CHAPTER - II
REVIEW OF LITERATURE

1. PARTIAL AND TOTAL FACTOR PRODUCTIVITY

Literature on productivity concept and causes and consequences of productivity change is readily available. The measurement of productivity is pre-eminently a quantitative and technical problem. The concept of factor productivity gives the contribution which one or all used factors make to production. This concept is reflected in a ratio between product (output) and the factor or factors used (input). The simplest productivity analysis can be conducted in terms of partial productivity ratios. These ratios are labour productivity (LP), capital productivity (CP) and material productivity (MP).

Total factor productivity (TFP) ratios based on the comparison of output with the input of man hour and tangible capital are better measure of efficiency than those based on labour or capital input alone.

There have been many studies on this important consumer industry of India. To have a Comprehensive idea of studies on productivity and production function, a brief review of them is desirable and an attempt is made in this chapter.
Balakrishna (1953)\(^1\) is one of the forerunners in productivity measurement in India. In his study the measurement of productivity is done in terms of unit labour requirements. He has employed another criterion, physical output per man-hour in the case of individual industries. They are useful in making inter-regional comparisons, but when two periods of time are taken into account they do not lend themselves to easy computations.

In the overall comparisons that are made in his study, a ratio of the unit labour requirements between the current and the base periods is calculated. A rise or fall in the index will indicate the position on the current year, the base year having always taken as the period of comparison.

For his study he has taken 12 industries for the years 1948, 1951 and 1953. Throughout his productivity measurement each year labour requirement is compared with that of the base year 1938, to find the changes in productivity.

The 12 industries taken for productivity measurement contribute roughly 75 per cent of output, input and in other aspects. As such generalisation being made on the basis of 12 industries will not have any serious error in the productivity indices.
A pioneering study by Beri (1962) estimates partial and total factor productivity indices for cement, cotton textile, iron and steel and sugar for the period 1948 to 1955. His study reveals an evidence of increasing returns to scale, high relative efficiency, increased capital intensity, presence of technological change and low elasticity of substitution in sugar industry.

Mukerji's (1963) study covers six industries Viz. Jute, Cotton, Iron and steel, Sugar, cement and paper. In his study an attempt is made to find the effect of 'localization' on 'Productivity' assuming of course the effect of other factors remaining more or less constant. In his study he concluded that 'localization' has no specific effect on 'productivity indices'.

Diaz Alejandro (1965) examines a simplified version of the Hirschman hypothesis, analysing labour productivity differentials between industries in the United States and the Argentine Republic. Professor Hirschman’s hypothesis is based on his belief that the modern technology embodied in capital equipment helps management in these countries perform unfamiliar and uncongenial tasks and coordinate the internal activity of the firm, while it is precisely these management skills which are most scarce in underdeveloped countries. For this reason labour productivity differentials between underdeveloped and fully industrialised countries should be much larger in labour intensive industries than in capital intensive industries. The general tendency
verified in his paper does not significantly hamper the likelihood of substantial industrial exports from semi-industrialized countries.

Mukerji (1966)\(^5\) examines productivity movements in the Jute textile industry from 1900 to 1958 and finds that productivity and real wages are almost completely unrelated except for a brief period.

Sastry (1966)\(^6\) attempts a similar exercise for sugar industry for the period 1951-1961 and finds that the growth in labour productivity in that industry is entirely attributed to the capital available per worker.

Shivamaggi, Rajagopalan, and Venkatachalam (1968)\(^7\) examined trends in wages in seven important industries during 1951 to 1961 and compared them with trends in labour productivity and costs of production during the same period by making use of time series data provided by CMI andASI. The seven industries covered were cotton textiles, Jute textiles, Iron and steel, Cement, Paper and Paper Boards, Chemicals and Chemical Products and Sugar. The index of labour productivity was constructed from the figures obtained by dividing value added in constant prices of man-hours. The relatively greater rise in labour productivity may be partly associated with the increase in fixed capital per unit of labour and improvement in management techniques.
Rajkrishna and Mehta (1968) have tried to identify the implications of major change in the productivity of large scale Indian Industries covered by CMI and ASI during 1946-1963. They have examined the capital intensity and the productivity of labour and capital for large-scale industries. They have observed that capital intensity had increased by nearly 100 per cent between the 6 year period 1948-53 and the period 1958-63. Productivity of labour as measured by value added (in constant prices) per employee, V/L, had also registered an increase of about 42 per cent. The productivity of capital as measured by value added per unit of capital, V/K, had declined by about 18 per cent. Total productivity declined steadily over the period and most of the gains in labour productivity were due to capital deepening.

