Department of Economics

Working Paper No. 0307

http://nt2.fas.nus.edu.sg/ecs/pub/wp/wp0307.pdf

Economic Reform and Productivity growth in Indian Manufacturing Industries: An interaction of technical change and scale economies

Sanja S. Pattnayak   Thangavelu, S. M.

Abstract:
This paper studies the effects of the key economic reforms of 1991 on the Indian manufacturing industries using a panel of manufacturing industries. A Translog cost function is used to analyze the production structure in terms of biased technical change and economies of scale. A panel consisting of 121 Indian manufacturing industries from 1982 to 1998 was used in our estimation. The results of our paper support the evidence that there are economies of scale (only moderate) in the Indian manufacturing industries and it has been exploited after the key economic reforms in 1991. Most of the industries in our study revealed bias technology change and majority of the industries have experienced capital-using technical change. This suggests that the key economic reforms of liberalizing the capacity licensing regime that allows greater investment in capital goods will have a positive impact on productive performance of the industries if the price of capital does not substantially increase after the economic reforms. We observe TFP improvements for most of the industries after the 1991 reform initiatives, which support the evidence of improvements in economic efficiency after the key reform initiatives of the 1991.

JEL classification: O3, O4, C23
Keywords: Total Factor Productivity, Bias Technical Change, Economies of Scale, Economic Reforms

 Corresponding author: Sanja S. Pattnayak, Department of Economics, National University of Singapore, 1 Arts Link, Singapore 117570, email: artp8530@nus.edu.sg.

1. Introduction

At the time of independence in 1947, India's agricultural, industrial and social development as well as its engineering and professional skills and capacities were very limited. Consistent with the economic development thinking at the time exemplified in the work of Lewis (1954); Nurkse, and others, and of the multilateral institutions such as the World Bank, India adopted import-substitution strategy of development. India's industrial policies were designed to protect its domestic industries through import tariffs and infant industry subsidies. The principal instruments used were an elaborate industrial licensing scheme under the Industries Development and Regulation Act (IDRA) of 1951 and a protective foreign trade regime. It controlled not only entry into an industry and capacity expansion, but also technology output mix and import content. Moreover, concentration of economic power was controlled by the Monopolistic and Restrictive Trade Practices (MRTP) Act of 1970 and the foreign Exchange Regulation Act (FERA) of 1973 was used to regulate foreign investment in India. The period also witnessed considerable expansion of public sector enterprises (PSUs) either through nationalization or setting up of new enterprises.

While these policies enabled India to develop a widely-based industrial structure, and technical and professional manpower, they were allowed to continue for too long, they led to considerable inefficiency in the industrial sector (Bhagawati and Desai, 1970; and Bhagawati and Srinivasan 1975. Thus, Bhagawati and Srinivasan (1975) concluded that the Indian foreign trade regime, along with the industrial licensing policy which eliminated all forms of competition, had adversely affected incentives to reduce costs and prevented improvements in product quality, design and technology. Wolf (1982) noted that by international standards, the industries in India were fragmented into many relatively small firms hindering exploitation of scale economies and product development. He attributed the key cause of the above inefficiencies to policies relating to industrial licensing and imports. Bhagwati (1998), Jha (1976, pp. 99-106), and Ahluwalia (1985) have also concluded in the similar vein.

The above suggests that while the import substitution strategy achieved limited success in creating a self-reliant economy, it grossly underemphasized the importance of efficient use of resources, particularly of labor and capital. The performance of public sector enterprises has proved to be considerably below expectations due to the over centralization of power for decision making concerning investment, mandating formal and informal distributional channels, limited managerial and multidimensional objectives. As a result, autonomy and commercial viability has suffered. Since the home market was well protected, the domestic enterprises were not compelled to improve efficiency in use of factor inputs, and in improving quality of their products. The New Industrial Policy (NIP) of 1991 has been a key element of India’s objective of integrating with the world economy in a market consistent manner, and enhancing efficiency and growth rate.

Accordingly, the New Industrial Policy (NIP) of 1991 is outward oriented, and represents a major paradigm shift. The key elements of the NIP are the abolition of licensing of capital goods, reduced list of industries to be reserved for the public sector, increasing foreign equity ownerships in domestic industries, private investment in infrastructure, freer import of capital goods, reduced tariff for consumer goods, deregulation in small scale industrial units, and allowing greater inflow as well as outflow of foreign investments. These aim to enhance productivity and efficiency in Indian industries by increasing competition, creating level playing field among public, private and foreign businesses, and generating environment which is conducive for technological growth.

Several recent studies have attempted to empirically estimate the differences in outcomes of post- and pre-liberalization policies on the Indian manufacturing industries. Ahluwalia (1991) estimated the annual TFP from 1960 to 1986 and showed that there was an increase in TFP growth in the late 1970s, the initial period of liberalization. However, Balakrishnan and Pushpangandan (1994) and Rao (1996) challenged this result. Using the "double-deflation" method, they suggested a rapidly declining TFP growth for the manufacturing industries after 1983. Study by Hulten and Srinivasan (1999) shows that there is little evidence of any positive impact from the initial economic reforms on TFP growth of the Indian manufacturing industries. They however found that there were other positive impacts on investment, labour productivity and capital per worker from the economic reforms. Some of the studies have concentrated on examining the impact of economic reforms on the scale effects in the manufacturing industries in India. Fikkert and Hasan (1998) analyzed the returns to scale for a panel of selected Indian manufacturing industries for the pre-liberalization period from 1976 to 1985 using a restricted cost function. Although they found large number of firms operating with increasing returns to scale, the results suggested that most of them were operating close to constant returns to scale. They suggest that there might not be significant gains in scale efficiency from the tentative steps in economic liberalization in the 1980s. In a similar panel study using a production function from 1986 to 1993, Krishna and Mitra (1998) show that there are increasing returns to scale in electronics, transport equipment and non-electrical industries; and that there was an increase exploitation of the scale economies after the economic liberalization. In a related study using selected industry level data with Translog cost function, Jha et. al (1993) shows that there exists biased technological change and economies of scale in two of the four industries analyzed for the initial economic reform periods.

