

**CONCEPT AND MEASUREMENT
OF CAPACITY: A REVIEW**

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L. G. BURANGE

**CONCEPT AND MEASUREMENT
OF CAPACITY : A REVIEW**

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L. G. BURANGE

**GOKHALE INSTITUTE OF POLITICS AND ECONOMICS
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INTRODUCTION

The existence of unutilised capacity results in wastage of scarce capital resources adversely affecting economic growth. The problem of capacity utilization has received some theoretical attention with the work of Chamberlin on the theory of monopolistic competition. Apart from this, this has been with the planners as an important problem. During the formulation of the Second Five Year Plan C. N. Vakil has focussed attention on this problem. Even earlier, in 1949 the Commercial Intelligence unit of Government of India started collecting figures on installed capacity for some Selected Industries. The approach document to Seventh Plan (Planning Commission, 1984) stresses that "The Seventh Plan has to lay emphasis on improved utilization of capacity by pinpointing the factors responsible for the existence of idle capacities. Continued, regular and intensive monitoring of all major public sector enterprises and especially of capacity utilization, should be used effectively for this purpose." Thus the capacity utilization is an important problem which affects many economic variables such as investment, prices, productivity, employment and income.

Capacity is usually understood as the maximum possible output with the available resources under normal conditions. But when it comes to measurement of capacity a large number of problems arise. Does maximum output refer to technical maximum

or whether costs are also to be considered? Does capital utilization mean capacity utilization? What resources are to be considered as variables and what are to be considered as given? How are normal conditions to be defined. The definition of capacity is thus beset with a number of problems. The object of the present study is to understand how different researchers have approached the problem of the concept of capacity and its measurement and to review the capacity estimates relating to the Indian manufacturing sector.

In Chapter I different approaches to the concept of capacity have been examined. Chapter II reviews the various methods of measuring capacity, their merits and demerits. In Chapter III the studies pertaining to the estimation of capacity in Indian manufacturing industries are reviewed.

CHAPTER I

THE CONCEPT OF CAPACITY

In economic analysis the notion of capacity plays an important role. The efficiency of the economic organisation is often measured by its potential to achieve full utilization of its resources. With Chamberlin's contribution to the theory of monopolistic competition, the concept of capacity received some theoretical attention. Though it is recognised that capacity plays an important role in planning the economic activity and in business cycle theory, a precise definition of the concept has proved to be elusive and a number of approaches have been suggested. We discuss below the different approaches to the concept of capacity and the problems involved in defining it.

1.0 Approaches to Capacity

There are two main approaches to the concept of capacity, namely

- i) Engineers' or technical concept of capacity,
- ii) Economists' or cost concept of capacity.

These approaches differ from each other in respect of the variable which is most important in the definition of capacity.

1.1 Engineers' or Technical Concept of Capacity

The production function is used in this approach which implicitly assumes given plant facilities, an uninterrupted flow of variable inputs such as labour and raw materials and normal organisation of production.

Suppose X = output, n = labour, k = stock of capital services then $X = f(n, k)$, assuming only these two factors of production are used. If we use labour actually employed (nf) and utilised flow of capital services (d), then $X = f(nf, d)$ will give us the actual output. But at full capacity, the relation will be $X = f(n, k)$. Therefore capacity output is the production flow associated with the input of fully utilised manpower, capital and other relevant factors of production. It is a technical concept since costs are not used, and technical relations (production function) are emphasised.

This approach again has two versions, one is 'pure engineers' approach' and other is modified engineers' approach (Moriss Budin and Samuel Paul, 1961).

1.1.1 Pure Engineers' Approach

In this approach the technical potential of equipments of the firm is generally built up from the estimates of the speeds of the major machines and finally assessed in terms of the limitations set by the slowest equipment. And on this basis estimates of capacity by allowing the shut down and repairs' time if regularly expected, are worked out with the help of production functions.

1.1.2 Modified Engineers' Approach

In this approach apart from technical constraints, consideration is given to other non-technical factors such as quantity and quality of variable labour force, quality of organisation, quality of raw materials etc. In view of the important role assigned to non-technical factors this approach is called as 'modified engineering' version of the concept of capacity.

The significant differences between these two approaches lie in the considerations given to the influences of management capabilities and established patterns of operation which include the effectiveness of plant lay out, supervisory controls over labour and method of operating time.

1) Installed Capacity

In this approach, considering the technical relations and taking into account the number of working shifts per day the installed capacity is determined. Depending upon the normal practice of operation of the individual industry, the "working period" is taken as "single shift working for 300 days" and for most of the industries as "double shift working for 300 days" and for continuous process industries "three shift working for 330 or 365 days" (NCAER, 1966).

The installed capacity is defined as "the maximum output that a plant is capable of producing and is established on the basis of the number of operable shifts appropriate to the

industry concerned assuming all the necessary inputs are available" (A. P. Srinivasamurthy, 1979).

ii) Rated Capacity

Rated capacity is defined as "the maximum production which a given plant is capable of producing under prevailing conditions in a country" (Gupta Meena and Thavaraj M.J.K., 1975). Generally rated capacity is equal to installed capacity but due to climatic conditions or due to changes in supply of inputs, it may be sometimes lower than installed capacity.

iii) Attainable Capacity

The rated capacity may not be attainable with the aging of the plant. The maximum output possible taking into account the aging of the plant and its useful life etc. is termed as attainable capacity.

iv) Available Capacity

Some times, because of changes in circumstances, non-availability of inputs, even the attainable capacity may not be available for a certain period of time. 'Then the available capacity is the maximum output that can be produced in a particular period within a given set of conditions'. Available capacity generally much less than the rated capacity (Gupta Meena and Thavaraj M.J.K., 1975).

v) Licensed Capacity

It is the capacity for which a firm has obtained a

licence from the issuing authorities. The licensed capacity is determined on the basis of technical and economical feasibility of the plant (Gupta Meena & Thavaraj M.J.K., 1975).

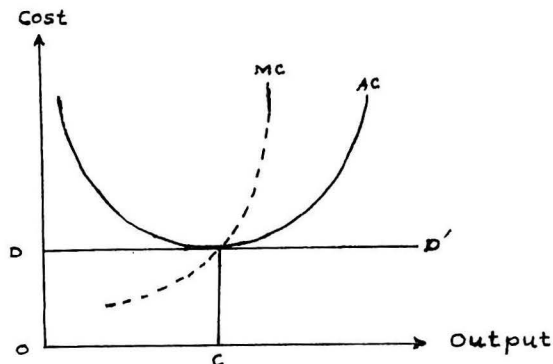
vi) Designed Capacity

It is the capacity of a plant in which technical factor is mainly considered at the time of installation of the plant (Gupta Meena & Thavaraj M.J.K., 1975). The designed capacity is likely to be higher than installed capacity as installed capacity is based on the working period prevalent in the industry in which the machine is used.

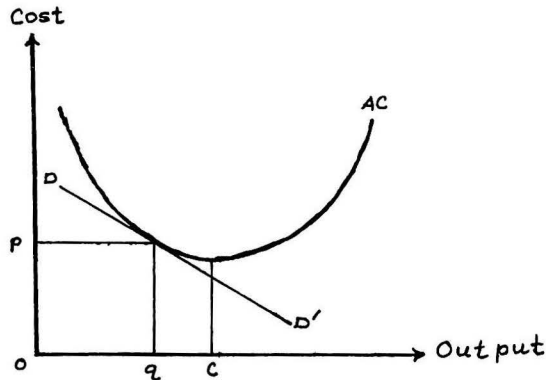
1.2 Economists' or Cost Concept of Capacity

Under this approach "the capacity would be defined as the output level associated with full competitive equilibrium" (L. R. Klein, 1960).

For a firm the capacity point would occur at the minimum of the average cost curve i.e. capacity for firm would be oc , as shown in the following figure. This implies zero profits at equilibrium point where marginal cost, average cost, price and marginal revenue all are equal.



For a firm in imperfect competition the capacity output is oq which is below full capacity output of a perfect competitive firm.



In general according to Raymond T. Bowman and Almarin Phillips (1955) capacity is defined "as the points of minimum short run unit cost, minimum long run unit cost, the equality of marginal cost and marginal revenue, the tangency of short and long run average cost curves, and the output at which short run marginal cost becomes infinite."

1.2.1 Economists' Approach has three versions

- i) L. R. Klein's version
- ii) Bert G. Hickman's version
- iii) Marginal cost approach

1.2.1.1 L. R. Klein's Version

According to L. R. Klein (1960) the economists' concept of capacity can be explained by using production function in lieu of cost function.

There are three assumptions, firstly, technology remains same i.e. production function remains same, secondly

minimum cost for any given output and lastly zero profits.

Suppose there are only two factors of production viz. labour and capital.

$$x = f(n,d) \quad (1)$$

$$fn/fd = w/q \quad (2)$$

$$px = wn + qd \quad (3)$$

where x = (Net) output, p = price of output, w = wage rate and q = price of capital services, n = labour, d = capital fn and fd are the marginal products of labour and capital respectively. This system of three equations has five variables (x , n , d , w/q and p/q). Incorporating the capacity values of inputs (labour and capital) in the above system, the capacity output can be determined. Thus this definition of capacity output in terms of zero profits shows how competitive economy depends on the existing price system. Though it seems similar to competitive point of equilibrium in terms of average cost, it gives clearer role for market prices in determining the capacity.

1.2.1.2 Bert G. Hickman's Version

According to Bert G. Hickman (1963) capacity is defined as that output which may be produced at minimum average total cost, given the existing physical plant and organisation of production and the prevailing factor prices.

Capacity at any given time is an output variable which depends on the size of capital-stock, state of production

technology and existing factor prices. To produce a certain level of output, a desired amount of capital stock is necessary which can be given by following equation.

$$\overset{*}{K}_t = a_1 + a_2 \bar{Y}_t + a_3 \bar{P}_t + a_4 T \quad (1)$$

where \bar{Y} = normal output level, $\overset{*}{K}$ = desired capital stock, \bar{P} = relative prices; T = state of technology and t = time.

With the help of above equation the capacity output can be estimated as follows:

$$Y_t^c = \frac{\overset{*}{K}_{t-1} - a_1 - a_3 \bar{P}_t - a_4 T}{a_2} \quad (2)$$

where Y^c = capacity output;

Y_t^c would be produced with the full utilization of actual capital-stock K_{t-1} , if labour input is adjusted to yield the least-cost combination with existing capital under existing state of technology and factor prices.

In above equation all variables except T are expressed in logarithms. Here it is to be noted that to estimate capacity at time t in a given industry is to derive above equation from the original investment regression and calculate the optimum output corresponding to the actual capital-stock.

The capacity derived in this way, will not depend only on capital stock but also on the relative prices and time, and the level of technology. Since a_4 will usually have negative value in the first equation, which shows that the effect of

technical progress is generally to reduce the capital stock necessary to produce a given output, the capacity of a given capital stock as computed from the second equation will usually increase over the time period.

The economic capacity of a given stock of capital will vary according to relative price change by altering the optimum combination of labour and capital inputs.

This version of capacity also takes into account the effects of scale economies. If there are neither economies nor diseconomies of scale, a_2 will have a value equal to unity, so that doubling of capital stock and labour input would double the capacity. If a_2 is less than one then capacity will more than double with doubling of the inputs, a case of increasing returns to scale of plant. When a_2 is greater than one then it will be a case of decreasing returns to scale.