Raghavachari's (1969) study is to investigate how technological advance has been reflected in productivity in the sugar industry. He used the data regarding sugar inputs from CMI for the period 1947-1958 and ASI data cover the subsequent period 1959-63. The main findings are:

(i) Introduction of new production techniques, which have contributed to the appreciable improvement in the industry's manufacturing efficiency. As a consequence of this, the productivity of major inputs has increased.
(ii) During 1947-63, labour productivity showed an upward trend at All India as well as Uttar Pradesh and Bombay.

(iii) Some improvement was noticed in the productivity of energy.

Sinha and Sawhney (1970)\textsuperscript{10} examine wage productivity relationships in cotton textiles, cement, sugar, jute, paper and paper products for the year 1950-63 on the basis of the data available from CMI and ASI. All the five industries studied indicate increase in productivity - ranging from 4.7 per cent in cement and sugar to 1.9 per cent per annum in cotton textiles. Total factor productivity also increased over a period of time in these industries.

Banerjee (1971)\textsuperscript{11} calculated partial productivity for both labour and capital for the years 1946 to 1964 for Indian manufacturing industries. Labour productivity was measured by gross value-added per person and capital productivity by dividing gross value added by capital. The former was found to increase, while the latter showed a decrease during the study period. He also came to the conclusion that increase in labour productivity was achieved mostly through capital deepening. He further calculated the fuel and material cost per unit of gross output. While the raw materials per unit of output cost declined, the fuel unit costs increased slightly over the period.
He also calculated the total factor productivity using Solow and Kendrick methods and estimated the efficiency parameter using CES production function. He observed a steady decline in the total factor productivity for the study period.

Annamalai (1978)\textsuperscript{12} deals with changes in productivity in Indian Cotton textile Industry and Tamil Nadu Cotton Textile Industry between 1959 and 1970 excluding the year 1967. In his study both partial productivity and total factor productivity ratios were computed by using Kendrick method. From his study he concludes that total factor productivity increased by about 1.3 per cent per annum for the whole period in the case of Indian Cotton textile industry and 0.5 per cent in the case of Tamil Nadu cotton textiles industry.

Mehta (1980)\textsuperscript{13} in his study on total and partial productivity for the period 1953-1965 computed partial productivity of capital and labour and total factor productivity by Solow and Kendrick methods. The total factor productivity indices measured by both methods showed a downward trend. The movements in labour productivity and capital productivity showed a diverse trend. Labour productivity increased significantly in industries like vegetable oil, chemicals, tanning, glass and glassware and insignificantly in matches, iron and steel and cement industries. However, capital productivity did not increase but decreased in
many industries. Labour and capital showed an inverse relationship.

In his study capital intensity was able to explain the growth in labour productivity in sugar, tanning, ceramics, cotton textiles, confectionery and sewing machines, while in the case of other industries, despite a rise in capital per person, it had not led to gain in labour productivity, implying that growth in labour productivity in many industries was not due to capital intensity. Accordingly, Mehta concludes that capital intensity need not increase labour productivity.

Sastry (1981) measured total factor productivity indices for the cotton textiles Industry for the period 1949-70. Three alternative measures of total factor productivity of Kendrick, Solow and Domar were analysed for All India. In the period up to 1961, the index was found to rise whereas after 1961, a declining trend was observed. A close correspondence was observed in the three indices calculated over the period. Sastry used energy consumption as a proxy for capital.

Jaishankar (1982) attempts to find the inter-relationships between productivity, output, employment and cost. Using labour productivity as the criterion and median as the statistical tool he selected 23 industries and divided them into 'high productivity industries' (HPI) group and 'low...
productivity industries ' (LPI) group. Each group consists of 11 industries. The HPI group indicates high output and high employment; on the other hand LPI group reveals low output and low employment. In the case of cost, LPI group is showing an increase; whereas in the case of HPI group, some are decreasing while few others have registered an increase. The study indicated that Indian industries have on the whole become more capital intensive during the period under review.

Mukherji's (1983)\textsuperscript{16} study aims to measure productivity and its growth in the factory sector of Bihar and makes comparisons with All India trends during 1950-67. His study reveals that the index of labour productivity of Bihar just about doubled while at the All India level the increase was more than double.

A significant increase in labour productivity had occurred both at the state and All India levels at a compound annual rate of 4.06 and 5.10 per cent respectively. Over the study period, the capital productivity index at the state level and All India level declined by as much as 71 and 67 per cent respectively. The index of total factor productivity declined significantly both at the state level and All India level. The rate of decline was marginally higher at the state level.

