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Impact of Major Liberalization on Productivity: The J Curve Hypothesis

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I. Introduction

India moved from a growth rate of 3.5% per annum during the period 1950-1 to 1979-80 to a growth rate of about 5.5% per annum thereafter because of gradual liberalization during the 1980's. Following the BOP crisis of 1990-1991, India undertook a deep and wide ranging liberalization of domestic and external policies. However, the growth rate barely moved from the 5.5%-5.8% range, during the 1990s [Virmani(2006a, b)].[4] Many analysts pointed to this puzzle: How could the limited reforms of the 1980s raise the growth rate of the Indian economy by 2 per cent points, while the relatively massive reforms of the 1990s have virtually no affect on the growth trend.

Virmani (2005) proposed the 'J curve of liberalization and productivity' arising from major/large trade (import) liberalization. It was argued that a major liberalization of the kind that happened in India in the 1990s, would lead to a structural transformation of the economy.[5] Because of the enormity of the change the transition from the old globally inefficient to a new more efficient structure would be characterized by a slowdown in (measured) productivity growth and GDP growth in the sectors undergoing this structural transformation. This was due broadly to obsolescence of product lines and capital used to produce it (which would still be a part of measured capital) the gradual adoption and spread of new technology and the diversion of human resource for learning. Virmani (2009) showed that the pattern of GDP growth resulting from the 1990s reforms was in line with the prediction of this hypothesis.[6] The present study analyses the productivity aspects of the growth transition to see if it is consistent with the J curve hypothesis.[7]

There has been an intense debate on the effects of economic reforms on productivity growth of the Indian organized manufacturing. Majority of the studies have found that productivity growth[8] in post reforms period of 1990s witnessed a slowdown as compared to its level in the 1980s.[9] This has baffled one and all, as the reforms process was expected to accelerate the productivity growth. Many studies have tried to provide explanation for this unexpected outcome of the reforms process. A few studies, instead of directly blaming the reforms to the slowdown, have held deteriorating capacity utilization responsible. They argue that owing to the surge in investment activities in the post reforms period, unaccompanied by commensurate expansion of demand, capacity utilization went on worsening in the manufacturing industry, adversely affecting the productivity growth (Uchikawa, 2001, Goldar and Kumari, 2003). Goldar and Kumari (2003) provide numerous evidences of deteriorating capacity utilization in the 1990s. One of the evidences they provide relates to the upward jump in the ratio of gross fixed capital

[4] Alternatively see Virmani (2009) chapter 1 for a summary.
[5] Alternatively, see Virmani (2009) chapter 3.
[6] Chapter 2.
[7] See Virmani and Hashim (2009) for some preliminary results using an alternative approach.
[8] Productivity growth refers to a growth in output that is not explained by some index of input growth. It is a catch-all measure that captures changes in efficiency, capacity utilization, scale economies, pure technical change etc.

[9] See, for instance, Trivedi *et al*. (2000), Goldar (2000), and Goldar and Kumari (2003), Balakrishnan *et al*. (2000), Srivastava *et al*. (2001) and Das (2003).

formation to gross value added (at 1993-94 prices) in the organized manufacturing in the in the 1990s. According to them, the ratio was only 44 per cent during 1985/86 to 1989/90 but touched as high as 76 per cent during 1995/96 to 1997/98. The situation became worse from 1997 through 2001. This is evident from the fact that the ratio of gross capital stock to the gross value of output (at 1993/94 prices) increased from an average of 78.6 per cent during 1992/93-1997/98 to 83.7 per cent during 1998/99-2001/02 before declining sharply to 70 per cent during 2001/02-2005/06. Thus, a right comparison of productivity growth between 1980s and 1990s can be made only if the productivity growth is measured net of capacity utilization. Interestingly, after adjusting for capacity utilization, Goldar and Kumari (2003) found that productivity growth in 1990s stayed at nearly the same level as during 1980s. But the question to answer remained as to why reforms failed to accelerate the productivity growth in the Indian manufacturing. In line with Athukorala and Rajapatirana (2000), they argued that such favorable, productivity-enhancing effects of economic reforms may be manifested with a time lag and hence expected an improvement in productivity growth in the years to come.

The study endeavors to analyze if productivity growth did accelerate in later years, by estimating productivity growth of Indian organized manufacturing industries during the post reforms period of 1992/93 to 2005/06.[10] Based on the broad phases of varying levels of output growth and capacity utilization, the study breaks up the post reforms into the following three sub-periods for a clearer understanding: 1992/93 to 1997/97; 1998/99 to 2001/02; and 2002/03 to 2005/06.[11] Productivity growth during 1990s (till 2001) is expected to be lower than that in the 1980s as we don't allow for adjustment of capacity utilization. However, as capacity utilization after 2001/02 improved considerably, and also enough time lag was allowed, it is expected that productivity growth for 2002/03 to 2005/06 would be much higher than that in the 1980s.

The rest of the paper is structured as follows: Section 2 provides the sources of data, scope of study, and construction of variables. This section also dwells on the trends in relevant variables of the manufacturing industries; Section 3 explains the methodology adopted for the estimation; Section 4 presents the empirical findings; and finally, Section 5 provides the summary and broad conclusions of the study.

II. Data and Variables

A. Sources of Data

For the purpose of estimating the productivity growth, the present study uses the data at two digit level of manufacturing industries drawn from the *Annual Survey of Industries* (ASI), published by the Central Statistical Organization (CSO), Government of India. These series up to

[10] This study, in fact, has used the data from 1991/92 but since in the measurement of growth estimate of first year is not available, the study may be considered to start from 1992/93.