1.2.1.3 Marginal Cost Approach

According to this approach (Frank de Leeuw, 1961) 'Capacity output is that level of output at which short run marginal costs are "X" per cent above minimum short run average total cost.'

Under this definition, capacity output represents a point at which cost of an additional unit of output is above the most efficient unit cost. Here the value of "X" would be the same for all firms at an aggregate measure and would be selected on the basis of empirical relationship between

capacity utilization and other variables for alternative X's; and "high" level of X may serve initial purpose. This approach has the advantage of the expectations about the relationship of capacity utilization to investment, prices and other variables. It also has the advantage of choice of selection of what should be included in the measure of capacity and what should not be. However, there is the problem of determining the most efficient unit cost and apart from this, it is scarcely feasible to use in practice.

1.3 Concept of Capacity for a Sector

All the above approaches of capacity are explained with respect to either firm or industry in different market structures.

The capacity of a sector is defined as below. "Given a particular conglomerate of capital (in physical sense) in a sector a certain range of output rates for the product would be carried on with the existing facilities, there being no tendency to add capital due to output variations alone. At some rate of output, however, there will be a tendency to buy more capital goods. New investment is induced. It is this rate of output which is to be called the 'capacity' of a sector" (Almarin Phillips) - (Daniel Creamer, 1961).

In above definition capacity is an economic limit to the rate of output with existing facilities of a sector. It is the rate of output after which capital additions would tend to be made. Under certain conditions of cost, the economic limit

may also coincide with a technical limit. That is to say no more could be produced by the establishment in the sector with existing facilities regardless of the costs involved.

In this definition technological or engineering approach in its pure form attempts to measure productive capabilities of plant and machinery without regard to the cost of complementary materials and demand for the products. The economic approach attempts to allow for costs, demand and alternative uses of resources. In this manner the definition of capacity for a sector is the combination of both the main approaches.

1.4 Concept of Capacity for an Economy

The concept of capacity at macro level is useful in the analysis of aggregate investment demand and in multiplier accelerator principles and in business cycle analysis too.

The capacity at economy level is defined as "the maximum sustainable level of output (per year) that can be got when an economy's available resources are fully and efficiently employed, given tastes and technology" (Gordon C. Winston, 1977). This approach to capacity implicitly takes into account both the engineering and economic approaches to capacity.

The capacity at economy level besides aggregating micro units has also to take into account the mutual compatibility of industries. It can be defined as "that level of output of the economy, which cannot be further increased without additional investment in the industry of which capacity

utilization is 100 per cent" (L. R. Klein, 1960). In this definition the supply constraint of the industry whose utilization is 100 per cent is emphasised. This capacity output at economy level can be computed by applying input-output technique.

1.5 Dimensions of Capacity

In all the above concepts of the capacity, there are two important dimensions.

i) The first is the physical or technological dimension where the physical output is to be taken into account.

ii) The other dimension is the time without which the capacity cannot be defined. The time dimension has two aspects.

First aspect of time dimension in defining capacity, is, the point of time one must refer capacity at beginning of the period or at the end of the period or average of the period. This is important because in the process of production the machinery or capital will depreciate over time and may not have the same capacity for the next period. Hence it is necessary to mention the capacity either at the beginning or at the end of the period.

The other aspect is that of operating time. If the plant is operating 8 hours a shift, 2 shifts per day and 6 days in a week and another plant of same size, is operating 8 hours a shift, 3 shifts a day and 6 days in a week, in both the cases capacity will not be the same, and in the second case it will

be higher than the first. Therefore how long the plant is operating is important and as such capacity cannot be expressed without referring this second aspect of time (Fredric Moore, 1957).

1.6 Assumptions Made in Defining Capacity

The following assumptions seem to be necessary for defining capacity.

i) Infinitely elastic supply of all variable factors needs to be assumed. For if there is no uninterrupted supply of variable factors then it is not possible to realise the capacity output and the resultant will not be defined as capacity output. Due to bottlenecks in the supply of variable factors there will be excess capacity and if it becomes a permanent feature then there will be no point in having high capacity which cannot be utilised.

ii) Technology remains same.

If technology goes on changing there will not be unique capacity for that period of time. Under such circumstance it will be difficult to define capacity and empirically to measure it in an appropriate manner.

iii) Capacity in Physical Unit

Capacity should be measured in terms of physical output rather than in value terms. In case it is measured in value terms it is difficult to institute inter-temporal comparison of capacities under inflationary price situations.

iv) Normal Practice

In defining capacity one must use the normal practice in regard to work hours, work week and number of shifts. The normal operating time should be used (Fredric Moore, 1957).

1.7 Difficulties in Defining Capacity

1.7.1 Economists' approach of capacity is difficult to define in case of multi-product firms and L-shaped cost curves, due to main problem of assigning the marginal cost for each product or the average cost and to get unique minimum point on L-shaped average cost.

Again with the same concept, there is no unique and uniform method of computing depreciation and this affects the costs and so the capacity.

In the case of engineers' approach, costs are not considered, production function is important, where capacity is an index combination of all fully utilised factors of production, but it is hard to measure capital stock and so to capacity. This concept of capacity refers to rated or assessed capacity. Empirically it is more operational than economists' concept of capacity.

In general the usefulness of either concepts depends upon the purpose of study. If the analyst is interested in quantitative analysis of the efficiency and allocation of resources then his concern is with economists' concept of capacity in which price plays an important role in resource

allocation. Though the basis of both these approaches is different, under certain conditions there is no dichotomy between these two.

1.7.2 General Difficulties

We note below some of the general difficulties besides the above relating to the definition of capacity.

i) If the capacity is defined in output units, then it has all the conceptual difficulties of output measurement. For example quality differences of products.

ii) If the capacity is defined with reference to either 'normal' practice or to costs; it depends to some extent on the relative prices of labour, machinery and other inputs. Here the concept of capacity is the set of various economic concepts difficult to define clearly.

iii) Though capacity is short-run restraint on volume of output which is imposed by the existing capital stock, availability of raw materials etc., conceptually each of the above approaches has restraint independently defined, but actually various restraints may combine and interact in a complicated way in practice (de Lecuw, 1961).

iv) Defining capacity in terms of cost is difficult because of various cost concepts. For the purpose one must use normal cost concept, which is abstracted from seasonal and cyclical changes in factor prices. Again one must distinguish between private and social costs too.

v) In case of multi-product units, though capacity may be defined either in value terms or standard product ratio, both of these have their own problems.

1.8 Uses of Capacity Concept

Below are noted some of the uses of capacity in the analysis of economic situations.

i) Capacity and associated utilization rates give us a combined measure for allocation of resources. In case of production function designed to show actual operations of the economy, one measures input variables by amounts actually used in the production process. For labour inputs one uses an employment variable, showing the number of man hours actually used during the period of production. Here one can use in general a labour force variable only in the full capacity version of the production function.

ii) The percentage utilization of capacity may tell us more about the overall economic efficiency than other available statistics such as unemployment. The purpose of capacity and utilization statistics is to attempt to extend the measures of underutilization of resources beyond such conventional statistics as the number of unemployed.

iii) The concept of capacity has important contributions to business cycle theory which rely heavily on capacity variables. The theories of business cycle are not fully operational without a proper definition of capacity; it helps to understand the nature of business cycle.

iv) In some cases capacity may be thought to be a substitute for stock of capital and difficulties in measurement of capital may be hoped to be overcome by measurement of the capacity. In general capacity measures a good deal more than the stock of capital, and it is difficult, indeed to consider a satisfactory measure overcoming deficiencies in capital measurement through capacity measurement (Klein L.R., 1960).

CHAPTER II

MEASURES OF ESTIMATING CAPACITY OUTPUT

2.1 As seen in the preceding chapter, there is no unique definition or approach to the concept of capacity; and similarly there is no unique and precise method for estimating the capacity output. There are various methods available in literature which differ from one other in various respects. The following are the major methods of estimating capacity.

- 1) Installed capacity
- 2) Using capital-output ratio
- 3) Trend through peaks
- 4) Size of capital-stock
- 5) Production function
- 6) McGraw-Hill Department of Economics method
- 7) Federal Reserve Board method
- 8) Potential: GNP
- 9) Macro capacity measure using input-output frame
- 10) Linear Programming method

2.2 Typology of Capacity Measures

These capacity measures can be classified in a number of ways based on the concept, scope, outcome of production process, the limiting factor (dominant variable) and source of information.

2.2.1 Concept

The measures can be classified on the basis of concept of capacity used in the methodology of the measure.

a) Engineers' Concept of Capacity

In the preceding chapter we have noted that there are two approaches to the engineers' concept of capacity.

1) Measures Based on Pure Engineers' Concept of Capacity

These measures consider mainly the technical aspect of capacity. Installed capacity and operating time measures belong to this category.

ii) Measures Based on Modified Engineers' Concept of Capacity

Under this category those measures are grouped together which are based on, not only technical relations but also on other non-technical factors. However, cost is not taken into consideration. Measures based on production function, capital-stock capacity and input-output fall in this category.

b) Economists' Concept of Capacity

Under this category all those measures are grouped together which are based on economists' concept of capacity, such as trends through peaks, capital-output ratio, linear programming where objective function involves cost concepts.

2.2.2 Coverage

In this category measures are grouped on the basis of

the scope of the measure, i.e. whether the measure is applicable to the economy or the industry or the plant.

i) Macro Measures

Measures which are used economy wide are grouped under this class. For example, potential GNP, input-output are applicable only at the macro level.

ii) Micro Measures

Measures which are applicable to industry or sector alone are called micro measures (For example, linear programming, capital stock capacity, capital-output ratio, installed capacity, Federal Reserve Board measure, McGraw-Hill measure etc.). By appropriate weighting macro estimates can be derived on the basis of these measures.

2.2.3 Product/Process

Measures may be classified according to the nature of industry in terms of product/process etc.

i) Measures for Single Product/Process

This group comprises all measures which are used in measuring capacity for single product/single processes industries.(For example, production function, Federal Reserve Board, McGraw-Hill, Capital-output ratio etc.).

ii) Measures for Multi-product/process

This group consists of all those measures which are

used to estimate capacity output of multi products/processes industries. In this group falls the linear programming method.

2.2.4 Source of Information

Under this class measures are grouped according to the source and methodology of collecting information. Measures are classified into two classes.

i) Measures Based on Survey

Under this sub-class measures grouped, are those which are based on the information collected by conducting field surveys asking for the primary information (McGraw-Hill and other survey measures).

ii) Measures Based on Non-survey

This sub-class comprises those measures which are based on the secondary data. (For example, trends through peaks, production function, capital-stock capacity, input-output, capital-output ratio, etc.).

2.2.5 Operating Time

Under this, measures are grouped together considering the operating time in terms of working shifts, i.e. those measures which consider operating time and those who do not.

i) Measures Based on Number of Working Shifts

Here only those measures which consider the number of shifts as an important variable in estimating capacity output are considered. (For example, installed capacity).

ii) Measures Not-based on Working Shifts

There are various measures which do not take cognizance of the working shifts directly, in their method of estimating the capacity output. (Trends through peaks, input-output, production function, Federal Reserve Board, capital-output ratio etc.).