Arun Ghose's (1984)\textsuperscript{17} paper examines some efficiency parameters of the steel, cement and sugar industries in order to focus attention on the problem of efficiency in Indian
manufacturing industry. His study is useful in two ways; first, in highlighting the reasons for the low productivity observed in a few important industries and secondly, in bringing out the absence of any direct link between investment and efficiency. With regard to Sugar industry he pointed out that the Sugar industry, predominantly in the private sector, is by and large highly inefficient today; that the totality of policies affecting the Sugar industry is not calculated to promote efficiency and higher productivity; and that government intervention in the affairs of the Sugar industry, ostensibly in the interest of the consumer and of the cane grower, has in fact made for the growth of a highly inefficient Sugar industry.

Alam Khan's (1984)\textsuperscript{18} study is concerned with the production function analysis and partial and total factor productivity indices for selected manufacturing industries of Bihar using CMI and ASI data for the period from 1946-47 to 1965-66. In his study he observed labour productivity and capital-labour ratio had increased during the study period. Capital productivity had declined as a result of capital deepening and substitution of capital for labour. Total productivity measured from Solow's method declined steadily in most of the selected industries as well as the manufacturing sector in the case of Bihar and India.

Annamalai (1986)\textsuperscript{19} deals with relationship between productivity and price in his study on price formation in Indian
manufacturing sector and four industries i.e. cement, sugar, cotton textiles and fertilizers for the period from 1959 to 1980. In his study the method of price fixation and changes in the price policy measures and its impact on production, price and profitability have been analysed elaborately at the individual industry level. For this he uses unit factor cost and partial factor productivity. Using these he computes the overall unit cost and total factor productivity. Relationships between these measures and price index have been analysed. He finds a declining tendency in total factor productivity which caused the cost of production to increase. Increase in labour productivity was equally matched by increase in wage rate. Invariably capital productivity declined in all manufacturing and in the four individual industries. Among four industries, negative trend in material productivity was noticed in three industries except fertilizer. The observation regarding productivity reveals the fact that technical efficiency had not improved over the period.

Dabir-Alai's (1987) study estimates total factor productivity (TFPG) rates for the large scale manufacturing industries using Solow and Kendrick methods for the period 1973-74 to 1978-79. His study concludes that the manufacturing sector is dominated by industries whose TFPG had remained positive over the period 1973-74 to 1978-79.
An attempt is made in Bhatia’s (1990) paper to study changes in productivity during 1965-1985 in India in relation to that in the U.K and the U.S. For this he estimates productivity indices for each country and the growth rates in the total factor productivity for the three countries for i) 1965-1975, ii) 1975-1985 and iii) 1965-1985 are worked out. Further cross country comparisons of total factor productivity are calculated. A comparison of the productivity indices amongst the three countries reveals that in the UK, the productivity index rose during 1965-73. It was stable during 1973-82 and increased between 1983 and 1985. In the US, the productivity index had increased steadily over the entire period 1965-85. The index increased from 92 in 1965 to 125 in 1985. In India total factor productivity declined during 1965-75. The index rose during the period 1975-85. The rise in productivity index in India after 1975 was higher than that in the U.K. It was higher than even that in the U.S. after 1980.

Ahluwalia (1991) attempts to analyse the long-term trends in total factor productivity and partial productivities in the organised manufacturing sector in India over the period from 1959-60 to 1985-86. The role of factor input growth and total factor productivity growth in accounting for the growth in value added is also explored. The analysis is conducted at a detailed level of disaggregation for 63 constituent industry groups at the three-digit level as well as for the four use-based sectors of
manufacturing, i.e. intermediate goods, consumer non-durables, consumer durables and capital goods. For as many as 36 industries accounting for over 50 per cent of the total value added in manufacturing in 1970-71, however, the contribution of total factor productivity growth was negative. The more important among these industries were food manufacturing except sugar, iron and steel, and non-ferrous metals. For almost all of the 63 industries, capital intensity showed a strong and significant upward trend. Labour productivity showed significant positive growth for fewer industries accounting for 64 per cent of the value added in manufacturing. There were a few industries which even experienced a decline in labour productivity. The trend in capital productivity was dominantly downward.

Chandrasekaran and Sridharan (1993) estimate total and partial factor productivity indices to analyse the operating performance of cotton industry in India from 1973-74 to 1986-87. The total factor productivity has been arrived at by using Kendrick’s index. For the purpose of finding out the estimates of input elasticities, neutral technical progress and returns to scale, Cobb-Douglas production function, CES and VES functions are used. They conclude that labour productivity in the cotton industry had increased at a higher rate than capital productivity and contributed to the growth of output and efficiency achieved. Low capital productivity observed in their study could be due to managerial factors.
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II.2. PRODUCTION FUNCTION

The total factor productivity approach is theoretically derived from production function. The total factor productivity approach, however, assumes constant returns to scale. Also the technical change cannot be measured through the total factor productivity index. Returns to scale and technological change can be estimated through production function approach. A production function is a relation between the maximum quantity of output and inputs required to produce it and the relation between the inputs themselves. The standard forms of production function are unconstrained Cobb-Douglas production function and Constant Elasticity of Substitution production function. A brief review of production function is made in this section.