[11] Only two sub-periods, viz., 1992/93 to 2001/02 and 2002/03 to 2005-06 would have served the purpose of present study. However, since most of the studies on productivity estimates of Indian industry have used data up to 1997/98, one more sub-period was introduced to make the results comparable

2001 have been obtained from the *EPW* data bases whereas the data for remaining have been taken from the *CSO* website. As the productivity estimation requires variables in real terms, input and output variables at current prices were deflated with the relevant deflators obtained from various sources. The WPI on various commodities were obtained from the Ministry of Statistics and Program Implementation, Government of India. Owing to the fact that each materials, energy and services consisted of variety of items in their own category, there was a need to construct a weighted price index for each of these three inputs. The required weights for this purpose were obtained from the 'Input-Output' matrix for the year 2003/04, published by CSO. The input-output matrix provides sector specific information on the purchases of inputs from other sectors of the economy, serving a useful purpose of constructing weights. To obtain a series on gross value of capital stock, the net value of capital stock obtained from ASI was multiplied by the gross net ratio (GNR) for the year 1973/74. The required GNR ratio was calculated from the *Reserve Bank of India Bulletin* (1976). In order to deflate the series on stock of capital, an implicit price deflator for capital was constructed. The required series were taken from the *National Accounts Statistics* (NAS).

B. Scope of the study

As mentioned earlier, the present study is based on time series data of two digit manufacturing industry for a period ranging from 1992/93 through 2005/06. The selection of time period was essentially based on the objective of analyzing the manufacturing growth trend through different phases of post reforms period. Due to non availability of data, the analysis could not be extended beyond the year 2005/06, though inclusion of two more years would have been much more desirable from the analysis point view. The following two digit industries were considered for the analysis: (1) Food products & beverages (2) Tobacco & related products, (3) Textiles products, (4) Wearing apparel, dressing & dyeing of fur, (5) Leather & related products, (6) Wood & wood products, (7) Paper & paper products, (8) Publishing, printing & related activities, (9) Coke, petroleum products & nuclear fuel, (10) Chemicals & chemical products, (11) Rubber and plastic products, (12) Non-metallic mineral products, (13) Basic metals, (14) Fabricated metal products, (15) Machinery & equipment n.e.c. (16) Office, accounting & computing machinery, (17) Electrical machinery & apparatus, n.e.c. (18) Radio, television & communication equipments, (19) Medical, precision & optical instruments, (20) Motor vehicles, trailers & semi-trailers, (21) Other transport equipments (22) Furniture & other manufacturing n.e.c.[12]

Out of the above industries, the analysis in present study focuses only on those industries which on an average formed a share of 5 per cent or more in the total output during the study period. On this basis, the following seven industries, in the ascending order of their shares in output, were selected for the analysis: (1) Food products & beverages, (2) Chemicals & chemical products, (3) Basic metals, (4) Textiles products, (5) Coke, petroleum products & nuclear fuel, (6) Machinery and equipment n.e.c., (7) Motor vehicles, trailers & semi-trailers. The remaining

[12] It should be noted that the following industries were excluded from the analysis: (i) Agriculture, hunting & related service activities, (ii) Other mining and quarrying, (iii) Recycling, and (iv) Other industries.

industries were put together in a category called 'Others'. The combined share of seven industries on an average stood at 73 per cent, the remaining 27 per cent being accounted for by the 'Others'.

C. Construction of Variables

In order to obtain the data at constant prices, all the required series were deflated with a relevant price indices with a base of 1993/94=100. In cases where the exact deflators were not available, the best suitable proxies for the industry concerned were picked up from the *WPI* series. As material, energy and services, each consist of variety of items in them, a weighted price series for each of these variables was constructed with the help of 'input-output matrix' of the year 2003-04.

Output

Series on real gross output of each industry was obtained by deflating the nominal figures by the *WPI* of the industry concerned. In some cases, proxies had also to be applied due to non-availability of exact series.

Capital

Net fixed capital (at constant price) is taken to represent the measure of capital stock. Following the usual practice, the net fixed capital stock series were constructed with the help of the *Perpetual Inventory method*. Towards this objective, the following set of information was used: (i) benchmark capital stock, (ii) price of capital assets, (iii) annual gross investment, (iv) life and depreciation of capital assets. The capital stock pertaining to the year 1973/74 was taken as the benchmark stock of capital for each industry. Selection of benchmark year was based on the availability of the 'gross net ratio' at 'all India' level for various industries. Two different price series of capital stock were used for deflation purposes. For deflating the benchmark capital stock (1973/74), a weighted prices index for machinery & construction was used by averaging it over a period of 15 years from 1958/59 to 1973/74. For deflating the capital stock series for remaining years, an implicit price deflator was used. The implicit price deflator was constructed by using the two series at current and constant prices for gross fixed capital formation of the registered manufacturing, obtained from NAS reports.

The annual gross investment series at current prices for a year was derived by adding depreciation of that year to the difference of net fixed capital stock of current year and previous year. By deflating the investment series so obtained by the price of capital, the annual series on real investment was obtained for each industry under consideration. Starting from the benchmark capital stock after allowing for fixed rate of depreciation, and adding real fixed investment for successive years, the net fixed capital stock series was constructed. Capital was allowed to depreciate at the fixed rate of 5 per cent per annum, assuming the life of capital stock of 20 years, as assumed in numerous similar studies including Banga and Goldar (2004).

Labour

Total persons engaged, as reported in ASI, have been taken as the measure of labor input for an industry. In order to make it comparable with other series on inputs, total emoluments, representing the expenses on account of total person engaged, was deflated with a price of series of labour with 1993/94=100. Price of labour was obtained by dividing the total emoluments by the total persons engaged.

Energy

ASI series on fuel consumed is assumed to represent the energy consumption of an industry. Owing to the fact that energy may include varying amounts of coal, petroleum products and electricity, depending upon the nature of an industry, the series on energy was deflated with the weighted price index, weights being derived from the input-output matrix.

Materials

The reported series on materials in ASI has been taken to represent the use of materials by an industry. Since material input may consist of numerous items depending on an industry, a weighted price deflator for this input too was constructed with the help of the input-output of the industry concerned.

Services

ASI doesn't provide a separate data series on services as an input used in the manufacturing process. Following Banga and Goldar (2004), an indirect procedure has been applied to obtain the same. Using the ASI data, the series on services were arrived at by subtracting the expenses on materials and energy from the total inputs. An approximated series on services so obtained would contain the following major items as per the definition provided in *ASI*: (a) cost of contract and commission work done by others on materials supplied by the factory, (b) cost of materials consumed for repair and maintenance of factory's fixed assets including cost of repair and maintenance work done by others to the factory's fixed assets, and (c) inward freight and transport charges, postage and telephone charges, insurance charges, banking charges, etc. For obtaining the expenses on services at constant prices, a weighted price deflator for this input too was constructed with the help of the input-output matrix. The input-output table provided information on the purchases of services (transport, banking, insurance, etc.) by the manufacturing industries. Since the price deflators for services are not available, implicit price deflators for major items of services were constructed using the service sector GDP series at current and constant prices as given in *NAS and corresponding weights are derived from the input-output matrix*. Thus, the series on services are deflated with the weighted price index.

