Sustainability of Output Growth in Indian Manufacturing: A Decomposition Analysis of Selected Industries

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Abstract: The present paper undertakes a decomposition analysis of the output growth of Indian manufacturing sector. Such an exercise becomes important in view of the non-sustainability of growth proposed by Krugman for the East Asian countries. As the law of diminishing returns to factor inputs is invoked in drawing the above inference, an attempt is made to estimate the contribution of four inputs, viz., capital, labour, energy and material, to the growth of output by estimating a translog production function for aggregate manufacturing sector and eight selected industries of India. A major finding of the empirical exercise relates to minimal or negative contribution of technology to output growth. Therefore, inputs, mainly, raw material has been contributing significantly to growth of output in Indian industries. Such a pattern of raw material-driven growth indicates the possibility of non-sustainability thesis advanced by Krugman.

Key Words: Krugman's Thesis; Sources of Growth; Total Factor Productivity; Translog Production Function.

JEL Classification: D24

1. Introduction

With the prediction of non-sustainability of growth registered by the East Asian countries, Krugman's thesis [Krugman 1994] leaves an implicit appeal for most of the developing economies to examine their positions. In a situation of fragile total factor productivity growth (TFPG), a syndrome which most of the developing countries encounter, it becomes imperative to undertake an analysis of growth-decomposition of output to identify its major contributing factors. Such a result is likely to help provide appropriate policy guidelines while projecting the long-run growth trajectory of the countries.

To agree with the argument advanced by Krugman on the East Asian growth it, however, is necessary to appreciate the idea that input-driven growth does not bypass the law of diminishing returns. As the phenomenal growth witnessed by the East Asian economies has only negligible growth of TFP and is contributed by a large dose of capital accumulation, its non-sustainability would follow as a corollary. An extension of the same line of reasoning to the growth path of developing countries is likely to describe its character.

A major reason of side-tracking the growth-decomposition analysis in recent years appears to be the concern for focussing attention on technology-driven productivity growth. As the contribution of exogenous technical progress, without the feature of diminishing returns to the growth process of an economy, is viewed as vital, it makes sense to address the question of TFPG directly without bothering to discuss the consequences of individual factors' contributions to output growth. Thus most of the studies concerned with TFPG tend to skip the documentation of factor contributions.

The present study aims at examining the contribution of factors - capital, labour, energy and raw material - along with technical change in the output growth registered by Indian industries. Results obtained through such an exercise is expected to help identify the character of growth path followed by the manufacturing sector of India in the context of Krugman's thesis. For that purpose, it considers the data of aggregate registered manufacturing sector and eight most polluting industries[1], viz., cement, chemical and chemical products, glass, iron and steel, non-ferrous metals, pulp and paper, pottery and earthenware, and structural clay[2]. Rest of the paper is organised as follows. Section 2 touches upon some of the main results of growth-decomposition studies. Methodology of the study is given in Section 3 while Section 4 gives empirical results. Major conclusions of the analysis are presented in Section 5.

2. Decomposition Studies

Consideration of contribution made by the individual factors to growth of output is a familiar tool in analysts' kit. The growth accounting method of estimating total factor productivity (TFP) makes use of such a route to obtain the contribution of technology to output growth. The recent developments of endogenous growth theories emphasise the role of diminishing marginal productivity of a factor to explain the possibility of convergence of growth rates among countries [Romer 1994]. Of late, Krugman has invoked diminishing returns feature of a factor to predict the non-sustainability of on-going high growth rate in the East Asian economies.

With the increasing realisation of the importance of contribution of individual factors in output growth, the method of estimation seems to have drawn greater attention. Use of econometric tools by specifying a production or a cost function have allowed researchers to overcome some of the restrictive assumptions involved in the growth accounting method. Features like constant returns to scale and Hicks-neutrality are no longer assumed to be part of production function while estimating TFPG. Moreover, existence of the regularity conditions underlying a production function such as concavity and monotonicity conditions are put to test. In the process, results obtained through the growth accounting approach that carry the danger of producing either an over or an under-estimate of TFPG [Denny et al. 1981; Park and Kwon 1995] is tried to be minimised.

It is not difficult to see that an estimation of TFPG with the help of translog cost function projects it as an interaction of scale economies and technical change and relaxes the assumption of constant returns to scale besides offering scope to test Hicks-neutrality [see, for example, Nadiri 1982; Fuss 1987]. Employment of a translog production function for the task [Jorgenson et al. 1987], on the other hand, provides for testing of Hicks-neutrality although the feature of constant returns to scale is retained. Estimated coefficients from both cost and production functions are put to test for their well-behavedness before drawing inferences. So efforts on decomposition of output growth into contributions of factors of production through econometric estimation tend to give results that have better precision.

A practice of considering the contribution of two factors of production, labour and capital, for estimating TFPG from value added is giving way to a careful examination of the existence of a value added function [Pradhan and Barik 1998; Williams and Lauma 1981]. Tests are being performed to ascertain the fulfilment of separability condition between primary and intermediate inputs in a production or a cost function. In the event of non-fulfilment of the separability conditions the researchers have the freedom of employing intermediate inputs like raw materials and energy along with capital and labour to account for their contribution to output growth.

