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HYPOTHESIS (ES)
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TECHNICAL EFFICIENCY ESTIMATION: A STUDY ON SMALL SCALE PINEAPPLE FARMS IN KERALA

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ABSTRACT

Agriculture in Kerala experienced a shift in area of production in the 1980's which is favourable towards pineapple cultivation. Though Kerala has a conducive environment for pineapple cultivation, it faces stagnation in productivity. In this context the present study is undertaken to analyse the efficiency in resource utilization in small scale intercropped pineapple cultivation in Kerala. The study is conducted among the farms having < 2ha of area of cultivation selected on the basis of stratified random sampling and data was through pre tested questionnaire. The efficiency is estimated by fitting a production function of Cobb-Douglass type on a Stochastic Frontier Model. The parameters of the function estimated by the Maximum Likelihood Estimation method and the method is validated using Generalized Ratio Test. The results of the study revealed that the mean technical efficiency of farms is 72 per cent and the major inputs that can contribute for the improvement of efficiency are plant density, weedicides and pesticides and chemical fertilizers. The exogenous variables that can reduce inefficiency are mode of ownership and experience of farmers. The study is concluded with some suggestions and the scope for further area of research.

KEYWORDS
maximum likelihood estimation, pineapple cultivation, productivity technical efficiency.

JEL CODES
C10, C13, Q15.

INTRODUCTION

Agriculture in Kerala has undergone a structural change by the end of 1980's. The shift in pattern of area of cultivation was favourable mainly to pineapple cultivation, one of the prominent fruit crop in Kerala. A statistics of shift in cropping pattern of area of cultivation showed a huge hike in area of pineapple cultivation and a decline in area of cultivation of traditional crops like ginger, turmeric and tapioca in the State. This shift in cultivation of pineapple gained its momentum when the farmers began to cultivate pineapple as an intercrop in new /replanted rubber plantations and coconut plantations and as a mono crop in converted paddy lands. The main reasons for the flourishing of pineapple cultivation as an intercrop are: firstly, unlike annual intercrops, pineapple is cultivated in the first 3-4 years of the new / replanted rubber and it gives income to farmers when there is no income from rubber plantations. Secondly the intercropping of pineapple in rubber plantations prevents soil erosion and helps to reduce weed growth in rubber plantations (Jose 1993 and Joy 2010). Thirdly, as a major part of pineapple cultivation is taken place in the leased lands, and considering the severe unemployment and high fragmentation of agricultural land in Kerala, the pineapple cultivation gives an opportunity to the thousands of land less farmers to engage in agriculture and earn a livelihood to their lives.

Main varieties of pineapple cultivated in Kerala are Kew and Mauritius. The variety mostly cultivated in Kerala is Mauritius, which is very much in demand as a fresh fruit throughout India and also in foreign countries because it is considered as the best in quality and has good flavor. More than 95per cent of the pineapple produced in Kerala is marketable as fresh fruit throughout India and pineapple is the only fruit in Kerala which has the marketable surplus. Joy, P.P (2010)

REVIEW OF LITERATURE

The literature regarding technical efficiency began in the 1950's with the work of Koopmans (1951), Debreu (1951) and Shephard (1953). Farrel (1957) was the first to use frontier production functions to measure technical efficiency. The method involves estimating a frontier production function in order to calculate the maximum output that can be obtained by each production unit with a given combination of inputs. Units that are technically efficient will be located at the frontier, while those that are not will appear below the frontier since they obtain less output than technically possible. The estimation of production frontiers has proceeded along two general paths i.e. deterministic frontier and stochastic frontier.

