WP/03/22

IMF Working Paper

Productivity Trends in India's Manufacturing Sectors in the Last Two Decades

Bulent Unel

INTERNATIONAL MONETARY FUND

 WP/03/22

IMF Working Paper

Asia and Pacific Department

Productivity Trends in India's Manufacturing Sectors in the Last Two Decades

Prepared by Bulent Unel[1]

Authorized for distribution by Kalpana Kochhar

January 2003

Abstract

Starting in the late 1970s, the Indian authorities implemented a series of reforms aimed at exposing the economy to greater competition and at liberalizing key aspects of economic activity. This paper investigates productivity trends in India's (registered) manufacturing sectors during the 1980s and 1990s. The main findings of the paper are (i) labor and total factor productivity (TFP) growth in total manufacturing and many of the component sectors since 1980 were markedly higher than that in the preceding two decades, although the extent of the acceleration in TFP growth depends critically on the underlying assumptions about factor elasticities and the assumed structure of the production function; (ii) productivity growth for total manufacturing as well as for many subsectors picked up further after the 1991 reforms; and (iii) classification of the best performing sectors and the weakest performing sectors, based on comparative TFP, remains robust to changes in underlying assumptions.

JEL Classification Numbers: O40, O47, E10

Keywords: Labor productivity, factor productivity

Author's E-Mail Address: Bulent Unel@brown.edu

[1] This paper was prepared during the author's assignment as a summer intern in the Asia and Pacific Department. The author is grateful to Jahangir Aziz, Kalpana Kochhar, and Ranil Salgado for their invaluable comments and constant support. He would also like to thank David T. Coe, Tarhan Feyzioglu, Yougesh Khatri, and seminar participants at the IMF for their helpful comments.

Content Page

I. Introduction

India's post-independence development plans emphasized industrialization as a very important instrument for sustained growth. Before 1980, based on the perception of Soviet Union success, it was thought that the key strategy for development was to focus on **large** and heavy industries under **state control** and **central planning**. The strategy also involved **import substitution, rigid price controls**, and **severe restrictions on private initiatives** (Srinivasan (1996)). This strategy is now widely acknowledged to have been unsuccessful. In the manufacturing sector, for example, the annual average growth rates of labor and factor productivity were about 2 percent and 0 percent, respectively, from 1959/60 to 1979/80 (Ahluwalia (1991), Table 3.2).

The disappointing performance of the industrial sectors, therefore, forced policymakers to revise their policy tools. In the late 1970s, they started to implement some reforms such as "reducing the barriers to entry and expansion, simplifying procedures, and providing easier access to better technology and intermediate material imports," (Ahluwalia (1991)). There were some additional reforms during 1980s, but the most radical reforms occurred since 1991, after the severe economic crisis in fiscal year 1990/91.[2]

The most important reforms were (i) reduction in and/or abolition of some restrictions, such as high tariff rates, import licensing, and quantitative restrictions on international trade; (ii) reducing the barriers to entry for foreign direct investment; (iii) abolition of industrial licensing for almost all industries; (iv) allowing private initiative in industries previously reserved for the public sector; (v) reduction in the tax rates along with simplifications in tax structures; and (vi) introducing greater flexibility in interest rates and improving the supervision and regulation of the banking system.[3]

Several studies have examined the impact of the reforms on the economy at an aggregate level (Joshi and Little, 1996; and Srinivasan, 1996). However, there have been few systematic studies of the effects of these reforms on productivity using aggregate or sectoral level data.[4] The purpose of this paper is to evaluate the impact of these reforms of the 1980s and the 1990s on the manufacturing sectors in India by analyzing the productivity performance of (registered) manufacturing over the period 1979/80 to 1997/98. Although six years of data may not be enough to fully evaluate the long-run implications of the reforms of the 1990s, analysis of

---

[2] During the 1980s, India's GDP growth rate was above 5 percent. However, this rapid growth reflected expansionary fiscal policy, which led to an unsustainable fiscal deficit of about 12 percent of GDP in 1990/91. For details, see Shome and Mukhopadhyay (1998) and Srinivasan (1996).

[3] For complete list and discussion, see Shome and Mukhopadhyay (1998) and Srinivasan (1996).

[4] An important exception is Ahluwalia (1991), but her analysis considers only the first half of the 1980s.

productivity trends through 1997/98 could provide some preliminary insights about the effects of the reforms and also enable some discussion of the priorities for the so-called "second-generation" reform agenda.

The main results of this paper can be summarized as follows. First, labor and total factor productivity (TFP) growth in total manufacturing and most of the subsectors since 1980 were remarkably higher than those in the period between 1959/60 to 1979/80, although the extent of the acceleration in TFP growth depends critically on the underlying assumptions about factor shares and the assumed structure of the production function. Second, the growth rates of these variables for total manufacturing and many subsectors picked up further after the 1991 reforms. Third, classification of the best performing sectors—chemical, machinery, and transport—and worst performing sectors—beverage and tobacco, wood, and paper—based on comparative TFP growth remains robust to changes in underlying assumptions.

The rest of the paper is organized as follows. Section II contains a description of the data. Section III outlines a theoretical framework for the empirical analysis. Section IV implements the growth accounting procedure to analyze the sources of economic growth in total manufacturing and each subsector before and after the reforms. Finally, Section V offers some concluding remarks and possible extensions of the current work.

II. Data Sources and Construction

The main data source is the *Annual Survey of Industries* (ASI), which is published by the Central Statistical Organization of India. The ASI considers only registered manufacturing sectors, which, in terms of value added, represent about 58–67 percent of total manufacturing. In the ASI, the manufacturing industry is classified into 23 sectors at two-digit industrial classification levels. In this paper, we have further grouped some closely related sectors, partly because of limits on the availability of relevant deflators from the wholesale price index, and partly to reduce the errors related to the reclassification of industries in 1987.[5] Hence, the quantitative analysis for this paper employs data for 13 manufacturing sectors over the period 1979/80 to 1997/98. Table 1 reports the composition of sectors.

---

[5] Cotton textiles, wool and silk textiles, jute textiles, and textile products sectors are combined under the textile sector. Basic metal and alloys and metal products sectors are combined under the metal sector. Machinery and machine tools are combined under the machinery sector. Finally, we ignored electricity, gas and steam, water works and supply, cold storage, and repair sectors. Dropping these sectors from consideration needs some further explanation. The repair sector data was so irregular that we could not conduct productivity analysis as in other sectors. However, we deliberately dropped the power sector from the analysis. The power sector was usually required to supply all the power demanded at regulated prices. Thus, output levels are not endogenous and hence the classic profit maximization approach will not be appropriate. To correct for this, the usual solution is to formulate the problem in terms of cost structure. For detail, see Christensen and Greene (1976).

Table 1. Manufacturing Sectors

1. Food Products	8. Rubber and Plastic Products
2. Beverage and Tobacco	9. Non-Metallic Mineral Products
3. Textile	10. Metal Products
4. Wood Products	11. Machinery and Machine Tools
5. Paper and Paper Products	12. Transport Equipment
6. Leather and Leather Products	13. Miscellaneous
7. Chemical and Chemical Products	

Source: *Annual Survey of Industries*.

