CHAPTER V

PRODUCTIVITY, TECHNICAL CHANGE IN INDIAN MANUFACTURING

5.1 <u>Introduction</u> :

The growth and developmental performance of developing economies is subjected to various constraints. The most important being the productivity performance of its factor endowments. For the better performance of the economy, productive resources of these countries should be organised in an efficient manner so as to improve their productivity. The preceding chapter explained the trends in partial and TFPG in Indian manufacturing The partial productivity analysis leads us to conclude that the labour productivity showed a positive growth and that of capital productivity indicated a falling productivity trend. The TFPG as measures through Solow and Kendrick indices showed an insignificant but a positive change in the productivity. The variation in productivity growth within in the manufacturing sector across industries are found to be substantial.

The slow growth of productivity in the industrial sector is associated with complex factors which are operating from supply and demand side. On the supply side, shortages of supply of infrastructures like transport, power, telecommunication etc. caused high input costs and inefficiency in the production process. Apart from these supply shortages, the non availability of advanced technologies, critical intermediate inputs, capital goods etc. arised due to foreign exchange shortages also affected the productivity. On the demand side, slow growth of incomes, low level of savings and investment have limited the size of the domestic market leading to imperfection in the market and inefficiency in the allocation of resources. In this chapter an attempt is made to measure productivity, technical progress and Elasticity of substitution through production function approach. In this chapter, section II presents various theoretical approaches to the production function, Section III analyses results of various major studies. In Section IV results of (a) Cobb-Douglas production function, (b) Translog production function approach are discussed.

5.2 Production Function : Theoretical Approaches :

The production function approach can be applied to study an individual industry or a group of industries of an economy. In a macro level study, an aggregate production function is used to analyse the impact of technological progress in addition to various other parameters such as returns to scale, elasticity of substitution etc. A production function is a technical relationship between the inputs and output. Being a purely technical relationship, it is independent of prices of output and factors of production. The production function, therefore, indicates in quantitative terms the physical relationship between the inputs and the output in a production process. It is a boundary relationship which indicates the present limits of a firm's technical production possibilities. It states that a firm can achieve a higher rate of output by using more inputs. In other words, a firm can not use fewer inputs without decreasing its output. The production function also indicates how substitution of one input for another takes place along the production frontier. It can also be used to analyse whether industry is operating under constant returns to scale or increasing returns to scale or decreasing returns to scale. Thus, the production function at different levels of aggregation provide degree of substitutability between factors, estimation of returns to scale and technical progress.

5.2.1 Different Forms of Production Functions :

The production function can be expressed in several forms. In a simple generalised form, let us assume that there are two inputs labour and capital, the production function can be written as,

$$q = f(K, L) \quad \ldots\ldots\ldots\ldots \quad (1)$$

q = Net output
K = Capital
L = Labour.

Generally, the different forms of production function are determined by the elasticity of factor substitution. The elasticity of factor substitution is a measure with which a variable factor can be substituted for others. The purpose of a production function is to understand and analyse the production structure of industrial segments, sectors, or of an economy as a whole.

Traditional economic theory assumes land, labour and capital as typical factors of production. Studies on manufacturing sector have assumed Labour, Capital and Raw material as factor inputs when gross output is taken as measure of output or else have taken labour and capital as factor inputs, i.e when net output of value added is taken as a measure of output. This particular study assumes two factor inputs viz. labour and capital with value added to represent the output. In economic literature there are different forms of production function of which some are rigid and some are highly flexible. The following are the different forms of production functions.

5.2.1.1 Leontief or Fixed Coefficient Production Function :

Leontief production function assumes strict complementarity i.e. zero substitutability of the factors of production. In this case factors are used in fixed proportions and no substitution is possible.

5.2.1.2 Linear Form of Production Function :

Linear form of production function assumes factors to be perfect substitutes. The shape of the isoquant for this type of production function is linear. Each factor can be used equally well in place of others and the marginal rate of technical substitution between factors remains constant. The elasticity of substitution is infinity. The above mentioned forms are the two extreme cases in economic literature. Between these two extremes lie different workable forms of production functions. Some of the important and widely used functions are (i) Cobb-Douglas (ii) CES (iii) VES (iv) Translog production function. A brief discussion of each of these is presented below.

5.2.1.3 Cobb-Douglas Production Function :

One of the most commonly used production function is the Cobb-Douglas production function, which assumes unitary elasticity of substitution. It can be written as

$$q = A_o L^{\alpha} K^{\beta} \qquad [2]$$

or

$$q = A_o L^{\alpha} K^{\beta} e^{\lambda t} \quad [3]$$

Where q, L, K and t refer to value added, Labour, Capital and time respectively. Technical progress is presumed to take place at a constant rate (λ). A, α and β are the parameters of the production function where 'A' is called the efficiency parameter, because, for every input combination, the greater the A, the greater will be the level of output. α and β represent elasticities of output with respect to labour and capital respectively. Using α and β the returns to scale ($\alpha + \beta$) can be estimated.

5.2.1.4 Constant Elasticity of Substitution (CES) Production Function :

The assumption of unitary elasticity of substitution made by Cobb-Douglas is dropped in CES production function. This form of production function assumes elasticity of substitution to be constant and need not necessarily be unitary, i.e. it may be greater than or less than one or equal to one. The mathematical form of production is

$$q = A [K^{-\rho} + (1 - \delta) L^{-\rho}]^{-1/\rho} \quad [4]$$

where, $A > 0$, $0 < \delta < 1$.

A, δ and ρ are the efficiency, distribution and substitution parameters. The elasticity of substitution is given as $\sigma = 1/(1 + \rho)$

5.2.1.5 Variable Elasticity of Substitution (VES) Production Function :

The CES function is subject to the limitation that the value of the elasticity of substitution is constant, though not necessarily unitary. But it is possible that the elasticity of substitution may vary (along a production path) when the capital - labour ratio varies due to changes in the factor price ratio.