D. Structure and trends of Variables

Structure of variables and their trends are discussed under the following sub headings:

Input Composition and Trends

Inputs have varying proportion of application in the manufacturing process. In general, material input occupies the largest proportion in total income (61.8 per cent), followed by capital (15.3 per cent), services (10.8 per cent), energy (6.3 per cent) and labour (5.7 per cent). A unique feature about the material input is that its share in total cost has virtually remained constant over the years at the aggregate level of manufacturing. Capital, the second largest input in terms of share, has seen its share dwindling over the study period. The declining share of capital could possibly be attributed to the heavy investment during the 1990s which saved the industries from making additional investment later even when demand started picking up rapidly after 2002. In contrast to this, the share of services, the next largest input, has grown the maximum among all the inputs at the rate of 4.3 per cent per annum during the study period, reflecting transformation in the production process in favor of services, mirroring the increase in share of services in national income. Reflecting movement towards energy efficient technology, the share of forth largest input, energy, has witnessed a decline at the rate of 1.4 per cent per annum. Among all the factors which have seen decline in its shares, the labour, already the least used input, has exhibited the maximum decline at the rate of 2.9 per cent per annum. Rapid decline in share of labour is a matter of serious concern given the dire need for increasing the employment in the manufacturing sector. There is, hence, an urgent need to address the issues plaguing the employment potential in the sector (Virmani and Hashim, 2009).

Table 1: Trend in factor shares of Manufacturing Industry

Period	SK	SL	SE	SM	SS
1992/93 - 1997/98	16.0 (1.39)	6.33 (-2.2)	6.70 (-0.4)	62.2 (-1.4)	8.68 (12.6)
1998/99 - 2001/02	15.1 (-2.0)	5.53 (-2.1)	6.26 (-0.6)	60.2 (1.48)	12.7 (-2.5)
2002/03 - 2005/06	14.3 (1.57)	4.75 (-3.1)	5.87 (-2.9)	62.8 (0.84)	12.1 (-1.7)
1992/93 - 2005/06	15.3 (-0.7)	5.65 (-2.9)	6.34 (-1.4)	61.8 (-0.1)	10.8 (4.3)

Note: Figures in parenthesis indicate the average annual growth rate of the variable concerned.

Industry Composition and Trends

Manufacturing sector in India is skewed in favor of just a few industries from the perspective of output share. Only 7 industries out of a total of 22 main manufacturing industries contributed as much as 73 per cent of the gross output over the study period of present study. Indicating a worsening case of such bias, the combined share of this small group of industries went on increasing over the years, contracting the share of 'Other' industries, which are apparently more labour intensive. There are only two industries - Coke, petroleum products & nuclear fuel and Motor vehicles, trailers & semi-trailers - which are responsible for pushing up the share of this small group of industries. While increasing share of these two critical industries may be a welcome sign, the declining combined share of other industries is not a healthy trend considering their importance for other sector of the economy and their huge employment potential. Efforts, therefore, needs be made to encourage healthy blend of sectoral growth.

Table 2: Trend in Industry Composition (shares) of Manufacturing (%)

Period	Food products & beverages	Chemicals & chemical products	Basic metals	Textiles products	Coke, petroleum products & nuclear fuel	Machinery and equipment n.e.c..	Motor vehicles, trailers & semi-trailers	Others
1992/93 - 1997/98	15.7	15.5	13.0	10.7	6.6	5.7	4.5	28.4
1998/99 - 2001/02	16.9	17.3	10.8	9.5	8.2	5.1	4.6	27.6
2002/03 - 2005/06	13.9	13.9	13.2	7.4	14.6	4.6	6.6	25.8
1992/93 – 2005/06	**15.6** (-2.0)	**15.6** (-0.7)	**12.4** (-0.7)	**9.4** (-2.9)	**9.3** (8.5)	**5.2** (-0.7)	**5.1** (6.8)	**27.4** (-0.7)

. Note: (i) Figures in bracket indicate the average annul growth of the corresponding share (ii) Industry with a share of less than 5% are classified under the category 'others'.

Trends in Output and input growth

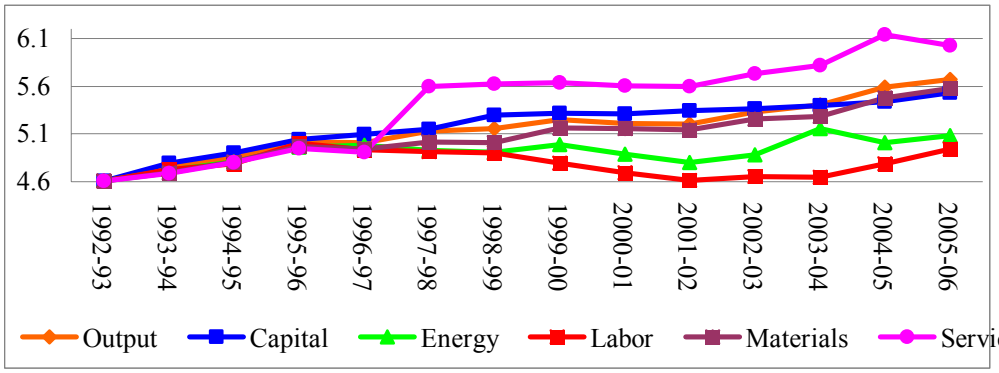
The growth in output and inputs portray a distinct pattern across the sub-periods, justifying the classification of sub-period defined in present study. First sub-period saw the output growth at an impressive rate of 8.7 per cent per annum. The use of inputs also grew at a relatively fast rate during this period to support the growth in output. Among all the inputs, however, capital (9.1 per cent) and services (16.6 per cent) grew more than proportionately. By creating a positive outlook about the economy, the first dose of economic reforms generated a heavy response from the investors. Reforms also helped in increasing the scope of the application of various components of services into the manufacturing sector. Second sub-period witnessed a slump in the expansion of output in back drop of slowing domestic and global demand. The growth in inputs also contracted accordingly. During the last sub-period of the study, output grew rapidly, in tandem with the buoyant growth of domestic and global economy. There was a spurt in the growth of all the inputs, except capital. Lower growth in capital can possibly be attributed to the excess capacity that was built during 1990s. Even though the application of services grew at a healthy rate in this period, it grew at much smaller rate than in the first sub-period. Varying proportion of services, along with its relatively large share in production process, makes it necessary to include services as one of the inputs in the model for estimating productivity growth.

