Import Liberalization and Productivity Growth in Indian Manufacturing Industries in the 1990s

Bishwanath Goldar and Anita Kumari

Abstract: In the post-reform period, there has been a notable decrease in the growth rate of total factor productivity (TFP) in Indian manufacturing. The econometric analysis presented in the paper indicates that the deceleration in productivity growth should not be attributed to import liberalization. Rather, the reduction in effective protection to industries appears to have had a favourable effect on productivity growth in Indian industries. It seems the explanation for the fall in the growth rate of productivity may lie partly in gestation lags in investment projects (there was a step up in investment activity in Indian industries following the reforms) and in a slow down in agricultural growth in the 1990s.

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1. Introduction

Since 1991, India has undertaken a major economic reforms programme. Under the programme, 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 and quantitative restrictions on imports have been removed or relaxed. These reforms in import policy, along with complementary changes in industrial policy, technology import policy and foreign direct investment policy, were aimed at making the Indian industry more efficient, technologically up-to-date and competitive, with the expectation that efficiency improvement, technological upgradation, and enhancement of competitiveness would enable Indian industry 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 inter-industry variations in productivity growth rates, aimed at assessing the effect of import liberalization on productivity growth in Indian industries in the 1990s.

2. Effect of Import Liberalization on Industrial Productivity

There are reasons to expect a favourable effect of 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 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 labour, 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; (f) Greater access to imported inputs and a more realistic exchange rate associated with a liberalized trade regime would enable industrial firms 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 of import liberalization on industrial productivity. However, this view or hypothesis does not have a 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. Some of them have found a significant favourable effect of import liberalization on industrial productivity. But, some have found no significant effect, while some 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 Centre for Monitoring Indian Economy (CMIE) database. Also, there is 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 favourable effect of reforms on industrial productivity. Balakrishanan *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 studies undertaken by Krishna and Mitra (1998) and Balakrishnan, et al. (2000) 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.[1]

[1] 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).

3. Import Liberalization in India in the 1990s

Prior to the trade reforms initiated in 1991, Indian industry enjoyed a high degree of protection against import competition thanks to a very high general level of tariff and extensive quantitative restrictions on imports. The tariff rates were reduced considerably in the 1990s. 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 2001).[2] 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 (see Table 1 and Fig. 1).[3]

Table 1: Collection Rates of Customs Duty: Selected Product Groups

	Duty rate (%)				
	1990-91	1995-96	1997-98	1998-99	1999-2000
Food products	47	23	16	15	17
Petroleum	34	30	29	29	27
Chemicals	92	44	37	34	37
Man-made fibre	83	36	36	49	65
Paper and Newsprint	24	8	13	11	9
Metals	95	52	44	51	53
Capital goods	60	33	41	42	40
All commodities	47	29	27	23	24

Source: *Economic Survey*, 2000-2001, Government of India, p.45.

The lowering of tariff rates was accompanied by a substantial relaxation of quantitative restrictions on imports. The non-tariff barrier (NTB) coverage in manufacturing declined from 90 per cent by the end of 1990 to 36 per cent in May 1995 (see Table 2). 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. The process of relaxation of quantitative restrictions on imports continued beyond 1995. Between 1995-96 and 1999-2000, the NTB coverage declined significantly in most industry groups (see Table 3). For aggregate manufacturing, the decline in NTB coverage was from 87 per cent in 1988-89 to 46 per cent in 1995-96 and further to 28 per in 1999-2000 (see Fig. 2).

[2] 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).

[3] The effective rate of protection to Indian manufacturing accorded by tariff was about 128 per cent in 1989-90. This came down to about 40 per cent in 1997-98. See Annex C.

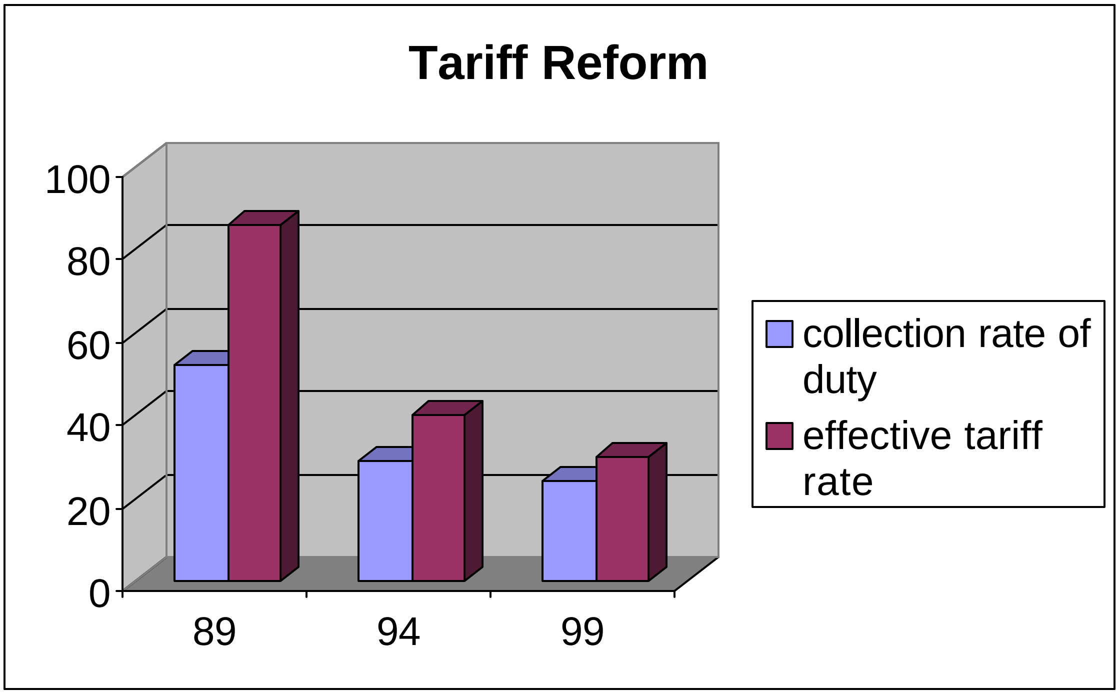

Fig. 1: Average Tariff Rates, 1989-90, 1994-95 and 1999-2000.

