The Impact of Rural Financial Services on the Technical Efficiency of Rice Farmers in the Upper North of Thailand[1]

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Abstract

After the financial crisis in 1997, the Thai government established and promoted financial services to rural areas to improve the quality of life of rural households and increase the productivity and technical efficiency of farmers. This paper seeks to investigate the impact of financial services on the technical efficiency of rice farmers. Stochastic frontier production functions are estimated using the survey data collected from 656 rice farmers in 2004. The average technical efficiencies of rice farmers were 79 per cent. Factors affecting the technical inefficiencies of rice farmers were land, amount of loans used for major rice production, experience, formal education and age. Hence, government policy that would improve the level of education of farmers and support rural financial services to farmers would lead to a significant increase in the level of technical efficiency of major rice production.

Keywords: *Stochastic frontier, production function, technical efficiency, Thai rural financial services*

1. Introduction

In the last two decades, Thailand has achieved impressive economic growth with an average annual growth rate of 7.8 per cent in GDP. Rapid economic growth led to changes in the structure of outputs. Between 1980 and 1995, the share of agriculture in GDP declined from 23 to 11 per cent. Meanwhile, the share of manufacturing industries increased from 29 to 40 per cent and the share of services remained approximately constant at 50 per cent (http://www.bwtp.org). Despite these changes, Thailand now has larger income inequality than in the past, especially between urban and rural areas. The majority of the population still lives in rural areas and works in the agricultural sector. People in the rural areas cannot improve their productivity because of the lack of access to the commercial financial system. The Eighth National Economic and Social Development Program, covering the period 1997-2001, was intended to support human development, improve the quality of life and promote community participation in order to increase employment opportunities, especially wage employment, in rural areas.

[1] Paper presented in a Contributed Papers session at the Annual Conference of the Australian Agricultural and Resource Economics Society at Coffs Harbour, 9-11 February 2005.

The financial crisis in 1997 affected the Thai economy and the performance of the rural financial institutions by increasing the number of non-performing loans from the banking system. The banking system or commercial financial institutions tended to reduce their credit to the production sector, particularly the agricultural sector. This led to a significant decline in household wealth and an increase in the income gap between the urban and rural sectors. The Thai government attempted to improve the financial services to rural areas in order to solve these problems by establishing and promoting community or non-commercial financial institutions. The poorest people and farmers without land or any assets are not eligible to receive loans from the commercial financial institutions. Therefore, organizations in the non-commercial financial sector are very important for the poor farmers. After the economic crisis, the non-banking system and the community financial units have been promoted by the government and their role in rural development has been increased.

In the past, the commercial financial institutions have played active roles in allocating credit to the agricultural sector in Thailand. However, most of the farmers are not eligible to receive loans from these financial institutions. Therefore, the non-commercial financial institutions have been established to help solve the financial problems of these farmers. We are interested to investigate the contribution of these financial institutions to the rural sectors. How do the financial services of these rural financial institutions affect the performance of rice farmers? The objectives of this paper is to examine the impact of the financial services of the rural financial institutions on the productivity and technical inefficiency of rice farmers in the Upper North of Thailand using stochastic frontier production functions. Chiang Mai and Chiang Rai provinces in the Upper North of Thailand are chosen as the study area.

The Upper North of Thailand covers about 60 per cent of the northern region and consists of nine provinces: Chiang Mai, Chiang Rai, Mae Hong Son, Lamphun, Prayao, Nan, Phrea, Lampang and Tak. These provinces are important for the agricultural production of the northern region and support a population of about three million people (Ministry of Agriculture and Cooperatives, 2002). About 70 per cent of people in the Upper North live in rural areas and are farmers. The main crop is “major rice”,[2] whose production in 2001 was 1.7 million tonnes or 8.1 per cent of the total production for the whole country. The main problem for rice farmers in Thailand is low productivity and efficiency. The average yields of major rice of the whole country for 1999, 2000

[2] “Major rice” refers to either non-glutinous or glutinous rice grown between May and October, irrespective of the time of harvest.

and 2001 were 348, 372 and 380 kilograms per rai,[3] respectively, compared with the world averages of 623, 621 and 619 kilograms per rai, respectively (Ministry of Agriculture and Cooperatives, 2002). However, the average yield for the north is higher than the national averages with the average yield of 491, 517 and 579 kilograms per rai for Chiang Mai and 462, 461 and 477 kilograms per rai for Chiang Rai for the years 1999, 2000 and 2001, respectively.

