



The estimation of technical efficiency of tea manufacturing firms in Sri Lanka: a stochastic frontier analysis

J.C. Rohan Jayatilake

*FASID/GRIPS Joint Graduate Program-International Development Studies Program,
National Graduate Institute of Policy Studies (GRIPS), Tokyo, Japan*

Abstract

This study applies the Stochastic Frontier Approach to estimate the technical efficiency of tea manufacturing firms in Sri Lanka. Also, the study investigates whether the production capacity of these manufacturing firms vary with the size and the location of the tea factories in three main tea producing regions in Sri Lanka namely up-country region, mid-country region and low-country region. The study estimates that the average technical efficiency of the tea manufacturing firms in Sri Lanka is 80%, indicating that there is a potential to increase the production by 20% through efficiency improvement, thereby reduce the cost of production. The results also reveal that the output capacity of the larger factories is higher than that of the smaller factories. The study identifies that the production capacity of tea factories vary between the regions. In fact, the low-country factories have the highest output capacity followed by up-country and mid-country.

Key words: *Technical efficiency, Tea manufacturing firms, Stochastic Frontier Approach*

Introduction

Tea is the main exports among the processed agriculture biomass in Sri Lanka. Moreover, Sri Lanka has been the world leader in made tea exports for many decades with more than 20 percent of the world market share (International Tea Committee, 2005). The tea industry is the dominant industry in Sri Lanka's plantation industry in terms of employment generation and foreign exchange earnings. Having 16.6 percent of the total agriculture GDP share, the tea sector contributes 1.4 percent to the GDP and accounts for approximately 14 percent of the foreign exchange earnings of Sri Lanka (Central Bank of Sri Lanka, 2004). Furthermore, it provides employment for about 15 percent of the total labor force. However, since the 1970s, after the nationalization of private estates, the tea sector underperformed, resulting in a substantial drop in Sri Lanka's share of tea in the world market from 40 percent in 1970 to 16 percent in 2003 (Wikramasinghe and Cameron, 2004). The main reasons for this low performance are low productivity of the tea industry, which is almost 50 percent lower than the major competitors,

and high cost of production, which is about 25 percent higher than them.

Low productivity and the increase in the cost of production have become severe challenges facing Sri Lanka's tea industry. The competitiveness of the Ceylon tea declined in the world tea market due to the high cost of production. This is mainly due to the poor management and low productivity in the cultivation and production practices of Sri Lanka's tea industry (Wikramasinghe and Cameron, 2004). It is estimated that the average cost of tea production increased by 16 percent to Rs.158.25 per kilogram in 2004 compared to the previous year due to the increase in input prices and wage hikes under a collective agreement in 2004 (Central Bank of Sri Lanka, 2004).

With the aim of improving the productivity of this industry, the Sri Lanka government adopted several strategies such as privatization of state owned tea holdings and restructuring the tea industry in 1992/93. First, state owned tea holdings were transferred to private management companies for five year contracts. As a result of the short contract period, companies did not invest in productivity

improvement strategies, which caused a further reduction in the efficiency. Then, in 1995 these companies were granted full property rights of the tea estates, aiming to provide incentives to invest in the productivity improvement of these estates. However, it is doubtful that there have been significant changes in the productivity improvement in the tea industry from privatization.

The final product of black tea is manufactured in tea factories, which consumes 30 percent of the total production cost. Therefore, low efficiency in the factory production can result in a high cost of production. Thus, efficiency improvement in the factory production became an important task in the tea industry to achieve higher competitiveness in the international market. It is, therefore, important to determine the level of productivity and efficiency of factory operations in the Sri Lankan tea industry, which can induce the interest of management of these plantation companies and the policy makers to take necessary adjustments to improve productivity.

