CHAPTER V

SIZE, CAPITAL INTENSITY, PRODUCTIVITY AND RETURNS TO SCALE.

5.1 Introduction :

The growth of the developing economies is often constrained by the scarcity of certain crucial resources. A developing economy often suffers from relative paucity of capital and plethora of labour. It is important, therefore, that these resources are used optimally. For maintenance of a high level of performance requires that the productive processes to be organized. They have to be so organized as to generate enough of surplus, to make for the progressively higher reinvestment potential in the future. This depends upon the efficient utilization of resources in the system.

It is well known fact that there exist more than one method of production for producing a given out put in majority of the cases. In this context the productivity analysis acquires great significance. The methods of production, may be distinguished on the technological characteristic of combination of the factors of production. Thus, such evaluation would raise questions pertaining to the relationship between capital intensity, labour intensity and productivity. The techniques of combination of capital and labour would produce the output and on the productivity of capital and labour employed.

The concept of productivity is based on the assumption of unique technological relationship between inputs and outputs.

This relation between inputs and outputs have been summarized by economists as the production function. Therefore the production function in brief deals with the set of technical relationships which govern the maximum quality of measurable output that can be obtained from a given set of inputs. With a given technology the inputs are transformed into outputs. For a given technology, there is a maximum amount of output that can be produced with given amounts of inputs. Production above this maximum is not possible. The production function at a specified level of technology summarizes the series of maximum output level corresponding to different levels of inputs. Thus, one can define a production function for an industry, giving output as a function of factor inputs and the level of technology.

The productivity analysis aims at isolating the contribution of different factors of production to output from such increases in output which can not be accounted for the increase in the quantity of input factors. Salter[1] provided one of the earliest analysis in this direction. The concept of `best productive technique' was introduced by him. The best practice technique was defined as the technique which happened to be the optimum with reference to both the technical as well as economic conditions prevailing at the time. With changes in techno-economic conditions the `best practice technique' must also change. This analysis by salter suggested a very plausible hypothesis for

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1. Salter, W.E.G., "Productivity and Technical Change", Cambridge (Press), 1960.

explaining productivity change but did not lead to any concrete econometric formulation for measuring productivity.

To determine the precise roles of influences by the factor inputs, one has to assume a precise functional relationship, describing the productive process. Therefore, at the base of any attempt of measure productivity and analyse its sources lies the concept of a production function, which gives the efficient set of unique relationships between inputs and output. The concept of production function is indispensable even for the most elementary measures such as output per unit of labour. This is because without an unique relationship between labour and output, the labour productivity cannot be interpreted in a meaningful manner. Similar is the relationship between capital and output.

The simplest indicators of productivity are the partial productivity measures derived by dividing the output by the relevant input. Therefore, there can be as many partial productivity ratios as there are inputs. The commonly used indicator is the labour productivity index, though economists consider capital productivity as a better index. While labour productivity does show the efficiency with which labour is being utilized, it is important not to interpret it as having been caused by labour alone. The labour productivity has to be understood as a product of a whole lot of inter acting economic relationships.

Various studies of Indian Industries attempted to measure the technical change. This has been done both through simple ratios or productivity indices of capital and labour and of capital per labour and through production function approach. Total productivity has been calculated by production function approach. Total factor productivity and technical progress, are synonymously used in the literature. Timberagen introduced the concept of Total Factory productivity (TFP) as the ratio between real product output and real factor inputs together for an international comparison of productivity growth, Stigler[2] developed the concept suggested to measure real total factor input by weighing real capital and real labour by their marginal products. The various TFP measures differ on account of differences in the underlying production function.

In addition to partial productivity indices, the total productivity measures are used in economic analysis. The total productivity measure take account of both capital and labour. These are supposed to reflect 'residual' or 'Technical progress' which cannot be attributed to either of the two factors, i.e. capital or labour. Compared to the partial productivity indices the total productivity methods are necessarily more exact in the sense that they provide us with a 'measure' of technical progress under certain assumptions, which are realistic and at times

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2. Stigler, B.J., "Economic problems in measuring productivity", in <u>Input, Outpput and Productivity Measurement</u>, Studies in Income and Wealth, Vol. 25, NBER, 1961.

unrealistic. For arriving at the total productivity indices different variations of production function are used. Total productivity was also calculated using Solow[3] and Kendrick[4] methods. Considerable work has been done on the theoretical and empirical problems of estimating the production functions of the Indian industries. These studies were mainly aimed at analysis of the contributory factors of output growth, returns to scale, partial and total productivity indices, technical progress, elasticity of substitution etc., with this back ground let us take a view of the present study the problems analysed.

Majority of the past studies sought to compare scale implications, have used industry aggregate data. The use of such data would be justifiable if the products made in these sectors were homogeneous. A comparison, when products made are similar has obviously greater validity. In addition majority of the earlier studies had serious problems regarding capital valuation. In this chapter, an attempt is made to analyse productivity aspects of small scale chemical enterprises. While doing so, some of the limitations of the past studies have been over come.

The study analyses the capital intensity of various categories of chemical enterprises. It is generally observed that

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3. Solow,R.M. "Some recent developments in the theory of production", in , The Theory and Empirical Analysis of Production, 1967.

—— 'Technical Change and Aggregate Production Function'. The Review of Economic and Statistics, 1957.

4. Kendrick,J.W., "Productivity Trends in the United States", NBER, 1961.

chemical industry being a modern industry even the small scale enterprises in this industry are capital - intensive. With higher use of capital in combination with other factors of production, the productivity of the factor inputs rise. In the present analysis the partial productivities are estimated (output-capital ratio and output labour ratio) for different chemical industrial categories.

Productivity and size is another aspect that has been dealt in detail in the literature on small scale enterprises. The results arrived at are contradictory in nature. In the present analysis this aspect is examined for various chemical industrial categories. Here size is denoted by the capital invested.

