Chapter IV

Total Factor Productivity Growth in Indian Manufacturing

Introduction

Having analysed the extent of competition and its main determinant, entry barriers, we move on to examine the performance of the industrial sector. Performance is analysed in terms of physical performance, that is, in terms of total factor productivity growth (TFPG). The theoretical literature emphasizing the notion that a particular structure of the market, influenced by the level of competition, has a definite bearing on the performance of the firms provides ample justifications for examining the productivity growth. Moreover, the issue of productivity growth has been widely discussed in the Indian context often linking to the policy changes adding relevance to our examination in the background of economic reforms. The chapter is organized as follows. Section I motivates the issue with a discussion of the importance of productivity growth and tries to situate the emphasis of productivity growth in the policy changes in India. A discussion of the theoretical considerations and methodological issues in the measurement of TFPG is presented in section II. In section III we present the current state of debate on productivity growth in Indian industry by providing a review of the studies. Section IV presents the methodology adopted and empirical estimates of TFPG for the manufacturing sector. Finally in section V we present estimates using firm level data for the recent years for understanding the changes in efficiency since the launching of the economic reforms in 1991.

I. Importance of Productivity Growth: Welfare enhancement and growth effects

Productivity growth is considered as the single main source of per capita output growth, a central component of economic welfare. It needs no emphasis that increasing the growth of output in the productive sectors has been the well-stated goal of policy makers for launching the economy on a higher growth trajectory in the long run. Explanations of the enhancement of output growth have unravelled miracles and
mysteries\(^1\). Two routes have been used to explain the higher output growth (a) in terms of factor augmentation and (b) in terms of factor productivities. As the first route exhausts in terms of saturation of the scarce factors of production the second route provides promising interpretations, often unexplainable in terms of short run factors, acquiring the label of the 'measure of our ignorance'. This has led to the insufficient attention devoted by the mainstream economic literature to the long run role of productivity growth often exaggerating its importance in the short run.

Contribution of productivity increases to economic growth is well brought out in growth accounting exercises. More importantly it has been realized that economic growth without productivity growth becomes unsustainable and does little for raising the standard of living\(^2\). Unravelling the growth process of industrialized countries since the eighteenth century shows that the growth was fuelled mainly by improvements in labour productivity. Madisson (1982) shows that the median increase in productivity among 16 industrialized leaders for 11 decades was about 1150 percent. This has resulted in a rise in per capita output of more that 300 percent in the United Kingdom, 1400 percent in West Germany, 1600 percent in Japan and nearly 700 percent in France and United States. Other variables too recorded remarkable growth rates with the median increase in exports from 1870 to 1979 for 15 countries increasing by 6300 percent.

In terms of human welfare too productivity growth plays a vital role in the long run. It contributes to the general standard of living of a society in two ways. First, when each worker produces more with a given outlay of effort, that person's family can generally expect (may be with some lag) to have more real income to spend on behalf of its members. Secondly, in an economy whose productivity is growing an increase in

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\(^1\) The recent explanations of the high rates of growth of the East Asian economies have provided multiple explanations. Some authors have coined this as the East Asian Miracle while some others disagree with this. See World Bank (1993) and Krugman (1994) for differing views on this issue.

\(^2\) See Krugman (1994) for views on slow productivity growth in former Soviet Union and recently in the East Asian economies He identifies the absence of productivity growth as the reason for the slowing down of the economy of the former Soviet Union. Also he predicts a fading away of the so-called East Asian miracle as TFGP is low in these economies according to him. Krugman's views have however been questioned, see Drysdale and Huang (1997).
outlays on social services such as education, wide spread public health etc. can be paid entirely out of the annual increment in national output that productivity contributes, hence entailing no offsetting reduction in private disposable incomes and expenditures\(^3\). The precise mechanisms of the impact of productivity growth in the long run needs no further discussion. Growth in gross domestic product and in labour productivity of industrialized countries and its contribution to enhancement of overall standard of living has been well documented and discussed\(^4\).

However, setting aside this importance of factor productivity growth in the growth process, popular discussions invoke increases in productivity as a suitable instrument for dealing problems such as inflation, unemployment and deficits in balance of payments. The basic shortcoming of all these suggestions for the use of enhancing productivity growth to deal with short run problems is that productivity growth is not readily responsive to attempts to change its magnitude, and that non-transient changes may come about only slowly. One can hardly carry out overnight introduction of profoundly new techniques (much less the requisite research and development) or substantial expansion of plant and equipment. Such measures require as much as a decade or more for their execution. The short run problems may well have disappeared or changed its character before one hope to bring substantial productivity changes to bear upon it. Thus while productivity growth can make enormous contribution to the living standards and that there is no substitute for productivity growth as is evident in terms of conditions of living since the beginning of industrial revolution, there are many other economic problems for which productivity policy offers no promising solutions.

Thus we are interested in productivity growth because it is a plausible route to an increase in the standard of living and higher rates of economic growth. In more open trade regimes, especially in the era of globalisation, productivity growth is also important in enhancing the competitiveness of a country’s exports. This is mainly

\(^3\) An argument explained at length in Abramovitz (1981).

through reductions in labour costs and thus the international price of the good concerned. For the above reasons, productivity growth has been a target of government policy. With the presumption that a more competitive market structure is desirable for enhancing TFPG, a major tool used by the policy makers is to infuse competition in the markets. This is an atheoretical approach, as it is not made clear whether market structure determines the level or the rate of growth of productivity. This has led to a proliferation of studies linking productivity growth to trade regimes hypothesising that more open trade regimes encourage productivity growth. It is however be noted that there exists scanty empirical evidence to support this.\(^5\)

It is in this context we analyse the emphasis on improvement of productivity in Indian industry spelt out by the changes in economic policies. Studies, which analyse productivity growth in post reform era, tend to over emphasise the short run implications of productivity growth often analysed in terms of competitiveness of exports and improvements in trade balance underplaying its role in the long run in terms of increasing social welfare.

The importance of the enhancement of productivity growth was recognized and articulated in the policy changes. This is explicit in the industrial policy of 1991, which ushered in major changes in the industrial sector. \(^6\) The major objectives of the New Industrial Policy package will be to build on the gains already made, correct the distortions or weakness that may have crept in, maintain a sustained growth in productivity, and gainful employment and attain international competitiveness. In pursuit of the above objectives, Govt. has decided to take a series of initiatives in respect of the policies relating to the following areas:(A) Industrial Licensing, (B) Foreign Investment, (C) Foreign Technology Agreements, (D) Public Sector Policy and (E) MRTP Act.\(^6\)

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To situate the recent thrust on productivity growth within the broad contours of industrial policy framework in India we sketch the changes in the policy framework over time. As some of the policy changes have already been discussed in the introduction we limit our discussions to those policy changes, which have a direct bearing on TFPG. The initial emphasis in the planned process of industrialization in India since independence was on capital accumulation. This was mainly due to the fact that capital accumulation was regarded as the driving force in the process of development implying a major role for state intervention in resource mobilization and investment. The emphasis was on heavy industries with a principal role assigned to the public sector. In view of industrial dispersal to achieve even development across regions the growth of small-scale sector was fostered. It should however be noted that the instruments for achieving the goals of industrialization over a period of time switched from being promotional to protective.

Public sector was expected to play a key role in the process of capital accumulation. This is because profits constitutes an important source of accumulation in a dynamic economy and determines the income distribution. Socialisation and the prevention of wasteful consumption by private capitalists are thus expected to accelerate accumulation. This argument relied on the crucial assumption that the public sector would expand by augmenting the internally generated surpluses. Towards this an industrial licensing framework was established to control not only the entry into an industry but also the expansion of capacity, technology, output mix, capacity location and the import content. Apart from this the exit routes were also blocked by labour legislation designed to protect the interests of those who were employed in the organized sector. The regulatory apparatus thus consisted of a series of legislations, which erected barriers to entry as well as to exit.