In this paper, we study the effects of liberalization on the economic efficiency of the Indian manufacturing industries in terms of economies of scale and biased technical changes using a cost function framework. The paper aims to make several new contributions to the existing literature. Most of the above papers only studied the initial liberalization period of 1980s and early 1990s. They were hence only able to capture the short-term effects of the economic reforms. While economic reforms are expected to have initial impacts, the significant effects are only felt several years later. In this paper, we capture the long-term effects of the economic reform using a 3-digit panel industry level data spanning from 1981 to 1998. We estimate the scale economies, biased technological change and dual TFP growth in a unifying framework of the flexible cost function. This allows us to compare the economic effects of the economic reforms in the semi-liberalized period of 1980s with the key reforms initiatives of the NIP. Third, the above model is estimated in a panel framework by pooling the 3-digit industries from 1980 to 1998. The larger panel consisting of 121 industries allowed us to improve the efficiency of our estimation and hence the results. While our study using the cost function is very similar to the study of Jha et. al. (1993), we improved their results in two aspects. The panel data study improves on their estimation. Also, we extended the study to the key reform initiative period of 1990s, which was not included in their study.

The results of our paper support the evidence that there is economies of scale (only moderately) in the Indian manufacturing industries and, that these were exploited after the key economic reforms in 1991. Most of the industries in our study reveal biased technological change, and majority of the industries have experience capital using technological change. This suggests that the NIP which has led to greater capacity utilization and investment in capital goods will in turn has positive impact on productive performance of the industries, provided the price of capital does not increase substantially[3]. The results also suggest that there are total factor productivity (TFP) improvements for most of the industries after the NIP, which supports the evidence that there have been improvements in economic efficiency.

The methodology and data is discussed in section 2. In section 3, we provide the empirical results. Section 4 provides concluding remarks.

2. Modeling the Structure of Production

The objective of the paper is to compare the changes in the production structure of the post liberalization period of 1990s with semi liberalization period of 1980s. The strategy of our study is to use the neo-classical production structure to measure technological changes and hence economic efficiency.

In order to estimate the underlying technology, one can examine either the production function or the associated cost function. A fundamental result is that under certain regularity conditions there exist cost and production functions, which are dual to

[3] The discussion on industrial licensing is given in Fikkert and Hasan (1998).

each other. Due to this unique correspondence between production and cost function one can well see all of the information about the underlying technology is contained in both functions. In this study, we used a translog cost function as given in Christensen (1971) and Christensen et al (1973). The Translog cost function can be viewed as a second order logarithmic approximation to an arbitrary twice-differentiable transformation surface. Since in its general form the Translog cost function imposes no prior restrictions on the production structure, it allows the testing of various restrictions- such as homotheticity, homogeneity, and unitary elasticities of substitution and the assessment of the sensitivity of parameters of interest to those restrictions.

2.1 Translog Cost Function

The Translog cost function is given as[4]:

$$LogC = \alpha_0 + \alpha_Q \log Q + \sum_i^n d_i D_i + \sum_i \beta_i \log P_i + \frac{1}{2}\gamma_{QQ}(\log Q)^2 + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \log P_i \log P_j$$
$$+ \sum_i \gamma_{iQ} \log P_i \log Q + \sum_i \gamma_{iT} \log P_i T + \gamma_{qT} \log QT + \alpha_t \log T + \frac{1}{2}\alpha_{tt}(\log T)^2 \tag{1}$$

where $i, j = 1,.......N$ index the N different inputs and all variables are defined around some expansion point. D_i , $i = 1,......, n$, is the industry dummies to allow for industry variations in our model. C, P, and Q are total costs, a vector of factor prices, and level of output respectively. The level of technology is given by the time trend T, which is assumed to be an index of level of technology that is produced external to the firm. Shephard's lemma ensures that the cost minimizing level of utilization of any input is

[4] In our study, we used long-run Translog Cost Function, which allows for adjustment of all factor inputs. Given our long sample period from 1982 to 1998 and the key aspect of the 1991 economic reform is reduce capacity constraints, it is reasonable to assume all factors adjust to their long-run equilibrium.

equal to the derivative of the cost function with respect to the price of that input. Using Shephard's lemma, we get a set of cost share equations that takes the following form.

$$S_i = \beta_i + \frac{1}{2}\sum_j \gamma_{ij} \log P_j + \gamma_{iQ} \log Q + \gamma_{iT} \log T, \qquad \text{for } i = 1, \ldots\ldots\ldots\ldots, N, \quad (2)$$

where $S_i = \frac{P_i X_i}{C}$ is the share of costs for by factor i. We may note here that the coefficients in the share equations are a subset of those in the cost function. In order to represent a well-behaved production structure, the Translog cost function given in equation (2) must satisfy three properties: (a) monotonicity, which requires that the estimated cost share in equation (3) must be positive for each input i; (b) concavity, i.e. the cost function be concave in input prices, which requires that the matrix of the second order derivatives $\left(\frac{\delta^2 C}{\delta P_i \delta P_j}\right)$ be non-positive- definite within the range of input prices; and (c) homogeneity, i.e. the cost function should be homogeneous of degree one in input prices. This last property places the following restrictions on the parameters of the cost function in equation (2):

$$\sum_i \beta_i = 1, \ \sum_i \gamma_{ij} = \sum_j \gamma_{ji} = \sum_i \gamma_{iQ} = \sum_i \gamma_{iT} = 0 \qquad (3)$$

The estimation of the translog cost function requires information on total cost, physical value of output and input prices.

