises, that is, the policies, practices and devices employed to make adjustments in the market; and the efficiency outcome in terms of output, profits, prices, innovations etc. Productive efficiency refers to the internal efficiency of a firm in the use of various resources. It has two forms, technical efficiency and the factor price efficiency. If it is assumed that the inefficiency in production is the all pervasive feature, then attention is paid to evaluate the degree of economy in resource, inputs used to produce a given output and selecting the best combination of inputs having regard to their relative prices. However, there are many problems in estimating market efficiency, allocative efficiency and productive efficiency of an enterprise.2

Since there are many problems in the construction of direct indicators of economic efficiency, market models are used as indirect criteria for judging economic efficiency. A perfectly competitive model entails productive, allocative as well as market efficiencies and so provides a precondition for economic efficiency. But perfect competition does not necessarily lead to maximisation of social welfare. Two types of lacunae emerge when perfect competition is used as an indicator of economic efficiency: (i) the welfare optimum to

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which it gives rise ignores income distribution and externalities, (ii) its assumptions are too restrictive that do not apply in the real world.

The unrealizable nature of the perfect competition has led to the examination of the most desirable form of competition out of realisable ones, the one that will lead to highest level of economic efficiency. This form of competition is known as workable competition. It is held that this workable competition should form the basic yardstick for measuring economic efficiency, instead of perfect competition. It is, however, not possible for workable competition to yield a unique outcome. So, alternative indicators of economic efficiency that may not be ideal but operationally quite useful have been used in various studies. In the present study following measures have been used to evaluate the economic efficiency of public sector units in nitrogenous fertiliser industry:

1) Capacity utilisation
2) Productivity
3) Commercial Profitability
4) Structure of costs

II.1 Capacity Utilisation

The capacity utilisation is computed as the ratio

of actual production to capacity. There are different concepts and various methods of measuring capacity. The concepts of capacity can broadly be divided into two categories: (a) engineering concepts (b) economic concepts.

According to an engineering or technical concept, the capacity of a manufacturing unit is the maximum output that can be produced per unit of time under normal working conditions. Normal working conditions are specified in terms of number of shifts, hours of work etcetera. Engineering concepts are two in number: (i) plant concept which is defined as the maximum output that can be produced with the existing plant and equipment, under normal working conditions, assuming that there are no constraints on the availability of variable factors of production; (ii) synthetic capacity which is defined as the maximum output produced per unit of time under normal working conditions with existing plant and equipment, when constraints on the supply of variable factors are taken into account. This type of concept was used by Klein (1960). The plant concept has the property of 'aggregation consistency', implying that the capacity of a group of sectors be equal to the

sum of the sub-sector capacities. This property, however, is not present in the synthetic concept.

The economic or cost concept is defined as the output that can be produced at minimum average total cost when the physical plant, organisation of production and factor prices are given. This concept is not aggregation consistent except for the special case in which the minima of the average cost curves for all the enterprises in the industry are equal. A variant of the cost concept of capacity has been proposed by F. de Leeuw (1962). In his study the definition and techniques of measuring capacity have been reviewed and an alternative approach to the definition of capacity has been suggested. The capacity has been defined in terms difference between marginal cost and average cost specifically as the level of output at which short run marginal cost exceeds minimum short run average total cost by some "given percentage". Capacity in this case would be a point at which the cost of additional unit of output is well above the most efficient unit cost, and so a high rate of capacity utilisation shall represent appreciable upward price pressure and a high level of investment demand. The value of given percentage has been taken to be the same for all firms in aggregative measure.

and has been determined by the amount of excess that empirical evidence shows to be essential to exert an impact on the capital goods industries. This definition of capacity is an improvement over the cost concept but empirical determination is more difficult.

Some important techniques of estimating capacity have been outlined below. Various studies using these techniques have also been reviewed bringing out relative merits and limitations of these techniques.

II.1.1 **Direct engineering estimates**

The most commonly used measures of capacity are based on engineering ratings of installed capacity of individual items under normal operating conditions. For the industries which manufacture fairly homogenous products such as cement, steel, fertilisers, et cetera, direct engineering estimates of installed capacity are available at the firm level. While reporting these estimates, details about normal operating conditions, that is, the number of shifts, number of hours of work, et cetera, should be specified. When the figures at the firm level are added up for all the firms in the industry, estimate of capacity for the industry as a whole is obtained. These estimates do not take into account cost factors, and unless marginal cost rises quite steeply beyond the point of minimum average cost, these estimates may far exceed the capacity estimates based on the cost concept.
Koti (1976) used direct engineering estimates to estimate capacity, that is, maximum production possible with the available equipment during the year, assuming normal operative conditions. The study estimated rates of capacity utilisation for 234 capital and intermediate goods industries. Out of these, 34 industries showed full capacity utilisation and the average rate of capacity utilisation for remaining 200 industries was 21 per cent. In the case of textile machinery, other machinery, cables and wires and NPK mixtures, the rate of capacity utilisation was more than 60 per cent. Shortage of raw materials and lack of demand were found to be the most important causes for under-utilisation of capacity accounting for 30.5 per cent and 29.4 per cent of the total unutilised capacity respectively. Labour troubles were responsible for 15 per cent of excess capacity.

Koti (1968) used same methodology as in the first study and covered mineral, metallurgical, engineering, chemical processing and some other industries. The study brought out that many intermediate and capital goods industries utilised less than 50 per cent of their capacities in 1967-68. Metal products, non electrical machinery and


equipment, fertilisers, and food industries utilised less than 40 per cent of their capacities. On the whole industrial production during the year 1967-68 was not even half of the total production capacity. Excess capacity in the case of 42 per cent of industries was due to lack of demand and in the case of 21 per cent industries due to shortage of raw materials. In 4 per cent of industries excess capacity was due to both of these factors. In another 17 per cent of industries it was due to labour problems and shortage of power and finance.

