CHAPTER III

ECONOMIC REFORMS AND ECONOMIC EFFICIENCY
A CONCEPTUAL FRAMEWORK
CHAPTER – III

ECONOMIC REFORMS AND ECONOMIC EFFICIENCY – A CONCEPTUAL FRAMEWORK

3.1. INTRODUCTION

In India, major economic reforms have been undertaken since July 1991 with the objective of increasing the productivity and competitiveness of the companies. The new policies have liberalised many government controls on production capacity, imported capital goods, intermediate inputs and technology. Foreign investment has also been liberalised. These reforms have made imported inputs cheaper and more accessible for companies and have exposed the companies to both domestic and international competition. These reforms have altered the economic environment in which the companies operate.

3.2. THEORETICAL PERSPECTIVE ON ECONOMIC REFORMS AND PRODUCTIVITY:

The relationship between Economic reforms and TFP growth has been the subject matter of controversy among economists. Although there are a number of theoretical and empirical studies on the impact of reforms on productivity, it is as yet a controversial issue. Even so, empirical studies on the relationship between economic liberalisation and growth have produced a mixed bag of results.

The conventional wisdom in favour of economic liberalisation is that the latter can lead to significant gains in productivity and efficiency. This view has, however been challenged by the theories of endogenous growth. The new growth theories do allow for the possibility that economic reforms may bring about a permanent change in productivity growth. However, the theoretical literature does not yield an unambiguous prediction on the direction of the change (Surveys by Rodrik 1988 and 1992; and Tybout 1992). Given this ambiguity, the impact of economic policies on productivity growth is ultimately an empirical question.

However, the available empirical evidence on this issue has been far from conclusive. Studies for developing countries that use firm or industry-level data do not find an unequivocal positive relationship between Economic Reforms and productivity growth (surveys by Havrylshyn 1990, Nishimizu and Page 1990 and Rodrik 1995).
3.3. THEORETICAL ISSUES RELATING TO TECHNOLOGY, TECHNICAL CHANGE AND TECHNICAL PROGRESS:

Technology in simple terms means the knowledge necessary to produce goods and services. More elaborately, technology refers to any tool or technique, product or process, physical equipment or method of doing or making by which human capability is extended.

Technology is a bundle of spectrum of techniques, which define the various combinations of inputs that will yield any given physical output. Technology thus defines a production function.

To measure technical progress the following method has been used:

a) Technical Change based on Time Trend

Technical change can be analysed and estimated by using production functions. One such type of technical change is a shift in the production function over time reflecting greater efficiency in combining inputs. It is called disembodied technical change, and it can be represented by the production function.

\[ Y = f(L, K, t) \] ............................... (1)

i.e.,

\[ Y(t) = f(L(t), K(t), t) \]

Where \( t \) is time.

b) Brown's method

Brown estimated technical change by taking first order differences: the model is of the following form:

\[ \Delta \ln Y = \alpha \Delta \ln L + \beta \Delta \ln K + m \]

\( Y \) – Output
\( K \) – capital
\( L \) – labour
\( m \) – technical change
\( \alpha, \beta \) - Co-efficients
c) Solow method

The following formula developed by Solow (1957) is used for the computation of technical progress.

Let the Cobb-Douglas Production Function assumed in the following form:

\[ V = A(t) \cdot L^\alpha K^\beta \] ................................ (1)

Where,

\[ \alpha + \beta = 1, \ V \text{ is the value added at constant prices, } L \text{ is labour input, } K \text{ is fixed capital at constant prices, } A(t), \alpha + \beta \text{ are constants} \]

Equation (1) can be written as

\[ V = A(t) \cdot \left( \frac{L}{K} \right)^\beta \] ............................... (2)

i.e.

\[ \frac{V}{L} = A(t) \left( \frac{K}{L} \right)^\beta \] ............................... (3)

By taking logarithms we get,

\[ \log \left( \frac{V}{L} \right) = \log A(t) + \beta \log \left( \frac{K}{L} \right) \] ............................... (4)

\[ \log A(t) = \log \left( \frac{V}{L} \right) + \beta \log \left( \frac{K}{L} \right) \] ............................... (5)

\[ A(t) = \text{Antilog} \{ \log \left( \frac{V}{L} \right) = \log A(t) - \beta \log \left( \frac{K}{L} \right) \} \] ............................... (6)

The parameter ‘\( \beta \)’ required for computation of \( A(t) \) has to be calculated by fitting a logarithmic equation (Equation 4) between \( V/L \) and \( K/L \) by the method of least squares. Equation (6) gives an average total productivity index for the study period by removing the effect of capital intensity from the labour productivity. But this gives only an average figure for the whole period under study. It would be more useful to know the change of this index with respect to time also. For this following procedure is followed. By differentiating (Equation 4) and expressing it in terms of differentials of discrete form we get:

\[ \frac{(V/L)}{(V/L)} = \frac{(A(t))}{A(t)} + (\beta \ K/L) / (K/L) \] \( \ldots(7) \)

or

\[ \frac{(A(t))}{A(t)} = \frac{(V/L)}{(V/L)} - (\beta \ K/L) / (K/L) \] \( \ldots(8) \)

Equation (7) expresses the proportional change in labour productivity \( (V/L) \) over time which is a sum of two components, viz., one due to proportional change in the shift
factor (A(t)) and other due to proportional change in capital intensity (K/L). The weight for the latter term is ‘β’. From the series of ( A(t)) / A(t), A(t) has been calculated for each year of the period under study using equation (8) by assuming the initial value of A(t) as unity. All A(t) values are expressed as percentages in terms of base year values.

