TOTAL FACTOR PRODUCTIVITY GROWTH IN INDIAN MANUFACTURING - A FRESH LOOK

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Abstract: Productivity estimates are sensitive to the measure of real value-added adopted. One source of bias in estimation is that due to the assumption of constancy of the relative price of material inputs. This paper provides estimates of total factor productivity in aggregate manufacturing industry having adjusted for changes in this relative price. These results indicate that, contrary to what is believed, productivity growth in the 1980s may, actually, have been slower than in the earlier decade.

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Total Factor Productivity Growth in Indian Manufacturing: A Fresh Look

by P. Balakrishnan and K. Pushpangadan

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The best known studies[1] of the growth of productivity in Indian industry have worked with the value added at constant prices as the measure of output. The latter is arrived at by deflating nominal value added by an index of manufacturing prices. Such a measure is valid only if the price of materials relative to the price of output is more or less constant during the period of analysis. When this relative price is changing, estimated value added is a biased measure. Ceteris paribus, this bias will carry over to the estimate of productivity[2]. While the problem has been recognised in at least one study of productivity growth in Indian manufacturing[3], it has never been followed up, in that we are yet to see estimates of productivity in the Indian economy that have taken into account changes, if any, in the relative price of the material inputs. Perhaps this is due to the enormous data requirements of such an exercise. The present paper makes an attempt to estimate, for the first time, total factor productivity growth in Indian industry having accounted for changes in the relative price of material inputs. The analysis is restricted to Aggregate Manufacturing.

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[1] See Ahluwalia (1991) and Goldar (1986).

[2] See Bruno (1984) and, Stoneman and Francis (1992).

[3] See Goldar (1992), p. 15.

The outline of the paper is as follows. Section 1 deals with the relevance of the constancy of the relative price of materials in measuring total factor productivity using value added. In this section, the temporal behaviour of raw material prices in India is also examined. In Section II, the method of computation of total factor productivity (TFP) is explained, and TFP is estimated from real value added, both adjusted and unadjusted for changes in the relative price of material inputs. This section also discusses the implication of the results. We conclude with a statement of the limitations of the analysis and with suggestions for further research.

I

We here examine how changes in the relative price of material inputs can effect the measure of real value added and thus measured productivity. Assume the case of a single output and a single material input. Value added in current prices is defined as

$$VA_t = P_tQ_t - P_{n,t}N_t \text{ ---------- (1)}$$

where 'P' is the price of output, 'Q' is output, 'P_n' is the price of the material input 'N', and 't' is the time subscript.

Real value added can be obtained from (1) in two different ways: the single-deflation method and the double-deflation method, respectively. In the single-deflation method, both components of value added - the value of output and the value of the input - are deflated by a single price index, i.e., that of output. The value added thus obtained will be denoted VASD. As per the double-deflation method, the value of output is deflated by the output

price and the value of input by an input price index. The value added thus obtained will be denoted VADD. From the above definitions, we have:

$$VA(SD)_t = \frac{VA_t}{P_t/P_0} = P_0Q_0 - \pi_t P_0 N_t \text{ ---------- (2)}$$

where $\pi = P_n/P$, and

$$VA(DD)_t = \frac{P_tQ_t}{P_t/P_0} - \frac{P_nN_t}{P_n/P_0} = P_0Q_t - P_{n,0}N_t \text{ ----------(3)}$$

Setting base period prices to one, the expressions in (2) and (3), respectively, may be re-written as follows:

$$VA(SD)_t = Q_t - \pi_t N_t \text{----------(2)}'$$

$$VA(DD)_t = Q_t - N_t \text{----------(3)}'$$

Now, it is apparent that real value-added arrived at by the single-deflation method is not invariant with respect to the current level the relative price of the material inputs. Therefore, in periods of a secular change in this price, the inherent difference between these two measures will widen. In periods when the relative price increases VASD will grow at a rate slower than VADD, while during periods during which the relative price decreases VASD will grow faster than VADD.

The analysis has so far been conducted for the case of a single output and a single input. The conclusions extend to the case of an aggregate of several outputs and several inputs.

A formal expression of the relationship between changes in the relative price of materials and VASD is provided by Bruno[4], an adapted version of which we present here.

Let the aggregate production function for the manufacturing sector be given by,

$$Q = Q(L, K, N) \text{ ----------(4)}$$

where 'Q' is output, 'L' is labour, 'K' is capital and 'N' is the amount of the material inputs. Real income 'Y' is then defined as

$$Y = Q - \pi_n N \text{ ----------(5)}$$

where $\pi_n = P_n/P$ = price of intermediate input/price of output. Under optimising behaviour, the marginal value product of the intermediate input must be equal to its price and real income may now be written as,

$$Y = Y(L, K; \pi_n) \text{ ---------- (6)}$$

In order to bring out the effect of a change in the relative price of the intermediate input on value added, express (6) in growth rate form. Differentiating (6) with respect to time

$$\frac{dY}{dt} = \frac{\delta Y}{\delta L}\frac{dL}{dt} + \frac{\delta Y}{\delta K}\frac{dK}{dt} + \frac{\delta Y}{\delta \pi_n}\frac{d\pi_n}{dt} \text{ ------(6a)}$$

Under profit maximisation, and via the 'envelope theorem', we have,

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[4] Bruno (1978 and 1984)

$$\frac{\delta Y}{\delta L} = \frac{w}{P}, \frac{\delta Y}{\delta K} = \frac{r}{P}, \frac{\delta Y}{\delta \pi_n} = -N \text{-----} (6b)$$

where 'w' is the wage rate of labour and 'r' is the rental rate of capital.

Substituting the above marginal conditions in equation (6a) and expressing it in growth-rate form yields[5]:

$$\dot{y} = (1-\beta)^{-1} (\alpha \dot{l} + \tau \dot{k}) - (1-\beta)^{-1} \beta \pi_n$$

$$= (1-\beta)^{-1}(\alpha \dot{l} + \tau \dot{k}) - b \text{-------} (6c)$$

where

α = share of labour input in the value of output,

τ = share of capital input in the value of output,

β = share of intermediate input in the value of output, and

$b = (1-\beta)^{-1} \beta \dot{\pi}$.

