Chapter III
APPROACH TO STUDY

3.1 Introduction

The process of increasing global integration, reinforced by the revival of the market economy, the emergence of new, generic and core-knowledge technologies as the vital competing resources and a growing tendency for techno-protectionism and strengthening of the international Intellectual Property Rights has intensified the technology based competition in the world markets during the 1990s (Aradhana Aggarwal, 2001).

As a result, India also launched a programme of economic policy reforms in the year 1991, which is outward, oriented and represents a major paradigm shift. The reforms consisting of stabilization cum structural adjustment measures were adopted with a view to attain macroeconomic stability and higher rates of economic growth. The major elements of reforms in the Indian industrial sector includes abolition of licensing of capital goods, reduced list of industries to be reserved for the public sector, increasing foreign equity ownerships in domestic industries, private investment in infrastructure, freer import of capital goods, reduced tariff for consumer goods, deregulation in small scale industrial units and allowing greater inflow and outflow of foreign investments. Because of these measures, Indian industrial sector was exposed to easy access of imported inputs and thereby to both domestic and international competitiveness.

This chapter presented into two parts, part I deals with the theoretical link between liberalization and industrial productivity and part II deals with the concepts, definitions and measurement of various modules used in the study.

3.2 Economic Reforms and Industrial Productivity – A Theoretical Perspective

The theoretical relationship between economic liberalization and improved industrial productivity / efficiency is not adequately comprehensible. The benefits and costs of economic liberalization for economies constitute an increasingly
controversial issue. The conventional view that economic liberalization is necessary and has automatic and generally positive effects for development is being challenged empirically and analytically.

The traditional theory of trade policy does not address the issue of how greater ‘openness’ might be related to rates of growth of productivity and output. Whereas the prominent neo-classical economists were of the view that the government policies cannot affect the steady state and the ‘engine of growth’ is exogenous technological progress. This view has however been challenged by the theories of endogenous growth. The emergence of ‘new growth’ theories in the late 1980’s provided a rigorous analytical framework within which trade liberalization can be linked with economic growth. The recent literature in trade theory has taught us (Helpman and Krugman 1989) that the impact of policy changes at the margin in the presence of imperfect competition is not unambiguous. In the presence of imperfect competition the marginal impact on welfare depends on the net effect of (a) a volume of trade effect, (b) a profit-shifting effect (c) a scale effect and (d) efficiency effects (Rodrik, 1992a and V.Srivatsava 1996).

There are number of theoretical arguments linking trade liberalization with higher rate of industrial productivity, and one among them is that the superior technology embodied in imported inputs will improve productivity. The availability of imported intermediate goods and of technology whether licensed or embodied in imported capital goods is an important source of gain in shedding a restrictive trade regime. The experience of the present day developed countries emphasizes the fact that mere accumulation of capital without improvements in knowledge is not sufficient to bring about growth. It is the continuous interaction between science and technology and economic, political and social conditions that create the path to progress and changes in the stock of such interaction sets the upper limit to economic growth.

Grossman and Helpman (1992) in particular emphasized this argument that technological change can be influenced by a country’s openness to trade. Trade liberalization enables cheaper and easier access to foreign technologies and global capital. It as well makes possible greater international exchange of information.
Lowering of trade restrictions makes possible import of capital and intermediate goods, which embody superior technology, and this helps in reducing costs and also in turn increasing productivity growth in the sector, which uses the product. Thus a country’s openness leads to improvements in domestic technology; helps the production process became more efficient and culminates in productivity improvements (D.K.Das, 2002). However, the theoretical literature does not yield 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 Havrylyshyn 1990, Nishimizu and Page 1990 and Rodrik 1995).

**3.3 Growth Model**

Growth is studied with reference to annual growth rates computed based on the compound interest rate formula adopted by the World Bank using the least-squares’ method.

The compound growth rate is given by the equation

\[ X_t = X_0 (1+r)^t \]

where \( X_t \) is the variable at the time period ‘t’, \( X_0 \) is the value of the variable corresponding to the origin chosen and ‘r’ is the annual Compound Growth Rate (CGR). On taking logarithms on both sides, the above equation becomes \( \log X_t = \log X_0 + t \log (1+r) \). The annual CGR, ‘r’ is estimated by fitting a linear regression trend line using least-squares method to the logarithmic annual values of the variable in the relevant period.
More specially, the regression equation takes the form

$$\log X_t = a + bt$$

where \( a = \log X_0 \) and \( b = \log(1+r) \) are the parameters.

If \( b^* \) is the least-squares estimate of the parameter \( b \), then the annual CGR is obtained by subtracting 1 from antilog \( b^* \). This may be multiplied by 100 in order to express it as a percentage.

### 3.4 Factor Productivity

#### 3.4.1 Types of Productivity

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

##### 3.4.1.1 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) **Average Productivity of Capital \((AP_K)\)**

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 is \( AP_k = Q/K \), where \( Q \) denotes output for a given period and \( K \) denotes capital for the period.

