Chapter II

Sources of Output Growth, Factor Substitution and Technical Progress in the Indian Textile Industries
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2.1 INTRODUCTION

The Indian economy pursued a standard conventional development strategy to increase national product through rapid industrialization. The government policy in India has encouraged the growth of manufacturing sector in all positive ways, allocating larger shares for industry in the various five year plans, incorporating taxes on imports, export and other subsidies, favoring industrial growth.

Analyzing the sources of output growth in terms of production function models has been an important area in applied economics. An examination of the growth of output of different individual categories provides the background information to understand the factors that seriously hamper the process of industrialization in developing economies. This chapter attempt to study the sources of output growth, factor substitution and technical progress in the Indian textile industries for the period, 1980-81 to 1997-98.

From the period of second five year plan, Indian industrial sector had a transition towards heavy capital intensive industrial activities. Industrialization as the driving force behind the development of a country, it also involves a number of structural changes such as, rise in the share of industrial output and employment, changes in production techniques, factor intensities, increase in productivity, import- export composition, patterns of demand etc. In the first phase of industrial development, industries like, food and textiles are considered as the back bone of the industry. In the second phase, it gave way to industries like chemicals, engineering, repair services etc.

The production function conveys the idea of the concept of the relationship in the transformation of input into outputs. Economists are often
interested in describing the production activity at the level of a firm or industry or the economy as a whole by using production function techniques. In economic theory, production function states quantitatively the general technological relationship between output and the various factors of production. A production iso-quant tells us about the unit of capital and labour necessary to produce a given amount of output.

A production function is a representation of the parameters like, efficiency of technology, technologically determined economies of scale, the capital intensity of technology, and the ease with which factors can be substituted for each other.

2.2. MEANING AND SIGNIFICANCE OF OUTPUT GROWTH

Output growth in the industrial manufacturing sector is an essential component for achieving economic development. The rate of manufacturing industrial growth is determined by the rate of expansion in the productive resources employed in the industrial sector and the rate of improvement achieved in factor productivity levels. An analysis examining the sources of output growth would be a useful research endeavor to know the potential of a nation in accelerating the process of economic growth. Without a viable manufacturing sector, economies will find it difficult to provide improved standard of living to its people. A number of studies have shown that the primary source of output growth in the past has been the improved manufacturing techniques that allow the realization of increased quantities of value addition from given quantities of capital and labour. Such an industrial system would provide opportunities to guarantee improvement in factor productivity levels, achieving better economies of scale and harnessing fuller potentials of a given technology.¹

2.2.1 FACTOR PRODUCTIVITY

An improvement in output growth is reflected by a movement from one iso-quant to another. The flow of output occurs when there is an increased use of capital and labour as factor inputs in the process of value addition. Such an
input-output relationship is technically referred to in economic analysis as "production function." By relating the flow of goods and services produced to any one or a sub-set of factor inputs in a given production function relationship, given scope to understand partial measures of factor productivity. Greater flow of factor services in the production process may lead to increase in output.

2.2.2 SCALE COEFFICIENT

Scale coefficient is an important factor responsible for output growth. It refers to a situation in which a given level of inputs can produce larger outputs. Economies of scale indicate the relative increase in output resulting from a proportional increase in all inputs or after adjusting for the use of all inputs optimally. In order to infer this logic, the modified and generalized models of Cobb-Douglas production function without imposing the restriction that sum of the coefficients of capital and labour are equal to one is used. Sum of the exponents of capital and labour is greater than one, i.e. \( \beta_1 + \beta_2 > 1 \), it indicates that increasing returns to scale, if \( \beta_1 + \beta_2 = 1 \), it would be a constant returns to scale and if \( \beta_1 + \beta_2 < 1 \), then decreasing returns to scale. This scale effect could be observed from the movement of iso-quants from one to another along the production function surface.

2.3 MEANING AND SIGNIFICANCE, AND IMPLICATIONS OF FACTOR SUBSTITUTION

The concept of elasticity of substitution (\( \sigma \)) is having an important place in production theory. It measures the sensitivity of factor proportions to changes in the marginal rate of substitution. The value of \( \sigma \) is essentially determined by the shape of the iso-quants, which in turn is determined by the marginal productivity of the inputs. The concept of elasticity of substitution was introduced to economic theory by J.R. Hicks in 1932. According to him, the elasticity of substitution is a measure reflecting the 'ease with which the factors can be substituted for one another'. It is the ratio of percentage change in the ratio of inputs to the percentage change in the marginal rate of technical substitution. In general, greater the value of \( \sigma \) the curvature of the iso-quants
will be steeper implying, lower degree of elasticity of substitution. Henderson J.M and Quandt R.E⁶ suggest five possible cases in terms of the value of ‘σ’. However, empirical analysis of production focuses on three convenient values of σ;

(i) σ = 0; at the limit, substitution between input pairs are impossible and the production process is characterized as the fixed factor proportion (Leontief). The iso-quants are L shaped and are not consistent with the assumptions of first and second-order partial derivatives. Economists refrain from using the concept of factor complementarities with L shaped iso-quants.

(ii) 0 < σ < 1; inputs are substitutable but not very easily. The iso-quants are negatively sloped (convex to the origin) and the marginal productivity of each factor is positive, indicating efficiency in factor utilization.

(iii) σ = 1; inputs are perfectly substitutable, the iso-quants are not necessarily parallel but they cannot intersect

The extent or degree to which capital and labour can be substituted is the focus of numerous empirical studies that utilize models with different specifications. The two functional forms are the Cobb-Douglas and the CES. The former is utilized by Moroney⁷ and the later by Arrow. K.G Chenery H.B., Minhas B.S Solow, R.M.⁸ The problems with these functional forms are restriction imposed on the value of σ, for example, the Cobb-Douglas form restricts σ to unity. While the CES specification of σ is constant. Another drawback is that both approaches assumes that the returns to scale is constant; this results in the long run average total cost curve being either constantly rising, (decreasing returns to scale), or constantly falling( increasing returns to scale). Ravenker⁹ strongly argued that σ can vary depending upon output and factor combinations as postulated by Hicks¹⁰ and Allen¹¹, therefore any model with an adhoc assumptions about the numerical values of σ may contain a specification bias. He develops a variable elasticity of substitution (VES) specification in which ‘σ’ varies with the input ratios. For empirical purposes, Christenson L.R,
Jorgenson D.W and Lau L.J [12] have devolved Translog production function convenient to estimate VES; the specification is also flexible.

The elasticity of substitution (σ) is a parameter of crucial importance in determining the pattern of resources use in any productive system. A recent development in micro economic theory suggests that the size of the elasticity of substitution between factors is relevant to economic growth. If the elasticity of substitution is high, the factors are quite similar to each other and increased output is possible by just increasing one factor. An increase in the ease of substitution is labour saving when capital is growing relatively rapidly. And capital saving when labour is faster growing factor. [13] High elasticity of substitution is bad signal for the distribution of income under the paradigm of modern technology.

Development theorists argue that as development proceeds, the differences in the factor substitution tend to narrow down across the industries and sectors, because at higher stages of development the scope for further replacement of new and additional capital increasingly becomes a difficult proportion. This led Minhas [14] to argue that the labour abundant low wage countries would tend to hold comparative advantage in industries which have relatively low capital intensity at the prevailing relative cost of capital and labour. Thus, the relative share of labour in the total output depends upon the extent to which labour can be substituted for capital and vice-versa. The greater the substitution of labour for capital, greater will be the share of labour in the traditional output. [15] However this depends on the nature and extent of the elasticity of substitution that characterize the manufacturing industries.

2.4 MEANING AND SIGNIFICANCE OF TECHNICAL PROGRESS

One of the persistent themes often seriously discussed in social sciences relates to assessing the impact of technology and technical change on all aspects of human life. Technology is an omnipotent and all pervasive elements affecting comprehensively every dimension of a social system. In fact, industrial development is the process of acquiring technological capabilities
Technology is a concept linked intricately with the manufacturing process. The concept of technology is closely related to the concept of invention and innovation. An invention while refers to the creation of a new technology or finding a new use of the existing technology, innovation is the first application of the invention in actual production. Although, technology is a static concept at a given point of time, the critical importance of technology is loaded in the dynamic properties of technological change over a period of time. Technological change is viewed as a change in an existing mode of production or the introduction of a new type of production process or of products. Technology may be defined as a pool of knowledge relating to the art of production. The technical progress is used to connote the forward direction of improvements in the techniques of production. The essential quantitative effect of technical progress is the shift in the production function enabling greater output being produced with the same volume of inputs or the same output with less input. In other words it refers to the use of inputs optimally in a production process. Technical progress in turn, is usually assumed to bring about improvements when evaluated from the criteria of efficiency, productivity and welfare. Hence, technical progress is regarded as the painless way to achieve rapid economic growth.

2.4.1 PRODUCTION FUNCTION AND THE CONCEPT OF TECHNICAL CHANGE

The concept of production function is closely related to the concept of "technology". The existing technology defines a unique production function at any given point of time; and technical progress marks an improvement in the existing technology, which results in the upward shift in the entire production function. If "Y" is the vector of net output, then "technology" at any point of time may be expressed by a transformation frontier.
\[ T(Y) = 0 \quad \ldots \quad \ldots \quad \ldots \quad (1) \]

If we have \( Y_1 \) and \( Y_2 \), then the movement from one point to another may be broken down into the movement from one frontier to another. The crucial measurement problem, while studying technological progress, is how we separate these two movements. Let "\( Y \)" denotes a single homogenous output and "\( X \)" the vector of inputs. Technically, a production function can be employed to express the relationship as:

\[ Y = f(X) \quad \ldots \quad \ldots \quad \ldots \quad (2) \]

Overtime, the output-input points change from \( (Y_1, X_1) \) to \( (Y_2, X_2) \). This movement can be broken down into three parts: (i) the movement along the iso-quant of a given production function (substitution) (ii) movement from one iso-quant to another along the same production function (scale -effect) and (iii) movement from one production function to another (technological change).

