J. ISSAAS Vol. 17, No. 1:135-146 (2011)

TECHNICAL EFFICIENCY ANALYSIS OF RICE PRODUCTION IN VIETNAM

Huynh Viet Khai [1] and Mitsuyasu Yabe [2]

[1] Agricultural Economics and Resource – Environmental Economics, School of Economics and Business Administration, Can Tho University, Vietnam
E-mail: hvkhai@ctu.edu.vn
[2] Laboratory of Environmental Life Economics, Department of Agricultural and Resource Economics, Faculty of Agriculture, Kyushu University, Japan

(Received: June 3, 2010; Accepted: April 19, 2011)

ABSTRACT

The measurement of efficiency in agricultural production determines the efficiency level of households in their farming activities. Farmers in developing countries do not use all potential technological resources, thus making inefficient decisions in their agricultural activities. Therefore, this paper made an effort to measure the technical efficiency (TE) of rice production and identified some determinants of technical efficiency of rice farmers in Vietnam. The Vietnam Household Living Standard Survey 2005-2006 (VHLSS 2006) was analyzed using stochastic frontier analysis method in the Cobb-Douglas production function. The calculated technical efficiency in the study was around 81.6 percent. The study demonstrated that the most important factors having positive impacts on technical efficiency levels are intensive labor in rice cultivation, irrigation and education. These play the important role in terms of TE score change, while agricultural policies did not help farmers cultivate rice more efficiently.

Key words: Cobb-Douglas production function, stochastic frontier analysis

INTRODUCTION

Vietnam used to be an agricultural importing country in the past. With policy reforms in 1986, Vietnam has gradually become one of the biggest agricultural exporting countries in the world. Recently, it has been the world's leading exporter of cashew, coffee, rubber, black pepper, and most of all, rice. Vietnam provided the world market more than 4.6 million tons of rice in 2006 with an estimated value of 1,275 million USD (Ministry of Agriculture and Rural Development 2008). Because of the important contribution of rice production to the gross domestic products (GDP) of the country, the government has paid much attention to rice cultivation as well as the effects of policies on rice farms. However, studies on the effectiveness and impacts of such policies are still limited. Have farmers grown their product efficiently with the available technologies? How have the policies undertaken by government impacted on rice production and on farmer technical efficiency? These are some of the questions the study partly sought to answer.

In recent years, there have been many studies on efficiency in developing countries. Thiam and co-workers (2001) examined the technical efficiency in developing countries based on 32 studies published before 1999. However, research on efficiency and analysis of relevant impacts on agricultural production as well as productive efficiency of farmers are very few in Vietnam. Kompas (2004) used stochastic production frontier for estimating technical efficiency of rice production in Vietnam based on a region-level panel data. The technical efficiency of rice cultivation was estimated at 65 percent in 1999, and 78 percent for rice areas of the Mekong River Delta. Linh (2007) used the

Vietnam Household Standard Survey 2003-2004 (VHLSS 2004) and estimated a technical efficiency of 79 percent for the whole rice farmers in Vietnam.

The study of Kompas (2004) was limited to the use of regional data in estimating technical efficiency, while undermining the technical efficiency at farm level. The study written by Linh (2007) provided plenty information on farmers at farm level; however fertilizer costs were used to estimate technical efficiency because of unavailable data on fertilizer quantity. This study tries to solve the limits by using the farm-level data from the VHLSS 2006, the latest national living standard survey. The survey contains information on fertilizer quantity, which is useful in calculating technical efficiency of rice cultivation. Also, since there are few studies on the relationships among efficiency, market indicators and farmers' characteristics in Vietnam, the study also makes try to provide these connections. This could be useful information for policy makers to form programs or legislations related to expand national food production potential more effectively.