DETERMINISTIC FRONTIERS

Deterministic Frontiers force all observations to be or below production frontiers so that all observations from the frontier are attributed to inefficiency. In deterministic specification, all deviations from the efficient frontier are under the control of the agent. However, there are some circumstances out of the agents control that can also determine the suboptimal performance of units. Regulatory –competitive environments, weather, luck, socio economic and demographic factors uncertainty etc. should not properly be considered as technical efficiency. Aiger and Chu (1968), Timmer (1971), Afriat (1972) and Richmond (1974) were the major contributors of deterministic thought. The estimation of efficiency in this model is either by means of linear programming techniques or by modification to least squares technique requiring all residuals to be non-positive. The Cobb-Douglas form model can be expressed as:

$Yi= f (Xi; \beta).\exp \{-Ui\}$

Where Ui is the farm specific technical efficiency parameter. If the firm is technically efficient, Ui takes the value zero and the production frontier function is the same as Y*, Ui takes the value less than zero for the firms which are not technically efficient and the firms accordingly obtain their output Yi < Y*. The negative value of Ui will vary among firms depending up on their technical efficiency accordingly to how close they are to the frontier. (Kalirajan & Shand 1986).

STOCHASTIC PRODUCTION FRONTIER

In Stochastic Production Frontier the disturbance term consists of two components, the first one represents technical inefficiency and the other the usual random noise. The advantage of the stochastic frontier over the deterministic frontier is that farm specific efficiency and random error effect can be separated. A key feature of the stochastic production frontier is that the disturbance term is composed of two parts, one symmetric and other one sided. The symmetric component captures the random effects outside the control of the decision maker including the statistical noise contained in every empirical relationship. The one sided component captures deviation from the frontier due to inefficiency. The Cobb-Douglas form model can be expressed as:

$Yi= f (Xi; \beta).\exp \{Vi-Ui\}$

Introduction of Vi in *equation* means that Y^*& Yi is stochastic and that Vi captures other random factors such as errors in measurements and deviation from the true functional relationship. The value of Vi therefore may either be positive, negative or zero. Thus the stochastic production frontier model is a composed error model $\varepsilon i = Vi-Ui$ where Vi is the two sided noise component and Ui is the one sided non negative technical inefficiency component of the error term. The two sided noise component Vi is assumed to be independently and identically distributed (iid) and symmetrically distributed independently of Ui. But the composed error term $\varepsilon i = Vi-Ui$ is asymmetric since $Ui \geq 0$.

Stochastic Production Frontier originated with three independent papers, published nearly simultaneously by three teams. Meeusen &van den Brock (MB)1977, Aigner, Lovell &Schmidt (ALS) 1977 and Battese &Corra(BC) 1977.These Stochastic Production Frontier models shared the composed error structure. MB assigned an exponential distribution to U, BC assigned a half normal distribution to U and ALS considered both exponential and half normal distribution for U. Parameters to be estimated include β,σ^2v and a variance parameter σ^2u associated with U. Either distributional assumption on U implies that the composed error (V-U) is negatively skewed and statistical efficiency requires that the model is estimated by maximum likelihood method.

IMPORTANCE OF THE STUDY

One of the peculiarities of land in Kerala is the higher fragmentation of the land in the state when compared with other states. The average operational land holding size is only 0.2 ha and marginal and small farmers have predominance in operational holding of land. Statistics regarding the percentage increase of area, production and productivity of pineapple for the period 1992-2007 revealed that area of cultivation increased by 62 per cent, production increased by 68 per cent and productivity increased by mere 0.59 per cent between the period The area and production of pineapple showed an increasing trend, but the productivity was in a stagnant stage for the same period (Economics and Statistics Department. Govt of Kerala, various years). A negative or narrow percentage change in yield coupled with positive change in production implies that the total gain in production has come from area expansion alone. The statistics revealed that in Kerala the sustainable growth of pineapple cultivation lies more on productivity improvement than on area expansion. Various studies also revealed that about 60 per cent of farmers engaged in pineapple cultivation are small operational holders (Padmini 2002).

The aforesaid discussions may lead to some relevant research questions regarding the intercrop pineapple cultivation in Kerala. What is the present level of efficiency in utilizing the available resources? Whether the low productivity of crop is due to the inefficient use of inputs by the farmers? If inefficiency exists among farmers, then what are the probable factors that contribute to inefficiency? etc. So the present study is aimed to find out the probable answers to the above research questions on small scale intercropped pineapple farms

STATEMENT OF THE PROBLEM

The pineapple farming in Kerala faces low productivity which may arise due to the inefficiency of input usage by farmers or may be of the inefficiency due to random factors outside the control of farmers or by both. It should be made clear about what type of inefficiency leads to low productivity before initiating actions to improve efficiency among the small farms.