2. Literature Review

There are previous studies on efficiency relating role of financial services. Since rural financial institutions provide credit to farmers, most of previous studies focused on access to credit of farmers. This variable was generally measured in two ways, namely, dichotomous membership in credit programs and actual loan uptake. Credit access may raise both technical efficiency and allocative efficiency in the agricultural sector. It affects the farmer's level of technical efficiency by allowing farmers to adopt more capital-intensive methods of production, i.e., to purchase more machinery and market inputs. Furthermore, to the extent that credit access is correlated with the provision of technical assistance by credit organizations, credit can also raise allocative efficiency by allowing farmers to substitute non-market inputs with market inputs and increasing a farmer's ability to bear risk. In addition, credit could increase the net revenue of farmers obtained from fixed inputs, market conditions and individual characteristics (Abdulai and Huffman, 1998). Therefore, previous empirical studies have estimated production functions, cost functions or profit functions.

The production function approach has traditionally been used to examine the technical efficiency of farmers. There are some empirical studies that include credit to explain production inefficiency. Ekanayake (1987) examined efficiency of 123 Sri-Lankan farmers. Cobb-Douglas production frontiers were estimated for farms that had either good or poor water access. He found that literacy, experience, and credit availability had a significant positive impact on the technical efficiency level of the farms with poor water access. Taylor and Shonkwiler (1986) analyzed the effect of agricultural credit programs on the technical efficiency for a sample of 433 farmers in Brazil. The frontier parameters were estimated by maximum likelihood methods, assuming that the technical inefficiency effects had half-normal distribution. It was found that the credit program had no impact on improving technical efficiency. Bravo-Ureta and Evenson (1994) examined the technical, allocative and economic efficiency for a sample of farmers from Eastern

[3] One rai is equal to 0.16 hectare.

Paraguay by using the decomposition methodology. Cobb-Douglas production frontiers were estimated for 87 cotton and 101 cassava producers. The findings showed that there was a very weak connection between efficiency and socioeconomic characteristics. Pinheiro (1992) used the same methodology as Bravo-Ureta and Evenson for estimating technical, allocative and economic efficiency for a sample of 60 farmers in the Dominican Republic. The analysis revealed that credit had no impact on technical efficiency, allocative efficiency and economic efficiency. Kalirajan and Shand (1986) estimated a translog production frontier for paddy using unbalanced panel data for 34 farm households for the three years, 1981-1983, in South India. The results showed a positive relationship between technical efficiency and farming experience, education, access to credit, and extension services.

The production function approach, however, is not able to capture inefficiencies associated with different factor endowment and different input and output prices across farms. (Abdulai and Huffman, 1998). Therefore, dual frontiers, either the profit function approach or the cost function approach, have been used in analyses of efficiency. It is because the dual relationships provide the flexibility in problem-solving when data are limited or are of a specific type. Nevertheless, the quality of the estimated dual relationships may not be good if price variability is small, firms have market power or measurement error has occurred (Lusk, Abdulkadri and Featherstone,1999). Ali and Flinn (1987) examined farm-specific profit efficiency for 120 rice farmers in Pakistan. A translog stochastic profit frontier was estimated by maximum likelihood. The finding showed that education had a significant role in reducing profit inefficiency. In addition, off-farm employment and difficulties in securing credit to purchase fertiliser increased profit inefficiency. Abdulai and Huffman (1998) applied a stochastic translog profit frontier to examine production efficiency for 256 rice farmers in Northern Ghana in 1992-93. The results revealed a negative and statistically significant relationship between access to credit and profit inefficiency. It means that farmers lacking credit to purchase fertiliser tended to experience higher profit inefficiency.