The laws of production describe the technically possible ways of increasing the level of production. The technical relation between factor input and output is denoted by production function. The present study intends to study the returns to scale in chemical enterprises. When the returns to scale indicated by the production function is favourable, it is profitable for the firm to expand production. In this study Cobb-Douglas production function is fitted for chemical enterprises and tested for returns to scale using Tintner's test.

The choice between alternative scales of production is confined to product lines, which can be manufactured both in large as well as small sectors. If industries are arranged according to their capital intensity, manufacturing costs and the final demand for the products, it may be found that only small scale units are a natural choice in certain industries. similarly in certain other manufacturing lines, only large scale units may be appropriate due to over whelming advantages of scale or unsuitability of small scale technology. This is borne out by the structure of Indian industries. In certain manufacturing lines, the small sector accounts for the entire capacity, while in certain other lines, only large scale units are functioning. Therefore the question of choice arises only in the product lines which can be made in both sectors.

A number of chemicals are manufactured both in large scale and in small scale sectors. Even among the small enterprises producing a particular type of product, the average cost of production varies with level of output, nature of plant and technology adopted. If the average cost of production falls with increasing size, then firms are said to be facing economies of scale, as a result firms only gain by expansion. Thus firms have an incentive to grow from smaller to medium into large scale unit.*

Before we take up the analysis and discussion it would not be out of place to discuss the various problems involved in measurement of factor inputs capital and labour. Most of the studies based on CMI and ASI data, report the book value of

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* Cost equations are fitted with linear quadratic equation for chemical enterprises. The results are presented in Appendix - 5A.

fixed capital. These studies have not made price adjustments for capital and therefore the conclusions reached by them could be misleading. Methods have been evolved to do the price adjustment and adjustments for depreciation. For computing realistic ratios of capital intensity, plant level information is needed. There are also certain problems pertaining to the representation of labour. Labour as a factor input include both workers as well as persons holding positions of supervision of management or employed in confidential positions. The term labour include both skilled and unskilled labour. As the productivity of one category differ from that of every other category of labour, aggregation of these would not be appropriate. The remuneration paid to each category of labour is assumed to be a proxy of the productivity of labour. Therefore, the remuneration could be used as a proxy. In the present study we have taken man days of labour employed to represent the labour input. Some of the partners in the enterprises and their family members were found working in the enterprises and were not taking any remuneration. Therefore, it was divided to take man days of labour worked as a representative of labour input instead of wage payments.

Measurement of capital poses number of problems. Capital as a factor of production is defined as a 'produced means of production'. Hence the concept of capital adopted here consists of only physical assets which are produced in the economy and are used for further production. Hence at any moment of time capital consists of fixed assets like machines and buildings and circulating assets like consumable stores. The problem of valuation enters when one refers to the value of fixed assets only. Inventories or circulating assets being measured at current price and therefore not facing the problem of depreciation as the former assets do. Views differ in case of the inclusion of `land' in fixed assets and `cash and bank balances and other liquid assets' in circulating capital. In this study we exclude both of them from the capital concept. In manufacturing sector land has a limited role i.e. that of providing space for activities and its productivity does not matter much.

Capital goods are built at different times at different costs and with different performance characteristics.[5] How are these measured in constant prices ? Hashim and Dadi[6] have summarized the problems involved in defining and measuring capital in five main reasons. They are :

(i) "Capital is a composite commodity" made up of different types of capital goods-each with its own characteristics and durability:

(ii) The composition of this "composite commodity" keeps on changing over time. A machine which goes out of productive use may not necessarily be replaced by the same type of machine. It might be replaced by altogether a different type, perhaps more productive, and yet not necessarily more costly. Thus this problem is the product of change;

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5. Denison, E.F., "Why Growth Rates Differ ?". The Brookings Institution, 1967.

6. Hashim, S.R. and Dadi, M.M. "Capital - output Relations in Indian Manufacturing", 1946 - 64. Baroda : The M.S. University of Baroda, Press, 1973.

(iii) The future productivity of capital is not exactly measurable, since a capital asset is productive over a considerable period of time and future is unpredictable. This renders utility measurement of capital goods immensly difficult;

(iv) The capital stock existing at any time has no linkage with current market valuations ....

(v) The productivity of a capital asset might not remain the same over its life time this renders it difficult even to measure the capital with reference to its original cost. This raises the controversy over the methods of depreciation and the concept of replacement costs.

There are different approaches to the measurement of capital such as (a) the discounted future income stream to be derived from it (b) labour time expended in the past i.e. the cost of producing a capital asset (c) replacement cost etc. Each of these methods have their merits and demerits.

For the purpose of this study, we have defined capital as only physical assets which as used for further reproduction, which consists of fixed assets and circulating assets. The fixed assets have different age structures. Therefore, the problems of valuation refers to them only. At this stage one has to choose between two alternative values of fixed assets viz. gross fixed assets (gross of depreciation) or net fixed assets. Gross fixed assets represent the (purchase price) original cost of assets while net fixed assets represent an idea of declining productivity of capital over the passage of time. The accounting practise use, measuring the declining productivity of capital (Annual survey of Industries report net fixed assets, i.e. depreciated capital). This is simply arbitrary and misleading.

Firms expenditure on maintenance and repairs of fixed assets are under taken for keeping the productive capacity more or less same. Hence these expenditures can be treated as reinvestment and hence there is no necessity to deduct depreciation from gross value of capital stock. For estimating the value of fixed assets at current prices, one needs the historical original costs converted into current prices. This method is followed in the present study.

The original purchase price of the fixed assets and the subsequent additions to the capital have been collected for each firm, by the year of purchase. These purchases by the firms for each year have been expressed at 1984-85 prices using RBI price index.[7] To this value, we add the inventories which are at 1984-85 prices. This value is represented as capital invested in a firm.

5.2 Studies on Productivity and Returns to Scale : A Brief Survey.

One interesting field of extensive study has been the relative efficiency or productivity of modern small scale enterprises vis. a - vis large scale Units.