It may be useful to point out that studies on TFPG estimation with the aid of econometric technique in India have not gone into decomposition analysis of the growth of output. Two recent exercises, Ahluwalia (1991) and Gangopadhyay and Wadhwa (1998), which estimate TFP in India through value added function are confined to a discussion on TFPG only. Thus discussion on the nature of contribution of individual factors have not yet been explicitly recorded by the econometric studies.

Studies that have assessed the contribution made by factors of production to output growth of Indian industries are Ahluwalia (1985 & 1991) and Goldar (1986). A major finding in these relates to higher contribution of capital in the growth of output (value added) compared to those of labour and technology. For example, Ahluwalia (1985) attributes the growth in value added to contribution of capital (86.8%) while Goldar (1986) puts it at 56.5%[3].

Studies addressing TFPG estimation from value added [Ahluwalia 1985 & 1991; Balakrishnan and Pushpangadan (hereafter B-P) 1994; Banerjee 1975; Brahmananda 1982; Goldar 1986] have included two inputs only while those taking gross output for the same problem [Pradhan and Barik 1998; Rao 1996] have taken three. Thus the nature of factor contribution in the presence of more than three inputs has not been examined as yet by the Indian studies[4].

Keeping in view the preceding discussion, the following analysis seeks to offer some insight on the nature of factors' contribution to output growth of Indian manufacturing industries by considering a translog production function. In view of the result of non-separability of primary and intermediate inputs [Pradhan and Barik 1998], it resorts to decomposition of output growth from gross output instead of value added including in the process four inputs. For a more precise estimation of the contribution made by the individual factors, it tests the curvature conditions as well as Hicks-neutrality assumption of the underlying production function. As a test to the robustness of the result obtained through econometric method, the traditional growth accounting procedure in the presence of four inputs is undertaken before drawing inferences.

3. Methodology

The present analysis attempts to estimate the contribution of factors of production along with TFP to the growth of output with a translog production function. The regression equation selected for this purpose takes the form:

$$\begin{aligned} ln\,Y &= \alpha_0 + \sum_i \alpha_i \, ln\,X_i + \frac{1}{2}\sum_i\sum_j \beta_{ij}\, ln\,X_i \, ln\,X_j \\ &\quad + \alpha_t t + \sum_i \beta_{it}\; t\, ln\,X_i + \frac{1}{2}\beta_{tt}t^2 + \varepsilon \qquad (i, j = K, L, E, M) \quad ....(1) \end{aligned}$$

where Y = output

X_i = i^th^ input

t = time variable

ε = error term.

The procedure adopted for estimating (1) assumes the production function to be homogeneous of degree one, i.e., it yields constant returns to scale. Therefore, its parameters are adjusted to satisfy the conditions:

$$\sum_i \alpha_i = 1, \;\; \sum_i \beta_{ij} = 0, \;\; \sum_i \beta_{it} = 0 \;\; and\; \beta_{ij} = \beta_{ji} \quad (i, j = K, L, E, M) \quad ....(2)$$

On differentiating (1) with respect to inputs (X_i) and applying the producers' equilibrium condition, $\frac{\partial Y}{\partial X_i} = \frac{P_i}{P}$ (P_i = price of X_i and P = price of Y), the i^th^ share equation obtained is

$$\theta_i = \alpha_i + \sum_i \beta_{ij}\, ln\,X_i + \beta_{it} t \quad (i, j = K, L, E, M) \quad ...(3)$$

The production function (1) and share equations (3) are estimated by Zellner's method so that the information contained in the input demand functions are taken into account. As the sum of the four factor shares, K, L, E and M, is unity, the problem of linear dependency and consequent singularity of residual covariance matrix is avoided by dropping one of the share equations. The present study drops the capital share equation[5]. Restrictions in (2) are imposed to the system of equations to satisfy the linear homogeneity condition on the production function. Software package SHAZAM is used to estimate the system of equations.

The restrictions imposed on parameters of (1) for the fulfilment of Hicks-neutrality conditions are:

$$\beta_{Kt} = \beta_{Lt} = \beta_{Et} = \beta_{Mt} = 0 \qquad ...(4)$$

Test for Hicks-neutrality is performed with the help of likelihood ratio [Christensen and Greene 1976] which follows a chi-squared distribution with degree of freedom equal to the number of independent restrictions imposed. A significant chi-squared value would imply the presence of technical bias.

The estimation procedure of the contributions made by TFP and factors of production to output growth is discussed in the following: The study derives the factor and TFP contributions from an estimated translog production function in which the average growth rate in output over the period of analysis is given by

$$\dot{Y} = \frac{1}{T}[ln\,\hat{Y}(K_T, L_T, E_T, M_T, T) - ln\,\hat{Y}(K_0, L_0, E_0, M_0, 0)] \qquad ...(5)$$

where $\dot{Y}$ = growth rate in output,

T = time variable for the final period

0 = time variable for the initial period

$\hat{Y}$ = estimated value of output as obtained from (1), and

subscripts T and 0 are used for indicating the level of inputs at final and initial periods respectively.