2.2.6 Dominant Variable

The measures can be classified according to the dominating variable as listed below.

i) Capital

This group comprises measures which have capital stock as dominant variable. (Example, capital-stock capacity and capital-output ratio).

ii) Employment

Measures grouped together here are based on employment rate/unemployment rate as the dominant variable. (Example potential GNP).

The measures do not have a single variable as a dominant one. They may be multi-variable measures.

Though the above types of classification are not neat in the sense that the groups are not always mutually exclusive, they would throw light on the nature of the measures. We have tabulated the broad characteristics of various measures in Table 2.1.

Table 2.1 : Characteristics of Capacity Measures

Sr. No.	Measure	Concept	Micro/Macro/Both	Influence of shifts	Dominant variable	Nature of data problem
1.	Installed capacity	Engineering	Both	Yes	Capital	Regular collection of capacity data
2.	Capital-output ratio	Engineering	Both	No	Capital	Estimation of capital data
3.	Trend through peaks	Economists'	Both	No	No single variable	Only production data
4.	Capital-stock	Economists'	Both	No	Investment	Estimation of investment function
5.	Production function	Engineering	Both	No	Theoretically many in practice employment	Econometric estimation and data on capacity values
6.	McGraw-Hill	Economists'	Both	Yes	Entrepreneurs' judgement	Collection of survey data
7.	Federal Reserve Board	Economists'	Both	Yes	Entrepreneurs' judgement	Survey data
8.	Potential : GNP	Economists' (Historical)	Macro	No	No single variable	Validity of historical relationship
9.	Input-output	Technical	Macro	Not applicable	Compatibility of sectors	Availability of input-output tables
10.	Linear programming	Engineering/ Economists'	Micro	Yes	Machine hours	Primary collection of data at micro level

Now we discuss the various methods of estimating capacity.

2.3 Installed Capacity

The installed capacity measure is widely used in India (Economic Division of Planning Commission 1955, NCEAR 1966, RBI, 1969), Government sources (MSP, DGTD) report the installed capacity for a wide range of products. In this measure capacity is defined for each product on the basis of a particular number of shifts working per day depending upon the normal practice of operation of the individual industry. The "working period" is taken as single shift working for 300 days "for most of the single and double shift industries", and for continuous process industries, "three shift working for 330 days or 365 days". Considering the technical relations and number of shifts and working days, capacity output is estimated on the assumption of uninterrupted supply of other raw materials.

The maximum output that a plant is capable of producing, is established on the basis of the number of operable shifts appropriate to the industry concerned assuming the availability of necessary inputs is called the installed capacity of that plant (Srinivasamurthy A.P., 1979).

Estimating in this manner the installed capacity of each industry and by a proper weighting, the aggregate index of capacity can be computed. Further by taking the ratio of actual output index to installed capacity output index the utilization rate can be obtained.

This measure is applicable at micro as well as macro level. This is also a measure which is largely based on engineering concept though economists' approach is also taken into account to some extent.

Installed capacity can be measured unambiguously in the case of single product firms, but in the case of multi-product firms installed capacity productwise has to be based on judgement.

The installed capacity estimates are naturally dependent on the shift pattern assumed. Samuel Paul (1974) observes that a significant number of units which are classified under single shift operation by MSP, actually work on two shifts and some even on three shifts basis and shows that the potential capacity is much in excess of the single shift equivalent. Thus depending on the assumption about the feasible pattern of shift operation capacity estimates vary.

The capacity utilization at the macro level is obtained by aggregating the individual utilization ratios at the micro level using value added as weights. Normally value added shares in the existing production are used as weights (RBI, 1969, Paul S., 1974). The value added shares of the capacity output would be more appropriate. It is also debatable whether value added or production should be used for weighting. While in the analysis pertaining to income value added weights are proper, if the focus is on production in physical terms, production may be more appropriate for weighting.

This installed capacity measure faces the problem of determining the working shifts which varies according to nature of industries. This measure some times gives percentage utilization rate more than 100 (RBI 1969, NCEAR 1966) which is very unrealistic.

2.4 Using Capital-Output Ratio

National Industrial Conference Board estimates capacity by using the minimum capital-output ratio. Here net fixed capital-stock is taken into account from the accounts of business operation and transactions as they are recorded in corporate balance sheets and profit and loss statements. To relate capital to output, only fixed capital is taken into consideration such as structures and equipment. The volume of structures and equipment is measured by the value (net of depreciation) placed on these assets by manufacturing enterprises in their balance sheets, with the corrected price changes.

Then capital-output ratios are calculated in value terms at constant prices and are examined for cyclical peak period, and a bench-mark year is selected, which is meant virtually full capacity utilisation point. This is the ratio, considered as capital capacity output ratio and using this ratio the capacity is estimated as follows (Almarin Phillips, 1963).

$$FC_t \div \frac{FC_0}{CO_0} = CO_t \quad (1)$$

$$\frac{O_t}{CO_t} = \text{capacity utilization rate at } t \quad (2)$$

where FC_0 = Fixed capital in bench-mark period

CO_0 = Capacity output in bench-mark period

FC_0/CO_0 = Capital capacity output ratio in bench
mark period

CO_t = Estimated capacity output at time t

O_t = Actual output at time t .

To get the utilization rate for the manufacturing sector as a whole the actual output in value terms at constant prices is added and divided by the sum of capacity output in value terms at the constant prices for the same industries in manufacturing sector. For aggregating capacity estimates for individual industries, they should be mutually compatible, which means if all the industries attempted to operate simultaneously at these capacity rates, there should be no bottlenecks of labour and material shortages.

This measure can be applied at the economy level as well. In 1978 this method was further developed by Panic (1978). Instead of capital-output he considers output capital ratio and constructs the series (Y_t/K_t) , $t = 1 \dots T$, where Y_t and K_t are output and capital-stock, $t = \text{time}$. Then by fitting a linear trend to actual output/capital series he derives 'capacity' output capital series (Christiano Lawrence J. 1981).

$$\frac{Y_t}{K_t} = a_0 + a_1 t + \hat{u}_t \quad t = 1 \dots T$$

The capacity output capital ratio is taken to be the point on the line with time deviation a_1 raised just enough so that it touches only one of observed Y_t/K_t series. By adjustment, in this way, Y/K ratio is called as $(Y_t/K_t)^c$, which is assumed to be capacity output/capital ratio. Then the ratio of (Y_t/K_t) to $(Y_t/K_t)^c$ is called capacity utilization i.e. $[(Y_t/K_t) / (Y_t/K_t)^c] \times 100 = \text{percent capacity utilization}$.

This takes into account the change in investment by fitting the linear trend with t .

The one serious limitation of the above method is the assumption that the output is related to net (depreciated) capital values. Output is better related with gross capital rather than with net capital. The gross net ratios of capital are not uniform over time and across the industries. This limitation becomes all the more serious in the case of developing countries.

In this measure the most formidable problem is that of measuring the capital stock. The deflation to constant money terms of capital stock values, depreciated or undepreciated, poses difficulty because capital produces an income stream into the future. The prices of capital goods reflect discounted values of this income stream as well as the cost of producing the total items. Deflation by usual methods to adjust to base year prices the various items of capital in subsequent years is not appropriate as the fact that technological changes may

have increased the discounted value of these as compared to the base years items. For this purpose no realistic alternative is available (Almarin Phillips 1963).

2.5 Trend Through Peaks

The method of constructing trend through peaks (Wharton) index of capacity utilization involves marking cyclical peaks for each of the industry index of industrial production and then fitting the line between successive peaks. Between present and last established peak, the previous line is extrapolated at its constant slope unless the index in present period exceeds the extrapolated trend line. A new line with a different slope is obtained if the present peak exceeds the earlier one. This way revisions are made in the last line segment till there is a cyclical decrease in the index of industrial production.

In this measure implicit assumption is that there is a fixed stock of capital in each industry which cannot be changed quickly and an unlimited supply of variable factors of production. The level of production in each individual industry is independent of the output of other industries. It also assumes that the actual peak output as the capacity output.

In constructing Wharton series the basic data are quarterly series constructed from three-month averages of seasonally adjusted monthly industry indices. In identifying the peaks following rules are followed (K. Krishnamurthy, 1961) which are not applicable to declining industries.

1) A quarter may be identified as peak if it is higher than or equal to two adjacent quarters.

2) If output is unchanged at peak level for two successive quarters, then second quarter is identified as peak.

3) If it is unchanged at peak level for three successive quarters, then middle one is identified as peak.

4) When output reaches a peak following a decline of no more than one quarter period, the second of the two highs is identified as the peak.

5) A new peak is established when actual output increases above the trend line fitted to the previous two peaks.

The ratio of actual output to the fitted trend line through peaks is called capacity utilization. For every quarter such ratios are obtained for all component industries and then a weighted average is taken. This method can be applied for a firm or industry or for the economy as a whole. As the capacity output had to be necessarily realised at least for a point of time this measure takes into account the limitation of not only factors like capital but all other factors like organisation management etc. The peak output is considered as the capacity output and the unutilised capacity, if any, at the peak is not taken into account. For this reason the method has an upward bias in the estimate of capacity utilization. But the great merit of this measure is that capacity as estimated could actually be realizable in the

economy. The data requirements for this method are not at all stringent and are easily available.

This measure is widely used in various countries both at micro and macro level (See Jim Taylor, David Winter and David Pearce, 1970; G. Briscoe P. O'Brien, D. J. Smyth, 1970; RBI, 1970; D. U. Sastry, 1984).

This measure is the simplest, easy to compute and yields estimates of capacity utilization over wide range of industries. It attempts to measure the degree of utilization of all factors of production together. Though this measure is attractive, it has its own demerits too. The implicit assumption made in the measure that every major peak represents capacity output which has the 100% utilization at that point is unrealistic and the method fails to distinguish differences in the intensity of utilization from one peak to another. Another assumption implied in extrapolating the line is that capacity output grows at a constant arithmetic rate between peaks. How can even growth rate take place where pattern of investment is expected to be procyclical? Even in the case of supply constraints and other rigidities due to market intervention through controls and regulations the identified peak may in fact be lower than the true peaks, which results in lower estimate of capacity and over estimation of utilization. This measure faces the problem of aggregation, since peaks of one industry may not synchronise with peaks of other industries. Capacity expansion may also take discrete jumps at the individual firm level, but aggregating

it over several firms it could appear as smooth and a continuous one. Even with these drawbacks it would be useful as a measure of changes in utilization rates over relatively short time intervals. This is the most popular measure which is widely used in various countries.

2.6 Use of Capital-Stock

Bert G. Hickman (1963) proposes a method to measure capacity using an investment function. He formulates an investment function which implies a precise relationship between capital stock and capacity. The basic investment regression equation is obtained as follows.

1) First it is assumed that the real net fixed investment in any year is proportional to the difference between actual and desired capital stock where the latter is defined as that stock which would be desired in long term equilibrium as per conditions prevalent in t . i.e.

$$K_t - K_{t-1} = b (\overset{*}{K}_t - K_{t-1}) \quad (1)$$

$0 < b \leq 1$ where K_t = actual capital stock; $\overset{*}{K}_t$ = desired stock of capital at the end of year t .