In the case of products whose co-efficient of determination values were low, the following procedure is used to calculate the Solow Index of TFP. This index is based on rate of productivity changes and is obtained as follows:

\[
\frac{(A(t))}{A(t)} = \frac{(V(t))}{V(t)} - Wt \left( \frac{(L(t))}{L(t)} + \pi \left( \frac{(K(t))}{K(t)} \right) \right)
\]

Where

\[
\frac{(V(t))}{V(t)} = \text{rate of change of real value added}
\]
\[
\frac{(L(t))}{L(t)} = \text{rate of change of labour}
\]
\[
\frac{(K(t))}{K(t)} = \text{rate of change of real gross fixed capital}
\]

Wt = share of labour in value added in year t

\[\pi\] = share of capital in value added in year t

To estimate ‘β’, we have used the following model:

\[O/L = f(K/L)\]

The estimating equation is

\[\ln O/L = \alpha + \beta (\ln K/L)\]

d) Measurement of Technical Change

Hick’s Neutrality:

According to Hicks, an invention is said to be neutral when it raises the marginal productivities of labour and capital in the same proportion. In other words, a technical change is neutral if the ratio of the marginal product of capital to that of labour remains unchanged at a constant capital-labour ratio.

A technical change is labour-saving if it raises the marginal product of capital relative to that of labour, at a constant capital-labour ratio.

If the amount of labour used is reduced absolutely and that of capital rises, then the technical change will be absolutely labour-saving and capital-using.
On the other hand, a technical change is *capital-saving* if it raises the marginal product of labour relatively to capital, at a constant capital-labour ratio. The given output will now require less capital relatively to labour.

**Harrod Neutrality:**

The alternative definition of neutral technical progress is given by Harrod in his *Towards a Dynamic Economics*. According to him, technical change is *neutral* if at a constant rate of profit (or interest) the capital-output ratio also remains constant. If the rate of profit remains constant after technical change but the capital-output ratio rises, then the technical change is *labour-saving*. On the other hand, if the capital-output ratio falls with technical change at a constant rate of profit, then the technical change is *capital-saving*.

The elasticity of substitution, 'e' is defined as the ratio of proportionate change in the ratio of factor inputs to the proportionate change in the ratio of marginal products.

\[
e = \frac{\Delta (K/L)/(K/L)}{\Delta (MRS)/(MRS)}
\]

### 3.4. DISEMBODIED AND EMBODIED TECHNICAL CHANGE

#### 3.4.1. Disembodied Technical change

In 1956 Abramovitz wrote the first paper followed by Kendrick and Solow in an attempt to measure the contribution of technical change to economic growth. They treated technical change as 'disembodied'. It is purely organisational which permits more output to be produced from unchanged inputs, without any new investment. It refers to any kind of shift in the production function that leaves the balance between capital and labour undisturbed in the long run. The production function for such technical change is

\[
Q = F(K, L; t) \quad \ldots\ldots(1)
\]

Where \(Q\) represents output, and \(K\) and \(L\) represents capital and labour inputs and 't' represents technical change.

Hicks neutral technical change as the basis, Solow postulated the production function in the special form as

\[
Q = A(t) F(K, L) \quad \ldots\ldots(2)
\]
where $A(t)$ is an index of technical change which indicates or measures the cumulated effects of upward shifts in the production function. Such a production function implies that technical progress is organisational in the sense that its effect on productivity does not require any change in the quantity of the inputs. Existing inputs are improved or used more effectively.

Assuming that $A(t)$ increases neutrally and exponentially at the rate of $(\lambda)$, the production function may be written in the Cobb-Douglas form as:

$$Q = A . e^{kt} . K^\beta . L^{1-\beta}$$

where $\beta$ is the elasticity of output with respect to capital and $(1-\beta)$ is the elasticity of output with respect to labour. In the case of constant returns to scale the values of $\beta$ and $(1-\beta)$ add up to one.

In disembodied technical progress, capital is assumed as homogenous and technical progress flows down from outside (economy). Productivity depends upon the amount of capital stock and not on its age. Disembodied technical progress improve the productivity of all factors of production or those of particular kind already existing. All disembodied technical progress is capital-augmenting in which existing capital is by one means or another made more productive.

Relying on the United States time series data where capital and output grew at approximately the same rate, Solow proceeded to focus on the rate of technical change. “By using data on the share of capital and labour, and the rates of growth of capital per head and output per head, the contribution of the ‘residual’ is obtained after calculating the contribution of capital. This residual is attributed to technical progress”. Solow came to the conclusion that during 1909-49 the average growth rate of output per head in the United States could be attributed 12.5 per cent to the increase in capital per worker and the residual 87.5 percent to technical change.