Technical change involves the shifting of the instantaneous production function. So that the full production function may be written as

\[ Y = g(x, a) \quad \ldots \quad \ldots \quad \ldots \quad (3) \]

Where, "\( a \)" is the vector of knowledge and if the time path \( a(t) \) for knowledge is known, we obtain the form

\[ Y = F(x, t) \quad \ldots \quad \ldots \quad \ldots \quad (4) \]

Where "\( t \)" denotes time. Differentiating equation (4) totally with respect to time and rearranging terms, we obtain

\[ \frac{Y}{Y} = \sum \left( \frac{F_i X_i}{F} \right) + \left( \frac{F_t}{F} \right) \quad \ldots \quad \ldots \quad (5) \]

Where dot denotes the derivative operator \( d/dt \). \( F_i \) denotes \( dF/dX_i \) and \( F_t \) denotes \( dF/dt \). If we write \( \beta_i \) for \( (FiXi/F) \) which is the distributive share of the \( i \)th factor. Then we obtain

\[ (F_t/F) = \frac{Y}{Y} - \sum \beta_i X_i / X_i \quad \ldots \quad \ldots \quad \ldots \quad (6) \]

This is the basic growth accounting equation. The rate of technical progress is given by \( F_t / F \).
2.4.2 CLASSIFICATION OF TECHNICAL PROGRESS

Technical progress can take several distinct forms depending on the way it enters into a production activity. The following are the major distinctions of technical progress viz (a) induced and autonomous technical progress; (b) embodied and disembodied technical progress and (c) neutral and non-neutral technical progress.

The above mentioned classifications suggested originally by Hicks are based on the cause and effect relationship between change in factor prices and the flow of inventions. As Hicks has put it, “those inventions which are the result of a change in the relative prices of the factors” may be called “induced inventions”. While the rest may be called ‘autonomous inventions’.  

2.4.2.1 EMBODIED AND DISEMBODIED TECHNICAL PROGRESS

Another way to classify the technical progress is to distinguish between embodied/ endogenous and disembodied / exogenous technical progress. This distinction is based on the whole range of available resources or only to a certain part of it. This type of technical progress which applies equally and alike to all resources (especially capital) in current use, irrespective of their date of installation in the process of production is termed as ‘disembodied’ technical progress. This kind of technical progress, can be looked upon as technical knowledge falling like manna from heaven, and can be rapidly treated as exogenous in as much as it can be regarded as being completely independent of the growth of factor inputs or changes in the composition of factor inputs. As against this, is the notion of embodied technical progress which applies only to that part of the whole range of available resources which has been produced and installed currently. The concept of embodied technical progress emphasized the view that much of the technical progress is usually “embodied” in new machines as machines invariably embody the technology existing at the time of their construction. It is obvious that the concept of embodied technical progress growth of factor inputs, especially capital accumulation, as the ‘vehicle’ or carrier of technical progress on the ground that ‘technical progress
increases the productivity of machines built in any period compared to machines built in the previous period, but it does not increase the productivity of machines already in existence\textsuperscript{22}.

2.4.2.2 NEUTRAL AND NON NEUTRAL TECHNICAL PROGRESS

The distinction between neutral and non-neutral technical progress is based on the existing 'balance' among various factors of production. Thus, technical progress is said to be 'neutral' or 'unbiased' (towards factors of production) if it leaves the existing 'balance' among the factor of production (especially the one between capital and labour) in current production unchanged overtime. As against this, if it disturbs the existing 'balance', it is regarded as a 'non-neutral' or biased technical progress.

Hicks\textsuperscript{23} has distinguished technical progress into neutral and non-neutral depending upon its effects on the rate of substitution between the factor inputs. Technical progress is said to be Hicks 'neutral if the ratio of the marginal product of capital to that of labour remains unchanged at a constant K/L ratio when the production function shifts. In other words, it does not change the marginal rate of substitution between factor inputs. Neutral technical progress shifts the iso-quant of the production uniformly away from the origin, leaving unchanged the slope of the iso-quant along any ray from the origin\textsuperscript{24}.

The technical progress is non-neutral when it alters the elasticity of substitution between capital and labour. Technological progress is capital deepening if at a constant K/L ratio, the MRTS\textsubscript{Lk} declines. Technological progress is labour deepening, if at a constant K/L ratio, MRTS\textsubscript{Lk} increases\textsuperscript{25} Hicks neutral technical progress can be represented by the following production function

\[ Y = A(t) f(K, L) \] \hspace{1cm} \ldots \hspace{1cm} \ldots \hspace{1cm} \ldots \hspace{1cm} \ldots \textsuperscript{(7)}

Where A(t), the efficiency index is a function of time; Y is the output and K and L are capital and labour respectively.
The scope of our present study does not encompass the determinants of technical progress but is restricted to estimation of technical progress coefficient and its contribution to output growth. Hence production function with Hick’s neutral technical change only is considered. The following term of Hicks’ measure of neutral technical progress is included in the production function.

\[ A = A_0 e^{\lambda t} \quad \ldots \quad \ldots \quad \ldots \quad (8) \]

Hicks’ neutral has been widely favored in empirical investigations because it provides a very convenient characterization of technical progress as an important factor in output growth.

2.5 THEORY OF PRODUCTION FUNCTION

Production function is a purely technical concept. It defines a functional relationship between factor inputs and commodity output. It describes the law of proportion that is the transformation of factor inputs into products at any particular time period i.e., the flow of goods and services as a function of the flow of productive services from capital, labour and other inputs in the production process. Such a relationship in economics is referred to as production function. Production function captures the process by which maximum output is realized by the optimal combination of inputs. In casual flow it expressed as a relationship between the given set of inputs and the resultant output. Production in an industry is essentially a process of value adding in its nature and the production function referrers to the theoretical relationship that exist between the factor inputs and commodity outputs. Over the last fifty years an extensive amount of literature has developed centering around the theory of production. Within the framework of neo-classical theory of production, we come across a variety of production function forms developed. The most popular being the Cobb-Douglas and the CES models.
2.5.1. FEATURES OF COBB-DOUGLASS PRODUCTION FUNCTION

Cobb-Douglas derived a production function relationship assuming a perfectly competitive market, profit maximising behaviour of firms (under which wages equal to the marginal product of labour and cost of capital to the marginal productivity of capital) and constant returns in the applied empirical research.

The computation and interpretation of the estimated parameters of Cobb-Douglas production can be made with relative ease in applied economic studies. The original specification of the model spelt out by Cobb-Douglas is of the following form:

\[ Y = AK^{\infty}L^{(1-\infty)} \]

Where, \( Y \) = value added, \( K \) = fixed capital and \( L \) = labour, \( A \) and \( \infty \) are constant.

Cobb and Douglas constraints the sum of exponents of \( K \) and \( L \) to be equal to unity, implying constant returns to scale in the industry. This is possible only if factors are paid according to their marginal products. However, in reality there exists a lot of disparity in factor payment and the structure of market organization. Therefore, empirical results are likely to lead non constant returns to scale operating in the industry. In its generalized form, we get the Cobb-Douglas production function as:

\[ Y = A.K^{a_1}L^{a_2} \]

The salient properties of a Cobb-Douglas production are elaborated below:

2.5.1.1 EFFICIENCY OF TECHNOLOGY

‘A’ denotes the efficiency of technology. Given the input and other aspects of the ‘abstract technology, ‘A’ determines the output that results due to the residual term. Changes in the efficiency characteristics are Hicks neutral, in that the marginal rate of technical substitution of capital for labour remains unchanged at any given ratio of capital and labour.
2.5.1.2 MARGINAL PRODUCTIVITY

Change in output due to a unit change in one factor, keeping the other factor as constant gives an idea of the marginal product of the factor. The function differentiated \( Y = A.K^{\beta_1}.L^{\beta_2} \) with respect to \( K \) and \( L \) yields the marginal productivity of capital and labour. Marginal productivity of capital will equal to

\[
MP_k = \frac{\partial Y}{\partial K} = A(\beta_1)K^{\beta_1-1}L^{\beta_2} = \beta_1 \frac{Y}{K} \quad \ldots \quad (11)
\]

Marginal productivity of labour will equal to

\[
MP_l = \frac{\partial Y}{\partial L} = A(\beta_2)K^{\beta_1}L^{\beta_2-1} = \beta_2 \frac{Y}{L} \quad \ldots \quad (12)
\]

Since \( \beta_1 \) is a positive constant and \( \frac{Y}{K} \) is the average productivity of capital, marginal product of capital is positive i.e \( \frac{\partial Y}{\partial K} \). \( Y/K > 0 \). Similarly, marginal product of labour \( \beta_2 \) is also positive i.e \( \frac{\partial Y}{\partial L} \). \( Y/L > 0 \). This property confirms to the theoretical criterion of positive marginal productivity.

Assuming perfect competition and profit maximization, these conditions imply marginal productivity to equal factor prices.

\[
\frac{\partial Y}{\partial K} = \beta_1 \frac{Y}{K} = \frac{r}{p} \quad \ldots \quad (13)
\]
\[
\frac{\partial Y}{\partial L} = \beta_2 \frac{Y}{L} = \frac{w}{p} \quad \ldots \quad (14)
\]

These conditions can be written as

\[
\beta_1 = \frac{rK}{pY}, \beta_2 = \frac{wL}{pY} \quad \ldots \quad (15)
\]

Here, the denominator \( pY \) is the value of output. In the numerator \( rK \) is the payment for capital and \( wL \) is the payment for labour. Thus, these conditions require that capital’s share of total income will be denoted by the parameter \( \beta_1 \), while the share of labour will equal to \( \beta_2 \) since, the total value of output equals total income, it follows

\[
PY = rK + wL \quad \ldots \quad (16)
\]
2.5.1.3 ECONOMIES OF SCALE

Degrees of economies of scale in Cobb-Douglas production function are determined by the sum of the coefficient of capital and labour. Thus it is the \((\beta_1 + \beta_2)\) degree of homogenous function. If \((\beta_1 + \beta_2) = 1\), there are constant returns to scale, \((\beta_1 + \beta_2) > 1\) implies increasing returns to scale and \((\beta_1 + \beta_2) < 1\) means decreasing returns to scale.

