An Assessment of Technical Efficiency in Intercropped Pineapple Production in Kurunegala District

M. T. C. AMARASURIYA[1] and JAGATH EDIRISINGHE[1]

[1]*Department of Agribusiness Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP)*

ABSTRACT

The study was carried out to estimate the technical efficiency of intercropped pineapple production in kurunegala district and for the identification of factors affecting the technical efficiency. Primary data were collected from eighty growers in kurunegala district using a pre-tested questionnaire. The stochastic frontier production function approach was used to analyze data. The pineapple production was determined as a function of land extent, plant density, labour, fertilizer, agrochemicals and worth of assets. The land extent, plant density, labour and fertilizer were found to be significantly affecting the pineapple production.

The technical inefficiency was regressed as a function of season, age, education, number of family members, land, plant density, ownership, experience, occupation, off farm income and constraint index. The technical efficiency was significantly affected by season, ownership, experience, off farm income and a constraint index. The mean technical efficiency of pineapple production was eighty five percent. The study reveals that there is a possibility, for further increase of productivity.

KEYWORDS: Frontier production function, Pineapple (*Ananas comosus*) production, Technical efficiency

INTRODUCTION

Pineapple is one of the leading commercial fruit crop grown in Sri Lanka. Pineapple production plays an important role in SriLankan economy making an export earning of rupees 271 million in 2004 and it is the highest exported fruit in Sri Lanka (Anon, 2004).The total exportation of pineapple was 4.3 million of kilograms in 2004. It had 5,188 hectares under cultivation and produced 48.1 millions of fruits (Anon, 2004).

Pineapple is grown as an inter crop or a mixed crop. 'Mauritius' and 'Kew' are the major varieties grown in Sri Lanka. Kurunegala and Gampaha are the major pineapple growing districts in Sri Lanka. 'Mauritius' is mainly grown in kurunegala district and 'Kew' is mainly grown in Gampaha district. Seventy percent of the pineapple production was produced in Kurunegala and Gampaha districts and remaining 30 % of the production was from Badulla, Kalutara, Matara, Hambanthota and puttalam districts (Sulaiman, 1999).

The major problems faced by the pineapple producers are decreasing income due to increased cost of inputs and the low productivity of existing lands. National productivity is far below the potential. The average productivity of pineapple is 10 mt/ha per annum, While the potential productivity is 20 mt/ha per annum (Heenkenda and Medagoda, 2001). Therefore the productivity of pineapple needs to be increased.

One way of improving the productivity is to improve the efficiency of input used. Therefore, this study was aimed to estimate the current level of the technical efficiency of the pineapple growers. Thereby to evaluate the factors that may lead to the inefficiency, in order to derive policy to increase the efficiency and thus productivity.

METHODOLOGY

Sample selection

Kurunagala district was selected due to two main reasons. First as it is the largest pineapple growing region in the country. Second as it is popularly intercropped with coconut in the coconut triangle. Data were collected from farmers in Giriulla, Kuliyapitiya, Dambadeniya and Pannala, where the pineapple cultivation is abundant in kurunegala district.

Data collection

The data for this study were collected from eighty randomly selected farmers using a pre tested questionnaire. This was done by a survey using the interview method, from March to June in 2006. From the eighty respondents; 40 growers were owners of initial (first year) cultivations, and the other 40 farmers owned mature (second year) cultivations.

Information on production and inputs were collected in order to estimate the level of technical efficiency. The Socio economic data of farmers were also collected to identify the factors that influence for the technical inefficiency.

Analytical method

Technical Efficiency (TE) of an individual farmer is defined in terms of "the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the farmer". The technical inefficiency is therefore defined as the amount by which the level of production of the farm is less than the frontier output.

This study focuses a stochastic frontier approach (SFA). When measuring technical efficiency, a production function is used. A production function is a model used to formalize the production relationship.

The computer program, Frontier Version 4.1, was used to estimate the stochastic frontier production function using maximum likelihood method (Battese & Coelli, 1995). The model can be specified as follows,

$Y_i = f(x_i,\beta) + e_i$ .... (1)
$e_i = V_i - U_i$ where, $i = 1, 2 \ldots N$

Where

Y_i is the production (or the logarithm of the production) of the i^{th} firm

$f(xi;\beta)$ is a suitable function such as Cobb-Douglas or translog production function.

x_i is input quantities of the i^{th} firm

β is a vector of unknown parameters to be estimated.

e_i is the composed error term

V_i is a random error, which is associated with random factors outside the control of the firm and it is assumed to be symmetric independently distributed as $N(0, \sigma_v^2)$.