The examination of working of the regulatory apparatus by the committees revealed that the policies of indiscriminate import substitution combined with a highly regulated domestic industrial policy framework created an economic environment in which entrepreneurs had strong incentives for rent seeking and little incentive for reducing
costs and improving quality. The high cost industrial structure that was spawned by the complex policy network reduced the competitiveness of India's exports. This led to a process of policy reorientation in the late seventies, which gained further momentum in the eighties. The crux of the reforms, as discussed in the introduction, consisted of "delicensing for certain industries, reducing the degree of regulation for many others, greater scope to larger private industrial houses to participate in the process of industrialization and an attempt to shift from direct physical controls to indirect controls."

The objective of the reforms, by a combination of liberalizing trade and relaxation of controls, was to make cheaper and better quality inputs available to Indian producers and to promote the import of embodied technology. Moreover, these changes were intended to modernize the industry and make it more competitive domestic and internationally. Loosening of controls was to promote competition and encourage entry and investments for achieving better capacity utilization, viable scales of production and to improve the productivity in the industrial sector. Thus from the changes in the policy regime it can be inferred that the enhancement of productivity growth was conceived as an integral component of the outcome of the reform process.

The impact of these policy changes has been subject to investigation with authors arriving at different results. Even though these studies use different methodologies, data and cover varying time points a complete picture on the net impact of the policy changes is yet to emerge. This is complicated by the multiplicity of the issues involved in analysing a switch in the policy regime. Similar to the other issues in the industrial sector there exists conflicting set of results with regard to the growth of total factor productivity too. Broadly two sets of results exist with the proponents of the liberalization pointing to the favourable consequences of the reforms and the critics highlighting the negative results. However these set of results triggered off a debate on

7 Ahluwalia (1991 p.5)
8 The relevant studies on the issues discussed here are reviewed in another section.
9 The studies, which report these results, are taken up for a close examination in a later section.
the state of our knowledge about TFGP in Indian industry. Substantial literature
dealing with the issues on productivity in Indian industry has appeared in recent times.
These issues may be put down to those revolving around measurement and those that
revolve around interpretation. As our focus in this chapter is mainly on measurement
we concentrate on these issues without undermining the issues of correct
interpretation. As an exposition of the theoretical issues are a prerequisite for
appreciating the magnitude of obstacles involved in the terrain of measurement we first
deal with the former.

II. Measurement of Total Factor Productivity Growth\textsuperscript{10}

There are many ways to quantify TFGP\textsuperscript{11}. As the commonly used measures vary in
their approaches to measurement according to definition of the concept they adopt, we
define productivity growth as is used in these studies before outlining these measures.
In general productivity growth can be defined as (a) the difference between values of
outputs and inputs in constant prices\textsuperscript{12}, (b) the ratio between the values of outputs and
inputs\textsuperscript{13} and (c) the ratio of the actual output to the potential output\textsuperscript{14}. The first two
approaches are called the classical approach and the third the frontier approach. We
dwell with these separately.

An early version of classical approach can be seen in Davis (1955). He defines a
measure of productivity as

\[
P = y - l - k - m
\]

(1)

Where \(y\) represents output, \(l\) labour, \(k\) capital and \(m\) materials in base year prices. This

\textsuperscript{10} The attempt here is modest. We provide an overview of some of issues, which have a direct bearing on the
discussions in the Indian context. The survey to that extent is not at all comprehensive. For detailed surveys See

\textsuperscript{11} For an exposition of the early works on productivity and historical roots of the concept see Griliches(1996).
The first measurement of productivity is credited to Tinbergen (1942).

\textsuperscript{12} As done in Davis(1955)

\textsuperscript{13} Schmookler(1952), Solow(1957) and Kendrick(1961) use this.

\textsuperscript{14} See Aigner, Lovell and Schmidt(1977), Meeusen and van den Broeck(1977) and Charnes, Cooper and
Rhodes(1978).
however can be a measure of the social profit in base year prices. For the sake of comparisons, $P$ is divided either by the value-added, final output or by the value of input resulting in a ratio. These ratios of output to particular input are called partial productivity measures, in which output is compared with one input at a time\textsuperscript{15}. Some of the most commonly used partial productivity ratios are output per man-hour termed as labour productivity and output per unit of capital, the capital productivity. Partial productivity ratios do not measure overall productivity changes but provides useful information on the measure of saving achieved in particular cost elements over time. As noted by Kendrick (1961) these measures fail to consider overall productivity changes as factor substitution, which changes the composition of inputs. Thus to measure changes in overall productivity output must be related to aggregate of corresponding inputs. This is generally done by constructing an index of weighted average of inputs using either relative prices or factor shares as the weight. Such an index, essentially output-input ratio is known a total factor productivity (TFP) index\textsuperscript{16}.

TFP can be expressed as

$$ TFP = \frac{Y}{\sum_i w_i X_i} \quad (2) $$

where $Y$ indicates the level of production $X_i$ the quantity of factor inputs i and $w_i$ some appropriate weights. Thus for two inputs capital ($k$) and labour ($L$) TFP can be expressed as

$$ TFP = \frac{Y}{w_L L + w_k K} \quad (3) $$

The issue here is to arrive appropriate weights. This can either be exogenously given\textsuperscript{17} or arrived statistically\textsuperscript{18}.

There are two approaches to the measurement of productivity growth defined as above,

\textsuperscript{15} See Kendrick(1961)
\textsuperscript{16} See Domar (1961) for alternate names
\textsuperscript{17} As done by Harris and Phillips(1984), Tidrick(1986) and other studies.
\textsuperscript{18} Nadri and Schankerman (1981) and Greene(1983) does this.
growth accounting and the econometric estimation of the production function. The former is a deterministic method, commonly referred to, as the index number approach while the latter is stochastic.

Growth accounting method arrives at total factor productivity growth (TFPG) as the difference between the growth in output and the growth in aggregate inputs. Index of TFP is constructed using the residual thus obtained. This index number approach has the advantage of not requiring direct estimation of the underlying technology. This avoids the econometric specification of and estimation of technology. The advantage of this method is aptly summarised by Good, Nadri and Sickles (1997). To quote, "Since they may embody less stringent assumptions that are required by econometric models, they may provide valuable checks on the results of those models. However, for the index number approach to provide meaningful estimates of productivity and productivity growth, fairly strong assumptions about the underlying technology and allocation decisions of the firms must be maintained. Notably one must often assume an inflexible description of the technology, that input and output price ratios and marginal rates of transformation, and/or that all inputs and outputs are measured. Over the last few decades many of these assumptions have been relaxed while still maintaining the advantages of traditional index number approaches." \(^{19}\)

The index number approach can be employed only if weights for the aggregation of the inputs are known. Two indices most often used in empirical research are Kendrick's arithmetic measure and Solow's geometric index\(^{20}\). These indices relate modern economic production theory to the weighting process. Kendrick's approach is based on a linear homogenous production function\(^{21}\) for two inputs, labour and capital. TFP is arrived by dividing aggregate output measure by the aggregate input measure. On the other hand the geometric index of total factor productivity growth rate is defined as

\[
\text{TFPG} = \frac{dY}{Y} - \left[ \alpha \left( \frac{dX_L}{X_L} \right) + (1- \alpha) \left( \frac{dX_K}{X_K} \right) \right]
\]

\(^{19}\) Good, Nadri and Sickles (1997, p.17)

\(^{20}\) See Kendrick 1961) and Solow(1957)

\(^{21}\) Nadri(1970) describes the corresponding production function.
Where Y denotes output, L labour input, K capital input and α the input expenditure share for labour. The measure is based on the Cobb-Douglas production function with constant returns to scale. Solow demonstrated that the residual growth would become a measure of technical progress, provided the share of the value of inputs in the total revenue may be used as weights for the aggregation. This involved the following assumptions: (i) competitive input and output markets; (ii) firms are profit maximisers operating under constant returns to scale; (iii) technological progress is disembodied; and (iv) existence of economy wide (aggregate) neoclassical production function with the standard properties. Under these conditions, the residual is to measure outward shifts in the production function over time. Viewed from this angle the later measures of TFPG by Kendrick and Domar are only an application of this principle to specific functional forms of production functions. Under situations of not too large changes in inputs and outputs Kendrick and Solow measures arrive at similar results as shown by Nadri (1970).