Various studies have compared the efficiency levels of small scale and large scale enterprises through the inter relationships between capital and labour, and output and surplus.

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7. Reserve Bank of India Bulletin, Reserve Bank of India, Statistical division.

The conclusions, however have been conflicting. One of the earliest studies was by Dhar and Lydall.[8] It compared the output-capital ratios for a number of reasonably homogeneous industry groups depicting size variation. On the basis of the exercises, Dhar and Lydall concluded that "for factories which employ 20 or more persons, output-capital ratios increase with the size of the unit. Compared to unregistered small scale enterprises also the relative position of modern small enterprises was noticed to be unfavorable. It was found that for enterprises employing less that 20 workers, the output - capital ratio was generally more favorable than those immediately above them, but not necessarily more favorable than large enterprises. Thus, Dhar and Lydall found small scale units, using modern machinery and hiring upto 50 workers, to be the most capital intensive type of enterprises. Similar findings were reported by Hajra.[9]

Sandesara[10] studied the scale and efficiency correlates over time 1953-1958 and covered 28 industries. Sandesara examined the relationship between various important ratios like capital-labour ratio and capital-output ratio and also between size and

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8. Dhar,P.N. and Lydall, H.F., "The Role of small Enterprises in Indian Economic Development", 1961, Delhi, pp. 10 - 32.

9. Hajra, S. "Firm Size andEfficiency in Manufacturing", The Economic Weekly, Aug. 1965.

10. Sandesara,J.C., (i) "Scale and Technology in Indian Industry", Bulletin of the Oxford University Institute of Economics and Statistics, 1966, 22, pp. 181 - 198.

    (ii) ---"Size and Capital Intensity in Indian Industry", 1969, Bombay, p. 24 - 36.

other economic characteristics like output, wages and surplus each per worker and unit of Capital. Sandesara's study revealed lack of positive association between size and capital intensity, but a positive association between size and output- capital ratio, and thus provided further evidence supporting the conclusions earlier reached by Hajra;[11] Dhar and Lydall.[12]

The approach and inference drawn by Dhar and Lydall, Hajra, and Sandesara, however have been disputed. Mehta[13] doubted the efficacy of measuring size variation by employment in.units, for this did not rule out the possibility of sick or ailing large scale units employing only a skeleton staff,and new units, under going teething troubles, being classified in the small size group. In his study, mehta examined capital labour and output capital rations for three size classes, according to fixed assets using ASI data for 32 industries for the period 1960-63. He found that in almost all industries capital labour ratio increased with size, labour productivity was also generally found to increase with size but not in the same proportion as capital intensity and as a natural corollary, output - capital ratio was noticed to decrease with size.

The conflict between the findings of mehta and those of Dhar-Lydall and Sandesara is some what baffling. This can not be

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11. Hajra - op.cit. Economic Weekly, Aug. 1965.

12. Dhar and Lydall - op.cit.

13. Mehta, B.V. "Size and Capital Intensity in Indian Industry", Bulletin of the Oxford University Institute of Economics and Statistics, 1969, 31, 189 - 204.

attributed to differences in the time period covered or in the sources of data. The difference in findings may partly be explained by the fact that while Dhar and Lydall, and Sandesara used total productive capital (fixed plus working) for measuring capital input, Mehta used fixed capital. Since the ratio of working capital to fixed capital is high in small scale units, efficiency comparisons based on fixed capital favour small scale units.

In her study, Bhavani[14] examines the relationships between the scale of operation, technology, capital intensity and relative efficiency drawing the data from the ASI and census of small scale Industrial units (CSSI)[15] for 46 industries. She finds that, in most cases, labour productivity and capital intensity in the census sector (which includes large scale units) exceeds those in sample sector and the CSSI. The ratio of value added to fixed capital in the census sector exceeds that in the sample sector for 31 industries and this pattern holds between the census sector and the CSSI for 18 industries. Clearly, the efficiency comparison between the census and the sample sectors of the ASI in Bhavani's study do not agree with Mehtas[16] study mentioned earlier and they are more in line with

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14. Bhavani,A. "Relative Efficiency of the Modern Small Scale Industries", M.Phil., disseration, University of Delhi, January, 1980.

15. Government of India, Development Commissioner, Small Scale Industries, 1976 - 77. "All India Report on the Census of Small Scale Industries", Volumes 1 & 2, New Delhi.

16. Mehta - op.cit. pp. 189 - 204.

the findings of Dhar-Lydall[17] and Sandesara.[18] Kurien[19] has observed that there is no a priori theoretical reason why a unit operated on smaller scale should be more labour intensive or for the matter capital intensive, than one operated on a large scale.

Bimal Jalan[20] has done some welcome research from unpublished data compiled in the course of the Annual survey of Industries, found that while the tiny sector (i.e. unit with Rs. 0.1 million capital) had the most favorable capital output ratio in a number of industries; out of 16 groups of industries considered, in as many as 11, the small scale sector had a higher capital output ratio than either the large scale or the tiny sector.

The RBI survey[21] of small industries (defined by capital) suggested that the large small scale (greater than 20 workers) have higher capital productivity than the small of the small scale units.

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17. Dhar and Lydall - op.cit.

18. Sanderasa - op.cit. pp. 181 - 198.

19. Kurien, C.T., "Small sector in New Industrial Policy", Economical Political Weekly, 4th Month, 1978.

20. Jalan,Bimal. N., "Productivity in Tiny, Small and Large scale sectors : A note": Economic and Political Weekly, Bombay, 20th May, 1978.

21. Reserve Bank of India, "Survey of small Industrial units, 1977", Department of Statistical Reports, Vol I & II, Bombay, 1979.

One study[22] compares the factor ratios and productivities for the SSI and the ASI, and concludes that the results are not particularly favorable to SSI. In the ASI data, one finds that the size class 200-500 employment, very nearly dominates all other size classes in having both higher labour and higher capital productivity.