2.5.1.4 MARGINAL RATE OF TECHNICAL SUBSTITUTION

At any point in a production iso-quant in addition to deducing the marginal productivity of capital and labour, there would also exist substitution between capital and labour, this will equal to

\[
MRS_{KL} = \left[ \frac{\partial Y}{\partial K} \right] = \left[ \frac{\beta_1 (Y / K)}{\beta_2 (Y / L)} \right] = \frac{\beta_1}{\beta_2} \frac{K}{L} \quad \ldots \ldots \ldots \ldots \quad (17)
\]

2.5.1.5 ELASTICITY OF SUBSTITUTION

Yet another property of the Cobb-Douglas function is found in the elasticity of substitution \((\sigma)\). It is used to measure the ease with which factor substitutability characterizes the curvature of the iso-quants. Cobb-Douglas have proved that given a perfectly competitive market and profit maximizing objective of the firms, the elasticity of factor substitution will always tend to be equal to unity in value, because the ratio of the marginal products of the factors to the ratio of the factor prices will always be proportionally equal to one.

Elasticity of Substitution = \(\left( \frac{\text{change in factor ratios}}{\text{change in the marginal rate of substitution}} \right) \).

\[
\sigma = \left( \frac{\partial (k/L)/(k/L)}{\partial (uRTS_{UL})/(uRTS_{UL})} \right) = 1 \quad \ldots \ldots \ldots \ldots \quad (18)
\]

Substitute the MRS and obtain

\[
\sigma = \left( \frac{\partial (k/L)/(k/L)}{\partial (\beta_1/\beta_2, (k/L))/(\beta_1/\beta_2, (K/L))} \right)
\]

\[
\sigma = \left( \frac{\partial (k/L)/(\beta_1/\beta_2)}{(\beta_1/\beta_2, \delta (K/L))} \right) = 1
\]
2.5.1.6 FACTOR INTENSITY

In a Cobb-Douglas production function, factor intensity is measured by the ratio $\frac{\beta_1}{\beta_2}$. The higher the value of this ratio, more capital intensive the technique is in the production process. Similarly, the lower the ratio of $\frac{\beta_1}{\beta_2}$, more the labour intensive the nature of the given technique.

This production function has been subjected to criticism and challenges, ever since its empirical application by Cobb and Douglas. However, its overall usefulness and its empirical adequacy have earned continued popularly among the economists. The merits of this function out weight the demerits, when we evaluate it, relative to other alternative forms of production functions. Of selecting this function Timmer\textsuperscript{29} writes, “The Cobb-Douglas production function is the slandered for the profession. Although, some of its secondary characteristics are disturbing........... Its primary characteristics....... of handling the data and the generally good fit........ Continue to recommend it to economists”.

2.5.2 CES PRODUCTION FUNCTION

In the past, many growth models have been developed and analyzed with the help of a production function methodology subject to certain restrictive features. For quite some time, the Cobb-Douglas production function provided a simple hypothesis with its input exponents adding up to unity and a unitary elasticity of substitution. The development of theoretically and empirically better and more representative production functions embracing a wide variety of hypothesis has resulted in greater accumulation of information on production theory. These empirical findings led to the derivation of mathematical functions having the properties of (a) homogeneity (b) Constant Elasticity of Substitution between capital and labour and (c) the possibilities of different elasticity’s for different industries. The most widely known and popular production function in recent times is the Constant Elasticity of Substitution (CES) production which includes CD as well as Leontief production functions as special cases. To avoid the unduly restrictive
assumption of the unitary elasticity of substitution and to provide a substantial generalization to the Cobb-Douglas production function. Arrow, Chenery, Minhas and Solow (ACMS) have derived a family of production functions with Constant Elasticity of Substitution which they abbreviated as the CES production function.

The CES production function is of the form:

\[ Y = \lambda \left[ \delta k^p + (1-\delta) L^{1-p} \right] \cdot \mu^p \]

Where \( Y = \) output, \( K = \) capital, \( L = \) labour, \( \lambda = \) efficiency parameter,
\( \delta = \) the distributive parameter, \( p = \) the substitution parameter, \( \mu = \) the returns to scale parameter, where \( \lambda > 0; \delta > 0; \mu > 0; p > -1 \). The parameter \( p \) in the CES production function determines the elasticity of substitution. The elasticity of substitution is given by

\[ \sigma = \left( \frac{1}{(1 + p)} \right) \]

The factor share is given by:

\[ wL + rK (1-\delta/\delta)K/L \]

Where \( W = \) wage rate, \( r = \) rate of interest, \( \delta = \) is not independent of the units in which \( K \) and \( L \) are measured. Further, in the CES production function \( \mu > 1 \) indicates increasing returns to scale \( \mu < 1 \) indicates decreasing returns to scale and \( \mu = 1 \) indicates constant returns to scale.

The CES production function tends to Cobb-Douglas production function as

\[ \sigma \rightarrow 1 \]. The parameters of the CES production function are thus to satisfy the mathematical properties:

\[ \lambda > 0; 0 < \delta > 1; \mu > 0; p > -1 \text{ and } \sigma = 1/(1 + p) \]

The methods of estimating the parameters are usually attempted in empirical works based on (i) using the equation of reduced form based on the conditions of profit maximization and perfect competition (ii) setting up the maximum likelihood function by introducing the stochastic variable to the
function and (iii) using the maximum likelihood method based on the approximate expansion of the production function using Tayler's series formula. ACMS have suggested the existence of relationship between $V/L$ (value added per labour) and $W/L$ (the real wage rate), independent of the stock of capital\textsuperscript{31} thus, they used the following functional form to estimate the substitution parameter assuming competitive market structure.

$$\ln(V/L) = \ln(\alpha) + \beta \ln(W/L) + \ln(\mu) \quad \ldots \quad (20)$$

Here, the substitution parameters $\sigma$ equals to $\beta$. Further, the equation (20) is homogenous of degree one i.e. it exhibits constant returns to scale. It is pointed out by Maddala\textsuperscript{32} that the estimate $\sigma$ is sensitive to the choice of the two exogenous variables from among the variables viz., $V$, $L$, $K$ and $W$. Yet another problem that arises in this method is that it intuitively assumes scale coefficient to be equal to unity. Grigis\textsuperscript{33} has developed the following form of unrestricted CES production function. The main advantage of this formulation is that it uses the same set of data, not requiring data on capital stock. 

The unrestricted CES production function takes the following form

$$V = \lambda [\delta k^p + (1-\delta) L^{1-p}]^{1/\mu} \quad \ldots \quad (21)$$

Differentiating with respect to labour ($L$) we get

$$\frac{dV}{dL} = -\frac{\delta \lambda}{\mu} \left( \frac{V}{L} \right) \left[ \frac{V^p}{\mu L} \right] \quad \ldots \quad (22)$$

Erectuating the marginal product of labour with wage rate

$$\left( \frac{V}{L} \right) = \left( \frac{\lambda P / \mu}{\delta (1-\delta)} \right)^{1/\mu} \left[ \frac{W}{L} \right]^{1/\mu} \quad \ldots \quad (23)$$

Expressing in logarithmic terms, we get

$$\ln \left( \frac{V}{L} \right) = \left[ \frac{\mu}{\mu + p} \right] \ln \left( \frac{\lambda P / \mu}{\mu (1-\delta)} \right) + \left[ \frac{\mu}{\mu + p} \right] \ln \left( \frac{W}{L} \right) + \left[ \frac{p (\mu - 1)}{\mu + p} \right] \ln(L) \quad \ldots \quad (24)$$
Interpreting this relation in a behavioural form, we get the estimating equation as

\[ \ln \left( \frac{V}{L} \right) = \ln \alpha + \beta_1 \ln \left( \frac{W}{L} \right) + \beta_2 \ln (L) + \ln (\mu) \quad \ldots \ldots \quad (25) \]

Where,

\[ \alpha = \left[ \frac{\mu}{\mu + p} \right] \ln \left( \frac{\lambda}{\mu(1 - \delta)} \right) \quad \ldots \ldots \quad (26) \]

\[ \beta_1 = \left[ \frac{\mu}{\mu + p} \right] \text{ and } \beta_2 = \left[ \frac{\mu}{\mu + p} \right] \quad \ldots \ldots \quad (27) \]

\[ \ln (\mu) = \text{error term} \]

From the estimated regression coefficient the CES production function parameters can be estimated by using the following terms.

\[ p = \left[ \frac{1 + \beta_1 - \beta_2}{\beta_1} \right]; \sigma = \left[ \frac{\beta_1}{\beta_2 + 1} \right] \text{ and } \mu = \left[ \frac{\beta_2 + 1 - \beta_1}{1 - \beta_1} \right] \quad \ldots \ldots \quad (28) \]

### 2.5.3 VES Production Function

The CES production function assumes the relationship between value added per labour and the wage-rate to be independent of the capital-labour ratio. If however, the capital-labour ratio varies due to changes in the factor price ratio, it is possible that the elasticity of substitution will vary with the verifications in capital-labour ratio. Accommodating this phenomenon in the production function methodology, the VES production function suggests that the substitution elasticity between factors to be a function of the coefficient of wage rate and the coefficient of capital-labour ratio. As long as the capital-labour ratio does not fluctuate over a wide range the CES and VES production function normally tend to yield similar results. In the lines of what Liu-Hildebrand and Lu-Hildebrand have developed, we have fit a more generalized Variable Elasticity of Substitution (VES) production function for
the 15 Indian textile industries at three digit level disaggregation for the period 1980-81 to 1997-98. The time series version of the Liu- Hildebrand production function takes the following form:

\[ \frac{V/L}{A} = \left[ \beta_1 \frac{W/L}{p} + \beta_2 \left( \frac{K/L}{m} \right)^{-p} \right]^{-1/p} \]

For the purpose of estimating the parameters of the VES production function using the equation (29), the following functional form of VES production function can be derived:

\[ \ln \left( \frac{V}{L} \right) = \ln \omega + \beta_1 \ln \left( \frac{W}{L} \right) + \beta_2 \ln \left( \frac{K}{L} \right) + \ln \left( \mu \right) \ldots \] (30)

From the equation (30), it follows that

\[ \beta_1 = \left[ \frac{1}{1+ p} \right]; \beta_2 = \frac{(p\mu)}{1+ p} \]

The variable elasticity of substitution in the above equation is defined as:

\[ \left[ \frac{1}{(1+ p) - (pM/S_k)} \right] \]

Where \( m = \beta_1 \left( \frac{1+ p}{p} \right) \) and \( S_k \) is capital's share in output.