There are only a few studies dealing with the efficiency of rice farmers in Thailand. All of them focused on the production frontier model and did not take account of credit in their models. Wiboonpongse and Sriboonchitta (2004) estimated the effects of production inputs and technical efficiency on jasmine and non-jasmine rice for 489 farmers in Chiang Mai Province, Phitsanulok Province and Tung Gula Ronghai in 1999. Factors affecting technical inefficiency were also analysed simultaneously with the production frontiers using the maximum-likelihood method.

Moreover, Sriboonchitta and Wiboonpongse (2004) analysed factors, especially neck blast, affecting the jasmine and non-jasmine rice production in Thailand. Another study on efficiency of rice farms in Thailand was conducted by Krasachat (2003). He estimated technical efficiency for 74 rice farm households in three provinces of the Northeastern region by using a non-parametric approach. The findings indicated a wide diversity of efficiencies among farmers and also suggested that the diversity of natural resources had an influence on technical efficiency. This study sought to estimate the effect of rural credit on the technical efficiency of Thai farmers in order to see the impact of rural financial services on the rural area.

3. Empirical Analysis

3.1 Data on Rice Farmer Samples

The data used in this study were obtained from surveys in Chiang Mai and Chiang Rai provinces. It was decided that a sample of about 600 farmers could be obtained given the resources and time available for the survey work. The sampling process involved selecting sample farmers separately in each province to ensure that sample farmers were chosen from both provinces. In each province, sample districts were selected from a frame of the districts. Four sample districts were selected from the 22 districts in Chiang Mai province and three sample districts were selected from the 16 districts in Chiang Rai province. Sample sub-districts were randomly selected from within the selected districts in each province (or the frame of the sub-districts). From the listing of all sub-districts in each district, at least one sub-district was randomly selected. A sample village was then randomly chosen within each selected sub-district. However, if the numbers of farmers in the selected village was relatively small, then one or two more sub-districts and villages were selected so that the total number of farmers in the sample reached at least 600. There were 11 sample villages obtained from Chiang Mai province and 10 villages from Chiang Rai province. All farmers in each sample village who grew major rice for commercial purposes were interviewed. The total number of farmers was 656, of which 545 were debtor farmers and 111 were non-debtor farmers. There were 331 sample farmers in Chiang Mai province, comprising 250 debtor farmers and 81 non-debtors farmers. In Chiang Rai province, there were 325 sample farmers, of which 295 were debtor farmers and 30 non-debtor farmers.

A summary of the values of the key variables in the stochastic frontier model is presented in Table 1. The land areas that were cultivated by sample farmers varied from very small (1 rai) to relatively large (70 rai) by Thai standards. The use of seed in major rice production varied from 5 to 560 kg. Some of the sample farmers did not use fertiliser and/or pesticide and herbicide. The average amount of loans for major rice production in the sample was about 9,800 baht, with the maximum amount of 100,000 baht. The average experience on major rice cultivation, highest education level and age of the head of household were about 27, 5, and 51 years, respectively, indicating that the rice farmers tended to be quite old with considerable experience in major rice cultivation, but relatively little formal education.

Table 1: Summary Statistics of Key Variables for Sample Rice Farmers

Variable	Sample Mean	Sample Standard Deviation	Minimum	Maximum
Output (kgs)	5,650.0	4,168.2	224	49,000
Land (rai)	9.6	7.1	1	70
Seed (kgs)	77.8	62.7	5	560
Fertiliser (kgs)	307.8	369.2	0	6,200
Total cost of pesticide and herbicide (baht)	645.6	765.3	0	8,800
Labour (man-hours)	402.3	552.2	8	6,560
Amount of loan for major rice cultivation (baht)	9,816.8	11,825.6	0	100,000
Experience of the head of household (years)	27.4	13.5	1	65
Highest education of the head of household (years)	4.6	2.1	0	16
Age of the head of household (years)	51.1	11.1	23	97

