Journal of Management
Vol. II, No. 1, October 2004, pp.26-34

Production Efficiency of Paddy Cultivation in The Eastern Province

A.N. Ahmed*
P. Sivarajah**

Abstract

This study focused on measuring the technical efficiency of paddy cultivation, to explore ways of increasing yield and productivity in the Ampara and Batticaloa districts. Both primary and secondary data were used in this study. Earlier studies revealed of stagnation in production and productivity of paddy since 1995 in both districts. The primary data were gathered through personal interviews among 100 farmers from each district for Yala (irrigated paddy) and Maha(rainfed paddy) during 2001/2002 period. In Ampara district the areas selected for field survey were Ninthavur and Akkaraipattu; while in Batticaloa district the areas selected were Kalawanchikudy and Vantharumoolai. The analytical framework used in this study was the Maximum Livelihood Estimates (MLE) of the Stochastic Frontier Model estimated with the "Frontier 4.1" computer software.

Results of the study indicated significant differences in productivity, resource use and technical efficiency in both Ampara and Batticaloa districts. The average yield/acre in Ampara district in Yala was 20 % higher than in the Batticaloa district, while the figure was 8 % higher in Maha season. Total cost of production was higher in Ampara district for both seasons when compared to Batticaloa district. This was mainly attributed to the higher level of input use in Ampara district.

Productive efficiency analysis indicates that the average technical efficiencies of paddy production were 64% and 82% in the Ampara and Batticaloa districts respectively. Also only about 12% and 61% farmers in Ampara and Batticaloa districts respectively had a technical efficiency of over 80% during Maha season; while during Yala season the technical efficiency figures were 30% and 76% respectively. Overall the study revealed that Batticaloa district farmers were more efficient in production and over 60% of farmers had a technical efficiency of over 80% during Yala and Maha seasons. This is attributed mainly to small farm size in Batticaloa district.

The findings suggest that increasing technical efficiency is the best approach of enhancing paddy production in both the districts. As both the two districts command a larger share of the total paddy production in the country, a concentrated effort should be made to raise their level of technical efficiency in the future.

Keywords: TechnicalEfficiency, Productivity, Stugnation, Paddy Production, production efficiency analysis

Background

Rice, the main staple food crop in Sri Lanka is given the highest priority by the government in agricultural policy issues. The annual paddy production was 2.9 million metric tons with an average of 3,672 kg per hectare harvested from a total 0.78 million hectares of lands cultivated by nearly 2 million farmers in two cropping seasons. If the consumption pattern remains same, with a projected annual population growth of 1.2% per year, the annual rice requirement in year 2010 will be 2.17 million tons (Herath et al. 1998).

* **Mr.A.N.Ahamed** is a Senior Lecturer in The Department of Biological Science, South Eastern University, Sri Lanka.
** **Mr.P.Sivarajah** is a Senior Lecturer in The Department of Agricultural Economics, Eastern University, Sri Lanka.

The prime objective of the study was to measure efficiency of paddy cultivation in the Ampara and Batticaloa districts. The district of Ampara is in the eastern region of Sri Lanka, which is referred to as the "Rice Bowl" of the country. This district has over 51, 278 hectare of paddy lands which gives the highest average yield of 3500-4200kg/hectare. In the *Maha* season it produced 11% and in *Yala* season it has produced 22% of the total national rice production. There are about 58,375 hectares of paddy land in Batticaloa district. Six DS divisions namely Eravur Pattu, Porathivu Pattu, Manmunai South West, Koralai Pattu, Koralai Pattu West, Koralai Pattu North are the major paddy producing divisions which accounts for 74 percent of the total production in the district.

Paddy cultivation is influenced by the seasonality of rainfall. There are, therefore two distinct cropping seasons in the study areas namely (1) the 'Maha' (wet) (ii) the 'Yala' (dry). The Maha cultivation is favorable during the following period: September / October to February / March depending on the timing of the Northeast monsoon. The Yala crop is mostly depend on the Southwest monsoon. It is grown from March / April to July / August. A 'meda' crop is also sometimes produced and it's production period overlaps with late Maha and early Yala seasons.

Earlier studies found that in Ampara the Marginal Value of Product (MVP) of land, fertilizer and labour had increased over time as a result of increase in market prices of output and improvement of yield. MVP of fertilizer could be enhanced via better technical efficiency. Fertilizer application was inefficient, mainly due to application at sub optimal levels. Overall, land is not intensively used. Reasons for sub optimal levels of fertilizer application and under utilization of land are lack of technical know how, capital scarcity and uncertainties pertaining to production due to vagaries of weather and tumbling market prices, but labour use was efficient in both cultivation seasons. (Rajasulosana C, 1995).