Detail analysis of the Translog cost structure highlights valuable insights on the interaction between technical change and factor inputs. The formulation of the cost function that allows for both the neutral and biased technical change as given in equation (4).

$$TE = \frac{\partial \log C}{\partial \log T} = \alpha_t + \alpha_{tt} \log T + \sum_i \gamma_{it} \log P_i + \gamma_{qt} Q \,. \qquad (4)$$

Neutral technical change acts as a pure shift of the cost function that leaves the factor shares unchanged and it is represented by the changes in the parameters α_t and α_{tt}. Biased technical change represents shifts in the level of technology that alter the equilibrium factor shares, holding factor prices constant, which is described by the parameter γ_{iT}. Technical change is said to be ith factor saving (i using) if the cost share of the ith factor is lowered (raised) for a given increase in technology and is represented by $\gamma_{iT} < 0 (\gamma_{iT} > 0)$.

It must be highlighted that the observation of bias technological change does not necessarily increase productivity growth. It is clearly observable from equation (4) that the measure of bias technical change, γ_{iT}, also affect the factor shares equation, where $\frac{\partial S_i}{\partial \log T} = \gamma_{it}$. More specifically, $\frac{\partial LogC}{\partial \log T}$ is negative if there is technical progress in a cost function. Hence, if there is bias technical change, it is given by a positive γ_{iT} and then an increase in the price of factor input i, P_i, will reduce technical progress and multifactor productivity growth.

Besides the impact on productivity, bias technological change could also have distributional effects in the economy. Technical change biases on factor shares are measured by computing γ_{iT} for each industry. The impact of technical change on factor shares is given by:

$$\frac{\partial \ln\left(S_K / S_L\right)}{\partial t} = \frac{\left(\partial S_K / \partial t\right)}{S_i} - \frac{\left(\partial S_L / \partial t\right)}{S_j} \qquad \text{for} \quad i \neq j\,, \qquad (5)$$

which directly reflects the impact of technical change on factor share. For example, if $\frac{\partial \ln\left(\frac{S_K}{S_L}\right)}{\partial t} > 0$, the biased technical change has greater impact on raising capital share than labour share. In this case, technical progress widens the income gap between capital and labour.

Hanoch (1975) has shown that economies of scale must be evaluated along the expansion path, whereas returns to scale are conventionally defined along an arbitrary input-mix ray**.** Returns to scale and economies of scale will differ unless the production function is homothetic. Since the scale elasticity (evaluated around a given point) is identical to the reciprocal to the elasticity of costs with respect to output, we could use the latter as measure of economies of scale. The general form of the scale elasticity from the Translog Cost Function is written as:

$$SE = \left(\alpha_Q + \gamma_{QQ} \log Q + \sum \gamma_{iQ} \log P_i + \gamma_{qT} \log T\right)^{-1}, \qquad (6)$$

and this will vary with relative factor prices and the level of output and technology. The cost function is homothetic if it can be written as a separable function of factor prices and output (Denny and Fuss, 1977). This implies that the optimal factor combination is independent of the scale of output, so that expansion path is linear. It is clear from the share equation (2) that homotheticity requires $\gamma_{iQ} = 0$, for all $i = 1,.........N$. In view of the restrictions given in equation (3), homotheticity imposes additional $N-1$

independent parameter restrictions. The cost function is homogeneous in output if the elasticity of cost with respect to output is constant.

2.2 Estimation and testing procedures

We estimate a system of equations consisting of cost function and N-1 of the cost share equations. As indicated earlier, exploiting the duality theory and estimating the cost share equations jointly with the cost function increases the statistical degrees of freedom, since the cost-share parameters are a subset of the cost function parameters. Each equation is appended with stochastic error term representing errors in the optimizing behaviour of the agents. The disturbances are specified to have a joint normal distribution, but contemporaneous correlations are allowed across the equations.

We impose the homogeneity restrictions given in equation (3) and employ the iterative Zellner-efficient method (IZEF) to estimate the model. The equation for the material factor cost share input was dropped in our system estimation and it must be noted that the parameter estimates are invariant to the choices of which share equations is deleted (see Kmenta and Gilbert, 1968). In this paper, we tested for both the scale effects and the neutrality of the technical change. The various parameter restrictions are tested with the Wald test, which is distributed asymptotically as a chi-squared with degrees of freedom equal to the number of independent restrictions being tested.

2.3 Data and the Construction of Variables

This study uses data from the Annual Survey of industries (ASI), published by Central Statistical Organization, Ministry of industry, Government of India, for the period 1980-81 to 1997-98 for organized sector of the manufacturing industries. The organized segment includes all factories registered under the Factories Act and excludes manufacturing enterprises employing fewer than 10 workers with electricity and those employing fewer than 20 workers without electricity.

The period of our study is from 1981 to 1998 and subsequently divided into two sub-periods i.e., 1981-1990 and 1991-98 on the basis of the economic reforms of 1991. The sub-periods allow us to compare the semi-liberalized period of 1981-1990 with key economic reforms in 1991-1998. The current study covers only 13 major industries in India: Food (Industry 20-21), Beverage (Industry 22), Wool, Silk and Man-made Fibers (Industry 24), Textile Product (Industry 26), Paper and Paper Products (Industry 28), Leather and leather products (29), Rubber, plastic, petroleum and coal products (30), Chemical and chemical products (31), Non metallic mineral products (Industry 32), Basic metal and alloys (Industry 33), Metal Products and Parts (Industry 34), Machinery and Equipments (Industry 35), Electrical and Related Equipments (Industry 36). The data sources and construction of all variables in our model is given in the appendix. All the data is debased to 1981-1982 prices. Details about the construction of the data and explanation are given in the appendix.