A generalised form of the CES function allowing for varying elasticity of substitution is given as :

$$q = A [\delta K^{-\rho} + (1-\delta) \eta (K/L)^{-c(1+\rho)} L^{-\rho}]^{-(1/\rho)} \qquad [5]$$

where, $\eta = (1 - b) / (1-b-c)$

$b = (1 / 1+\rho)$

A, δ and ρ are efficiency, distribution and substitution parameters.

If $c = 0$; then the VES function becomes a CES function. Elasticity of substitution is given as

$$\sigma = (b / 1-c) (1 + W_l / r_k)$$

where W_l and r_k are shares of Labour and Capital respectively.

When $c = 0 \quad \sigma = b = 1 / (1+\rho)$

i.e. the elasticity of substitution on a production function is constant (CES).

5.2.1.6 Translog Production Function :

Translog production function is a flexible production function which is a second order approximation to any arbitary production function which is twice differentiable. It also accommodates the values of elasticity of substitution varying from zero to infinity. The function is written as follows

$$\begin{aligned} \text{Log } Q = \alpha + \alpha_L \log L + \alpha_K \log K + \alpha_t \log t + 1/2\, \beta_{LL} (\log L)^2 + 1/2\, \beta_{KK} (\log K)^2 \\ + 1/2\, \beta_{tt} (t)^2 + \beta_{LK} (\log L)(\log K) + \beta_{Lt} (\log L)(t) + \beta_{Kt} (\log K)(t) \end{aligned}$$

....[6]

Differentiating log Q with respect to log L, log K and 't' respectively.

$$\partial \log Q / \partial \log L = \alpha_L + \beta_{LL} + \beta_{LK} (\log K) + \beta_{Lt}\, t \qquad [7]$$

$$\partial \log Q / \partial \log K = \alpha_K + \beta_{KK} (\log K) + \beta_{LK} (\log L) + \beta_K\, t \qquad [8]$$

The elasticities of value added with respect to labour and capital are not constant but depend on the input levels and time.

The rate of technical progress or TFPG in a translog production function is given by

$$\partial \log Q / \partial t = \alpha_t + \beta_{tt}\, t + \beta_{Lt} (\log L) + \beta_{Kt} (\log K) \qquad [9]$$

Where α_t is the rate of TFPG, β_{tt} is the rate of change of TFPG, and β_{Lt} and β_{Kt} define the bias in TFPG. If both β_{Lt} and β_{Kt} are zero, then the TFPG is of Hicks-neutral type. If β_{Lt} is positive, then the share of labour increases with time and there is a labour using bias.

Depending up on how the inputs are defined in a production function the output measure is selected. In the estimation of production function, labour and capital are taken as inputs. Here capital is inclusive of land; hence real value added is taken as a measure of output. When raw material is included in the production function. The appropriate measure of output is the gross output. Raw materials, fuels and other intermediate goods are used as input by firms in their production of output. Therefore a general form a production function can be written as

$$q = f(K, L, R) \qquad [10]$$

q = gross output, K = capital, L = labour, R = raw materials used in production.

5.3 Production Function Estimates : Major Studies :

Considerable number of studies have been conducted for estimating the production function and related aspects of the Indian manufacturing. The studies can be classified into different groups. They can be studies on output growth both partial and TFP, returns to scale; technical progress, elasticity substitution etc. The studies conducted were for different time periods and followed divergent methodologies. Hence their conclusions are equally diverse. The results are estimated through different forms production function, more often Cobb-Douglas (CD) production function has been used in most of the studies. However the other forms like Constant elasticity of substitution (CES), Variable elasticity of substitution (VES) and Translog functions are also used by some studies.

5.3.1 Studies on Returns to scale :

The Yeong Her Yeh's study (1966)[1] used different specifications of Cobb-Douglas production function and studied 29 Indian industries. The study observed increasing returns to scale in 17 industries, constant returns to scale in two industries and diminishing returns to scale in other 10 industries

Similar variations in the economies of scale were observed by Diwan and Gujarati (1968)[2] at the individual industries level in their study of 29 industries. They used CES production function and found high economics of scale during the period 1946 - 58 in most of the industries. Sankar (1970)[3] also found evidence of economies of scale in estimating the CES production function for 15 industries together covering the period 1953-58. Mehta (1980)[4] in his individual industry study using CD and CES forms of production function found that, in most of the cases constant returns to scale were operating for the period 1953 to 1965.

Dutta Majumdar (1966)[5] arrived at a similar conclusion of constant returns to scale for the total manufacturing industry, on the basis of study for the period 1951 - 1961. The study by Hashim and Dadi (1971)[6] also found evidence of constant returns to scale in Indian industries Narashimham and Fabrycy (1974)[7] gave estimates of returns to scale for 28 Indian industries for the period 1946 to 1958 using three different functions viz., CD, CES and Homothetic iso-quant and showed constant returns to scale in all 28 Indian industries individually and together.

However, Banerji (1971)[8] in his study of Indian industries for the period 1946 - 58 observed that the evidence regarding returns to scale was not categorical. He found statistically significant evidence of increasing returns to scale, using CD production function. There are other studies on returns to scale based upon individual industry performances, which showed considerable variation between different industries.

5.3.2 <u>Studies on Technical Change</u> (TFPG) :

There are different studies on technical change for different periods This has been undertaken by both simple ratio analysis (partial and TFPG) and production function approach. In the Indian context, one comes across the usage of both TFP approach and production function approach to isolate the technical change. Most of the earlier studies treated technical change and TFPG synonymously in the literature (Sastry 1981)[9]. The TFP analysis and results have been presented in Chapter IV of this thesis. Timbergen introduced the concept of TFP as the ratio between real output and real factor inputs. Stigler (1947)[10] developed the concept and recommended 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.

Reddy and Rao (1962)[11] attempted to measure the technical progress in the Indian industry for the period 1946 to 1957 using Solow method and found the existence of neutral technical progress in Indian industries.

Sengupta (1963)[12] using CES production function for 7 industries for the period 1948 to 58, found neutral technical change. The technical progress was not significant in Cement industry, significant in Iron and Steel and Jute industries and quite significant in the Sugar industry

Shivamaggi, Rajagopalan and Venkatachalam (1968)[13] studied partial and TFPG trends in seven industries. They have observed an increase in labour productivity and there was not significant change in TFPG in all the industries studied. Rajkrishna and Mehta (1968)[14] also arrived at the same conclusion for the period 1946 - 64. TFP declined steadily over the period.