An earlier study in Batticaloa district had found that land is intensively utilized when compared to other factors of production. This was mainly due to most of the farmers surveyed (more than 70%) being small holders cultivating on less than 3 acres of land in extent. Low resource use efficiency of fertilizer is due to lack of technical and managerial efficiencies. Labor use is very inefficient (Sathiyabavani, 1996).

Technical efficiency is most frequently associated with the role of management in the production process. It is assumed that difference in the efficiency of factor use attributable to difference in the entrepreneurial talents of the farmers. Probing into the reasons for variation in efficiencies would give further impetus to the production of rice by appropriate policy prescription. In this context, technical efficiencies and its determinants in rice production assume paramount importance to overcome the problem of production.

Analytical Framework

A Frontier production function analysis was done to measure technical efficiencies of rice production. The frontier production function measures efficiency against the best production technology. This estimates the maximum output obtainable with given inputs, enables the measurement of the farm specific technical efficiency as the vertical deviation of the farm specific output from the frontier output.

Simplified version of the Battese & Coellis model (1993) was used in this study. The frontier functions were estimated by adding the largest positive residual to the intercept term of average function until no residual would be positive and one would be zero. This corrected function could be used to calculate the potential output of each farmer given the level of inputs used in that particular farm. The efficient production frontiers for the farmers in Ampara and Batticaloa was estimated separately for both Yala 2001 and Maha 2001/2002.

Model Specification

The stochastic frontier production function was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). The original specification involved a production function specified for cross-sectional data which had an error term which had two components, one to account for random effects and another to account for technical inefficiency. This model can be expressed in the following form:

(1) $\mathbf{Y_i = x_i\beta + (V_i - U_i)}$, **i=1,...,N,**

where

- Y_i is the production (or the logarithm of the production) of the i-th firm;
- x_i is a k×1 vector of (transformations of the) input quantities of the i-th firm;
- β is an vector of unknown parameters;
- V_i are random variables which are assumed to be ibid. $N(0,\sigma_V^2)$,
- U_i are non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be ibid. $|N(0,\sigma_U^2)|$.

This original specification has been used in a vast number of empirical applications (Forsund, Lovell & Schmidt ,1980; Schmidt,1986; Bauer, 1990 and Greene,1993). A number of empirical studies (e.g. Pitt and Lee, 1981) have estimated stochastic frontiers and predicted firm-level efficiencies using these estimated functions, and then regressed the predicted efficiencies upon firm-specific variables (such as managerial experience, ownership characteristics, etc) in an attempt to identify some of the reasons for differences in predicted efficiencies between firms in an industry. But the two-stage estimation procedure has also been long recognized as one which is inconsistent in it's assumptions regarding the independence of the inefficiency effects in the two estimation stages. The two-stage estimation procedure is unlikely to provide estimates which are as efficient as those that could be obtained using a single-stage estimation procedure.

The Battese and Coelli (1993) model specification is expressed as:

(2) $\mathbf{Y_{it} = x_{it}\beta + (V_{it} - U_{it})}$,
i=1,...,N, t=1,...,T,

where

Y_{it}, x_{it}, and β are as defined earlier;

the V_{it} are random variables which are assumed to be iid. $N(0,_V^2)$

U_{it} which are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the $N(m_{it},\sigma_U^2)$ distribution; where:

(3) $\mathbf{m_{it} = z_{it}\delta}$,

where z_{it} is a p×1 vector of variables which may influence the efficiency of a firm; and

δ is an 1×p vector of parameters to be estimated.

The following Cobb-Douglas equation was applied to the above model:

(4) $\mathbf{\ln(Y_i) = \beta_0 + \beta_i \ln(x_i) + (V_i - U_i)}$

Efficiency Predictions

The computer program FRONTIER 41 was used which calculates predictions of individual firm technical efficiencies from estimated stochastic production frontiers. The measure of technical efficiency relative to the production frontier is defined as:

(5) $EFF_i = E(Y_i^* | U_i, X_i) / E(Y_i^* | U_i = 0, X_i)$,

where Y_i^* is the production of the i-th firm, which will be equal to Y_i when the dependent variable is in original units and will be equal to $\exp(Y_i)$ when the dependent variable is in logs. For production frontier, EFF_i will take a value between zero and one. The efficiency measure can be shown to be defined as:

Item	Logged Dependent Variable	Efficiency (EFF_i)
Production	Yes	$\exp(-U_i)$
Production	No	$(x_i â - U_i) / (x_i â)$

