The Developing Economies, XLI-4 (December 2003): 436–60

IMPORT LIBERALIZATION AND PRODUCTIVITY GROWTH IN INDIAN MANUFACTURING INDUSTRIES IN THE 1990s

Bishwanath GOLDAR
Anita KUMARI

Total factor productivity growth in Indian manufacturing decelerated in the 1990s, a decade of major economic reforms in India. Econometric analysis presented in the paper indicates that the lowering of effective protection to industries favorably affected productivity growth. The results suggest that gestation lags in investment projects and slower agricultural growth in the 1990s had an adverse effect on productivity growth. The analysis reveals that underutilization of industrial capacity was an important cause of the productivity slowdown. With corrections for capacity utilization, the estimated productivity growth in the 1990s is found to be about the same as in the 1980s.

I. INTRODUCTION

Since 1991, India has undertaken a major economic reforms program. Under the program, significant and far-reaching changes have been made in industrial and trade policy. Import liberalization has been a principal component of the economic reforms undertaken. Tariff rates have been brought down considerably[1] and quantitative restrictions on imports have been by and large removed.[2] These re-

Comments of Professor K. L. Krishna on an earlier version of the paper are gratefully acknowledged. We have benefited also from the comments received when the paper was presented at a seminar at the Institute of Economic Growth in December 2001. We thank the reviewers of this journal for their comments on an earlier version of the paper, which have helped us improve the paper considerably.

[1] The average effective tariff rate was reduced from about 86 per cent in 1989–90 to about 40 per cent in 1994–95 and further to about 30 per cent in 1999–2000 (Goldar 2002b). The collection rate of import duty came down similarly from about 47 per cent in 1990–91 (52 per cent in 1989–90) to 29 per cent in 1995–96 and further to about 24 per cent in 1999–2000. For manufacturing, there was a decline in the average rate of tariff from about 120 per cent in 1989–90 to about 33 per cent in 1997–98 (Goldar and Saleem 1992; Nouroz 2001).

[2] The nontariff barrier (NTB) coverage in manufacturing declined from 90 per cent by the end of 1990 to 36 per cent in May 1995 (Pursell 1996). Within manufacturing, the NTB coverage for machinery and intermediate goods declined considerably between 1990 and 1995. In 1995, the NTB coverage for these two groups of manufactured products was only 10 and 12 per cent respectively. The process of relaxation of quantitative restrictions on imports continued beyond 1995. For aggregate manufacturing, the decline in NTB coverage was from 87 per cent in 1988–89 to 46 per cent in

forms in import policy, along with complementary changes in industrial policy, technology import policy, and foreign direct investment policy, were aimed at making Indian industry more efficient, technologically up-to-date, and competitive, with the expectation that efficiency improvement, technological up-gradation, and enhancement of competitiveness would enable Indian industry to achieve rapid growth. Given that the main object of import liberalization was to improve industrial productivity, it is appropriate to ask how far has import liberalization contributed to the better productivity performance of Indian industry in the post-reform period. The present paper addresses this issue.

In the paper, estimates of total factor productivity (TFP) growth are presented for Indian manufacturing and major industry groups for the period 1981–82 to 1997–98. The object is to compare the growth rate in TFP in Indian industries in the 1990s, i.e., the post-reform period, with that in the 1980s. This is followed by an econometric analysis of inter-temporal and interindustry variations in productivity growth rates, aimed at assessing the effect of import liberalization on productivity growth in Indian industries in the 1990s. Another aspect that receives specific attention in the econometric analysis is the effect of capacity utilization on measured productivity growth.

II. EFFECT OF IMPORT LIBERALIZATION ON INDUSTRIAL PRODUCTIVITY

There are reasons to expect a favorable effect from import liberalization on industrial productivity. This is expected to occur through several channels: (a) import liberalization will provide to industrial firms greater and cheaper access to imported capital goods and intermediate goods (embodying advanced technology), which will enable the firms to improve their productivity performance; (b) greater availability of imported intermediate goods will enable the firms to exploit better the productivity enhancing potential of imported technology; (c) the increased competitive pressure on industrial units in a liberalized import regime will force them to be more efficient in the use of resources (which can be achieved through better organization of production, improved managerial efficiency, more effective utilization of labor, better capacity utilization, etc.); (d) the increased competitive pressure coupled with expanded opportunities for importing technology and capital goods will bring greater technological dynamism in industrial firms; (e) as the competitive business environment forces inefficient firms to close down, the average level of efficiency of various industries should improve; and (f) greater access to imported inputs and a more realistic exchange rate associated with a liberalized trade regime would enable

1995–96 and further to 28 per cent in 1999–2000 (NCAER 2000). During 2000 and 2001, there has been further relaxation of quantitative controls on imports. Currently, almost all commodities are free from quantitative restrictions on imports.

industrial firms to compete more effectively in export markets. This would allow them to increase their sales and reap economies of scale with concomitant gains in productivity.

Evidently, there are persuasive theoretical arguments for contemplating a positive effect from import liberalization on industrial productivity. However, this view or hypothesis does not have strong empirical support. There have been a number of empirical studies for developing countries, including the countries of Asia, in which econometric models have been estimated to assess the effect of import liberalization on industrial productivity.[3] Some of them have found a significant favorable effect of import liberalization on industrial productivity. But some have found no significant effect, while others have found an adverse effect of import liberalization on industrial productivity. Thus, on the whole, the empirical evidence on the relationship between import liberalization and industrial productivity in developing countries is mixed and no definite conclusion can be drawn.

As regards Indian industry, there are two recent studies, which have examined the effect of economic reforms on industrial productivity. These are by Krishna and Mitra (1998) and Balakrishnan, Pushpangadan, and Suresh Babu (2000). Both studies have used firm-level data taken from the Centre for Monitoring Indian Economy (CMIE) database. Also there is a similarity in the method of econometric analysis applied in the two studies. But the studies come up with conflicting results. Krishna and Mitra find evidence of a significant favorable effect of reforms on industrial productivity. Balakrishnan et al., on the other hand, find an adverse effect of economic reforms on industrial productivity. One serious limitation of both studies is that they have not used explicit trade liberalization variables in the econometric model estimated. Rather, a dummy variable approach has been taken to distinguish between the pre- and post-reform periods.

This study differs from the above two studies in several respects. The analysis of productivity is undertaken at the industry level rather than at the firm level. The source of data is also different. More important, an attempt is made here to incorporate explicitly variables representing trade liberalization in the econometric model estimated.[4]

III. PRODUCTIVITY GROWTH IN INDIAN MANUFACTURING

This section presents estimates of TFP growth in Indian manufacturing and seventeen two-digit industry groups in the period 1981–82 to 1997–98. Two other studies in which estimates of productivity growth in Indian manufacturing have been pre-

[3] For a review of this literature, see Das (2002).

[4] A careful econometric analysis of the effect of trade liberalization on industrial productivity in India has been undertaken recently by Deb Kusum Das for his Ph.D. dissertation. Findings of his earlier analysis of these issues are reported in Das (1998).

sented for the 1990s are Trivedi, Prakash, and Sinate (2000) and Srivastava (2000). Srivastava has carried out a careful and detailed econometric analysis of productivity growth and technical efficiency in manufacturing firms in India for the period 1980–81 to 1996–97, using data for about three thousand companies. Trivedi et al. have presented estimates of productivity growth for aggregate manufacturing and five major industry groups for the period 1973–74 to 1997–98. They have used industry-level data taken from the *Annual Survey of Industries* published by the Central Statistical Organisation (CSO), Government of India.

The basic data source used for the present estimates of industrial productivity is the same as that used by Trivedi, Prakash, and Sinate (2000). Also the methodology of productivity measurement adopted here is similar to the one used by them. However, greater care has been taken in the measurement of output and inputs (briefly discussed in Appendix), so as to obtain better estimates of productivity growth.