Murti and Sastri (1957) have fitted a Cobb-Douglas production function for the cross section data of the Indian Industrial sector as a whole, as well as for some of the selected product groups like cotton, jute, sugar, coal, paper, basic industrial chemicals and electricity industries for the years 1951 and 1952. The results indicate that the sum of the coefficients of labour and capital have differed significantly from ensuing constant returns to scale.

Sarkar (1965) has estimated Cobb-Douglas production
function in a modified regression equation in the form of

\[ P_i = a L_i^k C_i^j R_i^m \]

where \( P_i \) is output, \( L_i, C_i, R_i \) are labour, capital, raw materials, fuels, etc., respectively in \( i \)th year and \( a, k, j \) and \( m \) are statistically determined parameters for the Indian steel industry. He has studied the production function of the aggregate of firms of different regions, of different size – classes from the period from 1946 to 1958. He has also tested the regional homogeneity for different regions – West Bengal, U.P, Delhi, Punjab and Bombay by using Cobb-Douglas production function by dividing the period into two components, viz 1946-52 and 1953-58. He finds that the steel industry in West Bengal experiences a fairly high degree of increasing returns to scale. The industry is almost under constant returns to scale in Uttar Pradesh and Punjab and to some extent in Bombay. In Delhi alone the industry is under decreasing returns to scale.

In his study on "An Empirical Estimate of Elasticity of Substitution Production Function" Diwan (1965) tests the heroic assumption of constant returns to scale. For this purpose the time series data for the manufacturing sector of the United States Economy referring to the period 1919-1958 is used. He concludes that the true value of \( \sigma \) lies somewhere in between 0 and 1. This would suggest that the underlying production function in the manufacturing sector of the United States economy is neither

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Cobb-Douglas nor Leontief. He also states that the United States Manufacturing sector over the period 1919-1958 showed a tendency to follow the law of "increasing returns to scale". The price elasticity of demand for labour and capital has also been calculated. The value of price elasticity of labour comes to 0.46 and capital comes to 0.48.

Sastry (1966) has estimated three different forms of production function for the Indian sugar industry at the regional and national levels. His study is confined to the period 1951-61. CMI and ASI are the main sources of data for the study. The forms of the production function used in this study are:

i) \( P = A(t) L^\alpha K^\beta \)

ii) \( P = A(t) [ aL + BK ] \)

iii) \( P = e^{ct} L^\alpha K^\beta \)

He presents the partial elasticity of output with respect to labour (\( \alpha \)) and capital (\( \beta \)) and total factor productivity through the functional forms (i) and (iii) at the regional and national levels. The main findings are: i) total factor productivity has been falling at the regional and national levels; ii) increase in labour productivity is attributed to capital intensities and iii) labour is found to be marginally more efficient than capital in the tropical region while the reverse holds in sub-tropical region.
Yeh (1966) uses two different techniques to test the economies of scale for thirty Indian industries on the basis of time-series study for the period from 1946 to 1958. He uses the following form to estimate the returns to scale.

\[ \log Y = \log a + b_1 \log L + c_1 \log K + u \]

where \( Y \) denotes value added, \( L \) denotes the number of workers and \( K \) denotes the amount of capital. He concludes that the evidence of economies of scale which relies on the estimates of the sum of the exponents \( (b_1 + c_1) \) in Cobb-Douglas function. With regard to the measurement of efficiency, Yeh uses labour productivity. This is calculated by dividing value added by the number of workers. He finds that the average productivity of labour increases as the plant size increases.

Diwan and Gujarati (1968) studying 28 Indian industries for the period 1946-58 estimate elasticity of substitution for individual manufacturing industries from CES production function using time series data. Only two industries, namely starch and cement had an elasticity of substitution equal to or greater than one. The remaining 26 industries had values less than one. Of these 26, four industries, namely fruits and vegetables, wheat flour, paper and paper boards, and electric fans had an elasticity greater than 0.5 but less than one. All the others had values less
than 0.5. They concluded that elasticity of substitution in Indian industries is quite low. Most of their estimates were not statistically significant due to high standard errors.