Golder[23] in his study finds that the SSI (compared to the large scale establishments) generally have low labour productivity. He infers that the modern small scale sector is inefficient relative to the large sector in a large number of industries. He also finds that the relative efficiency of the SSI varies directly with the capital intensity, so that the SSI can not be relied upon as a source of efficient employment generation.

The study by Little and others[24] conclude that the hypothesized relationships between unit size and factor productivities / intensities fail. The smallest size class is quite often not the most labour intensive, nor does it have the highest capital productivity. There is considerable evidence from

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22. Shetty,S.L., "Industrial Growth and Structure", Economic and Political Weekly, October 2 & 9, 1982.

23. Goldar, Bishwanath "Relative efficiency of modern small scale industries in India", in Small Scale Enterprises in Industrial Development : The Indian Experiments (ed.) K. B. Suri., Sage Publications, 1988.2

24. Little, I.M.D., Dipak Majmudar, John Page, "Small Manufacturing Enterprises : A Comparative Analysis of India and other Economies", Oxford, 1987.

the most of the developing countries that in many industries the medium class 50-500 workers is the most beautiful.

The conclusions drawn by most studies are in aggregative terms without adequately reflecting the contrast among different size units. The inconclusive nature of the evidence also suggest the need for further statistical enquiries. But such studies should seek, identification of those homogeneous product lines in which scale economies appear to exist and those which are neutral to scale or where small plants show definite advantage. However, if the elusive concept of efficiency of different scales of production has to be measured, one may have to resort to engineering cum economic approach, and concerns itself with actual operations at the firm level.

The studies on production function have estimated Cobb - Douglas (CD), constant elasticity of substitution (CES) and variable elasticity of substitution (VES) production function for time series and cross section data. These studies emphasized on the estimation of the parameters and based on it, the relavent economic inferences are drawn. Let us take a view of some of these studies.

5.2.2 <u>Studies on Returns to Scale</u>

Many of the earliest attempts used the total industry aggregate data on inputs and outputs to estimate the production function and quantified the economies of scale in terms of return to scale parameter. The later attempts are for individual industry groups mostly to test the existence of economies of scale. More often, the Cobb – Douglas production functon has become handy for testing the economics of scale.

Studies Bringing out Constant Returns to Scale :

One of the early studies on Indian manufacturing production function in that of Dutta[25] who found evidence infavor of constant returns to scale for Indian manufacturing on the basis of cross section data for 1946-47. Murti and Sastry[26] estimated Cobb-Douglas production function with cross section data for the industrial sector as a whole, as well as for some groups of industries for the years 1951 and 1952. Data used was of 320 firms of 28 manufacturing industries. The hypothesis that the sum of elasticities of output which respect to labour and capital might differ from unity was rejected, indicating constant return to scale at 1% level of significance for each industry group, except for Jute Textiles production function estimated for total industry indicated the constant returns to scale or the sum of two elasticities was not statistically different from unity.

Dutta Majumdar[27] arrived at the constant return to scale of total industry, on the basis of a time series study for the

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25. Dutta,M.M., "The production function for Indian Manufacturing", Sankya, 15, 1955.

26. Murti, V.N. and Sastry,V.K. "Production function for Indian Industry", Econometrica, 25, 1957.

27. Dutta, Majmudar, D., "Productivity of Labour and Capital in Indian Manufacturing during 1951 - 1961", Arthaniti, 1966.

period 1951 to 1961. Aggregate studies of Dadi and Hashim[28] also found evidence of constant returns to scale in Indian industries. Narasimham and Fadrycy[29] gave estimates of return to scale of 28 Indian industries for the period 1946 to1958 using three different functions: Cobb-Douglas, CES and Homothetic Isoquant, and showed constant returns to scale in all 28 Indian Industries individually and together.

Studies Bringing out Increasing Returns to Scale :

The Yeong Her Yeh study[30] used many different specifications of Cobb-Douglas production function and showed that Indian Industries together enjoyed large economies of scale. His study covered the period, 1953-58 and inferred increasing return to scale. Diwan[31] also produced supporting evidence of increasing returns to scale for 1953-1958. Diwan and Gujarat[32] using the constant elasticity of substitution production function found

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28. Dadi,M.M. and Hashim,S.R., "An adjusted capital Series for Indian Manufacturing, 1946 - 64", Anvesak, Dec. 1971.

29. Narasimham,G.V.L. and Fabrycy, M.Z. "Relative efficiency of Organized Industries in India, 1949 - 58", The Journal of Development Studies, 1974.

30. Yeong Her Yeh, "Economics of scale for Indian Manufacturing Industries", The Econometric Annual of the Indian Economic Journal, Vol. XIV, 1966.

31. Diwan,R.K. "Returns to seek in Indian Industry", Indian Economic Journal, Vol.15, 1966.

32. Diwan,R. and Gujarati,D. "Employment and Productivity in Indian Industries", Artha Vijanana, Vol.10, 1968.

high economies of scale during the period 1946-1958. Sankar[33] also found evidence of economies of scale in estimating the constant elasticity of substitution production function for 15 industries together covering the period 1953-58. Similarly increasing returns to scale was observed by Sakong and Narasimham.[34]

Banerjee[35] in his study of Indian Industries together for the period, 1946-1958, observed that the evidence regarding returns to scale was not categorical. However, he found statistically significant evidence of increasing returns to scale estimating the Cobb-Douglas production function with labour and fixed capital as determinants. But, the capital coefficients were not found to be statistically significant in cases of inclusion of other explanatory variables viz. capacity utilization and/or technical progress individually or together, which was in conformity with the earlier evidences.

There are number of studies analysing individual industries also. The estimator of returns to scale for individual

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33. Sankar, V., "Elasticities of substitution and Returns to scale in Indian Manufacturing Industries", International Economic Review, Oct. 1970.

34. Sakong, I.I. and Narasimham, G.V.L., "Inter - Industry Resources Allocation and Technology Change", The Developing Economics, June, 1974.