Table 3: Growth in Output and Inputs of Manufacturing Industry (%)

Growth Rates	Total Output	Capital	Labour	Energy	Materials	Services
1992/93 - 1997/98	8.73	9.05	5.16	5.42	6.79	16.56
1998/99 - 2001/02	1.86	4.95	-7.52	-3.22	3.17	-0.02
2002/03 - 2005/06	11.63	4.64	8.26	7.10	11.02	10.78
1992/93 - 2005/06	7.59	6.62	2.42	3.43	6.97	10.17

.

Chart 1: Trends in output and Inputs [Logarithmic Indexes 1992/93 = Ln(100)]



III. Methodology for Measuring Productivity

Output growth can come either from larger application of inputs or from improvement in productivity of inputs or both. Growth in the productivity is emphasized on account of the fact that resources are limited and their judicious use is of paramount importance towards sustaining a high growth in output in the long run. Productivity growth is also considered vital for strengthening the cost competitiveness of industries.

The growth in productivity means getting more output from the same inputs or alternatively, using fewer inputs to obtain the same output (Tretheway et al., 1997). There are two measures of productivity growth, namely, partial factor productivity and total factor productivity (TFP). Partial factor productivity is calculated by dividing the total output by the quantity of an input. The main problem in using this measure of productivity is that it ignores the fact that productivity of an input also depends upon the level of other inputs used. For example, a higher dose of capital application may increase the productivity of labour even when other inputs including labour remain constant. The TFP approach overcomes this problem by taking into account the levels of all inputs used in the production of output (Hashim, 2003). Partial factor productivity, nevertheless, is useful in understanding a few details not evident from the TFP analysis. In present study, therefore, both partial as well as TFP are estimated for the manufacturing industries.

TFP growth can be calculated in number of ways. However, the two most common approaches applied in case of Indian manufacturing are 'growth accounting' and 'econometric estimation'. Growth accounting measure estimates the TFP growth by subtracting the weighted input growth from the output growth. The difference so obtained includes the effects of technological progress, scale of production, learning by doing, technical efficiency etc. The productivity growth can be understood to represent the exogenous shift of a frontier production function (Srivastava, 1996). Though the genesis of this approach can be traced back to the works of Tinbergen (1942) and Solow (1957), it was Jorgenson (1987) who showed that under certain conditions, the growth rate of TFP could be estimated as the growth rate of output minus the growth rate of total input. The growth accounting approach is based on the assumption that

producers are price takers in both output as well as inputs markets, so that output prices are equal to the marginal costs of production and factors are paid their respective marginal products. The approach also assumes technology to be of constant returns to scale. When it is difficult to satisfy these assumptions, a direct econometric estimation of production function is usually undertaken, which however, has its own limitations. The problems such as multicollinearity, autocorrelation and the need for large sample associated with the econometric estimation procedure may often pose serious challenge to the correct estimate of the parameters of production function (Trivedi et al., 2000). In order to avoid these problems, the present study makes the use of growth accounting approach for estimation of productivity growth.

There are various approaches within the growth accounting technique of estimating productivity growth. The present study is based on Translog index and does not apply either Kendrick Index or Solow Index as both these approaches suffer from their own limitations. Traslong index has the advantage that it does not make rigid assumptions about elasticity of substitution between factors of production. Nor does it assume technological progress to be Hicks-neutral. It also allows for variable elasticity of substitution. Most of the recent studies on the measurement of productivity in the Indian industries have undertaken discrete approximation of the Translog Production Function in the form of Translog Index.

For a five inputs case, the Translog Index can be defined as follows:

$$\Delta \ln TFP_t = \Delta \ln Y_t - \left[\frac{(SK_t + SK_{t-1})}{2} \times \Delta \ln K_t\right] - \left[\frac{(SL_t + SL_{t-1})}{2} \times \Delta \ln L_t\right] - \left[\frac{(SE_t + SE_{t-1})}{2} \times \Delta \ln E_t\right] -$$
$$- \left[\frac{(SM_t + SM_{t-1})}{2} \times \Delta \ln M_t\right] - \left[\frac{(SS_t + SS_{t-1})}{2} \times \Delta \ln S_t\right]$$

In the above equation, Y = output, K = capital, L = labour, E = energy, M = materials, and S = services. SK, SL, SE, SM and SS are income shares of capital, labour, energy, materials, and services respectively. All the income shares sum up to unity.

IV. Empirical Findings

Partial Factor Productivity Growth

Though the results on partial factor productivity growth of the five inputs show varied result across inputs as well as sub-periods, they are largely on expected lines. In the first sub-period, the productivity of capital declined marginally (-0.2 per cent), attributable mainly to large expansion of capacity immediately after the economic reforms. In the next sub-period (1998/99-2001/02) when growth in output declined considerably, the problem of excess capacity aggravated as reflected in 2.8 per cent decline in productivity of capital during this period. Capital productivity during the last sub-period (2002/03-2005/06) grew by a whopping 7.5 per cent. Substantial growth in output witnessed in the last sub-period allowed industries to utilize their

capacity to the fuller extent. Yet, the productivity of capital during the study period as whole could increase by only 1.2 per cent. Productivity growth of materials too followed a similar trend, except for the fact that recovery in case of material during third sub-period was much smaller.