Sankar (1970) has estimated the elasticity of substitution and returns to scale for 15 manufacturing industries in India by using CES production function with non-constant returns to scale. The main source of data for this study was the census of manufacturers available from 1946 to 1958. Due to variations in coverage in early years and also because of the effects of partition in 1947 and boom conditions in 1950-52, he has used only 1953-58 data for the study. Further regional differences in production conditions due to differences in composition of capital and labour inputs, utilisation and social overhead capital are also taken into account in the study. He has obtained estimates of the parameters directly from the production function using maximum likelihood and Bayesian techniques. On the basis of his findings, he rejects the fixed factor proportion hypothesis for 11 out of the 25 industries. He finds increasing returns to scale in a number of industries. Further, he prefers CES model over fixed proportion and C-D models, as the estimates of \( \sigma \) exhibit considerable variation among industries. Among the industries analysed, he finds that elasticity of substitution between capital and labour is 1.000 (modal value) for the Indian sugar industry.
Desai (1971) estimates the CES production function for the sugar industry of India. In his study the regional efficiency of the sugar industry is measured on the basis of the results of the production function. CES production function has been estimated by making use of cross-section data on output, capital, labour, wage rate, and rate of return to capital provided by ASI for the year 1960 and 1965. He studies the regional efficiency of sugar by attributing the residuals not accounted for by the contribution of capital and labour to regional efficiency. He concludes that CES type of production function is found to be a good fit for the Indian sugar industry. Regional efficiency coefficients indicate that for the both periods, the sugar industry in Uttar Pradesh and Bihar was more efficient than that in the remaining states of India.

Pathak (1972) has estimated Cobb-Douglas production function for nine individual industry groups in Gujarat on the basis of time-series data for the period 1960-66. Since the variables are not deflated due to lack of reliable price data, he introduced dummy variables to account for changes in price. In order to avoid the problem of multicollinearity and high inter correlation between capital (K) and Labour (L), production function of the following type has been estimated for such industry groups.
Log \( \frac{Q}{L} = a + a_1 D_1 + a_2 D_2 + a_3 D_3 + a_4 D_4 + a_5 D_5 + a_6 D_6 + \alpha \log \frac{K}{L} \)

His important findings are: higher elasticity of output (Q) with respect to K relative to L. \((\alpha + \beta)\) is around unity in most of the industry groups, showing an evidence of constant returns to scale.

Mehta (1974)\(^{34}\) has estimated Cobb-Douglas production function and CES production function for Indian sugar Industry on the basis of time series data from 1953 to 1965. Data of CMI and ASI have been adjusted to make them consistent so that magnitudes derived from CMI and ASI are comparable. He finds that the Indian sugar Industry shows that the total factor productivity is declining. Further, the elasticity of substitution between capital and labour is significantly different from unity as well as zero. In fact it is 0.54. This shows that there is an evidence of CES production function for the industry.

Barthwal (1975)\(^{36}\) has fitted various forms of production function VIZ, VES, CES and Cobb-Douglas for Indian paper industry by using the time-series data. His study covers the period from 1949-64. The main results obtained from his study are: 1) constant elasticity of substitution of unitary magnitude 2) almost no
technological progress in the industry during the period 1949-64.

3) Partial elasticities of capital and labour inputs were found to be of the order of 0.64 and 0.36 respectively.

Banerjee (1975) estimates elasticity of substitution for Indian industries together for the period 1946 to 1958 using the following five models of CES production functions:

1) \[
\log \left( \frac{V}{L} \right)_t = A + \sigma \log w_t + u_t
\]

2) \[
\log \left( \frac{V}{L} \right)_t = A + \sigma \log w_t + \alpha_t + u_t
\]

3) \[
\log \left( \frac{V}{L} \right)_t = A + \lambda \sigma \log w_t + (1-\sigma) \log \left( \frac{V}{L} \right) + \Sigma_t
\]

4) \[
\log \left( \frac{V}{L} \right)_t = A + \sigma \log w_t + p \log \left( \frac{V}{L} \right)_{t-1} - p \sigma \log w_{t-1} + \Sigma_t
\]

5) \[
\log \left( \frac{V}{L} \right)_t = A + \sigma \log w_t + \beta \log L_t + u_t
\]

The equation (1) is the familiar SMAC formulation relating the Log of V/L with the log of the wage rate. Relation (3) is the partial adjustment distributed log model. Equation (4) is the
serial correlation model corresponding to (1). Relation (5) is the modified SMAC form with the labour variable which allows for non-constant returns to scale.

The same relations are also used in the study of five Indian industries, namely, cotton textiles and Jute textiles for the period 1946 to 1963, Sugar 1946 to 1962, paper and bicycles for the period 1946 to 1958.

In both studies, model (4) does not seem to hold good, since the estimates of $\sigma$ by the above method was not statistically significant. Equations (1), (3) and (5) yielded statistically significant estimates for $\sigma$ in both cases. In none of the cases was the estimate significantly different from unity. By including the time trend, the estimate of coefficient of time trend was statistically significant only in one case (sugar).