35. Banerjee, A. "Productivity Growth and Factor Substitution in Indian Manufacturing" Indian Economic Review, 1971.

---"Capital Intensity and Productivity in Indian Industry", Mc Millan, 1975.

industries showed considerable variation between different industries. All the major industries are covered by these studies. There are not many studies that have estimated production function for small enterprises and more seem to have estimated returns to scale.

5.3 Capital Intensity Size and Productivity of Chemical Enterprises :

It is often assumed that size and capital intensity and hence labour productivity are positively related. There are no ground for such assumption in the theory of production or of the firm. In a developing nation where capital is scarce and labour abundant, economy should be exercised in regard to the use of capital, with reference to the objective. If the objective is maximization of Income, the technique which yeilds maximum of income per unit of capital should be preferred; in other words, the one which has the lowest capital output ratio. There is no a priori theoretical reason why a unit operated on smaller scale should be more labour intensive or for that matter capital intensive, than one operated on large scale.

In a developing nation like that of India the factor markets are more imperfect than developed nations. This imperfection is explained by a variety of reasons. As a result the price of capital tends to be low to that of labour than, it would otherwise be. Capital-intensive techniques are adopted, but if markets were perfect labour intensive techniques should have been adopted. In these nations the product markets, are relatively perfect less imperfect than factor markets. Therefore, the products produced by labour-intensive techniques can not compete in the market with products produced with capital intensive techniques. There is a reason to belive that an industry which is capital intensive is run on modern lines using sophisticated processes. The industries using sophisticated technologies have more capital backing the labour, hence resulting in higher labour productivity. In the real sense, the increase in productivity can not be attributed to labour alone, but also to other factors which back labour. In case of labour productivity estimated, other things do not really remain constant, as the theoretical assumptions make.

Table - 5.1 gives the capital intensity and labour productivity in chemical industries. The characters of he chemicals vary hence their production process are expected to exhibit different characters. The data reveal that, overall the chemical enterprises exhibit high capital intensity. The capital employed per man day of work is found to vary from Rs. 324 in other chemicals to Rs.650 in Fertilizers and pesticides. High capital intensity could be because of the nature of chemical industry and partly could be because capital is measured, at the gross purchase value expressed at 1984-85 prices. The capital requirement per unit of value added varies from 1.5199 in soap and cosmetics to 2.4716 in organic chemical industry. Labour productivity is also presented in the table by the industrial

Table 5.1 : Capital intensity and productivity of labour for different categories of chemical enterprises.

	Captial per man day of labour (K/L)	Capital Coefficient (K/Y)	Capital-output ratio (K/V.A)	Labour Productivity (VA/L)
Inorganic Chemicals	343.88	0.5322	2.4752	138.93
Organic Chemicals	396.09	0.6566	2.4716	160.26
Fertilizers and Pestidies	650.02	0.5186	2.4402	266.38
Dyes and Paints	434.87	0.4617	1.7316	251.14
Drugs & Pharmaceuticals	548.66	0.6553	2.2707	241.63
Soaps and Cosmetics	375.33	0.4073	1.5199	246.93
Other Chemicals	324.11	0.4443	1.5230	210.87

Where
K - Capital employed (Rs.).
L - Mandays of labour employed.
V.A - Value added generated (Rs.).
Y - Total output produced (Rs.).

category. Labour productivity is found to be highest in Fertilizers and pesticides and lowest in Inorganic chemicals Industry. It is observed that Inorganic chemical industry exhibit low productivity for both capital and labour. This indicates the relative inefficiency of this industry in comparision with other industries. The Inorganic chemicals also exhibit low capital intensity, indicating greater use of labour per unit of capital. This industry is more labour absorbing, however with low productivity. For other industrial categories,one does not find a definite relation. Soap and cosmetics industry which exhibit low capital intensity, exhibits relatively high labour productivity. This indicates that soap and cosmetics industry despite its labour intensive nature, has high productivity. Therefore, in addition to the capital intensity the nature of the industry has much role in determining the productivity in the same.

If there is one concept that has dominated the discussions on the growth theory and development plan, it is that of the capital output ratio. Capital output ratio maybe defined as a relationship between investment in a given industry for a given time period to the output of the industry. According to traditional economic theory, the increase in the capital per head with no increase in technical knowledge will sooner or later yield to diminishing returns. Attempts to test this theory indicated that output had grown roughly in proportion to capital in advanced countries over decades and seemed to substantiate the theory of constant capital output ratio over a long period.

In the literature of economic development labour intensity is indirectly estimated through a study of capital intensity. Capital intensity could be measured in terms of capital output ratio i.e. the amount of capital required for producing a unit of output. Capital intensity is also measured as capital required per worker. In this section our interest is to analyse the capital-output ratio by size of firms. Various studies have reported, contrary to the popular belief, that capital intensity show an inverse relation to size of the firm. Some of the recent studies too have reported similar findings. Among the small enterprises, the modern industries are found to be more capital intensive.

Capital coefficient measures the amount of capital required for producing a unit of output. The capital coefficients for various categories of chemical enterprises, by their size are presented in table 5.2. Here the size of firm is denoted by the capital invested. The results indicate that for the chemical industry as a whole, it is the firms in middle investment levels that have lower capital per unit of total output. Except in two industrial categories, viz, organic chemicals and fertilizers and pesticides, in all other industrial categories the smallest of the small enterprises require greater amounts of capital per unit of total output. The general pattern that can be observed is that the firms in middle investment groups require lower amounts

Table 5.2 : Capital required per unit of total output (capital coefficient) in chemical enterprises by capital invested.