The ASI data on total output, net value added, total input, total number of people engaged in production, depreciation, total net fixed assets, profit, labor compensation, and inventories are in levels at the end of the financial year, and all series are in nominal terms. By using appropriate price index series, we converted the nominal values to the real values, at 1993 constant prices.[6]

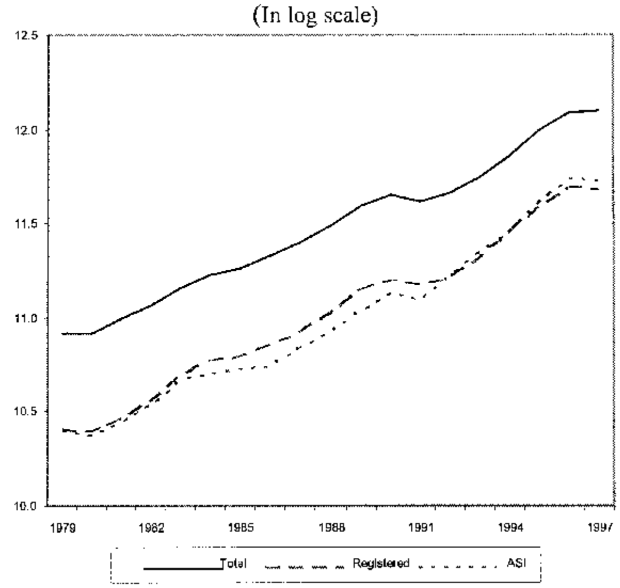
Although there are some problems with the reliability of the ASI, such as variations in coverage, changes in industrial classification, missing variables, and so on, the ASI is the only publicly available source for data on output, employment, compensation, capital stocks, etc. Ahluwalia (1991), for example, reports that there are differences between ASI data and the disaggregated National Accounts (NA) data, which are obtained by correcting for the changes in coverage and classifications in the ASI data. Although the exact comparison between the ASI and the NA is beyond the scope of the current work, Figure 1 reports the time series of total and registered manufacturing sectors in the NA as well as the time series of total manufacturing sector in the ASI.[7] Note that the differences between manufacturing in the ASI and registered manufacturing in the NA are not so substantial. Moreover, manufacturing in the ASI excludes some component sectors while the NA includes them. This suggests that misclassification and changes in coverage may not have significant effects on the analysis. In this figure, it is also clear that manufacturing in the ASI and the registered manufacturing in the NA have steeper

[6] In Appendix I, we discuss in detail the nature of the ASI data set and the construction of the basic variables such as gross value added, gross fixed capital formation, and price index series.

[7] Total manufacturing sector in the NA includes registered and unregistered manufacturing sectors. NA data on registered manufacturing also excludes the power sector, but includes repair and some additional miscellaneous subsectors. The ASI data refer to the total value added of the above 13 manufacturing sectors.

trends than total manufacturing in the NA, which implies that unregistered part has grown relatively more slowly.[8]

Figure 1. Total and Registered Manufacturing in the NA and the Total Manufacturing in the ASI
(In log scale)



Sources: ASI and author's own calculations.

III. Theoretical Framework

This section outlines a simple production framework on which the subsequent empirical analysis is based. Value added $Y_i(t)$ produced at time t in sector i is given by

$$Y_i(t) = F_i(K_i(t), L_i(t), t), \qquad (2.1)$$

where $K_i(t)$ is physical capital, $L_i(t)$ is the total amount of labor employed in production, and t is time and considered to be an index of TFP. In the rest of this section, to simplify the notation, the sector index i is suppressed.

[8] The growth rate of value added of the total, registered, and unregistered manufacturing sectors in the NA and manufacturing in the ASI are 6.5 percent, 7.1 percent, 5.6 percent, and 7.4 percent, respectively.

We now discuss two important elements of this production function: physical capital and factor productivity. Physical capital is accumulated by

$$\dot{K}(t) = I(t) - \delta K(t), \quad K(0)>0 \tag{2.2}$$

The variable $I(t)$ denotes the investment in physical capital and δ denotes the constant depreciation rate. Implicit in this formulation is the assumption that we are using net capital stocks.[9]

Turning next to factor productivity: the rate of productivity change $g(t)$ is defined by differentiating logarithm of equation (2.1) with respect to time holding all other inputs constant,

$$g(t) = \frac{\partial \ln F(K(t), L(t), t)}{\partial t}. \tag{2.3}$$

To measure the rate of productivity change, we differentiate logarithm of (2.1) totally with respect to time. After some algebraic manipulations and rearrangements it yields,

$$g(t) = \frac{\dot{F}}{F} - \varepsilon_K \frac{\dot{K}}{K} - \varepsilon_L \frac{\dot{L}}{L}, \tag{2.4}$$

where ε_x is the elasticity of input factor $x = K, L$.

Notice that thus far we have not assumed anything, except differentiability, about the production function and market structure. An ideal procedure for measuring TFP growth rates would be to use the above equation, but unfortunately, the elasticities of output with respect to the input factors are not available at the sectoral or aggregate levels. In the productivity literature, there are two fundamental assumptions used to address this problem: competitive markets and constant returns to scale of the production function. Competitive markets imply that factors are paid their marginal social products, which implies that the elasticity of output with respect to labor (capital) is equal to labor's (capital's) share, and the constant returns to

---

[9] The alternative is to use gross capital stocks. There is no consensus on the choice of capital stocks in productivity analysis. In the computation of capital stocks, gross or net, one needs initial capital stocks $K(0)$ at replacement cost, which are not available. However, if we use net fixed capital stocks in our analysis, under a reasonably simple assumption one can estimate initial net fixed capital by using equation (2.2). The assumption is that the fixed capital formation series has been growing at constant rate and this growth rate is equal to the growth rate of fixed capital formation series in the first few years after the initial period. Young (1995) and Hall and Jones (1999) also used the same technique to estimate the initial stocks. For details on the construction of the capital stocks, see Appendix I.

scale assumption implies that $\varepsilon_K + \varepsilon_L = 1$. Under these two assumptions, one can rewrite the discrete time approximation of equation (2.4),

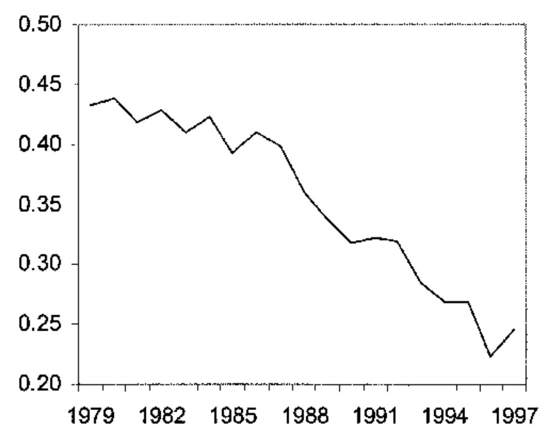
$$\ln g(t) = \Delta \ln Y(t) - (1 - \overline{s_L(t)})\Delta \ln K(t) - \overline{s_L(t)}\Delta \ln L(t), \qquad (2.5)$$

where $\overline{s_L(t)} = 0.5(s_L(t) + s_L(t-1))$.

Figure 2 reports labor shares of total manufacturing in India from 1979-80 to 1997–98. Two important things emerge from this figure: first, labor shares were relatively low, even at the beginning of the period, and second, they are generally monotonically declining over the period under consideration. The first suggests that competitive market assumption may not be true for manufacturing sectors in India, because it is well known that in advanced countries, where markets are close to perfect competition, labor shares are around two-thirds. The second implies that if markets were competitive, the elasticity of labor was monotonically declining over this period—a highly implausible conclusion.