(ii) **Average Productivity of Labour (\( AP_L \))**

Average labour productivity, may be defined as the ratio between employment of labour 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 is \( AP_L = Q/L \) where \( Q \) denotes Output for a given period and \( L \) denotes employment for the period.

(iii) **Marginal Productivity of Capital (\( MP_k \))**

Marginal productivity of capital is 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. We have derived \( MP_k \) from the following Cobb-Douglas function:

\[
Q = b.L^\alpha . K^\beta
\]

where \( b, \alpha \) and \( \beta \) are partial factor productivity, output capital elasticity and output labour elasticity respectively,

such that \( \alpha + \beta = 1 \).

Marginal productivity of capital is obtained by,

\[
MP_k = \frac{\partial Q}{\partial K} = b.L^\alpha . \beta . K^{\beta-1}
\]

\[
= \beta \left( b.L^\alpha . K^\beta \right) K^{-1}
\]

\[
= \beta \left( \frac{Q}{K} \right)
\]

\[
= \beta . AP_k
\]
(iv) Marginal Productivity of Labour (MP$_L$)

Marginal productivity of labour is 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. We have derived MP$_L$ from the following Cobb-Douglas function:

\[
Q = b \cdot L^\alpha K^\beta
\]

\[
MP_L = \frac{\partial Q}{\partial L}
\]

\[
= b \cdot \alpha \cdot L^{\alpha-1} K^\beta
\]

\[
= \alpha \left( b \cdot L^\alpha K^\beta \right) L^{-1}
\]

\[
= \alpha \cdot AP_L
\]

3.4.1.2 Total Factor Productivity

Productivity changes as production continues. It improves under favorable circumstances and deteriorates when unfavorable changes occur. The changes that lead to higher productivity of inputs are technological improvements, improvement in efficiency, increased education of labor, improvement in the quality of labor due to training, etc. Since such changes simultaneously affect different physical inputs favorably or unfavorably and since the resultant change in output cannot be attributed to the individual physical inputs, productivity improvements arising from such changes are collectively termed TFP growth. The origin of the term can be traced to the "Abramovitz residual," which refers to the growth of output unaccounted for by the factor inputs (Abramovitz, 1956). Today, TFP is considered an important source of output growth worldwide due to rapid progress in science and technology and various efficiency-enhancing measures.
3.5 Solow’s Index

The total factor productivity is measured by using Solow’s index. This index is based on the Cobb-Douglas production function. Consider the Solow’s approach with Hicks-neutral technical progress, the production function, \( P = (A) f(L,K) \) can be differentiated logarithmically to yield.

\[
\frac{\dot{P}}{P} = \frac{\dot{A}}{A} + \alpha \frac{\dot{L}}{L} + \beta \frac{\dot{K}}{K},
\]

The rate of increase in output due to productivity can then be approximated in the discrete case by

\[
\frac{\Delta A}{A} = \frac{\Delta P}{P} - \left( \alpha \frac{\Delta L}{L} + \beta \frac{\Delta K}{K} \right).
\]  

(5.3.1)

Under competitive equilibrium conditions,

\[
\alpha = \frac{\partial P}{\partial L} \cdot \frac{L}{P} \quad \text{and} \quad \beta = \frac{\partial P}{\partial K} \cdot \frac{K}{P}
\]

Introducing base period weights into equation (5.3.1) and multiplying by output in the base period, Solow’s estimate of the residual output becomes.

\[
\frac{\Delta A}{A} \cdot P_0 = \Delta P - \left[ \left( \frac{\partial P}{\partial L} \right)_0 \cdot \Delta L + \left( \frac{\partial P}{\partial K} \right)_0 \cdot \Delta K \right]
\]

Solow’s index, being based on the Cobb-Douglas production, assumes the elasticity of substitution to be unity. Although this appears quite restrictive this may not be a serious draw back. Under the assumption of competitive equilibrium the Solow’s index is equal to small changes in output and input.
Solow’s (1957) total productivity index is derived as follows,

Let us assume a Cobb – Douglas production function of the following forms

\[ Q = b \cdot L^\alpha \cdot K^\beta \]  
\[ (3.5.2) \]

where

\( Q \) = output

\( b \) = Total Factor Productivity

\( L \) = Labour input

\( K \) = Capital input

\( \alpha, \beta \) are the output elasticity of labour and capital respectively

such that \( \alpha + \beta = 1 \)

The equation (3.5.2) can be written as

\[ \frac{Q}{L} = b \cdot L^{-\beta} \cdot K^\beta \]

\[ \frac{Q}{L} = b \left( \frac{K^\beta}{L^\beta} \right) \]

\[ \therefore \ b = \frac{Q}{L} \left( \frac{K}{L} \right)^\beta \]

\[ \log b = \log \left( \frac{Q}{L} \right) - \log \left( \frac{K}{L} \right)^\beta \]

\[ \log b = \log \left( \frac{Q}{L} \right) - \beta \log \left( \frac{K}{L} \right) \]  
\[ (3.5.3) \]

\[ b = \text{Anti} \log \left\{ \log \left( \frac{Q}{L} \right) - \beta \log \left( \frac{K}{L} \right) \right\} \]  
\[ (3.5.4) \]
The parameter \( \beta \) required for computation of \( b \) has to be calculated by fitting a logarithmic equation (3.5.3) between \( Q/L \) and \( (K/L) \) by the method of least squares. Equation (3.5.4) 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 obtained.