3. Empirical Results

The cost function and share equations (capital (K), labour (L) and material (M) inputs) for each industry are estimated by using IZEF and by iterating on the estimated covariance matrix until the convergence is achieved. In our estimation, if any autocorrelation exist, we corrected the autocorrelation based on the formulation given in Judge et.al (1985). The estimated coefficients for the 13 industries are given in Table 1. Most of the key coefficients in the estimation are significant. The estimated factor shares are positive and the second derivatives of the Hessian matrix is negative semi-definite at every observation for all the industries. This suggests that our estimated Translog cost function corresponds to a well behaved Neo-classical cost function.

One of the key objectives of our paper is to analyze the neutrality of technical change in the Indian manufacturing industries. The biased technical change in the Translog cost function is identified by the coefficient of γ_{iT} for $i = k, l, m$. For example, for factor i, $\gamma_{iT} > 0$ indicates factor using technical change, $\gamma_{iT} < 0$ indicates factor-saving technical change and neutral technical change is indicated by $\gamma_{iT} = 0$. Wald test was employed to check if biased technical change has taken place in the 13 industries with the following restrictions $\gamma_{kT} = \gamma_{lT} = \gamma_{mT} = 0$. The results of no biased technical change across the 13 industries are given in Table 2. The results indicate that biased technical change has taken place in all industries except for Machinery and Equipment industry (industry 35), which experiences neutral technical change.

Also the Wald test indicates that the biased technical change is only marginally significant at 10 per cent level of significance for leather and leather products (industry 29) and rubber, plastic, and petroleum (industry 30), which suggests the biased technical change has only occurred weakly on these industries. The direction of the biased technical change could be inferred from the estimated coefficients in Table 1A and 1B.

However, we do observe greater biasness toward capital-using technical change as opposed to labour-using technical change ($\gamma_{kt} > \gamma_{lt}$) for 8 out of 13 industries in our sample (Food (industry 20-21), Beverage (industry 22), Textile Product (Industry 26), Paper and Paper Products (Industry 28), Rubber, Plastic, Petroleum and Coal Products (Industry 30), Non-Metallic Mineral Products (industry 32), Basic Metal and Alloys (Industry 33), and Metal Products and Parts (Industry 34)). We observed only labour-using technical change for Wool, Skill, and Man-Made Fibre (industry 24), Leather and Leather products (industry 29) and Electrical and Related Equipments (industry 36). Also, we observed capital-saving ($\gamma_{kt<0}$) and labour-saving ($\gamma_{lt<0}$) technical change for only Chemicals and Chemical Products (industry 31). This suggests that the economic reforms have led to greater usage of capital and to some extent use of labour inputs in their production. In fact, the results also suggest that the key industries are moving into more capital-intensive production structure. Since the key aspect of the 1991 economic reform in India is to de-license about 80% of Indian industry and reduce the controls on capital accumulation and imports of capital goods, the results of our paper do suggest that economic reforms have encouraged the Indian manufacturing industries to adopt more capital-using technology and to become more capital intensive.

As indicated previously, bias technical change could have distributional effects on the income and hence on factor shares. We estimated the biased technical change on factor share by the using the following derivative on factor shares as: $\frac{\partial \ln\left(\frac{S_K}{S_L}\right)}{\partial t} > 0$. If the derivative is positive, the biased technical change has greater impact on raising capital share than labour share. Table 3 shows the impact of bias technical change on factor shares.

Table 1A: Estimated Coefficients of the Trans-log Cost Function for Selected Indian Manufacturing Industries – 1981-82 to 1997-98