The a priori expectations about the statistical values of the parameters are as follows:

(i) \( 0 > m < \alpha \), (2) \(-1 < p < \alpha\), (3) \( p \neq 0 \)

It may thus be started that the 'a' priori estimates of the regression parameters should satisfy (i) \( \beta_1 \neq 1 \) (ii) \( \beta_1 > 0 \) and \( \alpha > \beta_2 > 0 \)

Unless the estimates of the equation (30) satisfy these conditions, it will be consistent with the underlying theory of output factor relationship.

2.6 REVIEW OF SELECTED STUDIES

Robort Solow works in more general frame wok (arbitrary constant returns to scale production function rather than Cobb Douglas production...
function, with the factor shares possibly changing from year to year.) what he found was that most about 7/8 of the growth in output is due to technical progress. Output per worker grows at a rate of 1.7 percent per year. Had there been no growth in the level of technical knowledge, the rate would have been 0.3 percent.

Ahuja\textsuperscript{38} examined capital intensity in the Indian manufacturing industries for the periods 1961-1967. He pointed out that industrialization in India has been relatively capital-intensive. Inspite of low capital productivity, the productivity of labour and capital were increasing directly in proportion to the increase in capital employed per unit of labour. The productivity of a composite unit of labour and capital declines as the capital employed per unit of labour.

Dhananjayan R. S and N Sasikala Devi\textsuperscript{39} have analyzed elasticity of substitution in four Asian nations using CES production function estimates for the period 1973-74 and 1986-87. The estimated degree of factor substitution was found high in South Korea, Singapore and Indonesia characterizing capital augmenting technology in most of the manufacturing industries. They also observed that though in India factor substitution remained well within plausible theoretical limits; general low factor substitutability emerged as a characteristic feature of the Indian manufacturing sector.

Tendon K.K\textsuperscript{40} has made a study on the changing pattern of industrial employment in Haryana. She based on the ASI data of the manufacturing sector in Haryana for the period f 1966 and 1978, finds that approximately 67.00% of the total employment was provided by cotton textiles, machinery and electrical apparatus, food products, transport equipments& metal products manufacturing industries in 1966. These industries in 1978 have provided for about 60.00% of the total employment. The patterns of structural changes have shown that the relative decline in the consumer goods industries was largely compensated by the increase in the share of engineering industry categories. In conclusion she points out that, the industrial structure over the period has
shown a tendency towards diversification, with elements of lopsidedness and imbalances in Haryana.

Shetty. S. L\textsuperscript{41} analyzed the industrial growth and structure as seen through the ASI for factory sector in India. Based on the summery results of 1978-79 he found the share of fixed capital by the various industries remaining the same as were in 1973-74. There was a general declining tendency in employment and emolument paid to labour. In the disposition of the value added in the factory sector, the share of wages while has fallen that of profits and interest payments rose sharply. The industry wise picture for the 23 major product groups at the two-digit level classification has revealed 43.9\% of the total capital being accounted by the electricity generating, transmitting, and distributing industries. However their shares in other attributes were low viz, 8.9\% in employment 10.5\% in gross output, 12.7\% in value added. After making comparative analysis between the positions in 1973-74, for which year the first summery results of the ASI was available and 1978-79, Shetty concluded that the three industry groups which have emerged predominant in the factory sector in terms of fixed capital are the electrical basic metals and chemical and chemical products. But these industries had unusually a small share in the total number of factory units on the inter industry differences in the structural ratios, the capital output ratio was phenomenally high in the electricity 8.25 and basic metals and alloys 3.18 among the industries where a low capital output ratio is found includes the cotton and jute textiles, metal products, wood products, and the beverages and tobacco products.

Herbert. H Tsang\textsuperscript{42} explained four types of relationship constituting an economic model of production are specified in order to deduce the mathematical form of the production function. A technical equation restricts the production function to be a member of the homogenous class. A behavioral equation describes the profit maximizing character of the producer. An empirical equation attempts to explain the average productivity of labour. Finally a demand function reflects the structure of the output market.
The derived production function is seen to fall into the wildly discussed CES-VES production function. The economic model thus in a sense provides a theoretical basis for the CES-VES production functions. The economic properties of the derived production function are also studies in detail and alternative estimation procedures are reviewed critically.

Sharma B. U\textsuperscript{43} by analyzing the performance of the Indian industries over the period 1951-1978, has found the growth of consumer goods industry showing signs of declining while the basic and capital goods industries have shown gradual increase in growth rates. To him the industrial policies which did a lot of good during the first two five year plans did not as per, the desired objectives result in generating adequate growth of employment in the industrial sector. For the overall development, Sharma pleads for an integrated approach to plan industrial growth by covering all agencies, involved viz, banking, finance, and agriculture.

Kumar A\textsuperscript{44} argues the need to provide specific thrust to develop the industrial sector in India. Tracing the weights assigned to the output of various industry categories, he found the weight of basic and capital good industries increasing from 20\% in 1950 to more than 48\% in 1970. According to him growth of capital good industries in India could increase only if adequate provisions are planed to ensure a study growth in consumer goods industries. The growth of consumer goods industries were constrained in India because of the phenomenon of fluctuations in the performance of agriculture and inequitable distribution of income. He is of the opinion that the policy of import substitution whereby tariff protection was given to the growth of indigenous industries has been nearly exhausted

Sudip Choudhary\textsuperscript{45} attempted to examine the structural changes and fluctuations in manufacturing factory sector, industries in India during 1956-60 to 1984-85. Using the data from ASI he classified manufacturing value added in different levels using industrial classification at two- digit, three- digit and use based classification. The result for the sectoral contribution to aggregate
growth of net value added indicates positive rates of growth in all the two and three digit industries. The result at three digit level has revealed that the electrical machinery registering a highest rate of growth at 14.08% per annum. In the two digit level the chemical products revealed that highest growth (19%) from the use based classification, he concluded that the contribution of capital goods was lower compared to consumer goods and intermediate goods.

Ahluwalia I. J\textsuperscript{46} in her study of industrial growth in India, examining the specific question of stagnation since the mid sixties by analyzing the estimated growth rates, in value added and net value of output for the various industry groups at two digit level desegregation reports, that the declaration was more pronounced in the industrial production data than the ASI data. She found the capital goods industries growing faster than the consumer goods industries in India. The structural transformation resulting due to greater levels of growth in capital goods industries was more significant during the first half of the 1960's. The basic goods industries increased their share in the net value added from 27.5% in 1960-61 to 30.7% in 1965-66, in the industries total and there jointly accounted for a little less than 50.0% of the goods on the other hand have down in their share from a high of 40.0% in 1960-61 to 35.0% in 1965-66 and stabilized at that level thereafter. She concludes that much of the structural changes in industrial sector had taken place during 1960-61 to 1965-66.

Thaker B.C\textsuperscript{47} has examined the changing structure of sectoral distribution of per capita income in non-agricultural sector in India. As regards the manufacturing sector, Maharashtra remained at the top from the point of view of earnings per worker during 1970-73 and 1980-83. Haryana was second and followed by Gujarat west Bengal, Karnataka and Punjab during 1970-73. However during 1980-83 Punjab was second in the earning per worker point of view, followed by Haryana, Gujarat, Utter Pradesh, and Karnataka. Manufacturing sector per capita income was contributing considerably in overall per capita income of the states, from a level of 20.0% in 1970-73.
The situation has improved to about 23.0% in 1980-83 as regards the share of manufacturing sector in the income of the state.

Arya fitted Cobb-Douglas production function for the period from 1961 to 1974 for Madras Cement Industry. He concluded that net capital has a greater explaining capacity for the gains in output growth rather than gross capital. He was reported an increasing returns to scale characterizing the Madras Cement Industry.

Metha fit Cobb-Douglas and CES production function for 27 large Indian manufacturing industries for the time period 1953 to 1965. His analysis of the sources of output growth suggests the following. The Cobb-Douglas production function indicated the elasticity of output with respect to labour to be significantly different from zero. He found when Tintner test was applied to the hypothesis of constant returns to scale, in five industries the hypothesis being rejected. During 1953-1965, the study indicates that there did not exist economics of scale.

Baghel and Pendse estimated the production function co-efficients using the Leontief, Cobb-Douglas, CES and VES production functions for the manufacturing sector of India covering the period 1973-74 to 1989-90. The study found that the co-efficient of wage rate $\beta$, which measures the elasticity of substitution in the ACMS function has yielded negative magnitudes. The regression co-efficient of the ACMS production function incorporated with Hick's neutral technical progress has not emerged significant in the manufacturing sector of India. The estimates of $\sigma$ from VES production function without time trend acquires theoretically implausible negative sign during the reference period. The VES production function with time trend yielded well behaved and theoretically well sustained co-efficient of factor substitution $\sigma$ for the Indian manufacturing sector. Therefore, they concluded that abundant factor was not easily substituted for the scarce factor in augmenting output growth.
Chandrasekaran and Sridharan\textsuperscript{51} have estimated input elasticity, neutral technical progress and returns to scale using the three production function forms viz., Cobb-Douglas, CES and VES covering the period 1973-74 to 1985-86 for the Indian manufacturing sector. Though the explanatory power of the CES and VES models were low, they were statistically significant. The CES model has yielded a positive co-efficient of elasticity of substitution. The elasticity of substitution inferred from the co-efficient of wage rate ($\beta_1$) in the VES production function without Hick's time trend yielded positive value though not within the theoretical limits i.e., the 'a' was around 2.240 and was also statistically significant. However, the incorporation of time trend 't' in the 'VES' function yielded not only negative elasticity of substitution but, the estimates were statistically not significant. From the VES estimates, the anthers have found that as the co-efficient of capital intensity and time trend were not statistically significant the changes in capital – labour ratio did not influence elasticity of substitution.