Venkataswami (1968, 1975)[15] using both CES and CD production function for the period 1948-67 for 28 industries found that technical change was relatively higher in new industries like Metal products, Chemical, Machinery etc., than in the old and well established industries, Cotton textiles, Food products etc.

Sankar (1970)[16] in his study on Indian industries found positive technical progress in six industries and negative in two other industries. Narasimham and Fabrycy (1974)[17] studied Indian industries for the period 1946-1959 measured the technological change in terms of simple time shifts of the production function. According to them, the rate of technical progress was not significantly different from zero.

Benerji (1971)[18] calculated TFP using Solow and Kendrick methods for the period 1948-64, he observed a steady decline in the TFP in the period. He also studied (1974)[19] the technical progress in five industries using Cobb-Douglas production function and came to the conclusion that traditional industries like Cotton and Jute textiles had not shown any technical progress, whereas Sugar, Paper, Bicycle industries by and large appeared to be subjected to positive technical progress.

Mehta (1980)[20] in his study for the period 1953 to 1965 used Solow and Kendrick methods He found TFP indices measured by the both methods showed a downward trend. Goldar (1985)[21] estimated productivity growth in Indian industries for the period 1959 to 1979 and observed TFP estimates do not find any appreciable decrease in growth rate. His estimates showed 1.3 per cent growth rate in TFP for the period.

Ahluwalia (1991)[22] studied productivity as a source of growth for the period 1959-60 to 1982-83 shows that there has been negligible and insignificant growth in TFP in the manufacturing sector, however she has found that there is turnaround of positive TFPG during 1980s. This study also proved that technical progress has a capital saving bias.

Balakrishnan and Pushpangadan (1994, 95 and 96)[23] studies on TFP for aggregate manufacturing sector showed slightly different results than that of Ahluwalia. Their study have adjusted for, the relative price changes and used Value Added Double Deflator (VADD) method. Their results of TFPG indicate that, contrary result than what was believed by Ahluwalia study of productivity growth in the 1980 that TFPG actually, have been slower than other estimates undertaken during 1980s.

Balakrishnan and Pushpangadan (1998)[24] indicated growth accounting method of TFP showed a decline in productivity growth in 1980s and the results in estimation of production functions yields an increase in productivity growth.

Mohan Rao's (1996)[25] work on productivity measures on Indian industry showed an improvement in industrial productivity performance in 1980s and indicated a improvement in productivity growth with positive rate of growth.

5.3.3 Studies on the Elasticity of Substitution :

The elasticity of substitution measures the pattern of resource use in a productive system. The concept of elasticity of substitution is of crucial importance for analysing the factor substitution It is defined as the ratio of percentage change in the ratio of inputs to the percentage change in the Marginal Rate of Technical Substitution (MRTS). The input combinations are changed to produce the same amount of output or input combinations change with different levels of output leads to changes in factor substitution. Various studies have been conducted in India to estimate the nature of elasticity of substitution in Indian manufacturing.

Sengupta (1963)[26] estimated a first degree homogeneous CES production function for seven industries covering the period 1948 to 1958. The study also analysed elasticity of substitution and tested the hypothesis that (a) elasticity of substitution equals to zero and (b) elasticity of substitution equals to one and found no consistent results in seven industries.

Diwan and Gujarati (1968)[27] studied 28 industries for the period 1946 to 1958 and formed elasticity of substitution in most of the industries in quite low (less than 0.5). Venkataswami (1968)[28] tested the hypothesis that elasticity of substitution equals to unity for the period 1948 to 1967. The result proved the hypothesis to be true in 21 out of 28 industries.

Sankar (1970)[29] used CES production function for the period 1946 to 1958. The results suggest that out of 15 industries seven showed the estimates close to one and six industries have the value less than unity.

Narasimham and Fabrycy (1979)[30] in their studies on Indian industries for the period 1946 to 1958, obtained the elasticity of substitution to be 0.7821. Kazi (1978)[31] studied nine Indian industries using cross section data for 1960, 1961 and 1962. The estimates of elasticity of substitution varied from zero to one Kazi (1980)[32] again estimated VES production function for 1973, 1974 and 1975 and suggested elasticity of substitution to be low in eight out of nine industries for the period.

Mehta (1980)[33] studied the elasticity of substitution for 27 industries with time series data using CES production function. His results indicated that the elasticity of substitution was not significantly different from zero in seven industries, significantly different from one in ten industries and significantly different from one in remaining ten industries.

5.3.4 Limitation of the Earlier Studies :

The quantity of research effort that has gone in to these areas are quite impressive. The survey reveals that considerable work has been done in all these areas and also found estimation of productivity and technical progress is a complicated issue. The research works on productivity over a period of time have taken in to its grasp sizeable improvements with various production functional approaches. All this earlier works have been based on the Census of Manufacturing Industries (CMI) and on the Annual Survey of Industries (ASI). These sources were available for two distinct periods, CMI data is available from 1946 to 1958 and ASI data is available for 1959 to 1971 and 1973 to 1993. In addition numerous firm level analysis based on primary data have been taken up.

Many of the earlier studies were restricted only to the CMI data. The latter studies worked with ASI data. This is because the data of CMI and ASI are not strictly comparable, since the coverage of period and classification industries are different. The CMI covered only those factories which employed not less than 20 persons and using power on any day of the operation during the year. The ASI, on the other hand, covered all the factories employing 10 persons or more on any day of operation during the year and using power and also those employing 20 or more persons on any day of operation during the year but not using power The ASI data has both the sample and census data. Some of the studies using only CMI data, they are Dutta (1955), Murti and Sastry (1957), Reddy and Rao (1962), Sen Gupta (1963), Sankar (1965), Yeong Her Yeh (1966), Diwan and Gujarati (1968), Narashimham and Fabrycy (1974) and Sakong and Narasimham (1974). Some of the studies, however, used only ASI data Kazi (1978 and 1980), Goldar (1985), Ahluwalia (1991), Balakrishna and Puspangadan (1994, 1995 and 1996), Mohan Rao (1996) etc. The studies which used both CMI and ASI data were Dutta Majumdar (1966), Singh (1966), Raj Krishna and Mehta (1968), Shivamaggi (1968), Venkataswami (1968 and 1975), Sankar (1970), Benerji (1971, 1973, 1974), Hashim and Dadi (1971), Mehta (1980), Sastry (1981). Most of earlier studies covered the period till 1970 only. The studies by Goldar (1985), Ahluwalia (1991), Balakrishnan and Pushpangadan (1994, 1995 and 1996), Mohan Rao (1996) have covered the period of eighties.

