

The Effects of Production Inputs, Technical Efficiency and Other Factors on Jasmine and Nonjasmine Rice Yields in Production Year 1999/2000 in Thailand^a

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Abstract

Both jasmine and nonjasmine rice yields in Thailand are substantially lower than the world rice yield. Sources of yield variations in both kinds of rice, i.e., production input, technical efficiency and other factors are investigated in this study. Factors affecting technical inefficiency are also analysed simultaneously with the production frontiers using maximum likelihood method by Frontier 4.1 computer program. The transcendental logarithmic (translog) and Cobb-Douglas stochastic production frontiers are used. The Cobb-Douglas frontier is finally selected for policy implications. It is found that the crucial factors influencing jasmine rice yield are technical efficiency, chemical fertiliser, labour, irrigation, severe drought and neck blast whereas those for the nonjasmine rice are the same except labour and neck blast. The factors affecting the technical inefficiency for nonjasmine in a negative relationship are male labour to total labour ratio and experience reflected by age while

the labour influences in the positive direction. For the jasmine rice, there is only one variable, i.e., male-labour to total labour ratio, that influences the technical inefficiency significantly.

Key word : Thailand, neck blast, stochastic production frontier, jasmine rice, nonjasmine rice, technical efficiency, technical inefficiency.

1. Introduction

Rice has been one of the major export products of Thailand since the old days even though its export role has become relatively less important nowadays. Quality rice has been strategised to replace non quality rice to avoid competition in the highly competitive price cutting non-quality rice market. Jasmine rice is a variety of quality rice promoted to replace the non-quality rice. The planted area of jasmine rice increased from 9.945 million *rai* (1 *rai* = 1/6.25 hectare) in 1989/1990 production year to 17.300 million *rai* in 1997/1998 production year,

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(73.96% increase). The share of jasmine rice planted area from the total rice planted area jumped from 16.80% to 28.27% in the same respective production years. The jasmine rice production share also moved in the same direction from 13.58% in 1989/1990 and reached 22.60% in 1997/1998 (Sriboonchitta and Wiboonpongse 2000). The export quantity share of jasmine rice to the total rice export quantity had been increasing substantially from 3.08% in 1989 to 27.40% in 1996 while value share had jumped from 4.11% to 39.01% in the same respective years. The jasmine rice export quantity increased 9.75 times from 1989 to 1996 in seven years. However, the export value of jasmine rice during the same period expanded from 1,358 million baht to 19,130 million baht, (14.09 times). This implied that the absolute price per ton of jasmine rice export was up by 44.42% in seven years whereas the nonjasmine rice export price increased by 14.97% (Sriboonchitta and Wiboonpongse 2000). This was the incentive for farmers to switch from nonjasmine to jasmine rice production and hence increased the its total production volume. The alternative to increase its production volume is to enhance its yield per *rai*. Nevertheless complaints still focus on low yields of both jasmine and nonjasmine rice production. The overall rice yields per *rai* from the latest four production years, 1994/1995 - 1997/1998, were 358, 347, 352 and 337 kg per *rai* respectively, which were rather stable and had no growth. The

jasmine rice yields were more stable and had no growth; 275, 277, 266 and 269 kg per *rai* in the same respective years (Sriboonchitta and Wiboonpongse 2000, Office of Agricultural Economics 1999). However, Centre for Agricultural Information (2000, pp13-14) reported that the Thai rice yield in 1998 was just 65.84% of the world average yield. Thus, factors affecting jasmine and nonjasmine rice yields have to be investigated in this study.

2. Method

The variables hypothesised to affect the yields of jasmine and nonjasmine rice production, Y (rice output (kg) per *rai*), in this study are (1) seed (kg per *rai*), X_1 , (2) chemical fertiliser (kg per *rai*), X_2 , (3) labour (man-hours per *rai*), X_3 , (4) other chemical substance using dummy variable $D_1=1$ if using other chemical substance and 0 otherwise, (5) location dummy variables, $D_2=1$, if the observation is from Phitsanulok province and 0 otherwise and $D_3 = 1$ if it is from Tung Gula Ronghai (the northeastern area) and 0 otherwise, (6) rice transplanting dummy variable $D_4=1$ if the observation is transplanting rice and 0 otherwise, (7) irrigated area dummy variable $D_5=1$ if it is irrigated area and 0 otherwise, (8) severe drought dummy variable $D_6=1$ if it has severe drought and 0 otherwise (9) neck blast dummy variable $D_7=1$ if it has neck blast and 0 otherwise. The signs of the coefficients of X_1 , X_2 , X_3 , D_3 , D_4 and D_5 are expected to be positive, D_6

and D_7 negative whereas the signs of D_1 and D_2 could be either positive or negative and (10) the last but not least factor which may affect the yield per *rai* is the technical efficiency which could be measured by using stochastic frontier in this study. Factors affecting inefficiency can also be investigated.

To consider the effects of these factors on jasmine and nonjasmine rice yields, the transcendental logarithmic (translog) and Cobb-Douglas production functions are estimated in this study. These functions are specified as follows.