The main objective of this study was to measure the possibilities of technical gains from enhancing the efficiency of rice farmers. The analytical method of the study is to measure the technical efficiency of rice farmers in Vietnam by applying a stochastic frontier and to identify some determinants of technical efficiency. The first step is to estimate farm-level technical efficiency (TE). The second step of analysis is to calculate Tobit function with the dependent variables TE and the independent variables of the important factors leading to technical inefficiency and social characteristics of the farmers. The next section introduces the theory of efficiency and analytical framework. The third part describes the VHLSS 2006 data used in the study and empirical model. The fourth explains the results of technical efficiency and discusses some impacts on the technical inefficiency. The final section is some conclusions withdrawn from the study.

Efficiency

Economic efficiency takes on to increase output without using more conventional inputs. The use of existing technologies is more cost-effective than applying new technologies if farmers cultivate their products with the existing technology inefficiently (Belbase and Grabowski,1985; Shapiro 1977). Economic efficiency can be classified in two: technical efficiency and allocative efficiency. Technical efficiency measures the ability of a farmer to achieve the maximum output with given and obtainable technology, while allocative efficiency tries to capture farmer's ability to apply the inputs in optimal proportions with respective prices (Farrell 1957; Coelli *et al.* 2005).

Measuring technical efficiency is to use inputs and output quantity without introducing their prices. Technical efficiency can be decomposed into three components such as scale efficiency (the potential productivity gain from achieving optimal size of a firm), congestion (increase in some inputs could decrease output) and pure technical efficiency (Farrell 1957).

It is assumed that a firm uses two inputs (X_1 and X_2) to produce a single output (Q) under the assumption constant returns to scale (Fig. 1). The *SS'* curve that represents the isoquant of full efficient firms could allow measurement of technical efficiency. If a given firm uses quantities of inputs at the point *A* to produce a unit of output, the technical inefficiency of that firm could represent as the distance *AB*. It is the amount by which all inputs need could proportionally reduce without a decline in output. This is usually expressed in percentage terms by the ratio *BA/OA*, which represents the percentage by which all inputs need to reduce to achieve technical efficient production. The technical efficiency (TE) of a firm is most commonly measured by the ratio:

$$TE = OB/OA \quad (1)$$

The value of TE ranges between 0 and 1, and represents the degree of technical efficiency. If

TE is equal to 1, telling the firm produces with fully technical efficiency. For example, at the point *B* firm could gain full technical efficiency because point *B* lies in the efficient isoquant curve.

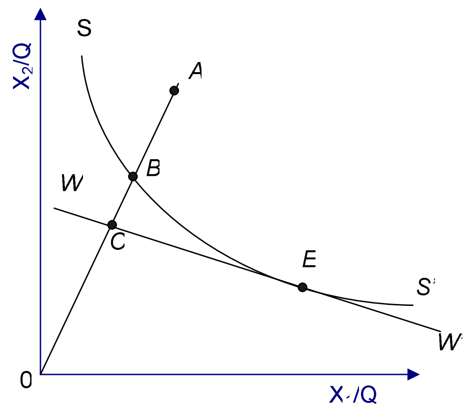

Fig. 1. Technical, allocative and economic efficiency

If the input price ratio, represented by the slope of the isocost line, *WW'* is also known, allocative efficiency (AE) at *A* can be calculated and identified by the ratio:

$$AE = OC/OB \quad (2)$$

The decrease in production costs with the distance from *B* to *C* would happen if production is performed at the allocatively and technically efficient point *E* instead of at the technically efficient, but allocative inefficient point *B*.

The total economic efficiency (EE) is defined to be the ratio:

$$EE = OC/OA \quad (3)$$

The distance from *A* to *C* also represents the cost cut in production if a firm produces at the point *C* with the technical efficiency and allocative efficiency instead of at the point *A* with technical inefficiency and allocative inefficiency. Economic efficiency is to combine technical efficiency and allocative efficiency.