Most of earlier studies on capital output and other ratios surveyed took book value of capital. The definition of capital by proper adjustment was not made and adjustments were not much for capacity utilisation. Very few studies have tried to adjust the capital for capacity utilisation like those of Hashim and Dadi (1971)[34], Ram Rao and Anjaneyulu (1972)[35]. Important studies like Yeong Har Yeh (1966)[36] have not adjusted for price variations and formed a serious limitation of his study on returns to scale.

Many of the earlier studies were pure econometric exercises. They had not given guidelines, for the policy purposes. The results of most of studies carried out for the period 1960, 1970 were not relevant to deal with the present day situation because as long time gap, with drastic change in domestic policies and international scene. The conclusions drawn would not be suitable to frame policies for a competitive and current economic situations.

5.4 Cobb-Douglas Production Function :

Most widely used production function in productivity estimates is based upon the Cobb-Doughals (CD) production function. This production function is compact and easy to work with. However this function assumes unitary elasticity of substitution between factor inputs and Hicks neutrality of technical progress. Benerji (1975)[37] made a systematic attempt to test the assumption underlying the CD specification and found empirical support for these assumptions.

With this production function, one can explain the laws of proportion, i.e., the transformation of factor inputs into outputs at any particular time period. This production function can be used to represent the technology of a firm or an industry, or of the economy as a whole. The production function includes all the technically efficient methods of production It is also used to measure technical progress and returns to scale. The factors of production together with the nature of technology utilized determines the output and the value added.

The production function in general form is

$$O = f(L, K, R) \qquad [7]$$

$$V = f(L, K) \qquad [8]$$

where,

V = Value Added, O = Gross Output, L = Labour,

K = Capital, R = Raw Materials.

However this functional form does not take technical progress in to consideration. So the above equation can be modified introducing time in the functional form

$$O = f(L, K, R, t) \qquad [9]$$

$$V = f(L, K, t) \qquad [10]$$

where t = represent time element.

The above production function can be expressed with a specific form of production function, namely the CD production function. As mentioned earlier this form is the most popular in applied research because of it's mathematical flexibility. In a specific form, the CD production function can be written as :

$$V = A.\ L^{\alpha}.\ K^{\beta}.\ e^{\lambda t} \qquad [11]$$

where, A = efficiency parameter

α = elasticity with respect to labour

β = elasticity with respect to capital

$\alpha + \beta$ = returns to scale

λ = rate of technical progress.

As the above production function (9) is in non linear form and its linear approximation can be through expressing it in Double Log form i.e.

$$\text{Log } V = \text{Log } A + \alpha \text{ Log } L + \beta \text{ Log } K + \lambda t \qquad [12]$$

The results of CD production function exercise conducted in this study, taking 16 major industries of ASI two digit level classification, are presented in the Table 5.1 In the following paragraphs, the C.D. production function analysis of on returns to scale and technical progress are discussed for individual industries as well as for all manufacturing sector.

Table 5.1 : Cobb-Douglas Production Function : Estimated Results for Indian Manufacturing Sector

$V.A = A.\ L^{\alpha}.\ K^{\beta}.\ e^{\lambda t}$

Ind. Code	A	α	β	λ	R^2	F.Ratio	D.W
Food Products (20-21)	0.5159	0.9158 (2.8941)**	0.3390 (1.9271)	0.0135 (0.647)	0.8908	43.5017	1.2589
Beverages & Tobacco Products (22)	3.2924	0.2251 (1.7691)	0.6337 (4.9506)**	0.0443 (1.2450)	0.8346	36.9146	2.1214
Cotton Textiles (23)	3 0094	0.6263 (2.1773)**	0.2444 (1 3324)	-0 0184 (-1.1138)	0.8151	24.5171	1.4209
Wool, Silk and Synthetic Products (24)	1.1237	0.2978 (1.9577)	0.5783 (6.8510)**	0.0452 (2.0599)*	0.9645	145.092	1.83340
Jute and Hemp Products (25)	1.5042	0.2142 (1.5053)	0.7682 (2.4798)**	0.0137 (0.9351)	0.8718	41.3047	1.5198
Textile Products (26)	0.3996	0 3314 (1.2828)	0.8419 (3 6634)**	0.0049 (1.2305)	0.9791	20.1273	1.5073
Wood and Wood Products (27)	4.5661	0.5786 (1 8593)	0.2467 (1.9061)	-0.0141 (1.4899)	0.7569	19.2108	1.2192
Paper and Paper Products (28)	2.0478	0.3218 (1.4075)	0.5819 (2.0942)**	-0.0248 (2.3674)**	0.7672	37.5781	1.3974
Leather and Leather Products (29)	5.2361	0.7604 (1.9854)	0.3307 (1.8861)	0.0312 (0.9884)	0.8698	38.1400	1.0493
Rubber,Rubber Products and Petroleum(30)	0.4278	0 3457 (1.8584)	0.7389 (3.1887)**	0.0137 (1.7286)	0.8824	40.0023	1.2711

cont...

Table 5.1 (cont..)