Source: From survey

3.2 Stochastic Frontier Analysis

The empirical results from our analysis indicate that the Cobb-Douglas production function is not an adequate representation of the data, given the specifications of the translog production function that is defined below. Because of this finding, results for only the translog stochastic frontier production function model are presented in this paper. The translog model that is estimated in this study is defined by

$$\ln Y_i = \beta_0 + \sum_{j=1}^{5} \beta_j \ln X_{ji} + \frac{1}{2} \sum_{j\leq}^{5} \sum_{k}^{5} \beta_{jk} \ln X_{ji} \ln X_{ki} + \sum_{j=1}^{2} \beta_{0j} D_{ji} + V_i - U_i \quad (1)$$

where

Y represents the quantity of rice harvested for the sample farmer (in kilograms);

X_1 is the total area planted to major rice (in rai);

X_2 is the total amount of seed sown (in kilograms);

X_3 is the amount of chemical fertiliser applied (in kilograms);[4]

X_4 is the total cost of chemicals (pesticides and herbicides) spent (in baht);[5]

X_5 is the total labour used in the activity that used most labour in cultivation of major rice (in man-hours);

the $V_i s$ are random errors that are assumed to be independent and identically distributed as $N(0,\sigma_v^2)$ random variables; and

the $U_i s$ are non-negative technical inefficiency effects that are assumed to be independently distributed among themselves and between to $V_i s$ such that U_i is defined by the truncation of the $N(\mu_i,\sigma^2)$ distribution, where μ_i is defined by:

$$\mu_i = \delta_0 + \sum_{j=1}^{5} \delta_j Z_{ji} \qquad (2)$$

where

Z_1 represents the total area planted to major rice, which is the same as X_1;

Z_2 represents the total amount of any loans used in major rice production (in baht);

Z_3 represents the experience of the head of household in rice cultivation (in years);

Z_4 represents the number of education level of the head of household (in years); and

Z_5 represents the age of the household head (in years).

The variables involved in the frontier production function comprise land, seed, fertiliser, chemicals and labour. These variables are major inputs affecting major rice production directly.

[4] More technically, X_3 is the maximum of the amount of chemical fertiliser applied and the variable, $1-D_1$, where D_1 is the dummy variable for chemical fertiliser, which has value one if chemical fertiliser was applied, and zero, otherwise. This uses the approach of Battese (1997) for handling zero-input values.

[5] As for the fertiliser variable, X_4 is the maximum of the total cost of chemicals spent and the variable, $1-D_2$, where D_2 is the dummy variable for pesticide and herbicide, which has value one if pesticides and herbicides were applied, and zero, otherwise.

The model for the technical inefficiency effects contains variables that are associated with human capital, such as experience in major rice cultivation, amount of schooling of the head of the household and the age of the head of the household. The area of land cultivated is included in modelling the inefficiency effects to permit the possibility that the size of the rice-farming operation may influence the level of inefficiency. If the coefficient of land is not zero, then the stochastic frontier model is called a non-neutral model as discussed by Huang and Lui (1993) and Battese and Broca (1997). The amount of the total loan used for rice farming operations is included in the inefficiency model to detect if the loans had a positive influence on the technical efficiency of rice production, as desired by the Thai government.

The amount of any loans used in major rice production, which represent the financial services from the rural financial institutions, was initially included in the production function as well as the model for the technical inefficiency effects, to test the effect of financial services on the productivity. It was found that the amount of loans used in major rice production had no significant effect on the level of production of major rice but it had a significant effect on the technical inefficiency of the rice farmers. For farmers who had loans to assist in meeting the cost of major rice production, the amount of loans were mainly used for purchasing other inputs, such as fertiliser and chemicals, used for growing rice.

A capital variable, defined as the total present value of equipment and machinery used in the growing of major rice, was also included in the production function and the model for the technical inefficiency effects in preliminary analyses. The empirical results showed that it had no significant effect on the level of production of major rice or on the technical inefficiency of production. Thus, the model defined above is the frontier model without the loan variable included in the production function.

In the model for the technical inefficiency effects, the logarithm of land was initially considered but it was found that the model with actual land, rather than its logarithm, resulted in a higher likelihood value for the data.