One may think that the decline is because of imperfect competition in the product market. In that case, the elasticity of labor is calculated by multiplying the labor shares by corresponding markup ratios (see Hall, 1988, and Roeger, 1995). The calculation of sector specific markup ratios depends on capital rental price, indirect tax rates, and other variables, for which no data are available.[10] Moreover, these markup ratios are typically calculated from regression analysis and are thus constant across time rather than time varying. Thus, even if it were possible to calculate the markup ratios, it would not offset the observed decline in the elasticity of labor.

Figure 2. Average Labor Shares in Total Manufacturing, 1979/80-1997/98



Sources: ASI and author's own calculations.

[10] Data on indirect tax rates are the most problematic and would require the use of input-output tables. However, such work is beyond the scope of this paper.

One possible reason for the decline in labor shares may be mismeasurement and/or missing data effects.[11] Given these facts, to check the robustness of the growth accounting results, we also consider an alternative case,[12] in which labor elasticity in all sectors is assumed to be 0.6.[13]

Testing the constant returns to scale assumption is more problematic. While we can test constant returns assuming some specific production functions, such as Cobb-Douglas or translog, these tests would require a large number of observations.[14] Therefore, we assume that the production functions satisfy constant returns to scale assumption. Note that deviation from this assumption could either increase or decrease calculated productivity growth rates: if the true production function were increasing (decreasing) returns to scale, then calculated productivity growth rates would be overstated (understated).

IV. Quantitative Analysis

In this section, we describe trends of key variables and report results of the growth accounting exercises, first for total manufacturing and then for the subsectors, as shown in Table 1. The simple production model, particularly equation (2.5), developed in the previous section provides a framework for the analysis.

A. Total Manufacturing

Figure 3a reports time series of total value added per worker (labor productivity) Y/L, capital per worker (capital intensity) K/L, and capital per unit of output (capital-output ratio) K/Y.[15] In

---

[11] Compensation of labor (total emolument) consists of wages and benefits. The ASI reports total emolument and benefits. However, incomplete reports for some sectors from some states make it unclear if the coverage of emoluments is uniform across the sample.

[12] Iwata et al. (2002) propose non-parametric analysis of factor productivity. Due to the relatively high standard errors in their estimates and the small sample problems, we did not consider that approach.

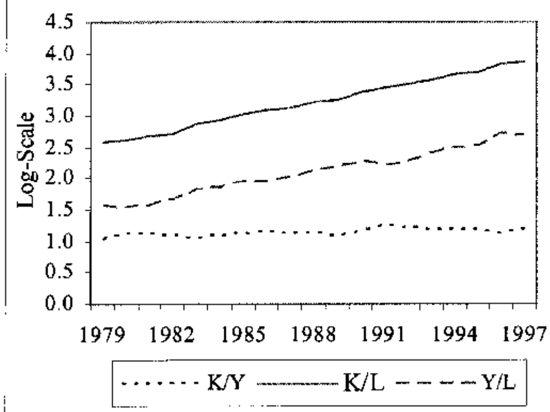
[13] Ahluwalia (1991) reports that the elasticity of labor is between 0.57 and 0.65 for total manufacturing sector in India. Moreover, for G5 countries the labor shares in manufacturing sectors vary between 0.50 and 0.75 (O'Mahony and de Boer, 2002).

[14] We tested the constant returns to scale assumption by assuming Cobb-Douglas production function for total manufacturing sector. However, the results seem to be implausible. The results are available from the author upon request. Tests assuming a translog production function require capital rental prices, which we do not have.

[15] In order to see growth trends clearly, we present series in log scales and output and capital in thousands of rupees (at 1993 constant prices).

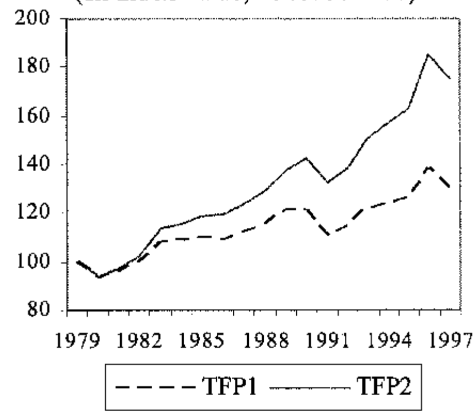
Figure 3b, two measures of TFP are used. TFP1 corresponds to the factor productivity calculated assuming the actual labor shares are equal to the labor elasticity, and TFP2 is calculated assuming a constant labor elasticity of 0.6. We normalize the initial TFP levels to 100 in 1979/80.

Figure 3a. Time Trends of Key Variables



Sources: ASI and author's own calculations.

Figure 3b. Time Trend of TFP
(In index value, 1979/80=100)



Sources: ASI and author's own calculations.

The main conclusions from these two figures are

- Over the period of 1979/80 to 1997/98, the capital-output ratio has been virtually constant. In contrast, labor productivity and the capital intensity have grown markedly. The corresponding average annual growth rates are about 6 percent, 7 percent, and 1 percent for Y/L, K/L, and K/Y, respectively.

- Under the assumption of perfect competition, the average annual growth rate of TFP is 1.8 percent, which is about 30 percent of overall labor productivity growth; under the assumption of a constant labor elasticity of 0.6, the average annual growth rate of TFP is 3.1 percent, which is about 50 percent of overall labor productivity.

By way of comparison, Bernard and Jones (1996) show that for member countries of the Organization for Economic Cooperation and Development (OECD), TFP growth accounts for at least 50 percent of overall labor productivity growth for the manufacturing sector over the period of 1970-87. Their analysis assumes perfect competition and therefore, they use observed labor shares, which are around 0.6. This implies that, if we assume 0.6 labor elasticity, factor productivity performance of the manufacturing sector in India is comparable with that observed in OECD countries at least until the late 1980s.

We turn now to a comparison of productivity trends before and after the launch of the reforms. First, how do productivity trends in the 1960s and 1970s compare with those in the 1980s and 1990s? Ahluwalia (1991) studies the productivity performance of total manufacturing and 63 component sectors in India for the period 1959–85.[16] However, in order to see differences in productivity trends before and after reforms, we only consider her results for the period 1959-79. Using actual labor shares, she finds growth rates for labor productivity, capital intensity, capital-output ratio, and factor productivity of 2.3 percent, 4.6 percent, 2.3 percent, and -0.1 percent, respectively.[17] Note that if labor elasticity is assumed to be 0.6, the corresponding factor productivity growth rate will be about 0.4 percent. Thus, the main findings are:

- Labor productivity growth in 1980s and 1990s is substantially higher—by about 3 times—than that in 1959–79. The capital intensity is also higher in the 1980s and 1990s, but the growth rate of capital-output ratio is lower, which implies that growth rate of capital efficiency was higher in the latter two decades.

- The contribution of TFP growth to overall labor productivity is markedly higher in the post–1980 period than in the pre–1980 period. Under the competitive market assumption, the TFP contribution is about 0 percent in the pre–1980 period and about 23 percent in the post–1980 period. Assuming a labor share of 0.6, the TFP contribution is about 15 percent in the pre–1980 period and about 50 percent in the post–1980 period.