2) Secondly he assumes that the desired stock of capital is a function of the expected long term or "normal" level of output (\bar{Y}) and relative prices (\bar{P}) in year t plus time trend. i.e.

$$\overset{*}{K}_t = a_1 + a_2 \bar{Y}_t + a_3 \bar{P}_t + a_4 T \quad (2)$$

T = time trend is used as a proxy for technological progress.
From equation (1) and (2) we get

$$K_t - K_{t-1} = ba_1 + (ba_2) \bar{Y}_t + (ba_3) \bar{P}_t + (ba_4) T - bK_{t-1} \quad (3)$$

Assuming businessmen's expectation of current levels to persist indefinitely into the future, using current outputs and relative prices the parameters are estimated. Two forms of relative prices are used. First is the price of capital relative to product and the other is the price of capital relative to wage rate.

This regression equation relates desired capital to normal output and prices. It measures the annual rate at which percentage gap between desired and actual stock is eliminated.

Using these estimates, capacity is defined as follows.

$$Y_t^c = \frac{K_{t-1} - a_1 - a_3 \bar{P}_t - a_4 T}{a_2}$$

where Y_t^c = capacity output at time 't'.

That is the capacity output depends on the size of the capital stock, the level of production technique and the relative prices of productive resources.

Above Y_t^c would be produced with the actual capital stock if labour input were adjusted to yield the least cost combination with existing capital, with existing technology and factor prices.

In this estimate value of a_2 decides the effect of economies of scale. Several advantages are claimed for this method. It is consistent with the basic theory of optimum economic production while avoiding the estimation of cost and production functions. The method allows for the effects of scale economies.

The problem of measurement of capital persists. Besides this Murry^a Brown points out that the capacity estimation of this method requires the reversibility of regression and this is a serious limitation. Unlike functional relations, regression relations not being exact, are not reversible.

2.7 Production Function

This method considers all the factors of production in estimating the capacity output. Capacity output is defined as "the production flow associated with the input of fully utilised manpower, capital and other relevant factors of production" (L. R. Klein, 1960). Here the relationship between actual volume of output and factors of production is estimated and that relationship is used to compute full capacity output corresponding to full utilisation of factors of production.

Actual output is defined as below (L. R. Klein & R. S. Preston, 1967).

$$X_t = A_e^{rt} L_{et}^{\alpha} K_{ut}^{\beta} v_t \quad (1)$$

where X_t = actual output, L_{et} = man hours employed, K_{ut} =

capital utilised, e^{rt} = a proxy for technical change and v_t = error term, t = time.

From this capacity output is defined as below

$$X_{ct} = A e^{\hat{r}t} L_t^{\hat{\alpha}} K_t^{\hat{\beta}} \quad (2)$$

where X_{ct} = capacity output, L_t = available man hours (exclusive of frictional unemployment), K_t = full utilised capital and e^{rt} = proxy for technical change. A , \hat{r} , $\hat{\alpha}$ & $\hat{\beta}$ are estimates of parameters in equation (1) and $V_t = 0$. Assuming L_t and K_t are measured without error, above relationship will hold good. While the data on manhours L_t are usually available, the measurement of total capital stock K_t poses problems. Carl Christ (1967) uses the rate of new investment as a proxy for unutilised capital stock on the assumption that new investment would be determined by the percentage of unutilised capital. Robert Solow (1957) uses rate of man hour employment as proxy assuming $\frac{K_{ut}}{K_t} = \frac{L_{et}}{L_t}$ (3)

Klein (1967) follows Solow in this respect. The assumption underlying (3) that the capital and labour are utilised at the same rate is a strong one and may have an empirical basis.

Assuming Cobb-Douglas production function capacity output is defined as in (2); K_{ut} defined as in (3) then we get

$$\left(\frac{X_t}{X_{ct}} \right) = \left(\frac{L_{et}}{L_t} \right)^{\alpha + \beta} v_t. \quad \text{The degree of homogeneity is}$$

assumed same as that of production function for industry.

Firstly L_t is obtained in terms of men and then converted into man hours; which is defined as follows.

$$L_t = L_{et} + L_{vt} + L_{ft} + \delta (L_t - L_{et} - L_{ft}) \quad (4)$$

where L_{et} = employed labour force, L_{vt} = involuntary unemployment, L_{ft} = frictional unemployment and δ = coefficient of response of labour supply to employment opportunities. Solving equation (4) we get

$$(1 - \delta) (L_t - L_{ft}) = (1 - \delta) L_{et} + L_{vt} \quad (4.1)$$

$$L_t - L_{ft} = L_{et} \left[1 + \left(\frac{1}{1 - \delta} \right) \left(\frac{L_{vt}}{L_{et} + L_{vt} + L_{ft}} / \frac{L_{et}}{L_{et} + L_{vt} + L_{ft}} \right) \right] \quad (4.2)$$

$$L_t - L_{ft} = L_{et} \left\{ 1 + (\mu - \mu_{ft}) / [(1 - \delta) (1 - \mu_t)] \right\} \quad (4.3)$$

$$\text{where } \mu_t = (L_{vt} + L_{ft}) / (L_{et} + L_{vt} + L_{ft}) \quad (4.4)$$

and

$$\mu_{ft} = L_{ft} / (L_{et} + L_{vt} + L_{ft}) \quad (4.5)$$

where μ_t = total unemployment rate, μ_{ft} = frictional unemployment rate.

Now expressing full employment man hours as actual man hours used, which gives a measure of potential man hours less frictional man hours.

$$1.0 + (\mu_t - \mu_{ft}) / [(1 - \mu_t) (1 - \delta)] \quad (5)$$

This adjustment factor is observable from published employment series provided we have μ_{ft} & δ . From this available man hours $L_t - L_{ft}$ can be estimated, by fitting linear segments through peaks, the smooth monotonic increasing trend of aggregate supply of man hours is obtained. The distribution of man hours in capacity input of labour to each industry is done by fitting linear segments between computed factor shares for each industry at peak demand points. Multiplying these percentages into series we get the trend in capacity man hours for each industry.

By assuming, the industries are cost minimizers which gives the increasing returns to scale. β/α estimated from factor share data.

$$\frac{q_t K_{ut}}{W_t L_{et}} = \beta/\alpha + z_t \quad (6)$$

where $q_t K_{ut}$ = non-wage income, $W_t L_{et}$ = wage income, t = time, z_t = error term

$$\left(\frac{\beta}{\alpha}\right) = \frac{1}{T} \sum_{t=1}^r \frac{q_t K_{ut}}{W_t L_{et}} \quad (7)$$

then estimating A , α & γ from the regression.

$$\log e^{(x_t)} = \log e^{(A)} + \gamma_t + \alpha \left[\log e^{(L_{et})} + \left(\frac{\hat{\beta}}{\alpha}\right) \log e^{(K_{ut})} \right] + \log e^{vt} \quad (8)$$

with the estimates \hat{A} , $\hat{\gamma}$, $\hat{\alpha}$ & $\hat{\beta}$ where $\hat{\beta} = \hat{\alpha} \left(\hat{\beta}/\hat{\alpha} \right)$

we compute the capacity output from equation (2) given K_t and L_t for each industry.

Then capacity utilization is defined as the ratio of X_t to X_{ct} . This measure is applicable to economy as a whole and it is widely used (K. Krishnamurthy, 1961; G. Briscoe, P.O'Brien and Smyth, 1970; Nayar & Kanbur, 1976, and Artus J. R. 1977).

Instead of using the Cobb-Douglas formulation of the production function other forms like the CES can also be used (Nayar & Kanbur, 1976).

This measure can be used both at the micro and macro levels. Under the assumptions that (a) the method of allocating labour force at full capacity among industries is correct, (b) that firms minimise cost in the factor market which are competitive, (c) that the functional form is appropriate and finally (d) that the observed data truly measure the relevant economic concepts, the engineering approach of the production function coincides with the economists' approach to capacity (Klein 1960).

This production function measure of capacity is conceptually very sound since capacity output is the function of not a single but of many variables such as capital, labour, and technological change etc, and uses the concept of capacity in its wider sense. The advantage of this measure is that it gives a decomposition of capacity output growth according to changes in the factors of production.

Once estimated the parameters of production equation do not remain same over the period of time; these should be re-estimated. Otherwise utilisation rates will become biased. The major problem with this measure is about the measurement of capital. The measurement problem with the capital is two-fold. One is the problem of estimating the replacement value of capital from the available depreciated or purchased value of capital. The other one which received great theoretical attention with the work of Joan Robinson (1953-54) and Sraffa is the validity of the very concept of aggregate capital which makes the aggregate production function concept meaningless.

2.8 McGraw-Hill Department of Economics

The economics department of the McGraw-Hill publication company conducts annual surveys. In the survey questions such as the following are asked to companies, "At the end of the (past) year, how did your capacity measured in terms of physical volume, compare with what it was at the end of the previous year?" Another question is "At which rate companies would

prefer to operate?" (Almarin Phillips, 1963).

In this measure no readymade definition of capacity was given to the companies; they were asked to set their own definitions and only hint was given to follow a common-sense definition of capacity such as maximum output under normal working conditions.

Then on the basis of the above data aggregating the utilization rate which is the ratio of actual output to capacity output, the economy wide utilization rate is obtained.

In addition to this, periodically the department conducts the utilization survey (George L. Perry, 1973) which is expected to overcome the difficulties of the above capacity survey. In this measure instead of asking questions related to capacity, questions were asked pertaining to utilization of capacity. This information is expected to take into account the changes in obsolescence of facilities, the changes in capital labour ratios, or in other structural changes. "It appears that respondents 'find' capacity when output rises sharply, and 'lose' it when output slackens" (George L. Perry 1973). Therefore it is the better source of information pertaining to short term bottlenecks, rather than to potential output. Particularly this does not provide an objective measure of the depth of recession (Artus Jacques R. 1977). These surveys are useful source of information on account of spare capacity as seen by the entrepreneurs.

This survey measure is likely to have bias and non-

random errors. Bias may enter in different ways such as mergers and consolidations, expansion in wrong industrial classifications, failure to report reduction in capacity due to bankruptcies of a firm and retirement of facilities and possible bias in case of results in primarily on the replies by large firms (Almarin Phillips, 1963).

Reporting of capacity in case of multi-product firms, which involves aggregation may have upward bias due to subcontracting. In terms of the final output capacity may not increase but in terms of value added it may, if the firm chooses to manufacture the same intermediate output. Here firm may report zero rise in capacity based on final output which is incorrect.

These direct surveys do not define the capacity and the definition is left to respondents and this may lead to different approaches for the capacity by different respondents. The estimates of capacity from the survey suffers from having no periodic bench mark so that any systematic error in the annual estimates of capacity growth from the operating rate bench marks are provided annually. This survey suffers from cyclical bias if respondents treat marginal facilities differently at different stages of the cycle. During the slack the idle facilities are likely to be ignored in estimating operating rates but may be counted when they were put back in use (George L. Perry 1973).

Though there are demerits of this measure, there are merits too. "The obvious advantage of the survey method is that direct question relating to capacity are reported to by persons likely to know the answers." (Almarin Phillips, 1963). This is a better source of information pertaining to the spare capacity as seen by the entrepreneurs.