Translog production function :

$$\begin{aligned} \ln y = & \alpha_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 \\ & + \frac{1}{2} \beta_{11} (\ln X_1)^2 + \beta_{12} (\ln X_1) (\ln X_2) + \beta_{13} \ln X_1 \ln X_3 \\ & + \frac{1}{2} \beta_{22} (\ln X_2)^2 + \beta_{23} (\ln X_2) (\ln X_3) \\ & + \frac{1}{2} \beta_{33} (\ln X_3)^2 + \sum_{i=1}^7 \gamma_i D_i + u \end{aligned} \quad (1)$$

Logarithmic transformed Cobb-Douglas production function :

$$\ln y = \omega_0 + \omega_1 \ln X_1 + \omega_2 \ln X_2 + \omega_3 \ln X_3 + \sum_{i=1}^7 \theta_i D_i + u \quad (2)$$

These two estimated production functions are compared, and then the most appropriate function is selected to explain the effects of the specified factors on jasmine and nonjasmine rice yields.

2.1 Production Frontier Estimation

To examine technical efficiency for jasmine and nonjasmine rice productions, production frontiers are needed to be estimated. If the production functions for jasmine and nonjasmine rice are specified respectively as

$$y_{1i} = X'_{1i} \beta_1 + \varepsilon_{1i} \quad (3)$$

$$y_{2i} = X'_{2i} \beta_2 + \varepsilon_{2i} \quad (4)$$

where y_{1i} = jasmine rice output, y_{2i} = nonjasmine rice output, X'_{1i} = a $k_1 \times 1$ vector of inputs for jasmine rice, X_{2i} = a $k_2 \times 1$ vector of inputs for nonjasmine rice, β_1 = a $k_1 \times 1$ vector of parameters associated with X_{1i} , β_2 = a $k_2 \times 1$ vector of parameters associated with X_{2i} , ε_{1i} and ε_{2i} = error terms for jasmine and nonjasmine rice production functions, i = the i th observation. The respective production frontiers may be written as

$$y_{1i} = X'_{1i}\beta_1 + v_{1i} - u_{1i} \quad (5)$$

$$y_{2i} = X'_{2i}\beta_2 + v_{2i} - u_{2i} \quad (6)$$

where $v_{1i} \sim N(0, \sigma_{v_1}^2)$, $v_{2i} \sim N(0, \sigma_{v_2}^2)$; u is truncated normal

$$f(u) = \frac{2}{\sigma_u (2\pi)^{\frac{1}{2}}} \exp\left(\frac{-u^2}{2\sigma_u^2}\right) \quad (u \geq 0) \quad (7)$$

The term $-u$ is the one-sided error. This implies that each observation is on or below the frontier. $-u$ is called "technical inefficiency" (Maddala, 1983, p195). The u_{1i} and u_{2i} are non-negative random variables and called technical inefficiency effects, which are assumed to be independently distributed such that u_{1i} and u_{2i} are defined by the truncation (at zero) of the normal distribution with means μ_{1i} and μ_{2i} and variances $\sigma_{u_1}^2$ and $\sigma_{u_2}^2$ (Seyoum, *et al.* (1998)). v is the usual two-sided error that represents the random shifts in the frontier due to favorable and unfavorable factors. It captures measurement error in y as well.

If u and v are distributed independently, and from Weinstein's result (1964), We obtain

$$g(\varepsilon_1) = \frac{2}{\sigma} \phi\left(\frac{\varepsilon_1}{\sigma_{\varepsilon_1}}\right) \left[1 - \Phi\left(\frac{\varepsilon_1 \lambda_1}{\sigma_{\varepsilon_1}}\right)\right] \quad (8)$$

$$g(\varepsilon_2) = \frac{2}{\sigma} \phi\left(\frac{\varepsilon_2}{\sigma_{\varepsilon_2}}\right) \left[1 - \Phi\left(\frac{\varepsilon_2 \lambda_2}{\sigma_{\varepsilon_2}}\right)\right] \quad (9)$$

where

$$\sigma_{\varepsilon_1}^2 = \sigma_{u_1}^2 + \sigma_{v_1}^2, \quad \lambda_1 = \sigma_{u_1} / \sigma_{v_1}$$

$$\sigma_{\varepsilon_2}^2 = \sigma_{u_2}^2 + \sigma_{v_2}^2, \quad \lambda_2 = \sigma_{u_2} / \sigma_{v_2}$$

$\phi(\cdot)$ and $\Phi(\cdot)$ = density function and distribution function of standard normal distribution respectively.

The estimation method for production frontiers was suggested by Aigner *et al.* (1977). To measure average inefficiency, Aigner, Lovell and Schmidt (1977) suggested to use $\lambda = \sigma_u / \sigma_v$ and

$E(-u) = \left(\frac{1}{2^2} / \pi^{\frac{1}{2}}\right)$. In case of the Cobb-Douglas, the production frontier may be expressed as

$$y = AK^\alpha L^\beta e^{-u} e^v \quad (10)$$

In this case the technical efficiency is

$$e^{-u} = y / (AK^\alpha L^\beta e^v) \quad (11)$$

where $-u$ is half normal. The mean of technical efficiency is, then, obtained as

$$E(e^{-u}) = 2 \exp\left(-\frac{\sigma_u^2}{2}\right) [1 - \phi(\sigma_u)] \quad (\text{Maddala, 1983, p195}) \quad (12)$$