A study by Gupta and Thavaraj (1975)\(^8\) has used direct engineering estimates in terms of rated and attainable capacities to measure capacity utilisation in nitrogenous fertiliser industry in India for the period 1968-69 to 1973-74. Costs have also been examined in relation to the level of capacity utilisation. Unit cost at full capacity has been calculated to determine the impact of underutilisation on profits. The study shows that utilisation of rated and attainable capacities varies from 20 per cent in certain plants in certain years to more than 100 per cent in other plants. Technical defects in installation, non-availability of materials of requisite quality, shortage

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of power, unscheduled breakdowns and disturbance in industrial peace contributed towards under-utilisation of capacity in different fertiliser units in India. This resulted in a significant increase in the cost of production and consequent reduction in profitability.

Sastry (1980) has used six measures. One of these measures estimates capacity in terms of maximum output per spindle/loom. This is a direct engineering estimate. Other five measures used in the study are Wharton index, RBI index of potential utilisation, measure based on two shifts, minimum capital-output ratio measure and NPC measure based on machine hours. All these measures have been used to find the extent of capacity utilisation in cotton mill industry for the period 1950-73. The capacity utilisation varied according to the measure employed. The range of variation ranged between 50 per cent and 90 per cent. Three of the measures namely, Wharton index, index of potential utilisation and maximum output per spindle/loom indicate high utilisation rates and also reveal close correspondence both in their levels and in their movement. In the case of remaining three measures the utilisation rates ranged between 50 per cent and 70 per cent. All the measures

except the one based on two shifts have shown a general
downtrend in capacity utilisation. Availability of raw
material was the most important factor determining capacity
utilisation. The demand factor was not very important in
determining capacity utilisation.

Kibria and Tisdell (1986)\textsuperscript{10} also used direct
engineering estimates in terms of following method to cal­
culate capacity utilisation:

\[ U = \left( \frac{K}{K'} \right) \times \left( \frac{T}{T' \times s \times t} \right) \]

where \( U \) is the index of capacity utilisation, \( K' \) is the
number of spindles installed and \( K \) the number of spindles
that operated throughout the year, \( T \) is the actual time of
operation, \( T' \) is the maximum time available for work per
shift of eight hours, that is, 2920 hours per year. \('s\)' is
the number of shifts worked and \('t\)' the ratio of maximum
attainable working time to total available hours which is
0.822 in the study. The period 1970-71 to 1974-75 has been
omitted from the operational ages of the mills as the period
is that of war for liberation. 1979-80 is the last year
covered by the study. It has been shown that the pattern of
utilisation is asymmetric (skewed to the left) though the

\textsuperscript{10} M.G. Kibria and C.A. Tisdell, "Life Patterns of Capacity
Utilisation by Manufacturing Firms in the LDC: A Study
of Jute Spinning in Bangladesh", \textit{Indian Economic Review},
approximate relationship appears to be unimodal. A quadratic function has been fitted to 17 oldest mills and the predicted values of initial capacity utilisation range from 42 per cent to 82 per cent in the case of light yarn and 37 per cent to 72 per cent in the case of heavy yarn. Breakages and downtime of machines due to unfamiliarity of managers with new equipment has been the cause of low utilisation in the first phase of life of machines. In the third phase low level of utilisation is because of breakage due to physical deterioration of machinery. Second phase is almost stationary. Fall in demand is not a significant cause of underutilisation.

In a study by Rao and Gupta (1987) capacity utilisation of NTC group of textile undertakings in India has been evaluated for the period 1981-82 to 1984-85 by using direct engineering estimates of capacity in terms of installed capacity. The level of capacity utilisation of 33 per cent of the NTC subsidiaries is over 75 per cent. In comparison, 38 per cent of consumer goods industries and 48 per cent of the public sector enterprises in India have achieved this level of capacity utilisation. Old and obsolete machinery, shortage of raw cotton and power supply, lack of demand, strained employer-employee relationship and multiplicity of products are the main causes for under-utilisation of capacity in NTC.

Reddy (1987)\textsuperscript{12} using direct engineering estimates for the determination of capacity, has estimated capacity utilisation yearwise, sectorwise and productwise for the period 1976 to 1985 in India. Longrun growth rates have also been estimated. It has been observed in the study that capacity utilisation for all industries put together increased gradually from 73 per cent in 1976 to 82 per cent in 1979. Subsequently it declined suddenly to 73 per cent in 1980. By 1985 it improved to 75 per cent. The linear growth rate of capacity utilisation was -2.5 per cent for the period as a whole. However, the growth rate was not significant. Among the different sectors phosphatic fertilisers registered maximum growth rate of 1.24 per cent. Lowest growth rate occurred in the case of paper and paper boards where it was -2.7 per cent, that is, capacity utilisation actually declined over the period. Among various products the maximum growth rate of 0.3 per cent occurred in the case of intermediate goods industries. Capital goods industries showed a decline of 1.5 per cent over the period. Among the policies for increasing utilisation promotion of shift work, elimination of shift differentials, promotion of labour amenities and incentives to managements for inducing them to work at night have been advocated.

Gupta (1989) also made use of direct engineering estimates in terms of installed capacity to measure capacity for calculating capacity utilisation. The objective of the study was to determine the relative performance of public and private sectors in fertiliser industry for the period 1969-70 to 1976-77. Four indicators, namely capacity utilisation, commercial profitability, productivity and structure of cost have been used for the purpose. Commercial profitability has been calculated by using six ratios with respect to capital stock and output. Productivity has been computed by using Kendrick's index of total factor productivity and also by using Cobb Douglas production function. Partial factor productivities of labour, capital and raw material have been calculated. Analysis of average total cost has been done. Rates of capacity utilisation have been computed and various factors responsible for low level of capacity utilisation in public sector have been identified. Private sector has been found to perform better than public sector in terms of all the indicators of performance.