3.4.2. Embodied Technical change - Vintage Approach

In the alternative model entitled Investment and Technical Progress (1960), Solow himself modified the residual approach based on disembodied technical change in which capital stock is regarded as homogenous and technical change flows down from the outside. In this model new capital accumulation is regarded as the vehicle to technical progress. Technical progress increase the productivity of machines built in any period.
compared with machines built in the previous period, but it does not increase the productivity of machines already in existence. Technical progress is embodied in new machines. Machines built at different dates are therefore qualitatively dissimilar, and cannot in the general case be aggregated into a single measure of capital. A separate production function is needed for each vintage. Total output is the summed up output of all the vintages in use.

3.4.3. Assumptions

This model assumed that,

a) Capital stock consists of machines of different vintages built in different dates.
b) New machines are more productive than machines of older vintage.
c) Technical change proceeds at some given proportional rate.
d) Technical change affects only new machines
e) All technical progress is uniform
f) Machines embody all the latest knowledge at the time of construction but do not share in any subsequent improvements in technology
g) Only gross investment in new machines is considered in the mode, and
h) The production function is linear homogenous of the Cobb-Douglas type.

Given these assumptions, the total output \( Q_v(t) \) at time 't' form the machines of each vintage 'V' is given by a Cobb-Douglas production function.

\[
Q_v (t) = B e^{\lambda_v} L_v (t)^\alpha K_v (t)^{1-\alpha} \quad \ldots (1)
\]

where \( B e^{\lambda_v} \) is the level of technology increasing neutrally and exponentially at the rate \( \lambda \), \( L_v (t) \) represents the quantity of labour operating the surviving stock of capital or vintage 'v' at time t; \( K_v (t) \) denotes the number of machines of vintage v still in existence at time \( t \geq v \); and \( \alpha \) and \( 1-\alpha \) are elasticities of output with respect to labour L and capital K.

Taking the quantity \( K_v(t) \) for gross investment which is the output of capital goods at time v, Solow Symbalises it by I(v). If capital goods are exposed to a constant force of mortality \( \delta \), than the average length of life of capital is \( 1/\delta \) and gross investment

\[
K_v(t) = K_v (V) e^{-\delta(t-v)} = I(v) e^{-\delta(t-v)} \quad \ldots . (2)
\]

50
3.5  ECONOMIC EFFICIENCY

We have studied the overall economic efficiency with reference to the following four dimensions:

1. Manufacturing Efficiency
2. Organisational Efficiency
3. Allocative Efficiency
4. Technical Efficiency

3.5.1 Manufacturing efficiency

Manufacturing efficiency is studied through average productivity, marginal productivity, partial and total factor productivity.

Definition of Productivity

In an industry, diverse resources like raw materials, labour, capital, plant, machinery and management are employed. Each of these resources is called input and helps to achieve the final production or output.

Productivity represents the relationship that exists between the output and the input or in other words it is the amount of output per unit of input. Productivity aims at the maximization of output by the most efficient and economic use of input and minimization of wastes. If an increase in production is effected by a corresponding increase in the quantum of input, there is no increase in productivity. It brings out the cumulative effect of a number of inter-related influences such as technological change, motivation, effort of workers, substitution of factors and organisational ethos. Therefore, productivity is the ratio of what comes out of business to what goes into the business i.e. it is the ratio of “outcome” to the efforts.

Productivity denotes the relationship between output and one or all associated inputs in real terms. Productivity establishes a technological relationship between inputs and outputs. However, this relationship should not be interpreted to imply a more engineering ratio, since productivity is influenced by a wide range of socio-economic and managerial factors as well.

In broad terms, productivity means the efficient utilization of the available resources of the production of goods and services required by the community. It aims at
the maximum utilization of the available resources, for the maximization of the benefits there from.

Significance Of Productivity Measurement

Productivity measurement helps to identify areas for corrective action towards planning, better utilization of resources and other measurement controls to achieve better performance. It helps to compare the performance in one period to performance in another period, in an organisation. Productivity ratios are useful to understand the nature of the industry, with regard to capital intensity; it also expresses the capacity utilization of these industries.

The main objective of emphasizing the importance of productivity is to "get more for less" that is "more output for less effort, for less capital or for less raw materials than before. Higher rates of economic growth at less economic technical and social costs." Higher productivity is a means to define a goal, namely rapid economic growth.

Productivity is so fundamental to promote and stabilize growth that it would be no exaggeration to say that an inadequate rate of growth of productivity might, in the long run endanger the very survival of an economic system.

Types of Productivity

There are two types of productivity namely (i) Partial factor productivity and (ii) Total factor productivity.