Jondrow et. al. (1982) showed the method of estimation of individual farm inefficiency by showing that the expected value of u for each observation could be obtained from conditional distribution of u , given ε and with the normal distribution for v and half normal for u . The expected value of inefficiency for each farm, given ε , can be obtained as

$$E(u | \varepsilon) = \frac{\sigma_u \sigma_v}{\sigma_\varepsilon} = \left[\frac{\phi(\varepsilon \lambda / \sigma_\varepsilon)}{1 - \Phi(\varepsilon \lambda / \sigma_\varepsilon)} - \frac{\varepsilon \lambda}{\sigma_\varepsilon} \right] \quad (13)$$

(Bravo - Ureta and Rieger, 1991; Wang et al. 1996)

2.2 Production Frontier Estimation with Inefficiency Equation

However, since u_{1i} 's and u_{2i} 's are non-negative random variables which are assumed to be independently distributed such that u_{1i} and u_{2i} are defined by the truncation (at zero) of normal distributions with mean μ_{1i} and μ_{2i} and variances, $\sigma_{u_1}^2$ and $\sigma_{u_2}^2$ respectively, Seyoum et al. (1998) defined each μ_i as a function of some explanatory variables

$$\mu_{1i} = \theta_{11} + \theta_{12} F_{2i} + \dots + \theta_{1m} F_{mi} \quad (14)$$

$$\mu_{2i} = \theta_{21} + \theta_{22} F_{2i} + \dots + \theta_{2m} F_{mi} \quad (15)$$

where $F_2, \dots, F_m$ are explanatory variables.

The maximum-likelihood estimates for all parameters of the stochastic frontier and inefficiency model, defined by equations (5) and (14); (6) and (15) are simultaneously obtained by using the computer program FRONTIER Version 4.1 (Coelli, 1996) which estimates the variance parameters in terms of parameterisation

$$\sigma_{\varepsilon_1}^2 = \sigma_{v_1}^2 + \sigma_{u_1}^2 \quad (16)$$

$$\sigma_{\varepsilon_2}^2 = \sigma_{v_2}^2 + \sigma_{u_2}^2 \quad (17)$$

and

$$\gamma_1 = \sigma_{u_1}^2 / \sigma_{\varepsilon_1}^2 \quad (18)$$

$$\gamma_2 = \sigma_{u_2}^2 / \sigma_{\varepsilon_2}^2 \quad (19)$$

(Seyoum *et al.* 1998)

In this study, the explanatory variables for the inefficiency equation for jasmine and nonjasmine rice are hypothesised as Education, Age, Labour force, and Male-labour ratio where Education = average education (years) of the members in the household, Age = average age of the members in the household, Labour force = labour force (adult persons) in the household and Male-labour ratio = male labour to total labour in the household.

2.3 Empirical Models

2.3.1 Models Used to Test for Model Suitability

The production models used to test for the most suitable model are equations (1) and (2).

2.3.2 Production Frontiers and Inefficiency Equations

The most suitable production model selected from 2.3.1 is then used to estimate the production frontiers for jasmine and nonjasmine rice simultaneously with the inefficiency equations written empirically as follows :

$$\begin{aligned} \text{For jasmine rice : } \mu_{1i} = & \delta_{11} + \delta_{12} \text{Education}_{1i} + \delta_{13} \text{Age}_{1i} + \delta_{14} \text{Labor force}_{1i} \\ & + \delta_{15} \text{Male - labor ratio}_{1i} + t_{1i} \end{aligned} \quad (20)$$

$$\begin{aligned} \text{For nonjasmine rice : } \mu_{2i} = & \delta_{21} + \delta_{22} \text{Education}_{2i} + \delta_{23} \text{Age}_{2i} + \delta_{24} \text{Labor force}_{2i} \\ & + \delta_{25} \text{Male - labor ratio}_{2i} + t_{2i} \end{aligned} \quad (21)$$

where δ 's and t 's are parameters and error terms respectively.

2.4 Estimation

used to estimate the production frontier

simultaneously with the inefficiency equation with the respective specified functional forms.

The computer program used for this simultaneous estimation is FRONTIER 4.1 (Coelli, 1996).

3. Data Collection

The data used in this study were collected by interviewing farmers in three areas, i.e., Chiang Mai Province, Phitsanulok Province and Tung Gula Ronghai, TGR, the northeastern area and major jasmine rice production area of the country. The sample size was 489 observations comprising 112, 176 and 201 observations from the corresponding areas. Some farmers who grew jasmine and nonjasmine would form two observations in the respective models.

Two sets of variables were prepared for two models, i.e., production frontier model and technical inefficiency model. All variables are described as follows.

The production area dummy variables D_2 and D_3 represent Phitsanulok and TGR where physical and biological environments differ from Chiang Mai.

Other environmental variables included are dummy variables of being transplanted (D_4) and irrigated (D_5) and having severe drought (D_6).

Neck blast disease (D_7) is a dummy variable (since degree of severity of blast was not measured for non-jasmine (only values for jasmine rice were available)). It takes value 1 when the farmer indicated having observed disease in his field.