Second, we examine how productivity trends compare between the 1980s and 1990s. In particular, we would like to examine whether there is a significant change in productivity trends after the reforms following the crisis of 1990/91. In order to evaluate the impact of crisis and reforms, we will consider three periods: the first is from 1979/80 to 1990/91; the second is 1990/91; and the third is from 1991/92 to 1997/98. Table 2 reports the growth rates of key variables and TFP1 and TFP2 in these periods.

Table 2. Growth Rates of Variables
(In percent)

Period	Y/L	K/L	K/Y	TFP1	TFP2
1979–90	6.3	7.3	1.0	1.8	3.2
1990–91	-4.9	5.8	11.0	-8.8	-7.2
1991–97	7.8	7.0	-0.8	2.5	4.7

Sources: ASI and author's own calculations.

[16] Ahluwalia (1985) studies the period 1959–79. However, the ASI data in that study are adjusted by using correction factors based on National Accounts and National Sample Surveys.

[17] In Ahluwalia (1991), the average growth rate of a variable *x* is calculated as the coefficient *b* in the regression of Ln x=a+bT, where T is time. In our case, however, we used geometric average of series. Growth rates based on regressions are generally about 0.1-0.4 percentage points higher than those based on geometric averages.

Two important points emerge from this table:

- The growth rates of labor and factor productivity are substantially higher in the 1991-97 period than those in the pre–1990 period.
- The sources of growth, however, remain broadly unchanged with factor productivity contributing about the same to the labor productivity as in the period prior to the reforms.

B. Manufacturing Subsectors

In this section, we analyze the productivity performance of the manufacturing subsectors. In particular, we will be interested in answering questions such as: are trends in aggregate productivity and key variables also reflected at the sectoral levels? Is the comparative ranking in the sectoral performance robust to different underlying assumptions? Which sectors performed relatively weakly and what are the reasons for this weak performance? In answering the latter, we try to address whether small-scale reservation policies play a role in explaining observed trends.

The share of value added, employment, and capital stocks of each sector in total manufacturing over the period 1979/80 to 1997/98 are reported in Appendix II, Tables II.1-II.3. One important point in these tables is that over this period the rankings of many of the sectors in a given table remain more or less the same, which suggests that the structural composition of Indian manufacturing has not changed much. From Appendix II, Table II.1, the four leading sectors are textile, chemical, metal, and machinery, and on average, they account for 62 percent of total value added and 45 percent of total manufacturing employment.

Using the growth accounting exercise, the growth rates of the key variables and the ratio of TFP growth to labor productivity Y/L for the 13 manufacturing sectors over the period of 1979/80 to 1997/98 are presented in Table 3.[18] In this table, sectors are ranked according to their value-added shares in total manufacturing. The last two columns, ***[8]*** and ***[9]***, represent contributions of TFP1 and TFP2 growth (in percent) to labor productivity growth, respectively.

[18] The associated figures for other sectors are available from the author upon request.

Table 3. Growth Rates of Variables and Contribution of TFP

(In percent)

Sector	Y [2]	Y/L [3]	K/L [4]	K/Y [5]	TFP1 [6]	TFP2 [7]	[8]	[9]
Metal	6.4	5.1	7.3	2.2	-0.3	1.4	-6	29
Chemical	8.8	6.1	6.1	0.0	1.1	3.2	18	52
Machinery	7.8	6.6	5.7	-0.8	2.6	3.9	39	59
Textile	5.7	5.5	7.3	1.8	0.9	1.8	16	33
Food	7.0	6.3	5.9	-0.4	0.8	2.1	13	33
Transport	7.4	6.5	6.2	-0.4	2.7	3.6	42	55
Rubber	11.2	7.6	6.7	-1.0	0.4	3.1	5	41
Mineral	8.5	6.8	10.5	3.7	-1.3	1.8	-19	26
Paper	3.9	2.5	7.2	4.8	-2.2	-1.0	-88	-40
Beverage	7.0	4.7	7.4	2.7	-1.6	0.5	-34	11
Miscellaneous	13.7	9.6	8.2	-1.3	2.4	4.3	25	45
Leather	8.8	4.9	3.5	-1.4	0.8	1.8	16	37
Wood	-0.6	0.2	8.0	7.9	-7.0	-5.6	-3,500	-2,800
Total	7.4	6.1	7.1	1.0	1.4	3.1	23	50

Sources: ASI and author's own calculations.

The results in this table along with the corresponding time series figures provided in Appendix III are striking:

- While labor and factor productivity in total manufacturing exhibit upward trends over time, the component sectors show disparate trends.

- **Labor productivity**: According to the third column, the labor productivity of most of the sectors is quite high. Notice that growth rates of almost all heavy-industry sectors—the focus of India's industrialization strategy—such as chemical, rubber, machinery, and transport—are above total manufacturing, while most of the traditional sectors lag below the average.

- **Capital intensity and capital-output ratio**: The fourth column along with the figures in Appendix III shows that capital intensity has generally increased substantially. However, capital productivity (the inverse of K/Y in Column 5) has not shown a corresponding increase in all sectors. Thus, when growth in labor productivity lags that of capital intensity, the sector ends up with poor capital productivity growth.

- **Total factor productivity**: The performances of these sectors in terms of TFP growth is more complicated. The differences between growth rates using the different assumptions about labor elasticity are substantial. The difference in estimates of TFP growth ranges between 0.9 percent and 3.1 percent. However, the distributions of the top and bottom sectors using the two measures of TFP and their contributions to labor productivity remain the same.

Comparison of productivity trends in the post–1980 period with those in the period 1959/60 to 1978/79 in Ahluwalia (1991) is complicated by the fact that Ahluwalia (1991) uses a different classification of industries. Ahluwalia analyzes productivity performance of 63 component sectors, whereas we grouped them into 13 sectors. However, her results show that most of the component sectors have low labor productivity growth and negative factor productivity growth [19] during that period, which suggest that productivity trends in the second period are markedly higher than those in the first period.[20]

A comparison of productivity trends before and after the 1991 reforms suggests that labor and factor productivity trends in most of the sectors are significantly higher after the 1991 reforms. In particular, significantly steeper trends can be observed in the chemical, metal, machinery, and transport sectors. Forbes (2002) reports that competition against imports and foreign direct investment (FDI) in several industries, in particular, in machine tools and instruments, pharmaceuticals, automobiles, synthetic fibers, and soaps and detergents, have substantially increased since 1991. Thus, the substantial increase in labor and factor productivity of these sectors might have resulted from removing barriers to international trade and FDI. In contrast, productivity trends in all of the traditional sectors either remained the same or declined.

It is important to note that all of the relatively weakly performing sectors are those that have relatively small value-added shares in total manufacturing, see Table 3 and Appendix II. Their weak performance may be related to the policy of reserving certain products and industries for small-scale production. Many researchers have criticized the policy of restricting the size of certain industries to small scale. First, they argue that many of these are the industries in which India has strong comparative advantage in the world markets (M.S. Ahluwalia, 1996). Second, these are usually labor-intensive industries and if the reservation restrictions stay in operation, with trade liberalization, these industries will find it almost impossible to survive (Panagariya, 2001).

Although data limitations preclude more definitive conclusions, these results suggest that the policy of reserving the production of some goods for the small-scale sectors has been associated with weaker labor productivity and TFP growth. Table 4 reports the share of reserved products

---

[19] As an example, labor productivity and factor productivity growth rates in component sectors of food are around 0 percent and -2 percent in the period 1959/60 to 1985/86. If we subtract the growth rates in the first half of the 1980s, we will get much smaller growth rates than those in Table 3.