Bruno refers to '-b' as the 'technical regress' term. The effect of technical regress, itself a function of the change in the relative price, on total factor productivity (TFP) is seen below. The first term on the right hand side of equation (6c) is the growth rate of net output due to primary factors, labour and capital. Let it be denoted by

[5] See 'Technical Note' for the derivation.

Re-arranging (6c)

$$\dot{v} - \dot{y} = b \text{----------} (7)$$

Equation (7) brings out the impact of the relative price of materials on productivity through its effect on real net output. Three such effects can be identified.

Case 1: the relative price is stable. Now,

$$\dot{\pi} = 0 \rightarrow b = 0 \rightarrow \dot{v} = \dot{y}$$

which implies that both net output due to the primary factors and the real income, which is the same as VASD, are equal. Hence there is no relative-price effect on measured productivity growth.

Case 2: the relative price increases. Now,

$$\dot{\pi} > 0 \rightarrow b > 0 \rightarrow \dot{v} > \dot{y}$$

Therefore, VASD is an underestimate of net output. The underestimation is proportional to the rate of change of the relative price of materials. This by itself can show up as a decline in measured productivity without there actually having been a change in the efficiency of production.

Case 3: the relative price decreases. Now,

$$\dot{\pi} < 0 \rightarrow b < 0 \rightarrow \dot{v} < \dot{y}$$

In this situation, we have the opposite of case 2, i.e., VASD is an overestimate of net output. This upward bias will show up as a productivity increase without any increase in the efficiency of input use.

The analysis clearly shows that any productivity measure derived from VASD when the relative price of materials is changing is biased to the extent that it does not include a correction for the change in this relative price. The problem is serious only if the relative price of materials actually does fluctuate. The relative price, the ratio of the price index of raw materials to that of manufactures, is graphed in Figure 1.

Notice the stability in the relative price during the fifties, fluctuation without any trend in the sixties, fluctuation around an increasing trend in the seventies, and a fluctuation around a decreasing trend in the eighties. Therefore, assuming constancy of the relative price of raw materials for this period would be inappropriate and VASD would yield a biased measure of real value added.

In the light of the behaviour of the relative price of raw materials in the Indian economy, as graphed in Figure 1, one would expect a negative correlation between the relative price of raw materials and TFP derived from VASD. A preliminary test of the hypothesis is conducted using TFP from two well known studies of total factor productivity growth in Indian manufacturing industry. We have computed the correlation coefficient between the relative price of raw materials and the index of TFP given in Goldar (1986) and Ahluwalia (1991). These are presented in Table 1.

Note that the correlation coefficient is significant and of the expected sign. The relationship seems to be stronger during the second period. Notice, from Figure 1, that the fluctuation in the relative price is greater during 1959/60 to 1985/86 than that during the period 1951 to 1965. These findings together suggest

Relative Price of Raw Materials to Manufactures (1950-51 = 100)

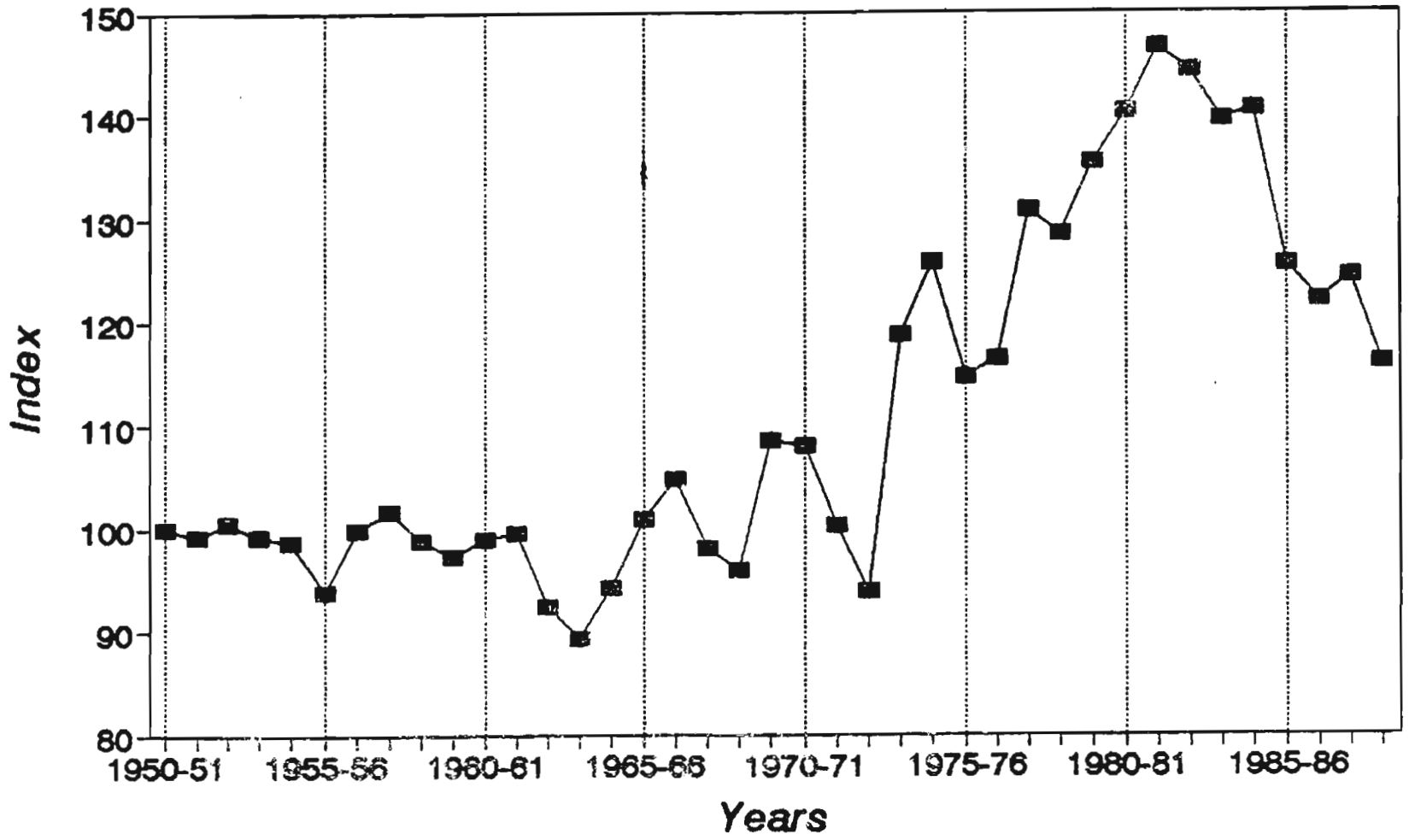

Table 1

Is there a correlation between the relative price of raw materials and TFP derived from VASD ?