Input variables includes seed (X_1), chemical fertiliser (X_2), labour (X_3) and other chemical input usually referring to insecticide, fungicide and pesticide (D_1) taking the value of 1 if the farmer used these other chemical inputs and 0 if otherwise. Except for the D_1 , all input variables were measured per area (*rai*) and expected to have positive relationship to production output. As for other chemicals (which farmers usually applied mostly as defensive measure), the positive sign is expected. It is not possible to measure the quantity of chemical used because farmers applied various kinds of chemical that come in different forms (liquid or powder).

Machine time, especially tractor time, spent on land preparation was not included in the production model since most farmers paid for hired tractor service at approximately the same rate per unit of land. The working time per unit of land in terms of the equivalent standard horse power tractor would then be approximately equal to all observations. This is because the contract is based on the same amount of service, i.e., finished ploughing.

Household characteristics are hypothesised to affect technical inefficiency are average age and education of the household members (years), labour force (adult persons), and the ratio of male labour to total labour.

Table 1 : Descriptive statistics for yield and variables affecting the yield of jasmine rice

Variable	N	Minimum	Maximum	Mean	SD
Y	282	11.66672	921.59881	354.70531	185.35869
X ₁	282	2.00000	70.39977	16.56432	11.77531
X ₂	282	0.90000	68.25018	13.21683	7.98064
X ₃	282	1.20000	84.40022	20.91309	15.75100
D ₁	282	0.00000	1.00000	0.76241	0.42636
D ₂	282	0.00000	1.00000	0.26596	0.44263
D ₃	282	0.00000	1.00000	0.52837	0.50008
D ₄	282	0.00000	1.00000	0.41489	0.49358
D ₅	282	0.00000	1.00000	0.26241	0.44073
D ₆	282	0.00000	1.00000	0.18794	0.39136
D ₇	282	0.00000	1.00000	0.74468	0.43682

Source : Survey

Table 2 : Descriptive statistics for the yield and variables affecting the yield of jasmine rice in logarithmic form

Variable	N	Minimum	Maximum	Mean	SD
$\ln Y$	282	2.4567	6.8261	5.6783	0.7193
$\ln X_1$	282	0.6931	4.2542	2.5535	0.7380
$\ln X_2$	282	-0.1054	4.2232	2.3997	0.6413
$\ln X_3$	282	0.1823	4.4356	2.7267	0.8606
D_1	282	0.0000	1.0000	0.7624	0.4264
D_2	282	0.0000	1.0000	0.2660	0.4426
D_3	282	0.0000	1.0000	0.5284	0.5001
D_4	282	0.0000	1.0000	0.4149	0.4936
D_5	282	0.0000	1.0000	0.2624	0.4407
D_6	282	0.0000	1.0000	0.1879	0.3914
D_7	282	0.0000	1.0000	0.7447	0.4368
$\frac{1}{2}(\ln X_1)^2$	282	0.2402	9.0491	3.5316	1.8691
$\frac{1}{2}(\ln X_2)^2$	282	0.0056	8.9176	3.0842	1.4391
$\frac{1}{2}(\ln X_3)^2$	282	0.0166	9.8371	4.0865	2.1991
$\ln X_1 \ln X_2$	282	-0.1888	14.3570	6.3277	2.7923
$\ln X_1 \ln X_3$	282	0.4863	14.5176	6.7274	2.5464
$\ln X_2 \ln X_3$	282	-0.3331	18.3447	6.4541	2.6718

Source : Survey

Table 3 : Correlation matrix for the logarithm of the yield and variables affecting the jasmine rice yield

	lnY	lnX ₁	lnX ₂	lnX ₃	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇
lnY	1.0000										
lnX ₁	-0.2460	1.0000									
lnX ₂	-0.0380	-0.0795	1.0000								
lnX ₃	0.4029	0.2449	-0.1624	1.0000							
D ₁	0.3556	-0.1121	-0.5842	0.1500	1.0000						
D ₂	0.0892	-0.0382	-0.1737	-0.0659	0.1663	1.0000					
D ₃	-0.4499	0.4543	0.4589	-0.2644	-0.3605	-0.6371	1.0000				
D ₄	0.3659	-0.6612	-0.4883	0.5915	0.1319	0.0633	-0.5453	1.0000			
D ₅	0.4538	-0.4406	-0.2875	0.3769	0.2572	-0.3590	-0.3407	0.4793	1.0000		
D ₆	-0.5480	0.2449	0.1146	-0.1677	-0.3073	-0.2896	0.4545	-0.3130	-0.2251	1.0000	
D ₇	-0.1398	-0.0795	-0.0689	0.0271	-0.0211	0.0948	-0.0971	0.0804	-0.3089	0.0527	1.0000

Source : Calculation

Table 4 : Descriptive statistics for yield and variables affecting the yield of nonjasmine rice

Variable	N	Minimum	Maximum	Mean	SD
Y	207	16.00002	1,050.00478	431.00815	188.36119
X ₁	207	1.95440	58.82342	15.169591	10.16220
X ₂	207	1.72000	40.00000	12.44645	7.07310
X ₃	207	1.06667	81.81822	21.78613	16.80959
D ₁	207	0.00000	1.00000	0.83575	0.37140
D ₂	207	0.00000	1.00000	0.48792	0.50107
D ₃	207	0.00000	1.00000	0.25121	0.43476
D ₄	207	0.00000	1.00000	0.51691	0.50093
D ₅	207	0.00000	1.00000	0.28502	0.45252
D ₆	207	0.00000	1.00000	0.10628	0.30894
D ₇	207	0.00000	1.00000	0.68600	0.46525