A. *TFP Estimation Method*

A three-input framework has been used for the TFP estimates presented in this paper, as done earlier by Rao (1996), Pradhan and Barik (1998), and Trivedi, Prakash, and Sinate (2000).[5] The translog index of TFP has been used for the measurement of TFP.

Under the three-input framework, the translog index of TFP growth is given by the following equation:

$$\begin{aligned}\Delta \ln TFP(t) = \Delta \ln Q(t) &- \left[\frac{SL(t) + SL(t-1)}{2} \times \Delta \ln L(t)\right] \\ &- \left[\frac{SK(t) + SK(t-1)}{2} \times \Delta \ln K(t)\right] \\ &- \left[\frac{SM(t) + SM(t-1)}{2} \times \Delta \ln M(t)\right]. \qquad (1)\end{aligned}$$

In this equation, Q denotes gross output, L labor, K capital, and M materials (including energy) input. $\Delta \ln Q(t) = \ln Q(t) - \ln Q(t-1)$. In the same way, $\Delta \ln L(t)$, $\Delta \ln K(t)$, and $\Delta \ln M(t)$ are defined. SL is the income share of labor, SK is the income share of

[5] One of the important advances in industry-level productivity measurement is the application of the gross output function, i.e., using gross output rather than value added as a measure of production at the industry level. In a sequence of papers that Jorgenson coauthored with Gollop and with Fraumeni, such a framework has been applied (see, for example, Jorgenson, Gollop, and Fraumeni 1987). Among the studies undertaken in the context of Indian industry, Rao (1996) and Pradhan and Barik (1998) have discussed the advantages of the three-input framework over the two-input framework.

capital, and SM is the income share of materials input. SL, SK, and SM add up to unity. $\Delta \ln TFP$ is the rate of technological change or the rate of growth of TFP.

Using the above equation, the growth rates of TFP have been computed for each year. These have then been used to obtain an index of TFP in the following way. Let A denote the index of TFP. The index for the base year, $A(0)$, is taken as 100. Then, the index for subsequent years is computed using the following equation:

$$A(t) / A(t-1) = \exp[\Delta \ln TFP(t)] . \tag{2}$$

Having obtained the TFP index for different years, estimates of TFP growth rate have been made for two subperiods, 1981–82 to 1990–91 and 1990–91 to 1997–98, and for the entire period 1981–82 to 1997–98. The estimation of TFP growth rate for the entire period has been done by fitting an exponential (or semi-log) trend equation to the TFP index. To obtain the growth rates for the subperiods, the kinked exponential model has been used.[6]

B. *Data Sources*

The basic source of data used for the productivity estimates is the *Annual Survey of Industries*, which has been the principal data source in most earlier studies on industrial productivity in India. For making price corrections to the reported data on gross output and intermediate input, suitable deflators have been constructed with the help of the official series on wholesale price indices (*Index Numbers of Wholesale Prices in India*, prepared by the Office of the Economic Adviser, Ministry of Industry). These have been taken from the official publications and the publications of the CMIE. For a few specific items, other sources of data have been used (mentioned later in Appendix) to construct price indices for those items. The construction of the deflator for intermediate input requires that the price indices for various categories of items be combined using appropriate weights (representing their shares in the intermediate input cost). For this purpose, the weights have been taken from an input-output table for 1989–90, prepared by the CSO. For constructing the capital input series for manufacturing industries, estimates of net fixed capital stock (for the benchmark year) and gross fixed capital formation (for different years) made by the CSO have been used. These have been taken from the *National Accounts Statistics* (*NAS*).

C. *Measurement of Output and Inputs*

Details of the methods employed for the measurement of output and inputs are given in Appendix. Suffice it to note here that deflated gross output is taken as the measure of output. The number of persons employed is taken as the measure of

[6] See Boyce (1986) for a discussion on this method of estimating subperiod growth rates.

labor input. Deflated fixed capital stock is taken as the measure of capital input. To obtain a measure of materials input, the time series on value of materials (including energy) consumed has been deflated by a price index formed by taking into account the cost structure as given in the input-output matrix for 1989–90. The estimates of deflated gross output and deflated material input have been worked out for the individual two-digit industries. These have then been added to obtain the estimate for aggregate manufacturing.

D. *TFP Estimates*

Estimates of TFP growth in the aggregate manufacturing sector are shown in Table I. Growth rates are presented for the periods 1981–82 to 1990–91 and 1990–91 to 1997–98, and for the entire period 1981–82 to 1997–98. The table also shows, for comparison, TFP growth rates for these periods computed from the TFP indices presented in the study of Trivedi, Prakash, and Sinate (2000). It will be noticed that the two sets of estimates are quite similar.

It is seen from Table I that the estimated growth rate of TFP for the period 1981–82 to 1990–91 is 1.89 per cent per annum. The TFP estimates indicate a significant growth in TFP in Indian manufacturing in the 1980s.[7] Also there is a clear indication of a fall in the rate of growth of TFP in the 1990s as compared to the growth rate in the 1980s. The estimated growth rate of TFP in Indian manufacturing for the 1990s is 0.69 per cent per annum as against 1.89 per annum for the 1980s. This finding of a decline in TFP growth in Indian manufacturing in the 1990s is in concurrence with the TFP estimates of Trivedi, Prakash, and Sinate (2000) as can be seen from Table I. Furthermore, this finding is in agreement with the results of econometric analysis presented by Srivastava (2000) and Balakrishnan, Pushpangadan, and Suresh Babu (2000).

TABLE I

TFP GROWTH IN INDIAN MANUFACTURING, 1981–82 TO 1997–98

Period	TFP Growth Rate (% per Annum)	
	This Study	Trivedi et al. (2000)
1981–82 to 1990–91	1.89	1.26
1990–91 to 1997–98	0.69	0.63
1981–82 to 1997–98	1.40	1.00

Note: The growth rates for subperiods are estimated by fitting a kinked exponential model.

[7] Total factor productivity growth in Indian manufacturing in the 1980s has been a subject of much debate among researchers in India. See Ahluwalia (1991), Balakrishnan and Pushpangadan (1994, 1998), Rao (1996), and Pradhan and Barik (1998). More recent contributions to this debate are Goldar (2000b), Goldar and Mitra (2002), Balakrishnan and Pushpangadan (2002), and Goldar (2002a).

For the entire period 1981–82 to 1997–98, the growth rate of TFP in manufacturing is estimated at 1.4 per cent per annum. This estimate of TFP growth rate is by and large in line with the estimates of Trivedi, Prakash, and Sinate (2000).

Total factor productivity estimates for two-digit industries are shown in Table II. The estimated growth rate of TFP for the period 1981–82 to 1990–91 is positive for twelve out of the seventeen groups. For the period 1990–91 to 1997–98, the growth rate of TFP is positive for eleven groups out of seventeen. In most cases, the growth rate for the latter period is relatively lower (eleven out of seventeen groups). This is consistent with the finding of a decrease in the growth rate of TFP in the 1990s as compared to the 1980s at the aggregate manufacturing level.

Trivedi, Prakash, and Sinate (2000) have presented TFP estimates for five major industrial groups, namely, textiles, metals and metal products, machinery and transport equipment, chemicals and chemical products, and leather and leather products. For textiles and chemicals, the growth rate of TFP is lower in the 1990s compared to the 1980s. For metals and metal products, and leather and leather products, the growth rate is higher in the 1990s. For machinery and transport equipment, no significant change in TFP growth rate is indicated. The estimates of TFP growth presented in Table II are broadly in agreement with the TFP estimates of Trivedi et al. for industry groups.