2.9 Federal Reserve Board Method

To estimate capacity in manufacturing sector Federal Reserve Board uses the information from different sources. The Board uses (i) the Commerce Department's estimates of manufacturers' fixed capital stock at constant prices. (ii) McGraw-Hill index of manufacturing capacity data and (iii) the capacity measure based on answers to another McGraw-Hill question : "How much of your capacity were you operating at the end of 19 —?" (deLeeuw F. Hearings, 1962). These different sources have different types of biases and to get rid of these, the Board combines them in two following equations.

$$Y_{3t}/Y_{1t} = a_1 b_1^t u_t \quad (1)$$

$$Y_{3t}/Y_{2t} = a_2 b_2^t v_t \quad (2)$$

where Y_1 = commerce department series on capital estimates

Y_2 = McGraw-Hill capacity index and

Y_3 = the indices based on the McGraw-Hill rate of operations, u , v , are random disturbances, and a 's and b 's are regression coefficient and t = time.

From the estimates of coefficients a and b, two values of Y_3 from each equation are obtained for all the years and then by taking average of these two values capacity output is estimated.

By taking the ratio of the actual output to estimated capacity output, the capacity utilization rate is obtained. By aggregating with to help of value added weights the utilization rate can be obtained at economy level.

This measure just uses the information from other sources but it does not overcome the basic difficulties such as measurement of capital and the problem of defining the capacity inherent in Mc-Graw-Hill survey. This measure is regularly used by the Federal Reserve Board.

To remove the different types of biases and errors Federal Reserve Board had also used a different procedure (deLeeuw F. 1966). Here data for gross capital stock series is obtained from official censuses of manufactures published in non-census years for establishment and not for companies. Assuming retirement as a constant fraction of the capital stock fluctuations are removed. i.e. $S_{t+1} = (1 - K)S_t + I_t$ where S_t = stock of capital of the starting period t, I_t = Investment expenditures in period t and k = retirement rate. The gross capital stock is preferred to net assuming capital-good yields constant services over its life time. Annual McGraw-Hill capacity indices are classified into "primary

processing" and "advanced processing" industries according to Federal Reserve weights.

The capacity series is computed for each group by dividing actual output by percentage operating rate of McGraw-Hill figures. Using above three series of information, capacity is estimated as follows:

$$X_1/X_2 = a_1 b_1^t u_t \quad (1)$$

$$X_1/X_3 = a_2 b_2^t v_t \quad (2)$$

where X_1 = FRB index of industrial production divided by McGraw-Hill capacity utilization figure.

X_2 = McGraw-Hill capacity index

X_3 = Gross capital stock

a_i = Antilogarithm of intercept regression coefficient for i th equation ($i = 1, 2$)

b_i = The antilogarithm of trend regression coefficient for i th equation ($i = 1, 2$)

$u_t; v_t$ = error terms and t = time.

Finally multiplying the 'calculated values' in equation (1) by X_2 and 'calculated values' in equation (2) by X_3 and taking the average of the two, capacity is estimated, then taking the ratio of actual output to this estimated capacity, capacity utilization rate is obtained. Here in this new estimate separate estimates have been prepared and utilization rate for primary and advanced processing industries.

The revision does not show any change in utilization rate except for 1948-51 for primary processing group and total manufacturing utilization rate is unchanged from 1954-65. (Edmanson Nathan, 1971). Then these estimates are made regularly available by Federal Reserve Board (Rost Ronald F. 1983).

This measure has the drawback that the bench marking to the utilization survey is based on historic statistical relationship which may change substantially over a period of time. Particularly recent year estimates based on simple time trend estimates at the drift are heavily weighted with historical information, and therefore the estimates fail to reflect any abrupt changes in investment and capital-stock to capacity. This is a useful measure as an alternative measure of estimating capacity.

2.10 Potential:GNP

This economy wide measure was first developed by Arthur M. Okun (1962) in which statistical relationship between percentage point changes in the unemployment rate and percentage changes in GNP is used. In other words this measure relates marginal output to marginal changes in unemployment rates.

Fitting the regression over past values, required parameters can be estimated as follows (Christiano Lawrence J. 1981).

$$\Delta U_t = d(t) + a_0 \Delta \log Y_t + a_1 \Delta \log Y_{t-1} + a_2 \Delta \log Y_{t-2} + a_3 \Delta \log Y_{t-3} + e_t \quad (1)$$

where Δ is first difference operator; U_t = unemployment rate, Y_t = real GNP, e_t = random error; $d(t)$ collection of dummy variables.

To get $\Delta \log Y_t$ as a function of distributed lag as past values of ΔU_t equation (1) can be inverted.

$$\Delta \log Y_t = \sum_{i=0}^n a^i \Delta U_{t-1} \quad (2)$$

where $a^i = 0, \dots, n$ computed from estimated coefficients of equation (1). Then

$$\log Y_t = \sum_{i=1}^n a^i U_{t-1} + c \quad (3)$$

where c = constant, thus equation (3) explains the historical relationship in between actual real output and actual unemployment rate. Assuming coefficients a^i ; $i = 0, 1 \dots n$ would have held if the economy had been at full employment.

$$\log \left(\frac{Y_t}{Y_t^f} \right) = \sum_{i=0}^n a^i (U_{t-1} - U_{t-1}^f) \quad (4)$$

where U_t^f = full employment/unemployment path, and $t = -n, -(n-1), -0, 1, \dots T$. Equation (4) gives Okun's estimate of output gap obtained by taking antilog of left hand side term of above equation (4) and multiplying the result by 100.

Capacity output is then computed using the above relationship between unemployment rate and percentage changes in output. Ratio of actual output to potential output gives utilization rate.

Edwin Kuh (1966), had tried to estimate potential output using the simple dynamic production function in which employment is important variable with capital stock, lagged output and employment. But due to multicollinearity, results are found to be inferior compared to the Okun measure.

The potential GNP measure is based on the historical relations between GNP and a single variable of unemployment rate; the direct influences of other factors of production and the fact that the observed historical relation may not recur in the present are not taken note of. Aggregation problems also are serious in this measure. In case of employment where a strong assumption that skill compositions of the labour force remains constant is needed, which apparently unrealistic.

2.11 Macro-Capacity Measure Using Input-Output Frame

Building up of a macro estimate from the micro estimates involves the problem of aggregating the micro estimates with appropriate weights. Such macro measure may not reflect the unutilised capacity of the economy as a whole in the sense that it would be possible to increase the level of output as indicated by such a measure. To increase the levels of output of different sectors not only capacities should exist in the

individual sectors but they must be mutually compatible. Using the input-output frame such compatibility can be ensured.

Following A. Manne L. R. Klein outlines such a procedure for National Index of capacity. Using percentage utilization of capacity data of individual industries determined by any measure, they are ordered in the descending order of capacity utilization. That industry nearest to 100% utilization can be made to utilize 100% capacity without additional investment in the economy resulting in to same proportionate rise in output of other industries. Here the final demand is assumed to increase in same proportion. The input-output system satisfies the equation $Ax = f$.

$AP_1X = P_1f$ where A = input-output matrix*, x = vector of industry output; f = vector of final demand; P_1 = reciprocal of the percentage utilization of capacity of the industry nearest to full utilization.

If f increases to P_1f then $AP_1X = P_1f$ in the very short run P_1X gives the capacity vector of outputs.

Now to raise the utilization of the second nearest full utilization industry is not possible without investing in first industry to create additional capacity. The required amount of investment is determined by capacity accelerator coefficient i.e. $I_1 = a_1 \Delta (X_c)_1$ where I_1 = Net investment in i th industry;

* Evidently A is not the usual input-output matrix while Klein does not make it clear to satisfy the equation A must be taken as equivalent to the usual $(I-A)$ matrix. We retained Klein's nomenclature.

$\Delta (X_c)_i$ = increase in capacity output of the i th industry and a_1 = capacity output accelerator coefficient. Investing I_1 leads second industry 100% utilization.

Now to make third industry 100% utilization investment will be needed in first two industries and the required amount will be obtained using respective capacity-output accelerators.

Such successive rounds can be continued till the investment potential is available i.e. till the capacity of the machinery sector is fully utilised and the last round the aggregate level of output is the capacity output in economy. This level of attainable capacity cannot be achieved instantaneously but within a reasonable time it should be possible to achieve this.

If some of the industries whose capacity is raised in successive rounds happen to be capital goods sector, larger investment potential becomes available and the capacity of capital goods sector becomes a variable than a constraint. The aggregate capacity with this larger investment potential can be estimated using input output system.

Another generalization is also possible incorporating the simultaneous expansion of capacity in the investment goods as capacity is expanded throughout the economy (see Klein 1960).

This measure for deriving aggregate capacity is conceptually good but is not easy to compute and it initially depends on the capacity utilization data obtained from other measure, consequently to some extent its reliability depends on

the reliability of the measure from which utilization rates are obtained. This measure has advantage of identifying the industry which is becoming a supply constraint on the utilization of other industries. This is very helpful in planning the capacity utilization programme of industries, because of its ability of predicting the required investment for different industries. Specially this measure has the advantage in planning industrial production structure.

2.12 Linear Programming

The concept of capacity is difficult to define in case of multiproduct and/or multi-process industry, the general method cannot be applied (e.g. engineering industries like machine manufacturing, chemical industries and petroleum refining industries).

In a production process different machines (n) are used by different products (m). Each machine is used for some time to produce each type of product, so ' $n \times m$ ' will be the order of the available time coefficient matrix. Measuring time coefficient in terms of hours, then number of hours each machine can work in a year is to be found out. Considering the number of working shifts and available time for each machine per shift the total hours available for each type of machine is obtained. Taking these machine-hours as the constraint an optimum product mix is obtained, maximising a postulated objective function like value added.

This is a programming problem because the total hours available for each machine is the constraint and the value added or profit is the objective function to be maximised. The capacity output is that output which maximises the value of the objective function with given availability of machine hours, (P. N. Mathur, S. P. Valavade & M. V. Kirloskar, 1967) and taking ratio of actual output to this capacity output is called as rate of capacity utilization.

According to Helen Malenbaum (1969) minimum cost concept is unrealistic and not good indicator of investment plans in as imperfectly competitive world. This also fails to provide measure of maximum sustainable output capabilities of existing plant and equipment. ^{She} He defines capacity output for various product mixes as the set of points on various possible product mix rays at which marginal cost had risen to some prescribed level.

James M. Griffin (1972) uses the economist concept of capacity which is defined as Minimum Average Cost for the general case of joint production and multiprocess industries. He outlines a procedure for estimating capacity in the U.S. petroleum refining industry. Using linear programming approach he finds out the minimum cost for various output levels treating product mix as fixed.

This linear programming measure has special advantage of switching over to either engineering concept or economists' concept, by defining the objective function of the given

problem. For example if you maximise physical output given the input constraint, it will be engineering approach and if you maximise value added, total profit given the price constraint or minimise the costs, will give economists' approach to capacity.

2.13 Conclusion

Of the measures generally those based on an economists concept of capacity are better than those on engineers' concept, since whatever is technically feasible may not be economically desirable (James Griffin, 1972). Economists' concept measures consider the general production situation whereas others do not. But the data requirements are so stringent that rarely it is possible to use them to any large degree. Measures like trends through peaks, capital output ratio, linear programming etc. are conceptually better than the ones based on production function, installed capacity. Even on the engineers' concept the measures based on the production function are better than those based on installed capacity, since under certain conditions production function measures tend to be identical with economic concept measures.