Laumas and Williams\textsuperscript{52} made an attempt to examine the substitution possibilities between capital and labour and materials in the two-digit Indian manufacturing industries. The results indicated labour and capital were almost equally facile substitutes. The value of the elasticity of factor substitution between raw materials and labour has varied between 0.411 and 1.416 and that between raw materials and capital has ranged from 0.663 to 1.077.

Noel V. R.\textsuperscript{53} studied the 'Impact of technical change on the aggregate productive function" in the USA for the period 1947-80. The study endeavors to look at both disembodied technical progress and embodied technical progress in capital stock and in the labour force of the United States. The results suggested that disembodied technical progress has been about three per cent per year and embodied technical progress in the capital stock to be approximately around three to four per cent per year. Educational attainment was found significantly enhancing the labour productivity. Finally when the issue of structural stability of the underlying production relationship was
addressed for the period 1971-80 the results indicated to certain degree of consistency.

Lakh Winder Singh and Singhal\textsuperscript{54} made a study on "Economics of scale and technical change" in the Punjab manufacturing industries for the period 1967-68 to 1981-82. They used the Cobb-Douglas and constant elasticity of substitution production functions and came to the conclusion that the output growth in the manufacturing sector of Punjab was achieved through the increased use a factor inputs and not because of the technological progress as well as the influence of economics of scale.

Vandyopodhayaya\textsuperscript{55} has made a study on productivity and technical change in the US high technology industries for the period 1967-82. His analysis was based on translog specification of cost of production functions. Using these function four different model were estimated viz., (i) a cost structure with strict homogeneity (ii) a cost structure with strong separability of material from capital and labour and (iv) a Cobb-Douglas form the results of his study has yielded the following conclusions, materials input growth was playing the most significant role in explaining productivity growth pattern in the high technology sector industries of the United States. Labour and capital on the other hand were complementary to each other in the process of output growth when labour was disaggregated between production and non production workers. Technical change in this sector was non-neutral in its nature since it was labour saving and capital and material using in its nature.

Mahindara Ramamohan\textsuperscript{56} measured the individual policy productivity and technical change in South Korean Textile industry during the period 1969 to 1985. One objective of his study is to evaluate the impact of industrial policy on the structure of production. A second objective is to examine unintended spatial bias of national industrial policy. These analysis done by using measures of technical progress, factor substitutes and scale economics obtained from an econometric estimation of a translog cost function and associated share
equations. Results indicate that national industrial policy was effective in achieving targeted goals.

Rajalakshmi\textsuperscript{57} has examined the trends in the productivity of manufacturing industries for the total manufacuring sector in Rajasthan and at All India level. Using deflated values she studied the labour and capital productivities and found higher productivities at All India level than those of Rajasthan. Capital intensity was higher in Rajasthan than All India level. On the whole capital intensity was found to be increasing rapidly during the period.

Dhillon\textsuperscript{58} has studied the productivity trends factor substitutability in the manufacturing sector Karnataka State. Using input and output in real terms he found that during the period 1968-69 to 1977-78 the capital intensity had increased but labour productivity have declined sharply in Karnataka's manufacturing industries.

Goel and Nair\textsuperscript{59} have analyzed labor productivity and output growth in Indian Mining and manufacturing industries during 1951-76. Employing identity equations they arrived at the following conclusions. There was a conflict between the share of employment and that of productivity in the given additional output of the sectors i.e., when the share of employment increases that of productivity declines and vice - versa. This implies that there cannot be any strategy of industrial development which ensures maximization of both employment and productivity simultaneously with a given targeted rate of growth of output.

Ahluwalia\textsuperscript{60} has investigated the productivity trends and growth of manufacturing sector as a whole at two-digit level for the period 1959-60 to 1979-80. Which examining the contributory factors underlying the increase in capital-output ratio of manufacturing sector the results reveal that a major part of the increases was due to the rising capital, output ratios across the board. The growth in labour productivity for manufacturing sector and its twenty industry groups was overwhelming accounted for by the process of capital
deepening, while the efficiency in use of factors actually declined for most of the industry groups.

Lakshmana Rao\(^61\) has studied the productivity trends in the Andhra Pradesh census sector manufacturing industries for the period 1960-69. The analysis revealed that labour productivity recorded a substantial increase during the period. A progressive rise in capital intensity was found to a factor responsible for the same. The capital productivity registered a steep decline after initial spurt during reference period.

Inderpal Kaur\(^62\) analysed using production function methodology, technical change and factor substitution in the Indian engineering industry during 1960-61 to 1984-85. She using the Cobb-Douglas, CES, VES and translog production functions, found that the returns to scale in Cobb-Douglas and CES production function gives similar results that the diminishing returns to scale in all the industry groups. In all the production functions, the technical change turned out to be quite high in the Transport and equipment group (38) and it quite low in the machinery group (36) and the electrical machinery group (37) and it could be termed as moderate in metal products group (35) the value of elasticity of substitution (\(\sigma\)) in the case of CES production function showed more than one in all the cases and was maximum in the Transport and equipment group (38). In the case of VES production function the value of \(\sigma\) was less than one in all the cases except in electrical machinery group (37). The value of \(\sigma\) turned out to be negative for metal products group (35) in the case of translog production function.

Savithiri\(^63\) has estimated technical efficiency, productivity and export in Indian engineering industry for the period 1980-81 to 1993-94. She has shown that factor substitution coefficient yielded theoretically well sustained positive magnitudes in the production function models viz., ACMS, CES, VES implying capital augmenting nature of output growth during the reference period. The study discerned that there has been divergent growth rates in absolute magnitudes in the number of factory establishments, fixed capital,
emoluments, employment and net value added implying structural changes emerging as an important feature characterizing the growth of Indian Engineering Industries.

Perez Agustin\textsuperscript{64} analyzed the hypothesis of the effectiveness of energy saving techniques to reduce the trade off between economic growth and energy preservation. In a general equilibrium vintage capital model with embodied energy saving technologies is questionable in a scenario of decreasing energy supply; only constant energy supply yields long run growth.

Zheng Jinghai\textsuperscript{65} investigates the productivity of State Operated Enterprises based on a sample of about 600 state enterprises using data envelopment and a malmquist index. Their empirical results show that the average technical efficiency was low for these firms. Considerable productivity growth was found, but it was accomplished mainly through technical progress rather than through efficiency improvement.

Elisha Au\textsuperscript{66} investigated long term trends in the demand for production and non production workers in Canadian Manufacturing based on data from Annual Survey of Manufactures. In contrast to trends in the US and UK, Canada’s manufacturing employment increased during the last three or four decades and the share of non production workers declined suggesting a shift in demand towards production workers and away from non production workers. A sector biased Hicks neutral technical change seems to offer a plausible explanation for this shift in labour demand.

Dupuy, Arnaud\textsuperscript{67} shows that Hicks Neutral technical change is identified as the information of order, obtained if the distribution of factor prices is replaced by the distribution of factor efficiency parameters. Together with Solow’s residual the information method enables to distinguish between the neutral and non-neutral part of technical and organizational change. An empirical evaluation of both methods using Jorgensons [30] US data for the period 1948-1999.
The main results of the paper are that

i) both neutral and non-neutral technical change must have occurred during the reference period;

ii) Three-fourth of the productivity slowdown observed in the 70s and 80s is due to a deceleration in the contribution of non-neutral technical changes.

Klump, Rainer using a normalized CES function with factor augmenting technical progress estimated a supply-side equation of the US economy from 1953-1998. Avoiding potential estimation biases that have occurred in earlier studies and putting a high emphasis on consistency of the data set required by the estimated system, robust results were obtained for the aggregate elasticity of substitution and for the parameters of labour and capital augmenting technical change. It was found that the $\sigma$ is significantly below unity and that the growth rates of technical progress show an asymmetrical pattern where growth of labour augmenting technical progress is exponential while that of capital is hyperbolic or logarithmic.

Saurav, Dev Bhatia analyzes the sources of output growth in Chicago for the period 1990-1997 by focusing on changes in the economy's interlinkages among sectors and in the structure of final demand markets. Using input-output tables at two points in time, it traces the output growth in various sectors due to changes in final demand, technology and a synergistic interaction between two. The results reveal that the outputs of the various sectors were noticeably influenced by changes both in final demand markets and inter industry linkages and changes in the markets were the overall drivers of growth.

Priyanka Dembla has been followed Cobb-Douglas production function and CES production function in the estimation of production relations; she also estimates both kinds of production relations using the more flexible translog (transcendental logarithmic model) form for the registered manufacturing sector. As a whole, as well as, for each use-based sector- i.e., consumer goods, intermediate goods, capital goods, and basic goods, using panel data for the
period 1973-74 to 1995-96 and attempts to reconcile and compare the two approaches. It also attempts to test for the presence of unit root in panel data of the relevant variables. The study reveals the importance of the additional explanatory variables used in the augmented model besides labour and capital stock in explaining production behavior in the sector. Another observation relates to the suitability of the translog specification.

Ronald J. Shadbegian and Wayne\textsuperscript{71} analyze the impact of environmental regulation on productivity using a Cobb-Douglas production function framework. Estimating the effects of regulation on productivity can be done with a top-down approach using data for broad sectors of the economy, or a more disaggregated bottom-up approach, using data from the US paper, steel, and oil industries. They use annual census bureau information (1979-1990) on output, labour, capital and material inputs, and pollution abatement operating cost and capital expenditure for 68 pulp and paper mills, 55 oil refineries and 27 steel mills. Adding an aggregate pollution abatement cost measure to a Cobb-Douglas production function, they find that a $1 increase in pollution abatement cost leads to an estimated productivity decline of $3.11, $1.80 and 5.98 in the paper, oil and steel industries respectively.