Source : Survey

Table 5 : Descriptive statistics for the yield and variables affecting the yield of nonjasmine rice in logarithmic form

Variable	N	Minimum	Maximum	Mean	SD
$\ln Y$	207	2.7726	6.9566	5.9179	0.6585
$\ln X_1$	207	0.6701	4.0745	2.4814	0.7230
$\ln X_2$	207	0.5423	3.6889	2.3472	0.6253
$\ln X_3$	207	0.0645	4.4045	2.7316	0.9212
D_1	207	0.0000	1.0000	0.8357	0.3714
D_2	207	0.0000	1.0000	0.4879	0.5011
D_3	207	0.0000	1.0000	0.2512	0.4348
D_4	207	0.0000	1.0000	0.5169	0.5009
D_5	207	0.0000	1.0000	0.2850	0.4525
D_6	207	0.0000	1.0000	0.1063	0.3089
D_7	207	0.0000	1.0000	0.6860	0.4652
$\frac{1}{2}(\ln X_1)^2$	207	0.2245	8.3009	3.3388	1.7526
$\frac{1}{2}(\ln X_2)^2$	207	0.1471	6.8039	2.9492	1.3906
$\frac{1}{2}(\ln X_3)^2$	207	0.0021	9.6998	4.1532	2.3355
$\ln X_1 \ln X_2$	207	0.7406	11.8741	6.0158	2.6326
$\ln X_1 \ln X_3$	207	0.2051	12.5742	6.3977	2.2409
$\ln X_2 \ln X_3$	207	0.1532	13.3729	6.3044	2.6486

Source : Survey

Table 6 : Correlation matrix for the logarithm of the yield and variables affecting the nonjasmine rice yield

	lnY	lnX ₁	lnX ₂	lnX ₃	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇
lnY	1.0000										
lnX ₁	-0.2595	1.0000									
lnX ₂	-0.0171	0.4257	1.0000								
lnX ₃	0.2250	-0.5742	-0.1870	1.0000							
D ₁	0.3566	0.0028	0.0020	-0.0368	1.0000						
D ₂	0.0206	0.2877	-0.0774	-0.4006	0.1719	1.0000					
D ₃	-0.4631	0.2488	0.3760	-0.0202	-0.4046	-0.5654	1.0000				
D ₄	0.3363	-0.7125	-0.4247	0.7027	-0.1155	-0.3715	-0.1533	1.0000			
D ₅	0.4350	-0.5418	-0.2368	0.4178	0.2221	-0.6163	-0.2177	0.5247	1.0000		
D ₆	-0.5352	0.1387	0.1392	-0.0331	-0.3548	-0.3366	0.5592	-0.1999	-0.1483	1.0000	
D ₇	-0.1468	0.0090	-0.0541	0.0214	-0.0752	-0.0268	0.1039	0.0125	-0.0801	0.0982	1.0000

Source : Calculation

Table 7 : Descriptive statistics for technical inefficiency and 4 variables affecting the technical inefficiency of jasmine rice

Variable	N	Minimum	Maximum	Mean	SD
Technical Inefficiency (TI)	282	0.06522	3.01465	0.57321	0.43518
Education	282	0.00000	14.00000	4.83379	1.64226
Age	282	25.50000	72.50000	43.46493	8.88551
Labour	282	1.00000	8.00000	2.56383	1.16801
Male-Labour Ratio	282	0.00000	1.00000	0.51858	0.16341

Source : Calculation and survey

Table 8 : Correlation matrix for technical inefficiency and variables affecting the technical inefficiency of jasmine rice production

	TI	Education	Age	Labour	Labour-Ratio
TI	1.00000				
Education	0.02029	1.00000			
Age	0.01991	-0.37481	1.00000		
Labour	0.10099	0.08946	-0.20309	1.00000	
Male-Labour Ratio	-0.12212	0.13276	0.00475	-0.08585	1.00000

Source : Calculation

Table 9 : Descriptive statistics for technical inefficiency and variables affecting the technical inefficiency of nonjasmine rice

Variable	N	Minimum	Maximum	Mean	SD
Technical Inefficiency	207	2.56455	0.07324	0.53187	0.42223
Education	207	0.00000	12.00000	4.60343	1.69665
Age	207	25.50000	72.50000	43.84739	8.98214
Labour	207	1.00000	8.00000	2.52657	1.10516
Male-Labour Ratio	207	0.00000	1.00000	0.50826	0.16413

Source : Survey

Table 10 : Correlation matrix for technical inefficiency and variables affecting the technical inefficiency of nonjasmine rice production

	TI	Education	Age	Labour	Labour-Ratio
TI	1.00000				
Education	-0.00698	1.00000			
Age	-0.06061	-0.46152	1.00000		
Labour	0.10699	0.05568	-0.12972	1.00000	
Male-Labour Ratio	-0.10461	0.20898	0.04080	0.06368	1.00000