Table 2: NTB Coverage of India's Imports 1990 and 1995

Sector	Estimated share of GDP in internationally tradeable goods protected by NTB	
	End 1990	May 1995
Agriculture	94	84
Mining	100	40
Manufacturing	90	36
Machinery		10
Intermediate		12
Consumer goods		79

Source: Pursell (1996).

Table 3: Coverage Ratio for Non-tariff Barriers on India's Imports

	Industry Based Classification	1995-96	1997-98	1998-99	1999-00
1	Food, beverages and tobacco	74.47	65.67	63.06	46.58
2	Textiles and leather	47.06	48.33	47.44	39.30
3	Wood, cork and products	41.99	24.03	20.00	2.87
4	Paper and printing	39.01	25.82	22.03	17.76
5	Chemicals, petrol and coal	32.29	22.52	20.77	12.57
6	Non-metallic minerals	76.48	46.32	40.41	19.05
7	Basic metal industries	13.21	14.46	11.87	9.03
8	Metal products and machinery	37.93	29.73	27.93	21.17
9	Other Manufacturing	46.44	30.56	27.39	17.19
10	Agriculture	67.10	80.07	76.93	59.00
11	Mining	27.71	27.09	27.09	26.97

Source: Computations done by Mihir Pandey for a Report of the NCAER (National Council of Applied Economic Research, New Delhi).

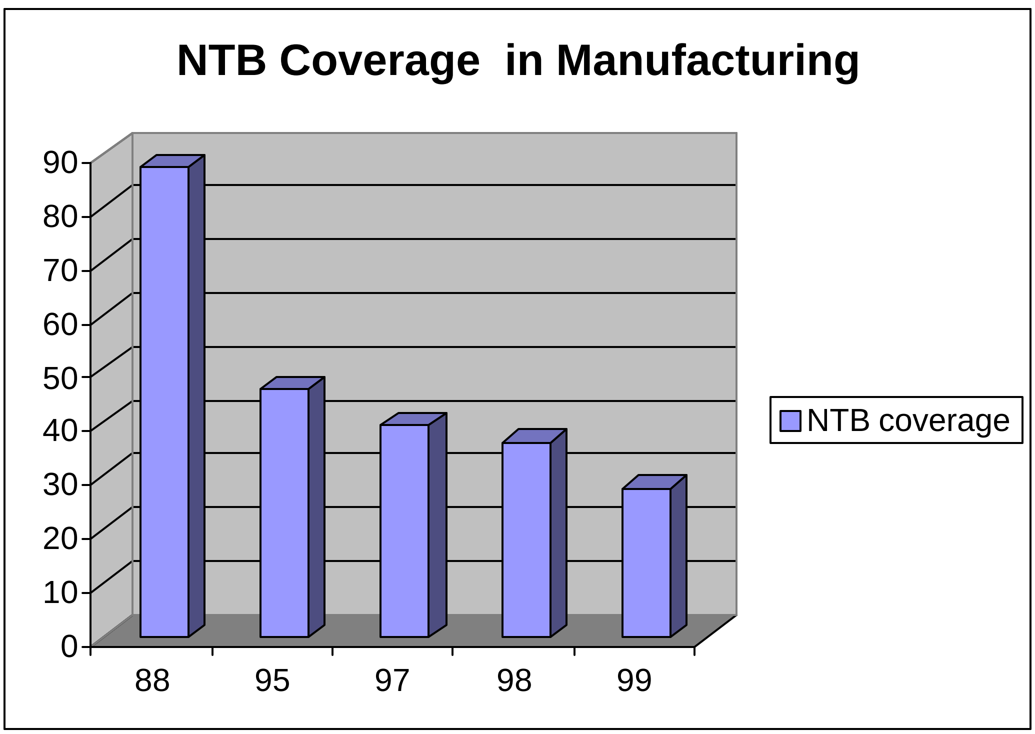

Fig. 2: NTB Coverage in the Manufacturing Sector, 1988-89 to 1999-00.

In this context, it should be mentioned here that while quantitative restrictions on imports of most intermediate and capital goods were removed during the 1990s, such restrictions continued on imports of most consumer goods. It is only in the last two years, 2000 and 2001, that quantitative restrictions on consumer goods imports have been removed. As a result of these recent changes in import policy, almost all manufactured goods have now become freely importable, subject only to tariff.

It is reasonable to argue that due to the removal of quantitative restrictions on imports of intermediate and capital goods, Indian manufacturing firms must have had in the 1990s a considerably improved access to imported capital goods and intermediate goods. Lowering of tariff provided cheaper access to such inputs. Further, because of the large reduction in tariff and removal of quantitative restrictions on imports, many manufacturing industries must have been exposed to greater competition from imported goods. Thus, there are grounds to expect a step up in the growth of manufactured imports in the 1990s as well as a marked increase in the degree of import penetration in domestic markets of manufactured products. Did these actually occur?

An analysis of trends in imports of manufactures reveals that there has been no noticeable surge in such imports. Rather, imports of manufactured articles in the 1990s were lower than the level that should have been reached based on the past trend. This is brought out by Fig. 3, which presents a comparison of manufactured imports (value in millions of US dollars) in the 1990s with the forecast of imports for this period based on an exponential trend fitted to the data for the 1980s and extended for the latter period. It is clearly seen that the imports of manufactures were lower than what one would forecast based on past trend.

Similarly, an analysis of trends in the import penetration ratio for the manufacturing sector reveals that there has been no sharp rise in the import penetration ratio in the 1990s. The import penetration ratio in the 1990s was not higher than that projected on the basis of the trend in the previous decade. This can be seen from Fig. 4 in which the import penetration ratio is plotted along with the trend line based on data for the 1980s. Evidently, the foreign producers of manufactured products have not been able to make major inroads into the Indian markets of manufactures products despite the significant lowering of tariffs and the removal of quantitative restrictions on manufactured imports.

Why has import liberalization not led to a surge in manufactured imports and a marked increase in the import penetration ratio? In part, this may be explained by the fact that the liberalization of import policy has been accompanied by a substantial depreciation of the exchange rate. The nominal exchange rate depreciated by about 50 per cent between 1990 and 1995 and the real effective exchange rate depreciated by about 24 per cent in this period (see Table 4). The depreciation of exchange rate made imported manufactured goods costlier. It neutralized to some extent the potential effects of lowering of tariff rates and relaxation of quantitative restrictions on imports.