Wishwanath Kumar\textsuperscript{72} estimated the Cobb-Douglas production function for structural changes in the Indian manufacturing sector as a whole for the period of 1980-81 to 1999-2000. In this study, Cobb-Douglas specification gives a good fit with given data on time series. The study implies that there are no structural changes in the production function for Indian manufacturing sector (as a whole) during the period 1991 to 1999 over the period 1981 to 1990.

B Goldar, V S Renganathan, Rashmi Banga\textsuperscript{73} analyses the effect of ownership on efficiency of engineering firms in India in the 1990’s, a decade of major economic reforms. Technical efficiency of firms estimated with the help of stochastic frontier production function. The results clearly indicate that foreign firms in Indian engineering industry have higher technical efficiency than domestically owned firms. No significant difference in technical
efficiency is found between private sector and public sector firms among the domestically owned firms.

Anusua data and Susan \textsuperscript{74} examined the production cost structure of the US textile industry using a dual cost framework. A translog cost function is used to measure substitution elasticities between inputs, scale economies, and the nature of technical change. The scope for factor substitution in textile remains limited with all substitution elasticities being less than unity. Labour and materials are compliments in apparel production, but there is evidence of substitution between capital and labour. The rate of technical change is higher in textiles than in apparels. Given the intense import competition from low wage countries, in both industries, technical progress is labour saving. Overall economies of scale are larger in apparel, however, the scale of economies have continued to increase in textile.

Jonathan Temple\textsuperscript{75} have made rigorous approaches to aggregation. The study indicate that aggregate production functions do not exist except in unlikely special cases. This paper considers the awkward implications for growth economics. It provides a conventional defense of growth theory in terms of 'parables' and then considers how empirical growth research might avoid the need for aggregate production functions.

S. S. Rajan, K. L. N. Reddy, and V. Pandit \textsuperscript{76} compares, the suitability of Cobb-Douglas production function (CD) and Translog production function of India’s petrochemical industry, taking into account the role of material inputs for a 25 years period. Empirical findings reveal the significance of material inputs and technical change in the augmented models. Corroborating the importance of technical change, the industry shows inter input substitution possibilities to be very strong, which have important implications for the long term growth of the industry.
2.7 MEASUREMENT OF FACTOR SUBSTITUTION AND TECHNICAL CHANGE

In order to estimate the production function parameters, ASI data for 15 Indian textile industries classified at three-digit level desegregation has been used. The variable selected for the study are value added (V) number of persons employed (L), gross value of fixed capital (K) and wages and salaries (W). Sources of output growth, elasticity of substitution and technical progress were estimated by fitting Cobb-Douglas production function, constant elasticity substitution production function, and the variable elasticity substitution production function for the period of 1980-81 to 1997-98 for the select 15 Indian textile industries.

2.7.1 COBB-DOUGLASS PRODUCTION FUNCTION

The study has estimated unrestricted Cobb-Douglas production function model by employing regression technique based on the ordinary least square (OLS) principle. This unrestricted Cobb-Douglas production function model in its estimating form takes the log linear expression as;

\[ \ln(V) = \ln(\infty) + \beta_1 \ln(K) + \beta_2 \ln(L) + \ln(\mu) \quad \ldots \ldots \quad (31) \]

Where

- \( V \) = gross value added
- \( K \) = gross productivity capital
- \( L \) = number of employs
- \( \infty, \beta_1, \beta_2 \) are the fixed parameters specified to assume non-negative magnitudes.

However, under certain situations some of the regression parameters of the Cobb-Douglas production function model may yield output elasticities with respect to capital and labour theoretically impossible magnitudes and hence result might obtain unreasonable scale coefficient.
2.7.2 COBB-DOUGLASS PRODUCTION WITH HICKS NEUTRAL TECHNICAL CHANGE

\[ \ln (V) = \ln (V) = \ln \infty + \beta_1 \ln (K) + \beta_2 \ln (L) + \beta_3 (t) + \ln (\mu) \ldots (32) \]

2.7.3 CES PRODUCTION FUNCTION

The unrestricted CES production function is used to estimate the elasticity of factor substitution, returns to scale and technical change.

\[ \ln (V/L) = \ln \infty + \beta_1 \ln (W/L) + \beta_2 \ln (L) + \ln (\mu) \ldots (33) \]

2.7.4 CES PRODUCTION FUNCTION WITH HICKS NEUTRAL TECHNICAL CHANGE

\[ \ln (V/L) = \ln \infty + \beta_1 \ln (W/L) + \beta_2 \ln (L) + \beta_3 (t) + \ln (\mu) \ldots (34) \]

Where,

\[ \sigma = \frac{\beta_1}{\beta_2+1}, \quad \mu = \frac{(\beta_2+ (1- \beta_1)/1- \beta_2)}{1- \beta_3} \quad \text{and} \quad \beta_3 = \lambda (1- \sigma) \ldots (35) \]

Hence,

\[ \lambda = 1- \sigma / \beta_3 \]

2.7.5 VES PRODUCTION FUNCTION

\[ \ln (V/L) = \ln \infty + \beta_1 \ln (W/L) + \beta_2 \ln (K/L) + \ln (\mu) \ldots (36) \]

2.7.6 VES PRODUCTION FUNCTION WITH HICKS NEUTRAL TECHNICAL CHANGE

\[ \ln (V/L) = \ln \infty + \beta_1 \ln (W/L) + \beta_2 \ln (K/L) + \beta_3 (t) + \ln (\mu) \ldots (37) \]

Where,

\[ \sigma = \beta_1, \quad \lambda = \beta_3/(1- \beta_1) \]

2.8 RESULT AND DISCUSSIONS

In this section, we have discussed the sources of output growth, factor substitution and technical progress characterizing the 15 Indian textile industries at three-digit desegregation based on the empirical estimates obtained from the fit production function models viz, Cobb-Douglas production function, (CDPF), the constant elasticity of substitution production function.
(CESPF) and the variable elasticity of substitution production function (VESPF) for the period 1980-81 to 1997-98.

2.8.1 SOURCES OF OUTPUT GROWTH

The empirical estimates of the Cobb-Douglass production function fit to the study of the sources of output growth in the Indian textile industries are discussed below.

2.8.1.1 FACTOR PRODUCTIVITY: COBB-DOUGLAS PRODUCTION FUNCTION WITH AND WITHOUT TECHNICAL PROGRESS

The estimates of the Cobb-Douglass, production function model for the 15 Indian textile industries at three digit product classification are given in the table (2.1). From the estimated coefficient of multiple determination $R^2$, it is evident that the statistical fit of the model has emerged significant in all the 15 industry categories for the reference period. The explanatory power of the model has ranged between 97.00 percent in manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265) and a low of 19.00 percent in manufacture of floor covering of jute, mesta, sannhemp, and other kindred fibers and coir (264).

As per the table, in all the 15 industries, the $\beta_1$ coefficient measuring the elasticity of growth in output on account of capital productivity has obtained theoretically specified positive sign property. Of these 15 industries, in 14 industries the $\beta_1$ coefficient has emerged statistically significant. In the remaining one industry viz, manufactures of knitted or crocheted textile products (260) the significance of capital productivity remained unaffirmed.

The regression coefficient of $\beta_2$, measuring the elasticity of output growth on account of labour productivity obtained theoretically specified positive sign in six out of 15 industries. In eight out of 15 industries, the $\beta_2$, coefficient assumed implausible negative values, these include the, weaving & finishing of cotton textiles on handlooms (233) weaving and processing in mills (235), bleaching, dyeing and printing of cotton textiles (236), embroidery
work, zari work and making ornamental trimmings (262), making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of floor covering of jute, mesta, sannhemp, and other kinder fibers and coir (264), manufacture of rain coats, hats, caps & school bags etc. from water proof textile(266), fabrics of plastic sheetings, manufacture of made-up textile articles: except apparels (267).

The coefficient of labour has emerged statistically significant in 10 out of 15 industry categories, viz, weaving & finishing of cotton textiles on handlooms (233), weaving & finishing of cotton textiles on power looms (234), cotton spinning, weaving and processing in mills (235), manufacture of knitted or crocheted textile products (260), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), manufacture of water proof textiles fabrics (268), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269).

The elasticity coefficient of both $\beta_1$ (capital) and $\beta_2$ (labour) assumed positive magnitudes satisfying the underlying theoretical specification and obtained well-sustained empirical estimation in seven industries categories except eight industry categories. In nine industry categories both $\beta_1$ and $\beta_2$ have emerged statistically significant.

The regression estimates of the Cobb-Douglas production function incorporating Hick’s neutral technical progress viz, the time trend is presented in table (2.2) For the 15 Indian textile industries at three digit desegregation. It can be seen from the table that the model has yielded statistically significant fit in all the industries in reference. The explanatory power of the model has ranged between a high of 97.6 percent in manufacture of all types of textile garments&clothing accessories n.e.c(except by purely tailoring establishments)
from not self produced material (265) and a low of 13.9 percent in manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264).

The $\beta_1$ coefficient measuring the elasticity of output growth on account of capital productivity obtained theoretically specified positive sign in all the 15 industry categories. Of these 15, in 10 industry categories, the elasticity of capital productivity on output growth has emerged statistically significant. These are the cotton ginning, cleaning and bailing (230), weaving & finishing of cotton textiles on handlooms (233), weaving & finishing of cotton textiles on power looms (234), cotton spinning, weaving and processing in mills (235), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), fabrics of plastic sheetings, manufacture of made-up textile articles: except apparels (267), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269).