The technical efficiency of an individual farmer is defined as the ratio of observed output to its corresponding stochastic frontier output, given the levels of the inputs used by the farmer. Hence the technical efficiency of the *i*-th farmer is expressed as

$$TE_i = Y_i / Y_i^* = \exp(-U_i) \qquad (3)$$

Estimates for the parameters for this stochastic frontier production function model are obtained by using the computer program, FRONTIER Version 4.1, written by Coelli (1996), which estimates the variance parameters in terms of $\sigma_s^2 = \sigma^2 + \sigma_v^2$ and $\gamma = \sigma^2 / \sigma_s^2$. Various tests of hypotheses for the parameters of the frontier model are carried out using the generalised likelihood-ratio statistic, λ, defined by $\lambda = -2\ln[L(H_0)/L(H_1)]$, where $L(H_0)$ is the value of the likelihood function for the frontier model, in which the parameter restrictions that are stated by the appropriate null hypothesis, H_0, are imposed; and $L(H_1)$ is the value of the likelihood function for the general frontier model. The generalised likelihood-ratio statistic has approximately a chi-square (or mixed chi-square) distribution if the null hypothesis is true.

3.3 Results and Discussion

3.3.1 Estimation of Frontier Model

The maximum-likelihood estimates of the parameters in the stochastic frontier model, defined by equations (1) and (2), are given in Table 2. The empirical analysis was conducted with mean-corrected values of the variables so that the coefficients of the logarithms of the inputs can be interpreted as elasticities at mean input values.

The estimate for the γ-parameter in the stochastic frontier model is quite large (0.975), which means that the inefficiency effects are highly significant in the analysis of the quantity of rice output of the farmers. The estimated coefficients of the variables for the frontier production function generally have the expected signs. The elasticities of the input variables, at the mean-input values, are all positive such that the values for land, labour and fertiliser are significant at the 10 per cent level. These values imply that the increase in land, fertiliser and labour by one per cent are likely to increase in major rice production by 0.850, 0.029 and 0.034 per cent, respectively (Table 2). The coefficients of the squares of the logarithms of land and chemicals are negative and statistically significant at the 10 per cent level. This indicates that the translog production function exhibits declining marginal productivities with respect to these inputs. The coefficients of the interactions between land and seed, land and chemicals, seed and fertiliser, fertiliser and chemicals, and fertiliser and labour are also significant at the 10 per cent level.

All of the coefficients of the explanatory variables for the technical inefficiency effects are highly statistically significant. The positive sign for land shows that larger farms tend to have higher technical inefficiencies in major rice production. The estimated negative coefficient for the amount of loans used for major rice production means that farmers who obtain larger loans for major rice tend to have smaller technical inefficiencies. This is presumably because farmers could buy production inputs at the most appropriate times and change their production practices when funds were available from loans. The negative sign for experience of the head of household means that farmers with greater experience in rice production tend to have smaller technical inefficiencies than these with less experience, *ceteris paribus*. The negative coefficient for formal schooling of the head of household indicates that household heads with the higher levels of schooling tend to have smaller technical inefficiencies. The negative sign for age shows that older farmers tend to be less inefficient in major rice production.

Table 2: Maximum-likelihood Estimates for Parameters of the Stochastic Frontier Model for Major Rice Farmers in the Upper North of Thailand