OBJECTIVES OF THE STUDY

The present study is carried out with following objectives.

1. To estimate the technical efficiency of intercrop pineapple cultivation in Kerala among the small farms
2. To identify the determinants of inefficiency in the intercrop pineapple cultivation in Kerala among the small farms.

HYPOTHESIS

The following null hypotheses are used to test the validity of the model.

1) H_0: Inefficiency effects are not present in small scale pineapple farms.

H_0:$\gamma = \delta_0 = \delta_1 \ldots\ldots \delta_k = 0$

2) H_0: Inefficiency effects are not stochastic.

H_0:$\gamma = 0$

3) H_0: Variables in the Inefficiency effects model have no effect on level of technical inefficiency.

H_0: $= \delta_0 = \delta_1 \ldots\ldots \delta_k = 0$

These null hypotheses are tested using the generalized likelihood ratio statistics λ defined by: $\lambda = -2\ln[L(H_0)-L(H_1)]$, where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the specifications of null and alternative hypothesis respectively.

METHODOLOGY

In Kerala, Ernakulam, Idukki and Kottayam districts together constitute 80 per cent of total area and 85 per cent of total production of pineapple in the state (Agricultural Statistics, Government of Kerala, various years). The present study is using primary data collected by conducting a sample survey among the pineapple farmers using a pre tested structured questionnaire. Multi stage sampling was used in the present study. A stratification of farmers was done on the basis of operational holdings of below 2 ha in the above districts and a sample of 149 and was selected by proportionate stratified random sampling. The technical efficiency estimation was done through Maximum likelihood (ML) estimation which was done by regression analysis. The results of the analysis were tested for significance using Generalised LR (Log likelihood Ratio) test. The technical efficiency (TE) is estimated for the small farms, using the stochastic production frontier technique.

Consider the following generalized stochastic production function that can be specified as

$Yi = f(Xi; \beta)\exp\{Vi-Ui\}$, i = 1, …,N ………..(1).

Where

Yi = Production of the i-th firm.

Xi = k ×1 vector of (or transformation of) the input quantities of the i^{th} firm.

β = vector of unknown parameters.

Vi = random variables which are assumed to be independently and identically distributed (iid) as $N(0, \sigma^2 v)$.

Ui = non-negative random variables that are assumed to account for technical inefficiency in production and are often assumed to be iid as $N(0, \sigma^2 u)$. It is assumed to be half normal, exponential and truncated from below at zero.

Let $X = (X_1,\ldots\ldots X_N) \geq 0$ be an input vector used to produce scalar output $Y \geq 0$ and let $Z = (Z_1,\ldots\ldots Z_Q)$ be a vector of exogenous variables that influences the structure of the production process by which inputs *X* are converted to output *Y*.

The log-linear Cobb-Douglas form of *equation* (1) can be written as:

$\ln Yi=\beta_0+\Sigma_n\beta_n\ln X_{ni} +Vi -Ui$………(2)

Where *ln* denotes natural logarithms, Yi, β and Xi are as defined in *equation* (1).

Vi = random variables which are assumed to be independently and identically distributed (iid) as $N(0, \sigma^2 v)$.

Ui = non-negative random variables that are assumed to account for technical inefficiency in production assumed to follow a truncated (at zero) normal distribution as $N(\mu_i, \sigma^2 u)$.

With these assumptions the mean of technical inefficiency effects μ_i is a function of the explanatory variables and can be specified as:

$\mu_i= Zi\delta+W_i$……….(3)

Where

Zi is a (p×1) vector of variables which may influence the efficiency of a firm; δ is an (1×p) vector of unknown parameters to be estimated.The technical efficiency of production for the i^{th} farm is defined as follows:

$TE_i = \exp(-U_i)$ …….(4).