The growth rate of output obtained from (5) is decomposed into the contributions of inputs X_i (i = K, L, E, M) and TFP. In such a formulation contribution of X_i is defined as the increase in output solely due to increase X_i, when the level of other inputs and time remain unchanged (Boskin and Lau 1990, *cited in* Felipe 1997). For example, the contribution of K at the initial time period 0, denoted by C_{K0}, is given by

$$C_{K0} = \frac{1}{T}[ln\,\hat{Y}(K_T, L_0, E_0, M_0, 0) - ln\,\hat{Y}(K_0, L_0, E_0, M_0, 0)] \qquad ...(6)$$

It may be noted that the contribution of K will change over time unless technical change is Hicks-neutral. In the presence of technical bias the contribution of K at the final time period T is

$$C_{KT} = \frac{1}{T}[ln\,\hat{Y}(K_T, L_T, E_T, M_T, T) - ln\,\hat{Y}(K_0, L_T, E_T, M_T, T)] \qquad ...(7)$$

The average contribution of K over the study period is obtained as the mean of C_{K0} and C_{KT}. For deriving the contribution of TFP at the initial time period ‘0’, $C_{TFPG,0}$, to the growth rate in output, $\dot{Y}$, the equation used is

$$C_{TFPG,0} = \frac{1}{T}[ln\hat{Y}(K_0, L_0, E_0, M_0, T) - ln\hat{Y}(K_0, L_0, E_0, M_0, 0)] \qquad ...(8)$$

Similarly, its contribution at time T is given by

$$C_{TFPG,T} = \frac{1}{T}[ln\hat{Y}(K_T, L_T, E_T, M_T, T) - ln\hat{Y}(K_T, L_T, E_T, M_T, 0)] \qquad ...(9)$$

Subsequently, the average contribution of TFPG is derived to be the mean of $C_{TFPG,0}$ and $C_{TFPG,T}$. It is worth mentioning that the procedure outlined above to obtain the contribution of TFPG does not consider it as a residual after subtracting the factor contributions from output growth that has been a practice in growth accounting approach.

Growth accounting procedure to decomposition analysis is obtained with the help of Divisia-Tornquist approximation to (1). When there are four inputs, viz., *K, L, E* and *M*, which account for the growth of output, TFPG is given by

$$TFPG = (\ln Y_t - \ln Y_{t-1}) - \frac{1}{2}\sum_i(\theta_{i,t} + \theta_{i,t-1})(\ln X_{i,t} - \ln X_{i,t-1}) \qquad ...(10)$$

$$(i = K, L, E, M)$$

where $\theta_{i,t}$ is the share of i^{th} input in output for t^{th} year.

It would be necessary to briefly touch upon the method adopted for construction of deflator for material and estimate of capital stock while estimating TFPG. For, a study of the present kind crucially depends upon the data source and construction of variables to be analysed (Krishna 1987). An important data source accessible to analysts, in general, is the Annual Survey of Industries (ASI) [Government of India (a)]. This source provides data in current prices, which needs to be transformed into constant prices for analytical purposes.

Of the four inputs and output considered in the study, finding out appropriate measures of capital and material variables pose a problem. Present analysis attempts to construct a deflator for material variable by taking a weighted average of the price indices of components of material input. It may be useful to point out that material input includes components such as raw materials and chemicals entering the production process. The deflator used for its estimation, therefore, combines the price indices of relevant components. Following the practice adopted by B-P (1994) and Park and Kwon (1995), the present study assigns weights to these components on the basis of structural coefficients provided in Input-Output Table 1991-92 [Government of India 1995]. As there is industry-wise variation in the structural coefficients, the weights assigned to components are allowed to vary from industry to industry. In the process industry-specific price indices for material input are obtained.

In case of capital variable, industry-specific capital stocks are used in the present analysis. For construction of industry wise capital stock, the study relies on the perpetual inventory method. The coverage of the study relates to the period 1963-64 to 1994-95. The detailed database and definition of variables are given in the appendix.

4. Empirical Results

At the outset it may be worthwhile to point out that the aggregate as well as the individual industries considered in the study could not meet the separability condition between primary and intermediate inputs[6]. Thus, the translog production function taken for estimation considers gross output instead of value added to be the dependent variable.

Before going into a discussion on the decomposition results, it is necessary to touch upon the features of estimated translog production function (1). The coefficients of the estimated functions are reported in Table 1. It may be seen from the table that majority of the coefficients are statistically significant. The production function seems to have a good fit, as the R^2 between actual and predicted values of ln$Y$ is more than 90% for the aggregate manufacturing and all individual industries (except that of pottery).