Analytical Framework

There are two methods widely used in the literature to estimate technical efficiency. The first one is an econometric approach which aims to develop stochastic frontier models based on the deterministic parameter frontier of Aigner and Chu (1968). The second is Data Envelopment Analysis (DEA), which uses a nonparametric approach or mathematical programming method that is useful for multiple-input and multiple-output production technologies.

The different techniques are applied to generate the strengths and weaknesses of the two methods. The econometric approach is stochastic and parametric. It has the ability to separate the effects of noise from the effects of inefficiency and confound the effects of misspecification of functional form (of both technology and inefficiency) with inefficiency, but generates good results only for single output and multiple inputs. On the contrary, the mathematical programming approach is not stochastic and not parametric. It cannot separate the effects of noise and inefficiency during the calculation of technical efficiency, and less sensitive to the type of specification error (Kebede 2001), but could be useful to apply to farms with multiple-inputs and multiple-outputs production.

Since rice production in Vietnam is an example of single output and multiple-input production, this study focuses on the use of an econometric approach for measuring technical efficiency based on the production frontier model. A production frontier model can be written as:

$$Y_i = f\left(X_{ij};\beta\right) + \varepsilon_i \qquad (4)$$

where Y_i is output of the i farms, X_{ij} is a vector of inputs used by farm i, and ε_i is a "composed" error term. The error term ε_i is equal to v_i - u_i. The term v_i is a two-sided ($-\infty < v_i < \infty$) normally distributed random error ($v \sim N\ [0,\sigma_v^2]$) that represents the stochastic effects outside the farmer's control (e.g., weather, natural disasters, and luck), measurement errors, and other statistical noise. The term u_i is a one-sided ($u_i \geq 0$) efficiency component that represents the technical inefficiency of farm (Coelli *et al.* 2005). The distribution of term u_i can be half-normal, exponential, or gamma (Aigner *et al.* 1977; Meeusen and Broeck 1977). The assumption of term u_i in the study is a half-normal distribution $(u \sim N\ [0,\sigma_u^2])$ mainly used the other studies. The two components v_i and u_i are also assumed to be independent of each other.

Equation (4) estimated by the maximum likelihood analysis creates consistent estimators for β, λ and σ, where β is a vector of unknown parameters, $\lambda = \sigma_u / \sigma_v$, and $\sigma^2 = \sigma_u^2 + \sigma_v^2$. The technical inefficiency of individual farms can be estimated by using the conditional distribution of u_i given the fitted values of ε and the respective parameters (Jondrow *et al.* 1982). If we assume that v_i and u_i are independent each other, the conditional mean of u_i given ε is identified by:

$$E\left(u_i \mid \varepsilon_i\right) = \sigma^* \left[\frac{f^*\left(\varepsilon_i \lambda / \sigma\right)}{1 - F^*\left(\varepsilon_i \lambda / \sigma\right)} - \frac{\varepsilon_i \lambda}{\sigma} \right] \qquad (5)$$

where $\sigma^{*2} = \sigma_u^2 \sigma_v^2 / \sigma^2$, f^* is the standard normal density function, and F^* is the distribution function, both functions being estimated at $\varepsilon\lambda/\sigma$.

With the assumption of half-normal model, a simple z-test will be used for examining the existence of technical inefficiency, the null and alternative hypotheses are H_0: $\lambda = 0$ and H_1: $\lambda > 0$ (Coell *et al.* 2005). The test statistic is:

$$z = \frac{\tilde{\lambda}}{se\left(\tilde{\lambda}\right)} \sim N\left(0,1\right) \qquad (6)$$

where $\tilde{\lambda}$ is the maximum likelihood estimator of λ and $se\left(\tilde{\lambda}\right)$ is the estimator of its standard error.

The technical efficiency of farm will be determined by using the following equation:

$$TE_i = \exp\left(-\hat{u}_i\right) = \exp\left(-E(u_i \mid \varepsilon_i)\right) \qquad (7)$$

TE_i is greater than zero and less than 1. The maximum-likelihood estimates of the parameters of function (4) and the farm-level TE in (7) formula are achieved by using STATA version 10 software.