In the case of multiple outputs TFP can also be measured as the ratio of an index number describing aggregate output levels and an index of aggregate input levels. These index numbers are expected to have the desirable properties as stated in Fisher (1927). Diewert (1976) adds two more properties to these\textsuperscript{22}. First is the possibility of the derivation of the index number from some underlying production, cost, utility, revenue, profit or transformation function. These indices were termed as ‘exact’ indices. Second, if the underlying functional form is flexible, that is, if it provides a second order local approximation to an arbitrary functional form then the exact index is termed as ‘superlative’. The popular Törnqvist-Theil quantity index is an example of a superlative index derived from a translog production function\textsuperscript{23}.

Two distinct strands in the literature can be seen on the econometric estimation of

\textsuperscript{22}Good, Nadri and Sickles (1997 p.70) acknowledge the contribution of Diewert’s along with Jorgenson and Griliches. To quote “As with Jorgenson and Griliches it is not possible to provide a comprehensive discussion of Diewert’s substantial work in this area”.

\textsuperscript{23} See Fare and Grosskopf (1995) for further discussions on the theory and calculation of productivity indexes.
TFPG—parametric and non-parametric. In the parametric approach an explicit functional form of a production, cost or profit function is specified and estimated econometrically. This estimated model is then utilised to compute the rate of productivity change and its components. Two different methodologies are used for this. One is to estimate flexible functional forms without giving much importance to the requisite economic properties of the cost/production functions and the equilibrium conditions arising from optimisation. Here we assume that the estimated function is cost or production function, as the case may be and interprets the results. The second method is to impose the properties and the equilibrium conditions and estimate the TFPG or test whether the production function is well behaved. Both the above approaches yield different set of results. The frontier approach too makes use of parametric and non-parametric methods. Frontier approach implies that efficient firms are those operating on the cost or production frontier, while the inefficient ones operate above the cost or below the production frontier\(^{24}\). The distance from the frontier is the measure of inefficiency and in deterministic frontiers models technical inefficiency is defined as the factor by which the level of production for the firm is less than its frontier output. In the stochastic frontier models the error component is composed of two parts of which a symmetric component captures the effects of factors outside the firm’s control. To avoid the problems in estimation often panel data versions of this are used.

Non-parametric analysis makes use of only minimal regulatory assumptions about technology and data envelopment analysis (DEA) is performed. This does not require any explicit functional form. Econometric approach can further be classified into primal and dual. While the primary approach requires data on input and output quantities, the dual approach makes use of input and output price information. Application of duality theory assumes that the outward shift in the production function is equivalent to the downward shift in the cost function over time and TFPG is computed as the difference between the change in total cost and the weighted change in the input prices. TFPG measure from the production function is equal to, and

\(^{24}\) Farrel’s (1957) paper is considered as the path breaking in this area.
opposite in sign, to the TFPG measure from the cost function. Development of the duality theory and flexible functional forms such as the translog and generalised Leontief, sophisticated estimation techniques and the development of panel data techniques has led to a plethora of studies using the econometric method.

Both the index number approach and econometric estimation implicitly assumes that technical change is disembodied. This requires that all inputs be measured in efficiency units for the estimation. The residual otherwise tend to be biased if technical progress is embodied in better machines and more skilled labour and the changes in quality are not incorporated. There are however, studies which emphasis that not only embodied technical progress is important and accounting for it will reduce the 'measure of our ignorance'.

Translating the above approaches into empirically measurable propositions often leads one into the rugged terrain of measurement issues. These involve simplifying assumptions as the toolkit of empirical research often presents an array of only limited options. The above approaches assume the existence of either an economy-wide, industry-wide or firm specific production function each having different implications on the final estimates. As is well known macro production function is a fictitious entity as there is no single macroeconomic decision maker who, allocates resources optimally or maximize profits collectively. However, growth accounting has combined growth theory and econometric measurement on the basis of it. As macroeconomic relations emerge as the sum total of microeconomic relations one needs to aggregate micro level information to arrive at an overall picture. As micro data with the required details are far from an ideal state of availability often aggregation is required. This poses serious problems of aggregation. This by now is well known in the literature and needs no further restatement.

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27 See Sato (1975) for issues in this regard.
The methodology we adopt does not require an economy-wide production function but
needs an industry-wide production function, which is not above criticism. Thus we
need to have aggregates of output as well as inputs, even though in a strict sense we do
not have to aggregate capital, labour and material inputs across different types as the
contribution to output growth of each component is weighted by its value share in total
output. The insuperable difficulties in the measurement and aggregation of capital has
been debated in the literature\textsuperscript{28} so too is labour as skill levels differ. Capital is
aggregated in our estimates across vintages as allowing for age structure because
without aggregation each vintage would be regarded as a different good. Lack of
detailed data prevents us for pursuing this with regard to labour. Aggregation is
permissible under two general conditions. First is that the prices of components of the
aggregate should grow at the same rate so that they can be, treated as a Hicksian
composite commodity. This condition rarely satisfied seems to be unrealistic in the
Indian context. Second, if the above condition is not satisfied one uses the Leontief’s
aggregation theorem. This states that the aggregate exist only if the marginal rate of
substitution between any two components within the aggregate is independent of the
level of any component outside the aggregate. This as shown by Hulten (1973) is
equivalent to having constant returns to scale.

This takes us into another set of issues in estimation namely biases in TFP
measurement due to the assumptions involved. There are three potential biases that
could creep in the process of estimation, (a) the scale factor, (b) capacity utilization
and (c) mark-ups affecting the residual\textsuperscript{29}. The residual TFP would be an overestimate
or underestimate depending the scale factor. The issue of scale factor has triggered of a
series of studies in the East Asian context exploring the possibilities of output growth
without TFPG\textsuperscript{30}. The ‘new growth theory’ stresses the importance of scale economies
in explaining high growth of the newly industrialised countries. The extent of the bias
in the residual is closely related to the existence of increasing returns to scale. The bias

\textsuperscript{28} See Harcourt and Liang(1971)
\textsuperscript{29} See Srivastava(1994) for a discussion of these biases and nature magnitude.
\textsuperscript{30} See Fellepe (2000) for a review of these studies.
could turn to be procyclical if the growth of capital stock is positively correlated to the
growth in output. Hall (1986, 1988) shows that correlation between the residual and an
exogenous variable shows the divergence of price from marginal cost. This implies
that the residual could have pro-cyclical bias due to the assumptions of perfect
competition and constant returns to scale\(^{31}\) and the direction of the bias depends on the
magnitude of the mark-up. If mark-up is greater than one TFP estimates could be an
underestimate of the true productivity growth. Another potential bias arises from the
varying use of capital\(^ {32}\). If the capital in use fluctuates with business cycle and the
measured values do not then the productivity estimates could be biased pro-cyclically.
As noted by Srivastava (1994) some of these biases might work in opposite directions
making it difficult to draw any clear conclusions on the extent of total bias in the
estimates. In order to tackle this issue of biases, TFP measurement is formulated in the
short-run framework or dynamic model. In such a framework some factor inputs such
as capital stock and special type labour are assumed to be quasi-fixed. This helps to
analyse productivity growth simultaneously with scale economies, market power and
capacity utilisation using generalized Leontief cost function\(^ {33}\). Studies adjusting for the
above mentioned biases are absent in the Indian context\(^ {34}\). The present study too does
not venture into this as the econometric estimations involve reliable estimates of cost
of capital unavailable in the Indian context.