U_i is a non-negative random variable associated with farm-specific factors (under the control of the firm), which leads to the i^{th} firm inefficiency of production; and ranges between zero and one.

U_i is identically and independently distributed as $N(0,\sigma_U^2)$.

The idea behind the stochastic frontier model is that the error term is composed of two parts. In the stochastic frontier production function, the model allows for specification of two equations. One equation specifies the main factors of production and the other equation specifies the variables that are assumed to cause inefficiency.

According to Battese & Coelli (1995), technical inefficiency effects are defined by,

$U_i = Z_i\,\delta_i + w_i$ .... (2)
$i = 1\ldots\ldots., n$

Where,

z_i – factors contributing to efficiency

δ_i – vector of unknown parameters to be estimated

w_i– unobservable random variables, which are assumed to be identically distributed, obtained by truncation of the normal distribution with mean zero and unknown variance σ^2, such that U_i is non negative.

Here TE was estimated using a two-stage process. First, was to measure the level of efficiency using a frontier production function. Second, was to determine socio-economic characteristics that determine levels of technical inefficiency. The computer program calculates predictions of individual growers' technical efficiencies from estimated stochastic production frontiers. The measures of technical efficiency relative to the production frontier are defined as:

$TE = Y_i / Y_i^*$, where $Y_i^* = f(x_i, \beta)$, highest predicted value for the ith firm
$TE_i = \mathrm{Exp}(-u_i)$

In the case of a production frontier, TE_i will be taken a value between zero and one. Therefore,
Technical inefficiency = $1 - TE_i$

According to Battese & Corra (1977), the variance ratio parameter γ, which is related to the variability of u_i (σ^2_u) to total variability (σ^2), can be calculated in following manner.

$\gamma = \sigma^2_u / \sigma^2$..(3)

where $\sigma^2 = \sigma^2_u + \sigma^2_v$

So that $0 \leq \gamma \leq 1$

If γ is close to zero, the difference between a farmer's yield & the efficient yield is mainly due to statistical error. If γ, is close to 1, the difference is attributed to the farmer's less than efficient use of technology.

The likelihood-ratio test is used to test the significance of the model. It is also used in testing the functional form of the model (Madan *et al,* 2000).

Production relationship can be expressed in several forms such as: Cobb-Douglas and translog functional forms.

Translog functional form

$$\ln y_i = \alpha_o + \sum_{k=1}^{6} \alpha_k \ln x_{ki} + \sum_{k=1}^{6}\sum_{j=1}^{6} \alpha_{kj} \ln x_{ki} \ln x_{ji} + \varepsilon_i$$

$$\varepsilon_i = v_i - u_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Cobb Douglas functional form

$$\ln y_i = \alpha_0 + \sum_{k=1}^{6} \alpha_k \ln x_{ki} + (v_i - u_i) \quad \ldots.. (5)$$

The study was used six independent variables in the above production functions. They are,

X_{1i} = Land (ac)
X_{2i} = Plant density
X_{3i} = Fertilizer cost
X_{4i} = Agrochemical cost
X_{5i} = Labour cost
X_{6i} = Assets value

A stochastic production function can be estimated using either the maximum likelihood method or using a variant of the COLS (Corrected Ordinary Least Squares) method (Richmond, 1974) (cited on Gunarathne, 2002). Heteroscedasticity is a violation of one of the requirements of ordinary least squares (OLS) in which the error variance is not constant. The consequences of heteroscedasticity are unbiased but inefficient. The variances are either too small or too large, leading to errors in the presence of heteroscedasticity. OLS is not best linear unbiased estimator (Betty Wambui Kibaara, 2005).Therefore, in this study maximum likelihood estimates of the parameters were used to estimate the production function.

The inefficiency related to farmer specific factors which can be expressed using the following multiple linear regression model.