However, no empirical research has been carried out to estimate the technical efficiency of the tea factories in Sri Lanka. Therefore, there is a great need to research the production efficiency of the off-farm tea processing, which may contribute largely to the present low performance of the tea industry in Sri Lanka. The aim of this study is to estimate the inefficiency of tea factories in Sri Lanka and to highlight the potential improvement in this sector by improving the technical efficiency of factory processing.

Methodology

The frontier concept initially introduced by Farrell (1957) highlights the idea of maximality and the best practice technology. This method measure the efficiency based on the benchmark of the most efficient firm. Following Kalirajan and Shand (1994), the general model of the stochastic frontier is;

$$\ln(Y_i) = f(X_i; \beta) + \varepsilon_i$$

$$\varepsilon_i = V_i - U_i,$$

where, $\ln(Y_i)$ is the logarithm of the output level of the i th ($i = 1, 2, \dots, n$) firm; X_i is a ($k \times 1$) vector of input level; β ($1 \times k$) is a vector of unknown parameters that are to be estimated.

ε_i is the composed error term which can be decomposed to V_i and U_i terms. V_i 's are the random errors in production, assumed to be independently and normally distributed as $N(0, \sigma_v^2)$ which derives from the factors outside the firm, and are independent of U_i 's. U_i 's are random variables, which are non negative and distributed as $N(0, \sigma_u^2)$ independently. This is assumed to account for technical inefficiency in production. The distribution of U_i is half normal. $|U_i| > 0$ reflects the technical inefficiency associated with the i 'th firm relative to the frontier ($|U_i| = 0$ for a firm whose production lies on the frontier and $|U_i| > 0$ for a firm whose production lies below the frontier).

The firm-specific technical efficiency of production for the i th factory (TE_i) is defined by the following equation:

$$TE_i = \exp(-U_i) = \frac{Y}{f(X_i; \beta) \exp(V_i)}$$

The estimation was carried using both the trans-log production function, which is a more basic form, and the Cobb-Douglas production function. The preliminary analysis revealed that the data set is best described by the Cobb-Douglas production function, which allows maximum flexibility in case of analyzing secondary data (Tybout, 1990). Thus, the model specified as:

$$\ln Y_i = \beta_0 + \beta_1 \ln L_i + \beta_2 \ln K_i + \beta_3 D_High$$

$$+ \beta_4 D_Mid + \beta_5 D_Size + v_i - u_i$$

where Y_i represents the value addition by the i th firm; L_i represents the labor cost of i th firm; K_i is the capital of i th firm; D_Hig denotes the dummy for high grown region, which is equal to 1 if the factory is situated in the up-country region (high-grown tea area), and otherwise 0; D_Mid denotes the dummy for medium grown region, which is 1 if the factory situated in mid-country region (medium-grown tea area), and 0 otherwise (if it is situated in the low-country region (low-grown tea area)), D_Size denotes the dummy for factory size, which is 1 if the factory is large (capital > 10 million rupees) and 0 otherwise. Also, v_i is the stochastic noise and ν_i is the technical inefficiency of the i th firm.

Results and discussion

The ML estimates of the Cobb-Douglas model is presented in Table 1. The FRONTIER 4.1 program estimates the variance parameters in terms of $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma^2$. The estimate of γ in this model is 0.86 and significant at the one percent level, which indicates a larger proportion of error is due to the inefficiency incorporated with the production process and not due to the random error. This indicates that the weaknesses in the input application methods and the technology used by the tea factories in Sri Lanka are largely responsible for the variation of the production function.

Table 1. Maximum likelihood estimates of the Stochastic Frontier model

Variable	Coefficient	Standard Error
Constant	0.522*	0.3029
Labor (lnL)	0.488*	0.3387
Capital(lnK)	0.408*	0.3112
D_High	-0.120*	-0.7381
D_Mid	-0.596**	-0.2046
D_Size	0.220***	0.1605
σ^2	0.108**	0.2210
γ	0.860*	0.4140
Log likelihood	5.687	

All the coefficient estimates are significant at least at the 10 percent level. The estimated ML coefficient of labor and capital are 0.49 and

0.41 respectively and are positive and significant at the one percent level. Therefore, a one percentage point increase in labor investment will increase tea factory value addition by 0.49 percentage points, holding the other conditions constant. Similarly, the output value addition capacity can be increased by 0.41 percentage points by increasing capital of the tea factories by one percentage point.