The production function estimates of the unrestricted Cobb-Douglas form for the aggregate manufacturing sector as well as for the five industries selected are presented. The growth of the manufacturing sector is by and large accountable in terms of the increases in inputs and there has been no evidence of any 'residual' factor in it. The hypothesis of constant returns to scale is not rejected conclusively. Sugar, paper and Bicycle industries showed significant growth during the period under
study. The unrestricted Cobb-Douglas production function in sugar Industry yielded significant and positive coefficients of both labour and capital. The returns to scale estimate was not significantly different from unity.

Gupta and Kirit (1976)\(^{37}\) have estimated different forms of production functions for Indian sugar industry for the period 1946-66 and for its sub-periods 1946-58 and 1959-66. The study reveals that the industry is found to have zero neutral technical progress, unit elasticity of substitution between labour and capital, evidence of increasing returns to scale and labour seems to be a more important factor than capital in terms of factor elasticity of output, marginal factor productivity and relative contribution to mean value added by sugar industry.

Dholakia (1977)\(^{38}\) has presented the various possible alternative estimates of the widely used Cobb-Douglas production function for the Indian iron and steel industry. These estimates of the production function have been derived from the time-series data on the iron and steel industry for the period 1946 to 1966 obtained from the various reports of CMI (1946 to 1958) and ASI (1959 - 66). His paper is devoted to a detailed examination of measurement of factor input, particularly the capital input. The following variant of the Cobb-Douglas production function is estimated on the basis of time-series data for the period 1946-66.
\[ Y = A L^a K^b e^{ct} \]

which can also be written in its logarithmic form as

\[ \log Y = \log A + a \log L + b \log K + c T + \epsilon \]

Where \( Y, L, K \) and \( T \) represent the variables output, labour, capital and time respectively. While \( A, a, b \) and \( c \) are the parameters representing the constant term, elasticities of output with respect to labour, capital and the rate of technical progress respectively.

He concludes that the elimination of errors in the measurement of capital input alters significantly the estimates of the relative contributions made by various factors to the growth of output and reduces the intensity of the problem of multicollinearity arising frequently in the estimation of time series production function.

Subramaniyan (1982)\(^{39}\) has estimated different forms of production function for sugar industry. In his study he estimates regional efficiency, partial elasticities of output with respect to capital and labour, marginal productivities, returns to scale, technological progress and the sources of output growth at the regional level as well as national level. The basic data for this study are extracted from CMI and ASI for the period from 1953 to 1969. The elasticity of substitution between capital and labour is
unity which implies that relevant form of production function is Cobb-Douglas production function. The study concludes that as Cobb-Douglas production function is not very well suited to analyse the economies of scale, CES production function is used even though \( \sigma \) appears to be unity for the industry. Regarding regional efficiency, the Cobb-Douglas production function with state dummy variables based on time-series data for the period 1953-1969 and for the two time components 1953-60 and 1961-69 reveal that Maharashtra is relatively most efficient region compared to all the other states under investigation.

Babu and Vani (1983)\(^{40}\) have estimated the CES function for the Indian manufacturing sector at constant prices for inputs and output for the two periods 1949-58 and 1959-66. They have concluded that there is a shift in the production function over the period 1949-66 and the substitution has also varied. Substitution possibilities differed in the two periods and hence the assumption of unitary substitution which is same for both periods is not valid. Further, during the process of development different industries may experience different types of technical progress and this might affect the elasticities of substitution differently.

Arya (1983)\(^{41}\) estimates production function for Associated Cement Co.Ltd for the period 1956 to 1974. The data have been taken from the annual reports of Associated Cement Co. Ltd. He
has fitted Cobb-Douglas production function to the data pertaining
to the Associated Cement Company Ltd, Bombay. His study shows
that constant returns to scale exists in the Cement Industry. The
elasticity of output with respect to labour is greater than that
of capital. Further his study indicates that the industry
experiences technical change which is of neutral type and there is
a shift in the production.

Sandhu and Sodhi (1985) have analysed the production
function analysis of small-scale engineering goods industry in
Punjab with the specific objectives of estimating a) output
elasticities with respect to labour and capital b) returns to
scale and c) substitution elasticity between labour and capital.
Data on various variables of interest, namely, value added,
capital and labour were obtained from the entrepreneurs by the
personal interview method through pre-tested schedules. The
information was collected for two points of time, viz. 1972-73 and
1977-78. In their case study there are two alternative forms of
the production function—Cobb-Douglas and CES—have been used. It
is evident from their study that capital elasticity (0.697) was
higher than labour elasticity (0.425) in the small-scale
engineering goods industry during 1972-73 and it was estimated as
0.718 and 0.335 respectively during 1977-78. Further their study
indicates that the engineering goods industry was experiencing
slightly increasing returns to scale during both the periods under
study, viz., 1972-73 and 1977-78. They have concluded that there
are no substantial capital-labour substitution possibilities, especially in machine tools and printing machinery industries.