Capital Invested	Inorganic Chemicals of labour	Organic Chemicals	Fertilizers and Pesticides	Dyes and Paints	Drugs and Pharmaceuticals	Soaps and Cosmetics	Other chemicals	Pooled
Upto 3 Lakhs	0.5657	-	0.2125	202857	-	0.6069	0.6330	0.5968
3 to 5 LAkhs	0.1912	0.3208	0.5562	0.6305	0.6657	0.4978	1.4001	0.4227
5 to 10 lakhs	0.3769	0,5772	0.3178	0.5713	0.3559	0.2890	0.4728	0.4392
10 to 15 lakhs	0.6725	1.0314	0.6235	0.1769	0.4804	0.7185	0.2537	0.4406
15 to 20 lakhs	0.6290	1.0641	0.3549	0.2638	0.6620	-	0.6035	0.5064
20 to 25 lakhs	0.5977	0.8888	-	-	0.5825	-	-	0.7913
25 lakhs	-	0.6234	0.6143	0.7222	0.7459	-	0.9483	0.7046
Industries	0.5322	0.6566	0.5186	0.4617	0.6553	0.4073	0.4443	0.5390

Where

K - Capital employed (Rs.).
L - Mandays of labour employed.
V.A - Value added generated (Rs.).
Y - Total output produced (Rs.).

of capital per unit of total output. For the chemical industry, one finds firms in Rs. 3-5 lakhs investment range require lowest amount i.e. Rs. 0.4227 of capital per unit of output. The largest of the firms are generally found to exhibit highest capital coefficients. A similar observation is made when firms are arranged according to size, using employment criteria.

In economic sense output generally means the value generated in the process of production. it is also called value added. Capital-value added ratio gives the capital required to generate a unit of value added. This is generally termed as capital-output ratio in economic literature. Given the technology the aim of the firm is to attain lowest capital-output ratio.

Capital-value added ratio for chemical enterprises by size, when size is denoted by capital invested is presented in table 5.3. The results indicate that capital-value added ratio is high for large firms. In case of organic chemicals and; fertilizers and pesticides the capital value added ratio is lowest for the smallest of the firms. In all other industrial categories the lowest capital required per a unit of value added generated is in the middle sizes. In two industrial groups Inorganic chemicals and organic chemicals the capital-value added is found to be lowest in Rs. 3-5 lakhs investment range. In case of Drugs and pharmaceuticals Soap and cosmetics the minimum is in the investment range Rs. 5-10 lakhs. For all chemical enterprises (Pooled) also the capital value added ratio is found to be lowest in Rs. 5-10 lakhs investment range. Generally the largest sized

Table 5.3 : Capital value added ratio in chemical enterprises by capital invested.

Capital Invested	Inorganic Chemicals	Organic Chemicals	Fertilizers and Pesticides	Dyes and Paints	Drugs and Pharmaceuticals	Soaps and Cosmetics	Other chemicals	Pooled
Upto 3 lakhs	2.4058	-	0.9320	5.9328	-	2.3886	2.8814	2.4688
3 to 5 lakhs	1.3107	0.6536	1.8900	5.3432	1.0141	2.8532	3.6210	1.9049
5 to 10 lakhs	2.7724	2.3961	2.1109	1.3840	0.5931	0.9687	1.5881	1.5738
10 to 15 lakhs	1.9172	4.0846	5.6374	7.6632	3.4844	2.8742	0.8801	2.0710
15 to 20 lakhs	3.0444	1.9562	1.0815	1.2546	3.3287	-	1.5658	1.7463
20 to 25 lakhs	3.9958	4.5022	-	-	1.0985	-	-	2.2544
25 lakhs +	-	2.5319	3.1002	2.0645	2.9680	-	5.5317	2.8497
Industries	2.4753	2.4718	2.4405	1.7315	2.2705	1.5200	1.5231	2.0785

Where
K - Capital employed (Rs.).
L - Mandays of labour employed.
V.A - Value added generated (Rs.).
Y - Total output produced (Rs.).

firms exhibit high capital value added ratio. A similar pattern has been observed when firms are arranged according to the employment generated.

With the efficient use of resources and factor inputs, the productivity of the enterprises raises. The partial productivities are the simplest indicators of productivity. These are derived by dividing the value added by the relevant input. The commonly used indicator is the labour productivity. Though the labour productivity show the efficiency of labours as pointed out earlier, one should be cautious not to intrepret it as having been caused by labour alone; it has to be interpreted as having been caused by a whole lot of economic relations. Generally it is observed that labour productivity increases with size. Value added per man day of labour (labour productivity) in chemical enterprises by capital invested in firms is presented in table 5.4.

The results are presented in table 5.4 reveal that in general the larger sized firms are more productive, creating greater value added per man day of labour. For all the chemical enterprises the labour productivity is found to increase with size, lowest being in the smallest size group. In case of soap and cosmetics, other chemicals and Dyes and paints, the small sized firms show lower labour productivity in comparison with larger firms. The Inorganic chemical industry exhibit very low labour productivity and in this industry, the smaller sized firms with lower capital invested are found to be highly

Table 5.4 : Value added generated per man day of labour (labour productivity) in chemical enterprises by capital invested.

Capital Invested	Inorganic Chemicals	Organic Chemicals	Fertilizers and Pesticides	Dyes and Paints	Drugs and Pharmaceuticals	Soaps and Cosmetics	Other chemicals	Pooled
Upto 3 lakhs	184.23	-	155.00	76.92	-	102.49	61.59	118.04
3 to 5 lakhs	265.13	176.94	193.16	47.65	178.40	128.69	53.68	128.63
5 to 10 lakhs	122.46	150.45	203.33	326.88	928.57	195.09	144..73	191.94
10 to 15 lakhs	123.71	155.64	130.36	418.28	172.17	437.27	441.21	225.61
15 to 20 lakhs	146.15	714.29	553.37	375.00	128.01	-	170.42	274.57
20 to 25 lakhs	120.06	121.90		-	408.67	-	-	181.02
25 lakhs +	-	290.05	268.44	251.11	227.60	-	206.99	241.61
Industries	138.93	160.26	266.38	251.14	241.63	246.93	210.87	211.97

Where

K - Capital employed (Rs.).
L - Mandays of labour employed.
V.A - Value added generated (Rs.).
Y - Total output produced (Rs.).

productive. In this industrial category, the largest of the existing firms are least productive.

