Productivity Growth Decomposition in the Manufacturing Industries of Food, Beverages, and Tobacco Products in India : A Stochastic Frontier Approach

***Prasanta Kumar Roy**
**** Purnendu Sekhar Das**

Abstract

The study applied stochastic production frontier approach to decompose the sources of total factor productivity growth *(TFPG)* of the organized manufacturing industries of food, beverages, and tobacco products in India into technological progress, changes in technical efficiency, economic scale effect, and allocative efficiency effect during the period from 1981-82 to 2010-11 during the entire period, during the pre- and post-reform period (1981-82 to 1990-91 and 1991-92 to 2010-11), and also, during two decades in the post-reform period (1991-92 to 2000-01 and 2001-02 to 2010-11) at the three-digit level of disaggregation of industries by NIC'04 and NIC'98. According to the estimated results, technological progress and allocative efficiency effect were the major contributors to *TFPG* of the organized manufacturing industries of food, beverages, and tobacco products in India during the study period from 1981-82 to 2010-11. Further, *TFPG* of the organized manufacturing industries of food, beverages, and tobacco products in India declined during the post-reform period (1991-92 to 2010-11), which is mainly accounted for by the decline in *TP* in this period, as our study revealed.

Keywords : organized manufacturing industries; food, beverages and tobacco products; stochastic frontier production function; total factor productivity growth; technological progress, technical efficiency change; economic scale effect and allocative efficiency effect

JEL Classification : C23, C51, C87

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The manufacture of food and beverages in India provides safe, high quality, healthy, and affordable food to millions of people in the world. Together with the tobacco industry, the sector is a large source of manufacturing output and employment. However, it faces a confluence of challenges such as imbalances in the food supply and demand, food price volatility, and food security. These are the factors that may hamper productivity and efficiency of this sector too. Huge population growth in the emerging and developing countries in the world is one of the main sources of growth in world food demand and in the trade of food products. Further, food consumption is becoming increasingly diverse and moving away from staple foods, especially in the emerging countries in the world like India. Once again, nearly one billion people in the world remain food insecure. Productivity in the tobacco industry as well as cultivation of tobacco has also declined recently probably due to increased health awareness and policy action taken by the Government to reduce tobacco consumption.

* *Assistant Professor,* Department of Economics, Midnapore College (Autonomous), Midnapore, Paschim Medinipur, West Bengal. E-mail: prasanta.agnik@gmail.com
** *Retired Professor,* Vinod Gupta School of Management, Indian Institute of Technology (IIT) Kharagpur, Kharagpur - 721 302, West Bengal. E-mail: psdas1942@gmail.com

The challenge for the increase in food productivity growth is to sustainably balance future demand and supply, and to ensure affordable food supplies for a growing world population, particularly for the poor who are the most vulnerable to volatile food prices. Innovation and technological progress may have become the most important factor to increase food productivity in India. However, innovation and technological progress of the 3-digit industries of food, beverages, and tobacco products of the country will require new training and skills development of workers and employers across the aforesaid industries of the country. Modern value chains have also led to substantial improvements in productivity and efficiency, and advanced knowledge and technology of the aforementioned industries. These improvements increasingly benefit the food, beverages, and tobacco industries of developing countries in the world and have spillover effects on their output and employment growth. Increase in labour productivity is another important factor to enhance food production, but it may exacerbate job losses and contribute to a growing share of temporary, casual, part-time, and contract workers who often lack social protection and other benefits. Jobs in the tobacco industry have also been found to be declining in the recent decades due to innovation of new techniques, changes in demand, and national and international tobacco control policies targeting consumption. This may significantly impact employment for tobacco growers and workers. The tobacco industry also faces important decent work deficits, particularly in leaf production, such as poor working conditions, exposure to hazardous and dangerous work, long hours of work, low pay, and the use of child labour.

In the present study we estimate technological progress *(TP),* technical efficiency change *(TEC)*, economic scale effect *(SC)*, allocative efficiency effect *(AEC)*, and total factor productivity growth *(TFPG)* of the manufacture of food, beverages, and tobacco products in India at the three digits level of NIC'04 and NIC'98 of six disaggregated industry groups such as production, processing, and preservation of meat, fish, fruits, vegetables, oils and fats (151) ; manufacture of dairy products (152) ; manufacture of grain mill products, starches and starch products, and animal feeds (153) ; manufacture of other food products (154), manufacture of beverages (155) ; manufacture of tobacco products (160) as well as total of these six at the all-India level using stochastic production frontier approach. We have used panel data of food, beverages, and tobacco industries of the above mentioned six industry groups and also total of these six over a period from 1981-82 to 2010-11 [during the entire period, pre-reform period (1981-82 to 1990-91), post-reform-period (1991-92 to 2010-11), and during decades of the post-reform period, that is, during 1991-92 to 2000-01 and 2001-02 to 2010-11 to estimate technological progress *(TP)*, technical efficiency change *(TEC)*, scale effect *(SC)*, allocative efficiency effect *(AEC)*, and *TFPG* of the same industry groups and further to decompose *TFPG* of the same into technological progress *(TP)*, technical efficiency effect *(TEC),* scale effect *(SC),* and allocative efficiency effect *(AEC).*

The estimation of the above components of *TFPG* for the afore-mentioned industry groups have also been made for the pre-and post reform periods, and also for different decades in order to examine the trend and variations in the *TFPG* and its different components during these sub-periods. To the best of our knowledge, none of the existing studies have decomposed *TFPG* of the manufacture of food, beverages, and tobacco products in India at the three digits level of NIC'98 of the aforementioned disaggregated industry groups using the models and methods that we have used in our study.

Brief Review of Literature

Over the past three decades, several studies have been made to measure the productivity performances of the Indian manufacturing industries (for example, Ahluwalia, 1991 ; Brahmananda, 1982 ; Dholakia & Dholakia, 1994 ; Goldar & Kumari, 2003 ; Goldar, 1986 ; Goldar, 2002 ; Goldar, 2004 ; Pal, 2002 ; Pushpangadan & Balakrishnan, 1994 ; Rao, 1996 ; Shrivastava, 1996). Majority of these studies focused on the measurement of productivity or the methodological aspects associated with it. Some of the studies have also examined the relationship between policy changes and movement of industrial productivity. Here, by productivity we mean total factor productivity *(TFP)*. A number of studies (see for example, Ahluwalia, 1991 ; Brahmananda, 1982 ; Dholakia & Dholakia, 1994 ; Majumdar, 1996; Pradhan & Barik, 1999 ; Rao, 1996 ; Trivedi, Prakash, & Sinate, 2000 among others) suggested a decline in the total factor productivity growth *(TFPG)* till 1970s with a turnaround taking place in mid-1980s (as shown by the studies of Ahluwalia, 1985 ; Brahmananda, 1982 ; Goldar, 1986) in line with the more open trade and industrial policies. It is to be noted that the turnaround of *TFPG* in the 1980s has remained a matter of contention. Pushpangadan and Balakrishnan (1994) argued that the *TFPG* during the 1980s was due to the fact of using a single deflation method. The turnaround vanishes if double deflation approach is adopted. In the literature on productivity growth in India, attempts have also been made to examine the relationship between economic reforms and manufacturing productivity. Some studies have showed that the *TFPG* improved in the post-reforms period (Krishna & Mitra, 1998 ; Pattnayak & Thangavelu, 2003 ; Tata Services Ltd., 2003 ; Unel, 2003) ; whereas, the studies by Trivedi et al. (2000), Balakrishnan et al. (2000), Goldar (2000), Srivastava (2000), Ray (2002), Goldar (2002), Pal (2002), Goldar and Kumari (2003), Goldar (2004, 2006), Das (2004), Kumar (2006), Trivedi (2004), and Rodrik and Subramanian (2004) found that economic reforms adversely affected industrial productivity.