TABLE 1: ESTIMATED COEFFICIENTS OF TRANSLOG PRODUCTION FUNCTION

Para-Meter	Cement	Chem.	Glass	Iron & Steel	Non-Ferr. Met.	Pottery	Pulp & Paper	Struct. Clay	Agg. Mfg.
α_0	9.2324 (133.41)	11.257 (137.53)	8.0719 (247.38)	11.3060 (210.39)	9.8345 (113.15)	7.2760 (91.12)	9.2544 (476.31)	8.0311 (249.29)	13.4920 (354.94)
α_K	0.2313 (11.48)	0.3085 (16.73)	0.1827 (12.82)	0.2090 (7.12)	0.3137 (7.20)	0.2375 (11.15)	0.2933 (18.48)	0.2805 (15.01)	0.1605 (10.02)
α_L	0.1020 (16.02)	0.1059 (32.05)	0.2335 (41.13)	0.1629 (15.25)	0.0863 (7.31)	0.2840 (21.70)	0.1336 (42.83)	0.2859 (25.19)	0.1572 (29.76)
α_E	0.2447 (21.57)	0.0484 (7.43)	0.1716 (19.44)	0.1113 (13.84)	0.0485 (3.35)	0.1767 (14.59)	0.1064 (12.72)	0.1315 (15.59)	0.0508 (9.73)
α_M	0.4221 (29.13)	0.5373 (39.27)	0.4121 (56.31)	0.5169 (29.41)	0.5514 (21.88)	0.3018 (23.75)	0.4667 (51.68)	0.3022 (34.70)	0.6316 (53.56)
β_{KL}	0.0432 (1.58)	-0.0028 (-0.62)	0.0107 (0.91)	0.0333 (1.84)	0.0139 (1.24)	0.0448 (2.97)	0.0130 (0.78)	-0.0283 (-0.73)	-0.0269 (-0.94)
β_{KE}	-0.0115 (-0.33)	-0.0163 (-1.89)	-0.0231 (-1.32)	-0.0238 (-1.87)	-0.0235 (-1.55)	-0.0326 (-1.49)	0.0470 (2.15)	-0.0013 (-0.05)	-0.0605 (-2.51)
β_{KM}	0.0950 (0.43)	0.0437 (2.53)	-0.0024 (-0.21)	-0.0190 (-0.83)	0.0544 (2.47)	0.0143 (0.62)	-0.0840 (-3.94)	0.0137 (0.77)	-0.0292 (-0.73)
β_{LE}	-0.0555 (-3.03)	-0.0024 (-0.23)	-0.0284 (-2.00)	0.0108 (1.02)	-0.0374 (-3.71)	-0.0188 (-2.28)	-0.0273 (-2.57)	0.0194 (0.84)	0.0323 (1.70)
β_{LM}	0.0099 (0.29)	0.0112 (1.43)	0.0129 (2.24)	-0.0274 (-2.02)	-0.0095 (-0.90)	-0.0176 (-0.86)	-0.0102 (-0.81)	-0.0214 (-1.93)	-0.0067 (-0.33)
β_{EM}	-0.0801 (-4.25)	-0.0638 (-5.78)	-0.0718 (-8.24)	-0.0738 (-6.26)	-0.0655 (-4.52)	-0.0624 (-4.76)	-0.0977 (-6.49)	-0.0630 (-7.63)	-0.0462 (-2.08)
β_{KK}	-0.1266 (-2.31)	-0.0246 (-1.09)	0.0148 (0.55)	0.0096 (0.22)	-0.0448 (-1.19)	-0.0264 (-0.68)	0.0240 (0.61)	0.0160 (0.26)	0.1166 (1.99)
β_{LL}	0.0084 (0.40)	-0.0060 (-0.61)	0.0048 (0.35)	-0.0168 (-1.07)	0.0330 (3.33)	-0.0084 (-0.66)	0.0244 (1.52)	0.0302 (0.88)	0.0014 (0.06)
β_{EE}	0.1472 (4.53)	0.0826 (5.34)	0.1232 (6.12)	0.0868 (6.05)	0.1264 (7.07)	0.1138 (4.60)	0.0780 (5.05)	0.0450 (1.75)	0.0744 (3.11)
β_{MM}	-0.0188 (-0.84)	0.0090 (0.52)	0.0614 (7.26)	0.1202 (5.38)	0.0206 (1.10)	0.0658 (3.72)	0.1920 (10.29)	0.0708 (6.39)	0.0822 (2.28)
α_t	0.0104 (1.07)	-0.0615 (-5.30)	-0.0012 (-0.26)	-0.0219 (-2.88)	-0.0666 (-5.46)	-0.0204 (-1.88)	0.0064 (2.64)	0.0252 (5.32)	0.0176 (3.58)
β_{Kt}	0.0106 (3.87)	-0.0003 (-0.39)	0.0025 (1.71)	0.0012 (0.57)	0.0007 (0.30)	0.0049 (2.59)	-0.0016 (-1.15)	-0.0014 (-0.50)	-0.0008 (-0.44)
β_{Lt}	-0.0028 (-1.74)	-0.0018 (-3.60)	-0.0046 (-4.84)	-0.0054 (-4.64)	-0.0002 (-0.26)	-0.0068 (-6.36)	-0.0016 (-1.76)	-0.0035 (-1.71)	-0.0025 (-2.05)
β_{Et}	-0.0003 (-0.20)	0.0018 (3.06)	0.0010 (0.93)	0.0023 (2.98)	0.0002 (0.32)	0.0018 (2.01)	0.0005 (0.61)	0.0027 (1.99)	0.0028 (2.68)
β_{Mt}	-0.0075 (-4.72)	0.0003 (0.51)	0.0011 (1.59)	0.0019 (1.49)	-0.0007 (-0.57)	0.0001 (0.11)	0.0027 (3.10)	0.0023 (2.62)	0.0005 (0.44)
β_{tt}	-0.0006 (-0.88)	0.0028 (4.16)	0.0006 (2.20)	0.0008 (1.88)	0.0032 (4.50)	0.0008 (1.22)	-0.0006 (-5.00)	-0.0024 (-7.91)	-0.0008 (-2.74)
R^2	0.98	0.95	0.99	0.96	0.94	0.87	0.99	0.99	0.98