TABLE II

ESTIMATES OF TFP GROWTH RATES, TWO-DIGIT INDUSTRIES, 1981–82 TO 1997–98

NIC Code	Description	Growth Rate of TFP (% per Annum)		
		1981–90	1990–97	1981–97
20–21	Food products	1.04	0.03	0.62
22	Beverages and tobacco	–0.61	–1.66	–1.04
23	Cotton textiles	2.44	–1.09	0.99
24	Wool, silk, and man-made fiber textiles	3.04	1.86	2.55
25	Jute textiles	–0.24	0.81	0.19
26	Textile products	1.45	–1.15	0.38
27	Wood, wood products, furniture	2.81	–9.86	–2.41
28	Paper, paper products, printing and publishing	–0.91	0.92	–0.16
29	Leather, leather products	–0.87	1.54	0.12
30	Chemicals, chemical products	3.14	1.15	2.32
31	Rubber, plastic, petroleum and coal products	3.58	–2.01	1.28
32	Nonmetallic mineral products	3.18	–0.41	1.70
33	Basic metals and alloys	0.59	2.57	1.41
34	Metal products	–0.07	1.07	0.40
35–36, 39	Machinery	2.06	1.22	1.72
37	Transport equipment	1.37	2.64	1.89
38	Other manufacturing	6.55	3.32	5.22
All	Manufacturing sector	1.89	0.69	1.40

Note: The TFP estimates are based on the three-input framework.

Based on his analysis of productivity growth for various industry groups, Srivastava (2000) reports that the growth rate of TFP decreased in the 1990s relative to the 1980s in food products and beverages, nonmetallic mineral products, tobacco products, wood and wood products, and machinery and equipment, while the rate of TFP growth went up in the 1990s in basic metals and alloys, fabricated metal products, paper and paper products, publishing and printing, leather and leather products, and rubber and plastic products. For textiles, chemicals, and motor vehicles, the evidence is mixed. However, for textiles, the evidence is on balance indicative of a fall in productivity performance, and for transport equipment an increase in TFP growth is indicated. It will be noticed that the TFP growth rates presented in Table II show a pattern considerably in agreement with the pattern reported by Srivastava in his study.

Why did TFP growth in Indian manufacturing decelerate in the 1990s? Was this due to a negative effect of import liberalization on the productivity of domestic industry, as a few studies for other developing countries have found? Or, were there other reasons for a slowdown in productivity growth? One possible explanation, at least a partial one, may lie in gestation lags. There was a spurt in investment activity in the 1990s in response to economic reforms.[8] Centre for Monitoring Indian Economy data reveal that the ratio of fixed investment (increase in gross fixed assets) to sales in manufacturing and mining was on average about 9 per cent during 1983–84 to 1990–91, which increased to about 12 per cent during 1991–92 to 1997–98. Data on investment given in the *NAS* indicate that gross fixed investment in organized manufacturing grew at the rate of about 10 per cent per annum between 1980–81 and 1990–91. The growth rate was higher at about 15 per cent per annum between 1990–91 and 1996–97. The ratio of gross fixed capital formation to gross value added (both at 1993–94 prices) in organized manufacturing was 44 per cent during 1985–86 to 1989–90. This ratio increased to 54 per cent during 1990–91 to 1994–95 and to 76 per cent during 1995–96 to 1997–98. This step-up in investment activity in manufacturing might have had an immediate adverse effect on productivity due to gestation lags.[9] A more detailed analysis of these issues is taken up in the next section.

[8] See Uchikawa (2001, 2002).

[9] Uchikawa (2001) has discussed the investment boom in Indian industries in the first half of the 1990s and drawn attention to the adverse effect it had on productivity. He notes (p. 3253) that as a result of the reforms, the Indian manufacturing sector had an investment boom in the first half of the 1990s. The boom was over by the mid-1990s. Although lumpy investment raised output sharply, demand did not expand as much as capacity. This led to underutilization of capacity and thus had an adverse effect on productivity. See also Uchikawa (2002, p. 48).

IV. ECONOMETRIC ANALYSIS OF PRODUCTIVITY GROWTH RATES

This section presents the results of a multiple regression analysis applied to study the effect of import liberalization and gestation lags on industrial productivity. The analysis is based on pooled cross-section and time-series data. Growth rates of TFP computed for the seventeen two-digit industries for different years during the period 1981–82 to 1997–98 are pooled for the regression analysis. The regression equation is specified as:

$$TFPG_{it} = \alpha + \beta_1 GO_{it} + \beta_2 ERP_{it} + \beta_3 NTB_{it} + \beta_4 (ERP_{it} \cdot NTB_{it}) + \beta_5 IKR_{it} + \beta_6 REER_t + \beta_7 GAGR_t + \gamma DUMLIB + u. \qquad (3)$$

In this equation, $TFPG_{it}$ is the growth rate of TFP in industry i in year t, GO_{it} is the growth rate of output (deflated gross value of production) in industry i in year t, ERP_{it} is the effective rate of protection accorded by tariff to industry i in year t, NTB_{it} is the extent of nontariff barriers on imports in respect of industry i in year t, IKR_{it} is the ratio of recently made investments to existing capital stock in industry i in year t, $REER_t$ is the real effective exchange rate in year t, and $GAGR_t$ is the growth rate of agricultural output in year t. *DUMLIB* is a dummy variable for the post-liberalization period (taking value one for 1991–92 onwards and zero for earlier years) and u is the error term.

In the cross-sectional regression analysis of productivity growth, output growth is commonly used as an explanatory variable (see, for example, Kennedy 1971; Kendrick 1973; Goldar 1986a; Ahluwalia 1991).[10] This is the reason for including output growth in the regression equation specified.

Since agriculture is an important source of demand for industrial products (both as intermediate inputs and as final consumer goods), agricultural growth is expected to have a demand-side effect on industrial productivity.[11] Agricultural growth has therefore been included as an explanatory variable in the regression analysis.

The ratio of recent investment to capital stock has been taken as an explanatory variable with a view to capturing the effects of gestation lags in investment projects on productivity. Other explanatory variables used in the model include effective rate of protection (*ERP*), nontariff barriers on imports (*NTB*), and real effective exchange rate (*REER*). These variables are expected to capture the effect of trade policy reforms and changes in exchange rate on industrial productivity performance. It should be pointed out that while the lowering of tariff and nontariff barriers exposes domestic industry to greater import competition, a depreciation of exchange rate

[10] This captures the effect of output growth on productivity through technological advance and scale economies.

[11] Goldar (1992) found a significant positive relationship between agricultural production and industrial productivity.

would to some extent neutralize the effects of reduced import barriers. This has indeed been the case with Indian manufacturing in the 1990s. To assess the effect of trade reforms on productivity, it is important therefore that the real effective exchange rate be included in the regression equation as an explanatory variable.

In the regression equation specified, an interaction term involving *ERP* and *NTB* has been included. The purpose is to allow the effect of tariff reduction on productivity growth to be different for different industries or different periods of time depending on the extent of quantitative restrictions on imports. It may be argued that if the extent of quantitative restrictions on imports is low (high), then the effect of tariff reduction on productivity will be larger (smaller).

The regression equation given above has been estimated by the ordinary least squares (OLS) method. However, to take into account industry-specific factors, intercept dummy variables, one for each industry, have been used, which amounts to applying the fixed-effects model.[12]

A. *Data Sources on Explanatory Variables*

Goldar and Saleem (1992) presented estimates of the effective rate of protection (ERP) for various input-output sectors (manufacturing industries) for the years 1980–81, 1983–84, and 1989–90. In a recent study, Nouroz (2001) has presented estimates of ERP for various input-output sectors (manufacturing industries) for the years 1987–88, 1992–93, 1994–95, and 1997–98, using a methodology similar to that used by Goldar and Saleem (1992). To get a complete series on ERP for the period 1980–81 to 1997–98, the ERP estimates made by Goldar and Saleem for 1980–81, 1983–84, and 1989–90 have been combined with the estimates of Nouroz for 1992–93, 1994–95, and 1997–98, and then these have been interpolated. Next, the input-output sectors have been mapped into the two-digit industry groups. For each two-digit industry group, an estimate of ERP for different years have been formed by taking a weighted average of the estimates for the constituent input-output sectors (value added weights). Appendix Table I shows the ERP estimates for two-digit industry groups for select years.[13]

As regards nontariff barriers on imports (NTB), the estimates presented in a report of the National Council of Applied Economic Research have been used for the analysis (NCAER 2000). These are estimates of the import coverage ratio, i.e., the

[12] The random-effects model was also tried. But the results were found poor as compared to the results of the fixed-effects model—the coefficients of several explanatory variables turned out to be statistically insignificant. Therefore, for presentation in this paper and for drawing inferences from the econometric analysis, the results of the fixed-effects model were chosen.