[20] Ahluwalia (1985) studies the productivity trends in two-digit manufacturing sectors over the period 1959/60 to 1979/80. Although the data sources are different, it suggests almost the same conclusion.

in total output across sectors. Note that in the wood, paper, and leather sectors the percentage share of reserved products on average increased substantially (quadrupled) over the period 1972-1987/88. During the same period, in machinery, mineral, and miscellaneous sectors it decreased from about 35 percent, 29 percent, and 64 percent to 9 percent, 14 percent, and 35 percent, respectively.[21]

The decline in the factor productivity growth rate in the paper, wood, leather, and, to some extent, textile sectors after the 1991 reforms seems to support the criticisms about the continuation of the policy of reservation for small-scale industries.

V. Summary and Concluding Remarks

In this paper, we analyzed the productivity performances of registered manufacturing sectors in India based on a carefully constructed data set. By applying standard growth accounting techniques we constructed factor productivity series for each sector. We found, for example, that the growth rate of labor productivity in total manufacturing during 1979/80 to 1997/98 is 6 percent, and factor productivity is 1½ percent under observed labor shares and 3 percent under the assumption of constant labor elasticity. These are remarkably high rates compared with those in the period 1959-79. A comparison of the performance of sectors before and after the 1991 reforms indicates that labor productivity and factor productivity growth rates increased by 24 percent and 46 percent, respectively. Although at the aggregate level there is a distinct upward trend in labor and factor productivity, sectoral growth rates vary considerably: in some sectors productivity growth increased very fast, and in some others, productivity growth remained more or less the same or even declined. There appears to be evidence that sectors that were opened up to trade and FDI experienced a pickup in productivity growth, but others, especially those sectors still reserved for small-scale manufacturing, did not perform as well.

There are several directions that the current work can be extended. The first is to check national accounts and national sample surveys to correct the possible measurement errors in the ASI. Second, note that in our accounting exercise we did not differentiate by the types of labor. In particular, our results exclude improvements in human capital. Productivity analysis based on more finely disaggregated labor and capital inputs will reveal more information about the performance of these sectors. Third, we computed the TFP growth rates under two benchmarks: observed labor shares and constant labor elasticity. Carefully constructed labor elasticity data based on three-digit level data could give us a more accurate picture of the factor productivity performance of these sectors.

[21] There are some sectors such as food and chemical products, where increases in labor productivity took place at the same time as an increase in the share of the reserved products.

Table 4. Share of Reserved Products in Total Output of Sector

Sectors	1987-88 No. of Reserved Products	1987-88 Percentage Share in Output	1972 No. of Reserved Products	1972 Percentage Share in Output
Food	17	35.8	0	0
Beverage-Tobacco	1	0.2	0	0
Cotton	0	0	0	0
Wool	0	0	0	0
Jute	0	0	0	0
Hosiery	31	80.1	0	0
Wood	14	56.8	2	20.9
Paper	30	24.8	0	0
Leather	17	46.9	2	12.1
Rubber	99	30.9	7	32.4
Chemicals	166	29.7	19	26.5
Minerals	39	14.5	8	28.8
Basic Metals	14	4.2	0	0
Metals	131	42.6	62	49.1
Machinery	55	8.8	2	32.8
Electrical Machinery	59	8.6	22	37.5
Transport	102	23.8	48	8.6
Miscellaneous	68	35.2	5	64.3

Sources: Reports on Census of SSI, 1972 and 1987-88, respectively; reproduced from Mohan (2002), Table 6.13.

Data Sources and Construction of Capital Stocks

In this appendix, we provide some detailed information about the *Annual Survey of Industries* (ASI) and about the construction of capital stocks.

Each year, ASI is compiled in several volumes and each volume focuses on either a particular sector or particular aspects of all sectors. In our case, we used the first volume, which contains summary results for factory sectors at two- and three-digit industrial classification levels. As indicated in the text, ASI summary results contain data on total output, net value added, total input, total number of people engaged in production, depreciation, total net fixed assets, profit, total emoluments (labor compensation), inventory levels, etc. We obtained data on value added by adding depreciation to net value-added data. In these surveys, the net fixed assets and depreciation data series need some more explanation. Recall that in order to conduct growth accounting we need data on net fixed capital stocks. At first glance, it seems that the net fixed assets series can be used to approximate net capital stocks. However, this is not correct, because net fixed assets data are at book value and not at replacement cost. The same criticism is valid for the depreciation series. However, we can use two series to construct the gross fixed capital formation series: subtract two consecutive years of book value of net fixed assets and add the depreciation in that year to this final value.

To convert nominal value added to real value added, we used WPI series for each sector. We, however, have three WPI series[22] each of which has a different base year: the first WPI series covers the period 1970–1982 and the base year is 1970/71; the second WPI series covers the period 1982-93 and base year is 1981/82, and final one covers the period 1993-97 and the base year is 1993/94. We simply spliced these three series and obtained overall WPI series at 1993/94 prices. Another important issue is to convert the nominal gross fixed capital series into real terms. Unfortunately, we do not have sector-specific fixed capital formation price index series. Instead, we used the aggregate regular manufacturing fixed capital formation price index series.

To construct capital stocks, we used the gross fixed capital formation series, which starts in 1970/71.[23] Obviously, in order to increase the reliability of our initial capital stocks estimates, we would need longer time series. However, in our case this was not possible because of the

[22] The first two series are taken from India Database, Volume 1, compiled by H.L. Chandhok and The Policy Group (1990); the third series is taken from the CEIC Database.

[23] For some sectors in some years, we obtained large negative numbers. Most probably this was due to measurement errors. We corrected this in the following simple way: if the capital deformation in a given year is greater than 4 percent of our estimated net capital stocks in that year, then we simply set the capital deformation level to 4 percent of estimated net capital stocks. This adjustment, however, did not have a significant impact on the subsequent results.

reclassification of industries in 1970.[24] We also assume a depreciation rate of 5 percent. The rationale for this rate is as follows: in the United States, official estimates of the average life of general industrial equipment and nonresidential industrial buildings are 16 and 31 years, which correspond to depreciation rates of 10.72 and 3.14 percent, respectively, see Katz and Herman (1997). However, since in India technological improvements are slower, we assume that the average life of equipment and machinery assets is 25 years with a corresponding depreciation rate of 7.2 percent. Moreover, we assume that equipment and machinery in manufacturing sectors is about 60 percent of the total capital stocks,[25] thus, assuming that the average depreciation rate will be around 5 percent. We also considered depreciation rates of 4 percent and 6 percent, but the results were largely unchanged.

At this point, it will be interesting to check the robustness of our results under different initial capital stocks levels. To do so we considered two cases: initial capital stocks in all sectors are (i) 15 percent more or (ii) 15 percent less than our initial estimates. Under these two cases, the growth rates of capital intensity, capital utilization, TFP1, and TFP2 increased marginally (by 0.2–0.3 percentage points) in total manufacturing. The different assumptions did not change the ranking of sectors, and moreover, under these two different initial estimates contributions of TFP to overall productivity changed by 3 percent. In fact, even a 50 percent change in initial stocks has only about a 10 percent impact on the contributions of TFP to overall productivity.[26]

---

[24] In fact, there are reclassifications both in 1987 and 1998. The reported data based on 1998 were incomplete, hence, we excluded 1998-99 and 1999-00 years. We compared the levels of some key variables before and after the reclassification of 1987, but we could not see any sudden ups and downs. In fact, in the 1987 classification, all of the new subsectors are at three-digit levels, which were a component of another three-digit level subsector in the previous classification. The same thing cannot be said for the 1970 classification. For some two-digit level sectors, we compare the levels of variables before and after the 1970 classification. Their results were substantially different.