	Food	Beverage	Wool, Silk, and Man-Made Fibre	Textile	Paper and Paper Products	Leather and Leather Products	Rubber, Plastics, and Petroleum, etc
α_o	9.1153** (2.936)	19.305** (5.037)	-2.284 (-0.059)	1.300 (0.499)	0.986 (0.422)	-4.521** (-2.521)	31.059** (4.602)
α_t	0.2640** (2.478)	-0.355** (-2.200)	0.281** (2.365)	-0.037 (-0.682)	0.0438 (0.920)	0.126* (1.723)	0.022 (0.141)
α_{tt}	0.00423** (3.3325)	-0.001 (-0.009)	0.0008 (0.536)	0.00025 (0.335)	0.0001 (0.126)	0.0006 (0.427)	-0.0012 (-0.830)
α_Q	-0.08931 (-0.255)	-1.097** (-2.658)	-0.899** (-2.996)	0.493* (1.937)	0.410 (1.579)	0.979** (4.987)	-2.2285** (-3.707)
γ_{QQ}	0.05918** (3.479)	0.084** (3.836)	0.097** (6.599)	0.021* (1.683)	0.025* (1.839)	0.0003 (0.022)	0.1425** (5.196)
β_L	0.9243** (16.378)	0.161 (1.165)	0.564** (10.639)	0.297** (4.926)	0.571** (5.991)	0.646** (5.860)	0.3472** (4.943)
β_K	1.1517** (10.949)	-0.365* (-1.942)	-0.637** (-4.683)	0.202 (1.320)	-0.005 (-0.032)	-0.328* (-1.803)	-0.8071** (-4.021)
β_M	-1.0761** (-8.331)	1.204)** (5.573)	-1.072** (7.532)	0.500** (2.896)	0.433* (1.957)	0.682** (3.133)	1.460** (6.806)
γ_{KK}	-0.0183** (-2.7912)	-0.034** (-2.800)	-0.127** (-7.585)	-0.013 (-0.698)	-0.122** (-4.527)	-0.026** (-2.434)	-0.0608** (-4.224)
γ_{KL}	-0.00660* (-1.743)	0.007 (1.017)	0.006 (0.918)	-0.014* (-1.909)	-0.026** (-3.598)	0.003 (0.795)	0.0132** (3.582)
γ_{KM}	0.0250** (4.069)	0.0275* (1.964)	0.121** (6.840)	0.0279 (-1.215)	0.1483** (5.209)	0.0225** (2.043)	0.0476** (3.223)
γ_{LM}	0.0052 (1.612)	-0.0270** (-2.306)	-0.0840** (-7.132)	-0.0290** (2.893)	-0.0351** (-3.606)	-0.0485** (-2.539)	0.0148** (2.078)
γ_{LL}	0.00140** (0.295)	0.020** (2.214)	0.077** (7.740)	0.043** (7.537)	0.061** (10.782)	0.046** (2.475)	-0.0280** (-4.949)
γ_{MM}	-0.0301** (-4.212)	-0.00045 (-0.224)	-0.0373 (-1.629)	0.0010 (0.375)	-0.113** (-3.460)	0.0260 (1.138)	-0.0624** (-3.651)
γ_{LQ}	-0.0184** (-6.837)	-0.001 (0.135)	-0.019** (-7.775)	-0.010** (-3.489)	-0.020** (-4.586)	-0.026** (-4.492)	-0.0113** (-3.588)
γ_{KQ}	-0.0346** (-6.875)	0.014 (1.630)	0.011* (1.727)	-0.004 (-0.661)	-0.011 (-1.406)	0.018* (1.721)	0.0274** (2.933)
γ_{QM}	0.0530** (8.653)	-0.0152 (-1.453)	0.0084 (1.222)	0.015* (1.814)	0.0321** (3.063)	0.0081 (0.686)	-0.016* (-1.645)
γ_{QT}	-0.0169** (-3.260)	0.017** (2.158)	-0.015** (-3.912)	-0.001 (-0.511)	-0.004** (-2.153)	-0.010** (-2.480)	-0.0029 (-0.379)
γ_{KT}	0.00635** (6.665)	0.004** (3.064)	0.002 (1.367)	0.004** (2.600)	0.007** (3.706)	-0.004 (-1.184)	0.0114** (5.831)
γ_{MT}	-0.0071** (-6.867)	-0.0028* (1.718)	-0.0043** (-2.074)	-0.0072** (-3.525)	-0.0099** (-4.184)	0.00065* (0.189)	-0.0121** (-6.019)
γ_{LT}	0.00076 (1.495)	-0.001 (-1.442)	0.0016* (1.918)	0.002** (3.474)	0.002** (2.313)	0.004** (2.189)	0.0008 (1.196)
Log-Likelihood Ratio	1275.75	690.23	528.45	688.07	549.15	412.51	695.04
Observations	306	170	153	153	136	119	170

Parenthesis – t statistics (** - 5 per cent level of significance, * - 10 per cent level of significance)
Industrial dummies are not shown in the Table

Table 1B: Estimated Coefficients of the Trans-log Cost Function for Selected Indian Manufacturing Industries – 1981-82 to 1997-98

	Chemical and Chemical Products	Non Metallic Mineral	Basic Metal and Alloys	Metal Products and Parts	Machinery and Equipments	Electrical and Related Equipments
α_o	10.548** (9.791)	-0.772 (-0.168)	11.923* (1.954)	-14.653 (-0.765)	9.899** (3.424)	-11.920** (-4.347)
α_t	-0.123** (-2.432)	-0.167** (-2.041)	0.185** (2.062)	-0.490** (-2.945)	-0.287** (-3.237)	0.008 (0.091)
α_{tt}	-0.0007 (-0.669)	-0.002** (-2.099)	0.001 (0.531)	-0.003** (-2.496)	-0.003** (-3.488)	-0.001 (-1.068)
α_Q	0.0632 (0.2884)	0.854* (1.947)	-0.670 (-1.045)	-0.447 (-0.510)	-0.209 (-0.806)	1.670** (5.901)
γ_{QQ}	0.0792** (3.669)	-0.003 (-0.142)	0.073** (2.411)	0.054 (1.272)	0.039** (3.071)	-0.030** (-2.067)
β_L	0.1875** (6.698)	1.032** (9.762)	0.363** (3.470)	0.702** (8.368)	1.093** (8.158)	0.523** (6.344)
β_K	-0.0041 (-0.034)	-2.002** (-10.745)	0.193 (0.670)	-0.150 (-0.845)	-0.045 (-0.255)	0.558** (3.274)
β_M	0.8166** (6.642)	1.969** (9.536)	0.444* (1.666)	0.448** (2.243)	-0.04816 (-0.220)	-0.0805 (-0.443)
γ_{KK}	0.0085 (0.4876)	-0.135** (-5.424)	-0.047** (-2.633)	-0.045** (-4.104)	-0.028** (-3.110)	-0.007 (-0.634)
γ_{KL}	-0.0114** (-3.329)	-0.023** (-2.844)	-0.003 (-0.993)	0.0001 (0.100)	0.002 (0.350)	-0.014** (-2.915)
γ_{KM}	0.0029 (0.166)	0.158** (6.438)	0.049** (2.932)	0.0450** (3.821)	0.025** (2.716)	0.0211* (1.770)
γ_{LM}	0.002 (0.347)	-0.033** (-2.520)	-0.011* (-1.900)	-0.0537** (-7.803)	-0.0384** (-2.990)	-0.0365** (-3.135)
γ_{LL}	0.0094** (2.290)	0.057** (5.504)	0.013** (2.485)	0.053** (8.437)	0.037** (2.833)	0.051** (4.656)
γ_{MM}	-0.0049 (-0.260)	-0.124** (-4.353)	-0.039** (-2.238)	0.0087 (0.587)	0.0124 (0.787)	0.0153 (0.894)
γ_{LQ}	-0.0095** (-4.052)	-0.033** (-9.693)	-0.005* (-1.818)	-0.022** (-6.126)	-0.026** (-4.710)	-0.019** (-4.809)
γ_{KQ}	0.0182* (1.849)	0.083** (9.227)	-0.016 (-1.151)	0.002 (0.292)	-0.001 (-0.148)	-0.018** (-2.161)
γ_{MQ}	-0.0086 (-0.841)	-0.0499** (-5.492)	0.0209 (1.569)	0.0197** (2.093)	0.0274** (2.765)	0.0376** (4.213)
γ_{QT}	0.0048 (1.065)	0.008* (1.903)	-0.011** (-2.580)	0.017** (2.608)	0.013** (3.189)	-0.003 (-0.640)
γ_{KT}	-0.003* (-1.677)	0.007** (3.948)	0.006** (2.695)	0.005** (3.409)	0.001 (1.165)	0.003 (1.505)
γ_{MT}	0.004** (2.151)	-0.0099** (-5.641)	-0.0060** (-2.815)	-0.0074** (-4.532)	-0.0014 (-1.151)	-0.0044** (-2.255)
γ_{LT}	-0.001** (-2.420)	0.003** (3.772)	-0.00003 (-0.058)	0.002** (3.731)	0.0002 (0.409)	0.002* (1.751)
Log-Likelihood Ratio	717.70	652.41	721.72	631.96	923.79	692.43
Obis.	153	119	136	119	170	153