These direct engineering estimates do not take into account cost factors, and unless marginal cost rises quite steeply beyond the point of minimum average cost, these estimates may far exceed the capacity estimates based on the cost concept. However, for empirical estimation of capacity utilisation these are the most suitable ones. That is why these are most commonly used.

II.1.2 The capital coefficient method

This method is based on the plant concept of capacity. Creamer (1961)\textsuperscript{14} described this method as follows. A year with lowest average capital output ratio is determined which normally turns out to be the year of peak output. Suppose \((K_o/Y_o)\) is the minimum capital-output ratio which is assumed to represent full capacity utilisation. Using time series on net capital stock \((K)\), capacity \((C)\) for any period \((t)\) between the peaks and after the last peak is calculated as follows:

\[
C_t = \frac{Y_t}{K_o} K_t
\]

where \(Y_o\) is the last peak output and \(K_o\) is the corresponding capital stock. Both capital and output are measured at constant prices. The capacity utilisation \((U_t)\) in period 't' is calculated as follows:

\[
U_t = \frac{Y_t}{C_t} = \frac{K_o}{Y_o} / \frac{K_t}{Y_t}
\]

Thus capacity utilisation is calculated by expressing capital coefficient for the base period as a ratio of that for the current period. Sastry (1980)\textsuperscript{15} made use of this measure to calculate capacity utilisation for period 1950-73.


\textsuperscript{15} D.U. Sastry, \textit{Op.Cit.}
II.1.3 **Trend-through-peaks method**

(a) **The Wharton index of capacity**

In this method the peaks are located from the time-series of output. The peak outputs are taken to be equal to capacity outputs for corresponding periods. The capacity outputs for the years between the peaks and after the last peak are determined by fitting a trend line through the peaks and by extrapolating it. The ratio of actual output to capacity output thus estimated from trend-through-peaks for any period gives the value of capacity utilisation.

There are some problems in using this method. Firstly, problems arise as regards the choice of the time series, that is, monthly or quarterly, identification of peaks and piece-wise linearisation. Secondly, the peaks which are identified may not truly reflect the capacity output of the industry. In an economy like India, which is characterised by supply constraints and other rigidities due to market interventions through controls and regulations, peaks which are identified may be lower than true peaks. Consequently the capacity gets under-estimated and utilisation over-estimated. Thirdly, it is assumed that capacity expansion takes place in a smooth and gradual manner which is not true. Fourthly,

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the straight line segments also imply a uniform rate of net investment between peaks for a given marginal capacity output ratio which goes against the standard acceleration principle.\textsuperscript{17} Lastly, there is also the problem of aggregation. When industries are aggregated, the peaks of one industry may not synchronise with the peaks of other industries.\textsuperscript{18} Not merely this, the levels and direction may also change in aggregation. Capacity expansion may as well take discrete jumps when observed at the individual firm level. But when it is aggregated over several firms it may look as though capacity expansion is smooth and continuous.\textsuperscript{19} Sastry (1980) used this method along with other five to measure capacity utilisation in cotton mill industry.

(b) The RBI index of potential utilisation

Divatia and Verma (1970)\textsuperscript{20} used a variant of the wharton school method to calculate the indices of potential production and potential utilisation ratios. Potential pro-

\begin{itemize}
\item \textsuperscript{18} J.R. Behram, "Cyclical Sectoral Capacity Utilisation in a Developing Economy", in Eckaus and Rosenstein Rodan (Ed.), Analysis of Development Problems: Studies of the Chilean Economy, North Holland, 1973.
\item \textsuperscript{19} D.U. Sastry, Op.Cit.
\item \textsuperscript{20} V.V. Divatia and Ravi Verma, "Index of Potential Production and Potential Utilisation Ratio for the Manufacturing Industries in India", Reserve Bank of India Bulletin, April, 1970, pp. 574-586.
\end{itemize}
duction for any given industry for any given year is defined as the peak monthly level of production index ever reached during or prior to the year under consideration (but since the beginning of 1960). The data have been taken from Index Number of Industrial Production (INIP) with 1960 as base. The definition implicitly assumes that potential of an industry once built up does not decline in a subsequent period. This is an unrealistic assumption in regard to industries and years for which net investment is negative. The Index of Potential Production for any given year, for any given industry is defined as the percentage ratio of potential production for the year to potential production for 1960. The Potential Utilisation Ratio for an industry is defined as the percentage ratio of the average monthly production index (INIP) to the potential production of an industry for the year under consideration. For highly seasonal industries, namely, tea, salt and sugar, potential production is defined in terms of yearly peaks, rather than monthly peaks. Potential utilisation ratio for these industries is the percentage ratio of annual production to potential production for the year.

The study presents the indices of potential production and ratios of potential utilisation for the 72 individual industries as well as for groups of industries for the period 1960-68. Industries have been grouped under two categories:
(i) input-based groups and (ii) use based groups. The use-based groups of industries include basic industries, capital goods industries, intermediate goods industries and consumer goods industries. The input-based groups include agro-based industries, metal-based industries and chemical-based industries. The potential utilisation ratio for all manufacturing industries was 87.7 per cent in 1960. It decreased to 80.2 per cent in 1963. All the different groups of industries also showed decline in potential utilisation ratio over the period. Index of potential production increased over the years. Maximum increase was shown by capital goods industries.

The estimates of capacity and capacity utilisation derived by the procedure of trend through peaks method correspond to the technical concept of capacity. Since factors of production other than capital may restrict actual output, the method implies a synthetic variant of technical capacity concept.