In contrast to capital and materials witnessing negative productivity growth during second sub period, labour and services recorded their best performance during this period. Despite similarity in the pattern of growth, however, both labour and services ended up recording much different growth rate over the study period. While productivity of labour increased by an average annul rate of 5.6 per cent that of services declined by 1.4 per cent. High growth in labour productivity can, no doubt, be linked to the application of modern technology combined with greater doses of capital; it can also be linked to the rigidity in labour laws, dissuading organized manufacturing industries to expand the employment as large as they would have done otherwise (Virmani, 2004, 2005; Virmani and Hashim, 2009). Negative productivity growth in services was the result of 6.6 per cent decline in its productivity during first sub period. Not surprisingly, therefore, Banga and Goldar (2004) found a decline in overall productivity growth for the post reforms period after they included services as additional input in their model. Even though the productivity of services became positive in subsequent periods, it was relatively low. When all other factors witnessed a surge in productivity growth during third sub period from the level in previous period, services saw deterioration in its productivity and ended up recording much slower growth than capital, labour and energy. Continuing poor performance of services on productivity front is a matter of concern as its share in production process is augmenting fast. Development of economically and technically efficient infrastructure facilities, such as banking, trade, transport, hotels etc holds the key in this regard. Energy recorded a healthy average growth of 5 per cent per annum during the study period, indicating that technological changes have been energy saving. Energy is the only inputs whose productivity has consistently improved across the sub periods.

Table 4:Growth in Productivity of Factors in Manufacturing Industry (%)

Period	Capital	Labour	Energy	Materials	Services
1992/93 -1997/98	-0.2	3.9	3.7	2.0	-5.6
1998/99 - 2001/02	-2.8	10.0	5.2	-1.2	2.0
2002/03 -2005/06	7.5	3.7	6.6	0.7	1.5
1992/93 - 2005/06	1.2	5.6	5.0	0.7	-1.4

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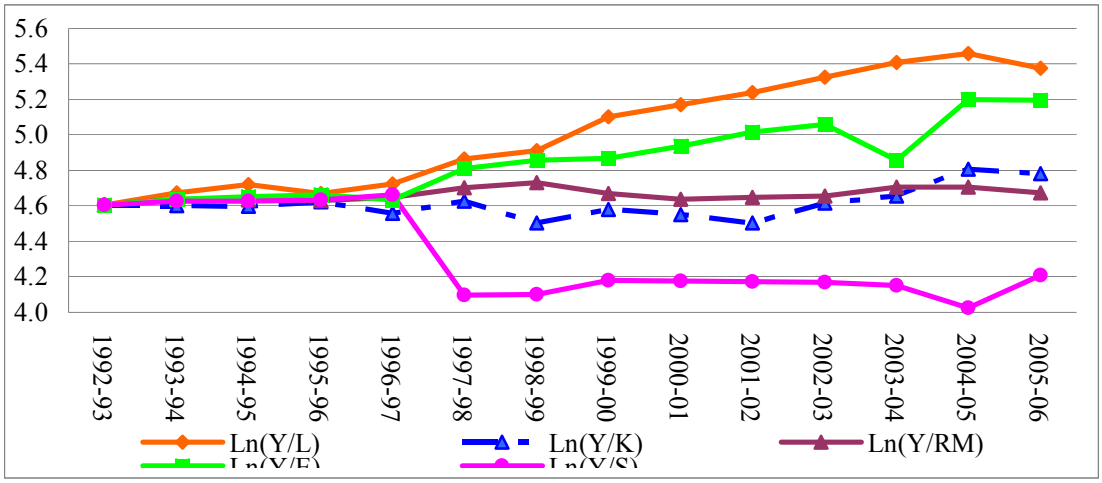
Chart 2: Trend in Productivity of Factors [Logarithmic Indexes 1992/93 = Ln(100)]



Source: Based on Authors' own calculations.

Likewise the productivity at aggregate level of manufacturing, partial factor productivity across sub periods vary greatly, and in general, maintain the same trend. Within a sub period, wide differences in partial factor productivity across industries are evident. As regards the productivity of capital, noteworthy is the exceptional growth during third sub period recoded by Motor vehicles (26.7%), Coke and petroleum products (13%), Machinery (10.7%) and Others (10%). It is interesting to note the same set of industries recorded similar exceptional growth in productivity of labour and energy as well in the third sub period. In case of materials and services, such exceptions were rare across the industries.

Table 5: Growth in Partial Productivity of factors across Industries and sub periods

	Food Products And Beverages	Chemicals And Chemical Products	Basic Metals	Textiles Products	Coke, Petroleum Products And Nuclear Fuel	Machinery And Equipment N.E.C.	Motor Vehicles, Trailers And Semi-Trailers	Others
	Capital							
1992/93 -1997/98	-2.8	-1.4	3.0	-0.2	0.9	1.6	4.3	-0.1
1998/99 - 2001/02	-2.2	-2.7	0.4	-0.3	-4.0	0.6	-6.9	-1.3
2002/03 -2005/06	3.7	6.6	5.1	4.8	13.0	10.7	26.7	10.1
1992/93 - 2005/06	-0.8	0.5	2.8	1.2	2.9	3.9	7.5	2.5
	Labour							
1992/93 -1997/98	3.6	4.7	7.9	10.1	6.4	8.2	10.6	6.3
1998/99 - 2001/02	4.2	3.2	4.6	5.5	11.8	10.7	6.7	8.2
2002/03 -2005/06	6.5	6.9	8.5	6.4	14.4	12.7	20.6	8.4
1992/93 - 2005/06	4.6	4.9	7.1	7.7	10.2	10.2	12.3	7.5
	Energy							

1992/93 -1997/98	3.3	3.9	4.3	4.5	-0.6	4.1	2.9	5.7
1998/99 - 2001/02	2.8	5.5	2.5	6.4	31.6	7.6	14.6	6.0
2002/03 -2005/06	3.0	9.5	1.5	5.4	13.8	25.6	31.0	10.5
1992/93 - 2005/06	3.0	5.9	3.0	5.3	12.7	11.2	14.2	7.1
	Materials							
1992/93 -1997/98	2.7	1.3	3.9	2.1	-0.5	3.2	0.1	1.4
1998/99 - 2001/02	0.7	-1.9	-3.1	-1.3	0.4	-0.7	-2.4	-0.9
2002/03 -2005/06	2.0	-1.2	-0.9	0.6	1.5	-1.1	8.9	1.9
1992/93 - 2005/06	1.9	-0.3	0.5	0.7	0.3	0.9	1.9	0.9
	Services							
1992/93 -1997/98	-9.5	-6.8	0.2	-5.4	-1.7	-3.3	-0.9	-5.4
1998/99 - 2001/02	-4.2	6.6	6.5	10.3	2.3	2.7	2.8	1.9
2002/03 -2005/06	0.1	1.8	-5.7	-1.0	7.9	1.9	53.7	3.7
1992/93 - 2005/06	-5.3	-0.5	0.3	0.3	2.2	-0.1	15.8	-0.7