DATA AND EMPIRICAL MODEL

Data

The latest data from the VHLSS 2006 were used. The survey included a household questionnaire of 85 pages that was based on the format used by the World Bank and other measurement surveys of living standards. The survey was adjusted to reflect the conditions in Vietnam. It was conducted by the General Statistics Office of Vietnam, with technical advice from the World Bank.

Data from a total of 9,189 rural and urban households were collected all over Vietnam. Approximately 4,216 rice farmers were interviewed. Households with missing information were eliminated, thereby reducing the number of households in the study to 3,733.

Empirical model

There are several functional forms for estimating the physical relationship between inputs and output. Since the Cobb–Douglas functional form is preferable to other forms if there are three or more independent variables in the model (Hanley and Spash 1993), the Cobb-Douglas production function with nine input independent variables was applied in this study. These independent variables were *Seed expenditures, Pesticide costs, Fertilizer quantity, Machinery services, Hired labor* for rice production, *Family labors for rice*, *Rice land area, Small tools and energy, and Other rice expenditures*. Family labor for rice production was calculated by multiplying the percentage rice value for a farm with the total family labor for the farm. Rice land area and fertilizer quantity were measured in units of hectares and kilograms, respectively. Other inputs were calculated from the expenditures in Vietnamese currency (thousand VND). The Cobb–Douglas stochastic frontier model is written as:

$$\ln Y_i = \beta_0 + \sum_{j=1}^{9} \beta_{ij} \ln X_{ij} + v_i - u_i \qquad (8)$$

In the second step, the Tobit function with a dependent variable of technical efficiency was applied to determine factors that have an effect on the technical efficiency of Vietnamese rice farmers. The Tobit function is given by:

$$TE_i = \delta_0 + \sum_{k=1}^{15} \delta_k W_{ik} + \varpi_i \qquad (9)$$

where Y_i is the rice output in kg; X_{ij} is the nine used inputs mentioned above; v_i is the two sided random error; u_i is the one-sided half-normal error; TE_i is the level of technical efficiency; W_{ik} is the variable representing socio-economic characteristics of famers to explain technical inefficiency; k is an *Ethnicity* (dummy variable is 1 if farmer is Kinh ethnicity, 0 otherwise) (k = 1), *Member* (the number of family members in persons) (k = 2), *Age* (the age of household owner years) (k = 3), *Gender* of owner (dummy variable is 1 if man, 0 otherwise) (k = 4), *Experience* (the number of rice growing years) (k = 5), *Primary school* (dummy variable is 1 if farmer has studied primary school, 0 otherwise) (k = 6), *Secondary school* (dummy variable is 1 if farmer has studied primary school, 0 otherwise) (k = 7), *High school* (dummy variable is 1 if farmer has studied primary school, 0 otherwise) (k = 8), *Farm value* in natural log (the total value of agricultural products gained by farmers) (k = 9), *Irrigation* (dummy variable is 1 if rice cultivation in irrigation land, 0 otherwise) (k = 10), *Rice monoculture* (dummy variable is 1 if farmers cultivate rice only, 0 otherwise) (k = 11), *Agricultural policy* (dummy variable is 1 if households have perceived benefits from agricultural policies, 0 otherwise) (k = 12), *Life improvement* (dummy variable is 1 if there is the existence of improving the present standard living compared with 2001, 0 otherwise) (k = 13), *Labor-land* *ratio* (Ratio of labor to land) (k = 14), *Nonagri. income share* (proportion of total farmer income earned from nonagricultural sources) (k = 15); ϖ_i is an error term of Tobit function.

In fact, there are differences in agricultural practices, cropping patterns, the types of agricultural land of rice farmers in various regions in Vietnam. Because this study is calculated by using the national information of rice farmers from the VHLSS data that is mainly to measure living standards of households, the result of technical efficiency was estimated in the sum of cropping patterns a year with the assumption of no big differences in land and technology used by the rice farmers across the country.

