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Estimating Economic Efficiency in Paddy Farms: A Case of Northwest Selangor IADP

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ABSTRAK

Kecekapan ekonomi boleh dibahagikan kepada kecekapan alokatif dan teknikal. Kecekapan teknikal didefinasikan sebagai kadar output sebenar terhadap kemungkinan teknikal output maksimum pada paras sumber-sumber yang ada, dan kecekapan alokatif dinyatakan sebagai kadar kemungkinan teknikal output maksimum pada paras sumber-sumber yang diberi terhadap output yang diperolehi pada paras sumber-sumber yang optimum. Objektif kajian ini ialah untuk mengukur kecekapan-kecekapan teknikal, alokatif dan ekonomi dengan menggunakan fungsi pengeluaran frontier berkebarangkalian terhadap penanaman padi di Selangor. Keputusan kajian menunjukkan sampel petani padi di dalam kajian tidak mempunyai kecekapan ekonomi. Kerajaan sepatutnya memainkan peranan penting di dalam pendidikan, pengembangan, perubahan sosial dan memberikan sokongan institusi supaya petani dapat memperbaiki kecekapan teknikal dan alokatif.

ABSTRACT

Economic efficiency can be measured as allocative and technical efficiency. A study to measure the technical, allocative and economic efficiency of paddy farms using the probabilistic frontier production function was carried out. Results showed that the sample paddy farmers under study are economiclly inefficient. There is still in technical efficiency a 15 percent potential for in creasing the output of farmers, and a 35 percent potential in allocative efficiency to increase output optimally. The government should therefore play a part in directing education, extension, and social change and provide institutional support in order to improve the farmers' efficiency technically and allocatively.

INTRODUCTION

The relative efficiency in agricultural production is an important aspect in developing countries. Farm efficiency has long been an area of interest in the investigation of farm operations as inefficiency can have important implications in economic survival, the size distribution of farms, technological adoption, and the overall levels of input.

Economic efficiency can be decomposed into two components namely, allocative and technical efficiency. A farm is said to be allocative or price efficient if it maximizes profits by equating the value of marginal product of each variable input to its price. It is technically efficient if it produces a higher level of output from the same level of inputs as compared to another farm. Moreover, technical efficiency and price efficiency are necessary, and when they occur jointly, are sufficient conditions for economic efficiency to exist (Yotopoulus and Nugent, 1976).

The concept of efficiency as a measure of economic performance and hence as a guide to policy formulation has often been questioned. At the same time there has been a considerable amount of theoretical and applied econometric research on the measurement of efficiency using the concept of frontier production function. Frontier production functions assume the existence of technical efficiency in different farms involved in production, such that, for specific values of factor inputs, the level of production are less than what would be the case if the farms are fully technically efficient. The objective of this paper is to analyze the extent to which a sample of paddy farmers in Northwest Selangor Integrated Development Project (IADP) have attained technical, allocative and economic efficiency using a probability frontier production function.

There are a variety of methods used for measuring and computing technical efficiency. Most involve the construction of a best-practice frontier of one kind or another and measurement of inefficiency relative to this frontier. Past empirical studies have used a variety of methods and specifications which include Dawson (1985), Ekanayake and Jayasuria (1987), Taylor and Shonkwiller (1986), Habibullah and Ismail (1992), Neff, Garcia and Hornbacker (1991) and others. Forsund, Lovell and Schmidt (1980), Schmidt (1985), Balbase and Grobowski (1985) and Ali and Chaudhry (1990). Bauer (1990), Battese (1992) and Button and Weyman-Jones (1994) presented a review of the concepts and models which have been suggested and surveyed the applications which have appeared in economic journals.

Discussion on Theoretical Framework

The production function is defined as the relationship that describes the *maximum possible* output for the given combination of input (Ferguson, 1966). However, a production function estimated by OLS method shows an *average* response and does not qualify for the theoretical definition of production function or frontier. Farrell (1957) employed a deterministic approach in which he estimated the frontier by using linear programming (LP), requiring all observations to lie at or above the frontier.