[13] The ERP estimates used in this paper have been measured by taking the tariff-based approach. In this approach, the ERP is rewritten in terms of tariff rates and input-output coefficients. This methodology assumes that tariffs are the only source of distortion, implying that there are no quantitative restrictions (QRs) or other nontariff barriers. For details, see Goldar and Saleem (1992) and Nouroz (2001).

percentage of imports covered by nontariff barriers. The estimates of the import coverage ratio could be obtained for various input-output sectors for the years 1988–89, 1995–96, and 1997–98. The estimates for the input-output sectors were aggregated to yield estimates for the two-digit industry groups in the same way as done for ERP. The estimates for 1988–89 were used for all the years from 1981–82 to 1990–91, assuming thereby that the extent of nontariff barriers changed very little in this period. The estimates for 1990–91 (same as 1988–89) and 1995–96 have been interpolated to obtain estimates for the in-between years. Similarly, the estimates for 1995–96 and 1997–98 have been interpolated to obtain the estimate for 1996–97.

The real effective exchange rate (*REER*) has been taken from a publication of the Reserve Bank of India (*Handbook of Statistics on Indian Economy*). The index is based on thirty-six country bilateral trade weights, base 1985 = 100. For 1981–82, the index of *REER* is 104.1. For 1990–91 the index is 75.6 and for 1997–98 it is 66.9.[14]

Agricultural growth has been measured as the rate of change in gross domestic product of the agriculture and allied sectors at constant prices of 1980–81. The data have been taken from the Reserve Bank of India, *Handbook of Statistics on Indian Economy, 1999*.

To capture the effect of gestation lags on productivity, the ratio of investment in fixed assets made in the previous two years to the existing fixed capital stock has been taken as an explanatory variable. Here, the assumption is that investments in plant and machinery need about two years' time to be able to achieve fully their potential output. This does not seem to be an unrealistic assumption to make.

The investment ratio variable described above has, however, a shortcoming. The construction of the variable is such that it should be highly correlated with the growth rate of capital input. Since in the computation of TFP growth, a weighted combination of the growth rate of capital input and growth rates of other inputs get subtracted from the growth rate of output, a spurious negative relationship may arise between the investment ratio variable and the rate of TFP growth. In view of this possibility, in some regressions, a different variable has also been tried for capturing the adverse effects of gestation lags on productivity. This is constructed as the ratio of investments made in two previous years to the investments made in the previous five years, and denoted by *I2/I5*. If there is a spurt in investment, this ratio should go up.

B. *Regression Results*

Table III presents the results of regression analysis. Regressions (1), (2), and (3) differ in regard to the investment ratio variable. In regression (1), the effect of the gestation lag is captured by the ratio of recent investment in fixed assets to existing

[14] For methodological details, see *Reserve Bank of India Bulletin*, July 1993, pp. 967–69.

fixed capital stock (*IKR*). In regression (2), *IKR* is replaced by *I2/I5* (for reasons given earlier). In regression (3), neither of the two investment-ratio variables is included in the equation. The specifications used in regressions (4), (5), and (6) are similar to those in regressions (1), (2), and (3), except that in these regression equations *NTB* and dummy variable for the post-liberalization period (*DUMLIB*) have been dropped (since the coefficients of these variables are found to be statistically insignificant).

The regression results presented in Table III clearly show a significant positive relationship between output growth and TFP growth. The coefficient of the output growth is positive and statistically significant at the 1 per cent level in all the equa-

TABLE III

DETERMINANTS OF PRODUCTIVITY GROWTH
(Dependent Variable: TFP Growth Rate)

Explanatory Variables	Regressions					
	(1)	(2)	(3)	(4)	(5)	(6)
GO	0.360***	0.357***	0.345***	0.354***	0.350***	0.339***
	(10.91)	(10.62)	(10.29)	(10.93)	(10.60)	(10.30)
GAGR	0.195***	0.196***	0.160**	0.182***	0.181***	0.151**
	(2.96)	(2.89)	(2.39)	(2.84)	(2.75)	(2.32)
IKR	–25.718***			–25.52***		
	(–3.65)			(–3.68)		
I2/I5		–7.980**			–7.609**	
		(–2.35)			(–2.27)	
ERP	–0.109**	–0.083*	–0.095**	–0.109***	–0.090**	–0.103**
	(–2.56)	(–1.92)	(–2.19)	(–2.74)	(–2.19)	(–2.53)
NTB	0.012	0.028	0.030			
	(0.30)	(0.73)	(0.78)			
ERP · NTB	0.0008*	0.0007	0.0008*	0.0008**	0.0007*	0.0009**
	(1.80)	(1.42)	(1.70)	(2.10)	(1.89)	(2.39)
REER	0.088**	0.108**	0.090**	0.058**	0.076***	0.068**
	(2.05)	(2.45)	(2.05)	(2.03)	(2.60)	(2.33)
DUMLIB	1.699	1.917	1.367			
	(0.95)	(1.05)	(0.75)			
Adjusted R^2	0.357	0.337	0.325	0.360	0.339	0.328
No. of observations	272	272	272	272	272	272

Notes: 1. Figures in parentheses are *t*-ratios.
2. *GO* = growth rate of output; *GAGR* = growth rate of GDP in agriculture and allied activities; *IKR* = ratio of recent investment in fixed assets to existing fixed capital stock; *I2/I5* = ratio of investments made in two previous years to the investments made in the previous five years; *ERP* = effective rate of protection; *NTB* = nontariff barriers on imports; *REER* = real effective exchange rate; *DUMLIB* = dummy variable for the post-liberalization period.
3. The estimated equations include a constant term and sixteen industry dummies.

* Significant at 10 per cent.
** Significant at 5 per cent.
*** Significant at 1per cent.

tions estimated. Such a relationship between output growth and productivity growth has been found in a large number of earlier studies, including studies for Indian industries (Goldar 1986a, 1986b, 1990, 1992; Ahluwalia 1991).

The coefficient of agricultural growth is positive and significant at the 5 per cent or 1 per cent level in all the regression equations estimated. This may be interpreted as showing the effect of agricultural growth on industrial demand and hence on industrial productivity.

The coefficients of the variables representing the pace of investment activity, *IKR* or *I2/I5*, are found to be negative and statistically significant at the 5 per cent or higher level. These variables have been used in the regression to capture the effect of gestation lags on productivity, and a negative relationship is expected.

Turning to the variables representing import liberalization, the coefficient of the *ERP* is found to be consistently negative and it is statistically significant at 10 per cent or higher level in the estimated regressions. In some equations, the coefficient is statistically significant at the 1 per cent level. This may be interpreted as showing the productivity enhancing effect of tariff reform (through increased competitive pressure on domestic industry).[15]

The coefficient of *REER* is found to be positive. It is statistically significant at the 5 per cent or higher level in the regressions. Since there is a negative relationship between *ERP* and TFP growth, a positive relationship should arise between *REER* and TFP growth. This is so because a depreciation of exchange rate (a decline in *REER*) will counter the effects of tariff reduction.