Table 1 presents the descriptive statistics of some important variables applied in stochastic frontier production model and some farm specific characteristics. The average area of rice famer is around 0.7 ha with a range of 0.017 to 9.75 ha, suggesting the big variability of sizes among rice farmers in Vietnam. The result also shows that farmers have much experience on rice cultivation with the mean of nearly 20 years while their average education is more than 6 years. The total value of farming that farmer earns after harvest is averagely 13.5 million VND. The result reveals that farmers in Vietnam have low education level and small-scale, but with much experience in rice production.

Table 1. Descriptive statistics of some important components in rice cultivation $^{\Psi}$

Item	Mean	Std. Dev.	Min.	Max.
Stochastic frontier variables				
Rice quantity (kg)	3,588.38	5,492.66	80.00	51,430.00
Seed expenditures†	363.05	577.89	8.00	8,064.00
Pesticide costs†	444.70	1,101.24	0	15,000.00
Fertilizer quantity (kg)	389.18	579.59	3.00	16,938.00
Machinery services†	501.50	990.34	0	14,800.00
Hired labor†	413.07	1,145.10	0	15,540.00
Small tools and energy†	134.49	368.21	0	5,925.00
Other rice expenditures†	134.77	266.46	0	4,360.00
Family labors for farming activities (hrs)	1,195.80	594.98	40.00	3,600.00
Percent of rice	0.68	0.25	0.01	1.00
Family labors for rice (hrs)	771.77	451.02	3.04	3,368.54
Rice land area (ha)	0.73	1.05	0.017	9.75
Farm-specific variables				
Education of the farmer (years)	6.27	3.81	0	12
Experience (years)	19.50	10.86	0	67
Total value of farming activities†	13,465.43	16,307.89	530	369,489
Non-agricultural income share	0.13	0.26	0	1.00

† In thousand VND

$^{\Psi}$ Unit in sum of cropping patterns a year

Source: Own estimates; data appendix available from authors

ESTIMATED RESULTS

Technical efficiency

The OLS estimate for choosing the relevant variables and stochastic frontier production for estimating technical efficiency are shown in Table 2. The variables estimated in the OLS and MLE models are statistically significant at 0.1 percent. The coefficient R^2 is equal to 0.94, showing that around 94 percent of the dependent variable is explained by independent variables in the OLS model.

Table 2. OLS and stochastic frontier production estimates.

Variables	OLS		Stochastic Frontier	
	Coefficients	**Standard error**	**Coefficients**	**Standard error**
Seed expenditures	0.0625†	0.0100	0.0574†	0.0093
Pesticide costs	0.0375†	0.0034	0.0339†	0.0031
Fertilizer quantity	0.1192†	0.0066	0.0931†	0.0065
Machinery services	0.0152†	0.0016	0.0135†	0.0015
Hired labor	0.0057†	0.0016	0.0053†	0.0015
Small tools and energy	0.0157†	0.0032	0.0133†	0.0029
Other rice expenditures	0.0139†	0.0017	0.0110†	0.0016
Family labors for rice	0.0392†	0.0058	0.0229†	0.0054
Rice land area	0.7231†	0.0119	0.7648†	0.0115
Constant	-0.0152	0.0590	0.1645†	0.0546
Function coefficient $^{\psi}$	1.035		1.016	
F-statistic model	689.55†			
F-statistic CRTS	5.48†			
σ_v			0.136	
σ_u			0.278	
σ^2			0.096	
$\lambda=\sigma_u/\sigma_v$			2.047†	0.010
Log Likelihood			506.29	
R^2	0.943			

Notes: † indicate statistical significance of the 0.001 level
$^{\psi}$ The sum of estimated coefficients
CRTS is constant returns to size
Source: Own estimates; data appendix available from authors.