Period	Correlation coefficient
1951-65	-.48**
1959-60 to '85-86	-.57*

** significant at 3.5 %; * significant at 1%.

Notes and sources: TFP is a translog index. For the first period estimates by Goldar and for the second those by Ahluwalia have been used.

that productivity estimates for Indian manufacturing industry need to be adjusted for changes in the relative price of inputs.[6]

II

Conventionally, productivity is measured by the average product of a single input, usually labour, over a period of time. It has been increasingly accepted that technical progress is the result of efficiency improvements across-the-board rather than in the use of a single input. Therefore the proper measure is the average product of all inputs. This has been called total factor productivity (TFP) or multifactor productivity. By definition,

$$TFP = \frac{Q}{X} \text{ ---------- (8)}$$

[6] Goldar discusses this bias in the single deflation method, but do not make any attempt to adjust the relative price effect. See Goldar (1992), p. 15.

where 'Q' = output and 'X' = a weighted index of all inputs. The total factor productivity growth (TFPG) is given by the time derivative of (8) expressed in growth rate form,

$$TFPG = \dot{q} - \dot{x} \text{----------} (9)$$

$$where \dot{q} = \frac{d\ln Q}{dt}, \quad \dot{x} = \frac{d\ln X}{dt}.$$

In order to compute the TFPG then we should express the growth rate of output and the growth rate of inputs in observable quantities. This is obtained from the use of production theory and optimising behaviour. For this purpose, we assume a stable relationship between output, input and time:

$$Q = Q(X, t) \text{ ---------- } (10)$$

where 'Q' stands for output, 'X' for a vector of 'n' inputs, and 't' for time. The rate of technical progress, TFPG, is then defined as

$$TFPG = \frac{\delta \ln Q(X, t)}{\delta t} \text{ ------ } (11)$$

Differentiating (10) with respect to time and expressing it in growth rate form,

$$\frac{d\ln Q}{dt} = \sum_{i=1}^{n} \epsilon_i \frac{d\ln X_i}{dt} + \frac{\delta \ln Q(X, t)}{\delta t}$$

$$where \epsilon_i = \frac{(\delta Q/\delta X_i)}{(Q/X)}$$

is the elasticity of output with respect to the ith input.
From the above we have:

$$TFPG = \frac{\delta \ln Q(X,t)}{\delta t} = \dot{q} - \sum_{i=1}^{n} \epsilon_i \dot{x}_i \text{ ---------- (12)}$$

$$where \dot{x}_i = \frac{d \ln X_i}{dt}$$

Expression (12) may be used for the measurement of TFPG only if output elasticity with respect to each input is known. But, under profit maximisation, the elasticity of output with respect to an input is equal to its share in value of output.
That is, under profit maximisation:

$$P(\delta Q/\delta X_i) = P_i$$

Therefore, after substitution, we have:

$$\epsilon_i = \frac{(P_i/P)}{(Q/X_i)} = \frac{P_i X_i}{PQ} = s_i$$

where 's_i' is the share of the ith input in the value of output.
Expression (12) can therefore be re-written as:

$$TFPG = \dot{q} - \sum_{i=1}^{n} s_i \dot{x}_i \text{ -------- (13)}$$

The second term in equation (13) is a Divisia index. The difficulty in using equation (13) is that it is applicable only to data generated continuously. But economic data come in discrete

form. Therefore an approximation to (13) in discrete form is needed. The following approximation has been suggested for the use of discrete data[7]:

$$TFPG = (\ln Q_t - \ln Q_{t-1}) - \sum_{i=1}^{n} \frac{1}{2}(s_{i,t} - s_{i,t-1})(\ln X_{i,t} - \ln X_{i,t-1}) \quad \text{----------(14)}$$

Expression (14) is referred to as the Divisia-Tornqvist approximation for the calculation of TFPG. All the variables in equation (14) are observable and thus TFPG can be calculated.

The focus of this study is the importance of correcting for changes in input prices when computing TFP. Since we are, at this stage, concerned with Aggregate Manufacturing we would really be interested in the relative price of raw materials. It is for this reason that we graph this relative price in Figure 1, and use the same relative price in the exercises reported in Table 1. However, the data on the manufacturing sector in the Indian economy (ASI) provides only the annual value of 'material' inputs as a whole. Hence for the empirical exercises that follow we have used a price deflator ('Pn') that combines the price of all intermediate inputs, produced inputs and raw materials.

Total factor productivity growth for alternative definitions of the real value added in Indian manufacturing industry has been computed using (14). From the results of this exercise index numbers are derived and presented, along with the two measures of value added, in Table 2.

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[7] See Chambers (1988), p. 233.

