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

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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 economically inefficient. There is still in technical efficiency a 15 percent potential for increasing 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 (Yotopoulos 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 Shonkwiler (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. For an efficient frontier, this should be estimated, so that

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

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

\[ \min \sum_{j=1}^{n} \mu_j \] (3)

subject to

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

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

\[ \sum_{j=1}^{n} \mu_j = \sum_{i=0}^{n} \sum_{j=1}^{m} \alpha_i X_{ij} - \sum_{j=1}^{n} Y_j \] (4)

where

\[ y_j = n \times 1 \text{ vector of } l \]
\[ x_{ij} = \log X_{ij}, \quad i=0,1,...,m \text{ and } j=1,2,...,n \]
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 $\alpha_i$ in order to

$$\min \sum_{i=0}^{m} \alpha_i X_i \quad (5)$$

subject to

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

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

$$TE_j = \frac{AGR_j}{MGR_j} \quad (6)$$

where $AGR_j$ and $MGR_j$ are the jth farmer's actual and maximum possible output, respectively. $MGR_j$ is measured by substituting the jth 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 (AEij) in the use of a variable inputs is

$$AE_{ij} = \frac{MGR_{ij}}{OGR_{ij}} \quad (7)$$

where $OGR_{ij}$ is output at the optimum level of the ith input, with the other inputs remaining at the level at which there were used by the jth 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 (AEj) of all inputs on the jth farm is estimated to be

$$AE_j = \frac{MGR_j}{OGR_j} \quad (8)$$

where $OGR_j$ is the jth farmer's output at the optimum level of all variable inputs.

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

$$EE_j = TE_j \cdot AE_j \quad (9)$$

**METHODOLOGY**

The empirically estimated Cobb-Douglas production function is specified as

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

where

- $Y$ = output of paddy (kg)
- $F$ = fertilizer (kg)
- $W$ = herbicide (lt)
- $C$ = chemical (lt)
- $L$ = labor (hour)
- $A$ = land area (ha)
- $\mu$ = error term
- $\beta_i$ = 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

minimize $\beta_0 + \beta_1 \ln F + \beta_2 \ln W + \beta_3 \ln C + \beta_4 \ln L + \beta_5 \ln A + \mu$

subject to

$$\beta_0 + \beta_1 \ln F_1 + \beta_2 \ln W_1 + \beta_3 \ln C_1 + \beta_4 \ln L_1 + \beta_5 \ln A_1 \geq Y_1$$

$$\beta_0 + \beta_1 \ln F_2 + \beta_2 \ln W_2 + \beta_3 \ln C_2 + \beta_4 \ln L_2 + \beta_5 \ln A_2 \geq Y_2$$

$$\beta_0 + \beta_1 \ln F_3 + \beta_2 \ln W_3 + \beta_3 \ln C_3 + \beta_4 \ln L_3 + \beta_5 \ln A_3 \geq Y_3$$

$$\beta_0 + \beta_1 \ln F_{174} + \beta_2 \ln W_{174} + \beta_3 \ln C_{174} + \beta_4 \ln L_{174} + \beta_5 \ln A_{174} \geq Y_{174}$$
where $F$, $W$, $C$, $L$, and $A$ 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, viz 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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output (kg)</td>
<td>3803.20</td>
<td>849.2100</td>
</tr>
<tr>
<td>Output price (RM/kg)</td>
<td>0.78</td>
<td>0.0538</td>
</tr>
<tr>
<td>Fertilizer (kg)</td>
<td>1.307</td>
<td>1463.9000</td>
</tr>
<tr>
<td>Fertilizer price (RM/kg)</td>
<td>0.07</td>
<td>0.0006</td>
</tr>
<tr>
<td>Herbicide (lt)</td>
<td>17.39</td>
<td>7.4108</td>
</tr>
<tr>
<td>Herbicide price (R/lt)</td>
<td>6.96</td>
<td>6.7265</td>
</tr>
<tr>
<td>Chemical (lt)</td>
<td>7.97</td>
<td>6.1543</td>
</tr>
<tr>
<td>Chemical price (RM/lt)</td>
<td>9.80</td>
<td>1.0004</td>
</tr>
<tr>
<td>Labor (hour)</td>
<td>56.18</td>
<td>20.8240</td>
</tr>
<tr>
<td>Labor wage (RM/hr)</td>
<td>1.68</td>
<td>0.5691</td>
</tr>
<tr>
<td>Land area (ha)</td>
<td>2.59</td>
<td>1.7678</td>
</tr>
</tbody>
</table>

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.

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

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output (kg)</td>
<td>3803.20</td>
<td>849.2100</td>
</tr>
<tr>
<td>Potential output at technical efficiency level (kg)</td>
<td>4476.60</td>
<td>946.43</td>
</tr>
<tr>
<td>Potential output at optimum level of input (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer</td>
<td>4143.10</td>
<td>636.34</td>
</tr>
<tr>
<td>Herbicide</td>
<td>3748.60</td>
<td>784.04</td>
</tr>
<tr>
<td>Chemical</td>
<td>4747.20</td>
<td>685.75</td>
</tr>
<tr>
<td>Labor</td>
<td>5077.90</td>
<td>1185.7</td>
</tr>
<tr>
<td>Overall</td>
<td>6893.10</td>
<td>970.86</td>
</tr>
</tbody>
</table>

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 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.

TABLE 4
Distribution of technical, allocative and economic efficiency

<table>
<thead>
<tr>
<th>Efficiency Level (%)</th>
<th>Technical Efficiency</th>
<th>Allocative Efficiency</th>
<th>Economic Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-40</td>
<td>–</td>
<td>–</td>
<td>4(2.3)</td>
</tr>
<tr>
<td>40-50</td>
<td>–</td>
<td>5(2.9)</td>
<td>29(28.2)</td>
</tr>
<tr>
<td>50-60</td>
<td>–</td>
<td>52(29.9)</td>
<td>77(44.3)</td>
</tr>
<tr>
<td>60-70</td>
<td>5(2.9)</td>
<td>71(40.8)</td>
<td>34(19.5)</td>
</tr>
<tr>
<td>70-80</td>
<td>42(24.1)</td>
<td>41(23.6)</td>
<td>8(4.6)</td>
</tr>
<tr>
<td>80-90</td>
<td>77(44.3)</td>
<td>5(2.6)</td>
<td>2(1.1)</td>
</tr>
<tr>
<td>90-100</td>
<td>50(2.87)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

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

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 economically 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 emphasized 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.

ACKNOWLEDGMENTS

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