Variable	Parameter	Coefficient	Standard error	t-ratio
Production Function				
Constant	β_0	9.17	0.47	19.37
Fertiliser Dummy	β_{01}	-0.09	0.32	-0.28
Chemicals Dummy	β_{02}	-0.39	0.36	-1.10
Land	β_1	0.850	0.032	26.22
Seed	β_2	0.004	0.025	0.15
Fertiliser	β_3	0.029	0.020	1.45
Chemicals	β_4	0.023	0.022	1.04
Labour	β_5	0.034	0.013	2.69
$(\text{Land})^2$	β_{11}	-0.20	0.10	-1.91
$(\text{Seed})^2$	β_{22}	-0.027	0.069	-0.39
$(\text{Fertiliser})^2$	β_{33}	0.017	0.023	0.72
$(\text{Chemicals})^2$	β_{44}	-0.026	0.019	-1.37
$(\text{Labour})^2$	β_{55}	0.005	0.015	0.33
Land x Seed	β_{12}	0.095	0.071	1.33
Land x Fertiliser	β_{13}	0.029	0.028	1.05
Land x Chemicals	β_{14}	0.055	0.012	4.51
Land x Labour	β_{15}	0.004	0.028	0.13
Seed x Fertiliser	β_{23}	-0.042	0.024	-1.70
Seed x Chemicals	β_{24}	-0.007	0.010	-0.70
Seed x Labour	β_{25}	0.020	0.025	0.82
Fertiliser x Chemicals	β_{34}	-0.0074	0.0032	-2.25
Fertiliser x Labour	β_{35}	-0.0122	0.0093	-1.32
Chemicals x Labour	β_{45}	-0.0063	0.0058	-1.07
Inefficiency Model				
Constant	δ_0	0.58	0.31	1.87
Land: (Z_1)	δ_1	0.104	0.031	3.36
Amount of Loans: (Z_2)	δ_2	-0.000040	0.000013	-3.14
Experience: (Z_3)	δ_3	-0.0087	0.0048	-1.81
Education: (Z_4)	δ_4	-0.40	0.13	-3.13
Age: (Z_5)	δ_5	-0.052	0.018	-2.93
Variance Parameters				
Total of Variance	σ_s^2	1.03	0.29	3.55
Gamma	γ	0.9751	0.0074	132.21
Log likelihood function		-86.347		

Formal tests of the various null hypotheses were conducted and the results are presented in Table 3. The first null hypothesis, H_0: $\beta_{ij} = 0$, for all i and j, which states that the Cobb-Douglas production function is an adequate representation of the data for major rice farmers, is strongly rejected by the data, as stated earlier. The second null hypothesis, H_0: $\gamma = \delta_0 = \delta_1 = ... = \delta_5 = 0$, which specifies that the technical inefficiency effects are not present in the model, is rejected. The third null hypothesis considered in Table 8, H_0: $\delta_1 = ... = \delta_5 = 0$, is strongly rejected, indicating that the explanatory variables in the inefficiency model do influence the technical inefficiencies of rice production. The fourth null hypothesis, H_0: $\delta_1 = \delta_2 = 0$, which specifies that land and the amount of any loans used for major rice production have no effect on the technical inefficiency, is rejected. Tests that the individual coefficients of these variables are zero indicate that the coefficients are significant. Furthermore, this model is a non-neutral stochastic frontier model with land since the inefficient effects were functions of the area of land on which rice is grown.

Table 3: Likelihood-ratio Tests of Null Hypotheses for Parameters in the Stochastic Frontier Production Function Model

Null Hypothesis	Test statistic λ	Critical value	Decision
H_0: $\beta_{ij} = 0$,for all i and j	46.46	25.00	Reject H_0
H_0: $\gamma = \delta_0 = \delta_1 = ... = \delta_5 = 0$	183.16	13.40	Reject H_0
H_0: $\delta_0 = \delta_1 = ... = \delta_5 = 0$	66.98	12.59	Reject H_0
H_0: $\delta_1 = \delta_2 = 0$	13.05	5.99	Reject H_0
H_0: $\delta_1 = 0$	14.45	3.84	Reject H_0
H_0: $\delta_2 = 0$	4.59	3.84	Reject H_0

3.3.2 Technical Efficiencies

The mean technical efficiency of all sample farmers selected from the Upper North of Thailand, given the specifications of the stochastic frontier model, is 0.792, while, the maximum and the minimum of the technical efficiency of the sample farmers are 0.966 and 0.056, respectively. About 62.3 per cent of the total sample farmers had very high technical efficiencies that were between 0.80 and 1.0 (Table 4).