Sampling and Field Survey

Two paddy producing areas were purposively selected from Ampara district; Nintavur and Akkaraipattu; whereas Kaluwanchikudi and Kiran were selected from the Batticaloa district. In Ampara district "Maha" cultivation was under rainfed conditions, supplemented by irrigation when necessary, while "Yala" cultivation was totally under irrigated water condition. In Batticaloa district during the Yala season, paddy cultivation was through irrigation (minor and major) water and the Maha under rainfed conditions. The research design consisted of three data collection methods based on primary, secondary and participatory data collection techniques. A stratified random sampling procedure was used to select 100 farmers each from both districts from different ASC range areas. A questionnaire survey was conducted to collect primary data for Yala 2000 and Maha 2000/2001 from July 2001 to April 2002 in both Ampara and Batticaloa districts.

Results and Discussion

Paddy Productivity and Input Use

A summary of data on input use, yield, and farmers' characteristics for both the districts are shown in Table 1. The average cultivated land size were 5.4 and 4.4 acres in Ampara and Batticaloa districts respectively, indicating a smaller land size in Batticaloa district indicating the presence of a higher degree of land fragmentation in Batticaloa district. Paddy productivity was higher in Ampara (1,608 – 1829 kg/ac) than in Batticaloa district (1288 – 1680 kg./ac). This was due to the adoption and use of modern varieties of paddy and timely irrigation in Ampara district compared to Batticaloa district.

Material costs (as % of total cost) were higher in Ampara (40%) than in Batticaloa (37%) district indicating the excessive use of inputs in Ampara district. Although Net Revenues were higher for Yala in both districts than Maha season, it was not significantly lower in Batticaloa for Maha season indicating a low profit situation. This was caused mainly due to poor rainfall in the late season and low market prices.

Technical Efficiency of paddy production

A Frontier Stochastic Production Function analysis was used to measure efficiencies of rice production for both Ampara and Batticaloa districts for Yala (irrigated) and Maha (rainfed) seasons. The mean technical efficiency for Batticaloa districts

Table 1: Paddy Productivity, Resource use & Farm characteristics Ampara & Batticaloa Districts

Indicators	Ampara (N = 100)	Batticaloa (N = 100)
1. Avg. Age of Respondent (yrs)	42	46
2. Avg.Land extent (ac.)	5.45	4.43
3. Avg.Yield (kg./ac) – Yala	1608	1288
– Maha	1829	1680
4. Avg.Family size (nos.)	4.5	4.7
5. Education level (>10 yrs)	72%	92%
6. Part-time farming (%)	25%	12%
7. Cost of Production (Rs./ac) – Yala	14,755	10,886
– Maha	15,076	12,775
8. Labour Cost (as % of total)	31%	40%
No. of Mandays	28	40
9. Material Cost (as % of total)	40%	37%
10. Net Revenue (Rs/ac) – Yala	8,565	9,549
– Maha	7,078	1,399

and Ampara district were 0.81 and 0.62 and respectively for both Yala and Maha seasons which indicates that the rice production was comparatively efficient in Batticaloa district in both seasons than in the Ampara district.

Majority of farmers in Batticaloa district (during Yala – 94.9% and Maha – 91.3%) were more efficient (falls into the category of 61% – 80% technically efficient) the farmers in Ampara (during Yala – 62% and Maha 57%) district. Thirty eight percent (38%) of the farmers during Maha and forty-three percent (43%) of the farmers during Yala, were technically of efficient below 60% when compared with 8.7% and 5.6% of the Batticaloa farmers during Maha and Yala respectively.

These mean efficiency values indicated that the Ampara farmers needed emphasis to increase their efficiencies. When total

Table 2: Technical Efficiency in Paddy Cultivation: Batticaloa and Ampara Districts

Technical Efficien	Maha		Yala	
	Ampara	Batticaloa	Ampara	Batticaloa
Mean efficiency value	62%[1]	81%	62%	81%
(0 – 20) range	-	1.1%	4%	1.1%
(21 – 40) range	9%[2]	1.1%	14%	-
(41 – 60) range	29%	65%	25%	45%
(61 – 80) range	50%	30.5%	27%	18.5%
(81 – 100) range	12%	60.8%	30%	76.4%

(Source: Survey data, 2002). NB: 1- denotes % technical efficiency, 2- denotes % farmers.

cost and the av. yield of the Ampara farmers were compared with the Batticaloa farmers, both the total cost of cultivation and the Average yield were high in the Ampara district. Therefore this can be achieved through using the production factors in an efficient manner, especially giving attention in the use of seed, fertilizer and agrochemicals.