Ind. Code	A	α	β	λ	R^2	F.Ratio	D.W
Chemical and Chemical Products (31)	0.5721	0.2984 (1.9295)	0.4528 (2.2661)**	0.0218 (0.5905)	0.9043	50.4478	1.3073
Non-metallic Mineral Products (32)	3.0283	0.2963 (1.0938)	0.4998 (6.1516)**	0.0071 (2.9336)**	0.9385	81.3575	1.4988
Basic Metal and Alloys (33)	1.4942	0.6433 (1.8315)	0.3782 (2.1349)**	-0.0183 (-0.7653)	0.7831	41.1573	1.6134
Metal Products (34)	3.5111	0.6639 (1.2537)	0.4343 (3.2780)**	0.0136 (1.1811)	0.8761	37.7050	1.3172
Machinery- Electrical, non-electrical (35-36)	1.8421	0.3233 (3.3286)**	0.5812 (2.5850)**	0.0313 (2.2752)**	0.9799	47.1882	2.3252
Transport Equipment Products (37)	3.9585	0 5547 (1.7127)	0.3243 (1.9308)	-0.0306 (1.3931)	0.7179	19.5423	1.8563
All Manufacturing	3.6198	0.2770 (1 8349)	0.8389 (3.1429)**	0.0079 (1.3602)	0.9765	221.690	1.7231

** = Significant at 1 percent level

* = Significant at 5 percent level.

The returns to scale is denoted by $(\alpha + \beta)$. If the value of $(\alpha + \beta)$ is greater than 1, the industry is said to face increasing returns to scale, if the value of $(\alpha + \beta)$ is less than 1, the industry is said to face decreasing returns to scale. In case the value of $(\alpha + \beta)$ is equal to one then the industry is said to face constant returns to scale.

5.4.1 Cobb-Douglas Production Function : Results :

The results of the study indicate that out of 16 industrial categories only 4 are facing increasing returns to scale and 10 industrial categories faced decreasing returns to scale.

For 'all manufacturing' the returns to scale $(\alpha + \beta)$ value is 1.1159, the sector is facing overall increasing returns to scale. However this value is not very high. The elasticity of value added with respect to labour is 0.2770 which is significant at 5 per cent level and elasticity with respect to capital is 0.8389 which is significant at 1 per cent level. The coefficient (λ) value is 0.0079 and is statistically insignificant. The rate of technical progress for 'all manufacturing' is almost zero which leads us to the conclusion that there is no significant importance of technical change on output perse. The value of the technical progress is less than one per cent for as many as 10 industrial categories thus indicating little contribution from technical progress towards productivity growth. In the following paragraphs the results of each of the industrial categories are discussed. For four industries the technical progress is negative and for other 10 industries it is positive, however, the value for technical progress coefficient is less than one per cent per annum for most of the industries. It implies technical progress though positive, have not contributed significantly to the value added in the Indian manufacturing. Therefore, CD production function estimates indicate technical progress have not contributed significantly to productivity growth in Indian manufacturing. The parameters estimated are tested for statistical significance using 't' statistic. When the parameter is statistically significant one can conclude that estimated relation holds true, otherwise we cannot say with confidence that the estimated relation holds true.

In case of Food products industry (20-21) ($\alpha + \beta$) value is 1.2548, this value indicates that this particular industry faces increasing returns to scale. The elasticity with respect to labour is 0.9158 and with respect is capital is 0.3390 which is lower and found to be insignificant. The coefficient representing rate of technical progress (λ) is 0.0135 and is found to be statistically insignificant. This indicates that for Food and Food products industry, the technical progress contribution is positive to productivity but is not significant.

For 'Beverage, Tobacco & Tobacco Products' (22) the returns to sale is 0.8588 that the industry is facing decreasing returns to scale and the rate technical progress for this particular industry is high but not significant. The elasticity of value added with respect to labour is 0.2251 and with respect to capital is 0.6337 which are significant for this industry. In case of Cotton Textiles Industry (23), it is found that the industry faces decreasing returns to scale, as the ($\alpha + \beta$) value is 0.8707. The elasticity with respect to labour 0 6263 and with respect to capital is 0.2444 which is significant at one per cent level. The coefficient representing rate of technical progress λ is -0.0184. This indicates that the technical progress for this industry is negative. As Cotton textiles one of the traditional industries in the Indian economy and is losing to modern textiles. This is a declining industry in the economy which operates with old techniques of production.

Wool, Silk and Synthetic industry (24) also faces decreasing returns to scale and the ($\alpha + \beta$) value is 0.8761. The elasticity of value added with respect to labour is 0.2978 per cent which is relatively low and insignificant. The elasticity with respect to capital is 0.5783 which is relatively high and is found to be significant. The λ value representing technical progress is 0.0452 this means that this particular industry facing positive and high technical progress. For the Jute, Hemp and Jute Products industry (25), ($\alpha + \beta$) is 0.9824 that the industry faces, nearly, constant returns to scale. The elasticity with respect to labour is 0.2142 which is significant at 1 per cent level. The value of elasticity with respect to capital is 0.7682. The coefficient of technical progress for this industry is 0.0137, indicating technical progress is around one per cent but the effect on productivity is not statistically significant.

In case of Textile Products (26) industry, it is found that the industry faces increasing returns to scale, ($\alpha + \beta$) value is 1.1933. The elasticity of value added with respect to labour is 0.3314 and with respect to capital is 0.8419 which is relatively higher in this industry. The coefficient representing rate of technical progress (λ) is 0.0049, showing technical progress is low in this industry and is statistically not significant.

In case of Wood and Wood Products (27), the ($\alpha + \beta$) value is 0.8253 thus indicating that this industry is facing decreasing returns to scale. The elasticity with respect to labour is 0.5786 and with respect to capital is 0.2667. The λ value showing technical progress is -0.0141, it means technical progress is negative contribution to this industry.

In case of Paper and Paper Products Industry (28), ($\alpha + \beta$) value is 0.9037 which indicates that the industry is facing constant returns to scale. The elasticity with respect to labour 0.3218 and with respect to capital is 0.5819 which is relatively high and significant. The technical progress has a negative effect on the productivity as the coefficient is -0.0248 and is statistically significant.

In case of Leather and Leather Products Industry (29) it is found that the industry faces increasing returns to scale as ($\alpha + \beta$) value is 1.0911. The elasticity with respect to labour is 0.7604 which is relatively high and elasticity with respect to capital is 0.3307. The coefficient representing rate of technical progress (λ) value is 0.0312. This indicates that for this industry the rate technical progress is 3 per cent per annum but not significant.