Source : Calculation

Empirical Results

The stochastic translog and logarithmic transformed Cobb-Douglas production frontiers for jasmine and nonjasmine rice are estimated and presented in Tables 11-14. One of the two functional forms, the translog and logarithmic transformed Cobb-Douglas, for each rice is selected to draw policy implication. By comparing the estimates of the stochastic translog production frontier (Table 11) with those of the stochastic logarithmic transformed Cobb-Douglas (Table 12) for jasmine rice, it is observed that the estimates of the coefficients of $\ln X_1$ and D_1 from the translog frontier have the wrong signs. In addition, the estimated coefficient of $\ln X_1$ is statistically significant. Moreover, the signs of the coefficients of $(\ln X_2)^2$ and $\ln X_2 \ln X_3$ are negative making no sense to explain the variation of rice yield at the low levels of these variables by using this translog functional form. In the stochastic logarithmic transformed Cobb-Douglas production frontier, all estimated coefficients have the correct signs except the estimate of the coefficient of D_1 . However, this estimated coefficient is not statistically significant.

For the nonjasmine rice the estimated stochastic translog production frontier is again not selected as the model for policy recommendation because the signs of the estimated coefficients of $\ln X_2$, $(\ln X_1)^2$, $(\ln X_2)^2$, $(\ln X_3)^2$, $\ln X_1 \ln X_2$ do not make sense in explaining the variation of

nonjasmine rice yield at some ranges of the associated variables particularly at the very low levels of the variables. Contrastly all signs of the estimated coefficients in the stochastic logarithmic transformed Cobb-Douglas production frontier are as expected. Therefore, this logarithmic transformed Cobb-Douglas functional form is again chosen for policy implication.

Consider γ_1 and γ_2 in Tables 12 and 14, they are statistically significant from zero. These imply that the production frontiers for jasmine and nonjasmine rice do exist. Then technical efficiencies of these two kinds of rice are measured and presented in Tables 15 and 16.

The significant variables explaining the variation of jasmine rice yield are fertiliser, labour, irrigation, severe drought, neck blast and technical efficiency. The production elasticities of jasmine rice yield with respect to fertiliser, labour are 0.15547 and 0.09088 respectively. Existence of irrigation in the planted area contributes 38.37% higher yield compared to the area with no irrigation. Every one percent of the total rain fed planted area which is converted to irrigated area, weighted average yields of jasmine rice in that area increases by 0.3837%. Severe drought is another factor that has a substantial negative effect on the jasmine rice yield. The severe drought on average reduces the yield by 33.08% when it happens. Neck blast which also has an important negative effect on the jasmine

rice yield, lowers the yield by 16.67%. The percentage of the farmers who faced severe drought in 1999/2000 production year was 18.79% whereas that of the neck blast was 74.47. Therefore the weighted average damage to jasmine rice yield, due to severe drought was 6.22% while the damage due to neck blast was higher at 12.41%.

For the nonjasmine rice, fertiliser, irrigation, severe drought and technical efficiency are important variables explaining the nonjasmine rice yield variation. The nonjasmine rice yield elasticity with respect to fertiliser is 0.10879. Irrigation factor adds 41.89% (higher) to the nonjasmine rice yield, than rainfed areas. This, again, implies that each percent of the irrigated area converted from rainfed area would generate an increase to the weighted average yield of nonjasmine rice in that area by 0.4189%. Severe drought decreases the yield by 18.79% compared to the yield with no severe drought. Neck blast which has a negative effect on the nonjasmine rice is statistically insignificant.

The average technical efficiencies are 67.93% and 71.58% for jasmine and nonjasmine rice respectively (Tables 15 and 16). It is observed apparently that the technical efficiencies of both kinds of rice in Tung Gula Ronghai are the lowest amongst the three areas of this study at about 62%. They are the highest in Chiang Mai province. It is found that the factors significantly influencing the technical inefficiency are Age,

Labour and Male-Labour Ratio for nonjasmine rice whereas there is only one significant variable in the jasmine rice, i.e., Male-Labour Ratio.

Policy Recommendation

To enhance the yield per *rai* of both kinds of rice, chemical fertiliser may be encouraged to be used more by, e.g., lowering the fertiliser price or providing more credit to buy fertiliser if it is found that the farmers are constrained with credit (further research is needed). On the weighted average, severe drought has less effect than neck blast on the jasmine rice yield but contrastly it has more effect for the nonjasmine. Nevertheless, drought and neck blast resistant rice variety research is recommended. Also drought could be handled by providing irrigation systems to such areas. Another factor that affects the rice yield is technical efficiency. Evidently the average technical efficiencies for both kinds of rice are substantially low causing the low rice yield. To reduce the technical inefficiency for jasmine rice production, it is recommended to use more male labour relative to the total labour. However for lowering the nonjasmine rice technical inefficiency, besides increasing the male labour, experience reflected by the age variable must be added. On the contrary, expanding labour causes more inefficiency. This suggests using less labour and perhaps more capital.

Conclusion

The logarithmic transformed Cobb-Douglas production frontiers estimated simultaneously with the technical inefficiency equations for jasmine and nonjasmine rice are selected as the models to draw policy implications. Chemical fertiliser plays an important role influencing the yields for both jasmine and nonjasmine rice.