The presence or absence of technical inefficiency was tested in the study using the important parameter of log likelihood in the half-normal model $\lambda = \sigma_u/\sigma_v$. If $\lambda = 0$ there were no effects of technical inefficiency, and all deviations from the frontier were due to noise (Aigner *et al.* 1977). The estimated value of $\tilde{\lambda}$ = 2.047 significantly differed from zero. The null hypothesis that there is no inefficiency effect was rejected at the 0.1 percent level using the Z-statistic, suggesting the existence of inefficiency effects for rice farmers in Vietnam.

The study also examined the null hypothesis that there is a proportional output change when inputs in the model are varied or farms produce rice with constant returns to scale. The function coefficient of OLS is 1.035, showing the possibility of Vietnamese farmers increasing returns to scale in rice production. The restricted least squares regression with the null hypothesis of constant returns to scale was estimated. The computed F statistic of 35.48 was more than the critical value F at the 1 percent level of significance[1]. Thus, the null hypothesis is rejected and the study concluded that technology does not exhibit constant returns to scale.

The result of the frequency distribution of technical efficiency of rice farmers is presented in Table 3 based on the estimate of the frontier function. The study reveals technical efficiency (TE) of Vietnamese rice farmers ranging from 16.5 percent to 98.5 percent, with an average of 81.6 percent. It indicates that the average farmer in the sample could save 17.2 percent (i.e., 1-[81.6/98.5]) of costs and the most technically inefficient could realize a 83.2 percent cost saving (i.e., 1-[16.5/98.5]) compared with the TE level of his most efficient counterpart. In addition, the highest TE level ranging from 80 percent to 90 percent comprises 1,922 farms, which is 51.5 percent of the total. The lowest TE score of fewer than 50 percent comprises 51 farms, or 1.4 percent, indicating that almost all farms in Vietnam achieve rather high technically efficient production.

Table 3. Frequency distribution of technical efficiency for rice farming

TE level (%)	Number of households	Percent (%)
>90≤100	590	15.80
>80≤90	1,922	51.49
>70≤80	800	21.43
>60≤70	270	7.23
>50≤60	100	2.68
≤50	51	1.37
Mean TE (%)	81.6	
Minimum TE (%)	16.5	
Maximum TE (%)	98.5	

Source: Own estimates; data appendix available from authors.

Factors affecting technical efficiency

To analyze which factors could have an impact on the rice technical efficiency, the Tobit model is applied with *TE* as a dependent variable and some key socio-economic independent variables related to technical inefficiency presented in the equation (9), instead of the OLS estimate that might produce biased results, often toward zero (Bravo-Ureta and Pinheiro 1997). The results of Tobit function estimate are performed in the Table 4. All the coefficients, except those of *Age* and *Agricultural policy* variables, in the model are significantly positive, revealing that technical efficiency can be influenced by these determinants in the model.

The study shows that one of the most important factors affecting an increase of technical efficiency of households is the utility of intensive labor in rice cultivation because the coefficient of *Labor-land ratio* variable is statistically significant and bigger compared to other variables at the level

[1] Calculated by the formula $F = \frac{(SSE_R - SSE_U)/J}{SSE_U/(I-K)}$, where SSE_R and SSE_U are the restricted and unrestricted sums of squared residuals and J is the number of restrictions.

of 1 percent. The more intensive the labor investment in rice land, the higher the technical efficiency of households. Moreover, the result also determines the factor of irrigation plays the very important and essential role in rice cultivation. Farmers with well irrigation produce rice more efficiently than those without irrigation, represented by the significant coefficient of *Irrigation* variable at 1 percent level in the model.

Table 4. Factors associated with technical efficiency.