Total Factor Productivity Growth

In line with the pattern of output growth, the TFP growth of the manufacturing sector was positive during the first sub period (1992/93 - 1997/98), slumped in the next (1998/99 - 2001/02) and rose sharply in the final sub-period (2002/03 -2005/06). In the first sub-period, TFP grew at the rate of 0.7 per cent per annum (table 6, last column). This represented a deceleration from the average annual productivity growth of 1.3 per cent registered during 1980/81-1989/90, as reported in Banga and Goldar (2004). It can therefore be argued that productivity growth in the post-reform period of the 1990s was lower than it was during the 1980s. TFPG started showing marked improvement in tandem with the buoyancy of industry as well as the economy during the 2000s. During 2002/03 to 2005/06 period, TFP grew impressively at the average rate of 1.9 per cent per annum (table 6, last column).

Productivity growth across the industry, by and large, conforms to the trend of productivity growth at the aggregate level. Most of the manufacturing industries performed the worst during second sub-period and the best during third sub-period. Yet, the magnitude of productivity growth across industries as well sub-periods vary greatly. Food and beverages is the only industry closest to the magnitude of productivity growth at the aggregate level. Motor vehicles, machinery& equipments, and textiles products did much better than the aggregate manufacturing in terms of magnitude of growth. In fact, the motor vehicles during third sub-period registered the highest productivity growth (8.1 per cent) ever registered by an industry in post reforms period. Chemicals; and Coke, petroleum products & nuclear fuel are the two industries which consistently recorded improvement in TFP growth, starting with a negative performance during first period. Basic metals is the only among the industries recording negative productivity growth even during third sub-period, despite starting with an impressive performance during first sub-period.

Industries forming the category 'others' recorded negative productivity growth during the first two sub-period, before registering a stupendous growth of 2.8 per cent for third period.

Table 6: TFP Growth in Indian Manufacturing Industries (%)

Period	Food products & beverages	Chemicals & chemical products	Basic metals	Textiles products	Coke, petroleum products & nuclear fuel	Machinery and equipment n.e.c.	Motor vehicles, trailers & semi-trailers	Others	All mfg
1992/93 to 1997/98	0.84	-0.42	3.02	1.27	-0.64	2.06	0.73	-0.04	0.73
1998/99 to 2001/02	-0.24	-0.33	-1.04	1.20	-0.47	1.00	-2.27	-0.08	-0.14
2002/03 to 2005/06	1.87	1.70	-0.37	1.46	2.93	2.21	8.09	2.75	1.89
1992/93 to 2005/06	0.83	0.21	0.89	1.31	0.43	1.80	1.98	0.74	0.81

Source: Authors' own calculation.

J curve of Productivity and Liberalisation

The BOP crisis that started in 1990 and impacted the economy severely in 1991 had its greatest impact on the manufactured sector. The manufacturing sector was also the one most directly affected by the trade and exchange reforms of the 1990s. Thus the J curve hypothesis (Virmani (2005), (2009)) is most relevant for the path of TFPG in this sector. TFPG growth decelerated in the first sub-period because of the combined effects of the BOP shock and the J curve effect arising from the dramatic import liberalization (removal of QRs on capital goods and intermediates and tariff reduction) and exchange rate reforms of the early 1990s (from fixed rate to managed float). With the completion of the liberalization in the late nineties-early 2000s (removal of QRs on consumer goods and further reduction in import duties), rendered certain types of capital obsolescent, measured TFPG growth therefore became negative 0.14 % during the second sub-period. As the dissemination of new technologies and products progressed from early adopters to others, TFPG accelerated sharply during the third sub-period to 1.9% per annum, almost 50% higher than the TFPG during the 1980s.

At a sub sector level one would expect the weakest J curve effect in globally competitive industries/sub-sectors and the strongest in those in which the technology productivity gap with global best practice was the largest. At the end of the 1980s, textiles and Gems and Jewlery had the highest share among manufactured exports. A substantial part of the Textile industry, with the possible exception of the segments based on man-made fibres and synthetic material, were globally competitive. The minimal effect of liberalization on TFPG in this sub-sector (1.3% 1.2%, 1.5%) is therefore consistent with the J curve hypothesis. The machinery and equipment sector shows a continuing high level of TFPG growth with a slight dip in the second sub-period (2.1%, 1%, 2.2%) that is similar to that of the textiles sector. This is slightly surprising, as this sub-sector was, at the start of reforms, neither prominent in the export basket nor was it reputed to be particularly advanced in technology. We hypothesise that capital goods production in India reflects the duality of the Indian economy in terms of modern formal, organized sector and unorganized, informal small scale sector. Much of the formal capital goods sub-sector

(represented in this study) produces capital goods for the latter, using "appropriate small scale technology," that has few competitive substitutes globally. Thus the degree of obsolescence from the dramatic opening of imports was limited to a small part of this sector with minimal impact on overall TFPG. On the other hand easier access to technology led further adaptation and incorporation of improved technology from the modern capital goods sector.