The coefficient of the *NTB* variable is found to be positive. This is contrary to the expected relationship. However, in none of the regressions shown in the table, is the coefficient statistically significant. The coefficient of the interaction term involving *ERP* and *NTB* (i.e., the product of these two variables) is found to be positive. It is statistically significant in most equations. This may be interpreted as showing that the effect of tariff reform on productivity is stronger if there is less quantitative restriction on imports.

The coefficient of the *DUMLIB* is found to be positive, but statistically insignificant. This variable is expected to capture the net effect of all factors connected with economic reforms other than those directly included in the equation. Any differences between the pre- and post-reform periods unconnected with the reforms also get reflected in the coefficient of *DUMLIB*. Since a statistically insignificant coefficient is found, it may be inferred that this group of factors did not on balance have an adverse effect on productivity growth in Indian manufacturing.

[15] A negative relationship between *ERP* and TFP growth was found by Goldar (1986b) in a cross-industry regression analysis for Indian manufacturing for 1960–70. Econometric analysis of TFP growth in Indian manufacturing industries undertaken in the studies of Goldar (1986a, 1990, 1992) and Ahluwalia (1991) has indicated an adverse effect of import substitution policy on productivity growth.

Interestingly, when the investment ratio variable and all the trade liberalization related variables (*ERP*, *NTB*, and *REER*) are dropped from the equation, the coefficient of the dummy variable, *DUMLIB*, becomes significantly negative. This shows that in order to obtain a proper assessment of the effect of reforms one should include in the econometric model variables reflecting the reforms process, rather than use of a dummy variable for the post-reform period and expect that this will capture the effect of reforms as some earlier studies for Indian industries have done.

To sum up, the results of the regression analysis do not indicate any significant adverse effect of import liberalization on productivity growth in Indian manufacturing industries. Rather, there are indications that a lowering of tariff may have contributed positively to productivity growth. Also it seems that the explanation for lower industrial productivity growth in the 1990s may partly lie in gestation lags in investment projects.

It might be instructive to make a comparison here between the average values of TFP growth rate and the explanatory variables in the pre- and post-reform periods. This is given in Table IV. The averages are taken from pooled data across industries and years.

The average TFP growth rate is much lower in the post-reform period (–0.29 per cent per annum) compared to the pre-reform period (2.02 per cent per annum), but the growth rate of output which is a key determinant of productivity growth is about

TABLE IV

AVERAGES OF VARIABLES IN THE PRE- AND POST-REFORM PERIOD

Variables	Pre-reform (1981–82 to 1990–91)	Post-reform (1991–92 to 1997–98)
TFPG (% per annum)	2.02	–0.29
	(5.49)	(7.84)
GO (% per annum)	8.26	8.35
	(9.76)	(12.27)
IKR	0.151	0.209
	(0.049)	(0.073)
ERP (%)	129.09	74.09
	(33.16)	(33.08)
NTB (%)	92.34	63.39
	(13.33)	(21.71)
REER (index, 1985 = 100)	90.51	62.89
	(10.40)	(2.87)
GAGR (% per annum)	3.37	2.27
	(5.83)	(4.15)

Notes: 1. Figures in parentheses are standard deviations.
2. *TFPG* = growth rate of total factor productivity; *GO* = growth rate of output; *IKR* = investment in previous two-year ratio to existing capital stock; *ERP* = effective rate of protection; *NTB* = nontariff barriers on imports; *REER* = real effective exchange rate; *GAGR* = growth rate of output of agriculture and allied activities.

the same in the two periods (around 8.3 per cent per annum in both periods). Thus, the difference in TFP growth rates cannot be traced to differences in the rate of output growth but is caused by some other factors. It is seen from the table that the ratio of recently made investments to capital stock was higher in the post-reform period compared to the pre-reform period. Thus, gestation lags in industrial investment projects may have depressed TFP growth in the latter period. The *ERP* is lower in the post-reform period and this should lead to higher TFP growth in view of the negative relationship found between *ERP* and *TFPG* in the regression analysis. But this favorable effect of reduction in *ERP* seems to have been offset partially out by the depreciation in *REER* in the post-reform period. It is seen from the table that the *REER* index was significantly lower in the post-reform period, which tends to reduce productivity growth since the regression analysis indicates a positive relationship between the index of *REER* and TFP growth rate.

As regards agricultural growth, it is seen from the table that the average growth rate of agricultural output (*GAGR*) is lower in the post-reform period (2.3 per cent per annum) as compared to the pre-reform period (3.4 per cent per annum). The slower agricultural growth may have led to a slow growth in demand for industrial product, which in turn may have caused underutilization with an adverse effect on productivity. Thus, the deceleration in productivity growth in Indian industry in the 1990s may in part be attributed to a slowdown in the growth of agriculture in this period.

V. CAPACITY UTILIZATION AND PRODUCTIVITY

Regression analysis presented above suggested that gestation lags in investment projects was one of the factors that caused a slowdown in TFP growth in Indian manufacturing in the 1990s. This, however, needs to be qualified because if gestation lags had seriously constrained industrial production in the mid-1990s, output growth should have picked up after 1997–98 because of accelerated investment during 1994–95 to 1996–97, which did not happen. Rather, the growth rate of real gross value added in registered manufacturing came down from 9.5 per cent per annum during 1990–91 to 1996–97 to 4.3 per cent per annum during 1997–98 to 2000–01.[16] Thus, gestation lags cannot provide an adequate explanation of the fall in the growth rate of TFP in manufacturing in the 1990s, though on the basis of the results obtained it seems this factor did make a contribution.

Uchikawa (2001, 2002) has pointed out that while the investment boom of the mid-1990s raised production capacities substantially, demand did not rise which led to capacity underutilization. He notes that underutilization of capacity manifested itself first in consumer durable and nondurable goods industries and then in capital goods and intermediate goods industries (Uchikawa 2002, p. 40).

[16] Growth rates are based on GDP of registered manufacturing at 1993–94 prices given in the *NAS*.

In consideration of the above points, there is clearly a need to incorporate capacity utilization into the regression analysis. It should be taken as an explanatory variable in the regression equations estimated to explain variations in productivity growth. Another variable that should be included in the regression equations is man-days worked per employee since it reflects effective utilization of the manpower available.

Table V presents the regression results obtained by including rates of change in capacity utilization and man-days worked per employee as explanatory variables. Data on employment and man-days worked are available in the *Annual Survey of Industries* (*ASI*), which were used to compute man-days per employee.[17] Capacity utilization rates were estimated for each two-digit industry for the period 1981–82 to 1997–98 using the minimum capital-output ratio method, applied earlier by Sastry (1984) and Uchikawa (2001, 2002), and several other studies. The estimates of capacity utilization obtained by this method are rather crude, but these had to be employed for the analysis as no better estimates of capacity utilization were readily available.

A strong positive relationship is found between the rate of change in capacity utilization and the rate of growth in productivity. This is obviously expected. On the other hand, the coefficient of the rate of change in man-days per employee is not statistically significant. The explanation for not finding a significant relationship between productivity growth and changes in man-days per employee probably lies in the fact there has not been much change in man-days worked per employee in most industries, especially in the 1990s (see Goldar 2000a).[18]

The average rate of change in capacity utilization (across industries and years) was 2.37 per cent per annum in the pre-reform period and –1.39 per cent per annum in the post-reform period. Since the coefficient of the variable is about 0.25, changes in capacity utilization would account for about 1 percentage point difference in the growth rate of TFP between the pre- and post-reform period. Thus, the fact that capacity utilization in industries was growing in the 1980s and falling in the 1990s can explain most the observed difference in the growth rate of TFP between the two periods.

As regards the other explanatory variables, the results reported in Table V are by and large similar to those reported in Table III. A significant negative relationship is found between *ERP* and TFP growth and a significant positive relationship between agricultural growth and industrial productivity growth. Two important differences that may be noted in the regression results after inclusion of capacity utilization

[17] Data on man-days are not available for 1997–98. The figures for 1996–97 were therefore repeated for 1997–98.