[25] According to the OECD's International Sectoral Data Base (ISDB), the share of capital stock of equipment and machinery in the "whole" economy is about 60 percent of total capital stocks. On the one hand, the manufacturing sector is usually more machinery and equipment intensive; on the other hand, in India due to cheap labor, equipment and machinery stocks may not be as high as those in OECD countries. Under these two contradictory forces, we think that a 60 percent ratio seems a reasonable approximation for India.

[26] With a 50 percent increase (decrease) in initial stocks, TFP1 growth rates increased (decreased) about 0.4(0.55) percent, which is substantial compared to the initial growth rates. However, with these changes, the time paths of capital intensity and the capital-output ratio exhibit sharp upward and downward trends in the first few years, but do not carry through to the remaining years. Moreover, if we compare the growth rates of these factors for total manufacturing over the period of 1980-85, our results are surprisingly similar to those of Ahluwalia (1991), which suggests that the errors in initial estimates are not substantial.

Table II.1. The Ratio of Value Added in Each Sector to Total Value Added

(In percent)

Year	Food	BevTob	Textile	Wood	Paper	Leather	Chem	Rubber	Mineral	Metal	Machine	Trans	Misc
1979	9.3	2.7	17.8	1.0	5.5	0.6	14.2	4.4	4.0	17.8	14.2	7.8	0.6
1980	6.5	2.5	17.7	0.9	5.7	0.6	13.3	4.3	4.3	19.6	15.8	8.1	0.7
1981	8.1	2.5	15.6	0.9	5.9	0.6	13.5	3.9	4.3	20.3	15.2	8.5	0.6
1982	9.5	2.3	13.8	0.8	4.7	0.6	13.7	5.0	5.2	18.3	16.5	8.7	0.7
1983	10.4	4.0	14.4	0.9	4.6	0.7	14.6	3.3	4.8	17.6	16.0	8.0	0.8
1984	9.6	3.2	13.5	0.8	5.2	0.8	13.9	4.5	5.2	15.8	18.3	8.2	0.9
1985	9.8	2.8	13.6	0.7	4.2	0.6	14.2	7.3	5.7	16.1	16.4	7.1	1.4
1986	9.7	3.3	15.4	0.7	4.7	0.6	14.0	7.1	5.2	14.6	15.6	8.1	1.1
1987	9.4	3.0	13.4	0.7	4.4	0.8	15.0	6.9	5.4	15.7	17.0	7.3	1.0
1988	10.1	3.0	12.4	0.8	4.0	0.7	15.5	7.0	5.3	17.5	15.4	7.3	1.0
1989	11.2	2.6	13.9	0.7	4.2	0.7	16.3	6.7	5.5	14.3	15.8	6.9	1.1
1990	9.1	2.6	14.1	0.8	4.3	0.8	16.2	7.3	5.8	15.5	15.2	7.3	1.0
1991	9.5	3.0	13.2	0.7	4.2	1.0	16.8	6.5	7.3	13.2	16.0	7.2	1.4
1992	8.5	2.8	12.5	0.4	3.6	1.0	19.1	8.4	5.2	14.9	15.5	6.7	1.4
1993	9.2	2.7	14.4	0.4	3.9	1.3	18.6	8.8	4.5	14.1	13.5	6.5	2.1
1994	9.4	2.6	13.2	0.3	3.9	0.9	17.1	8.2	4.5	15.2	16.0	7.1	1.5
1995	8.2	2.1	10.3	0.3	3.7	0.8	19.1	7.7	4.9	15.9	15.9	9.4	1.8
1996	6.9	2.4	12.3	0.4	3.3	0.6	18.8	9.4	5.9	15.3	14.6	8.3	1.6
1997	8.7	2.5	13.2	0.2	2.9	0.8	18.2	8.8	4.9	14.9	15.1	7.7	2.0
Avg	9.1	2.8	13.9	0.7	4.4	0.8	15.9	6.6	5.2	16.1	15.7	7.7	1.2

Sources: ASI and author's own calculations.

Table II.2. The Ratio of Employment in Each Sector to Total Employment

(In percent)

Year	Food	BevTob	Textile	Wood	Paper	Leather	Chem	Rubber	Mineral	Metal	Machine	Trans	Misc
1979	17.3	5.9	25.7	1.3	4.0	0.9	7.2	2.7	5.0	11.1	10.8	7.1	1.1
1980	19.0	5.9	24.1	1.2	4.2	0.8	7.1	2.5	5.2	11.3	10.5	7.0	1.0
1981	19.0	6.4	23.1	1.2	4.5	0.9	7.0	2.6	5.4	11.4	10.6	7.2	1.0
1982	17.6	6.3	23.5	1.2	4.6	0.9	7.0	2.8	5.8	11.3	10.9	7.1	1.0
1983	15.1	6.4	23.8	1.2	4.4	0.9	7.4	2.9	6.3	12.0	11.4	7.3	1.0
1984	15.0	5.2	23.9	1.2	4.3	1.0	7.5	2.8	6.1	12.8	11.6	7.6	1.0
1985	15.0	5.4	22.6	1.2	4.3	1.1	8.2	2.9	6.6	12.1	12.2	7.3	1.1
1986	14.7	6.0	22.8	1.1	4.2	1.1	8.0	3.1	6.5	12.3	11.5	7.5	1.2
1987	15.0	6.4	21.8	1.1	4.4	1.1	8.1	3.1	6.3	12.2	12.1	7.1	1.2
1988	14.9	6.3	21.0	1.1	4.0	1.4	8.4	3.3	6.4	12.4	12.1	7.5	1.3
1989	15.7	7.3	21.6	1.1	3.9	1.5	8.0	3.4	6.3	11.6	11.7	6.7	1.3
1990	15.7	6.9	21.1	1.0	4.1	1.5	7.8	3.6	6.2	12.1	12.1	6.7	1.3
1991	15.7	7.2	20.4	0.9	4.1	1.5	8.1	3.6	6.5	11.6	12.0	6.9	1.3
1992	16.3	7.3	20.1	1.0	4.0	1.5	8.4	3.7	6.1	11.9	11.8	6.6	1.4
1993	16.0	6.8	21.3	1.0	4.0	1.6	8.5	3.9	5.9	11.4	11.5	6.7	1.6
1994	15.6	7.5	20.9	0.9	4.1	1.7	8.6	3.9	5.8	11.2	11.3	6.9	1.5
1995	15.0	6.2	21.2	0.9	4.4	1.6	8.7	3.8	5.6	11.7	12.0	7.1	1.7
1996	15.4	6.8	20.8	1.0	4.3	1.5	9.1	4.2	5.6	11.1	11.1	7.3	1.7
1997	15.9	7.1	21.4	0.9	4.2	1.4	9.3	4.1	5.4	11.3	10.7	6.6	1.8
Avg	16.0	6.5	22.2	1.1	4.2	1.3	8.0	3.3	6.0	11.7	11.5	7.1	1.3

Sources: ASI and author's own calculations.