$INEFF_i = \beta_0 + \beta_1 SEA_i + \beta_2 AGE_i + \beta_3 EDU_i + \beta_4 MEM_i + \beta_5 LAND_i + \beta_6 DEN_i + \beta_7 OWN_i + \beta_8 EXP_i + \beta_9 OCCU_i + \beta_{10} INC_i + \beta_{11} CONS_i$ .... (6)

$INEFF_i$ = Inefficiency of the i^{th} grower
SEA_i = Seasonal effect of the i^{th} grower, a dummy variable equal to one if first season, zero otherwise
AGE_i = Age of the i^{th} grower
EDU_i = Education level of the i^{th} grower
MEM_i = No: of family members of the i^{th} grower
$LAND_i$ = Land area of the cultivation of the i^{th} grower
DEN_i = Plant density of the cultivation
OWN_i =Ownership of the i^{th} grower, a dummy variable equal to one if land is rental, zero if own
EXP_i = Experience in pineapple cultivation of the i^{th} grower
$OCCU_i$=Occupation of the i^{th} grower, a dummy variable equal to one if farming is full time, zero if part time
INC_i = Off farm income of the i^{th} grower
$CONS_i$ = Constraint index of the i^{th} grower
$\beta_0 - \beta_{11}$ = Coefficients to be estimated

The pineapple production was measured in kilograms which was the dependent variable. The extent of land was measured in acres. The labour was measured in terms of man days, a 8 hours working day of a man was considered as a man day. A woman day was considered as 0.75 of a man day. The expenditure on fertilizer and agrochemicals were measured in rupees.

Problems faced by the pineapple growers can be categorized in to five major problems. Severities of the problems faced by the individual growers were obtained according to the marks they had given out of ten for the each problem separately. These problems were introduced to the inefficiency model by converting them in to an index. Index was calculated for each grower separately as below.

Constraint index = $[(\Sigma X_i) / n] / 10$ .... (7)
X_i = marks given out of ten for the i^{th} problem
$i = 1$ ...., n

RESULTS AND DISCUSSION

Production relationship was developed using both Cobb Douglas and translog forms. Significance of the that the estimated coefficients are cross terms of translog function can be used to determine whether translog or Cobb Douglas form suits the data (Gunaratne, 2001). Few variables and few cross terms were significant in the translog form. Therefore the Cobb Douglas functional form was selected to measure the technical efficiency. But it imposes a restriction on the farm's technology by restricting the production elasticities to be constant and the elasticites of input substitution to be unity (Betty Wambui Kibaara, 2005).

The Maximum Likelihood (ML) estimates for the parameters of the translog function are presented in the Table 1.

Table 1 - ML estimates for the parameters of the translog function:

	Parameter	Coefficient	t-ratio
Stochastic frontier			
Intercept	β_0	3.5319*	3.445
Land (ac)	β_1	0.4621*	3.770
Plant density	β_2	0.7004	1.021
Fertilizer	β_3	0.0474	0.081
Agrochemicals	β_4	0.1779	1.909
Labour	β_5	1.3902*	2.864
Assets value	β_6	-1.1269	1.735
Land *Land	β_7	0.1203*	3.213
Plant den:* Plant den:	β_8	−0.0082	−0.209
Fertilizer* Fertilizer	β_9	0.0002	0.010
Agroche: *Agroche:	β_{10}	-0.0079	1.576
Labour* Labour	β_{11}	-0.1309*	-2.714
Assets: *Assets:	β_{12}	0.0706	1.914
Total variance (σ^2)		0.1195	2.981
Variance ratio (γ)		0.9681	50.280
Log likelihood function		56.38	
LR test		28.55	

* Significant at 5 percent level

The Maximum Likelihood (ML) estimates for the parameters of the Cobb Douglas production model are presented in Table 2.

The LR test value indicated that the model has a good fit. The estimated value for the γ was 0.92. This implies that the γ was close to one, and the different between the farmer's yield and the efficient yield is mainly due to the technical inefficiency. This implies that the technical inefficiency effects were significant in the stochastic frontier model.

All the variables in the estimated production function model had positive coefficients. The positive coefficient implies that any increase in the value of the variable would increase the production.

The estimated ML coefficients for land, plant density, fertilizer and labour were positive and found to have significant impact on pineapple production. This indicates that an increment of the level of inputs will increase the level of output. The coefficient of land showed high input elasticity.