In case of macro measures such as potential GNP which is based on the historical relations between GNP and a single variable of unemployment rate, the direct influences of other factors of production are ignored and the observed historical relation may not recur in the present.

The input-output measure has its own limitations such as the coefficient stability and reliability of the basic data. But this has various merits for the policy purposes as it enables the identification of bottlenecks in the economy.

Trends through peaks is no doubt simple, easy but has a built in upward bias of utilization.

All the micro measures except those based on linear programming fail to estimate capacity output of multi-product/process industries.

The measures based on survey information has the influence of animal spirit of optimism or pessimism based on current output levels. The non-survey measures are superior in terms of concept, method of estimation and the variables under considerations. The installed capacity is technically weak whereas trends through peaks is conceptually weak but technically good. The production function is conceptually sound but the measurement problems with both important variables, capital and labour are serious and more particularly with capital; the same problem is also faced by capital output ratio and capital-stock capacity measures. These latter two measures use the narrow concept of capacity treating capacity utilization synonymous with capital utilization.

In general there is no single measure which is ideal. Considering data availability and other things trend through peaks method seems to be operationally feasible to build a capacity utilization series on a continuous basis.

CHAPTER III

ESTIMATES OF INDUSTRIAL CAPACITY UTILIZATION IN INDIA

3.1 The problem of capacity utilization in India received wide attention from the academicians and planners as capacity utilization is important to tackle the problem of unbalanced industrial growth and efficient utilization of scarce resources. But unfortunately these studies were sporadic in nature and not sustained and continuous in character. The Economic Division of Planning Commission analysed the capacity utilization in 1955 for formulating the Second Five Year Plan. In the late sixties and early seventies much work was done on this aspect. Before reviewing the major studies which is the main theme of this chapter, we discuss the data sources for capacity measurement.

3.2 Data Sources

The main sources of data at the economy level for several products is provided by Monthly Statistics of Production of selected industries (MSP). At industry level there are various sources such as bulletins, annual reports, etc. There are very few surveys designed for capacity measure.

I) Monthly Statistics of Production

Monthly Statistics of Production (MSP) of selected industries of India is the most important source of data for capacity studies. MSP gives information on monthly and annual figures of installed capacity and production in physical units for various products besides the official index of industrial production and statistics on inventories.

The scope and coverage of MSP has been increasing over the period. Initially, in the years 1932 to 1935, it was covering only eleven industries (65 products) and was giving only production figures. In 1949 for the first time installed capacity figures for 26 industries were given for the months of January to February; but from April 1949 it discontinued giving the installed capacity. In November 1949 it again started giving installed capacity regularly in addition to the percentage utilization for 53 industries. In 1953 it stopped giving the percentage utilization. The products were classified according to International Standard Industrial Classification (ISIC) with 18 major industries. Since 1974 it started following NSIC classification. The latest MSP (1984) covers 477 items of industrial products.

The statistics regarding capacity, production and stocks, published in MSP are given to CSO by Directorate General of Technical Development (DGTD). DGTD also publishes data on installed capacity and production, both in value and

physical terms. This source since January 1968 covers only large units whose investment in fixed asset is more than Rs. 7.5 lakhs. The figures reported in the MSP pertain to the units registered with the DGTD. While every factory may not register with DGTD some units registered with DGTD may not be covered under factories act. But by and large the DGTD data can be presumed to reflect the factory sector.

Limitations of MSP

The MSP is the major and important source of information on production and capacity which is available on a continuous basis covering the organised manufacturing sector. But these statistics are subject to a number of limitations.

i) While the average monthly production figures given by MSP for each year are based on actual production figures for the month, the capacity figures reported for the year are the year-end capacity figures and are not the average monthly capacity as is the case with production figures. As a consequence the capacity figures are over-estimated. This point escaped the attention of almost all the researchers using this data. It is of course possible to derive the correct estimates of the capacity by looking into the monthly capacity figures of each year.

ii) The figures of capacity are reported by the firms on the basis of number of shifts per day and number of working days in a year as prescribed by the agency collecting the data

but not according to their actual working conditions at the factory level. This leads to under-estimation of capacity. The reporting firms have an incentive to misreport in some cases to understate capacity in an attempt to conceal the capacity installed without official sanction, in other cases to over-state capacity in a bid to claim more foreign exchange than the firms are entitled to on the basis of existing capacity. In case of single product-firm these opposing tendencies may not cancel.

iii) The product coverage of MSP while is fairly large, is not yet comprehensive. For some of the products while production figures are available; the installed capacity figures are not available.

iv) The basis of estimation of capacity is largely based on the judgement of the reporting units and that of DGTD Engineers. It is very difficult to say what precise notion of capacity these figures imply.

II) Annual Survey of Industries (ASI)

The ASI is replaced for the census of manufacturing industries (CMI) and the sample survey of manufacturing industries (SSMI) in 1959. ASI gathers statistics about installed capacity besides several other important variables from the census sector which includes factories employing on any day 50 or more workers and using power or 100 or more workers and not using power.

The capacity data are neither for the product nor for the unit. For every item-machinery the capital dimensions of that item are collected. But these data have never been published. Koti & Sowayajulu (1967) have analysed this data for Maharashtra for the year 1959 from the ASI schedules. However, these data by themselves are not useful for capacity estimation of a product as transition of capacity estimates from that of different machines to a units capacity is beset with many difficulties which are almost insurmountable.

III) The Bureau of Public Enterprises

This is another source of information on capacity and its utilization; but this is related to only public enterprises. The material collected from individual enterprises, are analysed and presented through different volumes. This source considers the financial year as the reference year. In this source the installed capacity utilization is given at plant level; but how the installed capacity was arrived at, has not been mentioned. The information is not confined only to the manufacturing sector as is the case with MSP but also mining items like iron-ore, coal etc. are covered.

Industrial Development Bank of India in its annual reports gives the capacity utilization data for the units for which it has provided financial assistance.

There are number of publications pertaining to different industries issued by industry organisations which give valuable

data on capacity. The textile, cement are some of the important industries for which such data are available.

3.3 Studies in India

There are various studies made in India, some of them at plant level or industry level and some of them covering the entire manufacturing sector. While a large number of them are journalistic articles, there are some methodologically important studies (for e.g. cotton textiles...) done for some products by academic researchers. Here the review is confined to major studies covering the entire manufacturing sector over a period of time.

1. Economic Division of Planning Commission (1955)

This is an early study on capacity utilization and was done by the Economic Division of the Planning Commission in 1955. The installed capacity approach is used and the MSP is its major data source. It covers 53 products for the period 1946 to 1954. It also classifies the products into three groups, that is consumer goods, durable consumer goods and producers goods industries, and it gives their unutilised capacity. The utilization rates vary a great deal over the products from 1% (in case of steel tubes) to 102 to 164% (steel ingots & metal for casting, 1952; Bicycles, 1952). Such wide fluctuations in the early period of planned are understandable. This study draws attention to the necessity of creating balanced creation of capacity.

The study had not aggregated the utilization ratios of the individual products. The overall index of capacity utilization is not given.

2. Morris Budin & Samuel Paul (1967)

In this study 75 industries are considered whose installed capacity data are given in MSP. The capacity estimates are based on the shifts pattern as given in MSP. Industries are classified according to shifts; 17 industries installed capacity is on the basis of three shifts and two industries capacity is on double shift basis and 56 industries capacity is given on the single shift basis. The study covers the period 1951 to 1959.

The study has shown inter industry variation in capacity utilization. Industries are classified into (1) Infrastructure industries, (2) Intermediate goods industries, and (3) Consumer goods industries. In case of infrastructure group industries e.g. steel and pig iron production, the utilization varies from 80 to 90% of capacity over the period. The other metal industries show high utilization rates throughout. In intermediate goods industries three shifts or even two shifts operations are not wide spread. Capacity utilization on the basis of one shift operation has improved from 60% during first half of the decade to 81% in 1957 and 82% in 1959. On an estimated two shift basis it seems this category has an utilization rate of less than 60% even during the later

years of Second Plan. The authors say that this low rate is because of automobile industry; if it is excluded then this group shows its utilization of 70% in first five years and 87% in 1958 and 89% in 1959, on single shift basis. On the basis of two shifts the utilization rate is about 55 or 60% for the entire period.

In case of the consumer goods industries especially paper products and enamel ware, large excess capacities exist even in 1959. In this group the textiles, paper products and vanaspati are three industries operating on three shifts and the paper products and vanaspati had large unutilised capacity.

The study also computes the overall index of capacity utilization by using the value-added weights which are used in the official production index. The following formula is used

$$I_{ac} = \frac{\sum (O_n^i W^i)}{\sum (C_n^i W^i)} \times 100$$

Where O_n^i = average monthly output of the ith item in nth year

C_n^i = average monthly installed capacity as reported for ith item in the nth year and

W^i = value-added weight for the ith item as used in the official index of industrial production.

The capacity utilization series has been evaluated for the

period 1951 to 59, which show an increasing trend from 74.62% in 1951 to 91.53% in 1959. They also compute utilization series excluding the textile and jute (the major traditional industries) which shows similar trend. The authors ascribe increasing trend due to increasing governmental efforts, increased demand for goods mainly due to developmental projects.

Venkatramaiah P. and Argade L. (1985) in an unpublished note argue that the formula used by Budin & Paul does not give economy wide estimates of capacity utilization and that the formula is patently wrong. They criticise it saying that instead of using aggregation of ratios of individual products, Budin & Paul use ratio of aggregates.

3. N.C.A.E.R. (1966)

National Council of Applied Economic Research (NCAER) made a study for the period 1955 to 1964 covering 276 products which are classified into two major groups that is metal and non-metal; and all industries are classified into 17 groups of industries (at the two digit level) as in MSP. Major source of data is the MSP and Indian Textile Bulletins.

The estimation of installed capacity is on the basis of a particular number of working days in a year and for a particular number of shifts working per day. Depending upon the normal practice of operation of the individual industry, the working period is taken as 300 days for single and double shifts, 330 or 365 days for three shifts industries. Considering

this the percentage under utilization using the formula; $U = (1 - \frac{p}{c}) \times 100$ is calculated; where U = percentage under utilization of capacity, p = actual output and c = annual installed capacity. Out of 276 products for 16 products as data are not available, only 260 products have been actually considered. Then industry-groupwise unutilised rates are computed for the period 1955 to 1964 and the underutilization rates are given. Many products show over utilization of the capacity which seems very unrealistic.

This study also computes the overall index of percentage under-utilization for the entire period. For this purpose only 14 industry-groups instead of 17, have been considered.

In constructing these indices, first, group indices of underutilization for each of the 14 groups have been computed. To get these group indices, the weighted average of the percentage underutilization figures of the individual products has been computed, taking value-added weights from MSP. For only 140 out of the 276 products both the value-added weights and capacity output are available. In case of over utilization, these products are treated as having zero underutilization. After computing group indices for each of the 14 industry-groups separately; the overall index of underutilization of the total industrial capacity in India has been evaluated by aggregating the individual group per cent underutilization. This study shows that the capacity utilization is around 89% with no particular trend over the period. The weights are not

taken as capacity value-added weights but are based on the value added by production in 1956.