Table 4: Technical Efficiencies of Sample Farmers in Producing Major Rice

Technical efficiency	Number	Percentage
Very low (0.000 – 0.200)	3	0.5
Low (0.201 – 0.400)	11	1.7
Medium (0.401 – 0.600)	57	8.7
High (0.601 – 0.800)	176	26.8
Very high (0.801 – 1.000)	409	62.3
Total	656	100.0

3.3.3 Elasticities

The elasticity of the mean output with respect to land, X_1, given the specifications of the translog non-neutral stochastic frontier production function, is obtained using the following expression (Battese and Broca, 1997):

$$\frac{\partial \ln E(Y_i)}{\partial \ln x_1} = \beta_1 + \beta_{11} \ln x_1 + \sum_{j \neq 1}^{5} \beta_{1j} \ln x_j - C\left(\frac{\partial \mu}{\partial \ln x_1}\right) \qquad (4)$$

where μ is defined in equation (2)

$$\frac{\partial \mu}{\partial \ln x_1} = \delta_1 x_1;$$

and C is defined by $$C = 1 - \frac{1}{\sigma}\left\{\frac{\phi\left(\frac{\mu}{\sigma} - \sigma\right)}{\Phi\left(\frac{\mu}{\sigma} - \sigma\right)} - \frac{\phi\left(\frac{\mu}{\sigma}\right)}{\Phi\left(\frac{\mu}{\sigma}\right)}\right\};$$

and ϕ and Φ represent the density and distribution function of the standard normal random variable, respectively.

The estimated elasticity of mean output with respect to land has two components. The first component is the elasticity of frontier output, which is estimated by 0.850, the coefficient of the logarithm of land in the production function. The second component of the elasticity of mean output with respect to land is the elasticity of the technical efficiency with respect to land. Using the mean value land of 9.6 (see Table 1), the estimate for δ_1 of 0.104 and the estimate for the constant, C, of 0.04887, the estimate for the elasticity of technical efficiency of land is found to be 0.049. Thus the estimated elasticity of mean rice output with respect to land is 0.801, estimated at mean input levels.

The coefficients of the logarithms of the four explanatory variables, seed, fertiliser, chemicals and labour, in the production function are partial elasticities of major rice output with respect to the corresponding variables, which were 0.004, 0.029, 0.023 and 0.034, respectively. However, the elasticities for seed and chemicals are not significantly different from zero.

4. Policy Implications and Conclusions

A translog non-neutral stochastic frontier production function is used in this study. The results show that the most significant variables explaining the variation major rice production are land, fertiliser and labour. The technical inefficiencies of production of farmers are significantly related to land, the amount of loan used for major rice production, the experience of the head of household, the formal schooling level of the head of household and the age of the head of household. Therefore, agricultural policy makers should focus on the factors affecting the efficiency of farmers including improving the schooling level of farmers, increase in the number of rural financial institutions and improve the borrowing conditions so that farmers can avail themselves of loans to assist in their major rice production operations. Education policies, which would encourage farmers through formal study and training programs, would lead to an increase in technical efficiency of rice production.

In the past, the Thai government has tried to increase rice production by increasing the land planted to rice. However, the low productivity is the crucial factor affecting major rice production. The government attempted to stimulate farmers to adopt new agricultural technology such as high yielding variety seed and modern agricultural machinery. The average yield of major rice has increased only slowly. It is because some farmers are not able to get access to agricultural inputs because they have insufficient funds for their production activities. From this empirical study, the basic agricultural inputs, land, fertiliser and labour, affect rice production. Therefore, it is very necessary for farmers to get funds to buy these inputs in appropriate quantities and at the right time. Loans from rural financial institutions are an important factor affecting the productivity and efficiency of farmers. The policy of the government of promoting rural financial institutions to rural areas in recent years has benefited farmers in terms of their productivity and efficiency of production.

The implication of this finding is that while all the variables are important determinants of efficiency, education of the head of household is the most crucial determinant of technical efficiency in the Upper North. Hence any government policy that would improve the level of education of farmers and support rural financial services to farmers would lead to a significant increase in the level of technical efficiency of major rice production.

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