Another issue is the treatment of materials. This is important in view of the fact that
the role of materials is implicit in the choice between gross production and value added
as the measure of output\(^ {35}\). Value added as a the output measure is consistent with two
assumptions\(^ {36}\) about the role of materials: (i) the elasticity of substitution between
materials and value added in \( Y = g[F(K, L), M] = g(V, M) \) is infinite, allowing one to

\(^{31}\) See Srivastava and Sengupta (2001) for a discussion of the procyclical nature of the residual.

\(^{32}\) Tybout (1992) discusses this.


\(^{34}\) Srivastava(1994) corrects for mark-ups and scale and Rao(1996) corrects for mark-up. These correction did
alter the magnitude of TFPG but not the trend.

\(^{35}\) This issue is debated widely in the Indian context. See Balakrishnan and Pushpangadan (1998).

\(^{36}\) See Griliches and Ringstad (1971).
(ii) The elasticity of substitution between materials and value added is zero, materials being used in fixed proportion to output, such that \( M = aY \). This model can then be written as \( Y = F(K, L) + M \). Value added is appropriate so long as \( a \) is either a constant or is uncorrelated with the levels of capital and labour. This last requirement is the assumption behind the existence of separability, whereby the marginal product of materials must be independent of the marginal product of the other two inputs. The use of value added further brings in the issue appropriate deflation to arrive figures in constant prices. Two methods are commonly employed to arrive value added at constant prices, the single and double deflation. Single deflation means deflating nominal value added with output price index. This suffers from the drawback that a fall in the relative prices of intermediate inputs can cause a rise in real value added confusing price and quantity effects. Double deflation though insists more on the existence of separability is superior provided the procedure adopted employ input price indices corresponding exactly to the intermediate inputs, which demands data requirements.

It emerges from the above survey that various methods of computing TFP growth involves various assumptions having important bearing on the results. The results thus are sensitive to both the method employed and data used. Interpretation of the results should thus be in light of the methodology adopted and underlying assumptions. The estimates of different results in the Indian context should thus be viewed from this perspective. We examine the major studies on Indian manufacturing from this standpoint.

III. Productivity growth in Indian industry: Trends and interpretations

As the question of productivity growth in the Indian economy is of such vital importance, there have been a number of studies on the issue covering different time points and using alternate methodologies. For a closer scrutiny on the studies we provide a

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purposive survey organised according to the issues placing importance on the methodological issues as mis-measurement or poor method may lead to misinterpretations.

We provide the available evidence of TFPG in Indian manufacturing in the following table. As interpretations of the studies prior to nineties are aplenty we limit to the set of studies in the recent times. Two detailed coherent surveys, Krishna (1987) and Balakrishnan and Pushpangadan (1998) have examined these studies carefully highlighting both theoretical and empirical issues. We review the works according to whether the estimates have been arrived at using the growth accounting methodology or by the econometric estimation of production functions.

Table 4.1. Summary Evidence on Productivity in Indian Manufacturing Industries

<table>
<thead>
<tr>
<th>Measure used</th>
<th>Time period</th>
<th>Data used</th>
<th>Result</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solow index</td>
<td>1946-1964</td>
<td>CMI, ASI</td>
<td>Change of 2.8% per annum</td>
<td>Hashim and Dadi (1973)</td>
</tr>
<tr>
<td>Solow index</td>
<td>1948–1964</td>
<td>CMI, ASI</td>
<td>Decline at a rate of 1.6 % per annum over 1950s and 60s</td>
<td>Banerjee (1975)</td>
</tr>
<tr>
<td>Kendrick measure</td>
<td>1951-61, 1951-81</td>
<td>CSO Economic survey</td>
<td>Annual compound growth rate of 0.10 %</td>
<td>Bhramananda (1982)</td>
</tr>
<tr>
<td>Solow measure and Translog</td>
<td>1959-1980</td>
<td>ASI</td>
<td>Ranges between -0.2 &amp; 0.3 (translog) &amp; -0.6(Solow)</td>
<td>Ahluwalia (1985)</td>
</tr>
<tr>
<td>Solow measure, Tinbergen (Translog)</td>
<td>1951-1979</td>
<td>CMI (51-65) ASI (59-79)</td>
<td>Growth of 1.3% per annum(51-65), 1.3% per annum(1959-79)</td>
<td>Goldar (1986)</td>
</tr>
<tr>
<td>Translog</td>
<td>1959-60 to 1985-86</td>
<td>ASI</td>
<td>TFPG of -0.4 per annum during '59-60 to 85-86</td>
<td>Ahluwalia (1991)</td>
</tr>
</tbody>
</table>
Table 4.1: contd...

<table>
<thead>
<tr>
<th>Study Type</th>
<th>Time Period</th>
<th>Data Source</th>
<th>Results</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Accounting</td>
<td>1963-64 to 1993-94</td>
<td>ASI</td>
<td>Increase in TFPG in some while decline in others</td>
<td>Pradhan and Barik(1998)</td>
</tr>
</tbody>
</table>

As is evident from the table various studies use different data sets, methodologies with varying time points and arrive at different set of results\(^{38}\). As both the previous surveys exhaust the discussion of the issues involved our observations are limited. We

\(^{38}\) Apart from the above reported studies Hulten and Srinivasan (1999) too compute TFPG for the period 1973 to 1992 and compare it with rest of the Asian economies. As the focus of their paper is inter-country comparison
notice that the results are sensitive to the method of estimation and the output measure used. Three alternate measures of output are used, (a) value added arrived using single deflation procedure, (b) value added arrived using double deflation procedure and (c) gross output. The estimates of these three measures vary substantially. While Ahluwalia (1991) using single deflation value added as the output measure reports an acceleration of TFP growth in the eighties, Balakrishnan and Pushpangadan (1994) arrives at a slow down of TFPG for the eighties using value added arrived by the double deflation procedure. But neither of the studies test for the existence of a value added production function and assumes its existence. On the contrary Pradhan and Barik (1998) tests for the existence of a value added production function and rejects, justifying their use of gross output as the output measure. It is interesting to note that they too arrive at similar results of Balakrishnan and Pushpangadan for the eighties. All statistically significant estimates of TFP growth using growth accounting and double deflation procedure in the manufacturing sector point to a decline in productivity in the eighties. Of all the studies which find estimates of negative TFP growth accounting and double deflation procedure in the manufacturing sector point to a decline in productivity in the eighties. Of all the studies which find estimates of negative TFP growth, Rao (1996) alone provides an explanation invoking the Verdoorn's Law.

It can also be noted that some of the studies, which use econometric estimation to arrive at TFP growth, report higher growth in the eighties. One notable example of this is Srivastava (1996) who reports decline in TFPG while growth accounting is used and an increase when econometric estimation is used. It emerges that there exist divergent trend in the growth of productivity according to the two approaches used. This issue far from settled has been highlighted in Balakrishnan and Pushpangadan (1998), to quote, “If the growth in productivity in the eighties may be used as the testing ground for our understanding of manufacturing productivity growth we must recognise that our knowledge is limited. As we have pointed out here, there remains an unresolved issue. This is that two equally mainstream approaches to estimation yield significantly different results. While growth accounting points to a decline in productivity growth in the eighties, the estimation of production functions yields an increase. This is puzzling. Until the superiority of one set of results over the other is conclusively established, we
cannot claim to know much about the growth of productivity in Indian manufacturing”\textsuperscript{39}

An interpretation of the TFPG is often done by relating it to the policy regimes. Studies which report acceleration in TFPG in the eighties attribute it to the policy changes. This argument, however, does not hold good when we consider the period of nineties. All the studies considering the period since 1991 report a decline in TFPG. As the extent of reforms is limited in the eighties compared to the nineties it would then be appropriate to evaluate the so called link between changes in policy and TFPG in light of the results for the nineties. Thus the available evidence point to a decline in TFPG since 1991 questioning the earlier explanations offered for the eighties.