In most of the above mentioned studies, technological progress is considered to be the unique source of *TFPG.* Further, most of the studies have discussed about the measurement of *TFPG* at an aggregate level of the Indian manufacturing sector. So, the question that arises here is that are there any sources of *TFPG* other than technological progress ? Furthermore, does there exist any study at all that measures *TFPG* at the disaggregated level for manufacturing industries in India ? Mitra (1999) used the methodology suggested by Cornwell, Schmidt, and Sickles (1990) to study the technical efficiency and *TFPG* in the Indian manufacturing industries at the disaggregated level. He used panel data for his analysis, which covered 15 states and 17 two-digit industries for the period from 1976 - 77 to 1992 - 93. A frontier production function was estimated for each of the industries using state-wise and year-wise panel data. Apart from the disaggregate study, he also estimated *TFP* at the all-India level. He used a two input framework (labour and capital) by using double-deflated value added. For this purpose, value of output and intermediate inputs had been deflated separately. His estimates showed that in four industries (food products, beverages and tobacco products, basic metals, and metal products) there was a decline in *TFPG* in the later period (i.e. 1985-86 to 1992-93) as compared with the former (i.e., 1976-77 to 1984-85) in most or majority of the states. In other 13 industries, there was an increase in *TFPG* in 1985-86 to 1992-93 in most or majority of the states. Although he measured technical efficiency and *TFPG* both at aggregated as well as at the disaggregated industry levels, he did not decompose the sources of *TFPG* of the Indian manufacturing industries both at the aggregated and at the disaggregated levels.

So, the question naturally arises: how can we decompose the sources of *TFPG* of the organized manufacturing industries both at aggregated as well as at disaggregated level of industries? In our study, our specific focus attempt is to decompose the sources of *TFPG* at the disaggregated level of the 3-digit industries of food, beverages, and tobacco products in India into technological progress, change in technical efficiency, economic scale effect, and allocative efficiency effect (Kumbhakar &Lovell, 2000) within the framework of the time varying stochastic frontier production functions. The study makes use of stochastic production frontier approach for the estimation and decomposition of productivity growth. The translog production function is used in this study as it is more appropriate to describe production activities at the disaggregated industry level, rather than at the aggregate country level. Both the data envelopment analysis (DEA) and the distant function approach can also be used here, but due to their non-parametric and deterministic nature, the stochastic frontier analysis seems to be the more appropriate approach.

Methodology

(1) Stochastic Frontier Production Model and Decomposition of *TFPG* : The stochastic frontier production function was originally and independently proposed by Aigner, Lovell, and Schmidt (1977) and Meeusen and Van den Broeck (1977). They used a stochastic frontier production model that allows decomposing *TFPG* into two components: technological progress *(TP)* and change in technical efficiency *(TE)*. Later, a large number of studies, among others, Domazlicky and Weber (1998), Nishimizu and Page (1982), Kumbhakar (1990), and Fecher and Perelman (1992), focused on decomposition of *TFPG* using the stochastic frontier approach. Some of the studies extended their analysis to deal with the issues of scale effect and allocative efficiency effect. By applying a flexible translog stochastic production function, Kumbhakar and Lovell (2000) ; Kim and Han (2001) ; Sharma, Sylwester, and Margono (2007) ; and Kang and Lee (2008) decomposed *TFPG* into four components: changes in technological progress, changes in technical efficiency, economic scale effect, and changes in allocative efficiency.

Singh and Singh (2017) used the stochastic frontier approach in order to examine the production structure and technical efficiency in the Indian pharmaceutical industry during 1974-75 to 2011-12. The empirical analysis based on the econometric technique showed that the translog production function with capital using non-neutral technological progress represented the technological relationship in the Indian pharmaceutical industry and that there were very less variations in the technical efficiency in the Indian pharmaceutical industry during that period.

In this section, we discuss the methodology for estimating stochastic production frontier and the decomposition of *TFPG*. Following Bauer (1990) ; Kumbhakar, Ghosh, and McGuckin (1991) ; Huang and Liu (1994) ; and Kumbhakar and Lovell (2000), we start with a standard stochastic frontier model that can be estimated by using panel data, in which the inefficiency effect is expressed as :

$$y_{it} = f(x_{it}, \beta, t) \exp(v_{it} - u_{it}) \text{ --------- } (1)$$

where, y_{it} represents the output of the i-th production unit ($i = 1 \ldots N$) in the t-th time period ($t = 1 \ldots T$) ; $f(.)$ denotes the production frontier of the i-th production unit in time 't'; x_{it} is the input vector used by the i-th production unit in time 't'; β represents the vector of parameters to be estimated; 't' is the time trend serving as a proxy for technological change ; v_{it} is the symmetric random error term, independently and identically distributed with mean zero and variance σ^2_v intending to capture random variation in output due to external shocks like weather, strikes, lock-outs, etc., and u_{it}'s are non-negative random variables associated with technical inefficiency of production, which are assumed to be independently distributed, such that u_{it}'s are obtained by truncation at zero of the normal distribution with mean $z_{it}\delta$ and variance σ^2_u .So that the technical inefficiency effect u_{it} in the stochastic frontier model (1) can be specified as :

$$u_{it} = z_{it}\,\delta + w_{it} \text{ -------- } (2)$$

where, z_{it} is the matrix of explanatory variables associated with the technical inefficiency effects of the i-th production unit in the year 't', δ is a vector of unknown parameters to be estimated, and w_{it} is defined by truncation of the normal distribution with zero mean and variance σ^2. Given the specification in equation (2), the technical efficiency *(TE)* level of production of unit 'i' at time 't' is then defined as :

$$TE_{it} = \exp(-z_{it} - w_{it}) \text{ -------- } (3)$$

It is to be noted that the technical efficiency index in eqn (3) varies between zero and unity. A measure equal to one indicates that a production unit operates with full technical efficiency given the combinations of inputs and the state of technology. '*TE*' is below one, which means that production processes are not optimal.

Taking logs and totally differentiating equation (1) with respect to time t gives the growth rates of output at time 't' for the i-th production unit as shown below :

$$\dot{y}_{it} = dlnf(x_{it}, \beta, t)/dt - du_{it}/dt = \partial lnf(x_{it}, \beta, t)/\partial t + \sum_j \partial lnf(x_{it}, \beta, t)/\partial x_{jt}.dx_{jt}/dt - du_{it}/dt \quad \text{---------} (4)$$

The first and second terms on the right-hand side of equation (4) measure the change in frontier output caused by technological progress *(TP)* and by change in input use, respectively, and the third term represents technical inefficiency effect. From the formula of output elasticity of input *'j'*, $\varepsilon_j = \partial lnf(x_{it}, \beta, t)/\partial lnx_j$, the second term can be expressed as $\sum_j \varepsilon_j \dot{x}_{jt}$,where a dot over a variable indicates its rate of change. Thus, equation (4) can be written as :

$$\dot{y}_{it} = TP_{it} + \sum_j \varepsilon_j \dot{x}_{jt} - du_{it}/dt \quad \text{---------} (5)$$

Thus, the overall productivity change is not only affected by *TP* and changes in input use, but also by changes in technical inefficiency. *TP* will be positive if the exogenous change in technology shifts the production frontier upward and it will be negative if the exogenous technological change shifts the production frontier downward. On the other hand, if du_{it}/dt is negative, *TE* improves and if du_{it}/dt is positive, *TE* deteriorates over time. Thus, $-du_{it}/dt$ can be interpreted as the rate at which an inefficient producer catches up with the production frontier.