The higher mean efficiency values for the Batticaloa district also could be attributed to the fact that the average farm size being small when compared to the Ampara farmers. (Yala 4.43 ac. and Maha 3.93 ac. vs. Yala 5.8 ac. and Maha 5.2 ac.). The small scale farmers always concentrate on higher yield / acre, while large scale farmers concentrate on total yield.

The age of farmer, experience in paddy farming, education level, poor participation in farmer's organization and the traditional believe in farming practices had a significant influence on the technical efficiency among low performing farmers in both Ampara and Batticaloa districts.

Multiple regression models were also fitted to study the effects of various production factors on the level of paddy yield. The land (Ac), labour (MD/ac), seed (Rs/ac), fertilizer (Rs/ac), agro chemicals (Rs/ac), power (Rs), age (years), experience (years), education level (values) and participation for cultivation were independent factors considered for the regression model against the paddy yield (Kg). The results of fitting the Cobb-Douglas production functions (4 functions were fitted 2 for Yala and 2 for Maha for the Batticaloa and Ampara districts) are shown in Table 3.

The Gama variance is close to 1.0, implying that that the technical inefficiency effects are significant in the stochastic frontier model. The estimated parameters of the production function confirms to a priori expectation.

The estimated production function for the Ampara farmers in Yala shows that land and agrochemical expenditure exhibited a highly significant effect on rice production ($P>0.001$). Contrary to expectations, the regression coefficient of agrochemical expenditure was found negative which implies excess utilization, thus resulting in its negative marginal product. The regression coefficient of age was positive as expected and significant. The estimated production function shows that factors of labour and power cost were found to be negative and insignificant. The negative sign of the regression coefficient of labour and power cost implies excess utilization, thus resulting in its negative marginal product. The positive sign of the regression coefficient of seed cost, fertilizer cost implies positive effect on rice production. The negative sign of the coefficient of chemical expenditure could be explained by the following reasons. Wrong timing of application such that it was already too late to control the crop damage caused by pest and disease infestations and the use of wrong chemicals and / or dosage of chemicals. The production elasticity (regression coefficient) of land was 0.13 indicating that one percent increase in land would bring about 0.13 percent increase in paddy output.

The estimated production function for the Ampara farmers in Yala shows that almost all factors exhibited insignificant effect on paddy production. The regression coefficient for labour cost, agro-chemical cost and power cost were found negative which implies excess utilization, thus resulting in its negative marginal product. The regression coefficients for seed cost,

Table 3: Maximum Likelihood Estimates (MLE) of Stochastic Frontier Production Functions (Maha 2000/2001&Yala 2001) (Dependent variable = Yield/Ac)

Variables	Ampara				Batticaloa			
Stochastic Frontier	Yala		Maha		Yala		Maha	
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Intercept	9.5481	4.9281	6.3142	2.9104	5.3779	4.543	5.0051	0.0981
Land(Ac)	0.1349***	2.9618	0.0122	0.1452	0.1641***	3.142	-0.0458	0.9953
Labour(Rs/ac)	-0.1038	-1.1288	-0.0373	-0.1963	0.0172	0.2687	-0.0369	-0.8520
Seed(Rs/ac)	0.0846	0.8990	0.2487	1.3371	-0.0737	-0.8466	-0.0471	-0.6710
Fertilizer(Rs/ac)	0.0868	0.6582	0.0205	1.0149	0.1804***	3.3054	0.1581**	5.8114
AgroChemicals(Rs.)	-0.2519***	-2.833	-0.0233	-0.2340	0.0887**	2.1508	0.07710**	2.1785
Power(Rs)	-0.0370	-0.4139	-0.1248	-0.3729	0.0536	0.4286	0.1630**	2.314
Inefficiency effects								
Age(Years)	0.8787**	1.7598	-1.1224	-0.5232	4.123**	2.3037	-6.5400	-1.144
Experience(Years)	-1.563	-1.330	0.5209	0.6721	-1.039***	2.714	2.9580	1.500
Education(Values)	0.4376	1.4466	0.1964	0.5419	1.217***	2.714	-0.1601	-0.6361
Participation for cultivation(values)	0.1690	0.4385	0.3597	0.5884	-3.293***	-3.2223	1.508	1.3498
Sigma squared	0.570	1.8522	0.3822	1.0214	0.508	3.9077	1.3466	1.6989
Gama Variance ratio	0.9846	80.239	0.5211	0.8201	0.909	24.910	0.9921	247.71

***Significant at 1% level, **Significant at 5% level land and fertilizer were positive which implies a positive effect on paddy yield.