II.1.4 The production function method

Klein and Preston (1967) used Cobb-Douglas production function to estimate capacity and its utilisation for a sample of 11 of the 30 industries which make up the Wharton index for period 1948 to 1960. The actual output and capacity

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output have been defined as follows

\[ X_t = A e^{kt} L_{et} K_{ut} \nabla_t \]  

(1)

\[ X_{ct} = A e^{kt} L_{t} K_{t} \]  

(2)

where \( X_t \) and \( X_{ct} \) are actual output and full capacity real output respectively at time \( t \), \( L_{et} \) is man hours employed at time \( t \), \( L_t \) is the available man hours at time \( t \), \( K_{ut} \) is real capital utilised at time \( t \), \( K_t \) is fully utilised real capital at time \( t \), \( \nabla_t \) is disturbance term at time \( t \) and \( e^{kt} \) is a proxy for technical change. The parameters in function (1) have been replaced by their estimates in function (2). The disturbance log \( \nabla_t \) has been given its expected value zero in (2). The data on labour available to a particular industry and the rate of capital utilisation was not available for the study. Therefore, figures for total labour 'belonging' to each industry were arrived at by interpolation between observations for peak years, assuming that available labour was fully employed in these years. Then the employment rate was computed from the figures on labour 'belonging' to the industry and labour employed in the industry. The same rate was applied to capital stock in existence to yield the capital stock in use in the given year. Then utilising the data on output, labour employed and the capital stock in use, capacity series were constructed by using function (2).
The assumption of equal rates of unemployment of owned capital and hired labour is unreasonable. Therefore, the model does not form a good theoretical basis for studies in the field of capacity measurement.

Desai (1976)\(^\text{22}\) has also used functional approach to estimate technological capacity and applied that to Indian Steel Industry. Capacity here means potential output of capital equipment, whereas Klein and Preston (1967) have taken it to mean the capacity of all factors together.\(^\text{23}\) It has been assumed in the study that output is homogenous. The annual output of a blast furnace for pig iron has been defined as follows:

\[ Y_p = W \cdot D \cdot M \cdot C \]

where \( Y_p \) is the output of pig iron in a year, \( W \) is the working volume of the blast furnace, \( D \) is the number of days in operation, \( M \) is the output of hot metal per tonne of coke, and \( C \) is the coke burning rate per day per cubic metre. Lack of direct estimates of \( C \) and \( D \) led to the use of \( C' \) and \( D' \) in place of \( C \) and \( D \). That is, instead of number of days worked by each furnace, average number of furnaces working in each


plant in a given year (D') has been used, and instead of being calculated for the whole day, the coke burning rate has been calculated in terms of the hours the furnace is in blast (C'). A residual parameter h has been used to account for discrepancies introduced by these vagaries of measurement. Thus

\[ Y_p = h \cdot W \cdot D' \cdot M \cdot C' \]

Since W is invariant, the capacity utilisation has been expressed as a product of four ratios, each representing the actual values of the remaining four variables divided by their maximum attainable value, that is,

\[ \frac{Y_p}{Y_p \text{ max.}} = \frac{h}{h \text{ max.}} \cdot \frac{D'}{D' \text{ max.}} \cdot \frac{M}{M \text{ max.}} \cdot \frac{C'}{C' \text{ max.}} \]

In the case of steel the ingot output of an open-hearth furnace has been expressed as follows:

\[ Y_s = A \cdot K \cdot X \]

where \( Y_s \) is the average daily ingot output of the furnace, A is the proportion of the time that the furnace has been in operation or the availability ratio, K is the output per heat and X is the number of heats in a day. However, in the final form average heat time has been used instead of X. That is,

\[ Y_s = \frac{24 \cdot A \cdot K}{H} \]

where H is the average heat time.
Therefore capacity utilisation for steel has been measured as

\[
\frac{Y_s}{Y_{s_{\text{max}}}} = \frac{A}{A_{\text{max}}} \cdot \frac{K}{K_{\text{max}}} / H_{\text{min}}
\]

The methodology has been used to estimate technological capacity for four major Indian steel plants at Bhilai, Rourkela, Durgapur and Jamshedpur for the period 1963-64 to 1969-70. The study has shown that adoption of local best practice could have increased the rated capacity by 7 per cent for both pig iron and steel. National best practice, if adopted, could have increased the rated capacity by 37 per cent for pig iron and 34 per cent for steel. Although adoption of national best practice would have required additional investment in ancillary equipment, but since it would not have required any additional investment in furnaces or infrastructure, it would have created capacity at much lower capital costs than new steel making facilities.

Harris and Taylor (1985) have used cobb-Douglas and C.E.S. production functions to estimate capacity and capacity utilisation for the period 1956 to 1982 for four UK industries. These estimates have been compared with the estimates produced by wharton method and capital-output-ratio method. In this study the labour supply available to an industry has been

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estimated by fitting linear segments to the peaks in the man-hour worked series. This approach is based on the past experience of the industry. The capital inputs available to an industry have been estimated by adjusting the capital stock for the trend increase in its utilisation rate, which resulted from the increasing use of shift working. The study has shown that wharton and capital-output ratio methods produce unreliable estimates of capacity utilisation.

II. 1. 5 Shift-approach

In a study by NCAER (1966) the degree of under-utilisation has been calculated on the basis of actual and desirable number of shifts in 140 industries for the period 1955 to 1964. Double shift was found desirable for 102 industries for which actual number of shift was one, and triple shift for 38 industries, actual number of shifts for 32 industries out of 38 was three and for 6 industries it was two. The study shows that degree of under-utilisation is considerably under-estimated when calculated on actual number of shifts rather than the desirable number of shifts. The reasons given by the respondents for not working their units for more than two shifts include (i) foreign exchange difficulties, (ii) inferior quality of indigenous raw materials, (iii) shortage of skilled labour, (iv) increase in labour costs.