From the above survey it emerges that the issue of TFPG in Indian manufacturing needs a fresh look in order to assess the impact of the policy changes. This is because of the multiplicity of the results available often arrived using tentative methodologies leading to nebulous interpretations. We thus measure the extent of TFPG for the period 1973/74 to 1995 to examine the trend in the eighties. For understanding the plausible changes since 1991 we test for a change in the efficiency levels of a sample of firms drawn from the CMIE using the frontier production function approach, which is taken up in another subsequent section.

IV. Total Factor Productivity Growth: Methodology and Estimates

Having reviewed the issues in productivity measurement and its bearing on Indian manufacturing we are now in a position to appreciate the necessity of a set of fresh estimates. We present it in the following section.

As a prelude to the analysis of TFP we first examine labour productivity growth in the manufacturing sector. From Table 4.1 it can be observed that there has been an increase in labour productivity growth in the second period. The periodisation corresponds to changes in policy regime. Except for beverages and tobacco products, textile products, paper and paper products, basic metals and alloys, and metal products

\textsuperscript{39} Balakrishnan and Pushpangadan (1998, p. 2242.)
all the industries witnessed an increase in labour productivity growth since mid-eighties with non-metallic mineral products registering the highest growth. Manufacturing on the whole too witnessed a growth in labour productivity. It should be noted that during this period the manufacturing output too increased at a faster rate while the employment growth was sluggish\(^4\). However, this growth in labour productivity does not mean the efficient utilization of labour as capital intensity too increased in the same period. While capital intensity grew at a rate of 12 percent in the first period, it registered a faster growth of 17 percent in the second period. Thus examining labour productivity alone might not provide meaningful results as partial productivities does not provide a clear picture of the over all factor productivity growth.

### Table 4.2. Growth of labour productivity.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Products (20-21)</td>
<td>5.519</td>
<td>6.012</td>
</tr>
<tr>
<td>Beverages, Tobacco, Tobacco Pts (22)</td>
<td>2.786</td>
<td>0.381</td>
</tr>
<tr>
<td>Textiles (23+24+25)</td>
<td>4.889</td>
<td>6.832</td>
</tr>
<tr>
<td>Textile Products (26)</td>
<td>4.748</td>
<td>4.259</td>
</tr>
<tr>
<td>Wood &amp; Wood Products, Furniture (27)</td>
<td>1.350</td>
<td>2.114</td>
</tr>
<tr>
<td>Paper &amp; Paper Products, etc (28)</td>
<td>7.648</td>
<td>3.237</td>
</tr>
<tr>
<td>Leather &amp; Leather &amp; Fur Products (29)</td>
<td>2.639</td>
<td>4.098</td>
</tr>
<tr>
<td>Rubber, Plastic, etc (30)</td>
<td>9.188</td>
<td>4.494</td>
</tr>
<tr>
<td>Chemicals (31)</td>
<td>1.714</td>
<td>6.714</td>
</tr>
<tr>
<td>Non-Metallic mineral pdts (32)</td>
<td>8.067</td>
<td>31.781</td>
</tr>
<tr>
<td>Basic metals &amp; Alloys (33)</td>
<td>7.369</td>
<td>4.572</td>
</tr>
<tr>
<td>Metal Products (34)</td>
<td>5.101</td>
<td>3.869</td>
</tr>
<tr>
<td>Machinery (35+36)</td>
<td>4.848</td>
<td>4.983</td>
</tr>
<tr>
<td>Transport Equipment &amp; Parts (37)</td>
<td>3.715</td>
<td>11.044</td>
</tr>
<tr>
<td>Other Manuf. industries (38)</td>
<td>9.825</td>
<td>12.448</td>
</tr>
<tr>
<td>Manufacturing Total</td>
<td>6.23</td>
<td>8.01</td>
</tr>
</tbody>
</table>

This leads us to an examination of TFPG in the manufacturing sector. We start with the testing for an appropriate measure of output. This is done by a test for the assumption of separability on the basis of which a choice between value added and gross output is made.

On the use of value added Griliches and Ringstad (1971) note that; “The measure of value added implies that the material inputs in the production process are treated asymmetrically: they are subtracted from gross output \( V = Y - M \) and hence not included explicitly in the list of inputs. This procedure has received a variety of justification in the past they include:

(1) It facilitates the comparison of results for different industries with different material use intensities and improves the comparability of data for individual establishments even within the same industry as long as they differ in their tickness (the amount of vertical integration).

(2) It facilitates the aggregation of output measures across industries through the reduction of double counting. When output is measured by value added only, the materials that are embedded in a particular product are not counted each time as the product crosses industry lines on its way toward final consumption.

(3) It reduces the problem of estimation and interpretation by the elimination of a variable M from both sides of the production relation.

(4) Materials are an asymmetric input. Often their use is closely associated with the level of gross output and hence their inclusion as an independent variable in a regression analysis would obscure the relationships of interest.

(5) Finally, any short run fluctuation in demand may be met without much change in their workforce or machinery in place, but will usually induce a similar fluctuation in the use of raw materials or energy input. In this sense, M is more endogenous than L and K and its use as an independent variable is more likely to
lead to a simultaneous equation biases if standard least squares estimation procedures are followed" 41

However, the concept of value added counters difficulty if one attempts to arrive a measure of real value added. The concept of real value added is not well defined in the literature. There are ambiguities about the relationship of real value added to the production function inclusive of all inputs. Consider a production function of the form

\[ Q = f(L,K,M) \]

Where \( Q \) is gross output, \( L \) the labour input, \( K \) capital input and \( M \) material input inclusive of energy inputs. Real value-added \( VQ \) may be defined as

\[ VQ = G (L,K) \]

if the production function is weakly separable in the form

\[ Q = F(G(L,K)M). \]

Thus the production function can be written in the form

\[ Q = F(VQ, M). \]

An aggregation formula can be selected and real value added defined as aggregate primary input. As measures of real capital inputs hardly exist, the aggregation of primary inputs becomes difficult. The method adopted by the UN and most countries is called double deflation. The value of gross output and materials are separately deflated and difference is defined as real value added or real net output.

\[ VQ^* = Q - M \]

It is implicitly assumed42 that the production function is additively separable of the form

\[ Q = VQ^* + M. \]

This method of measuring real net output though convenient introduces further assumptions into the output data as some form of separability is required for all cases of real value added. Weak separability of the material inputs from the non-material inputs is implied in all of the special cases.

42 See Sims(1969) for a justification for this.
The separability of material inputs capital and labour inputs can be tested using either a cost function as in Berndt and Christensen (1974), Berndt and Wood (1975) or by a production function as demonstrated by Jorgenson et al (1987). The present study employs a production function approach. The production function takes the form

\[ \ln Y = \alpha_0 + \sum \alpha_j \ln X_j + 1/2 \sum \beta_{ij} \ln X_i \ln X_j + \alpha_t + \sum \beta_{it} t \ln X_i + 1/2 \beta_{tt} t^2 \]  

(1)

Where \( Y \) is the output and \( X_j \) is the \( j^{th} \) input, the inputs being capital, labour and materials and \( t \) is the time variable. For the above specification the existence of a value added function can be tested by employing linear and non-linear separability conditions\(^43\). We limit to linear separability case only. Thus the above equation can be expressed as

\[ \ln Y = \alpha_0 + \alpha_m \ln M + \alpha_v \ln V \]  

(2)

Where \( V \) is the gross value added \( Y \) the output and \( M \) the materials. The value added function can be written as

\[ \alpha_v \ln V = \alpha_0 + \alpha_k \ln K + \alpha_l \ln L + \beta_{kl} \ln K \ln L + 1/2 \beta_{kk} (\ln K)^2 + 1/2 \beta_{ll} (\ln L)^2 + \alpha t + \beta_{kt} (\ln K)t + \beta_{lt} (\ln L) + 1/2 \beta_{tt} t^2 \]  

(3)

The restrictions imposed in the second equation on the parameters for the fulfilment of linear separability conditions are:

\[ \beta_{km} = \beta_{im} = \beta_{mt} = 0 \]  

(4)

As the TFP studies in the Indian context have used translog formulation of value added function, which assumes linear separability we do not venture to examine non-linear separability conditions for purposes of comparison. Moreover, in the non-linear case value added takes a linear logarithmic or Cobb Douglas form.