Notes: 1) The coefficients pertain to equation (1) in the text.
2) Figures in parentheses indicate t-ratios.
3) R^2 given is between actual and predicted values of ln$Y$.

The estimated function satisfies the regularity conditions of monotonicity and concavity. The monotonicity condition is met, as estimated factor shares are positive at every sample point. The concavity condition, which has been seen through the negative semi-definiteness of the Hessian matrix at the mean levels of inputs, is fulfilled by the estimated coefficients.

The likelihood ratio test conducted on the data of aggregate manufacturing sector over the period of study indicates the non-fulfilment of Hicks-neutrality conditions in the aggregate manufacturing sector. Since there are three independent restrictions[7] imposed for testing Hicks-neutrality (see equation (4)) the chi-squared value obtained would be significant at three degrees of freedom. As can be seen from Table 2, the aggregate manufacturing sector has a chi-squared value of 27.52 which is significant at 1 per cent level. It may be useful to note that the rejection of Hicks-neutrality test in case of aggregate manufacturing sector confirms the earlier result of Gangopadhyay and Wadhwa (1998).

An extension of Hicks-neutrality test carried on the aggregate manufacturing sector is supported at the level of individual industries (see Table 2). It can be seen from the table that the chi-squared values obtained from the test for individual industries, except for non-ferrous metals, are significant at 1 percent level.

An implication of the non-fulfilment of Hicks-neutrality test is that technical change in Indian industries involves a technical bias[8]. The nature of bias in aggregate manufacturing as well as individual industries is provided in Table 3. These results are obtained from the estimated β_{it} coefficients given in Table 1. It can be seen from Table 3 that the nature of technical change has been labour-saving and energy-using in the aggregate manufacturing sector. This indicates that labour share declined over time while energy share has gone up.

TABLE 2: RESULTS OF HICKS-NEUTRALITY TEST

Industry	Chi-squared value
Cement	28.80
Chemicals	22.98
Glass	36.03
Iron and Steel	43.07
Non-ferrous metals	02.66
Pottery	64.03
Pulp and Paper	26.40
Structural Clay	17.54
Aggregate Manufacturing	27.52

Note: Chi-squared values presented above are from likelihood ratio test. These values are significant at 1 per cent level in all cases (except for non-ferrous metals) as they refer to 3 degrees of freedom.

The feature of technical bias noticed in the aggregate manufacturing sector is also present among individual industries except in case of non-ferrous metals where it is Hicks-neutral. Although there is industry-wise variation in the nature of technical bias, labour-saving and energy-using biases seem to be important features of individual industries. While chemical, iron and steel, and pulp and paper have experienced labour-saving and energy-using technical bias, glass exhibits its labour-saving character. These four industries, therefore, follow the pattern observed in case of the aggregate manufacturing sector which was found to be labour-saving and energy-using. In contrast to these, cement has exhibited capital-using and material-saving technical change while pottery is solely material-using. The remaining industry, i.e., structural clay, shows the characteristic of both energy and material-using technical change. From these observations, it is apparent that Hick-neutrality usually assumed in the growth accounting method of estimation might not be valid in case of Indian industries.

TABLE 3: TECHNICAL-BIAS AMONG SELECTED INDUSTRIES

Industry	Nature of technical bias
Cement	Capital-using, material-saving
Chemicals	Labour-saving, energy-using
Glass	Labour-saving
Iron and Steel	Labour-saving, energy-using
Non-ferrous metals	Hicks-neutral
Pottery and Earthenware	Material-using
Pulp and Paper	Capital and energy-using, labour-saving
Structural Clay	Energy and material-using
Aggregate Manufacturing	Labour-saving, energy-using

Note: The nature of bias is ascertained by β_{it} coefficients of Table 1. Technical change is termed ith factor saving if $\beta_{it} < 0$. It is ith factor using if $\beta_{it} > 0$.