The coefficient of the size dummy is 0.22, which is positive and significant at the ten percent level. Thus, by rejecting the third null hypothesis, the result proves that the larger tea factories have more value addition capacity than the smaller tea factories in Sri Lanka. The estimated coefficient shows that the larger factories can add 0.22 more units of value to the output than that of the smaller factories under similar conditions.

A possible explanation for this difference is that larger factories have the advantage of economies of scale, and have better access to information and technology. Also, they have the greater capacity of product diversification, which ensures the cost advantage. Oustapassidis *et al.* (2000) argues that the smaller firms suffer from the cost disadvantages and they have little comparative advantage for the product differentiation over the large firms. Tea factories produce a wide range of products and this is highly depending on the factories ability to invest in the necessary production technology. Hence, the relative capacity for product diversification is higher in the larger factories as they can afford large capital investments on technology upgrades.

The coefficients of the regional dummies are 0.12 for the up-country region and 0.6 for the mid country region, which are negative and significant at the one percent and five percent level respectively. This indicates that there is substantial difference in the value addition capacity of tea factories between regions. More precisely, the results show that the low-country factories have the most value addition capacity, followed by the up-country and the mid-country factories the least.

There are three possible explanations for this difference in the low-country area than the other areas. The first possible explanation is that the factories in this region are fairly new, thus they use more modern technology in the

processing and drying such as CTC (cut, curl and tire) technology. Second, most of the newly built factories have private ownership, which are generally high in efficiency as their management methods and technology are modern, whereas state owned old factories, which are scattered in the up and mid regions, have outdated technology and traditional management systems. Third, tea factories located in this area, where the majority is tea small holdings, receive a continuous supply of green leaves from several numbers of holdings, unlike factories in the large estates in the up and mid country regions which cater mainly for their own production. Therefore, the factory can arrange the processing operations to avoid congestion and idling and can ensure a full-capacity running through out the year with out any fluctuation.

The possible reason for the mid-country factory's low performance compared to the up-country factories is the low specialization compared to the up-country region. The Up-country region is highly specialized for the tea industry, which is evident from the more than hundred-year long history of tea production in this region. Thus, adequate skilled labor and well established infrastructure benefit the tea industry in this region, which can offset the negative effects mentioned above.

The mean technical efficiency of the tea factories in Sri Lanka is estimated to be 80 percent, which indicates that the tea factories in Sri Lanka are not operating at their technical efficiency level. In other words, there is a 20 percent potential improvement in this sector, which can be achieved through efficiency improvement of the tea factories. Table 2 shows the estimated technical efficiency distribution of tea factories in all three regions. Technical efficiency, in this sample, varies in a wide range in which the minimum technical efficiency recorded was 41.6 percent while the maximum efficiency was 95 percent. Also, Figure 1 clearly presents the percentage distribution of the factories based on their technical efficiency, which shows 85 percent of the factories within the sample are operating above the 70 percent efficiency level.

Low technical efficiency of the tea factories mainly stems from outdated technology and poor management practices. Many large scale

factories use old dryers which consume lot of energy. Also, the energy loss is very high in these dryers, which eventually leads to the high cost of production. In addition, still there are a considerable number of state owned factories, which use traditional management systems. Since the work incentives are very low in these factories, workers are reluctant to contribute their full effort in the production process, which causes low efficiency. In light of these limitations, the Sri Lanka government has already taken some measures to upgrade the efficiency of the tea industry, such as privatization and rehabilitation of state owned tea plantations. However, there is little focus in these strategies to upgrade the tea factories, which contributes largely to the low efficiency of the tea industry.