Consider the following Cobb-Douglas production function in general form:

$$Y_j = \prod_{i=0}^{m} X_{ij}^{\beta_i} \varepsilon^{\mu_j} \qquad (1)$$

where $i = 1, 2...., m$ are inputs; $j = 1, 2,..., n$; Y_j = output of the j^{th} farm; X_{ij} = level of the i^{th} input on the j^{th} farm; β_i = parameters (including in intercept, β_0) to be estimated; μ_J = error term; and ε is the natural exponential. If μ_j is assumed to be randomly and normally distributed, Equation (1) can be estimated using the OLS method.

A measure of technical efficiency can be estimated using a linear programming (LP) method, which has been used by Timmer (1970,1971). Using Equation (1), assume that the disturbance terma are constrained to be one sided, that is, $\mu_j \leq 0$, so that the function is a frontier one. For an efficient frontier, this should be estimated, so that

$$\sum_{i=0}^{m} \alpha_i X_{ij} = Y^*_j \geq Y_j \qquad j = 1, 2, ..., n \qquad (2)$$

where $Y_j = Y^*_j + \mu_j$; Y^*_j is frontier estimate of Y_j and μ_j is residual from farm j^{th}. Only efficient farms satisfy the strict equality, In order to determine the unique vector, α_i, which satify (2), Timmer (1970) suggests minimizing the linear sum of residuals rather than minimizing linear sum of square residuals since the later accentuates the impact of extreme observations. Thus the problem is to find

$$\min \sum_{j=1}^{n} \mu_j \qquad (3)$$

subject to

$$\sum_{i=0}^{m} \alpha_i X_{ij} \geq Y_j \qquad j = 1, 2, ..., n$$

To solve this using LP methods, $\Sigma\mu_j$ is expressed as a linear function of α_i and X_{ij}. The production function in (1) is then summed over j and solved for $\Sigma\mu_j$, that is

$$\sum_{j=1}^{n} \mu_j = \sum_{j=1}^{n}\sum_{i=0}^{m} \alpha_i x_{ij} - \sum_{j=1}^{n} y_j \qquad (4)$$

where

$y_j = n \times 1$ vector of 1

$x_{ij} = \log X_{ij}$, $i = 0, 1,..., m$ and $j = 1, 2,...,n$

However, for any data set, the last term on the right hand side of (4) is a constant, so it can be removed without any consequence and what remain becomes the objective function that Timmer (1970) suggests which is computationally simpler when the objective function is divided by the number of observations. Thus, the LP problem is to find α_i; in order to

$$\min \sum_{i=0}^{m} \alpha_{ii} \bar{X}_i \qquad (5)$$

subject to

$$\sum_{i=0}^{5} \alpha_i X_{ij} \geq Y_j \qquad j = 1, 2, ..., n$$

From the probabilistic function coefficients, farm specific technical efficiency (TE_j) is measured as follows:

$$TE_j = AGR_j / MGR_j \qquad (6)$$

where AGR_j and MGR_j are the j^{th} farmer's actual and maximum possible output, respectively. MGR_j is measured by substituting the j^{th} farmer's level of resources into the estimated probabilistic frontier production function.

Allocative efficiency expressed as the ratio of technically maximum possible output at the level of resources to the output obtainable at the optimum level of resources. Farm specific allocative efficiency (AE_{ij}) in the use of a variable inputs is

$$AE_{ij} = MGR_j / OGR_{ij} \qquad (7)$$

where OGR_{ij} is output at the optimum level of the i^{th} input, with the other inputs remaining at the level at which there were used by the j^{th} farm. Farm specific optimum input levels is calculated by equating marginal value product (MVP) of an input with its price. The fact that AE_{ij} can take value of greater than 1. Thus, $AE_{ij} > 1$ or $AE_{ij} < 1$ depending upon under or over utilisation of input i over its allocatively efficiency level.

The overall allocative efficiency (AE_j) of all inputs on the j^th farm is estimated to be

$$AE_j = MGR_j / OGR_j \qquad (8)$$

where OGR_j is the j^th farmer's output at the optimum level of all variable inputs.