Solocum (1970) has calculated rates of under-utilisation for 382 industries by using the Monthly Statistics of Production (MSP). Two measures have been used to estimate rates of under-utilisation. The first measure is based on the number of shifts shown in the MSP, and the second one is based on one-extra-shift pattern. The cost of under-utilisation of capacity has also been estimated for the manufacturing sector as a whole for the period 1946 to 1964. The value of potential output, corresponding to full utilisation of capacity, has been estimated as the ratio of value of actual output as in the census of Manufacturing Industries (CMI) to the rate of utilisation calculated from the MSP. The difference between the value of potential output and the value of actual output has represented the loss of output due to under utilisation of capacity. This has been interpreted as the cost of under-utilisation. This cost varied between 2.5 per cent and 12 per cent of the total cost during the period. Seven industries, namely, Vanaspati, industrial gases, paints and varnishes, steel pipes and tubes, textile machinery, refrigerators, and railway wagons, have been studied in depth. Inadequacy of demand, shortage of raw materials and labour unrest were the most important causes of under utilisation of capacity in all the industries.

Samuel Paul (1974) also used shift approach to estimate the extent of capacity utilisation in Indian Industries using MSP data. The installed capacity has been re-computed assuming 2.5 shifts for industries reported to have been working on a two shift basis in MSP and two shifts for industries reported to have been working on one shift basis in MSP. In the study industrial capacity has been estimated for the period 1960 to 1970 and capacity utilisation for the period 1961 to 1971. The industries, in both the cases, have been divided into three categories, namely, consumer goods industries, intermediate goods industries and capital goods industries. The analysis has shown that during the period 1960-70, industrial capacity increased at the annual rate of 5.7 per cent. The growth was maximum in capital goods and intermediate goods industries as investment was stepped up in these industries through planning. Consumer goods industries showed steady growth during the period. The rate of growth of industrial capacity declined from 6.1 per cent in 1960-64 to 4.6 per cent in 1967-70. The rate of utilisation estimated on the basis of the MSP definition was 80 per cent. After making adjustment for multiple shifts the average utilisation rate turned out to be 53 per cent for the period 1961-71. The level of utilisation remained stagnant throughout the period under study. It was 54 per cent during 1961-65, 52 per cent during

1966-68 and 54 per cent again during 1969-71. In the case of consumer goods industries, utilisation improved from 46 per cent in 1961-65 to 49 per cent in 1966-68 and to 53 per cent in 1969-71. For capital goods industries it deteriorated from 58 per cent in the first period to 42-43 per cent in second and third periods. The levels of utilisation for intermediate goods industries were 64 per cent for first period and 61 per cent for second and third periods. The study has also examined the influence of industry characteristics and governmental policy on the pattern of capacity utilisation. In a similar study Winston (1971) has assumed 2.5 shifts for all the industries.

II.1.6 Cost-approach

Hickman (1964) has estimated capacity in terms of cost concept from econometric investment function. The method does not require the estimation of a production or cost function. It has been postulated that desired capital stock in period \( t \) (\( K_t \)) is a function of the expected long-run level of output (\( X_t \)) factor price ratio (\( P_t \)) and a time trend \( T \). The relationship linear in logarithms is

\[
\log K_t = a_1 + a_2 \log X_t + a_3 \log P_t + a_4 T \quad (1)
\]


The capacity output at which total cost is least depends on the size of the capital stock, the level of technology represented by $T$, and factor prices. The equation (1) determines the size of the capital stock which would enable the output to be produced at minimum cost given the factor prices and technology. The same equation, therefore, has been taken to specify the capacity output $X^c_t$ which would be produced with the existing capital stock $K_{t-1}$, if labour input were adjusted to yield the least-cost combination with existing capital, given the level of technology and factor prices. Thus capacity figures have been calculated from the equation

$$\log X^c_t = (\log K_{t-1} - a_1 - a_3 \log P_t - a_4 T)/a_2$$

Numerical values of $a_1$, $a_2$, $a_3$ and $a_4$ have been derived from the estimates of investment regression equations of the following type:

$$\log(K_t/K_{t-1}) = b a_1 + ba_2 \log X_t + ba_3 \log P_t + ba_4 T - b \log K_{t-1}$$

where $b$ measures the speed of adjustment of actual capital stock to the desired level. Long-term output ($X_t$) (price $P_t$) has been taken as a weighted average of current and recent outputs (prices).

**II.1.7 Non-parametric approach**

Fare et al (1989)\(^{30}\) have made use of non-parametric

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approach to estimate plant capacity, its utilisation and technical change. The measures have been based on observed best practice performance in a given industry and have been calculated as solutions to linear programming problems which are closely related to those used to calculate Farrell-type efficiency measures. An example using electric utility data has been employed to test the measures empirically.

II.2 Productivity

The concept of productivity is based on the assumption of a technological relationship between output and inputs, both measured in physical terms. The word productivity may refer to partial or total factor productivity, depending upon whether output is considered in relation to a single factor or to all the factors of production. When output is considered in relation to labour, capital or raw material singly, partial productivity of that factor is obtained. When output is considered in relation to all the factors of production taken together, total factor productivity is obtained. An increase in total factor productivity in the short run may be the result of increase in the rates of capacity utilisation. In the long run, it reflects changes in technology and organisation of production such as better machines per worker, more economical use of materials, improved organisation and labour relations and so on. There are a number of methods to measure total
factor productivity. These methods and various studies that have made use of these methods have been discussed in this section.