[18] Average growth rate in man-days per employee was 1.03 per cent per annum in the 1980s and 0.16 per cent per annum in the 1990s.

TABLE V

DETERMINANTS OF PRODUCTIVITY GROWTH: ADDITIONAL REGRESSION RESULTS
(Dependent Variable: TFP Growth Rate)

Explanatory Variables	Regressions					
	(1)	(2)	(3)	(4)	(5)	(6)
GO	0.206***	0.161**	0.135**	0.212***	0.160**	0.136**
	(2.69)	(2.38)	(2.18)	(2.78)	(2.36)	(2.20)
GAGR	0.209***	0.215***	0.203***	0.193***	0.195***	0.186***
	(3.18)	(3.20)	(3.08)	(3.00)	(2.99)	(2.89)
IKR	–13.900			–14.67*		
	(–1.58)			(–1.69)		
I2/I5		–3.446			–3.132	
		(–0.96)			(–0.87)	
ERP	–0.104**	–0.091**	–0.097**	–0.106***	–0.096**	–0.102**
	(–2.44)	(–2.14)	(–2.28)	(–2.65)	(–2.38)	(–2.54)
NTB	0.018	0.026	0.026			
	(0.46)	(0.68)	(0.70)			
ERP · NTB	0.0008*	0.0007	0.0008*	0.0007**	0.0007*	0.0008**
	(1.73)	(1.55)	(1.68)	(2.03)	(1.92)	(2.11)
REER	0.096**	0.107**	0.100**	0.057**	0.064**	0.060**
	(2.20)	(2.42)	(2.30)	(1.98)	(2.20)	(2.09)
DUMLIB	2.212	2.461	2.334			
	(1.23)	(1.36)	(1.29)			
CCU	0.190**	0.244***	0.272***	0.173**	0.234***	0.260***
	(2.20)	(3.27)	(3.94)	(2.04)	(3.16)	(3.82)
CMD	0.007	0.010	0.005	0.024	0.026	0.021
	(0.08)	(0.11)	(0.06)	(0.26)	(0.29)	(0.24)
Adjusted R^2	0.365	0.361	0.361	0.366	0.361	0.361
No. of observations	272	272	272	272	272	272

Notes: 1. Figures in parentheses are *t*-ratios.
2. *GO* = growth rate of output; *GAGR* = growth rate of output of agriculture and allied activities; *IKR* = ratio of recent investment in fixed assets to existing fixed capital stock; *I2/I5* = ratio of investments made in two previous years to the investments made in the previous five years; *ERP* = effective rate of protection; *NTB* = nontariff barriers on imports; *REER* = real effective exchange rate; *DUMLIB* = dummy variable for the post-liberalization period; *CCU* = rate of change in capacity utilization; *CMD* = rate of change in man-days per employee.
3. The estimated equations include a constant term and sixteen industry dummies.

* Significant at 10 per cent.
** Significant at 5 per cent.
*** Significant at 1per cent.

among explanatory variables are: (a) the coefficient of the output growth variable decreases in numerical value (but remains statistically significant),[19] and (b) the coefficients of variables representing gestation lags become statistically insignificant

[19] The elasticity of TFP growth with respect to output growth has been found to be in the range of 0.3 to 0.5 in most studies undertaken on Indian industries. It appears from the results reported in Table V that the true elasticity is lower, after controlling for capacity utilization.

(barring one equation). It may be argued that the capacity utilization variable captures the effect of gestation lags (due to the manner of estimation of production capacity). Hence, after inclusion of capacity utilization variable in the regression equation, the variables representing gestation lags may become statistically insignificant in explaining TFP growth.

A. *TFP Estimate for Manufacturing Adjusted for Capacity Utilization*

Since the above analysis clearly shows that capacity utilization had a major effect on productivity growth in Indian manufacturing, it is important that an estimate of TFP be made to correct for changes in capacity utilization. This has been done and is discussed further below.

Estimation of capacity utilization in manufacturing has been done on the basis of electricity consumption, using a methodology applied earlier by Mulaga and Weiss (1996).[20] The ratio of electricity consumption to capital stock is first computed for different years in the period under study. A trend line is fitted to the data, which is then shifted up so that it passes through the point having the largest positive residual. The actual ratio of electricity to capital is then compared with the ratio indicated by the trend line (adjusted) to compute capacity utilization. The estimates of capacity utilization in Indian manufacturing obtained by this method are shown in Figure 1. An alternate estimate based on the minimum capital-output ratio is also shown in the figure for comparison. This series on capacity utilization in manufacturing is obtained as a weighted average of the capacity utilization estimates for the various two-digit industries.

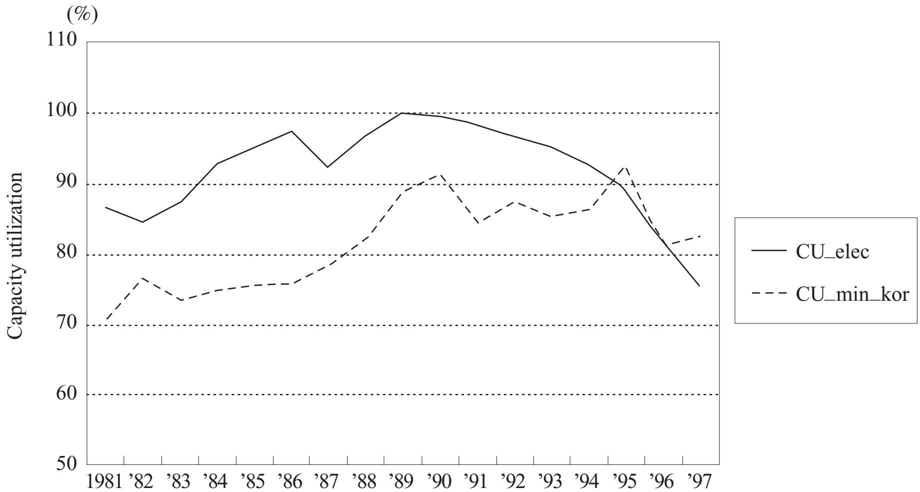
The capacity utilization series based on electricity consumption as well as that based on minimum capital-output ratio indicate an upward trend in capacity utilization in Indian manufacturing in the 1980s and a downward trend in the 1990s. For the 1990s, the estimates based on electricity consumption show a steeper fall in capacity utilization than the estimates based on minimum capital-output ratio.

The estimates of TFP growth in the manufacturing sector obtained after correcting for capacity utilization are shown in Table VI. The trend growth in TFP adjusted for capacity utilization was 1.3 per cent per annum in the period 1990–91 to 1997–98, only marginally lower than the 1.6 per cent per annum growth rate of TFP in the period 1981–82 to 1990–91. The difference between the growth rates of the two periods is not statistically significant.

Based on the results of regression analysis presented in Table V and the estimates of TFP presented in Table VI, it can be concluded that the deceleration in TFP growth in Indian manufacturing in the 1990s observed in several earlier studies was

[20] Data on electricity sold to industry by utilities have been used for this purpose. These data have been taken from Economic Intelligence Service, *Energy* (Mumbai: Centre for Monitoring Indian Economy, 2002). Since detailed data on industrial electricity consumption are not available, this methodology could not be applied to the two-digit industries.

Fig. 1. Capacity Utilization in Indian Manufacturing



Note: CU_elec = capacity utilization estimated based on electricity consumption; CU_min_kor = capacity utilization estimated by the minimum capital-output ratio method.