Partial Factor Productivity

The production process includes a number of inputs such as capital, labour, energy and materials. By relating the flow of goods to input variables, the partial productivity measures are obtained. It is typically expressed as a ratio of output to one or more of the inputs used in the production process. On the other hand, partial productivity is the ratio of output to one class of input. For example, labour productivity (the ratio of output to labour input) is a partial productivity measure. Similarly, capital productivity (the ratio of output to capital input) and material productivity (the ratio of output to materials input) are examples of partial productivities.
i) Partial Factor Productivity

a) Average Productivity of Capital

Average productivity of capital may be defined as the relationship between investment in a given economy or industry for a given time period and the output of that economy or industry for a similar time period. The average productivity ratios give us an idea about on an average, the units of capital required to produce a unit of output and the study of average productivity indices would help to trace the movement and measurement of capital productivity in each firm and its time pattern of change.

Average Productivity of capital (AP_k) = O/K

Where, O = Output for a given period
K = capital for a given period

Average Productivity of Labour

Average labour productivity, may be defined of the ratio between employment in a given economy or industry for a given time period and the output of that economy or industry for a similar time period. Average labour productivity is indicated as

Average Productivity of Labour (AP_L) = O/L

Where, O = Output for a given period
L = employment for a given period

b) Marginal Productivity of Capital

Marginal productivity of capital or capital co-efficient may be defined as the ratio between a change in output in a given economy or industry in a time period for a given change in gross block of that economy or industry, for a similar time period.

Marginal productivity of capital is indicated as,

\[ MP_k = \frac{\Delta O}{\Delta K} \]

where \( \Delta O \) = change in output for a given period
\( \Delta K \) = change in capital for a given period

Marginal Productivity of Labour

Marginal productivity of labour, may be defined as the relationship between the change in employment in a given economy or industry for a given time period, and the change in output of that economy or industry for a similar time period.
Marginal productivity of labour is indicated as
Marginal Productivity of Labour (\(MPL\)) = \(\frac{\Delta O}{\Delta L}\)
where \(\Delta O\) = change in output for a given period
\(\Delta L\) = change in labour or employment for a given period.

ii) Total Factor Productivity


Specify the production function for firm \(i\) in industry \(j\) at time \(t\) as:
\[ Y_{ijt} = A_{jt}f_{jt}(L_{ijt}, K_{ijt}, M_{ijt}) \] ............... (1)

Where \(Y\), \(K\), \(L\) and \(M\) stand for output, capital, labour and materials inputs, respectively, \(A_{jt}\) is an industry-specific index of Hicks-neutral technical progress and \(f_{jt}\) is a parameter allowing for firm-specific differences in technology. Totally differentiating (1) and dividing throughout by \(Y\), we have
\[ \left(\frac{dY}{Y}\right)_{ijt} = (\delta Y/\delta L)_{ijt} + (\delta Y/\delta K)_{ijt} + (\delta Y/\delta M)_{ijt} + (dA/A)_{jt} + (df/f)_{jt} \] ............... (2)

From the first order conditions for profit maximisation of a firm in Cournot equilibrium the expression for physical the marginal product(s) can be written as:
\[ (\delta Y/\delta L)_{ijt} = \left(\frac{w}{p}\right)_{jt}\{1/[1+(s_{ij}/e_j)]\} = \left(\frac{w}{p}\right)_{jt} \mu_{ij} \] ............... (3a)
\[ (\delta Y/\delta K)_{ijt} = \left(\frac{r}{p}\right)_{jt}\{1/[1+(s_{ij}/e_j)]\} = \left(\frac{r}{p}\right)_{jt} \mu_{ij} \] ............... (3b)
\[ (\delta Y/\delta M)_{ijt} = \left(\frac{n}{p}\right)_{jt}\{1/[1+(s_{ij}/e_j)]\} = \left(\frac{n}{p}\right)_{jt} \mu_{ij} \] ............... (3c)

Where \(p\) is the product price, \(w\), \(r\) and \(n\) are the price of labour, capital and materials, respectively, \(s_{ij}\) is the market share of firm \(i\) in industry \(j\), \(\mu_{ij}\) is the price-marginal cost ratio and \(e_j\) is the price elasticity of demand for the \(j^{th}\) industry.

Anticipating the estimation, which takes the form of estimating an industry-level production function for whole industries, it is assumed that the mark-up only varies across industries, and not between firms.

Now, substituting (3a)-(3c) into (2) and re-arranging terms, we have:
\[ (dY/Y)_{ijt} = \mu_{ij}[(wL/pY)(dL/Y) + (rK/pY)(dK/Y) + (nM/pY)(dM/M)]_{ijt} + (dA/A)_{jt} + (df/f)_{jt} \] ............... (4)
Denoting the factor shares \((wL/pY), (rK/pY)\) and \((nM/pY)\) as \(\alpha_l, \alpha_k\) and \(\alpha_m\), respectively, (4) may be re-written as:

\[
(d\ln Y)_{jt} = \mu_j[\alpha_l(d\ln L) + \alpha_m(d\ln M) + \alpha_k(d\ln K)]_{jt} + (dA/A)_{jt} + (df/f)_{jt} \ldots \ldots \ldots (5)
\]

Denoting the sum of factor shares as \(\beta/\mu\), where \(\beta\) is the returns-to-scale parameter and \(\beta = 1\) the constant returns-to-scale case, we can re-write (5) as a growth rate version of the production function in intensive form in capital:

\[
dy_{ijt} = \mu_j[\alpha_l dL + \alpha_m dm]_{ijt} + (\beta -1)(dK/K)_{ijt} + (dA/A)_{jt} + (df/f)_{jt} \ldots \ldots \ldots \ldots \ldots (6)
\]

Where the variables \(y, l\) and \(m\) stand for \(\ln(Y/K), \ln(L/K)\) and \(\ln(M/K)\), respectively.