Labour is a significant variable for jasmine rice yield but not for the nonjasmine. Irrigation, severe drought and neck blast affect the jasmine rice yield whereas only severe

drought and irrigation are significant but the neck blast for the nonjasmine rice. Technical efficiencies are still substantially low in both kinds of rice. The low technical efficiencies imply that there is a substantial gap to improve the rice yields of both kinds of rice by increasing their technical efficiencies. Enhancing experience, using more male labour relative to the total labour and using less labour in total would reduce the technical inefficiencies of nonjasmine rice whereas there is only male labour to the total labour ratio which reduces the inefficiency significantly if the ratio increases.

Table 11 : Estimates of stochastic translog production frontier and inefficiency equation for jasmine rice using Frontier 4.1

Variable	Coefficient	t – ratio
Stochastic Production Frontier		
Constant	5.81258	8.618***
$\ln X_1$	-0.55357	-2.087**
$\ln X_2$	0.40506	1.753*
$\ln X_3$	0.29929	1.372
D_1	-0.06241	-1.009
D_2	-0.18108	-1.705*
D_3	-0.37842	-3.615***
D_4	-0.00459	-0.055
D_5	0.37865	4.298***
D_6	-0.38743	-5.560***
D_7	-0.12133	-2.395***
$\frac{1}{2}(\ln X_1)^2$	0.08364	1.057
$\frac{1}{2}(\ln X_2)^2$	-0.02392	-0.462
$\frac{1}{2}(\ln X_3)^2$	0.06695	0.872
$\ln X_1 \ln X_2$	0.09137	1.929*
$\ln X_1 \ln X_3$	0.05900	0.926
$\ln X_2 \ln X_3$	-0.16618	-3.676***
Inefficiency Equation		
Constant (δ_0)	-17.68360	-1.204
Education (δ_1)	0.59106	1.348
Age (δ_2)	0.10199	1.429
Labour (δ_3)	1.20011	1.329
Male-Labour Ratio (δ_4)	-10.91165	-1.353

Variable	Coefficient	t - ratio
Variance Parameters		
$\sigma_{\varepsilon_1}^2$	6.34070	1.276
γ_1	0.99439	215.296***

Source : Calculation by using Frontier 4.1

Note : $\sigma_{\varepsilon_1}^2 = \sigma_{v_1}^2 + \sigma_{u_1}^2$ and $\gamma_1 = \frac{\sigma_{u_1}^2}{\sigma_{v_1}^2 + \sigma_{u_1}^2}$

: *** Significant at 1 percent level

: ** Significant at 5 percent level

: * Significant at 10 percent level

Table 12 : Estimates of stochastic Cobb-Douglas production frontier and in efficiency equation for jasmine rice using Frontier 4.1

Variable	Coefficient	t - ratio
Stochastic frontier Production Frontier		
Constant	5.81104	28.724***
$\ln X_1$	0.04819	1.1904
$\ln X_2$	0.15547	3.7194***
$\ln X_3$	0.09088	2.6852***
D_1	-0.02504	-0.4034
D_2	-0.21260	-1.9016*
D_3	-0.38378	-3.5855***
D_4	-0.03065	-3.5695***
D_5	0.32473	3.6117***
D_6	-0.40162	-5.5875***
D_7	-0.15864	-3.0497***

Variable	Coefficient	t - ratio
Inefficiency Equation		
Constant (δ_0)	-16.13644	-1.2847
Education (δ_1)	0.56447	1.5414
Age (δ_2)	0.08780	1.3868
Labour (δ_3)	1.15336	1.4474
Male-Labour Ratio (δ_4)	-11.66142	-1.6839*
Variance Parameters		
$\sigma_{\varepsilon_1}^2$	6.33564	1.4676
γ_1	0.99337	203.7784***

Source : Calculation by using Frontier 4.1

Note : $\sigma_{\varepsilon_1}^2 = \sigma_{v_1}^2 + \sigma_{u_1}^2$ and $\gamma_1 = \frac{\sigma_{u_1}^2}{\sigma_{v_1}^2 + \sigma_{u_1}^2}$

: *** Significant at 1 percent level

: ** Significant at 5 percent level

: * Significant at 10 percent level

Table 13 : Estimates of stochastic translog production frontier and inefficiency equation for nonjasmine rice using Frontier 4.1

Variable	Coefficient	t - ratio
Stochastic frontier Production Frontier		
Constant	5.14982	5.825***
$\ln X_1$	0.55751	1.585
$\ln X_2$	-0.16066	-0.502
$\ln X_3$	0.25814	0.865
D_1	0.18679	2.560**
D_2	0.05708	0.385
D_3	-0.14076	-1.0344
D_4	0.10754	1.325
D_5	0.32875	2.389**
D_6	-0.20925	-2.388**

Variable	Coefficient	t - ratio
D_7	-0.01378	-0.285
$\frac{1}{2}(\ln X_1)^2$	-0.13099	-1.181
$\frac{1}{2}(\ln X_2)^2$	-0.11249	-2.171**
$\frac{1}{2}(\ln X_3)^2$	-0.03562	-0.351
$\ln X_1 \ln X_2$	-0.07811	-1.150
$\ln X_1 \ln X_3$	0.00069	0.009
$\ln X_2 \ln X_3$	0.11657	1.752*
Inefficiency Equation		
Constant (δ_0)	-3.35721	-1.226
Education (δ_1)	0.08148	0.721
Age (δ_2)	-0.05760	-2.249**
Labour (δ_3)	1.06681	2.283**
Male-Labour Ratio (δ_4)	-10.80739	-2.157**
Variance Parameters		
$\sigma_{\varepsilon_2}^2$	4.51010	2.081**
γ_2	0.99467	342.540***