The Rubber, Plastic, Petroleum and Coal products industry (30), ($\alpha + \beta$) value is 1.0846 which indicates that the industry is facing increasing returns to scale only marginally The elasticity with respect to labour is 0.3457 and with respect to capital is 0.7389 which is relatively high is and found to significant for this industry. The coefficient representing rate of technical progress (λ) value is 0.0137. This indicates that the rate of technical progress for this industry is around 1 per cent per annum.

In case of Chemical and Chemical Products (31), it is found the industry faces decreasing returns to scale because ($\alpha + \beta$) value of the industry is 0.7961. The elasticity value with respect to labour is 0.2984 and the elasticity with respect to capital is 0.4528 and which is found to be significant at 1 per cent level. The rate of technical progress in this industry is around 2 per cent per annum which is high compared to other industrial categories however, it is not statistically significant.

In case of Non-Metallic and Mineral industry (32), (α + β) value is 0.7961 indicating the industry is facing decreasing returns to scale. The elasticity of value added with respect to labour is comparatively lower to 0.2963 and the elasticity with respect to capital is 0.4998 which is found to be significant at 1 per cent level. The industry is facing rate of technical progress with λ value being 0.0071 which is significant at one per cent level

The Metal and Alloy industry (33) faces constant returns to scale having (α + β) value is equal to 1.0215. The elasticity with respect to labour is 0.6433 and with respect to capital is 0.3782 found to be significant at 1 per cent level. The (λ) value is -0.0183 indicating this industry has negative technical progress

In case of Metal Products industry (34) the returns to scale is also found constant with (α + β) value equal to 1 0415. The elasticity of value added with respect to labour is 0.3233 and with respect to capital is 0.5812 which is found to be significant at 1 per cent level. The coefficient representing rate of technical progress (λ) is -0.0136 indicating technical progress in this industry is around 1 per cent per annum but negative, however it is statistically not significant.

For the Electrical and Non-Electrical Machinery's industry (35-36), the (α + β) value is 0.9045 facing decreasing returns to scale. The elasticity with respect to labour is 0.3233 and with respect to capital is 0.5812, both of them are statistically significant at 1 per cent level. The coefficient representing rate of technical progress (λ) value is 0.0313 and is also significant at 1 per cent level. This indicates that the rate of technical progress in this industry is around 3 per cent per annum.

In case of Transport and Transport Equipment Parts (37), industry also faces decreasing returns to scale, ($\alpha + \beta$) value is 0.8790. The elasticity with respect to labour is 0.5547 and with respect capital is 0 3243 both are not significant. The coefficient representing rate of technical progress (λ) value is -0.0306 which indicates that industry facing negative technical progress.

5.5 Translog Production Function :

The C.D. Production function assumes elasticity substitution to be unitary. In the real situation it does not always remain unitary. To correct this limitation of Cobb-Douglas production function new forms of production functions have been developed. The Constant Elasticity Substitution (CES) approach have been developed which assumes the value of elasticity is not unity but it remains constant However, it does not remain constant on a given production frontier. The Variable Elasticity of Substitution (VES) approach have been developed which assumes that elasticity of substitution varies on given production frontier. The translog production function developed during 1960s taking into consideration all these properties and therefore it has become a popular tool of analysis.

Translog production function is a flexible production function It incorporates all the important features of Cobb-Douglas, CES and VES production functions. It imposes relatively fewer a priori restrictions on the properties of production function. In particular, it does not assume a Hicks-Neutral or constant rate of technical change. The elasticity of substitution between inputs are allowed to vary with the level of inputs. Using translog form of production function one can test for the returns to scale, technical progress and elasticity of substitution.

The Trans Log production function with two factors of production (Labour and Capital) is given by

$$\text{Log } Q = \alpha + \alpha_L \log L + \alpha_K \log K + (1/2)\, \beta_{LL} (\log L)^2 + (1/2)\, \beta_{KK} (\log K)^2 + \beta_{LK} (\log L)(\log K) \quad [13]$$

In estimating this production function six parameters are to be estimated, thus equal number of degrees of freedom are lost when we introduce time as independent variables the parameters to be estimated increases thus we will be left with fewer degrees of freedom Therefore when one is working smaller number of observation fitting of translog function is a problem.

The present study makes use of 20 years data. To over come the problem of fewer degrees of freedom this study makes use of modified translog production function.

For the present analysis we have used the following form of translog function

$$\text{Log } (Q/L) = \alpha_0 + \alpha_1 \log L + \alpha_2 \log (K/L) + \alpha_3 [\log (K/L)]^2 + \lambda t \quad [14]$$

Using the estimated coefficients from the above function, the parameters of production frontier presented earlier can be estimated as follows.

(i) $\mu = (1 + \alpha_1)$ = returns to scale or

$\alpha_1 = (\mu - 1)$

(ii) $\alpha_2 = \mu (1 - \delta)$

$\alpha_2 = (1 + \alpha_1)(1-\delta)$

$\delta = (1 - \alpha_2) / (1 + \alpha_1)$

where, δ is distribution parameter.

(iii) $\alpha_3 = - (1/2) \rho \mu \delta (1 - \delta)$

$\rho = - 2 \alpha_3 [(\alpha_1 + 1/\alpha_2) (\alpha_1 + 1-\alpha_2)]$

where ρ : parameter of substitution.

(iv) $\sigma = 1 / (1+\rho)$

$\sigma = 1 / 1\text{-}2/3 [(\alpha_1 - 1/\alpha_2) (\alpha_1 + 1-\alpha_2)]$

where σ is elasticity of substitution.

Using this form of Translog production function the parameters are estimated (Table 5.2) which are used to estimate the returns to scale, elasticity of substitution (refer Table 5.3).

5.5.1 Returns to Scale in Tranglog Function :

Economies of scale is directly related to productivity performance in the manufacturing sector. As the structural and technological change is taking place across Indian industries the scale of economies also changes. If most of industries face increasing returns to scale, there is plenty of scope to attain sufficient economies of scale by enhancing the production to optimum levels.