The regression coefficient $\beta_2$ measuring the elasticity of output growth due to labour productivity has yielded theoretically specified positive sign in 11 industries viz, cotton ginning, cleaning and bailing (230), weaving & finishing of cotton textiles on power looms (234), cotton spinning, weaving and processing in mills (235), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266), manufacture of water proof textiles fabrics (268), manufacture of
textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269). The productive contribution of coefficient of labour $\beta_2$ has emerged statistically significant in eight industry categories, viz, weaving & finishing of cotton textiles on handlooms (233), weaving & finishing of cotton textiles on power looms (234), manufacture of knitted or crocheted textile products (260), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), manufacture of rain coats, hats, caps & school bags etc. from waterproof textile (266), manufacture of waterproof textiles fabrics (268). Out of 15 industries 5 industries, both $\beta_1$ (capital) and $\beta_2$ (labour) coefficients have emerged statistically significant.

On the whole the estimates of Cobb-Douglas production function incorporated Hick's neutral technical progress suggests that during the reference period the productivity of labour more favorably contributing to output growth in the Indian textile industries than the capital in output growth.

2.8.1.2 SCALE OF RETURNS

The sum of the exponents of the capital ($\beta_1$) and labour ($\beta_2$) in the Cobb-Douglas production function without time trend (table 2.1) implied increasing returns to scale in five out of the 15 industry categories, viz, cotton ginning, cleaning and bailing (230), weaving & finishing of cotton textiles on handlooms (233), manufacture of knitted or crocheted textile products (260), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), manufacture of waterproof textiles fabrics (268). Of these, the estimates were slightly upward biased in the case of the following two industries viz, manufacture of knitted and crocheted textile products (260) and manufacture of waterproof textile fabrics (268) with magnitude of 2.07 and 2.08 respectively. In the following three industry categories viz, cotton ginning, cleaning and bailing (230),
weaving & finishing of cotton textiles on handlooms (233), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), the scale coefficient with value around 1.00 portrays constant returns to scale. We find diminishing returns to scale in the remaining 10 industries viz, weaving & finishing of cotton textiles on power looms (234), cotton spinning, weaving and processing in mills (235), bleaching, dyeing and printing of cotton textiles (236), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266), fabrics of plastic sheetings, manufacture of made up textile articles: except apparels (267), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269).

In Cobb- Douglas production function fit with time trend (table 2.2) it can be found that the sum of the exponents of capital and labour measuring the scale coefficient in the following five industries characterizing an increasing returns to scale viz, cotton ginning, cleaning and bailing (230), weaving & finishing of cotton textiles on handlooms (233), manufacture of knitted and crotched textile products (260), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), manufacture of water proof textiles fabrics (268).

In the remaining 10 industries diminishing returns to scale, was observed viz, weaving & finishing of cotton textiles on power looms (234), cotton spinning, weaving and processing in mills (235), bleaching, dyeing and printing of cotton textiles (236), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), making of blankets, shawls, carpets, rugs and
other similar textiles products (263), manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266), fabrics of plastic sheetings manufacture of made up textile articles: except apparels (267), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269).

2.8.2 CES SCALE COEFFICIENT

Similar to the estimates of CDPF the fit unrestricted CESPF model without time trend, table (2.3), increasing returns to scale has characterized in two out of the 15 industries. They are, cotton ginning, cleaning and bailing (230), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265). Among them (265) the estimates were marginally upward biased. We find diminishing returns to scale in seven industry categories viz, weaving & finishing of cotton textiles on handlooms (233), bleaching, dyeing and printing of cotton textiles (236) making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of floor covering of jute, mesta, sannhemp and other kinderd fibers and coir (264), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266), fabrics of plastic sheetings, manufacture of made up textile articles: except apparels (267), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269). In weaving & finishing of cotton textiles on power looms (234), cotton spinning, weaving and processing in mills (235), manufacture of knitted and crotched textile products (260), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), manufacture of water proof textiles fabrics (268), the scale coefficients assumed theoretically implausible negative values.

In the fit CESPF model with time trend, table (2.4), increasing returns to scale characterized seven industries viz, weaving & finishing of cotton textiles on handlooms (233), bleaching, dyeing and printing of cotton textiles (236) making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of floor covering of jute, mesta, sannhemp and other kinderd fibers and coir (264), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266), fabrics of plastic sheetings, manufacture of made up textile articles: except apparels (267), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269). In weaving & finishing of cotton textiles on power looms (234), cotton spinning, weaving and processing in mills (235), manufacture of knitted and crotched textile products (260), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), manufacture of water proof textiles fabrics (268), the scale coefficients assumed theoretically implausible negative values.
textiles on handlooms (233), weaving & finishing of cotton textiles on power looms (234), cotton spinning, weaving and processing in mills (235), manufacture of knitted and crotched textile products (260), embroidery work, zari work and making ornamental trimmings (262), manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265). Among them weaving & finishing of cotton textiles on handlooms (233), cotton spinning, weaving and processing in mills (235), embroidery work, and zari work and making ornamental trimmings (262), the estimates were marginally upward biased. We find diminishing marginal returns in seven industries, cotton ginning, cleaning and bailing (230), bleaching, dyeing and printing of cotton textiles (236), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266), fabrics of plastic sheetings, manufacture of made up textile articles: except apparels (267), manufacture of water proof textiles fabrics (268), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269). In manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), making of blankets, shawls, carpets, rugs and other similar textiles products (263), the scale coefficients has assumed theoretically implausible negative values.

2.8.3 VES SCALE COEFFICIENT

The fit VES PF model without time trend in table (2.5) reveals increasing returns to scale characterizing three industries viz, the cotton ginning, cleaning and bailing (230), weaving & finishing of cotton textiles on handlooms (233), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266). Among them the manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264) the estimates is marginally upward biased. We find diminishing returns to scale in six industries, weaving & finishing of cotton textiles on power looms (234), manufacture of
knitted and crotched textile products (260), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholsterying and filling etc. (269). In cotton spinning, weaving and processing in mills (235), bleaching, dyeing and printing of cotton textiles (236), embroidery work, zari work and making ornamental trimmings (262), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material(265), fabrics of plastic sheetings, manufacture of made up textile articles: except apparels(267), manufacture of water proof textiles fabrics (268), the scale coefficient has assumed theoretically implausible negative values.

In the VES PF model fit with time trend, table (2.6) increasing returns to scale was observed in one industry, cotton ginning, cleaning and bailing (230). We find diminishing returns characterizing eight industry categories viz, weaving & finishing of cotton textiles on handlooms (233), weaving & finishing of cotton textiles on power looms (234), cotton spinning, weaving and processing in mills (235), embroidery work, zari work and making ornamental trimmings (262), making of blankets, shawls, carpets, rugs and other similar textiles products (263), the manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced materials (265), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholsterying and filling etc. (269). In six industries viz, bleaching, dyeing and printing of cotton textiles (236), manufacture of knitted and crotched textile products (260), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266), fabrics of plastic sheetings, manufacture of made up textile articles:
except apparels (267), manufacture of water proof textiles fabrics (268), the scale coefficient assumed theoretically implausible negative values.

2.8.4 ELASTICITY OF FACTOR SUBSTITUTION

In the following section, an empirical examination of the elasticity of factor substitution ($\sigma$) is discussed using two major types of production functions viz, CES and VES. Apart from the typical forms of CES and VES production functions the elasticity of factor substitution also were estimated by incorporating the time variable (t) in the functions. The estimates of elasticity of factor substitution ($\sigma_1$ and $\sigma_3$) through the fit CESPF without and with time trend are presented in tables 2.3 and 2.4 respectively. The VESPF without and with time trend the estimates of the substitution coefficients ($\sigma_2$ and $\sigma_4$) are given in tables 2.5 and 2.6.

2.8.4.1 ESTIMATES OF ELASTICITY OF FACTOR SUBSTITUTION USING CES PF WITHOUT HICKS NEUTRAL TECHNICAL CHANGE ($\sigma_1$) (TABLE 2.3)

The estimated magnitude of the elasticity of the factor substitution ($\sigma_1$), tended to be greater than one in the following seven industries, weaving & finishing of cotton textiles on handlooms (233), bleaching, dyeing and printing of cotton textiles (236), making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266), fabrics of plastic sheetings, manufacture of made up textile articles: except apparels (267), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269). The magnitude of $\sigma_1$ was around unity, closely associated with Cobb- Douglas production function specification in the industry engaged in, weaving & finishing of cotton textiles on handlooms (233). In two industries, cotton spinning, weaving and processing in mills (235), manufacture of water proof textiles fabrics (268), the $\sigma_1$ was greater than 0.50 implying capital augmenting type of factor substitution.
From the table it is evident that out of 15 industry categories, in 14 industry, the coefficient of determination $R^2$ emerged statistically significant except one industry, namely the manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264). In one industry viz, manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), $\sigma_1$, assumed theoretically implausible negative values.

2.8.4.2 ESTIMATES OF ELASTICITY OF FACTOR SUBSTITUTION USING CES PF WITH TIME TREND ($\sigma_3$) TABLE (2.4)

The empirical estimates of CES PF incorporating with Hicks neutral technical change are presented in table (2.4). It appears from the results that the introduction of time as an additional variable to detect exogenous technical progress has generally resulted in lowering the magnitude of factor substitution. The estimated ($\sigma_3$) values, acquire, theoretically implausible negative sign in the industries engaged in the manufacture of weaving & finishing of cotton textiles on power looms (234), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266). In the following three industries, viz., cotton spinning, weaving and processing in mills (235), manufacture of knitted and crotched textile products(260), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstery and filling etc. (269), the estimated value of factor substitution ($\sigma_3$) was greater than 0.50 in three industries, bleaching, dyeing and printing of cotton textiles(236), making of blankets, shawls, carpets, rugs and other similar textiles products(263), manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264), the coefficient of ($\sigma_3$) was upward biased.
2.8.4.3. ESTIMATES OF ELASTICITY OF FACTOR SUBSTITUTION USING VES PF WITHOUT HICKS NEUTRAL TECHNICAL CHANGE. $\sigma_2$. TABLE (2.5)

The estimates of the VES PF are presented in table (2.5) for the 15 textile industries at the three digit desegregation. The overall statistical fit of the model emerged significant with high coefficient of determination $R^2$ in all the 15 industries. In this modal we take into consideration the effect of capital-labour ratio, in addition to real wage rate in estimating the coefficient of factor substitution $\sigma_2$. The magnitude of the elasticity of substitution $\sigma_2$ was greater than unity in nine industries viz, cotton spinning, weaving and processing in mills (235), bleaching, dyeing and printing of cotton textiles (236), manufacture of knitted and crotched textile products (260), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265), fabrics of plastic sheetings, manufacture of made up textile articles: except apparels (267), manufacture of water proof textiles fabrics (268), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269). Among them a closer examination reveals that the values hovering around unity closely associated with CDPF specification in the following industries cotton spinning, weaving and processing in mills (235), bleaching, dyeing and printing of cotton textiles (236), manufacture of water proof textiles fabrics (268), the $\sigma_2$ was greater than 0.5 and characterized to the factor substitution offering a proximate explanation of capital using in the place of labour in the following industries, cotton ginning, cleaning and bailing (230), weaving & finishing of cotton textiles on handlooms (233), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266). the $\sigma_2$ estimates of factor substitution by assuming values, lower than 0.5 in cotton spinning other than in mills (charkha) (231), weaving & finishing of cotton textiles on power looms (234), manufacture of floor covering of jute, mesta,

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sannhemp, and other kinderd fibers and coir (264), tended to support the argument that in these industries output growth was accompanied by labour rather than capital augmentation.

