Technical Efficiency in Intercropped Pineapple Production in Kurunegala District

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ABSTRACT

The objective of the study was to estimate the current level of technical efficiency and to identify the factors affecting technical efficiency of intercropped pineapple production in Kurunegala district. A questionnaire based survey was carried out to collect the data from eighty pineapple growers. The data were analyzed by using the stochastic frontier production function approach. 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 had significant effect on pineapple production in Kurunegala district. 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 crops grown in Sri Lanka. Pineapple production plays an important role in Sri Lankan economy making an export earning of Rs. 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 million of fruits (Anon, 2004).

'Mauritius' and 'Kew' are the major varieties grown in Sri Lanka. It is grown as an intercrop or a mixed crop. Around 90 percent of pineapple is cultivated in Gampaha and Kurunegala districts providing a livelihood to a large number of people. Badulla, Puttalam, and Moneragala are the other districts where pineapple is being cultivated commercially.

The major problems faced by the pineapple growers are decreasing income due to high cost of production particularly due to fertilizer, and shortage of land for pineapple cultivation. 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). This emphasizes the need of productivity enhancement in pineapple.

Improve the efficiency of input used is one of the strategies that can be taken into the account as a way of improve the productivity. The study was aimed to estimate the current level of technical efficiency of pineapple growers and to identify the factors lead to inefficiency. Thereby, to derive policy measures to increase technical efficiency and thus productivity.

METHODOLOGY

Sample Selection

Selecting Kurunegala district to collect data was two fold. First it is the main district cultivating pineapple commercially covering 2,069 ha and second, is a popular intercrop under coconut in the coconut triangle. Data were collected from farmers in Giriulla,

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Kuliyapitiya, Dambadeniya and Pannala, where the pineapple cultivation is abundant within the selected area.

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 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 (Battese and Coelli, 1995). The model can be specified as follows,

$Y_i = f(x_i, \beta) + e_i$ ……………………........ (1)

$e_i = V_i - U_i \quad i = 1, 2 \ldots N$

where,

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

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

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

β = a vector of unknown parameters to be estimated.

e_i = the composed error term

V_i = 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 = 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. 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 and 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,β), highest predicted value for the ith firm

$TE_i = \text{Exp}(-u_i)$

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 and 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.

$$\gamma = \sigma^2_u / \sigma^2 \quad \text{...(3)}$$

Where, $\sigma^2 = \sigma^2_u + \sigma^2$

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

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

$$\varepsilon_i = v_i - u_i$$

$$\text{.....................} (4)$$

Cobb Douglas functional form

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

$$\text{..................} (5)$$

The study was used six independent variables in the above productions. 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, thiruchelvam 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 that the estimated coefficients 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.

$$INEFF_i = \beta_0 + \beta 1SEA_i + \beta_2 AGE_i + \beta_3 EDU_i + \beta_4 MEM_i + \beta_5 LAND_i + \beta_6 DEN_i + \beta_7 OWN_i + \beta_8 EXP_i + \beta_9 OCCU_i + \beta_{10} INC_i + \beta_{11} CONS_i \quad \text{...(6)}$$

Where,

$INEFF_i$ = 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

B_0-β_{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, an 8 hour 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 valued 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 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.

$$\text{Constraint index} = [(\Sigma X_i) / n] / 10 \quad \ldots\ldots (7)$$

Where,

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 cross terms of translog function can be used to determine whether translog or Cobb Douglas form suits the data (Gunaratne and Thiruchcelvam 2002). 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). Table 1 shows coefficients of the estimated parameters.

Table 1: Maximum Likelihood Estimates (MLE) for the parameters of the translog function

Variable	Coefficient	t- ratio
Intercept	3.5319*	3.445
Land (ac)	0.4621*	3.770
Plant density	0.7004	1.021
Fertilizer	0.0474	0.081
Agrochemicals	0.1779	1.909
Labour	1.3902*	2.864
Assets value	-1.1269	1.735
Land *Land	0.1203*	3.213
Plant den:* Plantden	-0.0082	-0.209
Fertilizer* Fertilizer	0.0002	0.010
Agroche: *Agroche:	-0.0079	1.576
Labour* Labour	-0.1309*	-2.714
Assets: *Assets:	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

Table 2: Ordinary Least Squares (OLS) and Maximum Likelihood Estimates (MLE) for the parameters of stochastic frontier (Cobb Douglas model) for the pineapple production

	Coefficient		t-ratio	
	OLS	**ML**	**OLS**	**ML**
Intercept	1. 8845	1. 5912*	3.550	3. 623
Land (ac)	0. 1309	0. 7345*	1.830	10. 219
Plant density	0. 5543*	0. 6117*	8.494	12. 176
Fertilizer	0. 1234*	0. 0918*	2.662	2. 593
Agrochemicals	0. 0343*	0. 0231	2.011	1. 569
Labour	0. 2356*	0. 1918*	2.588	2. 782
Assets value	0. 0017	0. 6501	0.032	1. 655
Total variance		0. 0539	4.390	
Variance ratio		0. 9246	15.551	
Log likelihood function		43. 5042		
LR test		13. 5615		

*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 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. 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 increases with the severities of the problems faced by the grower.

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.

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 did not 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 was 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 was higher in efficiency than the second season; with the time, efficiency was reduced. This can be a major reason for reduction in efficiency 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 graphically illustrate the 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 included as variables 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.

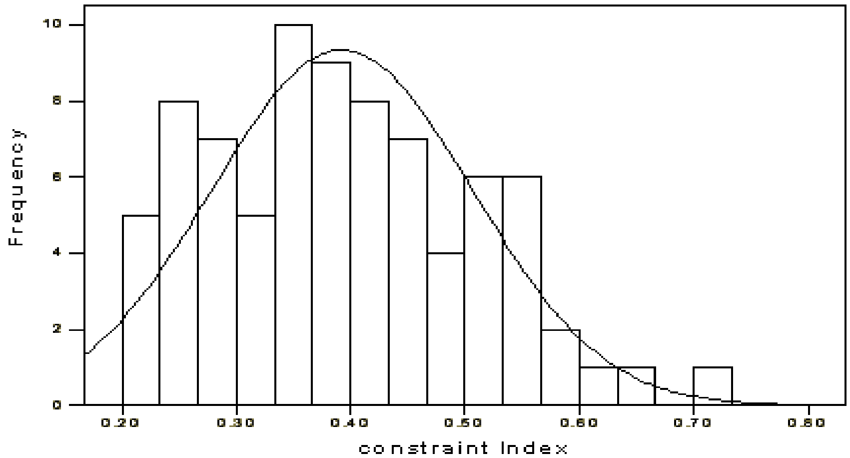

Figure 8: Constraint Index

Second way is by improving knowledge of the growers. Therefore the use of a proper extension system was evident. 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.

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