To examine the effect of *TP* and a change in technical efficiency on *TFPG,* let us express *TFPG* as output growth unexplained by input growth :

$$T\dot{F}P_{it} = \dot{y}_{it} - \sum_j S_j \dot{x}_{jt} \quad \text{---------} (6)$$

where, S_j denotes the observed expenditure share of input *'j'*.
By substituting equation (5) into equation (6), we get :

$$T\dot{F}P_{it} = TP_{it} - du_{it}/dt + \sum_j (\varepsilon_j - S_j)\dot{x}_{jt} = TP_{it} - du_{it}/dt + (\epsilon - 1)\sum_j \lambda_j \dot{x}_{jt} + \sum_j (\lambda_j - S_j)\dot{x}_{jt} \quad \text{---} (7)$$

where, $\epsilon = \sum_j \varepsilon_j$ denotes the measurement of returns to scale (RTS) and $\lambda_j = \varepsilon_j/\epsilon$. The last component in equation (7) measures inefficiency in resource allocation resulting from the deviation of input prices from the value of their marginal products. Thus, in equation (7), *TFP* growth can be decomposed into (a) *TP* that measures the shift in production frontier over time; (b) technical efficiency change $(-du_{it}/dt)$ that measures the shift in production towards the known production frontier ; (c) effect of scale change $[(\epsilon - 1 \sum_j \lambda_j \dot{x}_{jt}]$ which shows a production unit can be benefitted from economies of scale through access to a larger market, and (d) the allocative efficiency change denoted by $\sum_j (\lambda_j - S_j)\dot{x}_{jt}$ (Kumbhakar & Lovell, 2000).

(2) Model Specification : In our empirical analysis, we opt for a parametric approach by considering the time varying stochastic production frontier, originally proposed by Aigner et al. (1977) and Meeusen and Van den Broeck (1977) in translog form as :

$$Lny_{it} = \beta_0 + \sum_j \beta_j lnx_{jit} + \beta_t t + 1/2 \sum_j \sum_k \beta_{jk} lnx_{jit}.lnx_{kit} + 1/2\beta_{tt} t^2 + \sum_j \beta_{tj} t lnx_{jit} + v_{it} - u_{it} \;\; ; j,k = L, K \text{------} (8)$$

In equation (8), y_{it} is the observed output,*'t'* is the time variable, and *'x'* variables are inputs, subscripts *j* and *k* are index inputs. The efficiency error, u_{it} accounting for production loss due to unit-specific technical inefficiency, is always greater than or equal to zero and assumed to be independent of the random error, v_{it}, which is assumed to have the usual properties, that is, $v_{it} \sim iid\, N(0, \sigma^2_v)$.

The translog production frontier as specified in equation (8) is rewritten for two inputs as labour *(L)* and capital *(K)* in the following form :

$$Lny_{it}=\beta_0+\beta_L lnL_{it}+\beta_K lnK_{it}+\beta_t t+1/2\beta_{LL}L_{it}^2+1/2\beta_{KK}K_{it}^2+1/2\beta_{tt}t^2+\beta_{LK}lnL_{it}lnK_{it}+\beta_{Lt}L_{it}t+\beta_{Kt}K_{it}+v_{it}-u_{it} \quad (9)$$

where, the technical inefficiency function is assumed to be defined by :

$$U_{it}=\delta_0+\delta_1 SK_{it}+\delta_2 KI_{it}+\delta_3 RE_{it}+\delta_4 DT_{it}+w_{it} \quad (10)$$

where y_{it}, L_{it}, and K_{it} are, respectively the value added, labour input, and capital input for the i^{th} industry at time *'t'* ; SK_{it} denotes the index of employers' skill in the i^{th} industry in the year *'t'* measured by the ratio of the number of employees other than workers to total number of employees ; KI_{it} denotes the capital intensity of the i^{th} industry in the year *'t'* measured by the ratio of the stock of fixed capital to total number of employees ; RE_{it} denotes the rate of real emolument, and DT_{it} is the slope dummy which shows the impact of economic reforms on productivity growth (D_{it} takes the value '0' during the pre-reform period and it takes the value '1' during the post-reform period) ; w_{it} is the random error term, distributed as $N(0,\sigma^2)$ truncated at $-z_{it}\delta$, which ensures that $U_{it}\geq 0$. Equation (10) shows that the *TE* component has been correlated to the skill of employees, capital intensity, and the effects of economic reforms that is measured by industrial dummies.

The stochastic frontier production function defined by equation (9), and the technical inefficiency effects, specified by equation (10) can be jointly estimated by the maximum likelihood estimation (MLE) method using the software such as FRONTIER, LIMDEP etc. In this paper, we have employed FRONTIER 4.1 (Coelli, 1996) to estimate the stochastic frontier model.

After estimating the stochastic frontier model, the rate of technological progress can be evaluated by differentiating equation (9) with respect to time *(t)* as :

$$TP_{it}=\partial lny_{it}/\partial t=\beta t+\beta_{tt}t+\beta_{Lt}\,lnL_{it}+\beta_{kt}lnK_{it} \quad \text{-------} \ (11)$$

where, βt and β_{tt} are 'Hicksian' parameters and β_{Lt} and β_{kt} are 'factor augmented' parameters. It is noted that when technological progress is non-neutral, the change in *TP* may be varied for different input vectors. To avoid such problems, Coelli, Rao, Prasada, and Battese (1998, p. 234) suggested that the geometric mean between the adjacent periods be used to estimate the *TP* component. The geometric mean between time *'t'* and $t+1$ is defined as :

$$TP_{it}=[(1+\partial lny_{it}/\partial t)\,(1+\partial lny_{i,t+1}/\partial t+1)]^{1/2}-1 \quad \text{-------}(12)$$

The estimates of TE_{it}, on the other hand, are obtained through maximum likelihood procedure, where the maximum likelihood function is based on a joint density function for the composite error term $(v_{it}+u_{it})$.

The associated output elasticities of labour and capital can be estimated empirically based on the following equations :

$$\mathcal{E}_L=\partial lny_{it}/\partial lnL_{it}=\beta_L+\beta_{LL}lnL_{it}+\beta_{LK}lnK_{it}+\beta_{Lt}t \quad \text{-------} \ (13)$$

$$\mathcal{E}_K=\partial lny_{it}/\partial lnK_{it}=\beta_K+\beta_{KL}lnL_{it}+\beta_{KK}lnK_{it}+\beta_{Kt}t \quad \text{------} \ (14)$$

The above equations show the percentage change in output due to 1% change in inputs. They are used to estimate the aggregate returns to scale (ϵ). The scale elasticity output is given by the formula :

$$\epsilon=\mathcal{E}_L+\mathcal{E}_K \quad \text{-------} \ (15)$$

If scale elasticity exceeds unity, then the technology exhibits increasing returns to scale *(IRS),* if it is equal to one, the technology obeys constant returns to scale *(CRS),* and if it is less than unity, the technology shows decreasing returns to scale *(DRS)*.

Data and Variables

In this study, we use the panel data of the manufacture of food, beverages, and tobacco products in India at the three digit levels of NIC' 98 of six disaggregated industry groups such as production, processing, and preservation of meat, fish, fruits, vegetables, oils and fats (151) ; manufacture of dairy products (152) ; manufacture of grain mill products, starches and starch products, and animal feeds (153) ; manufacture of other food products (154) ; manufacture of beverages (155) ; manufacture of tobacco products (160) as well as total of these six at the all-India level during the period from 1981-82 to 2010-11. The data used in our study pertains to the period from 1981-82 to 2010-11 because our objective is to estimate and compare the performances of the afore-mentioned industries during last three decades starting from 1981-82 till 2010-11. The post reform period covers two decades. We propose to compare the performance of these industries during these two decades to examine whether the second decade has performed better than the first decade of the post reform period so far as the *TFPG* and its components are concerned. The panel data are prepared from the data on output and inputs collected from the various issues of Annual Survey of Industries (ASI) published by Central Statistics Office (Industrial Statistics Wing), Kolkata, Ministry of Statistics and Programme Implementation, Government of India.