In an estimate of (6), the term \((dA/A)_{jt}\), which can be thought of as the rate of productivity growth for industry \(j\), is captured by a constant term \(B_{0j}\). Next, \((df/f)_{jt}\) may be decomposed into a firm-specific effect \(g_{jt}\) and a disturbance term \(u_{jt}\). The resulting specification can be used to test for changes in the extent of competition and in productivity growth due to trade reforms. The change in the price-cost ratio can be investigated by adding an interactive slope dummy to the sum of the changes in variable inputs in (6) and a shift in the level of productivity growth can be accounted for by an intercept dummy. Incorporating these would give the estimating equation:

\[
dy_{ijt} = B_0 + B_1 dx_{ijt} + B_2[Ddx_{ijt}] + B_3 dk_{ijt} + B_4 D + g_{jt} + u_{jt} \ldots \ldots \ldots \ldots (7)
\]

Where,

- \(B_0 = dA/A\), \(B_1 = \mu\), \(B_2 = \text{change in } B_1\)
- \(B_3 = (\beta -1)\), \(B_4 = \text{change in } B_3\)
- \(dx = [\alpha_l dL + \alpha_m dm]\),
- \(dk = dK/K\), and
- \(D\) is a dummy accounting for the policy regime during any particular historical phase. Given our interest in this study the dummy takes the value zero prior to 1991 and one from that date on. Moreover, in this study we remain interested only in the behaviour of productivity growth.

Notice from (6) that there is a firm-specific factor in the form of \(f_t\) to take care of. We follow standard practice and allow for the possibility of this standing either for fixed or for random effects.
Finally, if $B_3$ is not significantly different from zero in an estimate of (7) we may conclude that the technology is characterized by constant returns to scale. Further, since there has been evidence of an impact of trade reforms on the scale parameter in some economies it would be advisable to allow for it in estimation. This is done by adding an interactive slope dummy to ‘dk’ which yields:

$$dy_{ijt} = B_{0j} + B_{1j}dx_{ijt} + B_{2j}[Ddx_{ijt}] + B_{3j}dk_{ijt} + B_{4j}D + B_{5j}[Ddk_{ijt}] + g_{it} + u_{it} \ldots \ldots (7)$$

3.5.2 Organisational Efficiency

To examine the Organisational efficiency, the conventional Cobb-Douglas Production Function has been used.

**Production Function:**

The following model was applied to data on output and input for estimating the CD function,

$$Y = AK^\alpha L^\beta T^\gamma$$

Where $Y$ = output
- $K$ = Fixed Capital
- $L$ = wages & salaries of Employees
- $T$ = Technology
- $A$ = Efficiency parameter
- $\alpha$ = Co-efficient of capital
- $\beta$ = Co-efficient of Labour
- $\gamma$ = Co-efficient of technology

The logarithm of both sides of the above model was taken to convert the equation into linear form; its log transformation is specified below:

$$\log Y = \log A + \alpha \log K + \beta \log L + \gamma \log T + u.$$  

The efficiency parameter ($A$) and the co-efficients of the inputs were estimated by applying the above equation.

Parameters ‘$\alpha$’, ‘$\beta$’ and ‘$\gamma$’ represent individually the proportionate change in output for a proportionate change in Capital, Labour and technology. The three input co-efficients taken together to measure the aggregate proportionate change in output for a given proportionate change in labour, capital and technology. This implies that $\alpha + \beta + \gamma$ show the degree of returns to scale.
If $a + P + y > 1$, it would imply that the output increase would be more than proportionate to the increase in inputs, if $a + P + y < 1$, it would imply that the output increase would be less than proportionate to the increase in inputs and if $a + P + y = 1$ the output would just increase proportionately to the rate of increase of inputs. Therefore there will be economies of scale, constant returns to scale or diseconomies of scale depending upon whether $a + P + y$ is less than 1, equal to 1, or greater than 1. This implies that the CD production function can represent any degree of returns to scale.

'A' in the CD function denotes the efficiency of the technology. Given the inputs and other aspects of the abstract technology. 'A' determines the output that results. In other words, for every input combination, the greater the 'A' the greater is the level of output. $a / \beta$ denotes the capital intensity of the technology. An increase in 'a' relative to 'b' indicates a capital using technology.

Theoretically, we expect that all the input coefficients shall have a positive sign and greater than zero i.e., $a > 0, \beta > 0, \gamma > 0$.

3.5.3 Allocative Efficiency

Allocative efficiency has been studied through MRS, K/L, and elasticity of substitution.