Parenthesis – t statistics (** - 5 per cent level of significance, * - 10 per cent level of significance)

Industrial dummies are not shown in the Table

Table 2: The Wald Test on Biased Technical Change and Economies of Scale in the Indian Manufacturing Industries: 1981-82 to 1997-98

Industry	$\gamma_{KT} = \gamma_{LT} = \gamma_{MT} = 0$	$\gamma_{QQ} = \gamma_{LQ} = \gamma_{KQ} = \gamma_{MQ} = \gamma_{QT} = 0$
Food	49.09** (0.0001)	93.09** (0.0001)
Beverage	10.884** (0.00433)	19.562** (0.00061)
Wool, Silk, and Man-Made Fibre	5.934* (0.05145)	105.32** (0.0001)
Textile	16.37** (0.00028)	4120.38** (0.0001)
Paper and Paper Products	17.582** (0.00015)	843.96** (0.00000)
Leather and Leather Products	5.8430* (0.05385)	1603.166** (0.00000)
Rubber, Plastic, Petroleum, and Coal Products	36.4078** (0.00000)	22.205** (0.00018)
Chemical and Chemical Products	8.3501** (0.01537)	2636.2964** (0.00001)
Non-Metallic Minerals	39.367** (0.00001)	504.419** (0.00000)
Basic Metals and Alloy	7.9642** (0.01865)	324.492** (0.00000)
Metal Products and Parts	24.534** (0.00000)	676.50** (0.00000)
Machinery and Equipments	1.5113 (0.46969)	335.481** (0.00000)
Electrical and Related Equipments	6.225** (0.04447)	2740.63** (0.00001)

Parenthesis – p-values

From Table 3, we observe a widening gap between the capital and labour share in those industries that have experienced capital-using technical change. However, the widening gap is more significant after the key economic reforms in the 1991, which is reflected in the declining impact of technology on the relative factor shares for the period of 1991 to 1998. Since the impact of technology on the relative shares are given as $\frac{\partial \ln\left(\frac{S_K}{S_L}\right)}{\partial t} > 0$ and that these industries have experienced greater impact of the capital-using technical change ($\gamma_{kt} > \gamma_{lt}$), we must observe a higher share of capital relative to the share of labour for the biased technology to have declining impact on the relative factor shares. The widening factor shares have two implications. It will increase the incentive to accumulate more capital since the owners of capital are gaining more from the technological change after the 1991 reforms. Second, it might have a dampening impact on total factor productivity growth if the rising capital share leads to a higher demand for capital investment and hence an increase in price of capital. This is clearly indicated in equation (4), where the raising capital price will reduce total factor productivity if there is capital-using technical change.

Table 3: The Effects of Biased Technical Change on Factor Incomes

Industry	1981-1990	1991-1998
Food	**0.633**	**0.488**
Beverage	**0.098**	**0.077**
Wool, Silk, and Man-Made Fibre	-0.004	-0.016
Textile	**0.005**	**-0.017**
Paper and Paper Products	**0.015**	**0.014**
Leather and Leather Products	-0.132	-0.101
Rubber, Plastic, Petroleum, and Coal Products	**0.058**	**0.035**
Chemical and Chemical Products	0.006	0.019
Non-Metallic Minerals	**-0.002**	**-0.017**
Basic Metals and Alloy	**0.033**	**0.027**
Metal Products and Parts	**0.005**	**-0.007**
Machinery and Equipments	**0.138**	**0.166**
Electrical and Related Equipments	-0.006	-0.007

Bold: Industries with capital-using technical change

The measure of total factor productivity growth (TFP) is given in equation (4) and the results are given in Table 4. The dual measure of TFP indicates that the key economic reforms of India in 1991 have been quite successful in increasing the total factor productivity of key Indian manufacturing industries. The results show that 10 out of 13 industries in our sample have experienced increases in their TFP growth. The key industries are Leather and Leather products, Chemical and Chemical products, Metal Products and Parts, Machinery and Equipments, and Electrical and Related Parts. In comparison, the TFP growth in the traditional industries such as Food, Beverage, Basic

Metal and Allloys, Wool, Silk, and Man-Made Fibre, Textiles, and Non-Metallic Minerals have remained either constant or have declined.