II.2.1 Tinbergen's method

The concept of total factor productivity defined as the ratio between real product or output and real factor input (a weighted sum of different inputs) was introduced by Tinbergen (1942)\(^{31}\), when he attempted an international comparison of productivity growth. The method is based on unrestricted Cobb-Douglas production function of following type

\[
Y = A(t) L^i K^j \quad \text{where } i + j \leq 1
\]

This allows for the possibility of non-constant returns to scale. Total factor productivity has been assumed to increase at a constant rate, that is,

\[
A(t) = A_0 e^{kt}
\]

therefore,

\[
Y = A_0 e^{kt} L^i K^j
\]

or

\[
\log Y = \log A_0 + i \log L + j \log K + kt
\]

where logarithms are natural. The parameters \(i, j\) and \(k\) can be estimated by regressing \(\log Y\) on \(\log L, \log k\) and \(t\). The coefficient of \(t\) is the estimated rate of growth of total factor productivity, net of effects of scale economies which

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are estimated by \((i + j - 1)\). Thus this method attempts to disentangle the effect of scale economies on output from that of change in total factor productivity and does not require the assumption of competitive equilibrium.

II.2.2 Kendrick's method

Kendrick (1961)\(^3\) developed an index based on the arithmetic combination of factor inputs to measure total factor productivity. The index of total factor productivity \(A_t\) is measured as follows:

\[
A_t = \frac{Y_t}{(W_0L_t + i_0K_t)}
\]

where \(Y_t\) is measure of output in constant prices in period \(t\), \(L_t\) is measure of labour input in physical units in period \(t\), \(K_t\) is measure of capital input in constant prices in period \(t\), \(W_0\) is wage rate in the base period and \(i_0\) is rental per unit of capital input in the base period.

This index has been derived from a production function linear in labour and capital. It assumes constant returns to scale, neutral technical progress, an infinite elasticity of substitution between labour and capital, and perfect competition in product and factor markets.

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Dholkia (1978)\textsuperscript{33} used this index to measure total factor productivity in public and private manufacturing enterprises for the period 1960-61 to 1975-76. The study has shown that performance of public sector was better than that of private sector in terms of growth of total factor productivity. The rate of growth of productivity was 4.3 per cent per annum for the public sector and 0.18 per cent per annum for the private sector. This implies that during the period public sector utilised the resource inputs with the most rapidly increasing efficiency.

Gupta (1982)\textsuperscript{34} also made use of this index to evaluate the performance of public and private sectors in the fertiliser industry for the period 1969-70 to 1976-78. Partial productivities of labour, capital and raw material have also been computed. It has been shown that during the period, total factor productivity and the productivities of labour and capital declined in both public and private sectors when all the units were considered. The average annual rate of decline was higher for private sector. Total factor productivity and

\begin{thebibliography}{99}
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productivity of labour in public sector showed an increase when performance of very old and obsolete units and new units facing teething troubles was excluded. In the case of raw material productivity, public sector depicted a much better performance as compared to private sector. Cross-sectional analysis of productivities showed relatively better performance of private sector as compared to public sector. Major factors responsible for relatively poorer performance of public sector were found to be the differences in the nature of feedstocks, technology and old age of the units in public sector.

II.2.3 Solow's method

Solow (1957) has assumed homogenous production function of degree one— which takes the following form

$$Q = A(t) f (K,L)$$

where $A(t)$ measures the cumulated effect of shifts over time. The total factor productivity index derived from this function is of the following form

$$\frac{\dot{A}}{A} = \dot{f} - (1 \frac{\dot{K}}{K} + J \frac{\dot{L}}{L}) \text{ where } 1 + J = 1$$

where $\frac{\dot{A}}{A}$ is rate of growth of total factor productivity.

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\( \frac{Y}{Y} \) is rate of growth of output, \( \frac{K}{K} \) is rate of growth of capital, \( \frac{L}{L} \) is rate of growth of labour, and \( i, j \) are respectively, shares of capital and labour in output in the current period. Thus, the rate of growth of total factor productivity is the difference between the rate of growth of output and a weighted sum of rates of growth of labour and capital.

Hashim and Dadi (1973)\(^{36} \) made use of this index to calculate change in total factor productivity for manufacturing industries for a period 1946-64. The growth in total factor productivity was found to be 2.8 per cent per annum and the contribution of total factor productivity growth in the value added was found to be 50 per cent.

Banerji (1975)\(^{37} \) also made use of this index to compute change in total factor productivity for manufacturing industries and five important selected industries over the period 1948-64. He found that productivity for registered manufacturing industries declined at the rate of 1.6 per cent per annum over the period.

The findings of these two studies are at variance with each other. Goldar (1986)\(^{38} \) compared the two studies and

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concluded that the differences in the estimates of change in total factor productivity could be traced to the differences in the capital series and the underlying assumptions.

Dabir-Alai (1987)\(^{39}\) has used Kendrick's index as well as Solow's index to calculate total factor productivity for 18 large scale manufacturing industries of India for the period 1973-74 to 1978-79. Partial productivities of labour and capital have also been calculated. Labour productivity showed an upward trend in all the 18 industries and capital productivity in 13 industries when terminal years 1973-74 and 1978-79 were compared. Year to year comparison, however, did not show a consistent upward or downward trend. Analysis of total factor productivity in terms of both the indices revealed that despite wide fluctuations in annual rates of total factor productivity growth for all the sectors, the unweighted annual average rates of growth were almost all positive.