In case of organic chemicals; fertilizers and pesticides; Drugs and pharmaceuticals the most productive firms are in middle investment groups. Over all one finds smallest sizes exhibiting lower productivity.

6.4 <u>Fitted Production Function and Testing of Returns to Scale</u> :

The engineering relation between inputs and output is technically called production function. [illegible] The production function in case of a firm is a technical relation showing how inputs are transferred into outputs. In the present section Cobb-Douglas production function is fitted for various categories of chemical enterprises using cross section firm wise data for the year 1984-85. The main point in favour of Cobb-Douglas type of production function is its convenience in interpreting elasticities of production.

The Cobb-Douglas production function has been tried through out the world in case of manufacturing sector. Some of the small scale industry studies too have fitted the Cobb-Douglas production function but none have tested for returns to scale. The choice in favour of this function appears to have been due to many interesting properties of the function.[36] This production

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36. For discussion on Cobb-Douglas Production Function, See.

Dadi, M.M. "Income share of Factory Labour in India", S.R.C., New Delhi, 1973. pp. 58 - 71.

function has also been criticized on some counts. The first objection against the function is that it suffers from inter correlations among different factors of production. Another attack on the function is in connection with the identification problem. The Cobb-Douglas production function,is said to be not capable of identifying when considered in relation to the cost function under equilibrium conditions. One of the serious limitations of the analysis carried out with in Cobb-Douglas framework is that they are circumscribed by the assumption of unitary elasticity of substitution. This production function is also criticised on the ground that the variables which appear in the function are all endogeneous variables and hence they are subject to simultaneous determination. Despite the various limitations mentioned above, some of serious nature,[37] the usefulness of this function has not reduced.

In the present analysis, two sets of production functions are fitted, the first set is fitted with value added as dependent variable, capital employed and labour (man days of labour) as independent variable. In the second set raw material used has been included as an independent variable, hence the gross output is taken as dependent variable. The gross output is inclusive of the raw material input, hence taken as dependent variable. The second set of results are tested for returns to scale using Tintners test.[38] The method followed is presented in

37. Dadi, M.M. op.cit., pp. 58 - 71.

38. Gerald,Tintner "A note on the Determination of Production Function from Farm Records", Econometrica, 1944, Vol. 12, pp. 26 - 34.

Appendix 5b. The result are presented in table 5.7.

Two sets of production functions are fitted. Production function is fitted to each industrial category separately and for the chemical industry (pooled). The value of the coefficient show the average percentage change in dependent variable, given increase in the amount of factor input by one percent. The functions fitted are as follows :

$$V = b0 \cdot x1^{b1} \cdot x2^{b2} \cdot U \text{ .... (i)}$$

$$y = \beta 0 \cdot x1^{\beta 1} \cdot x2^{\beta 2} \cdot x3^{\beta 3} \cdot e \text{ .... (ii)}$$

Where :

V = Value added

y = Gross output

x1 = Man days of labour employed

x2 = Capital employed

x3 = Raw material

U and e are error terms.

The second equation is tested for returns to scale using the following equations. The method adopted is presented in appendix 5B.

$$\left.\begin{aligned} & y = B0 \cdot x1^{\beta 1} \cdot x2^{\beta 2} \cdot x3^{\beta 3} \text{ ; and} \\ & \beta 1 + \beta 2 + \beta 3 = 1 \end{aligned}\right\} \text{ ----- (iii)}$$

The results of these three sets of equations are presented in tables 5.5 5.6 and 5.7 respectively. Let us now discuss the results for value added, gross output and returns to scale.

Value Added :

The production function fits well for different categories of chemical enterprises. 99 percent of variations in value added are explained by the independent variables. It is found from the table 5.5, that the elasticity with respect of labour is lower for all types of chemical enterprises. In case of organic chemicals and, Dyes and Paints the regression coefficients with respect to labour are found to be significant. For the chemical industry as a whole, 1 percent change in labour input brings 0.1022 percent change in value added. In case of other chemicals, changes in labour employed, does not show significant relation with production. In inorganic chemicals, soap and cosmetics, Drugs and pharmaceuticals, fertilizers and pesticides the regression coefficients are found to be low and nonsignificant.

The elasticities of production with respect to capital are found to be significant for industrial categories. In fertilizers and pesticides and; dyes and Paints the coefficients are significant at 1% level and in all other categories they are significant at 5% level.

With regard to returns to scale in different categories of chemical industries it is found that, the summation of

TAble 5.5 : Results of Cobb- Douglas, Fitted production function with value-added as dependent variable.

Industry	df	b_0	b_1	b_2	R^2	$\bar{R}^2$	$b_1 + b_2$
Inorganic Chemicals	14	1.022	0.0904	0.8953 *	0.9972	0.9968	0.9857
Organic Chemicals	9	1.0035	0.5411 **	0.6322 *	0.9985	0.9982	1.1733
Fertilizers and Pesticides	8	1.0326	0.3433	0.7434 **	0.9946	0.9930	1.0867
Dyes and Paints	12	0.9862	0.5738 **	0.6042 **	0.9938	0.9928	1.1780
Drugs and Pharmaceuticals	11	1.0135	0.1569	0.8573 *	0.9973	0.9968	1.0143
Soap and Cosmetics	7	0.9935	0.0271	0.9354 *	0.9977	0.9971	0.9625
Other Chemicals	13	1.0881	-0.2520	1.0941 *	0.9893	0.9877	0.8434
Pooled	92	0.9947	0.1022	0.8846 *	0.9962	0.9961	0.9868

$$V = Bo\, X_1^{b1} \cdot X_2^{b2}$$

Where

V = Value added

X_1 = Man days of labour

X_2 = Capital employed

b1 and b2 are regression coefficients of Man days of labour and capital employed respectively.

* indicates significant at 5% level.