Factor Substitution

The development of small enterprises has been mainly emphasized for the generation of employment in the face of growing unemployment and underemployment. The small enterprises are generally expected to use more labour and hence generate more employment and help in widespread income generation. The underlying premise is that small enterprises face a lower price of labour relative to other factors especially capital. One, therefore, expects a tendency for these enterprises to substitute labour for capital.

Elasticity of Substitution

Elasticity of factor substitution or technical substitution measures the degree of substitutability between two factors. Prof. J.R. Hicks, the inventor of this concept, define it as "a measure of the case with which the varying factor can be substituted for others".

If the two factors, capital and labour, are required in fixed proportions (machine one workers two) to give a unit of product, then the elasticity of substitution is zero.
If labour and capital are identical to that one is almost a perfect substitute for the other, then the elasticity of substitution between them is infinite.

When an increase in the quantity of one factor raises the marginal product of the other factor is the same proportion as then total product, the elasticity of substitution is unity. In other words, when with the increase in the quantity of labour, the marginal productivity of capital increase in the same proportion in which the total output increases, the elasticity is said to be unity.

Mrs. Joan Robinson defines elasticity of substitution as “the proportionate change in the ratio of amounts of the factors divided by the proportionate change in the ratio of their marginal physical productivities”.

Elasticity of substitution measures the case with which one factor can be substituted for another. The concept has got an important economic relevance because various factors of production have alternative substitution possibilities. Mathematically it can be shown as:

\[ \sigma = \frac{K \Delta (L/K)}{MP_L/MP_K \Delta (MP_K/MP_L)} \]

Where \( \sigma \) is the elasticity of substitution between K and L i.e. capital and labour, \( MP_K \) and \( MP_L \) are the marginal productivity of capital and marginal productivity of labour respectively.

The Elasticity of Input Substitution and the Shares of Factors of Production

As factor prices change, the firm will substitute a cheaper input for a more expensive one. This profit-maximising behaviour will result in a change of the K/L ratio, and, hence, to a change in the relative shares of the factors. The size of this effect depends on the responsiveness of the change of the K/L ratio to the factor price changes.

The elasticity of substitution is defined as the ratio of the percentage change in the K/L ratio to the percentage change of the MRTS\text{L,K}.

\[ \sigma = \frac{d(K/L)/(K/L)}{d(MRTS_{L,K})/(MRTS_{L,K})} \]  

(1)
In perfect input markets the firm is in equilibrium when it chooses the input combination at which the MRTS is equal to the ratio of factor prices

\[ \text{MRTS}_{L,K} = \frac{w}{r} \]

Where, \( w \) - wage rate; \( r \) - rate of profit.

Thus, in equilibrium with perfect factor markets the elasticity of substitution may be written as

\[ \sigma = \frac{d(K/L)/(K/L)}{d(w/r)/(w/r)} \]

(2)

The sign of the elasticity of substitution is always positive (unless \( \sigma = 0 \)) because the numerator and denominator change in the same direction. When \( w/r \) increases labour is relatively more expensive than capital and this will induce the firm to substitute capital for labour, so that the K/L ratio increases. Conversely a decrease in \( w/r \) will result in a decrease in the K/L ratio.

The value of \( \sigma \) ranges from zero to infinity. If \( \sigma = 0 \) it is impossible to substitute one factor for another; K and L are used in fixed proportions (as in the input-output analysis) and the isoquants have the shape of right angles. If \( \sigma = \infty \) the two factors are perfect substitutes: the isoquants become straight lines with a negative slope. If \( 0 < \sigma < \infty \) factors can substitute each other to a certain extent: the isoquants are convex to the origin. The Cobb-Douglas production function has \( \sigma = 1 \). In general the larger the value of \( \sigma \), the greater the substitutability between K and L.

We may classify \( \sigma \) in three categories:

- \( \sigma < 1 \): inelastic substitutability
- \( \sigma = 1 \): unitary substitutability
- \( \sigma > 1 \): elastic substitutability

There is an important relationship between the above values of \( \sigma \) and the distributive shares of factors. By definition

\[
\left[ \frac{\text{share of labour}}{X} \right] = \frac{wL}{X} \quad \text{and} \quad \left[ \frac{\text{share of capital}}{X} \right] = \frac{rK}{X}
\]
Thus the relative factor shares are
\[ \frac{\text{share of } L}{\text{share of } K} = \frac{wL}{rK} \]
\[ \frac{\text{share of } L}{\text{share of } K} = \frac{(w/r)}{(K/L)} \]

From (3) we can easily find the effect of a change in the w/r ratio on the relative shares of the two factors.