Table 5.2 : Translog Production Function : Estimated Results for Indian Manufacturing

$$Ln(Q/L) = \alpha_o + \alpha_1 \, Ln\, L + \alpha_2 Ln\,(K/L) + \alpha_3\, [Ln(K/L)]^2 + \lambda t$$

Industry	α_o	α_1	α_2	α_3	λ	D.W	R^{-2}	F.Ratio
Food Products (20-21)	-39.2471	1.1305 (6.2077)**	14.4267 (3.5041)**	-1.4898 (1.4997)	-0.0185 (-0.9351)	1.3135	0.6199	11.3296
Beverages & Tobacco Products (22)	8.3759	-0.2437 (1.3931)	-0.4378 (6.2402)**	0.0304 (3.3722)**	0.0306 (0.8841)	2.4024	0.6927	9.5423
Cotton Textiles (23)	-34.5384	1.3157 (1.0957)	11.3021 (4.6940)**	-1.1060 (1.6772)	-0.0344 (-2.2104)*	1.0828	0.6495	9.8029
Wool, Silk and Synthetic Products (24)	4.7630	-0.4452 (2.8571)**	1.5535 (1.4822)	-0.2283 (3.2662)**	0.0321 (2.7623)**	1.8704	0.8167	22.1579
Jute and Hemp Products (25)	-1.5233	-0.1803 (1.2205)	3.2208 (2.4329)**	-0.4284 (2.4226)**	0.0122 (3.7105)**	1.6287	0.6011	7.5339
Textile Products (26)	13.6768	-0.3458 (1.9959)	-4.4018 (2.8507)**	0.5828 (0.9529)	0.0509 (2.2076)*	2.3886	0.9126	50.5770
Wood and Wood Products (27)	14.5970	-0.7952 (1.8337)	-3.6720 (2.7719)**	0.4932 (3.0093)	-0.0047 (-1.2852)	1.6816	0.8194	22.5566
Paper and Paper Products (28)	18.7059	-0.3178 (1.6339)	-5.1998 (2.7399)**	0.5416 (2.7726)**	-0.0194 (-0.7629)	2.2665	0.7391	14.4564

cont.....

Table 5.2 cont...

$$\ln(Q/L) = \alpha_o + \alpha_1 \text{Ln } L + \alpha_2 \text{Ln } (K/L) + \alpha_3 [\text{Ln}(K/L)]^2 + \lambda t$$

Industry	α_o	α_1	α_2	α_3	λ	D.W	R^{-2}	F.Ratio
Leather and Leather Products (29)	24.5076	-0.1939 (-1 5553)	-9.3084 (3.0917)**	1.0896 (3 3034)**	0.0274 (1.0502)	1 9956	0.5170	6.0848
Rubber,Rubber Products and Petroleum(30)	35.6156	-0.2632 (-3.2809)**	-10.5930 (-1.0729)	0.9581 (6.2242)**	0.0135 (2.0407)**	1.6813	0.6075	8.3523
Chemical and Chemical Products (31)	34 3654	-0 5751 (1 5510)	-8 9938 (1 8979)	0 7867 (3 0080)**	0.0357 (2 5448)**	1 5892	0.9613	16.1461
Non-metallic Mineral Products (32)	12.1115	-0 1605 (1 6660)	-1 2205 (-1.7928)	0 1338 (2 9180)**	0.0081 (3 5820)**	1.5005	0.8308	24.3204
Basic Metal and Alloys (33)	-30.9325	0.3091 (2.4079)**	9.4494 (1.9663)	-0.6721 (1.9161)	-0.0408 (-1.7812)	1.9799	0.5313	6.3849
Metal Products (34)	-10.3720	-0.2482 (2 5794)**	6 4520 (4 8961)**	-0.6444 (-1.8474)	0 0254 (6.4079)**	1 5650	0.6242	8.8881
Machinery-Electrical, non-electrical (35-36)	2.7389	-0 5319 (1 5698)	1 8496 (2 6414)**	0.1502 (0.5605)	0.0391 (2 4638)**	1.8239	0.9374	72.1685
Transport Equipment Products (37)	-11.7983	-0 3958 (1.7127)	8 3158 (2.4638)**	-0.8519 (1 5187)	0.0233 (2.6848)**	1.3242	0.8798	21.8641
All Manufacturing	4.3221	-0.0787 (1.0205)	0 7542 (1.8697)	-0 0075 (-2.1661)**	0 0146 (2.1390)*	1 8912	0.9498	91 0256

σ is estimated using the parameter estimates α_1, α_2, α_3 of the production function.

* - Significant at 5% level

** - Significant at 1% level.

Table 5.2 presents results of calculations of returns to scale of translog function. Industries can be divided into three groups based on their returns to scale. The first groups contains three industries that show increasing returns to scale. In this analysis $(1+\alpha_1)$ value, gives the returns to scale of an industry. The industries showing increasing returns to scale are Food and Food Products (20-21) having $(1+\alpha_1)$ value of 2.1305, Cotton textiles (23) with value of 2.3157 and Basic metals industry (33) with value of 1.3071.

The second group consists of industries with economies of scale less than one i.e. facing decreasing returns to scale. The table indicates out of 16 industries 13 are facing decreasing returns to scale. The $(1+\alpha_1)$ value ranges from 0.4249 for Chemical and Chemical Products (31) to 0.8197 for Jute and Hemp products industry (25). The industries facing decreasing returns to scale are Beverage, Tobacco Products (22), Wool, Silk and Synthetic Fibre (24), Jute and Hemp products (25), Textile Products (26), Wood and Wood Products (27), Paper and Paper Products (28), Leather and Leather Products (29), Rubber and Rubber Products (30), Chemical and Chemical Products (31), Non-metallic Mineral industry (32), Metal Products (34), Machineries, Electrical and non-electrical (35-36) and Transport and Transport equipments industry (37).

None of the industries fall into third group of constant returns to scale However for 'all manufacturing' sector $(1+\alpha_1)$ value is 0.9213 which is nearer to one facing almost constant returns to scale. However the coefficient is not statistically significant. Therefore, with exception of three industries, most of the Indian industries are facing decreasing returns to scale.