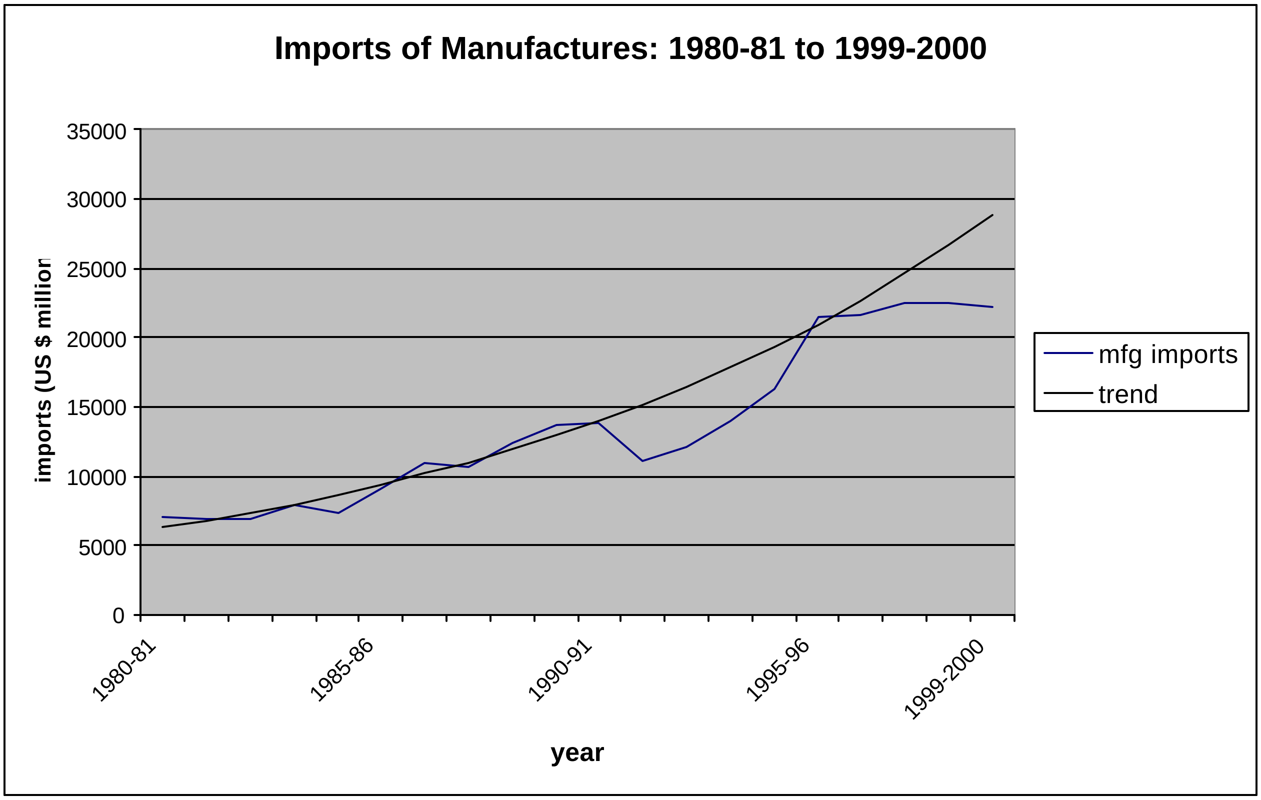

Fig. 3: Imports of Manufactures (in US $ million), 1980-81 to 1999-2000.

Source: The time-series on India's imports of manufactures (in US $) has been taken from Goldar (2001). This series is based on data taken from Reserve Bank of India, *Handbook of Statistics on Indian Economy*. An exponential trend has been fitted to the data on manufactured imports for the 1980s, and extended to the 1990s.

Another factor that might partially explain why tariff reduction did not significantly impact imports of manufactures is that there was a good deal of tariff redundancy or 'water in tariff' in the tariff structure prevailing in the 1980s. While, on average, the effective tariff rate for manufacturing industries (taking into account quantifiable exemptions) was over 100 per cent in the mid-1980s, the implicit tariff was about 50 per cent (Goldar and Saleem 1992). In other words, the effective tariff rates prevailing by the end of the 1980s exaggerated the protection accorded to the domestic industries by the tariff system. It follows therefore that the decline in the 'true' level of protection of domestic industry during the 1990s was lower than the reduction in the effective rates of tariff.