The technical efficiency of a farmer is between zero and one and is inversely related to the inefficiency effect. The parameters to be estimated are β,δ, λ, $\sigma^2 v$ and $\sigma^2 u$. $\sigma^2= \sigma^2 v+ \sigma^2 u$ and $\gamma= \frac{\sigma^2 u}{\sigma^2}$. The γ parameter lies between zero and one. If γ =0 then all deviations from the frontier are due to noise, while γ = 1 means all deviations are due to technical inefficiency. The log likelihood estimation of the parameters of both the stochastic frontier model and the inefficiency effects model is done through the software FRONTIER 4.1 was developed by Coelli (1996).

Empirical Model

The technical efficiency of small scale intercrop pineapple cultivation in Kerala is estimated by stochastic production frontier fitted to the Cobb-Douglas production function. The following stochastic frontier production function of the Cobb-Douglas type is specified to estimate the technical efficiencies of the farmers.

$LnYi=\alpha+ \beta_1 lnX_1+\beta_2 lnX_2+ \beta_3 lnX_3+ \beta_4 lnX_4+ \beta_5 lnX_5+ \beta_6 lnX_6+Vi-Ui$

Where

Yi = Actual output of the i^{th} farm (kg /ha)
α = Constant term
X_1 = Plant density (per ha)
X_2 = Total labour (Man days /ha)
X_3 = Manure (kg/ha)
X_4 = Plant protection chemicals (kg /ha)
X_5 = Chemical fertilizer (kg /ha)
X_6 = Irrigation (dummy variable),1 for irrigated, 0 for otherwise.
β_i = Unknown parameters to be estimated.
Vi = Symmetric component of the error term and
Ui = Non negative random variables which are under the control of the firm

The inefficiency model specified (Battese &Coelli 1995) was as follows:

$Ui = \delta_0+\delta_1 Z_1+ \delta_2 Z_2+ \delta_3 Z_3+ \delta_4 Z_4+ Wi.$

Where

Ui = Mean technical inefficiency
δ_0 = Constant
Z_1 = Experience of farmer (No of years)
Z_2 = Mode of ownership of cultivation (dummy) 1 if lease &0 if otherwise
Z_3 = Education level (No of years of formal education)
Z_4 = Access to farm extension service (dummy), 1 if seek advice &0 otherwise.
δ_k = Unknown parameters to be estimated.
W_i = error term

RESULTS AND DISCUSSION

The results of the present study are presented in the following tables and analysis is done accordingly.

TABLE 1: MAXIMUM LIKELIHOOD ESTIMATES OF SMALL SCALE FARMERS

Production function	Coefficient	Standard-error	t-ratio
β_0	0.361	1.119	
β_1	1.779	0.419	4.24*
β_2	0.744	0.214	0.347
β_3	-0.001	0.015	-0.078
β_4	0.208	0.103	2.019*
β_5	-0.135	0.063	-2.142*
β_6	-0.033	-0.041	- 0.803
Inefficiency effects	**Coefficient**	**Standard- error**	**t-ratio**
δ_0	0.045	0.198	
δ_1	0.192	0.095	2.021*
δ_2	0.021	0.063	0.333
δ_3	0.133	0.159	0.834
δ_4	-0.042	0.052	-0.816
Sigma-squared	0.062	0.005	10.94*
Gamma	0.99	0.143	6.92*

Source: Computed from primary data *Significant at 5% level.

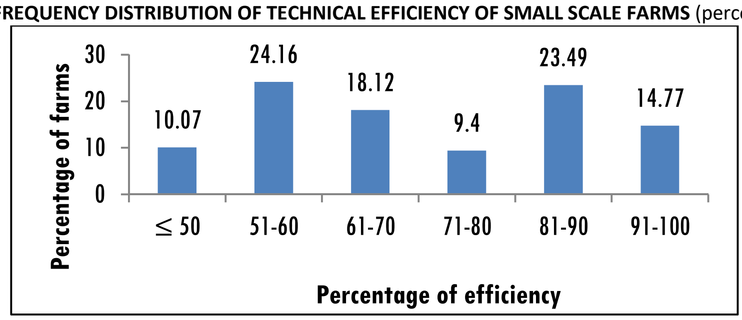
Mean efficiency : 72%
Minimum efficiency : 43%
Maximum efficiency : 99%