II.2.4 Index based on cobb-douglas function\(^{40}\)

The Cobb-Douglas production function \(Y = A L^i K^j\), \(i + j = 1\), assumes perfect competition in the product and factor markets and elasticity of substitution between labour and capital is assumed to be unity. The rate of growth of

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total factor productivity derived from this production function is

\[
\frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \left( \frac{\dot{L}}{L} + \frac{\dot{K}}{K} \right)
\]

where \( i \) and \( j \) are shares of labour and capital respectively in the value of output. \( i \) and \( j \) are constant in this index but not in Solow's index. Therefore, the operational difference between this index and Solow's index is that former uses constant weights while latter uses shifting weights.

II.2.5 **Index based on the CES function**

The CES production function is given by

\[
Y = A \left[ aL^k + (1-a) K^k \right]^{-1/k}.
\]

where \( Y, L, K \) refer to output, labour and capital and \( A, a \) and \( k \) are efficiency, distribution and substitution parameters respectively. The elasticity of substitution given by

\[
\frac{1}{1+a+k}
\]

can take any constant value from zero to infinity. The total factor productivity can be estimated as follows:

\[
A = \frac{Y}{\left[ aL^k + (1-a) K^k \right]^{-1/k}}
\]

II.2.6 **Divisia index**

The rate of growth of total factor productivity in terms of this index is defined as the difference between the

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41. Ibid.
rate of growth of real product and rate of growth of real factor input. The rates of growth of real product and real factor input are, in turn, defined as weighted averages of the rates of growth of individual products and factors. The weights being the relative factor shares of each product in the value of total output and of each factor in the value of total input. If a production function has constant returns to scale and marginal rates of substitution are equal to the corresponding price ratios, then shift in production function shows a change in total factor productivity. Jorgenson and Grilliches (1967) have defined rate of growth of total factor productivity as

$$\frac{\dot{P}}{\dot{P}} = \frac{\dot{Y}}{Y} - \frac{\dot{X}}{X} = \sum \omega_i \frac{\dot{Y}_i}{Y_i} - \sum \nu_j \frac{\dot{X}_j}{X_j}$$

$$\sum \omega_i = \sum \nu_j = 1, \quad \omega_i > 0, \quad \nu_j > 0$$

where $\dot{P}/P, \dot{Y}/Y, \dot{X}/X$ are Divisia rates of growth of productivity, output index and input index respectively. $\omega_i$ and $\nu_j$ are relative shares of the value of the $i$th output in the value of total output and the value of $j$th input in the value of total input. The main purpose of the study is to examine the hypothesis that if the quantities of outputs and inputs are measured accurately, growth in total output may be largely explained by growth in total input. The analysis relates to U.S. private

domestic economy for the period 1945-65. The first step in in the study has been to eliminate errors arising out of aggregation etc. The rate of growth of inputs initially explained 52.4 per cent rate of growth of output. After elimination of errors and correction for changes in rates of utilisation of labour and capital stock, the rate of growth of inputs explained 96.7 per cent rate of growth of output and rest was explained by change in total factor productivity.

Rajalaxami (1982)\(^4\) has used Divisia index to estimate the total factor productivity of a petro-chemical firm for the period 1974-75 to 1979-80. It has been found that there was a steep fall in productivity during 1976-77, but the enterprises gradually recovered from 1977-78 onwards.

II.2.7 Exact index number approach

This approach consists in assuming a certain functional form, preferably a 'flexible' one, for the producers production function and then deriving an index number formula that is consistent (exact) with the assumed functional form. Trans log functional form has been used. Since it is flexible, that is, elasticity of substitution between factors varies between zero and infinity, index number derived from this

function takes the following form if labour and capital are factors of production.

\[ A_{t+1} = \log \frac{Y_{t+1}}{Y_t} - \frac{1}{2} \left[ s_{t+1}^t + s_t^t \right] \log \frac{L_{t+1}}{L_t} \]

\[ - \frac{1}{2} \left[ s_{K_{t+1}}^t + s_K^t \right] \log \frac{K_{t+1}}{K_t} \]

where \( A_{t+1} \) is the growth in total factor productivity in \((t+1)\)th period over \(t\)th period, \(Y_t\), \(L_t\) and \(K_t\) are output, labour in physical units and real capital respectively in period \(t\). \(S_L^t\) and \(S_K^t\) are shares of labour and capital respectively in the value of output at current prices. Trans-log function is homogenous of degree one.

Lau (1979) has examined conditions of exactness for three index number formulae namely, the Tomqvist (1936), the Sato (1976) - Vartia (1974) and the Fisher ideal index number (1922) formulae. It has been proved that a once continuously differentiable and homogenous function of degree one, \(Q(q)\) is exactly indexed by the Tomqvist index number formula if and only if it is a member of the class of homogenous of degree one transcendental logarithmic functions, that is,

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A once continuously differentiable and homogeneous of degree one function of two variables $Q(q)$ is exactly indexed by the Sato-Vartia index number formulae if and only if it is a member of the class of homogeneous of degree one constant-elasticity of substitution functions.

A once continuously differentiable and homogeneous of degree one function is exactly indexed by the Fisher ideal index number formulae if and only if it can be written in the form

$$F(x) = \left( \frac{x' B x}{2} \right)^{\frac{1}{2}}$$

where $B$ is a constant matrix.

Ahluwalia (1985) has worked out the Solow and Translog measures of total factor productivity change at different levels of industrial aggregation for the period 1959–80 and for two sub periods 1959–65 and 1966–80. The study presents four alternative estimates of total factor productivity change for total industry, manufacturing and for the use-based and input-based classifications of industries. Of these, one relates to the Solow measure and three to the Translog measure. The three Translog measures differ among

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themselves slightly in regard to the capital stock series used. Solow's estimate showed a decline of 0.6 per cent per annum for aggregate manufacturing for the period 1959-80. Among various industry groups, the growth rate in total factor productivity ranged between -6.7 per cent per annum for Rubber Products and 3 per cent per annum for footwear. Translog estimates of total factor productivity for 1959-80 show that for aggregate manufacturing these estimates ranged between -0.2 per cent (Translog) and 0.3 per cent (Translog B), and for total industry range between -0.3 per cent (Translog) and 0.6 per cent (Translog B).