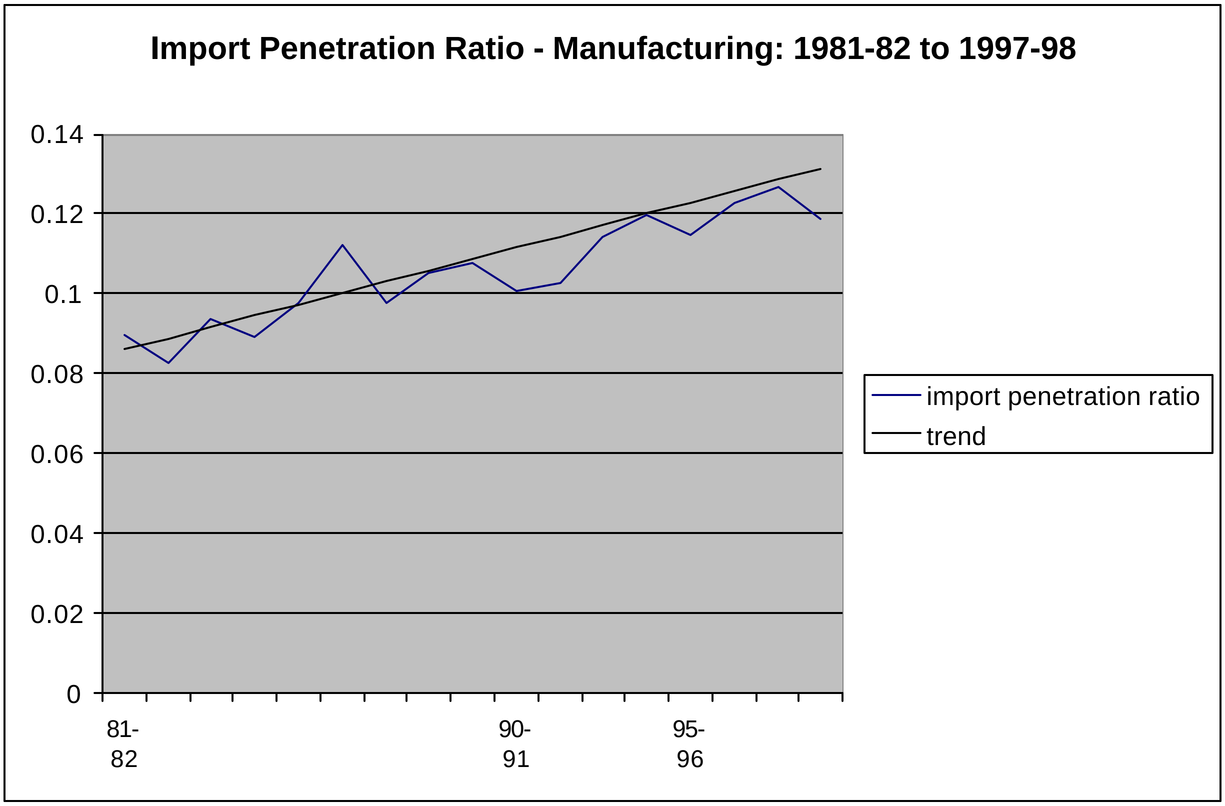

Fig. 4: Import Penetration Ratio in Manufacturing, 1981-82 to 1997-98

Source: Time-series on exports and imports of manufactures (in US $) have been taken from Goldar (2001). These have been constructed by using data taken from Reserve Bank of India, *Handbook of Statistics on Indian Economy*. The value of gross output of manufacturing (organized) has been taken from the *Annual Survey of Industries*. The output series has been expressed in US dollars using the dollar-rupee exchange rate taken from *Economic Survey*. Import penetration ratio has been computed as the ratio of imports to (output + imports – exports). A linear trend has been fitted to the time-series on import penetration ratio for the 1980s, and the trend line has been extended to the 1990s.

To sum up the above discussion, there was substantial liberalization of imports, especially manufactured imports, in India during the 1990s. However, this did not result in a noticeable surge in manufactured imports. Nor did it lead to a sharp increase in the import penetration ratio in the manufacturing sector. How is this to be interpreted? One possible interpretation is that the domestic industries did not in general face a greatly increased import competition following the reforms (say, due to a depreciation of exchange rate and continued quantitative control on imports of manufactured consumer products), and the industries in which increased exposure to import competition did pose a serious challenge to domestic firms did not suffer much probably because the firms were in majority of cases able to cut down costs (and improve product quality) to withstand import competition. It needs to be recognized at the same time that import liberalization did provide domestic manufacturing industry improved access to imported intermediate and capital goods with the concomitant advantages for productivity enhancement. Also, import liberalization reduced the anti-export bias of the protective trade regime prevailing earlier, contributing thereby to better export performance.

Table 4: Nominal and Real Effective Exchange Rate
(Base 1995 = 100; 10-country index)

	Nominal Effective Exchange Rate	Real Effective Exchange Rate
1985	380.5	188.1
1986	316.5	169.7
1987	279.2	158.9
1988	251.2	151.4
1989	225.2	138.7
1990	196.9	128.1
1991	151.8	110.2
1991-92	142.4	105.6
1992-93	117.4	95.5
1993-94	111.4	96.8
1994-95	106.8	101.7
1995-96	97.4	97.8
1996-97	95.4	100.8
1997-98	96.5	106.4
1998-99	85.3	101.9
1999-2000	83.9	101.9

Source: *Economic Survey*, 2000-2001, Government of India.

4. Productivity Growth in Indian Manufacturing

Having discussed the situation pertaining to import liberalization, we now turn to industrial productivity. This section presents estimates of total factor productivity growth in Indian manufacturing and 17 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 presented 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* (CSO).

The basic data source used for the present estimates of industrial productivity is the same as used by Trivedi *et al*. (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 Annex A), so as to yield better estimates of productivity growth.

4.1 TFP Estimation Method

A three-input framework has been used for the TFP estimates presented in the paper, as done earlier by Rao (1996), Pradhan and Barik (1998), and Trivedi *et al*. (2000). The translog index of TFP has been used for the measurement of TFP.[4]

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

$$\Delta \ln TFP(t) = \Delta \ln Q(t) - [\frac{SL(t)+SL(t-1)}{2} \times \Delta \ln L(t)] - [\frac{SK(t)+SK(t-1)}{2} \times \Delta \ln K(t)]$$
$$- [\frac{SM(t)+SM(t-1)}{2} \times \Delta \ln M(t)]. \quad (1)$$

In this equation, Q denotes gross output, L labour, K capital and M materials (including energy) input. Δ ln Q(t) = ln Q(t) – ln Q(t-1). In the same way, Δ ln L(t), Δ ln K(t) and Δ ln M(t) are defined. SL is the income share of labour, SK is the income share of capital, and SM is the income share of materials input. SL, SK and SM add up to unity. Δ ln TFP is the rate of technological change or the rate of growth of total factor productivity.

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:

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

Having obtained the TFP index for different years, estimates of TFP growth rate have been made for two sub-periods, 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 sub-periods, the kinked exponential model (or the spline function) has been used.[5]

TFP estimation at the aggregate manufacturing level has been done also by using the two-input framework. In this case, real gross value added (computed by both single and double deflation procedures) is taken as the measure of output. Labour and capital are taken

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[4] See Rao (1996) and Pradhan and Barik (1998) for a discussion on the advantages of the three-input framework over the two-input framework. See Goldar (1986) and Ahluwalia (1991) for a discussion on the merits of the translog index of TFP.

[5] See Pradhan and Barik (1998) for a discussion on this method of estimating sub-period growth rates.

as the two inputs. For the two-input framework, the translog index of TFP growth is given by the following equation:

$$\Delta \ln TFP(t) = \Delta \ln Y(t) - [\frac{SL(t)+SL(t-1)}{2} \times \Delta \ln L(t)] - [\frac{SK(t)+SK(t-1)}{2} \times \ln \Delta K(t)]. \qquad (3)$$

In this equation, Y is output (value added), L labour and K capital. SL is the income share of labour (in value added) and SK denotes the income share of capital. SL and SK add up to unity. Δ ln TFP is the rate of technological change or the rate of growth of total factor productivity.