The procedure adopted for estimating the translog production function is as follows. We assume that the production function is homogeneous of degree one, that is, it

yields constant returns to scale. Thus the parameters will satisfy the following conditions.

\[ \Sigma_i \alpha_i = 0, \Sigma_j \beta_{ij} = 0, \Sigma_i \beta_{ii} = 0 \text{ and } \beta_{ij} = \beta_{ji} \quad (i, j = K, L, M) \]  

(5)

Differentiating equation (2) with respect to inputs \( (X_i) \) and applying the producer's equilibrium condition, \( \delta f/\delta X_i = P_i \), the ith share equation obtained is

\[ \theta_i = \alpha_i + \Sigma_i \beta_{ij} \ln X_j + \beta_{it} \quad (i, j = K, L, M) \]  

(6)

In order to take into account the information contained in the input demand functions we estimate the production function and the share equation by the Zellener's iterative method\(^{44}\). The problem of linear dependency and consequent singularity of residual covariance matrix is avoided by dropping one of the share equations, as the sum of the three factor shares will be unity. We drop the labour share equation in view of finding that estimates are invariant to the share equation dropped while the earlier studies of Jha et al, (1991), Jha and Sahni (1991) estimate after dropping the material share equation. To satisfy the linear homogeneity condition on the production function, restrictions as in (4) are imposed to the system. The results of the estimates are present in Appendix II.

Tests for linear separability conditions is performed on the basis of likelihood ratio as suggested in Berndt and Wood (1975) and Christensen and Greene (1976). The likelihood ratio statistic follows a chi-squared distribution with degree of freedom equal to the number of restrictions imposed. A significant chi-squared value would indicate the rejection of the existence of value added function and thus the acceptance of output in place of value added as the appropriate variable for the estimation of TFPG. The likelihood ratio test conducted on the data of aggregate manufacturing sector over the period 1973/74 to 1995/96 indicates a chi-squared value of 18.15 which is significant at one percent level implying the non-existence of value added function in the aggregate manufacturing sector of India.

\(^{44}\) Zellener (1962).
Having decided on an appropriate measure of output variable we move on to compute the TFPG in the manufacturing sector.

Three methods of measuring TFPG at the aggregate level have attracted theoretical attention. We consider these three measures. The first method due to Hulten is defined as growth of a Divisia index of final output minus growth of a divisia index of primary inputs where primary inputs include capital, labour and other inputs. The second method is Domar aggregation over industry TFP growth rates. And the third method, the aggregate value added method is defined as the growth of aggregate value added minus growth of divisia indices of aggregate capital and labour.

Hulten's method can be written as follows

$$\mu^H = \sum_i \left[ \frac{q_i Z_i}{\sum q_i Z_i} \right] \left[ \frac{Z_i}{Z_i} \right] - \sum_k \left[ \frac{w_k J_k}{\sum k w_k J_k} \right] \left[ \frac{J_k}{J_k} \right]$$

Where $Z$ is final output of the product of the $i$th industry, $q_i$ is its price and $J_k$ is the $k$th primary input and $w_k$ is its price. By final output is meant that part of the industry sales which is not meant to be used up in the current period by the industries included in the aggregate. So if aggregate is the whole economy, final output is public and private consumption, investment and exports. Hulten (1978) showed the aggregate TFP growth rate as the solution to a maximisation problem. He showed that if (1) the economy is competitive (2) for all $j$ the $j$th primary factor is paid the same in all industries and (3) the underlying industry level production function are homogeneous of degree one then $\mu^H$ measures the outward shift of the social production possibility frontier.

Domar aggregation can be defined as

$$\mu^{DA} = \sum_i \left[ \frac{(q_i \gamma_i)}{\sum q_i Z_i} \right] \mu_i$$

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45 See Hulten (1978)
46 Domar (1961).
47 As in Jorgenson and Griliches (1967).
Where $\mu_i$ is the growth rate of TFP in the $i^{th}$ industry. $\mu^{DA}$ is a weighted sum and not a weighted average of industry TFPG with weights being the ratios of nominal gross output of each industry to total nominal final output. The sum of weights will be more than one since the aggregate gross output exceeds aggregate final output because of the inclusion of the sales made within manufacturing sector in gross output but not in final output. Domar (1961) arrived at the weighting scheme, which satisfies the condition that an aggregate TFPG is invariant to the degree of integration or aggregation of the economy. While the earlier scheme by Leontief (1953) does not satisfy this, Domar's scheme satisfies the requirements. "The intuition behind Domar aggregation is that an industry which sells a great deal to others receives a higher weight, because TFPG in this industry contributes not only directly to aggregate TFP growth but also indirectly, through lowering costs else where in the economy". The equivalence of Hulten's and Domar's method is shown in Hulten (1978) under some assumptions. Hulten's method though has a strong theoretical rationale is difficult to implement, while Domar's method is easier to implement. In Hulten's method the point of interpretation revolves around the issue of what are to be counted as primary inputs. For a totally closed economy the primary inputs are labour and capital. In an open economy or at a sectoral level it is necessary to count also inputs purchased outside the sector.

Aggregate value added method is based on the method of calculating aggregate value added, aggregate capital and labour. From Jorgenson(1987) it is as follows

$$\mu^{AV} = \frac{V}{V} - \left[ \frac{p_k}{p_v} \frac{V}{V} \right] \left( \frac{K}{K} - \frac{p_L}{p_v} \frac{V}{V} \right) \left( \frac{L}{L} \right)$$

Where $v$ is the aggregate real value added, $K$ is aggregate capital, $L$ is aggregate labour and $p_k$, $p_v$ and $p_l$ are the corresponding prices. The accounting identity relating output and inputs is $p_v V = p_k K + p_l L$

Aggregate value added is arrived as the sum of industry level value added. The growth of aggregate value added is a weighted average of growth rates of industry value

---

48 Oulton and O'Mahony (1994 p.120).
added, where the weights are the shares of each industry in aggregate nominal value added, these shares being observable. Note that value added function will only exist if either the prices of intermediate inputs and output happens to rise at the same rate or if intermediate input is weakly separable from the other inputs and from time. That is if the marginal rate of substitution between capital and labour is independent of the level of intermediate input and of time. This is a very restrictive assumption which we have discussed at length above.

Of three methods discussed above we use the Domar aggregation method to arrive at the estimates of TFPG for Indian manufacturing. As the first step we compute the TFP growth at the individual industry level confining to the two-digit level of disaggregation. TFP growth at the individual industry level is computed as follows.

The methodology, similar to that in Oulton and O'Mahony (1994), as in Jorgenson et al. (1987) is followed for TFP measurement. They assume that at the industry level there exists a production function relating to capital, labour, intermediate inputs and time and that capital labour and intermediate inputs are each aggregates which in turn depend on their components. Growth rates of output and inputs are measured and the growth rates of TFP are approximated by discrete, Tornqvist indices.

