Chapter II

PARTIAL PRODUCTIVITY RATIOS AND
TOTAL FACTOR PRODUCTIVITY
Chapter-II

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In this chapter the phenomenon of technological change is examined in terms of simple ratios. The ratio of output to an input is known as partial productivity ratio. There are as many partial productivity indices as there are factors of production. The most important and most often used are the partial productivity indices of labour and capital.

These productivity ratios can be represented by

\[ AP_L = \frac{V}{L} = \frac{\text{Output}}{\text{Labour Input}} \]  

(1.1)

which is the average product of labour or labour productivity;

\[ AP_K = \frac{V}{K} = \frac{\text{Output}}{\text{Capital Input}} \]  

(1.2)

which is the average product of capital or capital productivity;

\[ AP_m = \frac{V}{M} = \frac{\text{Output}}{\text{Material Inputs}} \]  

(1.3)

which is the average product of material. These ratios show the amount of output per unit of labour, capital and material foregone in its production. If these ratios rise, then there is an increase in the productivity of that factor. The inverse of these productivity ratios implies unit factor requirements per unit of output. Increase in any of the above partial productivity ratio means that over the period more output is possible with less and less inputs and there is saving in the use of a particular input overtime.
Capital per person = \( \frac{K}{L} = \frac{\text{Capital}}{\text{Labour}} \) (1.4)
is the average capital per person.

Value added per rupee of labour cost = \( \frac{V}{W} \) (1.5)

Inverse of (1.5) throws light on the share of labour in value added.

If the underlying production function is CES then the changes in labour productivity index can be broken into -

(i) neutral technological changes;
(ii) changes in inputs and economies resulting from changes in the scale of operation; and
(iii) non-neutral technological changes.\(^1\)

The change in labour productivity could be due to changes in any one or several of the forces mentioned above.

Similarly, average productivity of capital if generated by CES production function then changes in average capital productivity can also be broken into -

(i) neutral technical change;
(ii) changes in inputs and economies; and
(iii) non-neutral technological changes.

Changes in \( AP_L \) and \( AP_K \) could be due to changes in any one or several of the forces mentioned above and just the observation of the movements in labour productivity index or

capital productivity does not tell which force or set of forces generated that movement. These partial productivity ratios just denote the resources foregone in the production of an additional unit of output. Therefore the average product of any single factor cannot be used as an index of overall efficiency.

Sometimes different partial productivity indices have opposite trends and in that case no judgment is possible about overall industrial efficiency. However, if all the partial productivity indices have similar trends then it will be possible to draw inferences about the overall efficiency.

Inspite of the fact that the partial productivity indices of labour and capital assume a one factor world, they are important and in a particular context the average productivity of labour alone or capital alone may be important depending on the question in mind. The partial productivity indices have been used to find out implied production function with a view to approach the question of the sources of growth of output.

Partial productivity indices have been used to measure

2/ Salter, op.cit., 1969,
3/ Fabricant, op.cit., 1961,
technical change for a large number of countries. Most comprehensive productivity ratio is the total factor productivity ratio. This index measures the output per unit of labour and capital combined. Total-factor-productivity index can be calculated arithmetically and geometrically.

Kenderick's arithmetic measure of total-factor productivity is based on a linear production function of the form $V = aL + bK$, where $V$ is output, $L$ and $K$ denote labour and capital inputs and $a$ and $b$ are coefficients of labour and capital. Measured arithmetically, total factor productivity is given by:

$$ P = \frac{V}{a_0L + b_0K} \quad (1.6) $$

where $V$ is an index of output; $K$ and $L$ are index of capital and labour respectively; $a_0$ and $b_0$ are the base year weights. The weights are either prices of labour and capital services or the percentage shares of labour and capital in a base year. The weighted inputs of labour and capital in each year are added to get the total input. Then an index of output and also total input index is prepared. The ratio of output index to total input index will yield the arithmetic total factor productivity index.

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This measure involves comparing, "what the outputs of period II would have cost at the factor prices and unit factor requirement of I (real output) with what they did cost in constant I factory prices, but at the II level of productive efficiency (real input). Alternatively, we are comparing the actual real output of II with what the output of the factors would have been in II had the productive efficiency of I (real input) prevailed."°

Solow's geometric measure is based on the Cobb Douglas production function with constant returns to scale and neutral technological change. The functional form is -

\[
\frac{V}{L} = A \left(\frac{K}{L}\right)^b \quad (1.7)
\]

where \( V \) is output per person, \( \frac{K}{L} \) is capital per person and \( A \) and \( b \) are constants. Expressing above relation in logarithmic form, \((1.7)\) becomes