Rajalakshmi (1985)\(^4\) analyses the growth and productivity of the Transport Equipment Industry at aggregate level for the period between 1971 and 1981 by carrying out econometric studies utilising standard production functions such as Cobb-Douglas, CES and VES and Solow's total factor productivity indices. Her study of transport equipment industry at aggregate level comprises of nine individual industries which include Road transport, Rail transport, Ocean transport and Air transport equipments. The basic data for the Transport Equipment Industry have been mainly taken from the Annual Survey Reports published by the Bureau of Public sector Enterprises (BPE). An exponential time trend has been incorporated in the Cobb-Douglas production function to account for and measure neutral technological change of the form:

\[
V = a e^{\beta_1 t} L^{\beta_2} K^{\beta_3} \quad \text{(or)}
\]

\[
\log V = \log a + \beta_1 t + \beta_2 \log L + \beta_3 \log K + u
\]

The model derived form CES function of the following type has been attempted for this industry to estimate technical progress and elasticity of substitution.
Log \( w \frac{L}{V} = a_0 + a_1 t + a_2 \log w \)

where \( a_1 = -\lambda (1-\sigma) \) \( a_2 = (1-\sigma) \)

So \( \lambda = \frac{a_1}{\sigma-1} = -\frac{a_1}{a_2} \) and \( \sigma = 1-a_2 \)

The VES production function with the inclusion of a term for time is used in this study as follows:

\[
\text{Log} \frac{V}{L} = \log a + b_1 t + b_2 \log w + b_3 \log \frac{K}{L} + e.
\]

\( a, b_1, b_2 \) and \( b_3 \) are constants and \( e \) is the random error term.

She finds that estimates of Cobb-Douglas production function indicate the non-occurrence of neutral technological progress in it between 1971 and 1981. The marginal productivity of capital exhibits an almost steady decline and the marginal productivity of capital is very low though it shows a slight upward trend. The fitted CES function shows that the elasticity of substitution (\( \sigma \)) between capital and labour is 0.944 (almost unity) and the industry experienced negative technological change.

Agarwal (1986) applies Cobb-Douglas production function to estimate the coefficient of inputs, their marginal productivities and shares in total output and degree of returns to scale in 20 industries. For the seven industries data cover the period from 1967-71 and the remaining thirteen industries cover the period from 1975-80. The data for output and inputs have been collected.
from the ASI. From his study it is observed that the estimated coefficients of capital and labour are negative in some industries. The estimated coefficient of raw material is positive in all the seven industries for the period 1967-71. The estimated coefficients of capital are found negative in chemical and chemical products, non-metallic products, jewellery and watches, and water works and supply. The estimated coefficient of labour is found negative only in machine tools and parts.

Mani and Sathyanarayana (1991) in their paper make an attempt to study production function in sugar industry in a backward region with special reference to Chittoor Co-operative sugars Ltd, Chittoor, Andhra Pradesh. The CES, VES and the Cobb-Douglas production functions are fitted to the data under study to examine their relative importance. The data were collected directly from the office records of Chittoor Co-operatives Limited, for the period 1964-65 to 1984-85. The data were also used to estimate the elasticities of output and the returns to scale in addition to computing the marginal productivities of the factors. Their analysis reveals that the Cobb-Douglas production function is more suitable for the study. Chittoor Co-operative Sugars Limited is found to have zero neutral technical progress and it is operating under constant returns to scale. Labour is relatively a more important factor than capital in terms of factor elasticities of output and marginal factor productivity.
Singh and Ahmed Khan (1991) have attempted to examine i) the production and sales performance and ii) production efficiency of automobile industry in India between 1965 and 1985. The main sources of data are Automobiles manufactures Association of India and Annual survey of Industries. They find that the performance of the Indian automobile industry in terms of production and sales has been reasonable. Further the labour productivity in case of industry as a whole and motor vehicles and parts has observed an increasing trend with decline in 1979-80. Moreover, capital productivity in case of industry as a whole declined over the period.