The estimated production function for the Batticaloa farmers in Yala shows that the land, fertilizer cost and agro-chemical expenditure exhibited highly significant effect on rice production (at 1% probability level). The regression coefficient for labour cost and power cost were found insignificant which implies a positive effect on paddy yield. The regression coefficient for seed cost was found negative and insignificant. The negative sign of the regression coefficient implies excess utilization, thus resulting in its negative marginal product.

The production elasticity (regression coefficient) of land, fertilizer cost and agro-chemical expenditure were 0.16, 0.18 and 0.088 respectively indicate that paddy output would increase by 0.16, 0.18 and 0.09 percent with an increase in land, fertilizer and agro-chemical by one percent. The estimated production function for Batticaloa farmers in Maha shows that the fertilizer cost, agro-chemical expenditure and power cost were highly significant ($P<0.01$). The regression coefficient for land has a positive effect on paddy yield. The regression coefficient for labour and seed cost was found to be negative and insignificant which shows the negative effect on paddy output.

Conclusions and Implications

This study examined the problems of productivity and efficiency differences in paddy cultivation between the Ampara and Batticaloa districts. The stochastic frontier production function analysis technique was used to examine the technical efficiency of 200 farmers. Results from the study indicated a substantial difference in productivity and efficiency between the two districts.

The mean technical efficiency for Batticaloa and Ampara district were 0.82 and 0.64 respectively. Although paddy production was more efficient in the Batticaloa district than in Ampara district, the latter has more extent of paddy lands which could produce more if production efficiency is increased through better management skills.

Land size was found to have a significant impact on increasing paddy production in all areas. There was a negative effect of agro-chemicals on yield in irrigated rice in Ampara district. In case of Batticaloa district fertilizer, agrochemicals and farm had a positive effect on yield in both irrigated and rainfed cultivation.

The study revealed that the farmers in Ampara district were over utilizing the inputs, such as seed paddy, fertilizer and agro-chemicals at present. The study identified that proper extension and research activities would reduce the cost by at least 35% from its present level of input use. Proper water and soil management, use of organic fertilizer biopesticides, mechanization of cultivation and deep ploughing could increase the yield per acre and reduce cost of cultivation.

Acknowledgement

The authors wish to thank the National Science Foundation (NSF) for providing the funds (SIDA/2001/SS/01) to conduct this study, and acknowledge the help of the Field Res. Assistants in conducting the field survey and collecting data.

References

Aigner, D.J., Lovell, C.A.K. and Schmidt,P. (1977), 'Formulation and Estimation of Stochastic Frontier Production Function Models', *Journal of Econometrics*, 6, 21-37.

Battese, G.E. and Coelli, T.J. (1993), 'A Stochastic Frontier Production Function Incorporating a Model for Technical Inefficiency Effects', *Working Papers in Econometrics and Applied Statistics*, No.69, Department of Econometrics, University of New England, Armidale, pp.22.

Bauer, P.W. (1990), 'Recent Developments in the Econometric Estimation of Frontiers', *Journal of Econometrics*, 46, 39-56.

Coelli, T., (1994), A *Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation*, Department of Econometrics, University of New England, Armidale, NSW, 2351, Australia.

Forsund, F.R., Lovell, C.A.K. and Schmidt, P. (1980), 'A Survey of Frontier Production Functions and of their Relationship to Efficiency Measurement',*Journal of Econometrics*, 13, 5-25.

Greene, W.H. (1993), '*The Econometric Approach to Efficiency Analaysis*', in Fried, H.O.,

Lovell, C.A.K. and Schmidt, S.S.(Eds), *The Measurement of Productive Efficiency*, Oxford University Press, New York, 68-119.

Herath Banda,R.M., Dhanapala M.P., De Silva G.A.C & Hossain M.(1998), *Constraints to increase paddy production in Sri Lanka*, Paper presented at the workshop on prioritization of rice research, IRRI, Philippines.

Meeusen, W. and van den Broeck, J.(1977), 'Efficiency Estimation from Cobb-Douglas Production Functions With Composed Error', *International Economic Review*,18.

Pitt, M.M. and Lee, L.F. (1981), 'Measurement and Sources of Technical Inefficiency in the Indonesian Weaving Industry', *Journal of Development Economics*, 9,43-64.

Schmidt, P. (1986), 'Frontier Production Functions', *Econometric Reviews*, 4, 289-328.

Rajasulosana.,C (1995), The Impact of Structural Adjustment Programme-Removal of Fertilizer Subsidy on Paddy Production, M.Sc Thesis, Agricultural University of Norway.

Sathiyabavani,.K(1996). Resource Productivity and Allocative Efficiency of Resources in Paddy Production. 500 series Research Project Report, Department of Agricultural Economics, Eastern University, Chenkalady, 1996.