The variables used in this study are output, labour, and capital inputs. Gross value added *(GVA)* is used as the measure of output. Gross output is not taken here as a measure of output in order to avoid the possibility of double counting. Again, productivity estimation in our study assumes output to be a function of labour and capital only. It is, therefore, appropriate to take value added as a representative of output instead of the value of output itself. As value added is used as a measure of output, nominal output needs to be converted into real output either by single deflation or by double deflation. In our study, we have used single deflation method instead of double deflation since in our study, the materials inputs and fuels have been left out of the consideration due to non-availability of input price data. The real value added is obtained here by deflating nominal value added by wholesale price index *(WPI)* for the manufacturing products.

Total number of persons engaged is treated as labor input. As workers, supervisors, managers, storekeepers, office bearers, all working proprietors, and their family members who are actively engaged in the work of factory even without any pay have significant contributions to the productivity, total number of persons engaged is preferred to all other measures as labor input. Total emoluments divided by total number of persons engaged in production is considered as price of labour input in our study. The measurement of capital is the most complex of all input measurements. Actually, there is no universally accepted method for the measurement of capital and, as a result, several methods have been applied to estimate capital stock in different studies. In some studies, capital is treated as a stock concept and is, therefore, measured by the book value of fixed capital assets. Some studies have used the perpetual inventory accumulation method (PIAM) to construct capital stock series from annual investment data. Goldsmith (1951) was the first to introduce the PIAM in the literature. However, it is essential to point out that each of these measures has certain limitations. Despite these limitations, in our study, we used the PIAM method to get the series of capital stock. Rental price of capital that equals the ratio of interest paid and capital invested (Jorgenson & Griliches, 1967) is assumed to be price of capital in our study.

Empirical Analysis and Results

(1) Estimation of Stochastic Production Frontier and Technical Inefficiency Function : The maximum likelihood estimates for the translog stochastic frontier production function are reported in panel 1 of Table 1. Almost all the

Table 1. Panel Estimation of Stochastic Production Frontier and Technical Efficiency Model

Variables	Parameters	Coefficients	Standard Errors	*t*-statistics
Panel-1: Stochastic Frontier Production Model				
Constant	β_0	7.07 ***	2.97	2.38
lnL	β_L	-0.17	0.74	-0.23
lnK	β_K	-0.18	0.95	-0.19
t	β_t	0.182 ***	0.076	2.38
lnL^2	β_{LL}	0.098 **	0.051	1.92
lnK^2	β_{KK}	0.164***	0.036	4.52
t^2	β_{tt}	0.0004	0.0004	1.16
*lnL*lnK*	β_{LK}	-0.197**	0.068	-2.29
*lnL*t*	β_{Lt}	0.011 **	0.006	1.96
*lnK*t*	β_{Kt}	-0.027 ***	0.007	-4.12
Panel-2:Technical Inefficiency Effects Model				
Constant	δ_0	-0.38 **	0.197	-1.93
Skill of Employees (*OE/TE*)	δ_1	3.37 ***	0.747	4.51
Capital Intensity (*K/L*)	δ_2	0.27***	0.117	2.35
Real Emolument Rate (*RE*)	δ_3	-5.33***	1.596	-3.34
Industrial Slope Dummy (*DT*)	δ_4	0.0095 **	0.005	1.97
Panel-3: Variance Parameters				
Sigma squared	σ^2	0.042 ***	0.008	5.59
Gamma	Υ	0.60 ***	0.133	4.55
Log-Likelihood		60.10		

Note : *, **, *** denote statistically significant at the 10%, 5%, and 1% levels, respectively.

Table 2. Hypotheses and Their Test Results

Null Hypothesis	Test Statistics λ=-2[*L*(H0) -*L*(H1)]	Critical Value at 5% Probability Level	Critical Value at 1% Probability Level	Decision
Cobb-Douglas Production Specification $H_0=\beta_{LL}=\beta_{KK}=\beta_{LK}=\beta_{tt}=\beta_{Lt}=\beta_{Kt}=0$	57.75	16.81	12.59	Reject H_0
No technological change H_0: $\beta_t=\beta_{tt}=\beta_{Lt}=\beta_{Kt}=0$	71.60	13.28	9.49	Reject H_0
Neutral technological change H_0: $\beta_{Lt}=\beta_{Kt}=0$	46.15	9.21	5.99	Reject H_0
No technical inefficiency effects H_0: $\Upsilon=\delta_0=\delta_1=\delta_2=\delta_3=\delta_4=0$	45.61	16.81	14.45	Reject H_0
Exogenous variables included in the inefficiency effects model have no effect on the level of technical inefficiency H_0: $\delta_0=\delta_1=\delta_2=\delta_3=\delta_4=0$	45.52	15.08	11.07	Reject H_0
Each industry group is operating on the technical efficient frontier and the asymmetric and random technical inefficiency is zero H_0: $\mu=0$	5.43	6.63	3.84	Reject H_0 at 5% level

estimated coefficients of the translog stochastic frontier production function are found to be statistically significant at the conventional levels. However, as under translog specification, there may exist high level of multicollinearity due to the existence of interaction and squared terms, certain estimated coefficients are found to be statistically insignificant.

Panel 2 of Table 1 reports the estimated coefficients for the technical inefficiency effects model. All the coefficients of the technical inefficiency effects model are found to be statistically significant, which implies that a considerable amount of output variation is due to the presence of technical inefficiency effect. The estimated value of δ_1 , δ_2 , and δ_4 are found to be positive and statistically significant, indicating that employers' skill, capital intensity, and economic reforms measured by industrial slope dummy strengthened technical inefficiency effects of the manufacture of food, beverages, and tobacco products in India. However, the empirical test of efficiency made by Jana and Adhikari (2014) revealed that there was a significant hint of an upward shift of the productivity locus both for workers and employees on account of positive intercept dummy coefficients . The estimated value of δ_3 is, however, found to be negative and statistically significant at 1% probability level, which implies that an increase in employees' real emoluments rate will lower the technical inefficiency effects.

Panel 3 of the Table 1 reports the estimates of the variance parameters σ^2 and γ that test for the validity of technical inefficiency effect. Both the estimated coefficients are found to be statistically significant which confirms the presence of technical inefficiency effect in the output residual as indicated in panel 3. However, the estimated value of gamma (γ) is found to be 0.60. This implies that output variation of the manufacture of food, beverages and tobacco products in India is significantly dominated by the technical inefficiency factor.

(2) Hypotheses Tests for Proper Model Specification : We have performed a number of LR tests on the selection of functional form, one sided test on the inefficiency effects, etc. using the generalized likelihood ratio statistic, λ, given by :

$$\lambda = -2[L\,(H_0) - L\,(H_1)]$$

where L (H_0) and L (H_1) denote the values of the log likelihood function under the null (Ho) and alternative (H_1) hypotheses (see Table 2), respectively. If the given null hypothesis is true, λ has approximately chi-square (χ^2) distribution with degrees of freedom equal to the difference between the number of parameters under H_1 and H_0, respectively. The Table 2 presents the test results of the various null hypotheses as shown below.

