Annexures

Annexure I:
Single and Double-deflation Methods

In this annexure, we detail the differences between the estimates of real value added obtained by using single and double deflation methods. See the list of abbreviations for the notations used.

Equation AI.1 defines the nominal value added for year 't' (NV_t) as the difference between the gross output at price in that year (P_tO_t) and the cost of raw-material used (Pn_tN_t).

$$NV_t = P_tO_t - Pn_tN_t \quad \text{AI.1}$$

Nominal value added is converted into real value added (single deflation method) for year 't' (VSD_t) by deflating equation AI.1 by (P_t/P_o), i.e., the index of price for year 't' with respect to the base year 'o'. This is stated in equation AI.2.

$$VSD_t = (P_tO_t - Pn_tN_t)/ (P_t/P_o) = (P_oO_t - \Pi_tP_oN_t) \quad \text{AI.2}$$

Nominal value added (stated in equation AI.1) is converted into real value added (double deflation method) for year 't' (VDD_t) by deflating the P_tO_t by (P_t/P_o), and Pn_tN_t by Pn_t/Pn_o. In other words, nominal gross output is converted into real gross output by using the output price deflator index, whereas, the nominal value of inputs is converted into real quantity of inputs by deflating it by the price deflator index for the material inputs. This is stated in equation AI.3.

$$VDD_t = [(P_tO_t)/ (P_t/P_o)] - [(Pn_tN_t)/(Pn_t/Pn_o)]= (P_oO_t - Pn_oN_t) \quad \text{AI.3}$$

Setting P_o, P_{no}= 1 for the base year in equations AI.2 and AI.3, we get equations AI.4 and AI.5, respectively.

$$VSD_t = O_t - \Pi_tN_t \quad \text{AI.4}$$

$$VDD_t = O_t - N_t \quad \text{AI.5}$$

If Π_t is constant w.r.t. time, growth rate of VSD = growth rate of VDD.

If Π_t is rising w.r.t. time, growth rate of VSD < growth rate of VDD.

If Π_t is falling w.r.t. time, growth rate of VSD > growth rate of VDD.

Production function, i.e., dependence of real output on labour, capital and raw-material inputs has been described in equation AI.6. For simplicity in exposition, we have ignored the time subscript in equations AI.6, AI.7 and AI.8. Equation AI.7 links describes the relationship between the real value added obtained with single deflation method and the gross output.

$$O = f[L, K, N] \quad \text{AI.6}$$

$$VSD = O - (P_n N / P) \quad \text{AI.7}$$

If N is separable from L and K then, the real value added function can be written as equation AI.8.

$$VSD = g [L, K; \Pi] \quad \text{AI.8}$$

However, if raw-materials are not separable from the factors of production, then it would be inappropriate to estimate the real value added function as dependent only on L and K.

Annexure II:
Alternative Indices for Measuring Multifactor Productivity

In this annexure, we provide the details of the three major MFP indices, viz., the Kendrick Index (KI), the Solow Index (SI) and the Translog Index (TLI).

i) Kendrick Index

Kendrick index may be interpreted as the ratio of actual output to the output, which would have resulted from increased inputs alone, i.e., in absence of technological change. Kendrick index for TFP (A_t) for the time period 't' is stated in equation (AII.1).

$$A_t = O_t / (w_o L_t + r_o K_t) \quad \text{(AII.1)}$$

In the above equation notations 'w_0'and 'r_0' denote the factor rewards to labour and capital, respectively, in the base year 'o'. Generally, income shares are used as weights to compute the ratio of output to a weighted combination of inputs and thereby measure A_t. A number of assumptions, implicit in use of these weights are as follows. First, factor rewards are equal to their marginal productivity. In other words, the applicability of marginal productivity theory of distribution is assumed. Second, technological change is of Hicks-neutral type. In the case of Hicks-neutral technical change the marginal rates of technical substitution remain unchanged and the technical progress increases the output attainable from a given bundle of inputs. The third assumption made in the empirical studies is that of constant returns to scale. In brief, the assumption of constant returns to scale combined with the applicability of marginal productivity theory yields the product exhaustion or the Euler's theorem, which means that entire output is exhausted by payment to labour and capital. Thus, in the base year A_0 will be equal to unity by definition. One of the major limitations of the Kendrick Index is that it is based on a linear production function (and hence, infinite elasiticity of substitution between the factors of production) and does not allow for the diminishing marginal productivity of factors of production.