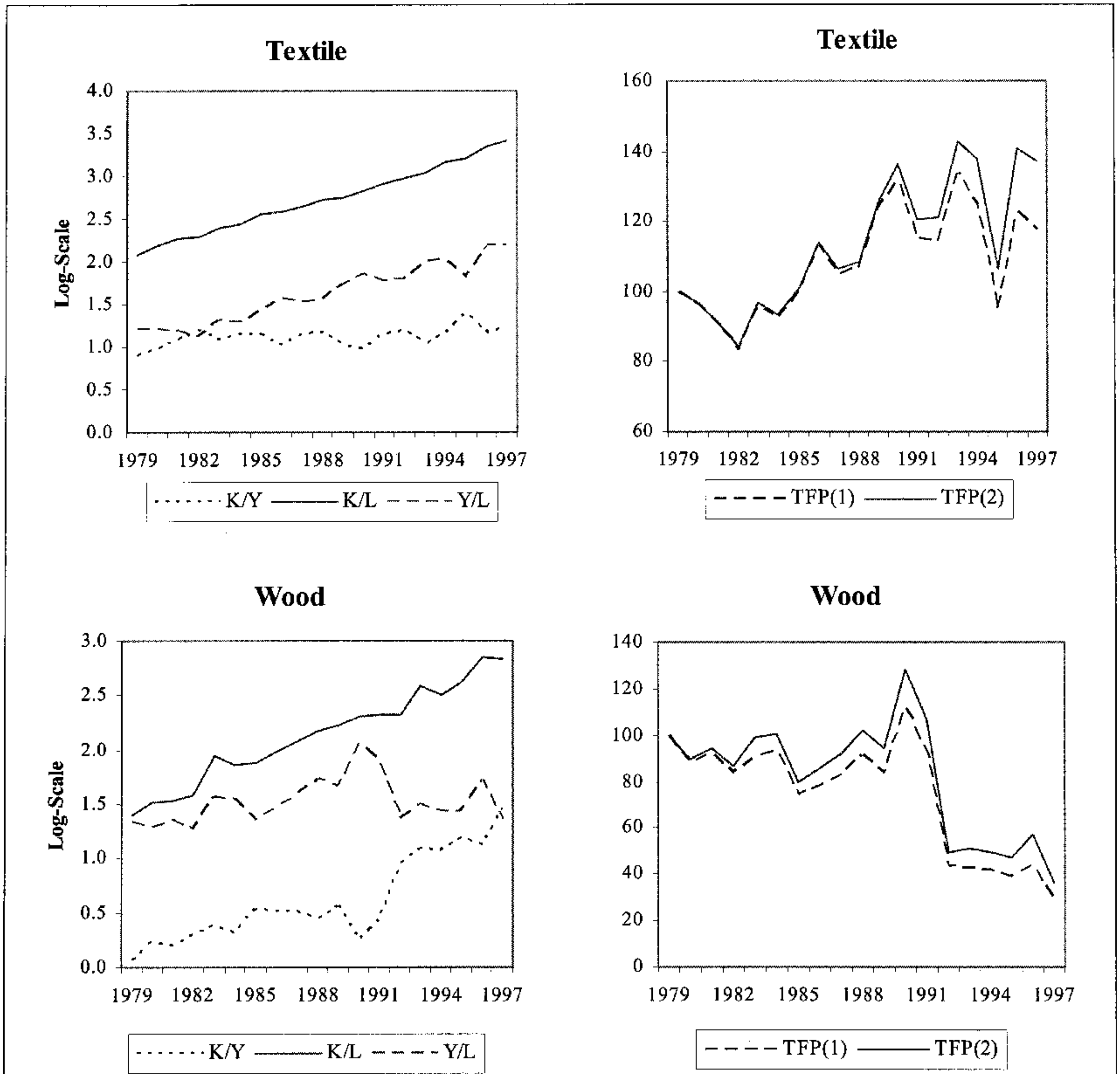
Table II.3. The Ratio of Net Fixed Capital in Each Sector to Total Net Fixed Capital

(In percent)

Year	Food	BevTob	Textile	Wood	Paper	Leather	Chem	Rubber	Mineral	Metal	Machine	Trans	Misc
1979	10.0	1.2	15.6	0.4	4.1	0.6	19.7	5.3	3.5	20.3	11.5	7.4	0.5
1980	9.6	1.1	15.6	0.4	4.5	0.6	20.0	4.5	3.8	21.1	11.1	7.2	0.5
1981	9.2	1.1	15.1	0.4	4.7	0.6	19.5	5.1	4.1	21.7	10.9	7.1	0.5
1982	8.9	1.0	15.3	0.4	4.9	0.6	18.3	5.5	4.5	22.0	11.0	7.1	0.5
1983	8.8	1.1	14.9	0.5	5.0	0.5	18.6	6.0	5.0	21.6	10.9	6.7	0.6
1984	8.5	1.0	14.6	0.4	5.4	0.5	18.0	6.0	5.1	22.2	10.7	7.1	0.6
1985	8.2	1.1	14.1	0.4	4.6	0.5	18.7	6.4	6.0	21.2	11.1	7.0	0.6
1986	8.2	1.2	13.7	0.4	5.2	0.5	18.9	6.5	6.7	20.6	10.4	7.0	0.6
1987	8.1	1.2	13.5	0.4	5.0	0.5	18.5	6.6	6.9	21.0	10.7	7.0	0.7
1988	7.8	1.3	12.8	0.4	5.0	0.5	18.3	7.5	7.2	20.7	10.8	6.8	0.7
1989	8.4	1.2	12.9	0.4	4.5	0.5	19.9	6.9	7.2	20.1	10.7	6.5	0.8
1990	8.0	1.2	12.2	0.3	4.5	0.6	19.5	7.0	6.6	23.4	10.2	5.9	0.7
1991	7.9	1.1	12.1	0.3	4.4	0.5	19.0	6.9	6.9	24.0	10.1	5.9	0.7
1992	7.7	1.2	11.9	0.3	4.1	0.5	19.1	7.0	6.6	24.6	10.2	5.9	0.8
1993	7.7	1.2	12.4	0.4	4.2	0.5	19.2	7.6	6.7	23.9	9.6	5.7	0.9
1994	7.7	1.3	12.6	0.3	5.2	0.6	19.5	6.8	6.7	23.4	9.6	5.5	0.9
1995	7.4	1.2	12.8	0.3	4.0	0.6	20.6	7.0	6.5	23.8	9.2	5.7	0.9
1996	7.2	1.3	13.0	0.4	4.6	0.6	19.8	8.8	7.1	20.9	9.1	6.4	0.9
1997	7.4	1.5	13.5	0.3	4.3	0.5	21.2	7.4	6.9	21.3	8.9	5.8	1.0
Avg	8.2	1.2	13.6	0.4	4.6	0.5	19.3	6.6	6.0	22.0	10.4	6.5	0.7