Farm specific economic efficiency (EE_j) is estimated, using the following function

$$EE_j = TE_j . AE_j \qquad (9)$$

METHODOLOGY

The empirically estimated Cobb-Douglas production function is specified as

$$\ln Y = \beta_0 + \beta_1 \ln F + \beta_2 \ln W + \beta_3 \ln C + \beta_4 \ln L + \beta_5 \ln A + \mu \qquad (10)$$

where

Y = output of paddy (kg)
F = fertilizer (kg)
W = herbicide (lt)
C = chemical (lt)
L = labor (hour)
A = land area (ha)
μ = error term
β_i = parameter estimates

The production function in Equation (10) was first estimated using ordinary least square (OLS) method. It was transformed into a deterministic frontier production function as follows

$$\text{minimize } \beta_0 + \beta_1 \ln \overline{F} + \beta_2 \ln \overline{W} + \beta_3 \ln \overline{C} + \beta_4 \ln \overline{L} + \beta_5 \ln \overline{A} \qquad (11)$$

subject to

$$\begin{array}{l}
\beta_0 + \beta_1 \ln F_1 + \beta_2 \ln W_1 + \beta_3 \ln C_1 + \beta_4 \ln L_1 + \beta_5 \ln A_1 \geq Y_1 \\
\beta_0 + \beta_1 \ln F_2 + \beta_2 \ln W_2 + \beta_3 \ln C_2 + \beta_4 \ln L_2 + \beta_5 \ln A_2 \geq Y_2 \\
\beta_0 + \beta_1 \ln F_3 + \beta_2 \ln W_3 + \beta_3 \ln C_3 + \beta_4 \ln L_3 + \beta_5 \ln A_3 \geq Y_3 \\
\quad \vdots \\
\beta_0 + \beta_1 \ln F_{174} + \beta_2 \ln W_{174} + \beta_3 \ln C_{174} + \beta_4 \ln L_{174} + \beta_5 \ln A_{174} \geq Y_{174}
\end{array}$$

where $\overline{F}$, $\overline{W}$, $\overline{C}$, $\overline{L}$, and $\overline{A}$ are mean values of the respective inputs.

The probabilistic function coefficients used in estimating efficiencies were obtained from Equation (11) and allocative efficiency of five variable input, vis fertilizer, herbicide, chemical, labor and land cultivated were estimated. The data used in this study consisted of production cost for a sample of 174 paddy farm in Northwest Selangor IADP). Variables collected include production data, quantity of inputs used and prices of inputs. A statistical summary concerning the above variable are presented in Table 1.

TABLE 1
Summary statistics of variables

	Mean	Standard Deviation
Output (kg)	3803.20	849.2100
Output price (RM/kg)	0.78	0.0538
Fertilizer (kg)	1307.10	1463.9000
Fertilizer price (RM/kg)	0.07	0.0006
Herbicide (lt)	17.39	7.4108
Herbicide price (R/lt)	6.96	0.7265
Chemical (lt)	7.97	6.1543
Chemical price (RM/lt)	9.80	1.0004
Labor (hour)	56.18	20.8240
Labor wage (RM/hr)	1.68	0.5691
Land area (ha)	2.59	1.7678

RESULTS AND DISCUSSION

The estimated OLS and probabilistic Cobb-Douglas production frontier models are given in Table 2. The data fit the model quite well as shown by an R2 of 0.7964. The OLS estimates showed that all coefficients have the expected signs and are significantly different from zero at the 1 percent level for fertilizer, chemical and labor, and 10 percent level for herbicide.

The OLS function portrays the response of the *average* farmers while the frontier function reflects the *best practice* of farmers. The intercept term in the frontier production function is higher than that estimated by the OLS method. In addition, some of the coefficients in the frontier function have increased viz. chemical, land area and labor. Coefficient for fertilizer and herbicide, on the other hand had decreased. This shows increased output if farmers used more chemical land area, increased labour but applied less fertilizers and herbicides. Thus, compared with the OLS *average* model, the envelope shifts vertically along with shifts in the slope of the production function for the probabilistic model.