In contrast to these two sub-sectors, the maximum technological gap with the global frontier was in the Automobile sector. Not surprisingly therefore the sharpest J curve effect is found in the Motor vehicles sub-sector, with TFPG at a low 0.7% in the first sub-period, collapsing to -2.3% in the second sub-period and then rising sharply to 8.1% in the third sub-period. Food products follow the same pattern (0.8%, -0.2%, 1.9%), but closer to that of manufacturing as a whole. Three sub sectors, Chemicals and allied(-0.4%, -0.3%, 1.7%), Coke, Petroleum products etc(-0.6%, -0.5%, 2.9%) and the residual sub-sectors 'Others'(-0.04%, -0.08%, 2.75%) follow a more prolonged period at the bottom with both first and second sub-period showing negative TFPG and then a sharp rise. This could be due to a combination of a sharper obsolescence effect and slower diffusion of technology. For instance both the chemicals and the 'other' sectors are characterized by a diversity of products and producers (including many small scale ones) so that the diffusion of technology may have been slower. Though the Petro products sector has less diversity of products and a small number of very large companies, the capital intensive lumpy nature of capital stock in this industry may have slowed diffusion of technology.[13]

The Basic metals sub-sector shows a TFPG pattern(3%, -1%, -0.4%) that is either, (a) still at the bottom of the J curve, in which case subsequent years should show a sharp uptick in TFPG, or (b) is the obverse of that predicted by the J curve hypothesis. Additional, post 2005-6 data points will be needed to resolve this issue.

Sources of Output Growth

Sources of output growth in manufacturing industry have shown dramatic changes over the years. Except material which has remained the largest contributor to the output growth across sub periods, factors have contributed differently during the three sub-periods. In first sub-period, capital contributed a significant 16.5 per cent of the total output growth on the back of a large expansion in investment activities. Contribution of labour was to the extent of 3.8 per cent, much better than its overall average (1.8 per cent) during the study period. Energy and services also registered much better contribution during this period than their average contribution over the study period. It was only material which contributed much smaller (48.7 per cent) than its average (56.8 per cent). Lower contribution of materials can possibly be attributed to the fast expansion of capacity which could not be utilized fully due to lack of commensurate growth in demand. If the demand had also grown faster, not only that material had ended up contributing more, but the contribution of other factors would have also been possibly higher, making a case of elevated

[13] This goes along with the oligopolist nature of the industry. Substantial government ownership may also have contributed to slowness in adopting new technology.

contribution of TFP. So the slower growth in productivity during the 1990s can be attributed to the slower growth in demand, which failed to fully utilize the fast expanding capacity.

Table 7: Sources of Output Growth in Indian Manufacturing (%)

Period	Growth rate of Output (%)	Sources of Output Growth					
		Capital	Labour	Energy	Materials	Services	TFPG
1992/93 to 1997/98	8.7	1.44 (16.5)	0.33 (3.83)	0.36 (4.15)	4.25 (48.7)	1.60 (18.4)	0.72 (8.35)
1998/99 to 2001/02	1.9	0.77 (41.6)	-0.4 (-22.0)	-0.2 (-11.2)	1.84 (99.1)	0.00 (0.40)	-0.14 (-7.4)
2002/03 to 2005/06	11.6	0.66 (5.71)	0.39 (3.37)	0.44 (3.82)	6.89 (59.2)	1.35 (11.6)	1.88 (16.2)
1992/93 to 2005/06	7.6	1.02 (13.5)	0.13 (1.79)	0.22 (2.93)	4.31 (56.8)	1.07 (14.1)	0.81 (10.7)

Source: Authors' own calculation. Figures in bracket indicate the percentage contribution of the corresponding variable in output growth.

In second sub-period, slump in the output expansion changed the sources of output growth drastically. Despite capital contribution in actual terms falling to around half, its share in output growth went up to 41.6 per cent. Labour and energy found their share shrinking to negative whereas the contribution of services came to near zero. Materials made a heavy contribution (99.1 per cent) to the growth in output during this period. Not surprisingly, the total factor productivity became negative during this sub-period.

Third sub-period witnessed the surge in output expansion and drastic changes in the composition of output growth. During this period, output grew by nearly 12 per cent. This happened despite the fact that contribution of capital in both absolute as well and share terms declined considerably. Decline in share contribution of capital be interpreted to mean that the existing capacity was utilized more intensely, as the contributions of other inputs went up significantly. Labour contributed 3.4 per cent of the output growth, much higher than the its average. Similar was the case with the contributions of energy (3.8 per cent), materials (59.2 per cent) and services (11.6 per cent). This also paved the way for considerable improvement in contribution of TFP to the output growth, reaching 16.2 per cent.

V. Summary and Conclusion

Majority of the studies on the impact the economic reforms on productivity growth in Indian manufacturing have found that productivity growth in the post reform period of 1990s declined as compared to its level during 1980s. Poor capacity utilization during the 1990s was attributed as one of the main reasons. However, even after correction for capacity utilization, Goldar and Kumari, 2003 did not find trace of productivity acceleration in the 1990s. They argued for a case of time lag between reforms and its impact on productivity growth and hence felt that productivity could improve in later years. The present study endeavors to see if productivity

growth indeed improved in later years when the issue of capacity utilization also eased. The study analyses the performance of productivity growth (both in terms of partial as well as TFP) along with other sources of output growth in post reforms period from 1992/93 to 2005/06. It laso anlsyes the performance of industries across the following sub periods when varying levels of output growth and capacity utilization was experienced: 1992/93 to 1997/98; 1998/99 to 2001/02; and 2002/03 to 2005/06. It uses *ASI* data on digit level of manufacturing industries and estimates the productivity growth through discrete approximation of the Translog Production Function in the form of Translog Index.

The results on partial factor productivity growth are largely on expected lines. In the first sub-period, the productivity of capital declined marginally, followed by a sharper fall in next sub period before registering heavy improvement in the final sub period, reflecting varying stages of capital utilization. Similar was the case with productivity growth of materials during the three sub-periods. However, the productivity of material over the study period could increase by less than 1 per cent. Furthermore, it recorded the lowest productivity growth among all inputs during the third period. Materials, being the largest input in the production process, would help the cause of overall improvement in productivity if its own performance can be improved. Efforts could be made to see how technology could be used to enhance the productivity of this dominant input.