Table 2

Value Added and Total Factor Productivity

YEAR	VASD	TFPSD	VADD 1973-74	TFPDD 1973-74
1970-71	100.0	100.0	100.0	100.0
1971-72	99.4	95.7	84.1	79.0
1972-73	103.8	96.8	84.2	76.8
1973-74	99.8	89.9	103.1	90.0
1974-75	108.4	93.4	128.1	105.5
1975-76	110.1	90.2	124.0	96.8
1976-77	122.1	93.6	150.5	108.7
1977-78	131.1	94.8	174.0	118.1
1978-79	152.2	104.9	214.7	137.3
1979-80	146.2	93.6	220.3	131.5
1980-81	136.1	83.0	208.0	117.0
1981-82	150.1	88.3	253.5	135.3
1982-83	172.7	96.4	310.4	154.9
1983-84	189.6	103.1	309.9	148.1
1984-85	195.4	100.8	328.4	146.4
1985-86	202.4	103.4	324.9	139.9
1986-87	202.8	99.1	316.4	129.3
1987-88	221.9	99.9	343.9	128.0
1988-89	252.1	106.8	384.7	133.2

Notes and sources: 'SD' and 'DD' denote whether the measure has been arrived at by the single or the double deflation methods, respectively. '1973-74' indicates that the weights used in the construction of the raw-material price deflator have been derived from input-output statistics for these respective years.

Since this study is motivated by the argument that appropriate measurement of productivity requires commencement from estimates of value added adjusted for changes in the relative price of material inputs, we focus on the difference in estimated productivity arrived at by the single-deflation and the double-deflation methods, respectively. In particular, these estimates have a

bearing on an hypothesis propounded in a widely-received recent study of the growth of productivity in Indian manufacturing industry. Ahluwalia has argued that there has been a turnaround in total factor-productivity growth since 1980. We quote: "As the rising fiscal deficits in the eighties created resurgent demand conditions, the re-orientation of the policy framework and the toning-up of the infrastructure sectors enabled a supply response to the rising demands through productivity improvements."[8] The evidence presented in this study provide for a plausible explanation of the observed phenomenon. That is, we are able to confirm a "turnaround" in productivity growth when we focus on the estimates of TFP derived from the VASD series. In this sense, we are able to replicate Ahluwalia's finding. The point, however, is that what we consider to be a more appropriate measure of real value added yields a quite different[9] account of productivity growth as is confirmed by the statistical exercise reported in Table 3.

This exercise involved a statistical[10] test for a change in TFP growth since 1980 using the two measures of TFP reported in Table 2. Note that these results indicate a higher growth of TFP since 1980 when VASD is used but not so when VADD is used.

The input-price deflator used to arrive at VADD is based on input-output coefficients for the manufacturing sector of the

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[8] See Ahluwalia (1991), p. 197.

[9] This possibility had been raised by Lahiri (1992).

[10] The procedure based on the use of dummy variables to test for a shift in the slope of the trend equation is identical to that used by Ahluwalia.

Indian economy. In Table 2 the estimates of VADD, and therefore TFP(DD),

Table 3

Testing for a change in TFP growth

	I	II	III
Constant	4.55 (133.63)	4.34 (63.32)	4.35 (66.67)
D1	-.33 (3.20)	0.70 (3.34)	1.18 (5.93)
Trend	.0001 (0.02)	0.05 (4.75)	0.08 (7.13)
D2	.02 (2.79)	-0.06 (3.71)	-0.11 (6.57)
R^2	.50	.77	.87
D-W	1.42	1.52	1.46

The estimates are from a semi-log trend equation for TFP. T = 1970-89, D1 and D2 are dummies that test for a change in the level ('Constant') and the rate of growth ('Trend'), respectively, for the period post-1980. I, II and III differ in the dependent variable: TFP having been derived from different measures of real value-added. 'I': TFP(SD), 'II' uses weights from the Input-Output for 1973-74 and 'III' from 1983-84.

uses coefficients drawn from the transactions table for 1973-74. The sensitivity of the estimates of value-added to the input-output coefficients used as weights in the construction of the input-price deflator, using the input-output coefficients drawn from the Input-Output Table for 1983-84, was now examined. The findings, with regard to both VADD and the growth of TFP, remained unchanged. So the figures are not reported in the text. However, the estimated TFP was used in the statistical exercise reported in Table 3. The finding with regard to the absence of an increase in the growth rate of TFP when VADD is used is confirmed.

Our own view of the estimates of TFP provided here is as follows. While it makes a distinct improvement over existing

estimates, it does in turn require correction for substitution bias, capacity utilisation, the fixity of inputs, instantaneous adjustment of inputs, and the existence of a mark-up in industry. These considerations constitute the next item on our research agenda.

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Appendix A: Data

A . 1 T h e P e r i o d o f S t u d y

The period of this study was chosen on the basis of the following considerations; the data availability and the behaviour of the relative price of raw materials. The relative price of raw materials, plotted in figure 1, is more or less stable during the fifties and sixties. Therefore, the period of study is restricted to 1970/71 - 1988/89, the most recent period upto which the data was available when we commenced upon the study. The ASI has not published its annual survey for the year 1972/73. For continuity, the values of 1972/73 were estimated as a simple average of figures for 1971/72 and 1973/74.

A.2 Value Added

Gross value added has been used. In the case of VASD this figure has been deflated by the index of the price of output. In the case of VADD, the value of inputs is deflated by the price of inputs and the resulting value deducted from real output (nominal output deflated by the price of output). Thus the computation of VADD requires two price indices, those for the price of output and the price of material inputs, respectively. The wholesale price index of manufactures (1970/71=100) is treated as the price of output. The material price index is a weighted index of the wholesale prices of major input groups, the weights having been calculated from the matrix of input-output transactions published by the Central Statistical Organisation. Inputs were grouped according to the availability of wholesale price indices that could be used to represent them most closely. The implied weights were now used to construct a weighted average input price. The weights assigned to

the wholesale price index for the input groups were as follows:

	% share '73-74	% share '83-84
'Food articles' (01)	1.16	1.09
'Non-food articles' (02-04)	32.45	18.31
'Egg, fish and meat' (05 & 07)	3.47	3.02
'Logs and timber' (06)	1.48	2.49
'Coal mining' (08)	0.93	2.22
'Minerals' (09-11)	5.78	10.64
'Food products' (12-13)	4.19	4.01
'Beverages and tobacco' (14-15)	0.55	0.42
'Textiles' (16-18)	7.78	9.84
'Wood and wood products' (20)	1.58	0.80
'Paper and paper products' (22)	2.65	2.81
'Leather and leather products (24)	0.85	0.55
'Rubber and rubber products (25)	1.53	1.68
'Mineral oils' (26)	1.14	4.58
'Chemicals and chemicals products' (28-32)	9.59	11.58
'Non-metallic min. products' (33-34)	0.96	1.37
'Basic metals, alloys & metal pdts' (35-37)	20.60	18.24
'Other misc. manfg. industries' (44)	0.27	1.06
'Electricity' (46)	3.03	5.30
	100.00	100.00

Notes: Figures in parentheses denote the commodity groups in the Input-Output Transactions Table.