The derivation of the TFP index and the estimation of TFP growth rates for the two sub-periods and the entire period is done in the same way as in the case of the three-input framework.

4.2 Data Sources

The basic source of data used for the productivity estimates is the *Annual Survey of Industries* (Central Statistical Organization, Government of India), 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 Number of Wholesale Prices in India, prepared by the Office of the Economic Advisor, Ministry of Industry). These have been taken from the official publications and the publications of the Centre for Monitoring Indian Economy (CMIE). For a few specific items, other sources of data have been used (mentioned later in Annex A) to construct price indices for those items. The construction of 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 Central Statistical Organization (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).

4.3 Measurement of Output and Inputs

Details of the methods employed for the measurement of output and inputs are given in Annex A. Suffice it to note here that deflated gross output is taken as the measure of output. Number of persons employed is taken as the measure of labour 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. 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.

For the estimates based on the two-input framework, deflated value added is taken as the measure of output. Both single and double deflation procedures have been used. In the former procedure, the value added series is deflated directly by a suitable price index for output. In the latter procedure, gross output and materials input are deflated separately. Then, deflated materials input is subtracted from deflated gross output to obtain the double deflated value added.

4.4 TFP Estimates

Estimates of TFP growth in the manufacturing sector are shown in Table 5. 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 *et al.* (2000). The two sets of estimates are quite similar.

It is seen from the table that the estimated growth rate of TFP for the period 1981-82 to 1990-91 is 4.27 per cent per annum when the single deflated value added method is used, and it is 7.76 per cent per annum when the double deflated value added method is used. The growth rate is 1.89 per cent per annum when the three-input framework is used. Evidently, the TFP estimates indicate a significant growth in TFP in Indian manufacturing in the 1980s.[6] 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. For the estimates based on the three-input framework, the growth rate 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 *et al.* (2000) as can be seen from Table 5. Furthermore, this finding is in agreement with the results of econometric analysis presented by Srivastava (2000) and Balakrishnan, Pushpangadan and Suresh Babu (2000).

[6] There has been a major controversy on TFP growth in Indian manufacturing in the 1980s. See Balakrishnan and Pushpangadan (1994, 1995, 1996, 1998), Rao (1996), and Pradhan and Barik (1998). In these papers, the single deflation procedure was questioned, and double deflated value added or the gross output function was used for estimating the total factor productivity. Based on the productivity estimates, it was concluded that TFP growth in Indian manufacturing was very low or negative in the 1980s. Goldar (2000) has argued that the estimates of TFP growth using the double deflated value added or the gross output function are sensitive to the base year of the price indices chosen for deflation. Thus, the finding of a very low or negative TFP growth in the 1980s in the studies of Balakrishnan and Pushpangadan and others may have a lot to do with the choice of base year of price indices. All these studies used price indices with base 1970-71=100. On the other hand, the studies (e.g. Trivedi *et al*. 2000) which have used price indices with base 1981-82=100, rather than the price indices with base 1970-71=100, have found a significant positive growth in TFP in Indian manufacturing in the 1980s. Goldar (2000) notes further that the estimates of TFP in manufacturing obtained by Balakrishnan and Pushpangadan using price indices with base 1981-82=100 give a TFP growth rate of 3.91 per cent per annum for the 1980s, while the TFP estimates using the price indices with base 1970-71=100 give a growth rate of –0.11 per cent per annum for the same period (both based on double deflated value added).

Table 5: TFP Growth in Indian Manufacturing, 1981-82 to 1997-98

Method	**TFP growth rate (per cent per annum)**	
	This study	Trivedi et al. (2000)
Single deflated value added		
1981-82 to 1990-91	4.27	3.06
1990-91 to 1997-98	1.60	1.96
1981-82 to 1997-98	3.17	2.61
Double deflated value added		
1981-82 to 1990-91	7.76	5.44
1990-91 to 1997-98	2.00	2.53
1981-82 to 1997-98	5.39	4.25
Gross output function (three input model)		
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

For the entire period 1981-82 to 1997-98, the growth rate of TFP in manufacturing is estimated at 3.2 per cent per annum using the single deflation method, 5.4 per cent per annum using the double deflated value added method, and 1.4 per cent per annum using the three-input framework. These estimates of TFP growth rate are by and large in line with the estimates of Trivedi *et al*. (2000).

TFP estimates for two-digit industries are shown in Table 6. 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 (11 out of 17 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 *et al*. (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 6 are broadly in agreement with the TFP estimates of Trivedi *et al*. for industry groups.

Table 6: Estimates of TFP Growth Rates, Two-digit Industries, 1981-82 to 1997-98

NIC code	**Description**	**Growth rate of TFP (per cent per annum)**		
		1981-90	1990-97	1981-97
20-21	Food products	1.04	0.03	0.62
22	Beverage & tobacco	-0.61	-1.66	-1.04
23	Cotton textiles	2.44	-1.09	0.99
24	Wool, silk and manmade fibre 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	Non-metallic 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**

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, non-metallic 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 would be noticed that the TFP growth rates presented in Table 6 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 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.[7] CMIE 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 *National Accounts Statistics* indicate that gross fixed investment in organised 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. This step up in investment activity in manufacturing might have had an immediate adverse effect on productivity due to gestation lags.[8] We now turn to a more detailed analysis of these issues.

5. Econometric Analysis of Productivity Growth Rates

A multiple regression analysis has been 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 different years for the 17 two-digit industries are pooled. The regression equation is specified as:

$$TFPG_{it} = \alpha + \beta_1 GO_{it} + \beta_2 ERP_{it} + \beta_3 NTB_{it} + \beta_4 (ERP_{it} * NTB_{it}) + \beta_5 IKR_{it} + \beta_6 REER_t + \gamma DUMLIB + u$$

In this equation, $TFPG_{it}$ is the growth rate 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 non-tariff 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*, and $REER_t$ is the real effective exchange rate 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.

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[7] See Uchikawa (2001).

[8] That gestation lags in investment projects could be a cause of the deceleration in industrial productivity growth rate in the 1990s was suggested by Goldar (2000). In a recent paper, Uchikawa (2001) has discussed the investment boom in Indian industries in the first half of the 1990s and draws 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.

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.

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 (See Annex B for discussion on the concept and estimation of ERP). 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). Annex C shows the ERP estimates for two-digit industry groups for select years.