** indicates significant at 1% level.

elesticities is less than unity in case of Inorganic chemicals, soap and cosmetics and other chemicals.

Gross Output : It may be seen from the table 5.6 that 84 to 96 percent of variations in gross output are explained by the independent variables. It is found from table that elasticity with respect to raw material are found to be significant for all industries. In case of organic chemicals and;soap and Cosmetics, the regression coefficient with respect to raw material is found to be significant at 5% level, in all other industrial groups it is found to be significant at 1% level. If the raw material inputs are increased by 1 percent, other things remaining same the output would increase by 0.53 percent for the chemical industry (pooled).

The elasticities with respect to capital are found to be significant for Inorganic chemicals, soap and cosmetics and other chemicals. In all other industrial categories, capital does not explain variations in gross output significantly. For all chemical enterprises (pooled), 1 percent change in capital invested, other things remaining same would lead to an increase in output by 0.36 percent. The elasticity with respect to capital for the chemical industry (pooled) is found to be significant at 1% level.

The elasticities with respect to labour is invariablely the lowest of all elasticities in all types of industries, except soap and cosmetics. The regression coefficient with respect to

Table 5.6 : Results of Cobb- Douglas, Fitted production function with total output as dependent variable.

Industry	df	B_0	B_1	B_2	B_3	R^2	$\bar{R}^2$	$B_1 + B_2 + B_3$
Inorganic Chemicals	13	0.4809	0.0861	0.2827*	0.6288**	0.9649	0.9568	0.9976
Organic Chemicals	8	0.4407	0.2234	0.2129	0.6206*	0.9121	0.8791	1.0569
Fertilizers and Pesticides	7	0.7829	0.4575	0.1322	0.5243**	0.9121	0.8745	1.1140
Dyes and Paints	11	-0.1264	0.1447	0.2427	0.7406**	0.9355	0.9179	1.1280
Drugs and Pharmaceuticals	10	1.4655	0.1777	0.2783	0.4271**	0.8758	0.8354	0.8831
Soap and Cosmetics	6	-0.9762	0.6938*	0.5499*	0.2920*	0.9697	0.9546	1.5357
Other Chemicals	12	0.0439	-0.0645	0.6445**	0.4339**	0.8677	0.8346	1.1429
Pooled	91	0.3536	0.1579*	0.3588**	0.5349**	0.9023	0.8991	1.0516

$$V = Bo. X_1^{B_1} . X_2^{B_2} . X_3^{B_3}$$

Where

V = Value added.

X_1 = Man days of labour.

X_2 = Capital employed,

X_3 = Raw material input,

B1,B2 and B3 are regression coefficient of mandays of labour, capital employed and raw material input respectively.

* indicates significant at 5% level.

** indicates significant at 1% level.

labour are found to be significant for soap and cosmetics of 5% level. For all other categories it in not found siginficant. One of the studies on small scale enterprises found that the elasticities of production with respect to labour significant for all other indsutries surveyed, except for chemical industry.[39] For all chemical enterprises (pooled) 1 percent change in labour input leads to 0.16 percent change in gross output. With respect to other chemicals changes in labour probably do not show any significant relation with production.

With regard to returns to scale in different categories of chemical industries, it is found that the some of elasticitics is less than unity in Inorganic chemicals and Drugs and Pharmaceuticals. In all other chemical categories the sum of elasticities is greater than unity. However a confirmation test is required before one proposes constant returns, increasing returns or decreasing to scale. Returns to scale have been tested for these results using Tintner's's test. The results are presented in table 5.7.

The results indicate that in five of the seven industrial categories, the hypothesis ($\beta_1 + \beta_2 + \beta_3 = 1$) is rejected. Therefore, in two industries viz, organic chemicals and; fertilizers and pesticides, the enterprises face constant returns to scale.

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39. Mohanty, Bedabati, "Economics of Small Scale Industries", Ashish Publishing House, New Delhi, 1986, pp. 41 - 45.

Table 5.7 : Testing of returns to scale : Cobb - Douglas production function.

Industry	df	β_0	β_1	β_2	β_3	F - ratio (calculated)
Inorganic Chemicals	13	0.2363	0.3784	0.1771	0.4445	11.1846 *
Organic Chemicals	8	-0.1494	0.5647	0.2962	0.1391	2.4638
Fertilizers and Pesticides	7	0.0210	0.2533	0.2243	0.5224	2.2006
Dyes and Paints	11	0.1982	0.1932	0.2219	0.5849	8.4047 *
Drugs and Pharmaceuticals	10	-0.1386	0.3527	0.2134	0.4339	16.7853 *
Soap and Cosmetics	6	0.7561	0.5785	0.3771	0.0444	83.7654 *
Other Chemicals	12	0.0727	-0.2024	0.7239	0.4785	7.5886 *
Pooled	91	0.9197	0.1749	0.3120	0.5131	82.8808 *

$Y = Bo.\ X_1^{\beta 1} .\ X_2^{\beta 2} .\ X_3^{\beta 3}$ and $\beta_1 + \beta_2 + \beta_3 = 1$

Where

Y = Gross output.

X_1 = Man days of labour.

X_2 = Capital employed.

X_3 = Raw material input.

B1, B2 and B3 are regression coefficients of mandays of labour, capital and raw material respectively.

If F-Ratio(calculated) is greater than F-Ratio(0.05 table value), then we reject the Null hypothesis that $\beta_1 + \beta_2 + \beta_3 = 1$.

* Significant at 5% level.

In other industrial categories the firms do not face constant returns to scale. In all these industries the F-ratio is found to be significant at 1% level. For the chemical industry as a whole (pooled) also the F - ratio is found to be significant, therefore we can conclude that the chemical indsutry in general do not face constant returns to scale.

If an industry is not facing constant returns scale, it is said to be either facing increasing returns to scale (sum of elasticities greater than one) or decreasing returns to scale (sum of elasticities less than one). Therefore, other industrial categories in chemical industry are said to either facing increasing or decreasing returns to scale.