Chandrasekaran and Sridharan (1993) have fitted Cobb-Douglas, CES and VES production function for the time series data obtained from ASI from 1973-74 to 1986-87 for Cotton industry in India. Cobb-Douglas production function in log linear form is used:

$$\log V = \log \alpha + \beta_1 t + \beta_2 \log L + \beta_3 \log K + \epsilon$$

where $V$ is value added, $\alpha$ is efficiency parameter, $\beta_2$ and $\beta_3$ are elasticities of output with reference to labour and capital. For empirical estimation of CES can be transformed with linear focus and log form

$$\log V/L = \beta_0 + \beta_1 \log w + \epsilon$$

Where $w$ is wage rate.
The variance or otherwise of elasticity of substitution to capital-labour ratio is tested by fitting variable elasticity of substitution (VES) function. It is expressed as follows:

$$\log \frac{V}{L} = a + b_1 \log w + b_2 \log \frac{K}{L} + \eta$$

where $a$, $b_1$, and $b_2$ are constants.

In their study, returns to scale is found to be 1.22 which means that cotton industry was operating under increasing returns. CES production function assumes a relationship between value added per labour and wage rate independent of capital-labour ratio. VES function fitted in this study has low explanatory power but still significant.

Anita Kumari (1993) measures total factor productivities as well as partial productivities for various public sector groups. The period chosen for her study is 1971-72 to 1987-88. For estimating the growth rate of TFP, Cobb-Douglas and CES production functions are used. She finds that the estimates of TFP for steel group and consumer group show a falling trend in all three direct measures of TFP. The estimates of growth rate of TFP given by the two production function methods are different from those given by direct methods.
<table>
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<th>Industries Covered</th>
<th>Data used</th>
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<td>Sarkar, A.K.</td>
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<td>S.No</td>
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<td>Sathyanarayana, E.</td>
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Summary of Reviews

Most of the studies of Indian Industries attempted to measure the technical change for the respective periods of study. 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.

The study by Balakrishna (1962) of 12 industries for the period 1948, 1951 and 1953 shows that the 12 industries considered for productivity measurement contribute roughly 75 per cent of output, input and in other aspects. Mukerji (1966), Sastry (1966) and Shivamaggi and his colleagues (1968) conclude that increase in labour productivity may be partly associated with increase in fixed capital per worker. The study by Raj Krishna and Mehta (1968) of 28 industries for the period 1946 - 1963 confirms the conclusions arrived at in some of the earlier studies. The study by Banerjee (1971) and Mehta (1980) shows that labour productivity was found to increase while capital productivity showed a decrease in many industries and total factor productivity showed downward trend. Alam Khan (1984) attempts a similar exercise for selected manufacturing industries for the period 1946-1967 and finds that labour productivity and capital - labour ratio had increased and capital productivity declined as a result of capital deepening. Annamalai (1986) examines partial and total factor productivity for Indian Manufacturing and four industries for the period
1959-1980 and finds a declining tendency in total factor productivity caused the cost of production to increase. Ahluwalia (1991) and Chandrasekaran and Bhavani Sridharan's (1993) studies are strictly comparable with other studies as labour productivity had increased at a higher rate than capital productivity.

It appears that the most of the empirical work has been based on the published sources, namely the CMI and/or the ASI. The quantity of research effort that has gone into the areas covered by this section is no doubt impressive. The review reveals that considerable work has been done on productivity analysis for Indian Manufacturing Industries. Studies at individual industry, inter-industry, inter-regional and inter-country productivity differences, etc., are limited.

Productivity studies have only labour productivity and capital productivity measured in terms of value added per worker and capital. This measure suffers from many obvious limitations. It is suggested that studies designed to measure a). Productivity of all factors, including labour, capital, raw materials, etc., and b). Productivity in real terms should be encouraged.

Sandesara, in his survey article, suggested that further research efforts on these problems, to be more meaningful, will have a). to tap other published material as may be available b). to collect detailed data from the field and c). to probe beyond
the statistical conclusions derived from the census and the survey data.

Considerable work has been done on the theoretical and empirical problem of estimating the production function of the Indian Industries. The studies are mainly aimed at analysing the contributory factors of output growth, returns to scale, elasticity of factor substitution, etc. These studies using the CMI and ASI data, both cross-section and time series, estimating Cobb-Douglas, Constant Elasticity of Substitution and Variable Elasticity of Substitution production functions for Indian Manufacturing Industries.

Many studies are based on both CMI and ASI data. These include those by Sastry (1966), Mehta (1974), Birthwal (1975), Gupta and Kirit Patel (1976), Dholakia (1977), Subramaniyan (1982) and Babu and Vani (1983). Many studies are restricted only to the CMI period up to 1958, in order to avoid the differences. These include those by Sarkar (1965), Diwan (1965), Yeh (1966), Diwan and Gujarati (1968), Sankar (1970) and Banerjee (1975). Very few studies have tried to adjust the capital for capacity utilisation like those of Dholakia (1977) and Subramaniyan (1982).
<table>
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