This study also computes the underutilization on the basis of desirable shifts given by the Perspective Planning Division (PPD) of the Planning Commission. The desirable shifts are decided on the basis of feasibility and techniques of production. The PPD has suggested multiple shifts pattern for 112 products only, of which 33 are to work on 3 shifts and 79 on two shifts. For the present study consulting the DGTD, 102 products are taken on two shifts basis and 38 products on 3 shifts basis. Thus 140 products are considered for multiple shifts operation and on this basis, as explained earlier, the overall index of underutilization of capacity has been computed for the period 1961 to 1964.

The underutilization indices of capacity based on desirable shift pattern are compared with actual shift pattern. The desirable working shifts pattern results in higher underutilization in all the years. In terms of the average, the present shift pattern shows 10.4% underutilization whereas desirable pattern shows 18.35% underutilization. That is the desirable pattern results in an increase of 8 per cent of underutilization.

In working out the capacity on the desirable shift pattern the authors take the capacity output for desirable double shift working as 1.8 times the single shift capacity and 2.7 times the single shift capacity in case of desirable

three shifts working. This, they did on the ground that it is not practicable to obtain exactly the same production in second or third shifts as can be obtained from the first shift. While this adjustment has merit, it is strange that the authors have not used these ratios in case of industries presently working on multiple shift basis. If this adjustment had been done the underutilization on basis of current working schedules would have been lower than the 10.45% reported by them.

According to Dhavan and Satyanarayana (1967) this study under-estimates the capacity utilization because of the method used to get annual output, multiplying monthly average output by 12, but this cannot be applied for capacity since it relates to the year-end month. Those industries which are utilising their capacity more than 100% are treated as having 100% utilization. This under estimates the overall index of capacity utilization.

4. Reserve Bank of India (RBI)

RBI had made two studies which are different from each other in various respects.

1) Installed Capacity Approach (1969)

In the first study of RBI the installed capacity approach has been used on the basis of norms of MSP. This study covers 163 products for the period 1963 to 1967. The main data source is the MSP; for 150 products MSP data for installed capacity and actual output are used and for the

other 13 products various other sources such as Reports of the Ministry of Petroleum & Chemicals, Annual Plans, Indian Textile Bulletin and Report of the Working Group on Oil Prices 1965 are used for installed and actual output. Then for tea and coal mining peak-output during 1963-1967 is assumed as capacity in individual years. The calendar year is used as the reference year for the entire period except for sugar industry and for which the fiscal year is considered.

All the 163 products are classified into three groups; (i) chemical, (ii) metal and engineering, and (iii) others. In this study in case of several products actual output exceeds the installed capacity output which is unrealistic. This study does not give overall index of capacity utilization for the manufacturing sector as a whole for each year. In their report they observe that the underutilization for all the industries together has increased from 17.7% in 1963 to 21.4% in 1967. For the chemical industries-group underutilization has increased from 29.5% in 1963 to 32% in 1967; in metal and engineering industries group the change is from 12.7% in 1963 to 23.2% in 1967 and in case of others the underutilization ratio has changed from 18.1% in 1963 to 19.4% in 1967. The study shows that over the period underutilization has increased.

This study also highlights the reasons responsible for the underutilization of capacity such as shortage of raw material, market demand, government policies etc.

11) Trends through Peaks (1970)

RBI's (1970) study had followed Wharton method. This study covers 72 industries which are broadly classified into two groups; use-based, and input-based industries. The use-based industries are further classified into four groups viz. basic industries, capital goods, intermediate and consumer goods industries. The input-based industries are subdivided into agro-based, metal-based and chemical-based industries. It defines the capacity output as "the peak (maximum) level of production attained for that industry at the point of time or prior to it at which potential is measured."

In this study monthly peaks are considered instead of quarterly, because of the availability of the monthly figures and monthly figures reflect industries' potential without additional investment better than quarterly figures and the monthly figures also reduce the amplitude of peaks.

This study has computed the overall utilization rates by using the value-added weights of 1960. Incidentally in this study 1960 is taken as the base year and it is the year in which output shows a high peak. As the value-added weights used pertain to the year 1960 which happens to be having a high peak of output, these weights reflect the capacity value-added weights. To get the capacity utilization index in this study the average production index is divided by the potential production index. In case of seasonal industries such as the salt

and sugar potential utilization refers to the average production to the potential production index for the year under reference.

Then potential utilization ratio for all manufacturing sector is compiled as the weighted average ^{of} at the ratios for individual industries; weights are the value-added figures. The potential utilization ratios are computed for manufacturing sector as a whole as well as for all groups of use-based and input-based industries. In case of all use-based groups the potential utilization ratios show decline. In case of basic industries it declines from 84.6% in 1960 to 83.2% in 1968, capital goods industries ratio declines from 76.8% in 1960 to 62.9% in 1968 and for intermediate goods the change is from 89.9% to 84.3%. Consumer goods industries ratio declines from 90.3% to 81.6% during the period.

In input-based group only chemical industries show improvement from 88.9% in 1960 to 90.0% in 1968. But in case of manufacturing sector as a whole, it declines from 80.7% in 1960 to 79.8% in 1967 which improves to 80.2% in 1968.

In this study the underutilization is ascribed mainly to shortage of raw materials and lack of demand.

In case of overall capacity utilization index, it shows a declining trend over the period from 87.7% in 1960 to 80.2% in 1968 with minor fluctuations. RBI had updated the series to 1973 on the basis of the same methodology covering five more years. The extended series shows that the situation

has deteriorated from 1968 to 73, i.e. utilization index declined from 80.2% in 1968 to 77.9% in 1973. But unfortunately RBI had stopped updating the utilization series since then.

5. Samuel Paul (1974)

In this study installed capacity approach is used. The study relies on MSP and ASI for data. The study covers by weight of manufacturing industries covered by MSP. For some of the industries production data from ASI is used but for those industries, for which installed capacity is not readily available are excluded from the study.

According to number of working shifts as adopted in MSP all industries are classified into three groups; the industries working for three shifts, those working for two shifts, and industries working only for single shift. According to Samuel Paul actually second and third groups industries are working more than the reported number of shifts. Therefore he assumes that second product group industries work 2.5 shifts per day instead of 2 shifts and for the third group industries two shifts instead of one shift and then he recomputes the installed capacity. Taking the ratio of actual output to recomputed installed capacity the utilization rates are computed for 42 groups of industries and are aggregated using value-added as weights. The rate of capacity utilization on the basis of MSP reported installed capacity seems to be around 80% but after adjusting for multiple shifts the average utilization rate is around 53% for the entire period.

The over-all utilization index increases from 50.4% in 1961 to 55.3% in 1970 and in 1971 it declines to 54.3%. This increasing trend is not in confirmity with the trend of other studies of RBI and NCAER.

In this study an attempt was made to explain capacity utilization by regression analysis using variables like market structure, pressure of demand, size of firm (fixed capital), import substitution, effective rate of protection (ERP), and import content of production. Using these variables an attempt is made to estimate capacity utilization for 1965 and to test the hypothesis that utilization rate is a function of the above six variables. But the fit was extremely poor, which may be because of the several approximation made in measuring the independent variables. This study shows that the market structure (monopoly or oligopoly) does not affect capacity utilization, which seems unrealistic. But this study attempts to explain the factors which affect the capacity utilization.

6. Nayar and Kanbur (1976)

This study uses the 'modified engineering approach' to capacity, using production function. In this study two types of production functions, Cobb-Douglas (CD) production function and Constant Elasticity of Substitution (CES) production function are used to compute two different series of utilization rates. Here various types of data sources are used to derive the required data. Mainly CMI, ASI, and year book of

International Labour Organization (ILO) are used. The output (Y_t) is taken as the gross-value-added concept rather than net-value-added due to non-uniformity in depreciation methods which are highly arbitrary. The capital stock (K_t) is also measured in gross terms. The gross fixed assets are defined as plant and machinery, buildings, miscellaneous assets such as furniture, fixtures, fittings, railway sidings etc. and land. The employment data i.e. labour (E_t) is taken from ASI & CMI which includes workers as well as the management personnel. Wages are directly taken from CMI & ASI. Wages include salaries and wages paid and money value of benefit and privileges enjoyed.

The values are expressed in 1949 prices. The index for deflating the values has been constructed from Net National Product at current and constant prices published by Government of India. The full employment supply of labour services (S_t) was extracted from the year books of ILO whose estimates are based on employment exchange data. The actual flow of capital services (K_{ut}) is obtained by deflating the gross fixed assets by labour utilization rates series; which is a minor variant of Klein's (1967) procedure of estimating capital utilization through labour utilization.

The coverage of the manufacturing sector is on the same lines as in CMI and ASI sources. CMI covers 29 major industries considering the factories employing 20 or more workers on a day and use power, and ASI census reports cover all the factories employing more than 50 with power or 100 or

more without power. The categories covered under the survey accounted for about 85% of India's total factory employment in 1959 and the period covered in this study is 1949 to 1965.

The finding of the study is that the both series show high rates of capacity utilization above 99% and the authors themselves agree that these utilization rates are very high, but they do not mention why this is so. Among the two series, CD series show slightly higher utilization than CES. Both the series show declining trend over the period from 98.63% in 1949 to 97.95% in 1965 in case of CD function and from 98.7% in 1949 to 97.50% in 1965 for CES function.

The data base of this study is extremely weak. Unutilised labour rates are based on employment exchange statistics whose limitations are well known. Capital utilization is derived from the labour utilization rates which themselves do not reflect the available quantum of labour. Further the authors mention that they used gross capital stock figures. Gross capital stock figures are not available from the ASI and CMI sources. In fact they are available no where. They do not say how they have obtained gross capital stock. If they have added depreciation figures to the base value it does not result in a proper estimate of the gross capital stock.

7. Economic Intelligence Service (1982)

The study made by economic intelligence service, of Centre for Monitoring Indian Economy (CMIE) had covered 620

products but mainly focus is made on 226 products due to non-availability of value-added weights for other products. MSP, ASI, DGTD, and various other company reports and bulletins etc. are the data sources. The period covered is from 1970 to 1980. Using the installed capacity approach the utilization rate for each product is obtained. This also gives the overall capacity utilization index which is the weighted average, in which value-added figures are the weights. The study shows a declining utilization over the period; from 85.2% in 1970 to 74.1% in 1978 and then the utilization goes upto 76.8 in 1980. There are minor fluctuations in the utilization rates. The CMIE is attempting to evolve a continuous regular and up-to-date series in capacity utilization. The study was updated to 1983 and projected utilization rate for 1984 is estimated to be 78.5%. The study shows an increasing trend of utilization in the eighties. The overall unutilized capacity is still large and is over 20%.

8. IDBI Estimates

The Industrial Development Bank of India (I.D.B.I.) gives capacity utilization estimates, in its annual reports, based on the data furnished by the units for which IDBI has provided assistance. IDBI covers 30 industries which are grouped into basic, capital & intermediate and, consumer goods industries. The 30 selected industries together have a weightage of 50.8% in the general index of industrial production. It might be noted that within each industry the IDBI

assisted units may account for only a small part of the industry's output. The reports do not mention how the capacity is assessed. Presumably they are based on installed capacity approach. The capacity utilization series are available from 1970 onwards on a regular annual basis. The series shows a declining trend of capacity utilization from 1970 to 1975 and from 1981 to 1983. Between 1975 and 81 the series shows fluctuations. The utilization of the capacity of 70% over the period is lower than the CMIE estimate of about 75%. This is to be expected as IDBI assisted units being new units might not have got over the teething troubles.