Table 2. The distribution of the technical efficiencies of tea factories

Efficiency Score	Number of factories
0.41 - 0.50	2
0.51 - 0.60	0
0.61 - 0.70	5
0.71 - 0.80	15
0.81 - 0.90	17
0.91 - 1.00	8

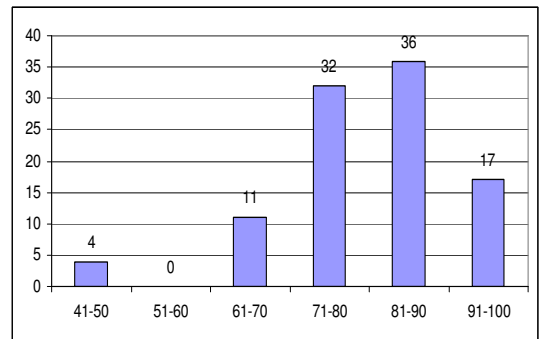


Figure 1. The percentage distribution of factory technical efficiencies within the sample

Conclusions

This study focused on the estimation of the technical efficiency of the tea factories in Sri Lanka applying the Stochastic Frontier

Approach. Also, the study investigated the influence of factory size and the location on their production capacity using micro level data of tea factories in three main tea producing regions in Sri Lanka, namely up-country region, mid-country region and low-country region.

The study results show that the inefficiency in the factory production operations significantly influence the factory productivity. The average technical efficiency of the tea factories in Sri Lanka is estimated at 80%, which indicates that there is a great potential to increase the production by 20% through efficiency improvement, thereby reduce the cost of production which is the greatest challenge in tea industry in Sri Lanka. In other words, if all the factories perform at their maximum technical efficiency, Sri Lanka can produce tea for the world market at a low cost, which would be more competitive than earlier.

The results also reveal that the value addition capacity of the larger factories is higher than that of the smaller factories. The study identifies that the production capacity of tea factories varies between the regions. In fact, the low-country factories have the highest output capacity followed by the up-country and then the mid-country.

Second stage analysis, which identifies the determinants of the inefficiency, should be done for a meaningful policy implication. This study, however, emphasizes the potential improvement of the Sri Lanka tea industry through factory efficiency improvement, which can allow Sri Lanka to regain the competitiveness in the world tea market.

References

- Central Bank of Sri Lanka. Annual Report of the Central Bank of Sri Lanka, Colombo, Sri Lanka, 2004.
- Farrell, M.J., "The measurement of productive efficiency", *Journal of the Royal Statistical Society*, Series A, Part 3, 1957, pp. 253-281.
- International Tea Committee, *Annual Bulletin of Statistics*, Sir John Lyon House, 5, High Timber Street, London EC4V 3NH, UK, 2005.
- Kalirajan, K. P. and Shand, R.T., "Frontier production functions and technical efficiency measures", *Journal of Economic Surveys*, 13(2), 1994, pp. 149-72.
- Oustapassidis, K., Vlachvei, A. and Notta, O., "Efficiency and market power in Greek food industries", *American Journal of Agriculture Economics*, 82, 2000, pp. 623-29.
- Tybout, J.R., Making Noisy Data Sign: Estimating production technologies in Developing countries", *Journal of Econometrics*, 53, 1990, pp. 25-44
- Wikramasinghe, D.W. Ananda and Cameron, Donald, "A cultural political economy of business strategy in a developing country context: The case of Sri Lanka tea industry", Unpublished Paper, 2004.

* *Corresponding Author: J. C. Rohan Jayatilake obtained his B.Sc. and M.Sc. degrees in Agriculture from University of Peradeniya, Sri Lanka. Then he joined Sri Lanka Administrative Service and was attached to the Ministry of Industrial Development as the Assistant Director of the Western Province Industry Development Center. Currently he is reading for his masters degree in International Development Studies at National Graduate Institute for Policy Studies in Tokyo, Japan.*