TABLE VI

TFP GROWTH RATE IN INDIAN MANUFACTURING, 1981–82 TO 1997–98: ESTIMATES CORRECTED FOR CAPACITY UTILIZATION

Period	TFP Growth Rate (% per Annum)	
	Corrected for Capacity Utilization	Not Corrected
1981–82 to 1990–91	1.6	1.9
1990–91 to 1997–98	1.3	0.7
1981–82 to 1997–98	1.5	1.4

Note: The growth rates for subperiods are estimated by fitting a kinked exponential model.

essentially a consequence of capacity underutilization in Indian manufacturing in this period. Once that is corrected for, the growth rate of TFP in the 1990s was about the same as that in the 1980s.

A question that presents itself here is: why trade and industrial reforms did not result in an accelerated productivity growth in Indian industry? On this question, it should be pointed out that such favorable, productivity-enhancing effects may occur with a lag (Athukorala and Rajapatirana 2000, pp. 166–75). The finding of significant positive relationship between trade reform and productivity in the regression analysis and the fact that the process of trade reforms continued in India during the late 1990s provides a basis for thinking that a marked improvement in productivity growth in Indian manufacturing should take place in the years to come.

VI. CONCLUSION

This paper examined trends in TFP in Indian manufacturing in the 1980s and 1990s. The estimates obtained indicated that during the 1990s, a decade of major industrial and trade reforms, there was a deceleration in TFP growth in manufacturing, corroborating the findings of several earlier studies. However, a closer examination revealed that: (a) capacity utilization was a significant factor influencing productivity growth in industries; and (b) there was an increase in capacity utilization in manufacturing in the 1980s and a fall in the 1990s. After making corrections for changes in capacity utilization, the TFP growth estimates for the 1990s were found to be about the same as in the previous decade.

Multiple regression analysis was carried out to study the factors influencing TFP growth in manufacturing industries. The results showed a significant favorable effect of tariff reforms on industrial productivity. The results also indicated that slower growth of agriculture in the 1990s and gestation lags in investment project may have had an adverse effect on TFP growth in Indian manufacturing in this period.

REFERENCES

Ahluwalia, Isher Judge. 1991. *Productivity and Growth in Indian Manufacturing*. Delhi: Oxford University Press.

Athukorala, Prema-chandra, and Sarath Rajapatirana. 2000. *Liberalization and Industrial Transformation: Sri Lanka in International Perspective*. New Delhi: Oxford University Press.

Balakrishnan, Pulapre, and K. Pushpangadan. 1994. "Total Factor-Productivity Growth in Manufacturing Industry: A Fresh Look." *Economic and Political Weekly* 29, no. 31: 2028–35.

———. 1998. "What Do We Know about Productivity Growth in Indian Industry?" *Economic and Political Weekly* 33, nos. 33–34: 2241–46.

———. 2002. "TFPG in Manufacturing: The 80s Revisited." *Economic and Political Weekly* 37, no. 4: 323–25.

Balakrishnan, Pulapre; K. Pushpangadan; and M. Suresh Babu. 2000. "Trade Liberalisation and Productivity Growth in Manufacturing: Evidence from Firm-Level Panel Data." *Economic and Political Weekly* 35, no. 41: 3679–82.

Boyce, James K. 1986. "Kinked Exponential Models for Growth Rate Estimation." *Oxford Bulletin of Economics and Statistics* 48, no. 4: 385–91.

Chaturvedi, D. N., and Amaresh Bagchi. 1984. "Age Structure of Fixed Capital in the Indian Economy, 1970–71 to 1980–81." *Journal of Income and Wealth* 7, no. 1: 82–103.

Das, Deb Kusum. 1998. "Trade Liberalisation and Productivity Growth: A Disaggregated Analysis of Indian Manufacturing Sectors." IEG Working Paper no. E/200/98. Delhi: Institute of Economic Growth.

———. 2002. "Trade Liberalization and Industrial Productivity: An Assessment of Developing Country Experiences." ICRIER Working Paper no. 77. New Delhi: Indian Council for Research on International Economic Relations. Available from http://www.icrier.res.in/pdf/deb.pdf.

Goldar, Bishwanath. 1986a. "Import Substitution, Industrial Concentration and Productivity Growth in Indian Manufacturing." *Oxford Bulletin of Economics and Statistics* 48, no. 2: 143–64.

———. 1986b. *Productivity Growth in Indian Industry*. New Delhi: Allied Publishers.

———. 1990. "Import Liberalization and Industrial Efficiency." In *Economic Liberalization, Industrial Structure and Growth in India*, ed. Ashok Guha. Delhi: Oxford University Press.

———. 1992. "Productivity and Factor Use Efficiency in Indian Industry." In *Indian Industrialization: Structure and Policy Issues*, ed. Arun Ghosh, Mridul Eapen, Haseeb A. Drabu, and K. K. Subrahmanian. Delhi: Oxford University Press.

———. 2000a. "Employment Growth in Organised Manufacturing in India." *Economic and Political Weekly* 35, no. 14: 1191–95.

———. 2000b. "Productivity Growth in Indian Manufacturing in the 1980s and 1990s." Paper presented at the conference in honor of Prof. K. L. Krishna, on Industrialization in a Reforming Economy: A Quantitative Assessment, organized by the Centre for Development Economics, Delhi School of Economics, Delhi, December 20–22.

———. 2002a. "TFP Growth in Indian Manufacturing in 1980s." *Economic and Political Weekly* 37, no. 49: 4966–68.

———. 2002b. "Trade Liberalization and Employment: The Case of India." Employment Paper no. 2002/34. Geneva: International Labour Organization.

Goldar, Bishwanath, and Arup Mitra. 2002. "Total Factor Productivity Growth in Indian Industry: A Review of Studies." In *National Income Accounts and Data Systems*, ed. B. S. Minhas. New Delhi: Oxford University Press.

Goldar, Bishwanath, and Hasheem N. Saleem. 1992. "India's Tariff Structure: Effective Rates of Protection of Indian Industries." Studies in Industrial Development, Paper no. 5. New Delhi: Ministry of Industry, Government of India.

Jorgenson, Dale W.; Frank M. Gollop; and Barbara M. Fraumeni. 1987. *Productivity and U.S. Economic Growth*. Cambridge, Mass.: Harvard University Press.

Kendrick, John W. 1973. *Postwar Productivity Trends in the United States, 1948–1969*. New York: National Bureau of Economic Research.

Kennedy, Kieran Anthony. 1971. *Productivity and Industrial Growth: The Irish Experience*. Oxford: Clarendon Press.

Krishna, Pravin, and Devashish Mitra. 1998. "Trade Liberalization, Market Discipline and Productivity Growth: New Evidence from India." *Journal of Development Economics* 56, no. 2: 447–62.

Mulaga, Geoffrey, and John Weiss. 1996. "Trade Reform and Manufacturing Performance in Malawi 1970–91." *World Development* 24, no. 7: 1267–78.

National Council of Applied Economic Research (NCAER). 2000. *Protection in Indian Industry*. New Delhi: NCAER.

Nouroz, Hasheem. 2001. *Protection in Indian Manufacturing: An Empirical Study*. Delhi: Macmillan India.

Pradhan, Gopinath, and Kaustuva Barik. 1998. "Fluctuating Total Factor Productivity in India: Evidence from Selected Polluting Industries." *Economic and Political Weekly* 33, no. 9: M25–M30.

Pursell, Garry. 1996. "Indian Trade Policy since the 1991/92 Reforms." Washington, D.C.: World Bank. Mimeographed.

Rao, J. Mohan. 1996. “Manufacturing Productivity Growth: Method and Measurement.” *Economic and Political Weekly* 31, no. 44: 2927–36.

Sastry, D. U. 1984. *The Cotton Mill Industry in India*. Delhi: Oxford University Press.

Srivastava, Vivek. 2000. “The Impact of India’s Economic Reforms on Industrial Productivity, Efficiency and Competitiveness.” Report of a project sponsored by the Industrial Development Bank of India. New Delhi: National Council of Applied Economic Research.