TABLE 2: DECILES RANGE FREQUENCY DISTRIBUTION OF TECHNICAL EFFICIENCY OF SMALL SCALE FARMS

Efficiency level (percentage)	Frequency	Percentage
≤ 50	15	10.07
51-60	36	24.16
61-70	27	18.12
71-80	14	9.4
81-90	35	23.49
91-100	22	14.77
Total	149	100

Source: Computed from primary data

FIGURE 1: FREQUENCY DISTRIBUTION OF TECHNICAL EFFICIENCY OF SMALL SCALE FARMS (percentage wise)



Source: Computed from primary data

The maximum likelihood estimation of production function of small scale farmers has an *a priori* positive sign for the coefficients of variables except for the variables manure, chemical fertilizer and irrigation (dummy variable) which shows a negative sign. The negative coefficient indicates the over use of the particular input and positive coefficient indicates under use of the particular input. The efficiency can be increased through the reduction of negative signed coefficient and can be increased by the additional use of positive signed coefficient. Among the elasticity of coefficient of various inputs, the coefficient of the input plant density is significant and the most prominent one. The elasticity is more than one which means increasing returns to scale and increase in pineapple output more than proportionately with one per cent increase in number of suckers. Other inputs in the model that increase efficiency by additional use are plant protection chemicals and total labour. Of these plants protection chemical is significant at 5 per cent level and the coefficient total labour is only indicative in nature and not significant. The negative signed coefficients of inputs are manure, chemical fertilizers and irrigation and of these, chemical fertilizer is significant at 5 per cent level and others are indicative in nature. The probable reason for the over use of chemical fertilizer may be due to application of chemical fertilizer to a lower number of suckers per hectare. The value of coefficients manure and dummy variable irrigation is small and the standard error of the coefficients seems to be higher as compared with the value of coefficient.

Among the inefficiency effects, the coefficients of the variables experience of the farmer,the dummy variable ownership of farm and level of education of farmers shows a positive relation with production function.The positive sign of coefficient of the inefficiency effects have a negative impact on the efficiency i.e., increase of these variables will reduce the efficiency. Among the inefficiency effects that increase inefficiency the coefficient of the variable experience of the farmer is significant at 5 per cent level. The experienced farmers may be reluctant to follow the scientific methods of cultivation and stick on their experience and probably this may lead to inefficiency in production. Similarly, the leased and educated small farmers are less efficient probably due to low plant density per hectare, even though the result is unexpected and only indicative in nature. The sign of the inefficiency variable access to farm extension services is negative and not significant which indicates that the more the farmers follows the practices advised by experts, the less the possibility of arising inefficiency in production.

The gamma (γ) parameter is 0.99 and is significant which shows that the onside error (inefficiency of the farmer) is the main source of total inefficiency and the random effect has no impact on the total inefficiency. The mean efficiency is 72 per cent which means on an average the farmers can improve efficiency by 28 per cent by the proper utilization of available resources.

TABLE 3: GENERALIZED LIKELIHOOD RATIO TEST OF SMALL SCALE FARMERS

Null Hypothesis (H_0)	Test Statistic(λ)	Critical value($\chi^2_{0.95}$)	Decision
H_0: $\gamma = 0$	16.33	7.05	Reject(H_0)
H_0 : $\gamma = \delta_0 = \delta_1 \ldots\ldots \delta_4 = 0$	53.06	11.91	Reject(H_0)
H_0 : $\delta_1 \ldots\ldots \delta_4 = 0$	51.05	9.45	Reject(H_0)

The table 3 presents the result of generalized likelihood ratio test of small scale farmers. The rejection of the first null hypothesis H_0: $\gamma = 0$, implies the existence of a stochastic production frontier ie the traditional average response function is not suitable. The second null hypothesis, which implies inefficiency effects are absent from the model is also rejected. The third null hypothesis farm specific factors have no effect on the level of inefficiency which is also rejected, indicates that the joint effects of the explanatory variables on the inefficiencies of production are significant although the individual effects of one or more of the variables may not be statistically significant.