The first null hypothesis that the technology in Indian manufacturing is a Cobb-Douglas (H_0: $\beta_{LL}= \beta_{KK}= \beta_{LK}= \beta_{tt} = \beta_{Lt}= \beta_{Kt}= 0$). The test statistic as shown in Table 2 has a likelihood ratio value of 57.75, which implies rejection of the null hypothesis at 1% significance level. In other words, it is not the Cobb-Douglas, but the translog model is the ideal model.

The second test we have conducted in this study consists of testing the null hypothesis that there is no technological change over time, that is, $H_0 : \beta_t= \beta_{tt} = \beta_{Lt}= \beta_{Kt}= 0$. The value of the test statistic as shown in Table 2 is 71.60, which is significantly larger than the critical value of 13.28 at 1% probability level. As a result, the null hypothesis of 'no technological change over time' is rejected. This means that the technological change is time - variant in the manufacturing of food, beverages, and tobacco products in India.

The third null-hypothesis is technological progress is neutral, that is, H_0: $\beta_{Lt} = \beta_{Kt} = 0$. The value of the test statistic in this case is found to be 46.15, which is much greater than the critical value of 9.21 at the 1% probability level. This indicates that the translog parameterization of the stochastic frontier model does not allow for neutral technological progress.

The results further reveal that the fourth null-hypothesis that specifies that the inefficiency effects are absent from the model, (i.e., H_0: $\gamma = \delta_0= \delta_1= \delta_2= \delta_3= 0$) is rejected. This implies that the traditional production function is not an adequate representation for the organized manufacturing industry in India so far as the manufacture of

Table 3. Rate of Technological Progress (in %) of the Manufacture of Food, Beverages, and Tobacco Products in India

Year/Industry	151	152	153	154	155	160	Total
1981-82	3.50	3.85	4.35	2.01	4.25	9.45	1.04
1982-83	3.20	3.84	3.45	1.85	4.02	9.11	0.74
1983-84	2.93	3.65	3.27	1.54	3.87	8.38	0.43
1984-85	2.90	3.60	3.86	1.39	4.04	7.40	0.38
1985-86	2.76	3.51	3.82	1.38	3.85	6.51	0.31
1986-87	2.52	3.19	3.91	1.33	3.49	6.72	0.23
1987-88	2.42	3.03	3.93	1.27	2.86	6.85	0.12
1988-89	2.30	3.00	4.01	1.01	2.62	7.27	-0.01
1989-90	2.17	3.14	3.86	0.65	2.70	7.50	-0.18
1990-91	2.06	3.43	3.47	0.59	2.62	7.47	-0.27
1991-92	1.71	3.48	3.44	0.66	2.38	7.37	-0.32
1992-93	1.38	3.45	3.49	0.55	2.19	7.06	-0.47
1993-94	0.88	3.32	3.37	0.24	1.78	6.77	-0.80
1994-95	0.36	2.60	3.31	-0.08	1.13	7.06	-1.19
1995-96	0.22	2.49	3.28	-0.18	0.78	6.88	-1.34
1996-97	0.27	1.92	3.20	-0.36	0.52	6.05	-1.49
1997-98	0.05	1.51	3.02	-0.65	0.53	5.72	-1.76
1998-99	-0.13	1.65	1.97	-0.67	0.19	5.34	-2.00
1999-00	0.01	1.60	1.62	-0.71	-0.37	5.03	-2.09
2000-01	0.02	2.07	2.23	-0.82	-0.40	5.13	-2.01
2001-02	-0.20	2.17	2.26	-0.84	-0.29	5.19	-2.03
2002-03	0.04	2.28	2.18	-0.85	-0.38	5.02	-2.04
2003-04	0.28	2.35	2.12	-0.81	-0.51	5.13	-2.02
2004-05	0.26	2.35	2.10	-0.82	-0.34	5.41	-1.99
2005-06	0.28	2.45	1.78	-1.03	-0.25	5.34	-2.12
2006-07	-0.03	2.34	1.43	-1.36	-0.37	5.13	-2.43
2007-08	-0.25	1.77	1.20	-1.62	-0.62	5.11	-2.70
2008-09	-0.53	0.82	0.85	-1.83	-0.89	4.82	-3.01
2009-10	-1.06	0.73	0.51	-2.06	-1.20	4.90	-3.32
2010-11	-0.17	1.90	1.56	-1.12	-0.06	5.83	-2.30
Average: 1981-82 to 2010-11 (Entire study period)	**1.01**	**2.58**	**2.76**	**-0.04**	**1.27**	**6.37**	**-1.16**
Average: 1981-82 to 1990-91 (Pre-reform period)	**2.68**	**3.43**	**3.79**	**1.30**	**3.43**	**7.67**	**0.28**
Average: 1991-92 to 2010-11 (Post-reform period)	**0.17**	**2.16**	**2.25**	**-0.72**	**0.19**	**5.71**	**-1.87**
Average: 1991-92 to 1999-00 (Decade-1 of Post-reform period)	**0.48**	**2.41**	**2.89**	**-0.20**	**0.87**	**6.24**	**-1.35**
Average: 2000-01 to 2010-11 (Decade-2 of Post-reform period)	**-0.14**	**1.92**	**1.60**	**-1.23**	**-0.49**	**5.19**	**-2.40**

Table 4. Rate of Technical Efficiency Change (in %) of the Manufacture of Food, Beverages, and Tobacco Products in India

Year/Industry	151	152	153	154	155	160	Total
1981-82	0.28	24.4	0.41	26.2	-5.63	-1.02	15.7
1982-83	7.86	19.8	3.12	20.6	10.2	0.18	14.3
1983-84	4.41	-27.8	-9.08	3.87	-16.1	5.55	2.90
1984-85	-13.3	14.9	-13.0	-1.99	22.2	-2.8	-3.93
1985-86	5.69	-20.4	25.0	-0.81	-5.77	-1.73	0.30
1986-87	-9.87	26.6	2.73	-1.84	-0.32	1.15	0.16
1987-88	7.48	7.70	-5.74	-0.24	-4.42	-0.76	-0.02
1988-89	-3.56	1.07	3.44	5.39	-6.84	2.35	3.61
1989-90	2.97	20.1	-6.65	-0.21	4.46	-0.97	0.67
1990-91	-0.04	-21.1	0.29	-8.73	-0.74	-0.23	-4.50
1991-92	-11.1	-17.7	-6.14	-3.99	-2.20	-0.60	-2.80
1992-93	-10.5	7.49	-13.2	-0.78	-12.3	-0.64	-3.10
1993-94	7.30	-10.9	5.46	6.68	3.43	0.24	3.87
1994-95	-10.3	8.86	15.2	-1.61	-8.76	-0.81	-1.36
1995-96	-0.86	-7.48	-3.00	-8.22	-3.02	-5.90	-6.73
1996-97	13.2	19.1	1.46	6.03	-5.69	6.70	7.75
1997-98	-13.5	-17.2	-12.3	-13.3	5.06	-4.73	-10.3
1998-99	-16.0	27.8	1.62	-1.50	1.82	3.99	0.30
1999-00	-0.68	-26.6	-17.4	-0.01	-6.42	1.22	-3.89
2000-01	-1.53	32.5	7.43	-2.36	-24.8	0.35	2.39
2001-02	6.73	0.19	0.79	3.38	8.17	-1.43	3.56
2002-03	-8.27	-0.81	1.96	-10.9	-0.66	1.58	-2.82
2003-04	7.25	-8.45	-12.1	-12.5	6.15	-2.08	-4.78
2004-05	-3.47	-4.92	7.30	11.0	-21.4	-1.13	1.22
2005-06	12.1	17.4	3.80	11.0	30.4	-0.27	11.0
2006-07	7.05	-23.2	13.7	3.22	34.4	1.42	4.63
2007-08	13.4	-0.44	-5.58	-24.3	7.78	-0.97	-2.91
2008-09	-4.32	4.00	6.45	1.34	-14.7	3.04	-1.09
2009-10	-21.2	-19.1	-23.2	4.83	-9.89	-0.46	-8.93
2010-11	-17.4	4.05	12.9	7.93	-28.4	-3.40	-2.44
Average: 1981-82 to 2010-11 (Entire study period)	**-1.67**	**0.99**	**-0.47**	**0.61**	**-1.47**	**-0.07**	**0.43**
Average: 1981-82 to 1990-91 (Pre-reform period)	**0.19**	**4.53**	**0.06**	**4.23**	**-0.30**	**0.17**	**2.92**
Average: 1991-92 to 2010-11 (Post-reform period)	**-2.60**	**-0.77**	**-0.74**	**-1.20**	**-2.06**	**-0.19**	**-0.82**
Average: 1991-92 to 1999-00 (Decade-1 of Post-reform period)	**-4.40**	**1.59**	**-2.08**	**-1.91**	**-5.29**	**-0.02**	**-1.39**
Average: 2000-01 to 2010-11 (Decade-2 of Post-reform period)	**-0.81**	**-3.14**	**0.61**	**-0.50**	**1.18**	**-0.37**	**-0.25**