Goldar (1986)\(^{46}\) computed total factor productivity indices by using a number of methods for the periods 1951-65 and 1959-79. The former period has covered the industries in the Census of Manufacturing Industries and the latter period has covered the industries in the Annual Survey of Industries. The average annual rate of growth of total factor productivity during 1951-65 was 1.13 per cent in terms of Solow's index, 1.27 per cent in terms of Translog index and 2.4 per cent in terms of Tinbergen's measure. The average annual rate of growth of total factor productivity during 1959-79 was estimated to be 1.29 per cent in terms of Solow's method and 1.31 per cent in terms of Translog method. Inter-industry differences in total factor productivity have also been made by using Kendrick's index for the period 1960-70 for 37 indu-

tries from ASI data. The growth in productivity varied between -11 per cent per annum in Cocoa, chocolate and Sugar confectionary and 3.9 per cent in Cement industry. Explanation of these inter-industry differences has been attempted through regression analysis by using output (value added), unionization ratio, concentration ratio, capacity utilisation, effective rate of protection and a dummy variable as explanatory variables. The dummy variable takes value unity for new industries and zero for old ones.

Vashist and Kundu (1990) have used Exact Index Number approach to examine the relative performance of public and private enterprises in the organised manufacturing sector for the period 1960-61 to 1984-85. Partial factor productivities of labour and capital have also been examined for both the sectors. The average annual rate of growth of total factor productivity was 1.7 per cent for the period 1960-85 in the private sector. The public sector did not exhibit any growth over the period. In terms of other indicator too public enterprises were found to be less efficient as compared to their private counterparts.

II.3 Profitability and Cost

Commercial profitability measures the difference between revenue and cost in relation to capital employed, out-

Various studies undertaken on profitability and cost have been discussed in this section.

Bhalla and Mehta (1970) have evaluated the financial performance of 33 public sector companies and 9 comparable private sector companies in terms of 'gross and net rates of return on capital employed over the period 1962-68. The gross rate of return on capital of all the public enterprises increased from 6.4 per cent in 1962-63 to 10 per cent in 1967-68. However, the gross return for private enterprises was 25 per cent in 1967-68. The reasons for low rates of return in public sector were identified to be that these enterprises started in unexplored fields, were burdened with non-revenue earning assets like townships and other social capital, and huge amounts were locked in capital works in progress which tended to reduce their rates of return.

Gupta (1977) studied the profitability of all the running concerns of Government of India for the period 1965-66 to 1973-74. Accounting ratios namely, gross profit as percentage of sales and capital employed, net profit as percentage of paid-up capital and net worth have been used to measure profit-


ability. Returns were found to be low and in many cases huge losses were incurred. Delays in construction and increase in construction costs resulted in over-capitalisation. Poor management, lack of coordination, lack of autonomy to undertakings, construction without assessment of demands and wasteful purchases led to poor performance. Most important causes for poor performance were, however, under-utilisation of capacity, high cost of production, low labour productivity, poor industrial relations and high costs of high level of inventory.

Bureau of Public Enterprises (1985) studied the profitability, capacity utilisation and investment cost per tonne of capacity for ten fertiliser plants for three years 1981-82, 1982-83 and 1983-84. Ratio of gross profits to gross capital employed and ratio of profits before tax to net worth have been used to measure profitability. Madras Fertilisers Limited and IFFCO (Kalol) exhibited highest ratio of gross profits to gross capital employed for first two years and all the three years respectively. Investment cost was found to be minimum for MFL (Madras) with Rs. 4034 per tonne of nitrogen and maximum for FCI-Sindri (Modernisation) with Rs. 11139 per tonne of nitrogen.

The major defect of the studies on profitability and costs is that the profitability has been calculated at historical cost. Fixed assets and costs have not been deflated with appropriate index numbers.

II.4 Studies Dealing with Fertiliser Industry

There are not many studies dealing exclusively with fertiliser industry. These studies deal with technology 

An important study is by Disney (1979). The study has analysed the relative costs of small coal-using plants and the larger modern natural gas or oil using complexes. He has concluded that in the case of large scale plants, total costs fell continuously over the range 110 to 200 thousand tonnes.

51. References of the studies on fertiliser industry are given in bibliography.

per annum of ammonia, even when transport costs were included. For the small-scale plants, the effect of transport costs outweighed the economies of scale and total costs rose as scale increased from 3 to 6 thousand tonnes per annum. Overall average costs were much lower for the large scale plants than the small scale plants.

Jain and Nand (1980)\(^5\) have analysed the productivity of Indian fertiliser industry by categorising the plants according to age, size, feedstock, process adopted, and product mix for period 1974-75 to 1978-79. By productivity it is not meant the partial or total factor productivity, rather, capacity utilisation.

Swaminathan and Jain (1985)\(^4\) have analysed the causes of downtime, i.e. under utilisation of capacity of ammonia and urea plants in India. In all 25 plants have been analysed for the period 1980-81 to 1983-84. Maximum downtime in ammonia and urea plants in the period was caused by mechanical breakdown.

Methodologically these studies based on fertiliser industry are not of much importance to the present study as most of these studies do not deal with economic efficiency.


These studies, however, provide valuable insight into the industry.

To sum up, there are a number of methods to measure economic efficiency in terms of capacity utilisation, productivity, profitability and cost; and there is enormous literature dealing with each one of these indicators of economic efficiency. The details of the methods adopted in the present study have been given in the chapters dealing with each of these indicators.