As regards non-tariff barriers on imports (NTB), the estimates made by Mihir Pandey for a report of the National Council of Applied Economic Research have been used for the analysis. These are estimates of the import coverage ratio, that is the percentage of imports covered by non-tariff barriers (See Annex B for discussion on the methodology). 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 non-tariff 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 36 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 (See Annex B for discussion on the concept and methodology).

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.

Regression Results

Table 7 presents the results of regression analysis. The first regression shown in the table makes use of all the explanatory variables. Regressions (2) to (6) are based on other specifications of the regression equation, in which one or more of the explanatory variables have been dropped.

Table 7: Determinants of Productivity Growth
Dependent Variable: TFPG

Explanatory variables	**Regressions**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
GO	0.347*** (10.47)	0.347*** (10.49)	0.346*** (10.56)	0.346*** (10.57)	0.336*** (10.00)	0.334*** (10.07)
IKR	-22.67*** (-3.20)	-23.00*** (-3.29)	-22.62*** (-3.21)	-22.92*** (-3.28)		
ERP	-0.103** (-2.38)	-0.108*** (-2.66)	-0.103** (-2.38)	-0.107*** (-2.65)	-0.092** (-2.09)	-0.102** (-2.48)
NTB	0.014 (0.35)		0.012 (0.31)		0.030 (0.77)	
ERP*NTB	0.00075@ (1.65)	0.00083** (2.14)	0.00073@ (1.62)	0.00080** (2.17)	0.00074 (1.59)	0.00091** (2.42)
REER	0.060 (1.41)	0.059 (1.40)	0.050* (1.73)	0.051* (1.78)	0.066 (1.54)	0.061** (2.10)
DUMLIB	0.548 (0.31)	0.440 (0.25)			0.436 (0.24)	
Adjusted R-Squared	0.337	0.339	0.339	0.342	0.312	0.316
No. of Observations	272	272	272	272	272	272

***Notes*:** Figures in the parentheses ( ) are t-ratios.
* Significant at 10% ; @ significant at 11%
** Significant at 5%; *** Significant at 1%.

GO= growth rate of output; IKR= ratio of recent investment in fixed assets to existing fixed capital stock; ERP= effective rate of protection; NTB= non-tariff barriers on imports; REER= real effective exchange rate; DUMLIB= dummy variable for post-reform period. The estimated equations include a constant term and 16 industry dummies.

The regression results presented in Table 7 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 one per cent level in all the equations 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). In the results presented in Table 7, the estimated elasticity of TFP growth with respect to output growth is about 0.35. It may be mentioned in this context that the estimates of this parameter obtained in the studies of Goldar and Ahluwalia are close.

The coefficient of the investment ratio variable (the ratio of investment made in fixed assets in the previous two years to the existing fixed capital stock) is found to be negative and statistically significant at the one per cent level. A negative relationship of this variable with TFP growth is expected, because the higher the share of recently made investments in capital stock, the greater should be the adverse effect of gestation lags on productivity.

Turning to the variables representing import liberalization, the coefficient of the ERP is found to be consistently negative and it is statistically significant at five per cent or higher level in the estimated regressions. In some equations, the coefficient is statistically significant at the one per cent level. This may be interpreted as showing the productivity enhancing effect of tariff reform.[9]

The coefficient of the real effective exchange rate (REER) is found to be positive. It is statistically significant at the 10 per cent or higher level in some of 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 dummy variable for the post-liberalization period (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

[9] A negative relationship between ERP and TFP growth was found by Goldar (1986) 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 (1986b, 1990, 1992) and Ahluwalia (1991) has indicated an adverse effect of import substitution policy on productivity growth.

DUMLIB. Since a statistically insignificant coefficient is found, it may be inferred that these group of factors did not on balance have an adverse effect on productivity growth in Indian manufacturing.

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.

Attention needs to be drawn to a shortcoming of the investment ratio variable used in the regression analysis for capturing the effect of gestation lags. 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 regressions (5) and (6), the investment ratio variable has been dropped. It will be noticed that the results with respect to other variables do not change much.

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. The regression equation estimated using I2/I5 in place of IKR is shown below (t-ratios in parentheses, industry dummies not shown):

$$\underset{}{TFPG} = \text{const.} + \underset{(10.2)}{0.34\ GO} \underset{(-1.72)}{-5.76\ I2/I5} \underset{(-1.87)}{-0.083\ ERP} \underset{(0.73)}{+0.029\ NTB} + \underset{(1.37)}{0.00064\ (ERP*NTB)}$$

$$\underset{(1.75)}{+0.076\ REER} + \underset{(0.4)}{0.68\ DUMLIB}$$

Number of observations = 272 adjusted-R^2 = 0.318.

The equation corresponds to Regression (1) in Table 7. The coefficient of I2/I5 is found to be negative and statistically significant at the ten per cent level. Dropping NTB and DUMLIB from the equation, the estimate becomes:

$$TFPG = \text{const.} + \underset{(10.2)}{0.34\ GO} \underset{(-1.73)}{-5.75\ I2/I5} \underset{(-2.21)}{-0.092\ ERP} \underset{(2.05)}{+0.00078\ (ERP*NTB)} + \underset{(2.27)}{0.066\ REER}$$

Number of observations = 272 adjusted-R^2 = 0.321.

In this case again the coefficient of I2/I5 is negative and statistically significant at the ten per cent level. This is indicative of an adverse effect of gestation lags on productivity. It is also seen that the coefficients of ERP, REER and the interaction term involving ERP and NTB are all statistically significant at the five per cent level.

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 significant effect on industrial productivity.[10] Agricultural growth has therefore been included as an additional explanatory variable in the regression analysis. 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 regression results are presented in Table 8. 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 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 DUMLIB have been dropped (since the coefficients of these variables are found to be statistically insignificant).

It is seen from Table 8 that the coefficient of agricultural growth is positive and significant at the five per cent or one per cent level in all the regression equations estimated. The results in respect of other variables are more or less similar to the results presented in Table 7. The coefficient of the variables representing the effect of gestation lag, I2 or I2/I5, is found to be negative and statistically significant at the five per cent or higher level. The results in respect of variables representing import liberalization also remain the same. The coefficient of the effective rate of protection is negative and statistically significant. The coefficient of the interaction term of ERP and NTB and that of real effective exchange rate are positive and statistically significant. The coefficient of output growth is positive and statistically significant at the one per cent level in all the equations. The coefficient of the dummy variable for the post-liberalization period is found to be positive, but not statistically significant as earlier. Thus, from the regression results obtained it may be concluded that agricultural growth had a significant influence on growth of industrial productivity. Also, the relationship observed in Table 7 between tariff reform and productivity do not change after controlling for variations in agricultural growth rate. The same is true in respect of the variables used for capturing the effect of gestation lags on industrial productivity.