Table 5. Rate of Scale Change (in %) of the Manufacture of Food, Beverages, and Tobacco Products in India

Year/Industry	151	152	153	154	155	160	Total
1981-82	0.24	1.05	-0.99	-0.27	0.57	-2.82	-0.25
1982-83	-0.31	-0.15	-1.31	-0.11	1.14	-3.31	-0.02
1983-84	-1.82	-2.04	-3.22	-0.19	-5.9	-0.80	1.88
1984-85	0.23	-3.72	3.28	0.408	2.67	7.88	-0.23
1985-86	-0.86	1.20	-0.87	-0.06	-2.07	-6.42	0.46
1986-87	-0.66	-3.36	0.62	0.054	-2.46	-2.11	0.48
1987-88	-1.89	-2.29	-1.18	0.045	-5.39	-2.75	1.02
1988-89	0.14	-0.91	-0.82	-0.01	-5.17	0.74	0.47
1989-90	-2.28	-2.28	0.52	0.194	2.36	-6.63	1.16
1990-91	0.24	2.51	-3.01	0.123	-2.25	2.33	0.68
1991-92	-2.22	0.82	-1.31	0.02	-0.83	-2.16	0.21
1992-93	-2.28	-3.51	-0.77	-0.12	-4.16	-2.46	0.76
1993-94	-1.68	-1.35	-1.58	-0.14	-0.21	2.39	0.45
1994-95	-3.27	-3.62	-0.30	-0.20	-7.15	-4.61	1.60
1995-96	-1.83	-9.98	-2.36	-0.13	-4.31	2.57	1.11
1996-97	-0.15	7.10	-0.06	-0.07	-1.96	-4.43	0.19
1997-98	-0.35	-15.0	-5.07	-0.29	-2.04	-1.94	1.19
1998-99	-2.86	11.6	0.60	-0.25	-0.97	5.06	0.41
1999-00	1.56	-10.1	-9.35	0.093	-6.24	-3.09	0.88
2000-01	0.76	7.71	6.40	-0.48	-2.37	-1.17	-0.03
2001-02	-0.44	-0.14	-0.05	0.041	0.18	-0.21	-0.01
2002-03	-3.49	0.52	-1.21	-0.34	0.15	-0.39	0.21
2003-04	5.32	0.18	0.22	0.03	-3.74	0.45	-0.02
2004-05	-4.49	-1.67	-2.79	-0.12	-0.47	0.66	0.03
2005-06	1.70	-1.57	-0.78	-0.61	1.35	-0.12	-0.01
2006-07	-4.18	0.17	-5.05	-1.85	-1.86	2.38	-0.05
2007-08	-3.19	-5.17	-1.51	-1.06	-3.42	2.87	-0.04
2008-09	-1.44	-10.4	-2.51	-1.28	-4.42	-3.75	-0.02
2009-10	-4.66	-13.5	-3.18	-0.78	-2.89	2.33	0.03
2010-11	-5.65	8.69	-3.58	-1.50	-4.39	-0.41	0.05
Average: 1981-82 to 2010-11 (Entire study period)	**-1.33**	**-1.64**	**-1.37**	**-0.29**	**-2.21**	**-0.66**	**0.42**
Average: 1981-82 to 1990-91 (Pre-reform period)	**-0.70**	**-1.00**	**-0.70**	**0.02**	**-1.65**	**-1.39**	**0.57**
Average: 1991-92 to 2010-11 (Post-reform period)	**-1.64**	**-1.96**	**-1.71**	**-0.45**	**-2.49**	**-0.30**	**0.35**
Average: 1991-92 to 1999-00 (Decade-1 of Post-reform period)	**-1.23**	**-1.64**	**-1.38**	**-0.16**	**-3.02**	**-0.98**	**0.68**
Average: 2000-01 to 2010-11 (Decade-2 of Post-reform period)	**-2.05**	**-2.29**	**-2.04**	**-0.75**	**-1.95**	**0.38**	**0.02**

food, beverages, and tobacco is concerned. In other words, this statistical test indicates that inefficiencies are very much present in the manufacturing industry in India under study.

The fifth null hypothesis asserts that the variables included in the inefficiency effects model have no effect on the level of technical inefficiency, that is, $H_0: \delta_0 = \delta_1 = \delta_2 = \delta_3 = 0$. The test result shows that the null hypothesis is rejected, confirming that the joint effect of these explanatory variables on technical inefficiency is statistically significant.

The last null hypothesis specifies that each production unit is operating on the technically efficient frontier and that the asymmetric and random technical inefficiency in the inefficiency effects are zero (H_0: $\mu = 0$). This hypothesis is also rejected in favour of the presence of inefficiency effects.

(3) Decomposition of Productivity Growth : Total factor productivity growth rates of the manufacture of food, beverages, and tobacco products at the 3-digit level of NIC'98 have steeply declined in all the industries from the pre-reform period (1981-82 to 1990-91) to the post-reform period (1991-92 to 2010-11). More important is the fact that during the second half of the post-reform period, that is, during 2000-01 to 2010-11, the *TFPG* rates for almost all the industry groups, that is, 151, 152, 153, 154, and 160 are all lower than those during the first half of the post-reform period, that is, during 1990-91 to 1999-00. The industry groups 153 and 155, however, have registered a slightly higher average growth rate during the second half over the first half (see Table 7). The identification of the factors contributing to this dismal picture of this vital sector is done by decomposing the *TFPG* into four components and analyzing their contributions to this appalling state of *TFPG* in this sector. The four components of *TFPG* are (a) technological progress, (b) technical efficiency change, (c) effect of scale change, and (d) allocative efficiency change. Our decomposition results are stated below :

The Tables 3, 4, 5, and 6 , respectively present the rate of technological progress *(TP),* technical efficiency change *(TEC),* scale change *(SC)*, and allocative efficiency change *(AEC)* in the organized manufacturing industries of food, beverages, and tobacco products in India during 1981-82 to 2010-11 during the pre-reform period (1981-82 to 1990-91), during the post-reform period (1991-92 to 2010-11), and during two decades in the post-reform period, that is, during 1991-92 to 2000-01 and during 2001-02 to 2010-11. The main finding of our decomposition is that technological progress and allocation efficiency effect are the major contributors to the *TFPG* of the organized manufacturing industries of food, beverages, and tobacco products in India and the decline in *TFPG* of the aforesaid industries during the post-reform period is mainly due to the decline in technological progress of those industries during that period. The decline in *TP* in these industries under study in India during the post-reform period may be explained by the fact that economic reforms failed to increase competition through improved technology and opening of the organized manufacturing industries of food, beverages, and tobacco products in India. The annual growth rates of *TP, TEC, SC,* and *AEC* of the organized manufacturing industries of the same, however, show wide fluctuations over the years during the entire period of our study.