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

Putting this relation in incremental form

\[
\frac{d\left(\frac{V}{L}\right)}{\frac{V}{L}} = \frac{dA(t)}{A(t)} + b \frac{d\left(\frac{K}{L}\right)}{\left(\frac{K}{L}\right)}
\]

or

\[
\frac{dA(t)}{A(t)} = \frac{d\left(\frac{V}{L}\right)}{\frac{V}{L}} - b \frac{d\left(\frac{K}{L}\right)}{\left(\frac{K}{L}\right)} \quad (1.8)
\]

° Kenderick, op. cit., pp. 11.
\[ \frac{d(V/L)}{V/L} \] is the rate of change of output and \[ \frac{d(K/L)}{K/L} \] is the rate of change of capital per person and \( b \) is the capital's share of output. Therefore, the rate of change of total factor productivity is the difference between the rate of change of output and a rate of change of capital per person multiplied by capital's share of output. This yields \( \frac{dA(t)}{A(t)} \) series, from which \( A(t) \) series can be derived by assuming the initial value of \( A(t) \) as one. Thus, the rate of change of total factor productivity is the difference between the rate of change of labour and capital. The weights are the percentage shares of labour and capital.

In these models, the effects of technical progress (as represented by a time term) and capital accumulation are separated. The basic procedure is to estimate the contributions made to the growth in output by increases in inputs of labour and capital over a period by multiplying the observed increases in inputs by observed factor prices (taken as a measure of marginal products) and deducting the result from the overall growth in output; the residual is attributed to technical progress.

Both these measures of total factor productivity implicitly assume a homogeneous production function. Under a competitive equilibrium the Kanderick measure and Solow measure are equivalent.\(^2\) The magnitude of technological change or residual

derived through total factor productivity approach will depend upon the form of production function. If the form of production function is misspecified, then errors will spill over into the residual. This error can be eliminated by estimating the parameters of a correctly specified production function.

Total factor productivity index has been calculated both arithmetically and geometrically for many countries which shows that conventionally measured inputs, capital and labour, explain only a minor percentage of growth of output.

The factor productivity indices have been also calculated for Indian manufacturing sector as a whole and for some individual industries. The general conclusion is that trend in total factor productivity index for Indian manufacturing sector is one of decline. This implies that overall efficiency is declining.

The phenomenon of technological change can also be examined in terms of prices and costs. This approach for


measuring the technical change is suggested by Salter. In this approach changes/output per head in each industry are correlated with changes in other economic variables such as prices, wages, costs, output and employment between two different points of time. Salter analysed prices, costs and output for British and American industries.

Salter found that changes in output per person and earnings per person are not correlated. The output per person however was found to be negatively correlated with unit labour cost, and unit materials costs. Also the differential savings in labour costs resulting from unequal increase in labour productivity were not offset by increased gross margins. Therefore output per head was found to be not correlated with unit gross margins and also no correlation was found between unit labour cost and unit gross margin cost. As a result of savings in labour and non-labour costs relative prices declined and as a result a strong negative correlation emerged between output per head and relative prices. The absence of a strong positive correlation between changes in unit labour cost and unit gross margin cost was noted which will be normally there in case of factor substitution taking place.

Salter also observed that industries with rapidly expanding output usually also have high rates of increases in output per head. From this very well attested relationship between rate of growth of productivity and rate of growth of
production, between industries as well as countries, increasing returns have been inferred.\textsuperscript{12} 

This investigation resulted in certain statistical associations. On this basis Salter concluded that differences in the rate of growth of labour productivity between industries are due to factor substitution, unequal rates of neutral technical advance and economies of scale. Above average labour productivity associated with saving in non-labour costs may be due to new technical knowledge. Economies of scale may also lead to simultaneous savings in all factors of production. Factor substitution may take place when there is change in relative factor prices, thus the inter-industry variations in productivity changes may be caused by variations in ease of factor substitution.

This essentially means examining changes in productivity and technical change in terms of prices and costs. This is essential because output per person alone measures only average labour productivity and does not itself reveal anything about technical change. Therefore changing productivity should be related to other economic variables.

Increased labour productivity may be due to increased personal efficiency of labour, factor substitution, technological change and economies of scale. In his framework, technical change will lead to saving in labour, capital, and

materials, saving in all factors may also be due to economies of scale. Factor substitution implies a negative relation between labour and non-labour costs.

In Chapter III, first growth profile of all the twenty seven industries is mapped vis a vis planned growth rate. Then trends in partial and total factor productivity indices are examined. In Chapter IV, cross-country inter-industry correlation study between the growth rates of various economic variables is carried out to find out the relationship between the growth in output per person, and growth in other economic variables like employment, wage rates, unit labour costs, unit gross margins etc.