ii). Solow Index

Solow (1957) used a linear homogenous Cobb-Douglas production function as stated in equation (AII.2), in order to obtain the TFPG. A variants of Equation (AII.2), converted into log-linear form is stated in equation (AII.3). Equation (AII.3) can also be written in the form of equation

(AII.4), as the first difference in logarithms of a variable can be expressed as proportionate change in that variable

$$O = A(t)\, K^{\beta}\, L^{1-\beta} \quad \text{(AII.2)}$$

$$\Delta\log(O/L) = \Delta\log A(t) + \beta\, \Delta\log(K/L) \quad \text{(AII.3)}$$

$$\Delta(O/L)/(O/L) = \Delta A(t)/A(t) + \beta\Delta(K/L)/(K/L) \quad \text{(AII.4)}$$

Assuming that the marginal productivity theory of distribution holds true, we get the expression for β, which is stated in equation (AII.5) where 'i' denotes the real return to capital. Substituting (AII.5) in (AII.4) we get equation (AII.5).

$$\beta = i\, K/O \quad \text{(AII.5)}$$

$$\Delta A(t)/A(t) = \Delta(O/L)/(O/L) - (i\, K/O)*\Delta(K/L)/(K/L) \quad \text{(AII.6)}$$

Feeding the data on O, L, K and i, we get a numerical expression for the residual $\Delta A(t)/A(t)$ from equation (10). This term is designated as growth rate of TFP (TFPG). Growth rates of TFP are used to construct TFP indices across time. Indices of A(t) are also referred to as the Solow residuals or Solow index of technological progress or Solow TFP indices. The above discussion highlights the fact that all assumptions of the linearly homogenous C-D function, viz., disembodied Hicks-neutral technical progress and unitary elasticity of substitution are built into Solow (1957) residuals. Moreover, these residuals are obtained by invoking the assumption of the marginal productivity theory of distribution, as mentioned in equation (AII.5). Constant returns to scale and product exhaustion assumptions enter Solow's analysis via the combination of equation (AII.3) and (AII.6). The Solow concept of TFPG is unambiguous for infinitesimally small and continuous shifts in technology across time. Empirical estimates of productivity change are based on a discrete set of price and quantity data. A solution to this problem lies in using a flexible form of production function, which is twice differentiable.

Annexure III

Selected Industries and their National Industrial Classification (NIC) Codes

Industry (Code as per NIC-1970)	Industry (Code as per NIC-1987)
1. Textiles and textile products	***1. Textiles and textile products***
a) Manufacture of Cotton Textiles (23)	a) Manufacture of Cotton Textiles (23)
b) Manufacture of Wool, Silk and Synthetic Fibres (24)	b) Manufacture of Wool, Silk and Man-made Fibre Textiles (24)
c) Manufacture of Jute,Hemp and Mesta textiles (25)	c) Manufacture of Jute and Other Vegetable Fibre Textiles, Except Cotton (25)
d) Manufacure of Textile Products (26)	d) Manufacure of Textile Products (26)
2. Metal and metal products	***2. Metal and metal products***
a) Basic Metal and Alloys Industries (33)	a) Basic Metal and Alloys Industries (33)
b) Manufacture of Metal Products and Parts except Machinery and Transport Equipment (34)	b) Manufacture of Metal Products and Parts except Machinery and Transport Equipment (34)
3. Machinery and transport equipment	***3. Machinery and transport equipment***
a) Manufacture of Machinery, Machine Tools	a) Manufacture of Machinery and Equipment

	and Parts, except Electrical Machinery (35)	Other Than Transport Equipment (35-36)
b)	Manufacture of Electrical Machinery, Apparatus, Appliances and Supplies and Parts (36)	b) Manufacture of Transport Equipment and Parts (37)
c)	Manufacture of Transport Equipment and Parts (37)	
4.	***Chemical and chemical products***	***4.*** ***Chemical and chemical products***
a)	Manufacture of Chemical and Chemical Products, except Products of Petroleum and Coal (31)	a) Manufacture of Basic Chemical and Chemical Products, except Products of Petroleum and Coal (30)
5.	***Leather and leather products***	***5.*** ***Leather and leather products***
a)	Manufacture of Leather and Leather and Fur Products, except repair (29)	a) Manufacture of Leather and Products of Leather, Fur & Substitutes of Leather (29)

Source: ASI, Central Statistical Organisation, Department of Statistics, Government of India.