5.5.2 Elasticity of Substitution :

The extent of substitutability between factors can be obtained by directly estimating the parameters of a suitably specified production function through regression analysis. The translog production function is used in this analysis to estimate elasticity of substitution. It does not assume a Hicks-neutral or a constant rate of technical change. The elasticity of substitution between inputs is also allowed to vary with the level of the inputs. The elasticities of value added with respect to labour and capital are not constant but depend on the input levels and time. Therefore from the results of translog production function, the elasticity of substitution is calculated and presented in Table 5.3. The coefficients α_1, α_2 and α_3 are used to estimate the distribution parameters, elasticity coefficient and elasticity of substitution The 'σ ' value provide information on the possibilities of factor substitution within the framework of the translog production function.

The larger the elasticity of substitution value of the measure, the more easily factor inputs can be substituted for one another. Conversely if the elasticity value close to zero that indicates factor substitution is not possible i e. they have to be used in fixed proportions and hence are not substitutes. In this analysis the elasticity of substitution is found to vary from 0.9668 in the case of Textile Products industry (26) to 1.4920 in Beverages and Tobacco product industry (22). The (σ) value for all manufacturing sector is 0.9012. However most of the individual industry elasticity of substitution value is found close to unity, indicating labour and capital can be substituted for one another to certain extent.

These figures are for the industrial categories hence they have to be interpreted with caution. If this were true, employing more labour would be possible to overcome unemployment problems, because labour can be substituted for capital without much loss of output. The manufacturing could switch to labour intensive technology in our labour surplus economy. These results do not indicate the firm level substitution between factor inputs. Therefore the elasticity substitution value of Indian manufacturing close to unity show that industries have some (i e.) scope to employ more labour without making much loss of productivity and output. Indeed proper allocation of factors like labour and capital will improve the overall productivity of the economy.

5.5.3 Technical Progress :

The translog production function also presents technical progress which has taken place in the Indian industry. The coefficient corresponding to time (λ) value gives the rate of technical progress. In this study 5 industries out of 16 industrial categories, the rate technical change is found to be negative, they are Food and Food Products (20-21), Cotton textiles (23), Wood and Wood Products (27), Paper and Paper Products (28) and Alloy and Metal industry (33). The negative technical progress for Alloy and Metal products industry is highest with (λ) value -0.0408 representing 4 per cent negative contribution for the industry. All other industrial categories are largely traditional manufacturers.

Table 5.3 : Translog Production Function : Estimates of Returns to Scale and Elasticity of Substitution.

Industry Code	Returns to Scale $1 + \alpha_1$	Elasticity of Substitution σ
Food Products (20-21)	2.1305	1.0371
Beverages & Tobacco Products (22)	0.7563	1.4320
Cotton Textiles (23)	2.3157	1.0531
Wool, Silk and Synthetic Products (24)	0.5548	1.0214
Jute and Hemp Products (25)	0.8197	1.0998
Textile Products (26)	0.6542	0.9668
Wood Products (27)	0 2040	0.9860
Paper Products (28)	0.6822	0.9889
Leather Products (29)	0.8061	0.9927
Rubber Products (30)	0.7368	0.9780
Chemical Products (31)	0.4249	0.9922
Non-metallic- Mineral Products (32)	0.8395	0.9783
Basic Metal and Alloys (33)	1.3091	1.0252
Metal Products (34)	0.7519	1.0271
Machinery- Electrical and Non-Electrical (35-36)	0.4681	0.9478
Transport Equipment (37)	0.6042	1.0630
All Manufacturing	**0.9213**	**0.9012**

However most of other industries face positive technical progress ranging from 1 per cent to 5 per cent for this period. The impact of technological improvements on total productivity varies drastically across industries. For the Industrial sector as a whole technological improvement accounted 0.0146 i.e. less than 1.5 per cent contribution between 1973-74 to 1992-93, which is statistically significant. The impact of technology output was significant in Textiles products (26) and Basic Minerals industry (32) with 5 per cent positive contribution

The technical progress in Beverages, Tobacco and Tobacco Products (22), Wool, Silk and Synthetic Fibre (24), Chemical and Chemical Products (31) and Machinery Electrical and non-electrical (35-36) are having 3 per cent technical progress. Leather and Leather products (29), Metal products (34) and Transport and Transport equipment (37) are facing 2 per cent technical progress. The Jute and Hemp products (25) and Rubber, Petroleum and Coal products (30) are having 1 per cent technical progress.

The Table 5.3 shows that for 'all industries' the elasticity of substitution variable is not significantly different from one and thus has neutral technology with substitution of factors of production. However, the positive technological progress in most of the industries and more advances of it, results in the factors of production becoming more dissimilar and harder to substitute for each other. Therefore the value of elasticity of substitution would decrease. It means that it becomes equally difficult to employ more labour factor to solve unemployment in the economy.

From the overall results derived from Translog production function observed that the Indian industry in general is facing decreasing return to scale. Most of the industries face positive but low rate of technical change though the change and the elasticity of substitution is found to close to unity.

5.6 Observations of Cobb-Douglas and Translog Function :

In this analysis, the comparisons between Cobb-Douglas and Translog production functions show that both production function results are to a great extent comparable. For all manufacturing, the returns to scale Cobb-Douglas analysis ($\alpha + \beta$) value is 1.1159 and translog analysis ($1+\alpha_1$) value is 0.9213. Out of 16 industries Cobb-Douglas function analysis shows 4 industries are facing increasing returns to scale, 2 industries face constant returns to scale and 10 industries are facing diminishing returns to scale. In the Translog analysis 3 industries face increasing returns to scale and 13 industries face decreasing returns to scale. Therefore both the analysis show most of Indian industries are facing decreasing returns to scale.

The technical progress, λ value for both analysis shows positive to 'all manufacturing' sector, but does not have significant contribution to productivity growth of this sector. The C.D. analysis shows out of 16 industries 5 industries have negative λ value and 11 industries have positive technical progress. The Translog production function analysis shows that out of 16 industries 4 of them face negative technical progress and 12 of them face positive contribution of technical progress. Overall it can be concluded that the technical progress is positive but not significant.

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