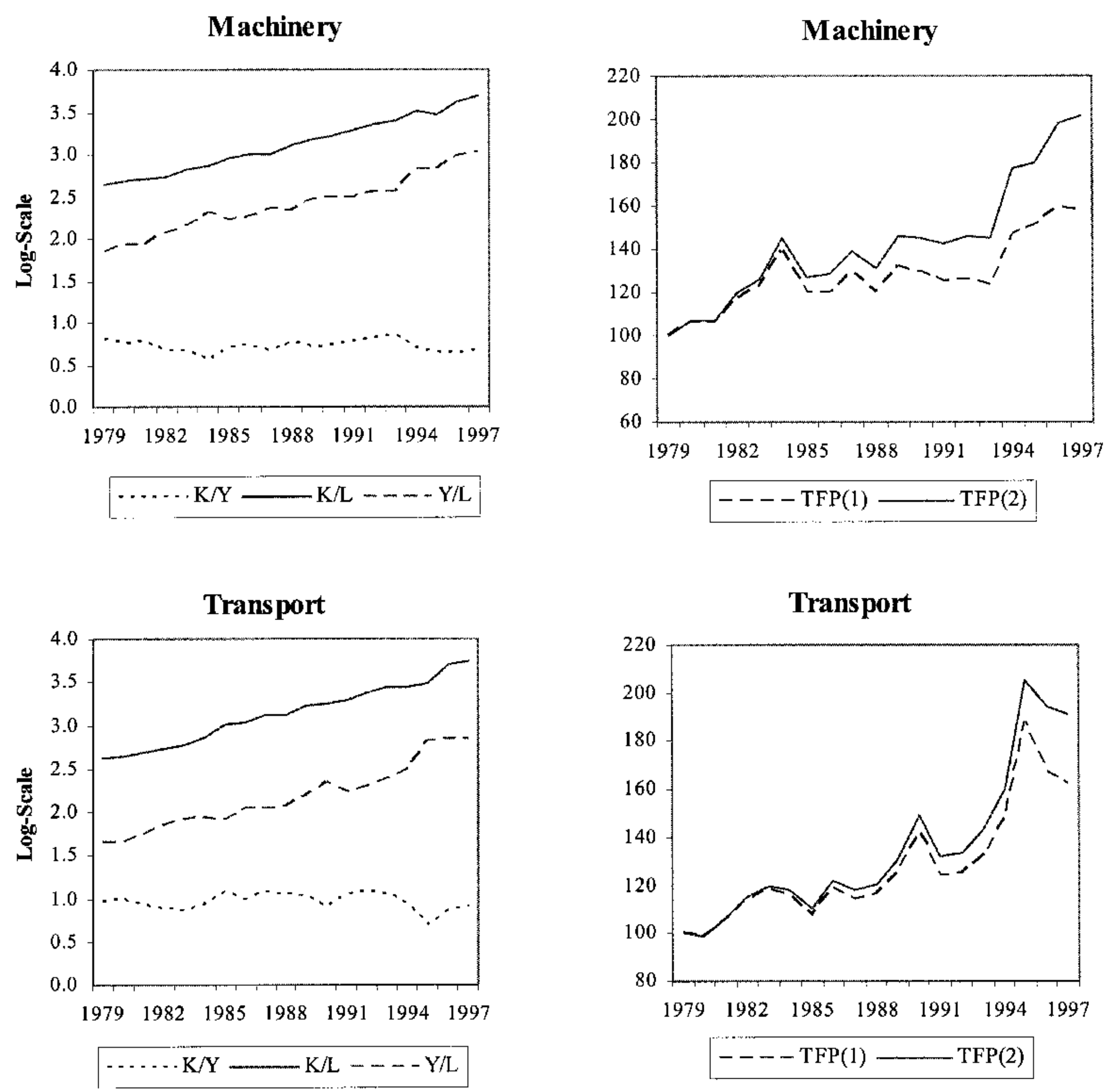
Sources: ASI and author's own calculations.

Figure III.1. Productivity Growth in Selected Sectors



Sources: ASI and author's own calculations.

Figure III.1. (Concluded) Productivity Growth in Selected Sectors



Sources: ASI and author's own calculations.

References

Ahluwalia, Isher J., 1985, *Industrial Growth in India: Stagnation Since the Mid-Sixties* (New Delhi: Oxford University Press).

———, 1991, *Productivity and Growth in Indian Manufacturing* (New Delhi: Oxford University Press).

Ahluwalia, Montek S., 1996, "Priorities for Economic Reforms", 13th Jawaharlal Nehru Memorial IFFCO Lecture.

Bernard, Andrew, and Charles I. Jones, 1996, "Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries," *American Economic Review,*" Vol. 86, pp. 1216-38.

Central Statistical Organization, 1970/71-1997/98, *Annual Survey of Industries: Summary Results for Factory Sector* (New Delhi: Central Statistical Organization).

Christensen, Laurits R., and William H. Greene, 1976, "Economies of Scale in U.S. Electric Power Generation," *Journal of Political Economy*, Vol. 84, pp. 655-76.

Economic Intelligence Service, 1998 and 2001, *Industry: Financial Aggregates and Ratios* (Mumbai: Centre for Monitoring Indian Economy).

———, 2001, *National Income Statistics* (Mumbai: Centre for Monitoring Indian Economy).

Forbes, Naushad, 2002, "Doing Business in India: What has Liberalization Changed?" *Economic Reforms and the Indian Economy*, ed. by Anne O. Krueger (Chicago: The University of Chicago Press).

Hall, Robert E., 1988, "The Relationship Between Price and Marginal Cost in U.S. Industry," *Journal of Political Economy*, Vol. 96, pp. 921-47.

———, and Charles I. Jones, 1999, "Why Do Some Countries Produce So Much More Output per Worker than Others?" *Quarterly Journal of Economics*, Vol. 114, pp. 83-116.

H.L. Chandhok, and the Policy Group, 1990, *India Database: The Economy, Vol.1*, (New Delhi: Thomson Press).

Iwata, Shigeru, Mohsin S. Khan, and Hiroshi Murao, 2002, "Source of Economic Growth in East Asia: A Nonparametric Assessment," IMF Working Paper, No. 13 (Washington: International Monetary Fund).

Joshi, Vijay, and I.M.D. Little, 1996, *Indian Economic Reforms 1991-2001* (Oxford: Clarendon Press).

Katz, Arnold J., and Shelby W. Herman, 1997, "Improved Estimates of Fixed Reproducible Tangible Wealth, 1929-95," *Survey of Current Business*, May.

Mohan, Rakesh, 2002, "Small-Scale Industry Policy in India: A Critical Evaluation," *Economic Reforms and the Indian Economy*, ed. by Anne O. Krueger (Chicago: The University of Chicago Press).

O'Mahony, Mary, and Williem de Boer, 2002, "Britain Postwar Productivity Performance," NIESR working paper.

Panagariya, Arvind, 2001, "India's Economic Reforms: What Has Been Accomplished? What Remains to Be Done?," Economics and Development Resource Center, Policy Briefs, No. 2.

Roeger, Werner, 1995, "Can Imperfect Competition Explain the Difference Between Primal and Dual Productivity Measures? Estimates for U.S. Manufacturing," *Journal of Political Economy*, Vol. 103, pp. 316–30.

Shome, Parthasarathi, and Hiranya Mukhopadhyay, 1998, "Economic Liberalization of the 1990s: Stabilization and Structural Aspects and Sustainability of Results," *Economic and Political Weekly*, July 18.

Srinivasan, T.N., 1996, "Indian Economic Reforms: Background, Rationale, Achievements, and Future Prospects, (unpublished, New Haven, Connecticut: Yale University).

———, 2002, "China and India: Economic Performance, Competition and Cooperation," (unpublished, New Haven, Connecticut: Yale Universtiy).

Young, Alwyn, 1995, "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience," *Quarterly Journal of Economics*, Vol. 110, pp. 641-80.