Assume that \( \sigma < 1 \). This implies that a given percentage change in the w/r ratio results in a smaller percentage change in the K/L ratio, so that the relative-share expression increases. Thus, if \( \sigma < 1 \), an increase in the w/r ratio increases the distributive share of labour. For example assume that \( \sigma = 0.5 \). Then a 10 per cent increase in w/r results in a 5 per cent increase in the K/L ratio. The new relative shares are
\[ \left( \frac{wL}{rK} \right)^* = \frac{(w/r)(1+0.10)}{K/L(1+0.05)} = 1.10 \frac{(w/r)}{1.05 \cdot (K/L)} > \left( \frac{wL}{rK} \right) \]

Clearly
\[ \left( \frac{\text{new relative shares ratio}}{\text{initial relative shares ratio}} \right) > 1 \]

If \( \sigma > 1 \) a change in w/r leads to a smaller percentage change in K/L, so that the relative share of labour decreases. For example assume that \( \sigma = 2 \). A 20 per cent increase in w/r leads to a 40 per cent increase in K/L. The new share ratio is
\[ \left( \frac{wL}{rK} \right)^* = \frac{1.2}{1.4} \cdot \left( \frac{wL}{rK} \right) < \left( \frac{wL}{rK} \right) \]

Clearly if \( \sigma > 1 \) the relative share of labour decreases following an increase in the w/r ratio.

With a similar reasoning it can be shown that if \( \sigma = 1 \) the relative shares of K and L remain unchanged.

In summary, an increase in the w/r ratio will cause labour's share, relative to capital's share, to increase, if \( \sigma < 1 \) decrease, if \( \sigma > 1 \) remain the same, if \( \sigma = 1 \)
A decrease in the w/r share will have the opposite effects of the share of labour relative to capital's share.

It should be noted that there is a two-way causation between w/r and K/L. Changes in the capital/labour ratio result in changes in the relative factor prices, and hence in changes in the shares of the factors to total output. The effects of changes of the K/L ratio on factor shares can be explored with the use of the elasticity of substitution. The analysis is analogous to the one we used above for changes in the w/r ratio.

From the above discussion it is clear that the concept of the elasticity of substitution is very important in the neoclassical theory of income distribution. It is extremely useful in examining the way in which changing input prices or input ratios affect income shares. Given that changes in w/r lead to changes in K/L and vice versa, it follows that predictions about factor shares following changes in one of these ratios are bound to be misleading if they do not take into account the possibility of the associated changes in the other ratio.

**Determinants of Elasticity of Substitution**

Elasticity of substitution is determined by the changes in wage rate and the cost of capital. If wage rate rises relative to cost of capital, the marginal productivity of labour will rise but because of relatively low employment of labour, the relative share of labour will decline. Similarly if the cost of capital rises relative to wage rate, the marginal productivity of capital will rise by the relative share of capital will decline.

Thus, the variables involved in the measurement of relative share of labour and capital or capital-labour ratio (K/L), the wage rate per worker (W/L), the net value added per worker (V/L), and the time variable (t), the time variable is mostly taken as a proxy for knowing the neutral technical change and it is also includes the residual effects.

**Elasticity of Substitution based on Constant Elasticity of Substitution**

Constant Elasticity of Substitution (CES) production function permits $e_s$ to take on any value from 0 to $\infty$. The form of this function is as follows:

$$ V = \alpha [\delta K^{p} + (1-\delta) L^{p}]^{1/p} \quad (CES \ I) $$

Where $V$, $K$ and $L$ refer to output, capital stock and labour input and $\alpha$, $\delta$ and $p$ are efficiency distribution and substitution parameters, respectively and the elasticity of substitution is
In this function the elasticity of substitution can take any constant value from zero to infinity. This function will generate isoquants which will be downward sloping and convex to the origin. However, in this formulation, only constant returns to scale can be represented. This implies that this formulation is incapable of characterizing any degree of returns to scale. Technical progress may be introduced into the ACMS production function in three ways. Hicks neutral technical change can be introduced by putting \( A = aoe^{\lambda t} \) and hence the function will be as follows:

\[
V = Aoe^{\lambda t} [\delta K^{\rho} + (1-\delta) L^{\rho}]^{1/\rho} \quad \text{(CES II)}
\]

This means that in Hicks neutral case the efficiency of both factors changes equally.

In Harrod neutral case only labour is gaining in efficiency, thus the functional form will be

\[
V = A [\delta K^{\rho} + (1-\delta) (L e^{\lambda t})^{1/\rho}]^{1/\rho} \quad \text{(CES III)}
\]

The Solow type of neutrality is that of capital gaining in efficiency may be expressed as

\[
V = A [\delta (e^{\lambda t} K)^{\rho} + (1-\delta) L^{\rho}]^{1/\rho} \quad \text{(CES IV)}
\]

These formulations only test whether there is any neutral technical change. Therefore, the CES production function has been also modified to study the rate of factor augmentation and the extent to which the technical progress is biased towards uneven factor saving.

\[
V = [(E_L L)^{\rho} + (E_K K)^{\rho}]^{1/\rho} \quad \text{(CES V)}
\]

Where \( E_L L \) and \( E_K K \) are labour and capital inputs, respectively, in efficiency units, \( L \) and \( K \) being measured unconventionally.

These formulations of CES production function assume constant returns to scale. For giving up the assumption of constant returns to scale, Brown and de Cani introduce one more parameter, \( m \), which can characterize any degree of returns to scale. This has the same general form but can exhibit any degree of returns to scale. This is as follows:

\[
V = A [\delta K^{\rho} + (1-\delta) L^{\rho}]^{(-m \rho)} \quad \text{(CES VI)}
\]
In this a new parameter \( m \) has been introduced; \( m \) will be greater, equal or less than one for increasing, constant and decreasing returns to scale, respectively.