TABLE 2
Estimated parameters of OLS and probabilistic frontier production functions of paddy farms

	OLS	Probabilistic Frontier
Fertilizer	0.0717 (5.6740)*	0.0420
Herbicide	0.0227 (1.6850)***	0.0028
Chemical	0.1184 (9.0790)*	0.1325
Labor	0.1486 (6.9480)*	0.1946
Land area	0.1200 (9.0530)	0.1531
Intercept	6.7797 (66.2400)*	6.9678
R2	0.7964	
SSE	1.5557	

Note: Figure in parentheses are t-statistics

* Significant at 1% level
** Significant at 5% level
*** Significant at 10% level

Technical, allocative and economic efficiencies were measured, using Equations (6), (7), and (9) respectively. The results are shown in Table 3. The sample of farmers have a technical efficiency mean of 0.8515 with standard deviation of 0.0826. This means that there exists a 15 percent potential for increasing farmers production at the existing level of their resources. The higher production gap that exists between the *best-practice* farmers and *average* farmers suggests the need to improve the existing agricultural extension services in order to exploit the above-mentioned potential.

The economic significance of inefficiency can be expressed in terms of the losses of output. The sampled farms have an allocative

TABLE 3
Potential output and efficiency measure of paddy farms

	Average	Standard Deviation
Output (kg)	3803.20	849.2100
Potential output at technical efficiency level (kg)	4476.60	946.43
Potential output at optimum level of input (kg)		
Fertilizer	4143.10	636.34
Herbicide	3748.60	784.04
Chemical	4747.20	685.75
Labor	5077.90	1185.7
Overall	6893.10	970.86
Technical Efficiency Ratio	0.8515	0.0826
Allocative Efficiency Ratio		
Fertilizer	1.0725	0.0633
Herbicide	1.1936	0.0272
Chemical	0.9371	0.0857
Labor	0.8882	0.0753
Overall	0.6474	0.0806
Economic Efficiency Ratio		
Fertilizer	0.9130	0.1019
Herbicide	1.0159	0.0968
Chemical	0.7974	0.1034
Labor	0.7554	0.0891
Overall	0.5509	0.0857

efficiency mean level of 0.6474 and a standard deviation of 0.0826. This means that there exist a 35 percent potential for increasing farm output by using optimum input combination. From Table 4, it can be noted that about 2.6 percent of the farmers were at least 80 percent efficient in terms of allocative efficiency. The results showed that the output loss due to allocative inefficiency ranged from 25 percent to 55 percent. Inefficiency in labor contributed most to the overall allocative inefficiency. This could be partly attributed to the labor shortages during land preparation and planting time. Only 1.1 percent of the farmers are at least 80 percent efficient in terms of economic efficiency. It ranges from

TABLE 4
Distribution of technical, allocative and economic efficiency

Efficiency Level (%)	Technical Efficiency	Allocative Efficiency	Economic Efficiency
30-40	–	–	4(2.3)
40-50	–	5(2.9)	29(28.2)
50-60	–	52(29.9)	77(44.3)
60-70	5(2.9)	71(40.8)	34(19.5)
70-80	42(24.1)	41(23.6)	8(4.6)
80-90	77(44.3)	5(2.6)	2(1.1)
90-100	50(2.87)	–	–
Minimum (%)	63.97	45.30	
Average (%)	85.15	64.74	55.09
Maximum (%)	100.0	84.83	82.32

Note: Figure in parentheses are percentage from total

0.3660 to 0.8232 with a mean of 0.5509. This implies that there exists a potential for increasing the output of the farmers by more than 45 percent simply by adopting a technology of the *best-practice* farmers and through optimal resource allocation.

CONCLUSION

The purpose of this paper is to measure farm efficiency using probabilistic frontier production methodology. The production function is estimated from a sample of paddy farms and farm efficiencies was measured in terms of technical, allocative and economic efficiencies.

Results of the study show that the technical efficiency ratio is 0.8515. This indicates that there still exist a 15 percent potential for increasing the output of the farmers, if the production gap between the *average* and the *best-practice* farmers can be narrowed. In terms of allocative efficiency, there is still a 35 percent potential for increasing in output optimally allocating given inputs. With respect to economic efficiency, results indicate that farmers are economiclly inefficient with a mean efficiency ratio of 0.5509. This indicates that there are enormous potential for the farmers to increase output by adopting the best technology and through optimal resource allocation.

The findings of the study emphasied the need to improve farm efficiency at all levels.

Mechanisation should be promoted while technology utilisation upgraded at farm level. Government efforts should be directed in education, extension, social change and support in order to improve the extent to which farmers are technically and allocatively efficient.

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