The value of outputs and the value of inputs is taken from the following sources: 'Wages and Productivity in the Organised Manufacturing Sector, 1960/61 to 1976/77', Central Statistical Organisation (1979), and 'Annual Survey of Industry', various issues.

The relevant prices are presented in Table A.1. Other variables used in the construction of value added, by single and double-deflation methods, are presented in Table A.7. Value added is presented in Table 2.

A.3 Capital Stock

The estimation of the capital stock is a controversial issue both in theory and in practice. The issues are very familiar; therefore,

we do not enter into a discussion.[11] We follow the standard practice of the perpetual inventory method for the generation of a capital stock and assume, as is widely done, that the services of capital are proportional to its stock. The perpetual-inventory method requires an estimate of the capital stock for a bench-mark year and estimates of investment in the subsequent periods. As was done in the earlier studies, especially that of Goldar and Ahluwalia, we too have selected 1960 as the bench mark year for the estimation of the replacement cost of fixed capital. This is solely due to the availability of data on the book value of fixed capital in 1960 for most of the industries for which Hashim and Dadi (1973) provide the ratio of purchase value to book value (referred to as gross-net ratios) of capital. Hashim and Dadi have estimated these gross-net ratios for fixed capital after analysing the balance sheets of about 1000 firms covered by ASI. For our analysis, total fixed capital (excluding the intangible assets) were grouped into the following: (1) land and improvement of land (2) building and construction, (3) plant and machinery and (4) transport and other fixed assets. The gross-net ratio for the land is assumed to be unity. For the other three groups the GNR is taken from Hashim and Dadi (1973, Table III.1). Where the gross-net ratio is not given by Hashim and Dadi, we have taken it to be twice the book value of fixed capital.[12] After estimating the gross value of the fixed capital at purchase price for the Factory[13] sector in 1960, the

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[11]. An excellent survey of the literature is given in Goldar (1986) and in Hashim and Dadi (1973).

[12] Goldar (1986) provides some evidence why this would be a reasonable conversion factor.

[13] All the preceding exercises were undertaken only for the Census sector since the breakdown of assets (according to categories such as land, buildings, etc.) in the Sample sector was not available to us. The ratio of the value of fixed capital at

following adjustment was made to account for the age structure of the assets. Hashim and Dadi provide the gross value of capital purchased during the period 1901-1945 and in each remaining year until 1960. This proportion is applied to the gross-value of fixed capital in 1960 to obtain the year-wise value of fixed capital bought in the past. To adjust for age-structure, the estimate for each year is then inflated using the current-to-purchase price ratios given in Hashim and Dadi[14] to obtain the gross value of fixed capital at replacement cost in 1960 prices.

The investment figures were obtained using the formula:

$$I_t = (B_t - B_{t-1} + D_t)/R_t$$

where 'B' is the book value of the fixed capital, 'D' is depreciation, and 'R' is an appropriate deflator for fixed capital. For 'R' we have used the wholesale price index of machines and machine tools (base 1960-61=100). The capital stock at any year is then calculated as follows:

$$K_t = K_0 + \sum_{t=1}^{T} I_t$$

where 'I_t' is investment in year 't' in 1960 prices and 'K_0' is the capital stock in the bench mark year in 1960 prices.

However there was a problem of calculating the capital stock in the manufacturing sector per se. Recall that 'Manufacturing' is

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replacement cost to its book value in 1960 (2.42) was used to arrive at an estimate of fixed capital at replacement cost in this sector. The figures for the Census and Sample sectors were aggregated to arrive at the figure for the Factory sector.

[14] Table III.4, p. 20

'All Industries' minus 'Electricity, Gas and Steam'. Given our choice of the benchmark year as 1960, in order to arrive at the capital stock in 1970, we require data on the value of fixed capital in 'Electricity, Gas and Steam' for the period 1960/61 - 1969/70. This information is available for the census sector but not the sample sector. Therefore the fixed capital in the manufacturing sector during the period includes the fixed capital of the firms in th 'Electricity, Gas and Steam' segment of the sample sector. There is hardly any firm producing electricity in sample sector. But there exist firms in the sample sector producing gas and steam. As a result, our estimate of investment in the manufacturing sector during the period 1960-61 to 1969-70 would be an overestimate. However, we do not consider this to be a serious problem.

Data used at various stages in the calculation of the capital stock series are presented in Tables A.2 to A.6. Sources: Book value of capital - 'Wages and Productivity in the Organised Manufacturing Sector, 1960/61 to 1976/77', Central Statistical Organisation (1979), and 'Annual Survey of Industry', various issues; index of the price of machinery and machine tools -'India Data Base' and 'Index numbers of wholesale prices', Ministry of Industry.

A.4 Labour

Total employment is used. The data is presented in Table A.7. Sources: 'Wages and Productivity in the Organised Manufacturing Sector, 1960/61 to 1976/77', Central Statistical Organisation (1979), and 'Annual Survey of Industry', various issues.

A.5 Factor shares

Note that the use of (14), the Divisia-Tornqvist approximation to total factor productivity growth, requires knowledge of the share of each primary factor in the value added. For VASD, the share of total emoluments in the value added is taken as the share of wages. But for VADD, the share is defined as the ratio of real emoluments to VADD. Assuming constant returns to scale, the capital share is got as one minus the share of wages.