Table 4: TFP for Selected Indian Manufacturing Industries

Industry	1982-1989	1990-1998
Food	-0.034	-0.071
Beverage	0.0072	0.0068
Wool, Silk, and Man-Made Fibre	**0.030**	**0.035**
Textile	**0.067**	**0.066**
Paper and Paper Products	**0.063**	**0.064**
Leather and Leather Products	**0.060**	**0.073**
Rubber, Plastic, Petroleum, and Coal Products	**0.049**	**0.063**
Chemical and Chemical Products	**0.069**	**0.074**
Non-Metallic Minerals	0.001	-0.002
Basic Metals and Alloy	**0.058**	**0.059**
Metal Products and Parts	**0.139**	**0.151**
Machinery and Equipments	**0.008**	**0.022**
Electrical and Related Equipments	**0.060**	**0.074**

So a comparison of technical change before and after 1991 reforms suggests that the TFP trends in most of the sectors are significantly higher after 1991 reforms. Competition from imports and foreign direct investment (FDI) in several industries, in particular, machine tools and instruments, pharmaceuticals, automobiles, synthetic fibres, soaps and detergents have increased substantially since 1991 (Forbes, 2002). Thus the increase in productivity of these sectors might have resulted from removing barriers to international trade and FDI. In contrast, productivity trends in all of the traditional sectors either remained the same or declined.

The measurement of economies of scales for the selected industries is given in Table 5. We also tested if economies of scale exist in the selected industries by imposing the restrictions that $\gamma_{QQ} = \gamma_{LQ} = \gamma_{KQ} = \gamma_{MQ} = \gamma_{QT} = 0$. The Wald test statistics on these restrictions across the industries are given in Table 2. The Wald test suggests that all industries in our sample have scale effects. It is clear from Table 4 that all the selected industries in our study have experienced economies of scale (or marginal economies of scale) except in the manufacture of leather and leather products, which has experienced diseconomies of scale. As in Fikkert and Hasan (1998), we found economies of scale in Paper, Chemicals and Chemical Products, and Machinery and Equipments[5]. Due to a wider spectrum of industries in our sample, we also found economies of scale in Beverage, Textile, Non-Metallic Minerals, and Metal Products and Parts. We also observed constant returns to scale for Wool, Silk and Man-Made Fibre, Food, and Electrical and Related Equipments.

The results of our paper also support the reduction of returns to scale effects after liberalization as reported in Krishna and Mitra (1999) for the selected Indian manufacturing industries. As suggested by Krishna and Mitra (1999) that the increase exploitation of the returns to scale might be due to the presence of inflexibility of the industries during the pre-liberalization periods of 1991. However, we do not observe significant exploitation of economies of scale as reported in their study. In our results, 12 out of 13 industries have experienced either an increase in the dual measure of the economies of scale (higher dual measure of economies of scale means that the returns to scale have declined) or no change in the scale effects. Out of the 13 industries, 6 industries have experience reduction of returns to scale, which suggest the increase in the exploitation of the returns to scale after the key economic reforms of 1991. The rest of the 6 industries did not experience any decline in the economies of scale.

[5] However, our estimate of economies of scale is much higher than that was reported in Fikkert and Hasan (1998) as their sample for the years 1976 to 1985. We have used a more recent sample series from 1982 to 1998.

Table 5: The Economies of Scale for Selected Indian Manufacturing Industries

Industry	1982-1989	1990-1998
Food	0.99	0.89
Beverage	**0.73**	**0.92**
Wool, Silk, and Man-Made Fibre	0.98	0.97
Textile	**0.92**	**0.93**
Paper and Paper Products	0.92	0.91
Leather and Leather Products	1.10	1.07
Rubber, Plastic, Petroleum, and Coal Products	**0.95**	**1.10**
Chemical and Chemical Products	**0.68**	**0.75**
Non-Metallic Minerals	**0.75**	**0.84**
Basic Metals and Alloy	0.91	0.86
Metal Products and Parts	**0.80**	**1.00**
Machinery and Equipments	**0.60**	**0.70**
Electrical and Related Equipments	1.00	0.96

4. Conclusion

This paper has analyzed the effects of liberalization on the Indian manufacturing industries initiated by the 1991 economic reforms. The results suggest that the key industries have experienced capital-using technical change and increase in total factor productivity growth. The study also suggests that the industries in our sample have experienced economies of scale and the scale effects have been exploited more intensively since the 1991 economic reforms.

Capital-using technical change in the Indian manufacturing industries has policy implications in terms of capital accumulation and increasing total factor productivity in the manufacturing industries. Since the results suggest that the technical change is increasing capital share relative to labour share, the income of owners of capital has increased since the 1991 economic reforms. This has increased the returns for investing in capital goods and hence capital accumulation. The likely impact of these changes is an increase in the prices of capital goods; and in the case of capital-using technical change, dampening of the growth of total factor productivity. The results so far suggest that the total factor productivity growth has improved after the 1991 economic reform for most of the industries in our sample. However, we do not expect this result to hold in the future if the demand for capital investment increases substantially. To mitigate this outcome, the government may consider keeping the interest rate and hence cost of capital low. The other option might be to provide more effective and targeted tax incentives and subsidies for selected capital investment and thus keeping the cost of capital in key sectors low. This could by stimulating the investment in capital, increase total factor productivity growth in the manufacturing sector.

As the economy liberalizes and permits greater inflow of capital into the economy, the usage of foreign capital could make important productive contribution to the industrial structure. We do observe the increase in capital usage in the production structure, which in turn suggests that the key industries are moving towards more capital-intensive production. It would be useful to concentrate future research efforts on determining the contribution of foreign capital and technology to the productive performance of the Indian manufacturing industries, both directly and indirectly through enhancing competition.