Decomposition of Output Growth: A major focus of the present study is to analyse the contribution of inputs and TFPG to output growth. On the basis of the methodology outlined earlier, source specific growth of output is reported in Table 4. Two features can be brought out from these results. One, material input is the major contributor to output growth in the Indian manufacturing sector. Two, TFP has a negligible or negative contribution to output growth.

TABLE 4: CONTRIBUTIONS OF INPUTS TO OUTPUT GROWTH (ECONOMETRIC ESTIMATION)

Industry	Contributions of					
	K	L	E	M	TFP	Total
Cement	2.83	0.25	2.10	1.56	0.97	7.71
Chemicals	3.50	0.34	0.69	4.62	-1.38	7.77
Glass	2.35	0.12	0.97	1.90	1.34	6.69
Iron & Steel	2.03	0.15	0.58	3.54	-0.42	5.88
Non-ferrous metals	3.23	0.41	0.98	3.34	-1.26	6.70
Pottery	2.46	0.15	0.81	1.36	0.04	4.82
Pulp & Paper	2.32	0.19	0.87	3.63	-0.30	6.71
Structural Clay	2.58	0.52	1.01	1.93	-1.29	4.74
Aggregate Manufacturing	1.47	0.24	0.37	3.95	0.56	6.59

It can be seen from the table that material input has an annual average contribution of 3.95% while TFP has contributed only 0.56% in an output growth of 6.59% of the aggregate manufacturing sector. Thus material input accounts for 59.94% of the growth. Further, the combined contribution of inputs is worked out to be 91.5% of output growth which indicates its input-driven nature.

An extension of the analysis to individual industries supports the finding of aggregate manufacturing sector noted above. The table shows that material input contributes the maximum to output growth in four (viz., chemicals, iron and steel, non-ferrous metals, and pulp and paper) out of the eight selected industries. In case of the remaining four industries capital input has contributed maximum to output growth.

As input and TFP contributions in Indian studies have focused on growth accounting method the present analysis gives the results obtained through that procedure in Table 5. It can be seen from the table that these results broadly agree to the ones presented in Table 4. The difference between the two approaches is with respect to magnitude of input contributions and output growth rate. It can be seen that while output growth was estimated to be 6.59% in the econometric method, it was at a higher level of 6.81% in the growth accounting method.

TABLE 5: CONTRIBUTIONS OF INPUTS IN OUTPUT GROWTH (GROWTH ACCOUNTING METHOD)

Industry	Contributions of					
	K	L	E	M	TFP	Total
Cement	2.72	0.32	2.14	1.72	1.40	8.30
Chemicals	3.11	0.34	0.74	4.97	-1.65	7.50
Glass	2.08	0.14	1.11	1.62	1.43	6.38
Iron and Steel	2.06	0.18	0.67	3.94	-0.58	6.27
Non-ferrous metals	2.41	0.38	1.36	3.13	-1.23	6.05
Pottery	2.23	0.24	0.97	1.28	0.00	4.72
Pulp and Paper	2.28	0.31	0.92	3.55	-0.49	6.57
Structural Clay	2.70	0.72	1.23	2.08	-1.32	5.40
Aggregate Manufacturing	1.58	0.24	0.38	4.03	0.59	6.81

The difference noticed in results of econometric and growth accounting approaches may be due to i) biased technical change that was captured through the econometric estimation; ii) econometric method giving an average growth rate between the last and first observations while the growth accounting method indicating the trend growth. Keeping in mind these limitations, it can be inferred that growth accounting method may be producing an over-estimate of TFPG[9].

5. Summary and Conclusions

After the inference drawn by Krugman on the non-sustainability of input-driven growth of the East Asian countries, there remains a concern for the long run growth trajectory of most of the developing countries. The decomposition of output growth into contribution of individual factors and TFP seem to hold the key for understanding the sustainability or otherwise of the growth process of these countries.

For that purpose, the present exercise attempts to examine the contribution of inputs to the growth of output by considering the aggregate manufacturing sector and eight industries of India during the period 1963-64 to 1994-95. Input contributions are derived from an estimated translog production function after testing for its curvature conditions such as monotonicity and concavity. Major findings of the study indicate that output growth in the Indian industrial sector is driven by capital and raw material inputs while the contribution of TFP remains either minimal or negative. The estimated results indicate that TFP in aggregate manufacturing sector has contributed only 8.5 % of the output growth. Individual industries broadly conform to the observation made on the aggregate sector. While the contribution of raw material in the output growth remains higher in 4 out of 8 industries, capital contributes the most in the remaining four.

The growth decomposition results obtained through econometric method do not make significant departure even when their estimation was undertaken through growth accounting rule. Hence, a predominantly raw-material-contributed output growth of the Indian manufacturing is difficult to contest. Seen in terms of these results, therefore, manufacturing sector of India does not remain outside the purview of the sustainability issue raised by Krugman.

Notwithstanding the striking feature of raw material-driven growth of output observed in Indian industries, data limitations involved in estimating it remains an important factor. It is, therefore, necessary to be cautious while applying these results to policy formulation. Specifically the construction of output series for aggregate manufacturing sector in constant prices making use of wholesale price index numbers, constructing material input deflator with the help of input output table[10], neglect of unregistered sector[11], market imperfection and capacity utilisation would have influenced the results of the present analysis.