To elaborate we use the following notations.

\[ Y = \text{Real gross output} \quad X = \text{Real intermediate input} \]

\[ K = \text{real capital stock} \quad L = \text{Labour input} \]

\[ N = \text{No. of industries} \quad t = \text{Time} \]

\[ P = \text{input price} \quad q = \text{output price} \]

\[ v = \text{Value share} \quad v = \text{Average of} \ v\ \text{at two points in time} \]

\[ \Delta_u = \text{difference between a variable} \]

In each industry the following accounting identity holds:

\[ q_i \ Y_i = P'_k K_i + P'_L L_i + P'_X X_i \quad i = 1, \ldots, N_i \quad (1) \]
That is the value of output equals the value of inputs. It is assumed that each industry's technology can be described by a constant returns to scale production function

\[ Y_i = F^i (K_p, L_p, X_i, t), \quad i = 1, \ldots, N \]  

(2)

Then rate of growth of TFP \( \mu \) can be defined as the rate of growth of output with respect to time, holding all inputs constant:

\[ \mu_i = \frac{\partial \ln \gamma_i}{\partial t} = \frac{d \ln \gamma_i}{dt} - (K_i / \gamma_i) \left( \frac{\partial \gamma_i}{\partial K_i} \right) \left( \frac{d \ln K_i}{dt} \right) - (L_i / \gamma_i) \left( \frac{\partial \gamma_i}{\partial L_i} \right) \left( \frac{d \ln L_i}{dt} \right) - (X_i / \gamma_i) \left( \frac{\partial \gamma_i}{\partial X_i} \right) \left( \frac{d \ln X_i}{dt} \right) \]  

(3)

Assuming that firms maximize profits and are price takers in product and factor markets, we can replace elasticities with value shares.

\[ \mu_i = \frac{d \ln \gamma_i}{dt} - v^i_x \left( \frac{d \ln X_i}{dt} \right) - v^i_k \left( \frac{d \ln K_i}{dt} \right) - v^i_L \left( \frac{d \ln L_i}{dt} \right) \]  

(4)

Where \( v^i_x \), \( v^i_k \) and \( v^i_L \) are the value shares of intermediate input, capital and labour respectively and are given by:

\[ v^i_x = p^i_x \frac{X_i}{q_i \gamma_i} \]

\[ v^i_k = p^i_k \frac{K_i}{q_i \gamma_i} \]  

(5)

\[ v^i_L = p^i_L \frac{L_i}{q_i \gamma_i} \]

Thus TFP growth in industry \( i \) is equal to growth of output minus a value share weighted average of growth of inputs. The instantaneous growth rates of output and inputs cannot be directly observed. However under the further assumption that the production function is translog, it can be shown that the average growth of TFP over the discrete interval \((t-u)\) to \( t \) is measured exactly by the following Tornqvist index
\[ \Delta_u \ln (\text{TFP}_i) = \Delta_u \ln Y_i - \nu^i_x \Delta_u \ln X_i - \nu^i_k \Delta_u \ln K_i - \nu^i_L \Delta_u \ln L_i \]  \hspace{1cm} (6)

\[ i = 1, \ldots, N, \]

Where

\[ \nu^i_x = (\frac{1}{2}) \left[ \nu^i_x(t) + \nu^i_x(t-u) \right] \]

\[ \nu^i_k = (\frac{1}{2}) \left[ \nu^i_k(t) + \nu^i_k(t-u) \right] \]  \hspace{1cm} (7)

\[ \nu^i_L = (\frac{1}{2}) \left[ \nu^i_L(t) + \nu^i_L(t-u) \right] \]

We use the above method and compute total factor productivity growth at the individual industry level, basically at the two-digit level of disaggregation. For the sake of convenience in computation we add certain industries, that is, in the industry groups of textiles and machinery, which leaves us with fifteen industries the total of which forms aggregate manufacturing. The data and construction of variables are discussed in the Appendix. Industry level estimates are added up using the Domar aggregation to arrive for the figure at the aggregate level. As the ASI data does not provide inter-industry flows we arrived the final output by matching the industrial groups at two digit level with that of the corresponding ones in the input-output tables. The input output (I-O) table of 1973/74 was used for the period 1973/74 to 1978/79, I-O table of 1978/79 for the period 1979/80 to 1983/84, I-O table 1983/84 for the period 1984/85 to 1989/90 and I-O table of 1989-90 for the rest of the years. The results are presented in table 4.3.
Table 4.3. Estimates of TFP growth rates for the manufacturing sector

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Products (20-21)</td>
<td>1.87</td>
<td>0.98</td>
<td>1.08</td>
</tr>
<tr>
<td>Beverages, Tobacco, Tobacco Pts (22)</td>
<td>1.01</td>
<td>0.88</td>
<td>0.57</td>
</tr>
<tr>
<td>Textiles (23+24+25)</td>
<td>1.66</td>
<td>0.29</td>
<td>0.99</td>
</tr>
<tr>
<td>Textile Products (26)</td>
<td>2.32</td>
<td>1.05</td>
<td>1.47</td>
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<tr>
<td>Wood &amp; Wood Products, Furniture (27)</td>
<td>3.24</td>
<td>-4.36</td>
<td>1.18</td>
</tr>
<tr>
<td>Paper &amp; Paper Products, etc (28)</td>
<td>1.02</td>
<td>0.98</td>
<td>1.00</td>
</tr>
<tr>
<td>Leather &amp; Leather &amp; Fur Products (29)</td>
<td>0.94</td>
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<td>1.03</td>
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<tr>
<td>Rubber, Plastic, etc (30)</td>
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<td>Basic metals &amp; Alloys (33)</td>
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<td>Metal Products (34)</td>
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<td>Machinery (35+36)</td>
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<td>Transport Equipment &amp; Parts (37)</td>
<td>1.49</td>
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<td>Other Manuf.industries (38)</td>
<td>2.26</td>
<td>1.08</td>
<td>1.08</td>
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<tr>
<td>Manufacturing Total</td>
<td>2.67</td>
<td>0.16</td>
<td>1.53</td>
</tr>
</tbody>
</table>

Note: Growth rates are annual averages.

The periodisation in table corresponds to the pre-reform and the reform era. This helps us to examine the effects of the policy changes on TFPG. We consider the period after 1985 as the era of reforms as substantiated by Srivastava (1994). We discuss the results of the aggregate manufacturing first. For the entire period we find a growth rate of 1.5 percent in TFP for the manufacturing sector. This estimate is not comparable with some of the existing estimates as the period considered varies. However, when compared to the estimates of Trivedi et al (2000) for the period 1973/74 to 1997/98 are higher for the corresponding figures arrived using the gross output function and lower to those arrived using value added, single and double deflation. When the two sub periods are considered we notice a decline in TFPG in the era of reforms with the
growth rate falling from 2.67 percent in first period falling to 0.16 percent in the second period. This result is similar to that of Balakrishnan and Pushpangadan (1994) for the period since 1982 and the rest of the studies for the 1990s. Thus on the whole there has not been any improvement in TFPG since the reforms and in fact there has been a decline.

At the disaggregate level we notice that except in two industries, leather products and transport equipment, rest of the industries witnessed a decline in TFPG since the mid-1980s. The decline has been largest in wood and wood products and chemicals. For the whole period the TFPG varies between 2.57 for rubber plastics etc. and 0.57 for beverages and tobacco, while in paper and paper products it has grown at a steady annual rate of around one percent year. The growth in TFPG was the highest in the industrial groups of wood, chemicals and rubber products in the first period and it is these industries which registered steep decline in the second period. In order to understand the yearly fluctuation we plot the TFPG over the years for the industrial groups in the graphs 4.1 to 4.5 in the Annexure. Given the self-explanatory nature of these figures we do not venture into any descriptive analysis. It can be noticed that TFPG in most industries shows a fluctuating trend.