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.

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

Table 8: Determinants of Productivity Growth
Dependent Variable: TFPG

Explanatory variables	Regressions					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
GO	0.360*** (10.91)	0.357*** (10.62)	0.345*** (10.29)	0.354*** (10.93)	0.350*** (10.60)	0.339*** (10.30)
GGDPA	0.195*** (2.96)	0.196*** (2.89)	0.160** (2.39)	0.182*** (2.84)	0.181*** (2.75)	0.151** (2.32)
IKR	-25.718*** (-3.65)			-25.52*** (-3.68)		
I2/I5		-7.980** (-2.35)			-7.609** (-2.27)	
ERP	-0.109** (-2.56)	-0.083* (-1.92)	-0.095** (-2.19)	-0.109*** (-2.74)	-0.090** (-2.19)	-0.103** (-2.53)
NTB	0.012 (0.30)	0.028 (0.73)	0.030 (0.78)			
ERP*NTB	0.0008* (1.80)	0.0007 (1.42)	0.0008* (1.70)	0.0008** (2.10)	0.0007* (1.89)	0.0009** (2.39)
REER	0.088** (2.05)	0.108** (2.45)	0.090** (2.05)	0.058** (2.03)	0.076*** (2.60)	0.068** (2.33)
DUMLIB	1.699 (0.954)	1.917 (1.05)	1.367 (0.750)			
Adjusted R-Squared	0.357	0.337	0.325	0.360	0.339	0.328
No. of Observations	272	272	272	272	272	272

***Notes*:** Figures in the parentheses ( ) are t-ratios.
* Significant at 10% ; ** Significant at 5%; *** Significant at 1%.

GO= growth rate of output; GGDPA= 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= non-tariff barriers on imports; REER= real effective exchange rate; DUMLIB= dummy variable for post-reform period. The estimated equations include a constant term and 16 industry dummies.

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 9. 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 annum) compared to the pre-reform period (2.02% per annum), but the growth rate of output which is a key determinant of productivity growth is about the same in the two periods (around 8.3% 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 much higher in the post-reform period compared to the pre-reform period, and this may be a cause of lower TFP growth due to gestation lags in industrial investment projects. 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 favourable effect of reduction in ERP seems to have been offset partially out by the depreciation in real effective exchange rate in the post-reform period. It is seen from the table that REER index was significantly lower in the post-reform period, which tends to lower productivity growth since the regression analysis indicates a positive relationship between the index of REER and TFP growth rate.

Table 9: Averages of Variables in the Pre and Post- Reform Period

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

***Notes*:** Figures in the parentheses are standard deviations
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= non-tariff barriers;
REER= real effective exchange rate;
GGDPA= growth of real GDP in agriculture and allied activities.

As regards agricultural growth, it is seen from the table that the average growth rate of agricultural output (GDP) 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 under-utilization 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 slow down in the growth of agriculture in this period.

6. Conclusion

The main findings of the study are as follows:

(a) There was substantial liberalization of imports in India in the 1990s under the economic reforms programme. This did not, however, result in any surge in manufactured imports. Nor did it lead to a sharp rise in the extent of import penetration in the manufacturing sector.
(b) There was significant growth in total factor productivity in Indian manufacturing in the 1980s. In the post-reform period, there has been a notable decrease in the growth rate of TFP in manufacturing.
(c) The deceleration in productivity growth in manufacturing in the 1990s does not seem to have been caused by import liberalization. Rather, the reduction in effective protection to industries appears to have had a favourable effect on productivity growth in Indian industries.
(d) There was a step up in investment activity in Indian industries following the reforms. The gestation lag in investment projects may have had an adverse effect on productivity and this appears to be an important cause of the deceleration in total factor productivity growth in Indian manufacturing in the 1990s.
(e) The agricultural growth has also been an important factor in influencing industrial productivity. The slow down in agricultural growth in the 1990s seems to have been another important cause of the deceleration in total factor productivity growth in Indian industries in the 1990s.

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Annex A: Measurement of Output and Inputs

Labour: Total number of persons engaged in industrial units is taken as the measure of labour input. This is reported in the ASI (*Annual Survey of Industries*). For the recent issues, it is reported under the head "persons engaged"; for earlier issues, it is reported under the head "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:

(a) Aggregate manufacturing sector. An estimate of net fixed capital stock for the registered manufacturing sector for end-March 1971 (benchmark) is taken from NAS (*National Accounts Statistics*).[11] 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 investment 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 Baghchi, 1985).

(b) 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.[12] 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.

[11] 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.

[12] 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.

Output, intermediate input and value added: 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. The latter has been subtracted from the former to obtain real value added by the double deflation procedure. To obtain real value added by the single deflation procedure, the value-added series has been deflated directly by a suitable price index. Needless to say that 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 99 sectors of the 1989-90 input-output table, belonging to agriculture, mining, manufacturing, and electricity.[13] For some sectors, the available wholesale price index series could be used directly. In some other cases, the available category-wise price indices have been combined to form the price index for the relevant input-output sector.[14] 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.[15] 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.[16]

(3) For each input-output sector engaged in manufacturing (66 sectors), a price index for intermediate inputs has then been formed. This is done by taking a weighted average of price indices of the 99 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. For deriving a price index for deflating value added (for the single deflation procedure), the output price indices of the constituent sectors are combined according to the value added of the different sectors.

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

[14] 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.

[15] 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 month-wise. 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.

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

Annex B: Measurement of Effective Rate of Protection, Non-Tariff Barriers and Real Effective Exchange Rate

Effective Rates of Protection

A measure of protection that takes into account tariffs on both the inputs and the output is the effective rate of protection. The Effective Rate of Protection (ERP) is defined as the percentage excess of domestic value added introduced because of tariff and other trade barriers:

$$ERP = [(VA_d - VA_w)/ VA_w] * 100, \qquad (B.1)$$

where VA_d = value added at domestic prices, and

VA_w = value added in the absence of domestic tariffs.