We know that the scale effects, which measure the effect of input changes on output growth, will be zero if rate of technical substitution *(RTS)* is constant; it will be greater (less) than zero if *RTS* increases (decreases). This relationship holds so long as there is positive input growth (Kim & Han, 2001). It is seen from the Table 5 that the contribution of scale effects to *TFPG* of the organized manufacturing sector of food, beverages, and tobacco products in India are very low or even negative (less than zero) in most of the cases. This could be due to larger unit cost of production. It can, therefore, be said that the organized manufacturing industries of food, beverages, and tobacco products in India have not been benefitted from economies of scale. The changes in technical efficiency effect (Table 4) are also found to be negative or very negligible in most of the cases.

The Table 7 shows that the manufacture of tobacco products (160) and the production, processing, and preservation of meat, fish, fruits, vegetables, oils and fats (151) have registered, respectively the highest and the lowest growth rate of *TFP* during 1981-82 to 2010-11. As many as five industry groups including total of food,

Table 6. Rate of Allocation Efficiency Change (in %) of the Manufacture of Food, Beverages, and Tobacco Products in India

Year/Industry	151	152	153	154	155	160	Total
1981-82	-1.94	-8.16	2.49	-3.2	0.02	0.34	-3.44
1982-83	0.99	-1.75	-0.76	6.00	-6.10	7.30	2.44
1983-84	14.2	0.91	37.3	16.1	15.6	2.10	19.7
1984-85	1.86	0.20	-21.8	11.0	-8.3	-0.02	3.90
1985-86	3.48	0.93	4.81	2.56	2.36	22.1	5.10
1986-87	6.97	8.54	0.81	3.43	8.08	-3.25	2.26
1987-88	5.18	12.1	-2.44	1.43	3.80	-1.24	1.38
1988-89	0.11	0.95	1.16	3.68	22.3	-0.16	4.16
1989-90	5.33	-2.01	-1.65	9.30	-1.30	0.65	1.57
1990-91	1.30	-4.80	7.79	7.23	1.75	-0.14	6.27
1991-92	4.31	-4.50	5.91	-0.93	2.94	0.53	0.76
1992-93	7.93	-0.27	-4.15	-0.88	9.64	-0.61	1.28
1993-94	5.51	-2.72	1.92	6.34	0.93	-0.20	5.77
1994-95	14.7	7.98	3.46	9.73	19.6	-0.03	9.63
1995-96	4.26	24.1	-1.46	4.80	7.30	4.34	6.86
1996-97	1.44	-16.7	2.23	1.26	9.05	-0.07	0.52
1997-98	-1.73	50.0	-2.21	8.37	10.8	0.51	5.79
1998-99	7.52	-21.4	6.40	6.00	-16.0	0.76	7.06
1999-00	3.53	13.7	27.1	-2.82	34.6	1.79	5.93
2000-01	2.57	-11.2	-11.3	6.45	0.28	0.91	0.43
2001-02	4.15	-3.17	-0.52	1.34	0.08	-0.39	0.25
2002-03	6.68	2.90	1.02	3.42	-1.60	0.93	3.49
2003-04	-16.2	-3.81	4.09	0.25	6.25	0.44	-0.01
2004-05	5.21	2.52	-1.27	1.90	-1.30	0.01	1.74
2005-06	-4.88	-2.25	1.14	0.29	-6.7	0.58	-1.11
2006-07	2.85	-1.40	6.93	7.27	4.58	-0.89	7.39
2007-08	6.87	8.05	1.84	5.86	-2.00	-0.32	6.06
2008-09	3.33	16.1	10.5	4.87	9.4	0.04	5.86
2009-10	7.21	29.3	8.72	3.52	4.24	1.39	8.95
2010-11	12.1	-18.6	7.99	6.33	13.4	4.14	6.60
Average: 1981-82 to 2010-11 (Entire study period)	**3.83**	**2.52**	**3.20**	**4.36**	**4.79**	**1.39**	**4.22**
Average: 1981-82 to 1990-91 (Pre-reform period)	**3.75**	**0.70**	**2.77**	**5.76**	**3.82**	**2.77**	**4.33**
Average: 1991-92 to 2010-11 (Post-reform period)	**3.87**	**3.44**	**3.41**	**3.67**	**5.27**	**0.69**	**4.16**
Average: 1991-92 to 1999-00 (Decade-1 of Post-reform period)	**5.01**	**3.90**	**2.78**	**3.83**	**7.89**	**0.79**	**4.40**
Average: 2000-01 to 2010-11 (Decade-2 of Post-reform period)	**2.73**	**2.97**	**4.04**	**3.51**	**2.65**	**0.59**	**3.92**

Table 7. Rate of *TFPG* (in %) of the Manufacture of Food, Beverages, and Tobacco Products in India

Year/Industry	151	152	153	154	155	160	Total
1981-82	2.08	21.2	6.26	24.7	-0.79	5.95	13.0
1982-83	11.7	21.7	4.50	28.4	9.27	13.3	17.5
1983-84	19.7	-25.0	28.3	21.3	-2.55	15.2	24.9
1984-85	-8.31	15.0	-27.7	10.8	20.7	12.5	0.13
1985-86	11.1	-15.0	32.8	3.08	-1.64	20.5	6.17
1986-87	-1.03	34.9	8.07	2.98	8.78	2.50	3.14
1987-88	13.2	20.6	-5.43	2.51	-3.15	2.11	2.50
1988-89	-1.02	4.11	7.79	10.1	12.9	10.2	8.23
1989-90	8.18	19.0	-3.91	9.94	8.22	0.54	3.22
1990-91	3.56	-200	8.54	-0.79	1.39	9.43	2.18
1991-92	-7.33	-18.0	1.90	-4.25	2.29	5.14	-2.15
1992-93	-3.47	7.16	-14.7	-1.23	-4.64	3.35	-1.53
1993-94	12.0	-12.0	9.17	13.1	5.93	9.20	9.29
1994-95	1.54	15.8	21.7	7.83	4.84	1.62	8.68
1995-96	1.79	9.13	-3.54	-3.74	0.75	7.90	-0.09
1996-97	14.7	11.4	6.83	6.86	1.92	8.24	6.97
1997-98	-15.5	19.3	-16.6	-5.86	14.4	-0.40	-5.07
1998-99	-11.4	19.7	10.6	3.57	-15.2	15.1	5.78
1999-00	4.41	-21.0	1.96	-3.44	21.5	4.95	0.81
2000-01	1.82	31.1	4.74	2.78	-27.3	5.22	0.78
2001-02	10.2	-1.00	2.49	3.93	8.14	3.17	1.76
2002-03	-5.04	4.89	3.96	-8.66	-2.47	7.14	-1.17
2003-04	-3.30	-9.70	-5.68	-13.1	8.15	3.94	-6.83
2004-05	-2.48	-1.70	5.34	11.9	-23.5	4.94	1.00
2005-06	9.23	16.0	5.95	9.66	24.8	5.53	7.78
2006-07	5.68	-22.0	17.1	7.28	36.7	8.04	9.53
2007-08	16.9	4.21	-4.06	-21.1	1.75	6.70	0.41
2008-09	-2.95	10.6	15.2	3.11	-10.6	4.15	1.73
2009-10	-19.7	-2.60	-17.1	5.52	-9.74	8.16	-3.28
2010-11	-11.2	-4.00	18.9	11.6	-19.4	6.16	1.91
Average: 1981-82 to 2010-11 (Entire study period)	**1.83**	**4.46**	**4.12**	**4.63**	**2.38**	**7.01**	**3.91**
Average: 1981-82 to 1990-91 (Pre-reform period)	**5.92**	**7.65**	**5.92**	**11.3**	**5.31**	**9.22**	**8.10**
Average: 1991-92 to 2010-11 (Post-reform period)	**-0.21**	**2.86**	**3.21**	**1.29**	**0.92**	**5.91**	**1.82**
Average: 1991-92 to 1999-00 (Decade-1 of Post-reform period)	**-0.15**	**6.27**	**2.21**	**1.57**	**0.46**	**6.03**	**2.35**
Average: 2000-01 to 2010-11 (Decade-2 of Post-reform period)	**-0.27**	**-0.50**	**4.21**	**1.02**	**1.38**	**5.79**	**1.29**