Appendix B: Technical Note

$$\frac{dY/dt}{Y} = \frac{wL}{PY}\frac{dL/dt}{L} + \frac{rK}{PY}\frac{dK/dt}{K} - \frac{\pi_n N}{PY}\frac{d\pi_n/dt}{\pi_n}$$

$$\dot{y} = \left(\frac{wL}{PY}\right)\dot{l} + \left(\frac{rK}{PY}\right)\dot{k} - \left(\frac{\pi_n N}{PY}\right)\dot{\pi}_n$$

where:

$$\frac{wL}{Py} = \frac{wL}{P(Q - \pi_n N)}$$

$$= \frac{wL}{(PQ - P_n N)}$$

$$= \frac{(w.L/PQ)}{(1 - P_n N/PQ)}$$

$$= \frac{\alpha}{(1-\beta)}$$

where α = share of wages in the value of output and

β = share of intermediate inputs in the value of output.

Similarly, we can show that

$$\frac{rK}{PY} = \frac{\tau}{(1-\beta)}, \qquad \frac{\pi_n N}{PY} = \frac{\beta}{(1-\beta)}$$

where τ is the share of capital in the value of output.

Table A.1

Year	Index of Manufacturing Prices	Index of Raw Material Prices	Relative Price of Raw Material (1950-51=100)
1950-51	46.9	43.8	100.00
1951-52	57.4	53.2	99.24
1952-53	47.1	44.2	100.48
1953-54	49.1	45.5	99.23
1954-55	46.0	42.4	98.70
1955-56	44.6	39.1	93.87
1956-57	49.1	45.8	99.88
1957-58	51.3	48.7	101.65
1958-59	52.0	48.0	98.84
1959-60	53.9	49.0	97.34
1960-61	58.5	54.1	99.02
1961-62	60.5	56.3	99.64
1962-63	62.7	54.1	92.39
1963-64	65.5	54.7	89.42
1964-65	69.1	60.9	94.37
1965-66	72.7	68.5	100.89
1966-67	80.8	79.1	104.82
1967-68	91.8	84.1	98.10
1968-69	92.8	83.1	95.89
1969-70	92.0	93.3	108.59
1970-71	98.0	98.8	107.95
1971-72	108.4	101.6	100.36
1972-73	119.0	104.4	93.94
1973-74	139.5	154.7	118.74
1974-75	168.8	198.3	125.79
1975-76	171.2	183.3	114.65
1976-77	175.2	190.6	116.49
1977-78	179.2	218.8	130.74
1978-79	179.5	215.4	128.49
1979-80	215.8	272.8	135.36
1980-81	257.3	337.14	140.30
1981-82	270.6	370.57	146.64
1982-83	272.1	366.75	144.33
1983-84	295.8	385.39	139.51
1984-85	319.5	419.62	140.63
1985-86	342.6	401.55	125.50
1986-87	359.4	409.48	122.00
1987-88	384.4	446.27	124.31
1988-89	414.4	449.23	116.08

Table A.2
Book value of fixed assets in manufacturing industry, 1960 (in Rupees)

ASI No	Industry	Land	Building & Construction	Plant & Machinery	Other Equipments
202	Milk & Milk Products	1346715	9116761	14418250	4451764
205	Flour, Rice & Dal Mills	2802440	11981380	16584699	3615018
206	Bakery Products	1363294	6358437	9133179	1534976
207	Sugar & Gur	19653243	151651498	453981393	44179055
208	Cocoa, Chocolate, etc	1500	342246	1092912	290335
209	Miscellaneous Food	23533711	227462434	273029719	36967716
211	Alcohol & Spirit	646296	7298470	11385386	2258161
212	Wine	20000	139402	476212	27532
213	Soft Drinks	3028857	22551108	3579837	873532
220	Tobacco	3580324	27829643	22768635	9933797
231	Textiles	89380094	529674689	1476742237	74947432
232	Knitting Mills	65748	680130	2550279	400521
233	Rope & Twine	632454	1055095	2063284	370987
239	Ginning, Pressing, etc.	6831837	15010221	18759257	2141564
241	Footwear	82118	922190	5165977	588353
251	Wood	869162	8621658	23239800	2311776
252	Wooden Products	89028	216473	511565	89822
259	Wood Working	96445	1101966	1747271	457443
260	Furniture & Fixture	4038924	15859591	10218179	1113841
271	Paper & Paper Products	17609297	138222208	317829394	15718387
280	Printing	8585779	62788537	110395908	18047263
291	Tanneries	516582	1476232	3474931	326752
300	Rubber & Rubber Products	3971462	32738130	62057828	7734445
311	Chemicals	27872371	198093931	499646395	63377178
312	Vegetable Oils	162942	1789029	3254696	317329
313	Paints, Varnishes,etc.	740663	7625879	6172037	2886632
319	Misc. Phar & Chem. Products	21936967	100818923	133226575	29164736
321	Petroleum refineries	32491146	69423011	273226756	38248949
329	Misc. Petroleum Products	309241	397172	2484706	198942
331	Bricks & Tiles	7926914	35758811	61353932	10263949
332	Glass-wares	3522332	18427555	29128200	5339505
333	China Clay Wares	1815394	17706043	24604883	4820626
334	Cement	28491589	126145206	336814116	24739382
339	Misc. Non-metallic Min. Prds.	4748066	15480620	21506932	4337901
341	Iron & Steel	120255467	205868947	1697269538	73546291
342	Non-ferrous Basic Metal	5721745	42673014	97411455	5109455
350	Metal Products	9407437	46874219	113161141	11293841
360	Non-electrical Machinery	19901849	87542280	181215570	30748241
370	Electrical Machinery	16911848	101216538	144141973	19428034
381	Ships and Boat Buildings	5486957	21474266	28804618	12113814
382	Railway Rolling Stock	20880883	186735726	209952632	29528031
383	Motor Vehicles	6158594	85373070	189555769	18214673
384	Repair of Motor Vehicles	17053964	42093564	13204788	5966955
385	Motor Cycles & Bicycles	2745226	21448647	52278266	11989663
389	Manufacture of Aircraft	0	15353380	17181483	10595740
391	Surgical Instruments	544198	2212718	4703753	1148164
392	Survey Instruments	47990	111815	323731	115500
393	Watches and Clocks	3347	188340	491376	57164
399	Miscellaneous	4058934	17899600	27595582	6007688