Labour and services followed a different pattern of productivity growth by recording their best performance during second sub-period. Among all the inputs, labour recorded the best productivity performance at the rate of 5.5 per cent pert annum. Besides the larger use of capital and modern technology, this could possibly be attributed to the rigid labour laws which keep the growth in employment lower than its potential. Services, after recording heavy negative growth during first sub period, showed improvement in productivity during next sub periods. But its productivity growth even during third sub period continued to be low and in fact deteriorated from its level in the previous sub period, highlighting the need for promoting productivity oriented services. Energy is the only inputs having consistently improved its productivity growth over the years, indicating the application of energy efficient technology. Result on partial factors productivity across industry showed an exceptional growth in productivity of capital, labour and energy during third sub period in Motor vehicles; Coke and petroleum products; Machinery' and Others.

Growth in TFP also increased during first, slumped in next and rose sharply in the final sub-period. In the first sub-period, TFP increased at the rate of 0.7 per cent per annum (without adjusting for capacity utilization), slower than 1.3 per cent during the 1980s as reported in Banga and Goldar (2004). Adding second sub period to it would further deteriorate the productivity performance of the post reform period up to 2001. However, during 2002/03 to 2005/06 period, TFP grew impressively at the average rate of 1.9 per cent per annum, much better than the productivity growth of 1980s. Hence, as was expected by Godar and Kumar (2003), economic reforms have started showing positive impact on productivity.

Productivity growth across industry, by and large, conform to the trend in productivity growth at aggregate level. Yet, the magnitudes of productivity growth across industries as well as across sub-periods vary greatly. While Food and beverages stood close to the performance at aggregate level, Motor vehicles, machinery& equipments, and textiles products did much better. Chemicals and Coke are the two industries which consistently recorded improvement in TFP growth, starting with a negative performance during first period. Basic metals is the only among the industries recording negative productivity growth even during third sub-period, despite starting with an impressive performance during first sub-period. Industries forming the category 'others' recorded negative productivity growth during the first two sub-period, before registering a stupendous growth of 2.8 per cent for third period. There is hence a need not only to accelerate the productivity growth in manufacturing sector in general, but also pay a special attention, where productivity growth is lagging.

Results on sources of output growth have shown dramatic changes across sub-periods. In first sub period, capital and services had much larger share than their average over the study period. In the second sub-period, the share of capital and materials went up significantly while those of labour, energy, services and productivity slumped. Opposite happened in the next sub period, when shares of capital and materials declined considerably as against the share of labour, energy, services and productivity witnessing recovery. Contribution of productivity to the output growth during 2002/03 to 2005/06 at 16.2 per cent was much higher than during the previous sub-periods. It was also more than double of the contribution of productivity at 7 per cent during 1980s as estimated by Banga and Goldar (2004). Reforms, hence, have indeed started showing positive impact on productivity growth and its contribution, albeit belatedly.

The J curve of liberalization and productivity growth hypothesis, proposed in Virmani (2005) and Virmani (2009) consistent withand supported by the pattern of TFPG growth found in this study. TFPG growth decelerated in the first sub-period because of the combined effects of the BOP shock and the J curve effect arising from the dramatic import liberalization and exchange rate reforms of the early 1990s. With the completion of the liberalization in the late nineties-early 2000s, rendered certain types of capital obsolescent, measured TFPG growth therefore became negative 0.14 % during the second sub-period. As the dissemination of new technologies and products progressed from early adopters to others, TFPG accelerated sharply during the third sub-period to 1.9% per annum, almost 50% higher than the TFPG during the 1980s.

The pattern of TFPG growth in the sub-sectors of manufacturing, with a few exceptions, was also broadly consistent with the J curve hypothesis. At a sub sector level one would expect the weakest J curve effect in globally competitive industries/sub-sectors and the strongest in those in which the technology productivity gap with global best practice was the largest. At the end of the 1980s, textiles had a high share of manufactured exports and a substantial part of the Textile industry was globally competitive. The minimal effect of liberalization on TFPG in this sub-sector (1.3% 1.2%, 1.5%) is therefore consistent with the J curve hypothesis. The machinery and equipment sector shows a continuing high level of TFPG growth with a slight dip in the second

sub-period (2.1%, 1%, 2.2%) that is similar to that of the textiles sector. In contrast to these two sub-sectors, the maximum technological gap with the global frontier was in the Automobile sector. Not surprisingly therefore the sharpest J curve effect is found in the Motor vehicles sub-sector, with TFPG at a low 0.7% in the first sub-period, collapsing to -2.3% in the second sub-period and then rising sharply to 8.1% in the third sub-period. Food products follow the same pattern (0.8%, -0.2%, 1.9%) close to that of manufacturing as a whole. Three sub sectors, Chemicals and allied(-0.4%, -0.3%, 1.7%), Coke, Petroleum products etc(-0.6%, -0.5%, 2.9%) and the residual sub-sectors 'Others'(-0.04%, -0.08%, 2.75%) show a more prolonged period at the bottom followed by a sharp rise.

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Appendix

Table: Average share of inputs across industry: 1992/93 to 2005/06

Industry	Shares of				
	Capital	Labour	Energy	Materials	Services
Food Products & Beverages	9.20 (-1.9)	3.80 (-1.6)	3.17 (-0.0)	73.54 (-1.0)	10.29 (11.9)
Chemicals & Chemical Products	21.20 (-1.5)	4.93 (-1.1)	8.36 (-2.0)	54.47 (0.4)	11.03 (3.4)
Basic Metals	16.49 (0.5)	5.37 (-2.7)	12.24 (-0.3)	56.98 (-0.2)	8.92 (2.6)
Textiles Products	12.03 (-1.6)	7.91 (-2.3)	8.87 (1.5)	60.09 (-0.6)	11.10 (6.0)
Coke, Pet. Products & Nuclear Fuel	13.48 (-1.3)	1.36 (-5.8)	1.85 (-6.1)	80.31 (0.5)	3.00 (-0.8)
Machinery & Equipment (nec).	15.51 (-1.8)	8.91 (-1.1)	2.57 (-0.2)	56.83 (-0.3)	16.18 (3.7)
Motor Vehicles, Trailers & Semi Trailers	15.26 (-1.8)	6.56 (-4.3)	2.67 (-3.2)	63.39 (-0.7)	12.13 (6.9)
Others	16.42 (-1.1)	7.40 (-1.7)	4.95 (-0.2)	56.71 (-0.3)	14.52 (3.9)

Note: Figures in parenthesis indicate the average annual growth rate of the variable concerned.