Appendix

For the present study, data requirements are on capital, labour, energy, material and output. Data on these variables for the years 1967-68 to 1994-95 are taken from the 'Summary Results for the Factory Sector', whereas for the period 1963-64 to 1966-67 they are from 'Capital, Employment, Output Estimates for Factory Sector by Capital Size' published by the Central Statistical Organisation, New Delhi in the series Annual Survey of Industries (ASI) [Government of India (a)]. As Summary Results were not published for the years 1970-71 and 1971-72, data for these have been estimated on a *pro-rata* basis from the Census Sector[12] of the respective years using the ratio between factory sector and census sector for the year 1969-70. As no survey was conducted during 1972-73, data included in the series for this year are the simple averages of the years 1971-72 and 1973-74.

Given below are the definitions of variables, respective deflators and input shares.

Capital: For estimating aggregate capital stock, the present study adopts the standard practice of perpetual inventory method with benchmark year 1960-61. Industry specific gross capital stock for the benchmark year is estimated from the book value of fixed capital, taking into consideration gross-net ratio provided by Hashim and Dadi (1973) (reproduced in B-P 1994). Gross investment figure at constant prices (1970-71 = 100) for the year *t* is obtained as $I_t = (B_t - B_{t-1} + D_t)/R_t$ where *B* is book value of fixed capital, *D* is depreciation and *R* is wholesale price index [Chandhok, 1990; Government of India (b)] for non-electrical machineries and machine tools. The capital stock at year *t* is obtained as $K_t = K_0 + \sum_t I_t$ where K_0 is capital stock in the benchmark year (1960-61) at 1970-71 prices. No capital discarding is assumed. Share of capital in output is the residual after shares of other inputs (at current prices) are deducted. This implicitly imposes constant returns to scale on the production function.

TABLE A1: WEIGHTS USED FOR CONSTRUCTION OF MATERIAL INPUT INDEX IN SELECTED INDUSTRIES

Commodity Groups	Cem.	Chem.	Glass/ Pottery st.clay	Iron & Steel	Non-ferr. Metals	Pulp & Paper	Agg. Mfg.
1. Food Articles (1-4,12,14)	0.00	0.00	0.19	0.00	0.00	0.01	2.70
2. Non-Food Articles (5-11,13)	0.03	0.17	2.38	0.32	0.17	5.79	17.88
3. Minerals (16-19)	58.03	30.49	38.40	7.47	30.49	2.90	7.37
4. Food Products (20-23)	0.00	0.00	0.08	0.00	0.00	0.51	4.35
5. Textiles (24-28)	27.23	0.24	1.26	0.17	0.24	1.75	10.91
6. Wood Products (29)	0.06	0.21	0.84	0.05	0.21	0.20	1.10
7. Paper products (30)	0.02	0.08	1.36	0.02	0.08	67.69	3.32
8. Leather Products (31)	0.00	0.00	0.00	0.00	0.00	0.04	1.42
9. Rubber Products (32-33)	0.18	0.32	1.25	0.06	0.32	1.08	3.57
10. Chemical Products (36-39)	0.16	8.60	6.44	1.78	8.60	12.62	23.51
11. Non-Met. Min. Prod. (40-41)	2.66	0.48	35.86	1.05	0.48	0.24	2.08
12. Basic Metals (42-43)	6.45	55.69	8.75	74.02	55.69	4.30	16.58
13. Other Misc. Mfg. (53)	5.16	3.72	31.96	15.06	3.72	2.85	5.21
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Notes: 1) Figures in parentheses indicate industry groups as per Input-Output Table, 1991-92.

2) Glass, pottery and earthenware, and structural clay are assigned the same material input price index (that of Non-metallic Mineral Products except Cement) as structural coefficients at the requisite disaggregated level are not available.

Labour: Labour variable represents 'total employees' ('total persons engaged' since 1980 -81) which includes both workers and other employees receiving wages and salaries. Share of labour is emoluments divided by output at current prices.

Energy: This includes fuel, lubricants, electricity and gasoline consumed by the factory. The deflator used for neutralising price changes is the wholesale price index for fuel and lubricants. Energy share is obtained by dividing value of fuels and lubricants as given in the ASI by gross output.

Material: Material input includes all items of raw materials, components and chemicals entering into the production process. The present study constructs a price deflator of material input by combining price indices of the components through suitable weights. The weights assigned to the components are taken from the Input-Output Table 1991-92 [Government of India 1995]. The structural coefficients presented for the 60 sectors in Input Output Table 1991-92 have been re-grouped into 13 sectors[13]. The resultant sectoral weights are given in Table A1. It may be noted that although such a procedure provides industry specific deflators, limitations in the construction of material price index which have been pointed out in the earlier studies [B-P 1994; Rao 1996] persist. The share of material input is materials consumed divided by output at current prices.