The equation (3.5.4) may be re written as

\[
\log \left( \frac{Q}{L} \right) = \log b + \beta \log \left( \frac{K}{L} \right)
\]

(3.5.5)

By differentiating equation (3.5.5) and expressing it in terms of differentials of discrete form we get

\[
\frac{\Delta Q}{Q} = \frac{\Delta b}{b} + \beta \frac{\Delta K}{K}
\]

That is

\[
\frac{\Delta b}{b} = \Delta \left( \frac{Q}{L} \right) - \beta \left( \frac{K}{L} \right)
\]

(3.5.6)

The equation (3.5.6) expresses the proportional change in labour productivity \( Q/L \) over time of sum of two components, viz., one due to proportional change in the shift factor \( b \) and other due to proportional change in capital intensity \( K/L \). The weight for the latter term is \( \beta \). From the series of \( \Delta b/b \), \( b \) has been calculated for each year of the period under study using equation (3.5.6) by assuming the initial value of \( b \) as unity. All \( b \) values are expressed as percentages in terms of base year values.
In the case of products whose co-efficient of determination values are low, the following procedure is used to calculate the Solow’s Index of TFP. This index is based on rate of productivity changes and is given as follows

\[
\left( \frac{\Delta b}{b} \right) = \left( \frac{\Delta Q}{Q} \right) - \left\{ \omega \left( \frac{\Delta L}{L} \right) + \pi \left( \frac{\Delta K}{K} \right) \right\}
\]

(3.5.7)

where,

\[
\left( \frac{\Delta b}{b} \right) = \text{rate of change of TFP}
\]

\[
\left( \frac{\Delta Q}{Q} \right) = \text{rate of change of output}
\]

\[
\left( \frac{\Delta L}{L} \right) = \text{rate of change of labour}
\]

\[
\left( \frac{\Delta K}{K} \right) = \text{rate of change of capital}
\]

\[
\omega = \text{share of labour}
\]

\[
\pi = \text{share of capital}
\]

\[
\omega + \pi = 1
\]

3.6 Technology and Technical Progress

3.6.1 The Concept of Technology

The term technology 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.

Technological change or progress on the other hand viewed as a change in an existing mode of production or the introduction of a new type of production process or of products. Blang defines technical progress as “an addition to existing technical knowledge”. Technical progress is also considered as an agent of technology transfer and it could be used to measure the role of technology transferred (Gee, 1974). In
industrialized countries, various macroeconomic studies have arrived at the conclusion that the contribution of ‘technical change’ is far greater significance than in the growth of resources per capita and that technical change accounts for a very high proportion of the growth of real national income (Abramovitz, 1956).

3.6.2 Types of Technical Change

Technological changes have different forms depending upon the way it enters the production considerations. Professor Hicks has distinguished the technical progress into neutral and non-neutral, depending upon its effect on the rate of substitution of factors of production. Another way of classifying technical change is based on the nature of factors, which are responsible for technical progress viz., embodied/endogenous and disembodied / exogenous.

3.6.2.1 Neutral Technical Change

A technical change that affects the labour and capital inputs equally so that there is no change brought about in the capital-labour ratio in the production process. In this case, output changes without corresponding change in the factor proportions.

3.6.2.2 Non-neutral Technical Change

In this case a change in output is caused by a change in one of the factor inputs being substituted for others.

3.6.2.3 Disembodied Technical Change

Disembodied technical change is purely organizational in character which permits more output to be produced from unchanged inputs, without new investment. Change in output due to disembodied technical change is reflected by a shift in the production function.
3.6.2.4 Embodied Technical Change

It involves an augmentation in the effectiveness of factor inputs due to various possible improvements in their quality or efficiency over time.

3.6.3 Measurement of Technical Progress

The measurement of technical progress is integral to the overall measurement of productivity in industry. One feasible method to gauge technical progress is to understand it in terms of factor substitutability.

Technical Progress Based on MRS

(i) Capital Deepening Technical Progress

Technical progress is capital deepening (or capital using) along a line on which, while the K/L ratio is constant the MRS_{LK} increases. This implies that the technical change raises MP_{K} more than the marginal product of labour. The ratio of marginal product (which is the MRS_{LK}) decreases in absolute value.

(ii) Labour Deepening Technical Progress

Technical progress is labour deepening (with constant K/L ratio) if the MRS_{LK} increases. This implies that the technical progress increases the MP_{L} faster than the MP_{K}. Thus MRS_{LK} increases if the minus sign is taken into account.