In the above we have reviewed studies dealing with capacity utilization covering the manufacturing sector. We now propose to briefly outline some related studies using input output and programming techniques.

Mathur (1969) using the unutilised capacity figures estimated from MSP and the 1963 input-output table for the Indian economy, estimates the investment necessary in different sectors of the economy so that the capacity of the machinery sector can be fully utilised. The study identifies the sectors in which the investment is necessary so that the economy can grow in a balanced manner.

Jayshree Shah (1977) using the RBI index of utilization rates and a 144 sector input-output table, tries to estimate, for the period 1960 to 73, the increase in final demand possible, if the capacity is fully utilised. Another study by

Mathur, Valavade and Kirloskar (1967) attempted to estimate capacity in case of multi-product/process industries. Data on time requirements on each of the machines for each of the products are collected from some units of the machine tool industry and using Linear Programming approach the optimum output was estimated. Different objective functions (maximization of production, value-added, contribution of overhead costs) were tried and utilization rates were computed. The data pertains to mid-sixties and 40 to 45 per cent of the capacity was found to be unutilised. The more interesting finding is that even with capacity output 35 to 50% of the capital equipment remains unutilised because of the imbalance of the equipment. While part of this imbalance can be attributed to the limitations of the model, the figures are too large to be ignored.

Gokhale Institute of Politics and Economics (Koti, 1968) made a study on capacity utilization for the year 1968 using survey method. The results were based on the replies received from 475 factories covering 517 products of which 199 products correspond to 117 MSP products. The economy-wide estimate of capacity utilization is only 50% compared to the RBI estimate (based on Wharton method) of 80%. This estimate is closer to that of Paul's estimate of 53%. Koti uses rightly the value of capacity output as weights for aggregation unlike many others who use production value-added weights. Koti's estimate looks to be very much on the lower

side. Apart from the non-representative character of the survey as the survey was conducted in a recession year it is likely that the respondents have over estimated under-utilised capacity.

3.4 Causes for Underutilization of Capacity in India

Though the focus of this study is on the measurement of capacity utilisation and not on the causes for the under-utilization of capacity, we enumerate below the causes for underutilization reported in various studies reviewed above.

According to C. N. Vakil (1955) it is the perpetual tendency of the firms to have reserve capacity to meet the sudden rise in demand. Technological indivisibilities of industries, the minimum possible extent of expansion may be substantially more than what is required. Underutilization of capacity may be because of the difference between expectations and the results.

According to Economic Division of Planning Commission (1955) the underutilization of capacity is due to the shortage of raw materials, basic inputs, and labour trouble. There is no effective publicity and advertisement to create favourable market conditions. Underutilization may be due to outdated machinery. Lower consumption demand which is constrained by lower level of consumers' income also affects utilization.

NCAER (1966) study reports that the shortage of foreign exchange is an important reason for underutilization.

According to RBI (1969) the licensing policy is responsible for permitting creation of capacity in excess of availability of raw materials and the market demand for products. Unbalanced growth of industries also is responsible for creating bottleneck problem which ultimately results in underutilization of capacity. The existence of uneconomic units is also responsible for underutilization of capacity through higher costs of production. Power shortage and transport bottlenecks also contribute to underutilization of capacity. The increasing prices of raw materials especially petroleum based raw materials even in 1969 affected various industries adversely in capacity utilization.

The effective rate of protection, size of the firm, and the import substitution are also important variables affecting capacity utilization (S. Paul, 1974).

The managerial shortcomings are also responsible for underutilization (B. Karim & B. T. Bhide, 1975) and it is especially true in case of public enterprises. The skill and availability of managerial personnel affects adversely the capacity utilization. The managerial deficiency has been emphasised as the utmost important cause for underutilization of capacity (R. Reddy & D. Reddy, 1975).

The lack of demand and the shortage of raw materials are important reasons (R. Koti, 1967) affecting 30.5% and

29.4% respectively, of total value of unutilised capacity and labour trouble accounts ^{try} 15%. Some natural calamities like fire, damage etc., are also reported in the survey as causes for underutilization of capacity.

According to CMIE (1982) the excess capacity already created is also one of the reasons for underutilization of capacity apart from the earlier mentioned reasons.

These are the important factors affecting capacity utilization over the period of time in Indian industries.

3.5 Conclusion

The different available estimates of underutilization of capacity in the organised manufacturing sector of the Indian economy are given in Table 3.1. The earliest available estimate is for the year 1949. In all 7 estimates covering different time span during 1949-84 are available. Two of them are based on Production Function approach, on trend through peaks and the rest five are based on installed capacity approach. Estimates based on Production Function approach show a very high level of capacity utilization (98%). This high level we suspect is due to the failure in getting proper estimate of capacity capital and labour. The rest of the estimates show considerable levels of underutilization varying from 10 to 20%. It may not be unreasonable to infer that 15% of the capacity remains under utilized more or less throughout the period. The more disturbing aspect is that there is no

increasing trend in capacity utilization. A capital scarce economy like ours can ill-afford so much unutilised capacity. It is strange that no official index on such an important aspect is available, though data on this aspect are regularly collected. The Central Statistical Organization should undertake to construct a capacity utilization index on monthly basis like Index of Industrial Production.

Table 3.1: Capacity Utilisation Estimates in the Organised Manufacturing Sector in India
(Per cent)

Sr. No.	Year	Estimates							
		Nayar and Kambur (1976)		M. Budin and S. Paul (1967)	NCAER (1966)	RBI (1970)	S. Paul (1974)	CMIE (1984)	IDBI (1981)
		CD fn. (1)	CES fn. (2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	1949	98.63	98.17	-	-	-	-	-	
2.	1950	98.63	98.17	-	-	-	-	-	
3.	1951	99.31	99.08	74.62	-	-	-	-	
4.	1952	99.31	99.08	76.99	-	-	-	-	
5.	1953	99.08	98.86	75.36	-	-	-	-	
6.	1954	99.08	98.86	82.27	-	-	-	-	
7.	1955	98.86	98.63	87.52	86.7	-	-	-	
8.	1956	98.66	98.40	92.16	89.0	-	-	-	
9.	1957	98.63	98.17	92.29	89.2	-	-	-	
10.	1958	98.17	97.72	89.12	84.8	-	-	-	
11.	1959	98.63	98.17	91.53	86.4	-	-	-	
12.	1960	98.40	97.95	-	88.2	87.7	-	-	
13.	1961	98.17	97.72	-	89.1	88.9	50.4	-	
14.	1962	97.95	97.52	-	90.4	88.5	N.A.	-	
15.	1963	97.72	97.05	-	89.4	86.7	55.2	-	
16.	1964	97.95	97.50	-	89.5	87.6	N.A.	-	
17.	1965	97.95	97.50	-	-	87.9	55.3	-	
18.	1966	-	-	-	-	83.2	51.9	-	
19.	1967	-	-	-	-	79.8	51.3	-	
20.	1968	-	-	-	-	80.2	53.0	-	
21.	1969	-	-	-	-	80.5	53.9	-	
22.	1970	-	-	-	-	80.4	55.3	85.2	
23.	1971	-	-	-	-	77.4	54.3	82.2	
24.	1972	-	-	-	-	79.6	-	78.2	
25.	1973	-	-	-	-	77.9	-	76.8	
26.	1974	-	-	-	-	-	-	72.5	
27.	1975	-	-	-	-	-	-	72.9	
28.	1976	-	-	-	-	-	-	74.8	
29.	1977	-	-	-	-	-	-	74.4	
30.	1978	-	-	-	-	-	-	74.1	
31.	1979	-	-	-	-	-	-	76.1	
32.	1980	-	-	-	-	-	-	76.8	
33.	1981	-	-	-	-	-	-	77.0	
34.	1982	-	-	-	-	-	-	75.9	
35.	1983	-	-	-	-	-	-	77.9	
36.	1984 (likely)	-	-	-	-	-	-	78.5	

Note : RBI (1969) estimates of capacity utilization based on installed capacity approach for the years is 82.3 for 1963 and 78.6 for 1967. Koti's estimate for 1968 based on survey data is 50%.

CONCLUSION

In a general sense the term capacity is defined as the maximum output that can be produced with the available resources under normal conditions. But conceptually capacity is defined in various ways. Mainly there are two broad approaches to capacity i.e. Engineering and Economists'. In the first the technical conditions are mainly considered and not the costs, but in the second, mainly costs are taken into account.

The Engineering approach can be further sub-divided into two versions, namely, 'pure engineering approach' in which technical potential of equipment of firms are emphasised (Production function approach), whereas in second version 'modified engineering approach' in addition to technical conditions, non-technical factors also considered (installed capacity). This has various forms such as installed capacity, rated, attainable, licensed capacity and designed capacity.

The Economists' capacity mainly considers the cost. This has three different versions. Firstly L. R. Klein's version which uses the production function and prices in determining capacity output. Secondly Bert Hickman's version is based on the size of capital stock and relative prices in determining the capacity. The last version uses the marginal

costs, where the marginal cost is higher by certain percentage than minimum average total cost.

Capacity concept has time and technical dimensions without which capacity is difficult to define. Defining capacity calls forth certain assumptions such as uninterrupted flow of variable factors, constant technology, output in physical unit and normal practices of operation.

Though there are different approaches and versions to capacity, it is difficult to define it precisely. In case of economists' approach L-shaped cost curve poses the problem of assigning the minimum point on cost curve. As the engineering approach defines capacity as an index of all fully utilised factors of production, the problem of measurement of capital poses severe limitation on this measure. The problem of finding what the normal practices are is another problem. The economists' approach seems superior to engineering approach since whatever is technically feasible may not be economically profitable. But the economists' approach of measurement is more difficult because of the data requirements and estimation problems.

In spite of the many difficulties in defining the capacity, measurement of capacity is necessary. The capacity concept is useful in determining the economy's potential economic efficiency and to analyse the business cycles. Because of various approaches to capacity, there are different measures based on different approaches and versions of capacity. All

these measures are classified into different groups (which are not always mutually exclusive) on the basis of scope, concept, dominant variable, data source etc. There is no single measure which is an ideal one. The 'trends through peaks' measure seems to be better one among all the measures.

In Indian context various studies have been made, by using different methods, but no attempt has been made to compute regular and continuous series of capacity utilization rates over the period. The different studies show different economy-wide estimates for the same time period. The maximum number of studies are based on the installed capacity approach. The estimate based on the production function technique, shows higher utilization than all other studies. The estimates based on installed capacity with the shifts adjustment shows minimum utilization rates. The other estimates based on installed capacity and trend through peaks methods show the capacity utilization rates which fall in between the higher and lower utilization measures.

Considering all these measures, it looks that at least 15% of the capacity of the manufacturing sector in India remains unutilised over the past three decades. A certain amount of unutilised capacity is necessary for price stability and this is estimated to be 5.5% by Paish (Pearce D. W. and Taylor J. 1968). Even allowing for this Indian manufacturing sector has substantial unutilised capacity which the economy can ill-afford. It is unfortunate that though adequate data base

exists for a regular compilation of the unutilised capacity index, no such index is compiled. The Central Statistical Organisation should undertake to compile a capacity utilization index on the monthly basis like the index of industrial production.

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