2.8.4.4 ESTIMATES OF ELASTICITY OF FACTOR SUBSTITUTION USING VES PF WITH HICKS NEUTRAL TECHNICAL PROGRESS $\sigma_4$, TABLE (2.6)

The VESPF estimates incorporated with Hicks neutral technical change for the 15 textile industries at three digit desegregation presented in table (2.6) The magnitude of $\sigma_4$ assumed theoretically predicted positive values for 11 industries out of 15 industries. The magnitude of $\sigma_4$ was above unity for four industries, bleaching, dyeing and printing of cotton textiles (236), fabrics of plastic sheetings, manufacture of made up textile articles: except apparels (267), manufacture of water proof textiles fabrics (268), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269), implying higher degree of substitutability between capital and labour. In the following industries, cotton ginning, cleaning and bailing (230), cotton spinning, weaving and processing in mills (235), manufacture of knitted and crotched textile products (260), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), the $\sigma_4$ estimates assumed magnitudes greater than 0.5 implying a high degree of capital augmenting factor substitution characteristics, during the reference period. The $\sigma_4$ estimates was less than 0.5 in weaving & finishing of cotton textiles on power looms (234), manufacture of rain coats, hats, caps& school bags etc. from water proof textile (266), implying a low degree of capital augmenting factor substituting characterizing the reference period. In the remaining four industries, weaving & finishing of cotton textiles on handlooms (233), making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of floor covering of jute, mesta, sannhemp, and other kinderd fibers and coir (264), manufacture of all types of textile garments & clothing accessories n.e.c
(except by purely tailoring establishments) from not self produced material (265), o4 assumed theoretically implausible negative values.

2.8.5 HICK’S NEUTRAL TECHNICAL PROGRESS

In the following section, we discuss the production function estimates of Hick’s neutral technical progress obtained by incorporating the time element in the CDPF, CESPF and VESPF models. We symbolically represents these estimates of hicks neutral technical progress as $\beta_3$, $\lambda_2$ and $\lambda_3$.

2.8.5.1 ESTIMATES OF TECHNICAL PROGRESS USING COBB-DOUGLAS PRODUCTION FUNCTION ($\beta_3$). (TABLE 2.2)

In table (2.2), we have provided the Cobb-Douglas production function model based empirical estimates of Hick’s neutral technical change for the 15 textile industries at three digit desegregation. The $\beta_3$ coefficient, which measures the contribution made by the Hicks neutral technical change to output growth, $\beta_3$ has obtained positive sign in 11out of 15 industries. Theoretically implausible negative values were seen in four industries weaving & finishing of cotton textiles on handlooms (233), bleaching, dyeing and printing of cotton textiles (236), manufacture of floor covering of jute, mesta, saanhemp, and other kinderd fibers and coir (264), manufacture of all types of textile garments & clothing accessories n.e.c (except by purely tailoring establishments) from not self produced material (265).

A close examination of the magnitude of $\beta_3$, indicates that in the following five industries, engaged in, cotton spinning, weaving and processing in mills (235), manufacture of all types of threads, cordage, ropes, twines & nets etc. (261), embroidery work, zari work and making ornamental trimmings (262), making of blankets, shawls, carpets, rugs and other similar textiles products (263), manufacture of rain coats, hats, caps & school bags etc. from water proof textile (266), the output growth having increased due to exogenous technical progress.
2.8.5.2 ESTIMATES OF TECHNICAL PROGRESS CES PRODUCTION FUNCTION: $\lambda_2$

The estimate regression coefficient of the unrestricted CES PF for the three digit level Indian textile industries are presented in table (2.4). The estimated coefficient of Hicks neutral technical change $\lambda_2$ is found assuming a negative characteristics in the industries engaged in, weaving & finishing of cotton textiles on handlooms (233), embroidery work, zari work and making ornamental trimmings (262), making of blankets, shawls, carpets, rugs and other similar textiles products (263), The Hicks neutral technical change $\lambda_2$ being a source of output growth in the cotton ginning, cleaning and bailing (230), the $\lambda_2$ estimates were biased with high magnitudes around 49.78.

2.8.5.3 ESTIMATES OF TECHNICAL PROGRESS USING VES PRODUCTION FUNCTION WITH HICKS, $\lambda_3$

Table (2.6.), portrays the estimates of Hicks neutral technical progress, obtained by fitting VES PF the model has taken into account the influence of capital labour ratio on output growth in addition to real wage rate. The time coefficient is incorporated in the model ton capture the contribution to Hicks neutral technical progress on output growth.

The magnitude of Hicks neutral technical progress $\lambda_3$ shows a positive contribution to output growth 13 out of 15 industries. We observe upward biased $\lambda_3$ in the industries engaged in manufacture of all types of threads, cordage, ropes, twines & nets etc. (261) with magnitude of 29.01 and in manufacture of knitted and crocheted textile products (260), with magnitude of 26.09. In the remaining three industries, the output growth on account of exogenous technical progress has ranged between a high of 16.82% in the case of, embroidery work, zari work and making ornamental trimmings (262), and a low of 0.096% in the case of cotton ginning, cleaning and bailing (230). The $\lambda_3$ assumed theoretically implausible negative sign in the following industries, making of blankets, shawls, carpets, rugs and other similar textiles products.
(263), manufacture of textile/textile products n.e.c like linoleum, padding wadding upholstering and filling etc. (269).

On the whole we notice the coefficient of multiple determination \( R^2 \) emerging statistically significant in both Cobb-Douglas production function and VES PF and it is not significant in the CES production function. The Hicks neutral technical progress assumed theoretically implausible negative values in four industries, in the CES PF model \( \lambda \) estimates were negative three industries, and in the VES PF \( \lambda \) estimates shows negative magnitudes for two industries.
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Table 2.1
Regression estimates of cobb-douglas production function for the cotton textile industries in India, during the year 1980-81 to 1997-98

\[ \ln(Q) = \alpha + \beta_1 \ln(K) + \beta_2 \ln(L) + \mu \]

<table>
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<th>Industry code</th>
<th>( \alpha ) (t-value)</th>
<th>( \beta_1 ) (t-value)</th>
<th>( \beta_2 ) (t-value)</th>
<th>R² F</th>
<th>R²</th>
<th>( \mu )</th>
<th>D-W</th>
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<td>0.005867</td>
<td>0.946021</td>
<td>0.938824</td>
<td>1.527553</td>
<td>2.964479</td>
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<td>0.926009</td>
<td>0.916143</td>
<td>1.428769</td>
<td>2.532966</td>
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<td>0.904555</td>
<td>0.901829</td>
<td>0.832379</td>
<td>1.593888</td>
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Note:
* = 't' significant at 95 percent  ** = 't' significant at 90 percent  @ = 'F' significant at 99 percent  significant @@ = 'F'significant at95 percent
Table 2.2
Regression estimates of Cobb-Douglas production function with Hick's neutral technical progress for the textile industries of India during, 1980-81 to 1997-98

\[
\ln(Q) = \ln(\alpha) + \beta_1 \ln(K) + \beta_2 \ln(L) + \beta_3 (T) + \mu
\]

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Note: * = 't' significant at 95 percent ** = 't' significant at 90 percent @ = 'F' significant at 99 percent significant @@ = 'F' significant at 95 percent
Table 2.3
Regression estimates of CES production function for the textile industries in India during 1980-81 to 1997-98

\[ \ln (V/L) = \ln \alpha + \beta_1 \ln (W/L) + \beta_2 \ln (L) + \mu \]

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Note:
* = 't' significant at 95 percent ** = 't' significant at 90 percent
@ = 'F' significant at 99 percent significant @@ = 'F' significant at 95 percent
Table 2.4
Regression estimates of CES production function with Hick's neutral technical progress of textile industries in India during 1980-81 to 1997-98
\[ \ln (V/L) = \ln \alpha + \beta_1 \ln (W/L) + \beta_2 \ln (L) + \beta_3 (T) + \mu \]

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Note: * = 't' significant at 95 percent  ** = 't' significant at 90 percent  @ = 'F' significant at 99 percent  @@ = 'F' significant at 95 percent
Table 2.5
Regression estimates of VES production function for the textile industries in India during 1980-81 to 1997-78
\[ \ln(V/L) = \alpha + \beta_1 \ln(W/L) + \beta_2 \ln(K/L) + \mu \]

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Note:
* = 't' significant at 95 percent  ** = 't' significant at 90 percent  @ = 'F' significant at 99 percent  @@ = 'F' significant at 95 percent
Table 2.6
Regression estimates of VES production function with Hick’s neutral technical progress of textile industries in India during 1980-81 to 1997-98

\[ \ln(V/L) = \ln(\alpha + \beta_1 \ln(W/L) + \beta_2 \ln(K/L) + \beta_3 (T) + \mu) \]

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