This ratio measures the distortions introduced due to both tariff and non-tariff barriers on the input prices as well as the final output prices, and therefore measures the true level of protection as compared to world prices.

The ERPs used in the 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 as,

$$ERP_j = (t_j - \sum_{i=1}^{n} a_{ij}\, t_I)/(1 - \sum_{i=1}^{n} a_{ij}), \qquad (B.2)$$

where a_{ij} is the free trade input coefficient per unit of output. Effective rates of protection are thus an increasing function of output tariffs and a decreasing function of input tariffs. In the tariff-based approach, ERPs are measured using published tariff rates. The advantage of using nominal or published tariff is that it contains information about the formal (potential) protective structure adopted by the government.

The ERPs have been calculated according to equation (B.2) using the input-output coefficients estimated by the CSO[17] and the published tariff rates (taking into account quantifiable exemptions). The Simple Corden method of calculating the ERP[18] has been used. The value

[17] The estimates of Goldar and Saleem (1992) and Nouroz (2001) are based on the IO table for 1983-84. Mihir Pandey has made similar tariff-based estimates of ERP for the 1990s. These are based on the IO table for 1989-90.

[18] The other methods are the Simple Balassa, the Sophisticated Balassa and the Sophisticated Corden methods. They all differ according to the treatment of the non-traded inputs. The rank order of the sectors does not change according to the method used, however.

added (VA) is calculated as the returns to the primary factors directly involved in productive activity. This is done by subtracting costs of the traded inputs used directly in production from the value of output. Non-traded inputs are treated as part of the primary sectors of production, thus overestimating the true VA.

This methodology assumes that tariffs are the only source of distortion, implying that there are no quantitative restrictions (QRs) or other non-tariff barriers. In India, trade is restricted by both tariff and non-tariff barriers. This was especially significant in the pre-1991 period. Since then, there have been reductions in both tariffs and quantitative restrictions. However, the extent of NTBs is still significant. Given that there are substantial non-tariff barriers, the true protection levels will be different than what is obtained through the tariff based method. The protection levels obtained through this method described above should therefore be considered as the protection that is accorded by the tariff policy. Finally, it should be noted that to apply equation (B.2) properly the input-output coefficients should be at international prices. However, the input-output matrices prepared by the CSO are at domestic prices, and the use of these coefficients for the estimation of ERP as commonly done introduces a bias in the estimates.

Non-Tariff Barriers

Non-tariff barriers are measured using the Coverage ratio (frequency) method. The coverage ratio measures the percentage of commodities within a category that are affected by an NTB. The coverage ratio shows the extent of non-tariff barriers envisaged by trade policy.

Coverage ratios are defined as the percentage of products within a category that is affected by an NTB.

Define $w_i = m_i / \sum m_i$ as the import weight, where m_i = imports of the i^{th} commodity where $\sum m_i$ is the total imports.

Let n_i = (1 if there are NTB's
(0 if there are no NTB's.

Then, the NTB coverage ratio is defined as $\sum n_i w_i$.

An alternative is to calculate simple averages of the coverage ratios. Another variant assigns different weights to the different types of NTBs, and uses that to derive a more sophisticated measure. The present study uses the NTBs calculated by Mihir Pandey for a study of the National Council of Applied Economic Research. The computations have been done in the following way.

First the coverage ratios are calculated by assigning different weights to different types of NTBs and then the average for a category[19] is calculated.

The coverage ratio for each input-output sector is calculated according to two different weighting schemes. In the first, each 8-digit tariff line is given a number according to the following scheme:

0% if no NTB applies to the tariff line (i.e. if no licensing is required)

50% if imports are subject to special import licenses (SIL)

100% if imports are otherwise restricted or prohibited.

A simple average of all the tariff lines within an input-output sector gives the frequency of NTBs for that sector. If the trade policy is different within a tariff line then a simple average of the components within that tariff line is taken. The simple average for the input-output sector gives the frequency of NTBs, i.e. the extent of NTBs.

In the second scheme, the weights are as follows:

0% if no NTB applies to the tariff line

100% if imports are canalized, restricted or prohibited (even if imports are allowed under SILs).

The NTB measures used for the regression analysis are based on the second scheme.

Real Effective Exchange Rate (REER)

Nominal exchange rate is defined as the relative price of domestic currency in terms of foreign currency. The real effective exchange rate (REER) is usually defined as the nominal exchange rate adjusted by domestic local-currency prices relative to foreign local-currency prices.[20] It is “real” because it adjusts for the relative inflation rates in the domestic economy and foreign economies. It is “effective” because it is constructed as a weighted average of the exchange rates relative to the countries trading partners. The weights are based on trade flows in the base year.

[19] This is the broad methodology used by UNCTAD.
[20] See Reserve Bank of India Bulletin, July 1993, pp. 967-69.

The REER is a proxy for a countries degree of competitiveness in world markets. An appreciation in REER results in a fall in the country's competitiveness, while a depreciation in REER leads to an increase in competitiveness.

The REER used for the regression analysis in this study is the one constructed and published by the Reserve Bank of India. It is based on the rupee's value against currencies of 36 countries. It is based on trade weights.

The formula used for the computation of REER may be written as:

$$REER = \prod_{i=1}^{n} \left[\left(\frac{e}{ei} \right) \left(\frac{P}{Pi} \right) \right]^{wi},$$

where

e= exchange rate of rupee against a numeraire (SDRs) in index form (1985=100);

ei= exchange rate of currency i against the numeraire (SDRs) in index form (1985=100);

e/ei= exchange rate of rupee against currency i in an index form (1985=100);

P= India's wholesale price index (1985=100);

Pi= Consumer price index of country i (1985=100);

wi= weight attached to country/currency i in the index [Σ wi =1]; and

n= number of countries/currencies in the index other than India.

The index constructed by the RBI is based on exchange rates *vis-à-vis* 36 countries. The weights wi are computed as wi= Xi/[ΣXi], where Xi is India's bilateral trade (export plus imports) with country i in the base period. An export-weight-based index is also computed by the RBI, for which the weights are worked out on the basis of India's exports to each of the 36 countries in the base period.

Annex C: ERP (Effective Rate of Protection) Estimates for Two-digit Industries

(per cent)

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	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	99.5	121.8	128.0	100.5	58.4	41.0