Variables	Explanation	Coefficients	t-test
Ethnicity	(1=Kinh, 0=Other ethnicity)	0.0178***	4.42
Member	(Number of members per household)	-0.0011	-1.07
Age	(The age of household owner in years)	-0.0003**	-1.84
Gender	(1=male, 0=female)	0.0058	1.37
Experience	(Number of rice growing years of owner)	0.0006***	3.79
Primary school	(1=Primary school, 0=otherwise)	0.0066	1.29
Secondary school	(1=Secondary, 0=otherwise)	0.0090*	1.83
High school	(1=High school, 0=otherwise)	0.0117**	2.07
Farm value	(Total value of farm products in VND 1,000)	0.0355***	13.74
Irrigation	(1=irrigation land, 0=non-irrigation)	0.0846***	8.12
Rice monoculture	(1=growing rice only, 0=growing mixed crops)	0.0214***	3.42
Agricultural Policy	(1= policy benefit perceptions, 0 = otherwise)	-0.0151***	-3.02
Life improvement	(1=existing life improvement, 0 = otherwise)	0.0221***	4.46
Labor-land ratio	(The ratio of labors and land)	0.1060***	10.97
Nonagri. income share	(Proportion of total income from nonagricultural sources)	0.0022	0.36
Constant		0.3464***	12.64
σ		0.0931	

Notes: 1) ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.1 level respectively
2) The number of observation is 3,733 households
Source: Own estimates; data appendix available from authors.

Similar to other studies, the significant positive coefficients of *Primary school* and *Secondary school* variables reveal that the level of education is a necessary element of technically efficient increase for rice farmers. Farmers who have secondary school level or above produce rice more productive or better than those without education or with only primary study.

Agricultural Policy variable is a dummy variable. Households were asked about their perceptions of the three main policies of the government, namely preferential credit, provision of cultivation land for ethic households, agro-forestry and fishery promotion. The variable is set to 1 if farmers have perceived benefits from one or more of these policies, and zero if they feel they have not benefited from government support programs. The expected coefficient of this variable has a negative sign because good policies might help farmers cultivate rice better and more efficiently. However, the study have reverse conclusion. Farmers who feel benefits from the government policies have the score of technical efficiency lower than those who have not perceived benefits from the agricultural policies undertaken by the government. The result reveals there is something wrong with the current policies being implemented by the government. Possible explanations could be that policies has targeted policies to some specific people, for instance, the poor who might grow rice less technically efficiently, or that policies are not strong enough to help households improve their farming skills and more technical efficiency in rice farming.

Ethnicity variable is a dummy variable. It is equal to 1 for Kinh ethnicity (The major racial people in Vietnam) and 0 for other ethnicities. Its estimated coefficient is significantly negative at 0.1 percent level, signaling that Kinh households could produce their rice with higher TE than others. Possible explanations could be that Kinh households have more education and experience levels than others. The estimated result shows that Kinh famers have averagely 7 school years and 20 years experience for rice farming while other ethnic ones go to school for 5 years and have the experience of 16 years on average.

Life improvement variable is derived by asking whether the present standard living of households has improved when compared with 2001. The estimated coefficient is negative and statistically significant at 0.1 percent level. Farmers who have higher ability to improve their lives use inputs more productively.

CONCLUSIONS AND RECOMMENDATIONS

This study attempted to estimate rice technical efficiency and identify its determinants. The analysis estimated the TE level to be 81.6 percent. These results suggest that increase in output and decrease in cost could be obtained using available technology. There was a big difference in technical efficiency among farmers in the sample, suggesting the potential ability of output increase by using inputs more efficiently.

The study also examined the relationship of the various attributes with the technical efficiency of farmers. The Tobit model was applied to analyze the equation of TE, demonstrated as functions of rice farmers' social-characteristics and other specific variables leading to technical inefficiency. The results revealed that intensive labor in rice land is the most important factor in helping farmers increase the technical efficiency of rice production. The second most important is irrigation. Farmers in the irrigated land produce rice more efficiently than those in the non-irrigated region while improving farmer's cultivation experience helps in obtaining higher TE. The study also investigated that the more the education levels of the farmers, the higher his/her technical efficiency in rice farming.