Output: The output variable represents the gross value of output as given in the ASI. This includes ex-factory value (i.e., exclusive of taxes and inclusive of subsidies) of products and by-products manufactured during the accounting year. The industry specific deflators used to neutralise price changes are index numbers of wholesale prices of relevant commodity groups (see, Table A2).

TABLE A2: OUTPUT DEFLATORS USED IN SELECTED INDUSTRIES

Industry	Index Number of Wholesale Prices of	
Cement	III. H. iv. 235	Cement
Chemicals	III. G	Chemicals and chemical Products
Glass	III. H. ii	Glass and Glass products
Iron and Steel	III. I. i (a)	Iron, Steel and Ferro Alloys
Non-Ferrous Metals	III. I. i (b)	Non-Ferrous Metals and Alloys
Pottery and Earthenware	III. H. iii	Earthenware and Earthen Pottery
Pulp and Paper	III. D	Paper and Paper Products
Structural Clay	III. H. i	Structural Clay Products
Aggregate Manufacturing	III.	Manufactured Products

Notes:

1. The selection of polluting industries in the present paper is more due to a study undertaken by the present authors for analysing environment-friendly behaviour of producers in the most polluting industries.
2. The industry codes as per the National Industrial Classification (NIC) (used since 1973-74) and Standard Industrial Classification (SIC) (used up to 1971-72) are given in Table A3 below:

TABLE A3: INDUSTRY CODES IN ASI CLASSIFICATION

Industry	NIC Code	SIC Code
Cement	324	334
Chemicals	31 (30 since 1989-90)	31
Glass	321	332
Iron and Steel	330+331+332	341
Non-Ferrous Metals	333+334+335+336+337+338+339	342
Pottery and Earthenware	322+323	333
Pulp and Paper	280+281+282+283	271
Structural Clay	320	331

These selected industries have a contribution of 34.25 per cent combined in the aggregate manufacturing sector's output.

3. Refers to registered large scale sector for the period 1959-79. For the difference of this estimate with that of Ahluwalia (1985) see Krishna (1987).

4. Estimation of translog cost function with four inputs has been undertaken by Jha et al. (1993) to derive technical bias and scale economies. However, as the work had a different focus, it did not encompass the issue of factor contributions.

5. The choice of the share equation dropped is immaterial as estimates are invariant to share equation dropped [Christensen and Greene 1976]

6. The separability of intermediate inputs from primary inputs is tested on the basis of likelihood ratio [Pradhan and Barik 1998]. The restrictions imposed on (1) are $\beta_{KE} = \beta_{KM} = \beta_{LE} = \beta_{LM} = \beta_{Et} = \beta_{Mt} = 0$. The chi-squared values obtained from separability tests in aggregate manufacturing and selected industries are reported in Table A4. The results show that separability between primary and intermediate inputs is rejected in all cases at 1% level.

TABLE A4: RESULTS OF TEST ON SEPARABILTY

Industry	Chi-squared value
Cement	26.91
Chemicals	99.78
Glass	45.82
Iron and Steel	62.30
Non-ferrous metals	89.89
Pottery	33.92
Pulp and Paper	109.47
Structural Clay	64.64
Aggregate Manufacturing	53.98

7. The degree of freedom will be three as the number of independent restrictions in $\sum_i \beta_{it} = 0 \quad (i = K, L, E, M)$ (see equation (2) in the text) is three. It may be useful to point out that by restricting any three parameters equal to zero, the fourth one becomes zero automatically.

8. Technical bias is seen through a significant β_{it} ($i = K, L, E, M$) coefficient in the estimated production function. Technical change is termed i^th^ factor saving if $\beta_{it} < 0$. It is i^th^ factor using if $\beta_{it} > 0$.

9. On the other hand, estimation through growth accounting is capable of capturing the fluctuation in TFPG, which an econometric method fails to record. For example, it can be said that TFPG might

have experienced an improvement during 1987-95 compared to the preceding period of 1982-87. It is seen that the contribution of the major source to output growth in the aggregate manufacturing sector, i.e., material input, has declined from 95.64% during 1982-87 (in an output growth of 5.66%) to 61.03% during 1987-95 (in an output growth of 8.35%).

10. The input output table covers registered as well as unregistered sectors while the ASI data covers registered sector only [see Dholakia and Dholakia (1994) for discussion on the problem].

11. See Sastry (1995).

12. For survey purposes the ASI divides firms into census and sample sectors depending upon the number of persons employed. The 'census sector' comprises all factories employing 50 or more workers working with the aid of power (100 or more workers working without the aid of power), whereas the 'sample sector' comprises factories employing 10 to 49 workers working with the aid of power (20 to 49 workers working without the aid of power). 'Factory sector' is the total of census and sample sectors. It is useful to note that all the units falling under census sector are surveyed while a probability sample is included from the sample sector.

13. The material price index constructed by B-P (1994) includes energy in addition to raw material components whereas the present study segregates energy inputs from material. Moreover, the sectoral classification in the Input-Output Table, 1991-92 is different from that in earlier tables. This necessitated re-grouping into 13 major input groups in contrast to 19 groups taken by B-P (1994).

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