Trivedi, Pushpa; Anand Prakash; and David Sinate. 2000. “Productivity in Major Manufacturing Industries in India: 1973–74 to 1997–98.” Development Research Group Study no. 20. Mumbai: Department of Economic Analysis and Policy, Reserve Bank of India.

Uchikawa, Shuji. 2001. “Investment Boom and Underutilisation of Capacity in the 1990s.” *Economic and Political Weekly* 36, no. 34: 3247–54.

———. 2002. “Investment Boom and Capital Goods Industry.” In *Economic Reforms and Industrial Structure in India*, ed. Shuji Uchikawa. New Delhi: Manohar Publishers.

APPENDIX

MEASUREMENT OF OUTPUT AND INPUTS

Labor

Total number of persons engaged in industrial units is taken as the measure of labor input. This is reported in the *Annual Survey of Industries* (*ASI*). For the recent issues, it is reported under the heading “persons engaged”; for earlier issues, it is reported under that of “number of employees.”

Capital

Gross fixed assets at 1980–81 prices is taken as the measure of capital input. This has been computed in the following way:

(1) *Aggregate manufacturing sector*. An estimate of net fixed capital stock for the registered manufacturing sector for end-March 1971 (benchmark) is taken from *National Accounts Statistics* (*NAS*).[a] This is multiplied by a gross-net factor to get an estimate of gross fixed capital stock for the year 1970–71. The ratio of gross to net fixed assets in medium and large public limited companies (as reported in *Reserve Bank of India Bulletin*) was 1.86 in 1970–71. Thus, the net fixed capital stock for registered manufacturing for the benchmark year, reported in *NAS*, is multiplied by 1.86 to get an estimate of gross fixed capital stock for the benchmark year. To build the capital series from the benchmark capital stock estimate, the perpetual inventory method is used. Thus, gross in-

[a] Note that while the productivity estimates are made for the period 1981–82 to 1997–98, the capital series is built from 1970–71. The purpose in building the capital series from an earlier year is that the pre-1971 assets would form only a part of the capital stock of 1981–82 and hence any error in the estimation of the benchmark capital stock will be rendered relatively small.

vestment in fixed assets in registered manufacturing in 1971–72 is added to the benchmark capital estimate (1970–71) to obtain the capital stock estimate for the next year, i.e., end-March 1972. In this manner, the entire capital series is built. The gross fixed investment series is taken from *NAS* (the series on gross fixed capital formation at 1980–81 prices for registered manufacturing). In preparing the time series on capital stock, it is important to allow for discarding of assets (Goldar 1992). The rate of discarding has been taken as 2.6 per cent per annum (based on some estimates available from a study undertaken by Chaturvedi and Bagchi 1984).

(2) *Two-digit industries*. The benchmark estimate of gross fixed capital stock made for registered manufacturing for 1970–71 is distributed among various two-digit industries in proportion to the fixed capital stock (net) of these industries reported in *ASI*, 1970–71. This provides the benchmark capital stock estimates for individual two-digit industries. Then, for each industry and for each year, the gross investment at current prices are computed, taking the difference in the book value of fixed capital assets reported in *ASI* and depreciation.[b] For each year, gross investment in fixed capital assets is available for the registered manufacturing sector from *NAS*. This is distributed among the two-digit industries in proportion to the gross investment (at current prices) computed from *ASI* data. In this manner, the real fixed investment is obtained for each two-digit industry for each year, from 1971–72 to 1997–98. Then, following the perpetual inventory method, the time series on fixed capital stock has been constructed for all the two-digit industries. In this case again, the rate of discarding is taken as 2.6 per cent per annum, to be consistent with the capital series for aggregate manufacturing.

Output and intermediate input

Time-series data on gross output and cost of intermediate inputs have been deflated by suitable deflators (base 1981–82 = 100) to measure real output and real intermediate input. Needless to say, the construction of deflators for gross output and intermediate inputs is crucial for the proper measurement of output. The procedure followed for constructing the deflators is described below:

(1) In the first step, price indices have been formed for each of the ninety-nine sectors of the 1989–90 input-output table, belonging to agriculture, mining, manufacturing, and electricity.[c] For some sectors, the available wholesale price index series could be used directly. In some other cases, the available category-

[b] Gross investment in year t denoted by $I(t)$ is computed as $I(t) = B(t) - B(t-1) + D(t)$, where $B(t)$ is the book value of fixed assets in year t and $D(t)$ is depreciation of fixed assets in year t, both as reported in *ASI*.

[c] The input-output table for 1989–90 has 115 sectors of which 99 belong to agriculture, mining, manufacturing, and electricity.

wise price indices have been combined to form the price index for the relevant input-output sector.[d] For three sectors, the wholesale price index series did not seem appropriate for forming deflators of intermediate input. In these cases, other sources of data have been used. Thus, for crude oil, data on domestic prices of crude oil have been taken from *Petroleum and Natural Gas Statistics* and a price index has been formed.[e] Similarly, a price index for electricity used in industries has been formed using data on electricity tariff paid by industries.

(2) For petroleum products (as inputs to industries), the prices of naphtha and fuel oil/LSHS have been considered. The fact that fertilizer units have been paying a lower price than other industries has been taken into account in preparing the price indices of petroleum products as inputs to industry. Three price indices have been formed for this purpose: one for the consumption of petroleum products in fertilizer plants, one for petrochemical units, and one for other industries.[f]

(3) For each input-output sector engaged in manufacturing (sixty-six sectors), a price index for intermediate inputs has then been formed. This is done by taking a weighted average of price indices of the ninety-nine sectors (discussed in (1) above). The column for the relevant sector in the Absorption Matrix provides the weights used.

(4) The input-output sectors have been mapped into the two-industry classification of *ASI*. To work out the price indices for the two-digit industries, the weighted averages of the price indices of the constituent input-output sectors have been taken. For combining the intermediate input price indices of different constituent sectors, the expenditures on intermediate inputs are used as weights. For deriving a price index for gross output of a two-digit industry from the output price indices of the input-output sectors, the weights used are the gross output of the constituent sectors.

[d] In a number of cases, no suitable price index was available. Therefore, some approximation became necessary, and the best price index among the available ones was applied.

[e] For working out a price index for crude oil, price of indigenous onshore crude oil in India has been taken from *Indian Petroleum and Natural Gas Statistics*. This price is available monthly. The average of April to March for each financial year has been taken, and then the index for crude oil with base 1981–82 =100 has been constructed.

[f] These prices have been taken from *Fertilizer Statistics*.

APPENDIX TABLE I

ERP (Effective Rate of Protection) Estimates for Two-Digit Industries

(%)

Industry Group	1980–81	1983–84	1989–90	1992–93	1994–95	1997–98
20–21	129.86	172.06	176.92	63.60	72.11	58.81
22	113.70	149.55	188.74	78.09	68.84	78.96
23	135.25	154.06	141.70	111.58	47.44	49.01
24	121.04	139.88	145.81	113.08	70.29	41.02
25	159.35	177.63	154.95	148.70	112.70	59.80
26	117.89	139.16	148.50	111.86	68.86	43.21
27	92.10	123.00	150.68	184.01	88.24	49.19
28	71.20	81.28	88.73	101.28	34.45	21.55
29	124.69	139.36	156.57	101.42	55.37	44.74
30	73.08	94.85	111.84	113.66	65.73	31.85
31	169.61	212.77	155.94	114.36	79.80	55.06
32	70.42	90.51	135.91	92.60	67.59	44.38
33	73.62	133.77	136.63	111.93	44.14	27.65
34	108.96	111.63	122.19	58.33	52.53	27.38
35–36	67.38	71.65	81.78	72.27	29.06	26.56
37	89.33	94.69	71.83	91.36	63.22	45.11
38	65.51	85.06	115.13	118.59	64.29	32.16
Manufacturing	99.50	121.80	128.00	100.50	58.40	41.00

Note: For two-digit industry codes, see Table II.