Source: Annual Survey of Industries, 1960, Vols. 1-10

Table A.3
Gross-net ratios (GNR) for components of
Fixed Capital, 1960, ASI (3-digit level)

ASI No.	Industry	Gross-Net Ratio		
		Building and Construction	Plant and Machinery	Other Equipments
205	Flour, Rice & Dal Mills	1.3781	2.6730	1.5200
206	Bakery Products	1.1682	1.1620	1.3941
207	Sugar & Gur	1.6555	2.2164	2.4659
208	Cocoa, Chocolate, etc	1.5071	1.8693	2.0360
209	Miscellaneous Food	1.3437	1.9630	1.8582
211	Alcohol & Spirit	1.9483	2.4021	2.0384
212	Wine	1.6448	1.7923	1.8812
220	Tobacco	1.5380	1.9800	2.3875
231	Textiles	1.9432	2.3190	2.2413
232	Knitting Mills	1.6667	2.7241	2.2500
233	Rope & Twine	2.2226	2.5013	2.6493
239	Ginning, Pressing, etc.	1.7290	2.6647	2.1294
251	Wood	1.3951	1.5861	2.1639
252	Wooden Products	1.5649	1.4751	2.0691
260	Furniture & Fixture	1.0818	1.2399	1.2681
271	Paper & Paper Products	1.4501	1.6906	1.8135
280	Printing	1.2511	2.3460	2.1134
291	Tanneries	2.4860	2.8512	2.9528
300	Rubber & Rubber Products	1.3178	1.7100	1.6917
311	Chemicals	1.2760	1.5382	1.6507
312	Vegetable Oils	1.6850	2.4827	1.7095
313	Paints, Varnishes,etc.	1.8848	2.6083	2.2842
319	Misc. Phar & Chem. Prdts	1.5043	1.8188	1.9680
321	Petroleum refineries	1.3316	1.4973	1.8458
331	Bricks & Tiles	1.8957	2.2284	1.8560
332	Glass wares	1.3443	1.5283	1.5013
333	China Clay wares	1.9037	2.1617	2.1064
334	Cement	1.3256	1.7122	1.8770
339	Mis.non metal mineral pdt.	1.6348	2.5093	2.3383
341	Iron & Steel	1.3297	1.5777	1.5778
342	Non ferrous basic metal	1.4723	1.8871	1.9982
350	Metal Products	1.3290	2.0077	2.0958
360	Non-electrical Machinery	1.3505	1.5564	1.5287
370	Electrical Machinery	1.3386	2.0392	1.9140
381	Ships and Boat buildings	1.4199	1.4676	1.8063
382	Railway Rolling Stock	1.4789	1.9872	1.7144
383	Motor Vehicles	1.7376	1.6846	1.8238
384	Repair of Motor Vehicles	2.5124	2.2314	1.3776
385	Motor Cycles & Bicycles	1.2771	1.4159	1.4680

Source: Hashim and Dadi (1973), Table III.1.

Table A.3.1

GNR for industries not covered
by Hashim and Dadi

ASI No.	Industries	GNR used
386	Manufacture of Aircraft	Same as for 389
202-1	Milk and	Average of 205 to 209
202-2	Milk products	"
203	Can. & Preser. of fruits	"
206	Can. & Preser. of fish	"
213	Breweries	Average of 211 and 212
241	Manf. of footwear	Double the book value
259-1	General wood working	Average of 251 and 252
259-2	Cork & wood products	,,
329	Misc. Petroleum products	Same as for 321
391-1	Surgical instruments	Same as for 399
391-2.1 and 391-2.2	Measuring devices	"
391-3	Scientific instruments	"
391-4	Math. survey, drawing instr	"
392-4	Photographic instruments	"
393	Watches, clocks	"
394-1	Jewellery	"
394-2	Mints	"
399-3	Pencil and pencil making	"
399-4	Fountain pen	"
399-5	Button making	"
399-6	Ice making	"
399-7	Plastic moulded goods	"
399-8	Celluloid articles	"
399-10	Brooms & brushes	"
399-11	Games & sports goods	"
399-12	Toy manufacturing	"
399-14	Wrapping items	"
399-15	Bone crushing	"
399-16	Slate & slate products	"

Table A.4

Age Composition of Gross Fixed Assets in 1960
(At current prices)

Year of Purchase	Gross Fixed Assets (Rs.Lakhs)	Percentage Share	Current-to-Purchase Price Ratio
1901-45	6479052	28.01	2.814
1946	833586	3.60	1.658
1947	769140	3.33	1.513
1948	679592	2.94	1.235
1949	848529	3.67	1.222
1950	854359	3.69	1.210
1951	577631	2.50	1.017
1952	866502	3.75	1.163
1953	837383	3.62	1.222
1954	926128	4.00	1.210
1955	1154408	4.99	1.222
1956	1347734	5.83	1.152
1957	1603320	6.93	1.120
1958	1733809	7.50	1.120
1959	1911713	8.27	1.100
1960	1704368	7.37	1.000
	23127254	100	

Source: Hashim and Dadi (1973), Table III.4.