Thus it can be concluded that TFPG in Indian manufacturing declined since the mid-1980s, the period corresponding to the launching of economic reforms. This lends support to the recent evidence of a decline in TFPG since 1980s and 1990s arrived at by using different methodologies. Our analysis also reveal that in almost all the industries except two at the disaggregate level there has been a decline in TFPG since mid 1980s. This questions the postulated link between economic reforms emphasising more open trade regimes and the growth in productivity. In order to examine this proposition further we examine a set of selected industries within the manufacturing sector using firm level data.
V. Economic reforms and changes in efficiency.

It is widely believed that market characterised with entry barriers and absence of foreign competition fails to achieve scale efficiency and technical efficiency. The empirical evidence for this is however scanty. Rodrik (1988) notes that 'there is practically no direct evidence on the importance of scale economies in specific industrial sectors of the developing countries'. Also Pack (1988) notes that 'there is no clear confirmation of the hypothesis that countries with export orientation benefit from greater growth in technical efficiency in the components sectors of manufacturing'. This is further confirmed by Bhagwati (1988) when he points that 'although the arguments for success of export promotion strategy based on economies of scale and X-efficiency are plausible, empirical support for them is not available'. In light of the above arguments we test for an increase in technical efficiency in the set of industries, which experienced major tariff reductions.

For the purpose we examine seven major industrial groups within manufacturing sector. They are food products, textiles, chemicals, metals and metal products, non-metallic mineral products, machinery and transport equipment and parts. These industrial groups broadly correspond to the two-digit level of disaggregation and are chosen on the basis of tariff reductions. The nominal tariff rates over time are presented in Table 4.4.

Table 4.4 The nominal tariff rate over time

<table>
<thead>
<tr>
<th>Industry</th>
<th>1987-88</th>
<th>1992-93</th>
<th>1994-95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textiles</td>
<td>135.6</td>
<td>102.4</td>
<td>60.3</td>
</tr>
<tr>
<td>Chemicals:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>115.1</td>
<td>102.4</td>
<td>60.4</td>
</tr>
<tr>
<td>Other</td>
<td>122.1</td>
<td>107.1</td>
<td>63.7</td>
</tr>
<tr>
<td>Transport Equipment</td>
<td>87.8</td>
<td>72.1</td>
<td>55.6</td>
</tr>
<tr>
<td>Machinery:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>101.9</td>
<td>91.1</td>
<td>56.1</td>
</tr>
<tr>
<td>Non-electrical</td>
<td>82.3</td>
<td>66.5</td>
<td>27.8</td>
</tr>
</tbody>
</table>

We examine two cross sections of firms drawn from the CMIE at two different time points to examine changes in technical efficiency. We consider the years 1993 and 1998 as we expect a growth in technical efficiency with acceleration in reforms. Details of the data are discussed in the appendix.

The methodology of Tybout et al (1991) is used and a translog stochastic frontier production function of the following form is estimated\(^{49}\):

\[
Y_{it} = \beta_0 + \beta_K K_{it} + \beta_L L_{it} + \beta_M M_{it} + \frac{1}{2}\beta_{kk} K_{it}^2 + \frac{1}{2}\beta_{ll} L_{it}^2 + \frac{1}{2}\beta_{mm} M_{it}^2 + \beta_{kl} K_{it} L_{it} + \beta_{lm} K_{it} M_{it} + \beta_{kl} L_{it} M_{it} + u_{it}
\]

Where the subscripts i and t indicate the observation for the \(i^{th}\) firm for the \(t^{th}\) year

\(Y\) is the natural logarithm of the value of output

\(K\) is the natural logarithm of the gross capital stock

\(L\) is the natural logarithm of the labour hours

\(M\) is the natural logarithm of material input

\(T\) is time trend to allow the frontier to shift over time which is interpreted as technical change

As we compare two cross sections 1993 and 1998 both are in 1993 prices. We use net fixed assets of the firms as reported in the balance sheet as the measure of capital. As the issue is to estimate changes in efficiency we examine the same set of firms for both the time periods. Finally to test for changes in efficiency we compare the intercepts of the equation for the two time periods and compute the ratio of 1998 and 1993 intercept, which if greater than one, indicate a shifting out of the frontier. For understanding the changes in the efficiency levels of the firms we compute the ratio of the average of the firms for 1998 and 1993 for which a value greater than one indicates improvements in efficiency. All the estimations are done using the software Frontier 4.1 and results are reported in the appendix.

\(^{49}\) For details about the model see Battese and Coelli(1995).
Table 4.5. Testing for improvements in efficiency since 1993

<table>
<thead>
<tr>
<th>Industrial group</th>
<th>Intercept ratio</th>
<th>Mean efficiency ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>1.96</td>
<td>1.34</td>
</tr>
<tr>
<td>Food products</td>
<td>1.34</td>
<td>0.98</td>
</tr>
<tr>
<td>Machinery</td>
<td>0.22</td>
<td>0.95</td>
</tr>
<tr>
<td>Metals &amp; metal pdts</td>
<td>1.75</td>
<td>0.97</td>
</tr>
<tr>
<td>Non-metallic minerals</td>
<td>0.49</td>
<td>0.96</td>
</tr>
<tr>
<td>Textiles</td>
<td>0.69</td>
<td>0.87</td>
</tr>
<tr>
<td>Transport equipment</td>
<td>6.01</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Source: computed.

The test for an improvement in efficiency since 1993 as reported in Table 4.5 shows that in four out of seven industries the frontier has shifted out indicating change in efficiency. Transport equipment witnessed the maximum improvement with ratio indicating a value above 6. In textile and machinery there has been drastic decline in 1998 compared to 1993. These results however, could be misleading as the frontier would shift out if any one or more firms acquire better technology. So in order to understand the scenario of the industry we examine the ratio of the mean efficiency of the firms for both the years as reported in column 2. It can be noticed that in five out of seven industries the mean efficiency has come down in 1998 compared to 1993\(^5\). Two industries namely chemicals and transport equipment witnessed overall improvements in the efficiency levels. From this it can be concluded that on the whole there has been a decline in efficiency in majority of the industries considered in 1998 compared to 1993 pointing to the fact that successive generations of reforms have failed to enhance the efficiency.

\(^5\) Parameswaran (2000) also report similar results for a sample industries.
To sum up

In this chapter we examined the performance of the manufacturing sector in terms of improvements in TFPG. From the theoretical discussions it emerged that a test for the existence of value added production function needs to be undertaken prior to the acceptance of value added as the output measure. Our empirical test rejects the existence of value added production function leading us to the use of gross output as the output measure. Thus our results do not seem to suffer from the bias due to deflation procedure widely discussed in the Indian context. Using the Domar aggregation method we find no evidence for an improvement in TFPG since the eighties. In fact there is a decline in TFPG since mid-eighties coinciding with the era of economic reforms. At the disaggregate level too majority of industries witnessed a decline in TFPG since 1985. However a caveat needs to be added. As our results of TFPG are not corrected for the biases due to imperfect competition, scale economies and capacity utilisation the TFP measure could very well be an over / under estimate. We further notice that there has been no improvement in TFPG since 1991, even after the acceleration of the reforms. Testing for efficiency for two-time points 1993 and 1998 in selected industrial group too reveals that mean efficiency has come down in 1998. This leads one to ponder on the often-postulated links between policy regimes and productivity growth.
Annexure

Figure 4.1: TFPG in Manufacturing Industry

Figure 4.2: TFPG in the Manufacturing Industry
Figure 4.3: TFPG in the Manufacturing Industry

TFPG in Manufacturing Industry
(1973/74-1995/96)

Figure 4.4: TFPG in the Manufacturing Industry

TFPG in Manufacturing Industry
(1973/74-1995/96)
Figure 4.5: TFPG in the Manufacturing Industry