Annexure IV

Estimation of Capital Stock Series

The measurement of capital stock has been a controversial issue both in theoretical and in empirical contexts. There is no universally accepted method for its measurement and several methodologies are used in estimation of capital stock. We have used the Perpetual Inventory Accumulation Method (PIAM) for generating the series on capital stock. The PIAM requires the estimates of capital stock for a benchmark year and investment in the subsequent years. This method has been followed by other researchers as well (Ahluwalia [1991] and Balakrishnan and Pushpangadan [1994]). The time-series on capital stock at current prices, has been generated by using equations (AIV.1) and (AIV.2).

$$I_t = B_t - B_{t-1} + D_t \qquad \text{(AIV.1)}$$

$$K_t = K_0 + \sum_{i=1} I_i \qquad \text{(AIV.2)}$$

Notations used in these equations are as follows. I is the gross capital formation/investment, B is the book value of fixed capital, D is depreciation, K is the stock of capital at current prices. Subscript ‘t’ has been used to denote time. The gross investment figures were obtained using equation (AIV.1). Data on all the variables mentioned in this equation are available in ASI. We have taken the estimates of capital stock at current prices for 1964 (K_0) from Hashim and Dadi (1973) and have treated this year as the benchmark year. Gross capital stock for the subsequent years have been arrived at by adding the gross investment figures (from equation (AIV.1)) to the stock of capital of the previous year, as mentioned in equation (AIV.2).

The series on gross capital stock at current prices (K_t) has been converted into real capital stock series by using two alternative price indices, viz, Gross Domestic Capital Formation Deflator

index and WPI for Machines and Machine tools, both with base 1981-82=100. The former real capital stock series has been referred to as K1 and the latter as K2, in this study.

Annexure V

List of Commodity Sectors as Classified in Input-Output Table (Code No.)

1. Textile, yarn, fabric & manufactures
- Cotton textiles (24)
- Wollen textiles (25)
- Art silk and synthetic fibres (26)
- Jute hemp mesta textiles (27)
- Other textiles (28)

2. Manufacture of metals
- Iron and steel (42)
- Non-ferrous metals (43)

3. Machinery & transport equipment
- Tractors and other agricultural machinery (44)
- Machine tools (45)
- Other non-electrical machines (46)
- Electrical machinery (47)
- Rail equipment (50)
- Motor vehicles (51)
- Other transport equipment (52)

4. Chemical & allied Products
- Fertilisers (36)
- Pesticides (37)
- Other Chemicals (39)

5. Leather and Manufactures
- Leather and leather products (31)

Note: Figures in brackets indicate the commodity sector number in the input-output table, 1991-92, in A Technical Note to the Eighth Plan of India (1992-97), Perspective Planning Division, Planning Commission, Government of India, New Delhi, 1995.

Annexure VI

Compilation of Input Price Index

Input price index series for the various industry groups were compiled using the technological coefficients from the input-output table, 1991-92. This input-output table has been constructed by the Planning Commission (1995) using the inter-industry transactions matrix, 1983-84, provided by the Central Statistical Organisation (CSO), Department of Statistics, Ministry of Planning. The inter-industry table of 1983-84, which was originally constructed for 115 sectors, has

been aggregated into 60 sectors and has been used in the Eighth Plan exercies. The 1983-84 inter-industry table has been updated to 1991-92 by the Planning Commission on the basis of input norms, commodity output, exports, imports, investment, public and private consumption, each at the prices prevailing in 1991-92.

The input price indices for the various industry groups were computed as a weighted average of the wholesale price indices of various inputs. It is for the first time that a group of 60 inputs has been used for estimating the relative input-output prices in the Indian manufacturing and used in the productivity study.