The mean technical efficiency of pineapple growers was 84.98 percent; thus there is a possibility to increase the efficiency of pineapple production by

Table 2 - OLS and MLE for the parameters of stochastic frontier (Cobb Douglas model) for the pineapple production:

	Parameter	Coefficient OLS	Coefficient ML	t-ratio OLS	t-ratio ML
Stochastic frontier					
Intercept	β_0	1.8845	1.5912*	3.550	3.623
Land (ac)	β_1	0.1309	0.7345*	1.830	10.219
Plant density	β_2	0.5543*	0.6117*	8.494	12.176
Fertilizer	β_3	0.1234*	0.0918*	2.662	2.593
Agrochemicals	β_4	0.0343*	0.0231	2.011	1.569
Labour	β_5	0.2356*	0.1918*	2.588	2.782
Assets value	β_6	0.0017	0.6501	0.032	1.655
Total variance (σ^2)			0.0539	4.390	
Variance ratio (γ)			0.9246	15.551	
Log likelihood function			43.5042		
LR test			13.5615		

*significant at 5 percent level

15 percent without any additional cost. However efficiency varies from 50 to 97 percent. The distribution of technical efficiencies of studied pineapple growers were given in table 3.

Table 3 - Technical efficiency levels of pineapple growers:

Technical Efficiency (%)	Number of Farmers (%)
<60	3.75
60-69	2.50
70-79	12.50
80-89	46.25
90-100	35.00
Maximum	0.97
Minimum	0.50
Average	0.85

Inefficiency measures resulted here, were related to farmer's specific factors which were analyzed using multiple linear regression procedure. The result of the regression is given in Table 4.

Table 4 - Results of the regression procedure for inefficiency model:

Variable	Parameter estimate	Pr>F
Intercept	8.457*	0.007
Season	-1.439*	0.046
Age	1.124	0.385
Education	1.011	0.928
No: of family mem:	-1.075	0.567
Land	1.114	0.451
Plant density	-1.285	0.200
Ownership	-1.283*	0.045
Experience	-1.363*	0.030
Occupation	1.124	0.430
Off farm income	1.394*	0.037
Constraint index	1.420*	0.003

* Significant at 5 percent level.

The coefficients of the off farm income and constraint index were positive and significant. The positive and significant coefficient of off farm income suggests that growers who are only involving in farming are more efficient than those who get the off farm income.

The positive and significant coefficient of constraint index suggests that inefficiency increase with the severities of the problems faced by the grower. If the problems exist in lower levels, inefficiency is reduced and if the problems exist in higher levels, inefficiency is very high. Levels of the problems are depended on the grower.

Major problems faced by the growers were high input cost, lack of certified price, labour shortage, high cost of mulching materials and marketing difficulties. Most of the growers do not devote much time for the cultivation, reasons being the price fluctuations, marketing difficulties and high cost of production. They keep the cultivation to obtain extra income with minimum use of resources, since even then it is profitable. Therefore they didn't consider much about the optimum utilization of the cultivation

The coefficients of the season, experience and ownership were negative and significant. A negative coefficient implies that any increase in the value of the variable lead to reduce the level of technical inefficiency (increase the efficiency). The knowledge of the growers about the cultivation is increased with the experience. If the growers obtain lands for rent, due to rent fee efficiency is very high. Therefore the negative coefficients of ownership and experience reveal that the proper knowledge and rental ownership encourage growers to reduce inefficiency.

The negative and significant coefficient of season implies that first season of the cultivation is higher in efficiency than the second season; with the time efficiency is reduced. This can be a major reason of efficiency reduction in pineapple cultivation. The education, age, number of family members, land, plant density and occupation of the grower did not show any significant impact on efficiency.