Therefore, to gain the TE score of rice farmers, the government should focus on encouraging rice farms to produce more efficiently in terms of the utility of labor. In addition, the government policies should concentrate to invest in irrigation and increase the level of farmers' education, knowledge about new technology applications and expenditure management through short trainings or extension services. These activities are also needed to be reformed and developed more effectively. Moreover, since almost all members currently supported to study more or attend short trainings are male. However, the results found there were no differences in technical efficiency between male and female header, therefore government should also give more priorities to support female for improving their education.

Although the government has had a variety of agricultural policies that target cultivating rice more efficiently, they have not been successful. The study revealed there was no positive relationship between the TE and agricultural policies. Farmers who benefited from policies were less able to grow rice efficiently. A possible explanation is that households who received support are poor, and thus, they might produce rice less efficiently than others. Another possible interpretation is that policies are not sufficiently strong or effective in helping farmers produce rice more efficiently. An in-depth study is needed to discover the impact of these policies on the technical efficiency of farmers, and determine the reasons of and solutions to these ineffective policies.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to two anonymous reviewers for their invaluable comments, which led to significant improvement of the manuscript. Our warmest thanks go to Mr. Joseph Arbiol at our laboratory for reading.

REFERENCES

Aigner, D. J. and Chu, S. F. 1968. On estimating the industry production function. *The American Economic Review.* Vol. 58, No. 4, 826-839.

Aigner, D. J., Lovell, C. A. K. and Schmidt, P. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics.* Vol. 6, No. 1, 21-37.

Belbase, K. and Grabowski, R. 1985. Technical efficiency in Nepalese agriculture. *The Journal of Developing Areas.* Vol. 19, No. 4, 515-525.

Bravo-Ureta, B. E. and Pinheiro, A. E. 1997. Technical, economic, and allocative efficiency in peasant farming: evidence from the Dominican Republic. *The Developing Economics.* Vol. 35, No. 1, 48-67.

Coelli, T. D. S. P. R. and George E.B. 2005. *An Introduction to Efficiency and Productivity Analysis*. Springer Science, New York.

Farrell, M. J. 1957. The measurement of productive efficiency. *Journal of the Royal Statistical Society. Series A (General).* Vol. 120, No. 3, 253-290.

Hanley, N and Spash, C. L.1993. *Farm Management Research for Small Farmer Development*. Food and Agriculture Organisation of the United Nations, Rome.

Jondrow, J., Knox Lovell, C. A., Materov, I. S. and Schmidt, P. 1982. On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics.* Vol. 19, No. 2-3, 233-238.

Kebede, T. A. 2001. Farm Household Technical Efficiency: A Stochastic Frontier Analysis: A Study of Rice Producers in Mardi Watershed in the Western Development Region of Nepal. Thesis/Dissertation, The University of Bergen.

Kompas, T. 2004. Market reform, productivity and efficiency in Vietnamese rice production. *International and Development Economics Working Papers, Asia Pacific School of Economics and Governmnet, Australian National University, Australia.*

Linh, H. V. 2007. Efficiency of Rice Farming Households in Vietnam: A DEA with Bootstrap and Stochastic Frontier Application. *Working papers, University of Minnessota, Minesota, USA.*

Meeusen, W. and Broeck, J. v. D. 1977. Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. *International Economic Review* Vol. 18, No. 2, 435-444.

Ministry of Agriculture and Rural Development. 008. General report on agricultural product import and export and rural development. Ha Noi, Vietnam.

Shapiro, K. H. 1977. Sources of technical efficiency: the roles of modernization and information. *Economic Development and Cultural Change.* Vol. 25, No. 2, 293-310.

Thiam, A., Bravo-Ureta, B. E. and Rivas, T. E. 2001. Technical efficiency in developing country agriculture: a meta-analysis. *Agricultural Economics.* Vol. 25, No. 2-3, 235-243.