Acknowledgements

We would like to thank Parkash Chander, J. Thampapillai, and Mukul Asher for their helpful comments and incisive suggestions, which helped to improve the paper substantially. However, we are solely responsible for any errors and omissions that may remain in the paper.

Appendix:

Gross Output: At the 3-digit industry level, we used the gross output as the key output of the industries (most of the studies use value added as one of the variables except Rao (1996)[6]). The wholesale price index of manufactures debased to 1981-82=100 is treated as the price of output.

Labor Inputs: The 'number of employees' measures labor input in our study and no skill and quality adjustments are made to arrive at a measure of labor inefficiency units. Data on number of employees and total emoluments are extracted from various issues of ASI.

Capital Stock: The data in capital stock at 2- and 3-digit industry levels are available in ASI. Fixed capital is used in the present study. The capital stock is deflated by the capital stock deflator derived by dividing total net capital stock at 1980-81 prices by the net capital stock at current prices. The value of the net capital stock is reported in National Accounts Statistics of India 1950-51 to 1995-96 published by Economic and Political Weekly (EPW) Research Foundation, India.

Construction of Material Input Price Deflators: The material price index to deflate material inputs is not currently available and thus material price deflators were derived from the input-output tables. The material price index is a weighted index of wholesale prices of major input groups; the weights have been calculated from the matrix of input-output transactions published by Central Statistical Organization (CSO). The value of the output and material input is taken from Annual Survey of Industry (ASI), various issues. The input-output transaction matrix (1978-79 and 1983-84) is used to construct the price deflators.The material inputs price index is constructed as follows. In the first instance we divided the input groups into six broad categories i.e., food products, textiles, chemicals, basic metals, machinery and others. The economic survey of India has been used to create these categories. These categories can be obtained from the index number of wholesale prices table. The purpose of creating such categories is to create weights on the basis of the inputs going as outputs to all the industries under study. This information is obtained from the input-output table published by Central Statistical Organization, government of India. As mentioned earlier, value of total inputs of each sector is divided by the total value of the inputs of all the sectors taken together going to a particular industry to obtain the weights for that sector.

The respective wholesale price indices are multiplied by the weights to arrive at new indices for a particular industry group. The wholesale price index for various groups is obtained from the Economic Survey of India. Similarly, index for all the industry groups are created and used as price deflators to arrive at the value at a constant price (here 1981-82=100). The price deflators thus created are given in the Appendix below.

[6] See Rao J.M., Economic and Political Weekly; November 2, 1996.

Construction of Variables:

Interest rate (r) = interest paid/loan

Depreciation rate (d) = depreciation/fixed capital

Interest rate (r) + depreciation (d)

Price of capital (Pk) = Price index of capital(r+d)

Price of labor (Pl) = Total emolument/No.of employees

Input price:

Value of fuel + Value of material inputs

Price of fuel = Total amount spent on fuel/amount spent of fuel + amount spent on material inputs

Price of material inputs = Total amount spent on material inputs /amount spent of fuel + amount spent on material inputs

Price of inputs = Price of fuel + price of material inputs

Share of labor (Sl) = Total emoluments/total cost

Share of inputs (Si) = Total expenditure on inputs/total cost

Share of labor (Sk) = Total expenditure on capital /total cost

References

Ahluwalia, I.J. (1991) Productivity growth in Indian Manufacturing, Oxford University Press, Delhi.

Ahluwalia, I. J. (1985), Industrial Growth in India, Oxford University Press, Delhi.

Bhagawati, J. N. (1998) The Design of Indian Development, India's Economic Reforms and Development: Essaya for Manmohan Singh, Isher Judge Ahluwalia and I.M.D. Little, Eds. Oxford University Press, Delhi, 23-39.

Bhagwati, J. N. and Desai, P. (1970) India, Planning for Industrialization, Industrialization and Trade Policies Since 1951. Oxford Univ. Press, London.

Christensen L.R. and W.H Green (1976) Economies of Scale in the US Electric Power Generation, Journal of Political Economy, **84**, No. 4.

Desai, A. 1995 Output and Employment effects of Recent Changes in Policy. In: Kapila R., Kapila, U. (Eds.), Understanding India's Economic Reforms. Academic Foundation, Delhi, 106-107

Fikkert, Brian and Rana Hasan. (1998) Returns to Scale in a Highly Regulated Economy: Evidence from Indian Firms, Journal of Development Economics, **56**, 1, 51-79.

Forbes, Naushad, (2002) "Doing Business in India: What has Liberalization Changed?" Economic Reforms and the Indian Economy, ed. by Anne O. Kruger (Chicago: The University of Chicago Press).

Government of India, Annual Survey of Industries (various issues), Central Statistical Organization, Ministry of Industry, New Delhi.

Hulten Charles and Srinivasan Sylaja. (1999) Indian Manufacturing Industry: Elephant or Tiger: New Evidence on The Asian Miracle, NBER Working Paper, 7441.

Jha, L.K. (1976) Shortages and High Prices- the Way Out, Indian Book Company, New Delhi.

Judge G. George, Lutkepohl Helmut, Hill Carter R., Introduction to the Theory of Econometrics, Second Edition.

Kmenta, J., and Gilbert, R.F. (1968) Small sample properties of alternative estimators of seemingly unrelated regression, J. Amer. Statist. Association **63** (December), 1180-1200.

Krishna Pravin and Devashis Mitra (1998) Trade Liberalization, Market Discipline and Productivity Growth: New Evidence from India, Journal of Development Economics, **56**, 447-462.

National Income Accounts Statistics, Input-Output Transactions Table-1983-84, (1990), Central Statistical Organization, Department of Statistics, Ministry of Planning, Government of India.

Wolf, M. (1982) India's Exports, Oxford University Press, New York.