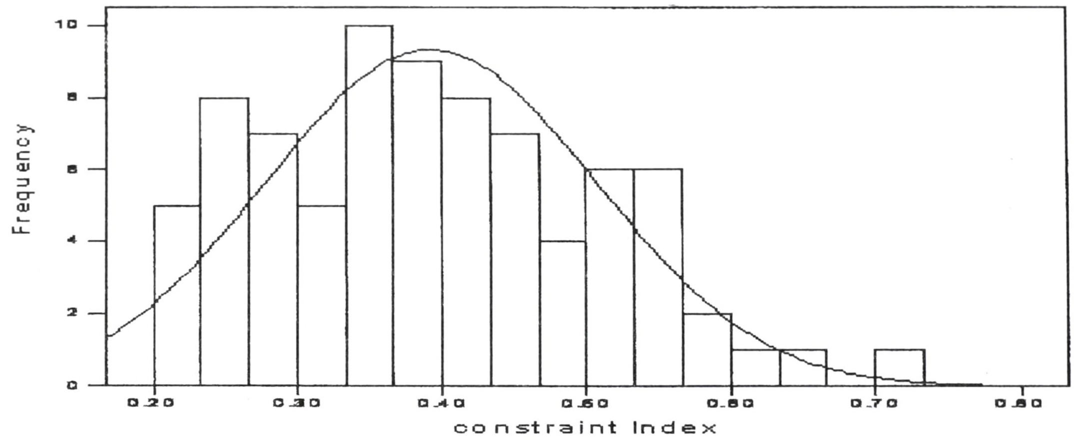

Figure 1 - Distribution of Constraint Index:

CONCLUSIONS AND POLICY IMPLICATIONS

Cobb Douglas production function was estimated for pineapple production in the kurunegala district. The results indicate that land, labour, fertilizer and plant density have positive and significant impact on pineapple production. The average technical efficiency of pineapple production is 85 percent. The results indicate that, there is a possibility, for further increase of the pineapple production by 15 percent without using any additional inputs. An index was developed to measure the severities of the problems, by that problems were include as a variable for the inefficiency model. The inefficiency model indicates that season, ownership, experience, off farm income and constraint index have significant effect on technical inefficiency. Less income growers are more efficient than higher income growers. Inefficiency increases with the increment of problems and decreases with the rental ownership and experience of the growers.

Thus the inefficiency can reduce mainly by three ways. First way is by solving the problems, such as improving the marketing facilities, implementation of the guaranteed price scheme, which will encourage growers. Second way is by improving knowledge of the growers. Therefore the use of a proper extension system is evident here. Third way is to formulation of a specific methodology to increase the efficiency of the cultivation beyond the first season. This can be a better solution, if it can be implemented.

ACKNOWLEDGEMENT

The authors wish to thank thanks Ms.Janakee Alvis, (Regional Agricultural Research & Development Centre, Makandura) for providing information and data about pineapple production.

REFERENCES

Amarasinghe, S.T.C and J.Weerahewa. (2001). "An assessment of technical efficiency of potato production." *Tropical agricultural Research,* 13: 292-300.

Anon, (2005). "Extent and Production of Pineapple", Department of Censes and Statistics, Colombo, Sri Lanka.

Anon, (2004)."Exports of Pineapple". Department of Custom. Colombo, Sri Lanka.

Basnayake, B.M.J.K and H.P.Gunaratne. (2001). "Estimation of technical efficiency and it's determinants in the Tea small holding sector in the mid country Wet zone of Sri Lanka " *Tropical agricultural Research,* 14: 137-150.

Battese, G.E and G.S. Corra. (1977). "Estimation of a Frontier Model." *Australian journal of Agricultural Economics,* 21: 167-179.

Battese, G.E and T.J.Coelli. (1995). "A Model for Technical Inefficiency in a Stochastic Frontier Production Functions." *Empirical Economics,* 20: 325-332.

Betty Wambui Kibaara. (2005). "Technical efficiency in Kenyan's Maize production." The Colorado State University, p 31.

Gunaratne, R.U.M.S and S.Thiruchelvam. (2002). "Comparative study on technical efficiency of paddy production under major and minor irrigation schemes in Anuradhapura District." *Tropical agricultural Research,* 14: 341-350.

Heenkenda, H.M.S (2001). "Present status of the fruit industry and issues on organic fruit production in Sri Lanka." Horticultural Crop Research and Development Institute, Peradeniya, Sri Lanka.

Madan M.D, J. Ferdinand, Paraguas and B. Gaspar. (2000). "Technical efficiency of tilapia growout pond operations in thePhilippines." *Aquaculture Economics and Management,* 4: 33-34.

Sulaiman, S.F.M (1999). Pineapple Production and Research in Sri Lanka, ISHS Acta Horticulturae, 529, Available at http://www.actahort.org/ .[Retrieved February 2, 2006).