beverages, and tobacco products recorded more than 3.5% average annual growth rate of *TFP* during that period. We further see from Tables 3 - 6 that the contribution of *AEC* to *TFPG* is the highest among all the *TFP* components. The effect of technical efficiency change and scale change are found to be very insignificant, mostly negative ; whereas, the contribution of *TP* is moderately high in most of the cases. The Table 5 compares the *AEC*'s contribution to *TFPG* during 1981-82 to 1990-91 (pre-reform period) with that during 1991-92 to 2010-11 (post-reform period).

From the Tables 3 to 6, it is also clear that the average annual growth rate of *TFP* has fallen from the pre-reform period to the post-reform period in all the industry groups including the total of all the industry groups. *TP* happens to be the most important factor responsible for the decline in *TFPG* in all the industry groups during the post-reform period as compared to the pre-reform period. Further, *AEC* has made significant positive contribution to *TFPG* in four industry groups including the total one during that period. This is a clear pointer to the fact that the registered manufacturing industries of food products under study have improved their allocative efficiency during the study period so far as the allocation of resources is concerned.

The effect of scale change on *TFPG* has been negative in as many six out of seven manufacturing units except that the total one during both the pre-& post-reform periods. In case of total industry under study, its contribution, though positive, was very low, ranging from 0.02 to 0.68 percentage points. Thus, in general, the effect of *SC* to *TFPG* is very negligible. But, interestingly, while *TP* declines in all the industry groups, *AEC* has made significant improvements in almost all the industry groups. Further, the results reveal that during the second half of the post-reform period (2000-01 to 2010-11), *TP* declines at a higher rate in all the industry groups under study. However, *AEC* has been largely responsible for the higher *TFPG* in the organized manufacturing industries of food, beverages, and tobacco products. As regards the technical efficiency change, its contribution has been very negligible throughout the period and also during different sub-periods such as during the pre-& post-reform period and during different decades of the post reform period. It can ,therefore, be said that the organized manufacturing industries of food, beverages, and tobacco products in India have not been benefited by the technical efficiency effect.

Summary and Conclusion

The paper examines the sources of *TFPG* of the organized manufacturing industries of food, beverages, and tobacco products in India during the period from 1981-82 to 2010-11, during the entire period, pre-reform period (1981-82 to 1990-91), post-reform period (1991-92 to 2010-11), and also during two different decades of the post-reform period (1990-91 to 2000-01 and 2001-02 to 2010-11) at the all-India level using stochastic production frontier approach. The methodology involves decomposition of the sources of *TFPG* into four components, that is, technological progress, technical efficiency, economic scale, and allocation efficiency.

The main findings of the decomposition analysis are reported in the following paragraphs :

(i) Average total factor productivity growth rate of all the industries in this sector declines sharply during the post-reform period.

(ii) During the periods under study, technological progress and allocative efficiency effect have been the main driving force of total factor productivity growth in the organized manufacturing industries of food, beverages, and tobacco products in India. Furthermore, technological change of the organized manufacturing industries of food, beverages, and tobacco products in India has been responsible for the decline in *TFPG* of that sector during the post-reform period.

(iii) The technical efficiency change of the organized manufacturing sector of food, beverages, and tobacco products is, however, found to be very negligible or even negative in most of the cases.

(iv) With respect to scale effect, its contribution to *TFPG* of the organized manufacturing industries of food, beverages, and tobacco products in India has been also very small or even negative.

(v) The allocative efficiency, that is, the efficiency in resource allocation in this sector has improved from the pre-reform period to the post-reform period. This implies that deregulation and delicensing of the economy in the post-reform period has reduced the price distortion measured by the gap between price and marginal cost in this sector.

The findings suggest that although there has been a positive change in the technological progress during the pre-reform period, it declines during the post-reform period. This trend in the technological change can be attributed to (a) negative change (in the statistical sense) in the technical efficiency, (b) very small or negative scale effect, and (c) allocative efficiency also drastically fell during the last half of the post-reform period in case of all the six industries in this group of food, beverages, and tobacco products.

Research and Policy Implications

To improve the economic condition of this sector, the total factor productivity should be raised well above its present rate of growth. For that, the industries have to improve their technical efficiency as well as the scale effect. Input quality, particularly the quality of labour should also be improved. It is human resources that play a vital role in improving the productivity of all the inputs used in the production of goods under this sector. To achieve this goal, appropriate vocational training of labour should be undertaken and strict supervision of the activities of the managers, officers, etc., should be conducted.

Besides this, social partners need to be engaged in the identification of appropriate vocational training, retraining, and other capacity building initiatives. These initiatives will raise productivity, reduce the number of low-skilled workers, and smooth the transition to new organization and production models. Necessary steps need to be taken in identifying and applying food safety standards, policies, and programmes. Steps for developing targeted training programmes for workers on food safety, risk management, food quality, and related regulations, and linking them to vocational training on occupational safety and health issues should be taken up in all sincerity. Implementing work place safety and health practices to reduce workers' vulnerability and prevent major outbreaks should also be given priority. These steps, it is believed, will improve the economic condition so far as efficiency factors are concerned and thereby will improve the *TFPG* rate of these industries in the coming years.

Limitations of the Study and Scope for Further Research

The study decomposes total factor productivity growth *(TFPG)* of the organized manufacturing industries of food, beverages, and tobacco products in India at the disaggregated level of 3-digit industries. However, so far as the manufacturing industries are concerned, this industrial sector is less important (as far as the proportion of revenues of these industries in the total revenues of the other manufacturing industries taken individually such as manufacture of chemical and chemical products, petroleum and coal products, basic metal and alloys industries, metal products and machinery equipments, manufacture of transport equipments, etc. is concerned).

So, it is required to estimate the *TFPG* components of the aforementioned industries which are the most important so far as their revenues are concerned. There is further scope to estimate the *TFPG* components of the major industry groups at the more disaggregated level such as at 4-digit or 5-digit level. This will provide a clear picture of the movement of *TFPG* components of Indian industries at a more disaggregated level compared to 2-digit or 3-digit levels.

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About the Authors

Prasanta Kumar Roy, M.A. in Economics (1st Class), U.G.C- NET, is an Assistant Professor in Economics at Midnapore College (Autonomous), Midnapore, West Bengal. He has been teaching there for more than 16 years. He has more than eight publications in many reputed Indian Journals.

Dr. Purnendu Sekhar Das, M.A., PhD, is a retired Professor of Vinod Gupta School of Management, IIT Kharagpur. He has more than 35 publications in many reputed Indian as well as foreign journals. More than 30 scholars have completed their PhD under his guidance.