Table A.5

Industries included under each 3-digit classification

ASI No.	Industry	ASI Nos.
205	Flour, Rice & Dal Mills	205-1, 205-2, 205-3
206	Bakery Products	206
207	Sugar and Gur	207-1, 207-2
208	Coca, Chocolate, etc	208
209	Miscellaneous Food	209-1 to 209-10
211	Alcohol and Spirit	211
212	Wine	212
220	Tobacco	220-1 to 220-6
231	Textiles	231-1 to 231-9
232	Knitting Mills	232
233	Rope and Twine	233
239	Ginning, Pressing, etc.	239-1 to 239-9
251	Wood	251-1, 251-2
252	Wooden Products	252
260	Furniture and Fixture	260-1, 260-2, 260-3
271	Paper and Paper Products	271-1 to 271-7
280	Printing	280-1, 280-2
291	Tanneries	291
300	Rubber and Rubber Products	300-1 to 300-4
311	Chemicals	311-1.1, 311-1.3, 311-2.1, 311-2.2, 311-3 to 311-10
312	Vegetable Oils	312-1
313	Paints, Varnishes,etc.	313
319	Misc. Pharm & Chem. Pdts.	319-1 to 319-12
321	Petroleum Refineries	321
331	Bricks and Tiles	331-1 to 331-4
332	Glass-wares	332-1 to 332-5
333	China Clay wares	333-1 to 333-3
334	Cement	334
339	Misc. non-metallic Mineral Products	339-1, 339-2 339-5 to 339-8
341	Iron and Steel	341-1 to 341-5
342	Non-ferrous basic metal	342
350	Metal Products	350-1 to 350-14
360	Non-electrical Machinery	360-1, 360-3, 360-7 360-9, 360-10, 360-12 360-13 360-4.1 to 4.9 360-4.12 to 4.14 360-5.1, 360-5.2, 360-5.4 360-5.6, 360-5.8 360-5.10 to 5.14 360-6.1, 6.2 360-8.1, 8.2 360-11.1 to 11.3, 11.5, 11.6

(contd.)

Table A.5 *(contd.)*

ASI No.	Industry	ASI Nos.
370	Electrical Machinery	370-1.1 to 1.4, 370-1.6 370-1.9 to 1.11 370-2.1 to 2.4 370-4
381	Ships and Boat buildings	381-1, 381-2
382	Railway Rolling Stock	382-1 to 382-3
383	Motor Vehicles	383
384	Repair of Motor Vehicles	384
385	Motor Cycles and Bicycles	385

Table A.6

Year	Fixed Capital (Book Value)	Depreciation	WPI of Machines & Machine Tools (1960=100)	Investment (Current Prices)	Investment (Constant Prices)	Capital Stock (At 1960 Prices)
	'B'	'D'	'R'	'I'	'I'	'K'
1960	12,800,794,983	1089721150	100.00			30,399,995,711
1961	14,965,859,162	1359753526	103.13	3514317705	3408308078	33,808,303,789
1962	20,779,713,628	1896760413	107.81	7720614879	7161150033	40,969,463,821
1963	27,376,463,054	2035557976	111.56	9632307412	8655849781	44,225,303,602
1964	27,335,775,086	2403213315	116.41	7412525337	6367807001	50,593,110,603
1965	31,336,906,468	2788717282	122.50	6739848664	5501917277	56,095,027,880
1966	37,961,825,296	3279746698	130.94	9904668526	7564422359	63,659,450,239
1967	42,019,499,000	3692237000	136.41	7749900704	5681485052	69,340,935,291
1968	44,808,004,210	4072480106	137.50	6860995316	4989814775	74,330,750,066
1969	47,874,200,000	4598800000	141.25	7664995750	5426645692	79,757,295,758
1970	51,701,720,000	5081022000	156.25	8908542000	5701466880	85,458,762,638
1971	51,610,200,000	5067300000	163.28	4975780000	3047367656	88,506,130,294
1972	53,254,700,000	5549500000	172.81	7194000000	4162893309	92,669,023,603
1973	56,069,150,000	5977000000	190.94	8791450000	4604360065	97,273,383,668
1974	58,883,600,000	6404500000	244.06	9218950000	3777290653	101,050,674,321
1975	66,575,700,000	6904400000	270.63	14596600000	5393625866	106,444,300,187
1976	86,138,600,000	7681400000	266.88	27244300000	10208637002	116,652,937,190
1977	96,111,500,000	8717700000	270.00	18690600000	6922444444	123,575,381,634
1978	107,685,900,000	9758400000	285.78	21332800000	7464730454	131,040,112,088
1979	126,279,200,000	11878200000	330.31	30471500000	9225052034	140,265,164,122
1980	150,951,200,000	13823000000	361.88	38495000000	10637651123	150,902,815,245
1981	167,704,600,000	16284000000	397.81	33037400000	8304766693	159,207,581,936
1982	195,725,700,000	17639300000	418.13	45660400000	10920275037	170,127,856,975
1983	227,270,800,000	20117300000	443.44	51662400000	11650435518	181,778,292,493
1984	280,178,300,000	28387700000	463.91	81295200000	17524057932	199,302,350,425
1985	310,857,400,000	34071700000	510.31	64750900000	12688460502	211,990,810,927
1986	347,455,400,000	37376700000	538.33	73974700000	13742759942	225,733,570,869
1987	440,800,000,000	52830000000	560.00	146174600000	26102607143	251,836,178,012
1988	526,900,000,000	60610000000	605.91	146710000000	24212982474	276,049,160,486

Table A.7

Year	Value of Output (Rs.Lakhs)	Material Inputs (Rs.Lakhs)	Emolu-ments (Rs.Lakhs)	No. of Employees	Capital Stock (Rs.Lakhs)
1970-71	1302632	968776	155387	4803554	854588
1971-72	1449061	1081837	174542	4996336	885061
1972-73	1637475	1216719	198203	5071072	926690
1973-74	1825888	1351601	221864	5145807	972734
1974-75	2448358	1824969	270708	5412872	1010507
1975-76	2769203	2127180	302761	5667666	1064443
1976-77	3144162	2415150	314606	5871150	1166529
1977-78	3588004	2787639	357585	6227813	1235754
1978-79	4067250	3136337	394662	6373477	1310401
1979-80	4832928	3758016	466888	6816864	1402652
1980-81	5616303	4423569	523344	6811204	1509028
1981-82	6717250	5333348	577781	6864347	1592076
1982-83	7849696	6249109	685477	7042930	1701279
1983-84	8399371	6488792	783192	6791375	1817783
1984-85	9604910	7478506	899039	6773638	1993024
1985-86	10930676	8568656	925113	6393475	2119908
1986-87	11894210	9410586	996984	6432633	2257336
1987-88	13770200	10864200	1157700	6708000	2518362
1988-89	16666700	13108200	1280900	6730000	2760492