To estimate the coefficients of the CES function, we have used Kmenta's approximation of the following form:

\[
\log V = \log A - \frac{m}{\rho} \log [\delta K^\rho + (1-\delta) L^\rho]
\]

By Kmenta's approximation it can be written as

\[
\log V = \log A + \frac{m}{\rho} \log k + m (1-\delta) L^{1/2} \rho m (1-\delta) 9\log K - \log L)^2
\]

or

\[
\log V = \beta_1 + \beta_2 \log K + \beta_3 \log L + \beta_4 \log K - \log L)^2
\]

where \( A + \text{antilog} (\beta_1) \) \( m = \beta_2 + \beta_3 \)

\[
\frac{\beta_2}{\beta_2 + \beta_3} = \frac{-2 \beta_4 (\beta_2 + \beta_3)}{1} \quad \text{and} \quad \rho = \frac{-\beta_4}{\beta_2 \beta_3}
\]

and \( e_s = \frac{\sigma}{1 + \rho} \)

Based on the above, labour and capital co-efficients, magnitude of technical change and substitution parameters were estimated both for cross section and time series.

### 3.5.4 Technical Efficiency

To measure Technical efficiency the concepts and method used by T.A.Bhavani has been followed.

Efficiency is a relative concept. It is measured either with respect to the normatively desired performance of a firm/industry or with that of any other firm/industry. Thus, the efficiency measures suggested in the literature are basically methods of comparing the observed performance of a firm/industry with some prespecified standard performance. Production frontier serves as one such standard in the case of technical efficiency.

Theoretically, the concept of a production frontier is none other than the production function. By definition, production function represents the maximum possible output for any given set of outputs. Thus, it sets a limit or frontier on the observed values of dependent variable in the sense that no observed values of output is expected to lie above the production function. It is, therefore, referred as production frontier or frontier function. As the production frontier represents the maximum obtainable output for any
given set of inputs, any deviation of a firm from the frontier is taken to indicate the extent of firm's inability to produce maximum output from its given sets of inputs and hence represents the degree of technical inefficiency. The difference between the production function and production frontier is of statistical nature. The usual estimation of production function by Ordinary Least Squares (OLS) assumes that error term \( u \) can be positive and negative with zero expectation. However, this specification is not compatible with the definition. This can be shown by writing the production function as

\[
Y = f(X) e^{-u} \quad \text{.................................................. (1)}
\]

\( e^{-u} \) is the multiplicative error term and can be taken as the ratio of observed output \( Y \) to potential output \([f(X)]\). That is

\[
e^{-u} = Y/f(X) \quad \text{.................................................. (2)}
\]

Thus, the usual multiplicative error term can be taken as a measure of technical efficiency. As the production function is expected to represent maximum possible output, the observed output \( Y \) would always be less than or equal to potential output \([f(X)]\). Accordingly, \( e^{-u} \) should lie between zero (when \( Y=0 \)) and unity (when \( Y=f(X) \)). If we rewrite (1) in log-linear form

\[
\ln Y = \ln[f(X)] - u \quad \text{.................................................. (3)}
\]

\( u \) takes values between 0 and \( \). It shows that the appropriate way of estimating a production function is to treat \( u \) as a random variable with \((0, \) ) range and hence drawn from a one-sided statistical distribution. In this way production function (3) represents a frontier as given by its definition. This is known as frontier model and is employed to estimate technical efficiency. By assigning a suitable statistical distribution to \( u \), we can estimate the parameters of the distribution along with the parameters of the production function. In the absence of any \textit{a priori} reasons to select one particular distribution, we explore three most widely used alternative statistical distributions namely, the Gamma, the Exponential and the Half-Normal. The frontier function is specified in terms of Translog form with three inputs viz., capital, labour and materials. The frontier function has been estimated by Corrected Ordinary Least Squares (COLS) method. We write the equation (3) in case of Translog form as follows.
\[ \ln Y = \alpha_0 + \alpha_k \ln K + \alpha_l \ln L + \alpha_m \ln M + \frac{1}{2} r_{kk} (\ln K)^2 + r_{kl} \ln K \ln L + r_{km} \ln K \ln M + \frac{1}{2} r_{ll} (\ln L)^2 + r_{lm} \ln L \ln M + \frac{1}{2} r_{mm} (\ln M)^2 - u \]  

According to the COLS method, \( \alpha_0 \) and \( r_{ij} \) of the frontier function given in (4) can consistently be estimated by OLS with the exception of intercept term. The intercept term obtained through OLS is downward biased. Hence, it is to be corrected upwards so as to yield a consistent estimate of \( \alpha_0 \). This is corrected in COLS procedure by using the moments of OLS residuals. The actual correction factor, however, depends on the specification of the error distribution.

### 3.6 CONCLUSION:

The above chapter discusses the methods and tools used to estimate the impact of policy shifts on the economic efficiency in Small Scale Engineering Industries.