Thus, it can be concluded here that the proposed inefficiency stochastic frontier production is a significant improvement over the stochastic frontier which does not involve a model for the technical inefficiency effects.

FINDINGS

1. The mean technical efficiency of small farms is 72 per cent and The inefficiency parameter gamma has the value of 0.99 in small farms, and is significant at 5 percent level which indicates that the inefficiency that exists is not due to random factors but due to the factors which are under the control of farmers
2. The rejection of various null establish that the traditional average response function is not suitable to estimate the efficiency, inefficiency effects are present in the model, and the inefficiency variables have an effect on the level of technical efficiency of pineapple cultivation
3. The major inputs that affect the efficiency of small farms are plant density, weedicides and pesticides and chemical fertilizers (negative) and in the case of medium farm size, the major inputs are plant density, total labour (man days per hectare), manures per and weedicides and pesticides.
4. All exogenous variables have a negative impact on inefficiency and the significant ones are experience of farmers and mode of ownership of cultivation. i.e. more experienced farmers manage farms efficiently and leased land cultivation reduces inefficiency in farming among the small farms

SUGGESTIONS

The following are some of the suggestions based on the findings:

1. The improvement in productivity can be achieved only through the harmonious effort of farmers, agricultural experts and government which is much needed in Kerala for the sustainable growth of pineapple cultivation
2. The productivity can be improved by increasing the present plant density to the recommended level and extending the intercrop cultivation to coconut plantations as well as by cultivating the crop as a pure crop. Along with this, following a scientific practice of cultivation as recommended by Kerala Agricultural University may help to improve the yield per hectare in the state.
3. Increasing the efficiency in utilization of inputs helps to for bring down the unit cost of pineapple farming. Efforts should be taken to improve the input efficiency, especially in small farmers who face loss in cultivation more often.

CONCLUSION

The present study revealed that there is a room for further improvement in technical efficiency by the proper utilzation of available resources. It can be concluded from the study that through a joint effort of the government, agricultural experts and farmers, the pineapple cultivation in Kerala can enhance the income level of farmers and can contribute towards the economic growth of the nation.

LIMITATIONS

The following are the limitations that affect the present study.

1. The study does not cover the entire form of pineapple cultivation in Kerala. The pure crop and intercropping in coconut plantations are outside the scope of the present study.
2. The present study does not consider the scale inefficiency and time varying inefficiency, if any which exists in the pineapple cultivation.
3. There exist differences in the fertility, texture of land and the availability of rain on cultivation, and these matters are not covered under the present study

SCOPE FOR FURTHER RESEARCH

Some areas where future research on pineapple cultivation can be done are given below.

1. The cost efficiency of the cultivation will yield a picture about cost optimization possibilities of pineapple cultivation in Kerala.
2. The marketing efficiency and other marketing aspects of pineapple cultivation are the areas that require further research which can improve the income level of farmers.

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APPENDIX

DESCRIPTIVE STATISTICS OF SMALL SCALE FARMS

Variables	N	Minimum	Maximum	Mean	Std. deviation
Output Y(kg/ha)	149	2180	80275	51478	13441
Plant density X_1(No/ha)	149	14500	25000	19528	2313
Total labour X_2(Man days/ha)	149	494	719	608	54
Manure X_3 (kg/ha)	149	3400	9386	6284	1427
Weedicide & Pesticide X_4(kg/ha)	149	12.50	48.99	31.57	7.43
Chemical Fertilizer X_5(kg/ha)	149	3582	10959	7335	1630
Irrigation X_6 (dummy variable)	149	0	1	0.64	0.48
Experience of farmer Z_1 ((No of years)	149	4	36	18	7
Mode of ownership of cultivation Z_2 (dummy variable)	149	0	1	0.41	0.49
Education level Z_3 (No of years of formal education)	149	5	17	10	3
Access to farm extension service Z_4 (dummy variable)	149	0	1	0.25	0.43

Source: Computed from primary data

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