Source : Calculation by using Frontier 4.1

Note : $\sigma_{\varepsilon_2}^2 = \sigma_{v_2}^2 + \sigma_{u_2}^2$ and $\gamma_2 = \frac{\sigma_{u_2}^2}{\sigma_{v_2}^2 + \sigma_{u_2}^2}$

: *** Significant at 1 percent level

: ** Significant at 5 percent level

: * Significant at 10 percent level

Table 14 : Estimates of stochastic Cobb-Douglas production frontier and inefficiency equation for nonjasmine rice using Frontier 4.1

Variable	Coefficient	t - ratio
<u>Stochastic frontier Production Function</u>		
Constant	5.53302	19.5394**
$\ln X_1$	0.62272	1.1615
$\ln X_2$	0.10879	2.1972**
$\ln X_3$	0.05456	1.2838
D_1	0.15071	1.9609**
D_2	0.05497	3.3378***
D_3	-0.16969	-1.1316
D_4	0.13091	1.4704
D_5	0.34989	2.4069***
D_6	-0.20817	-2.0763**
D_7	-0.02479	-0.4938
<u>Inefficiency Equation</u>		
Constant (δ_0)	-4.74622	-1.7419*
Education (δ_1)	0.15120	1.4355
Age (δ_2)	-0.06292	-2.0931**
Labour (δ_3)	1.11520	2.5003***
Male-Labour Ratio (δ_4)	-10.15546	-2.3889***
<u>Variance Parameters</u>		
$\sigma_{\varepsilon_2}^2$	4.07026	2.3573***
γ_2	0.99140	208.5320***

Source : Calculation by using Frontier 4.1

Note : $\sigma_{\varepsilon_2}^2 = \sigma_{v_2}^2 + \sigma_{u_2}^2$ and $\gamma_2 = \frac{\sigma_{u_2}^2}{\sigma_{v_2}^2 + \sigma_{u_2}^2}$

: *** Significant at 1 percent level

: ** Significant at 5 percent level

: * Significant at 10 percent level

Table 15 : Technical efficiency of farm households in producing jasmine rice

Technical efficiency		% of total	% of total	% of total farm	
		farm	farm	households in	% total farm
		households in	households in	Tung Gula	households
		Chiang Mai	Phitsanulok	Ronghai	
Very low	(0.0000 –				
	0.2000)	0	0	5.4	2.8
Low	(0.2001 –				
	0.4000)	3.4	6.7	18.8	12.4
Medium	(0.4001 –				
	0.6000)	6.9	6.7	13.4	10.3
High	(0.6001 –				
	0.8000)	50.0	42.7	30.9	37.9
Very high	(0.8001 –				
	1.0000)	39.7	44.0	31.5	36.5
รวม		100.0	100.0	100.0	100.0
Average		0.75108 ^{1/}	0.73321 ^{1/}	0.62426 ^{1/}	0.67932 ^{1/}

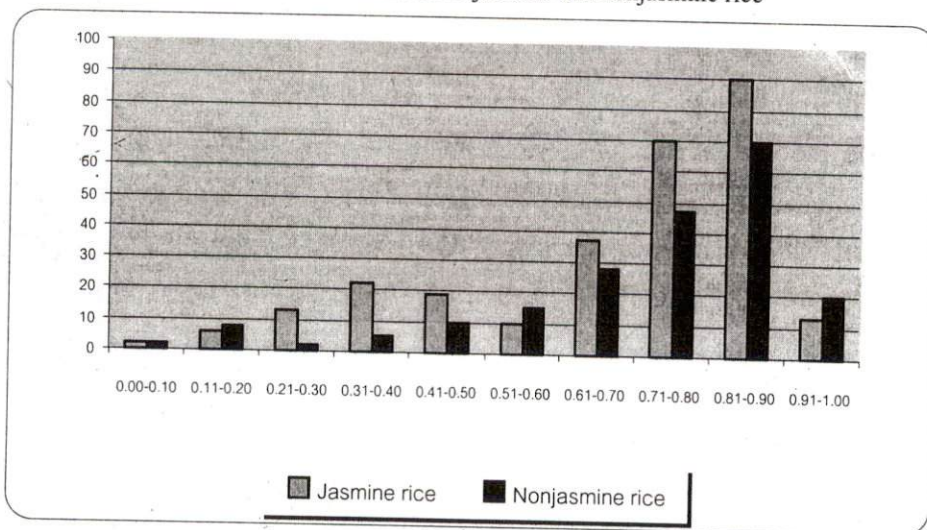
Source : Calculation

Note : ^{1/} simple average of the total observations

Table 16 : Technical efficiency of farm households in producing nonjasmine rice

Technical efficiency		% of total	% of total	% of total farm	
		farm	farm	households in	% total farm
		households in	households in	Tung Gula	households
		Chiang Mai	Phitsanulok	Ronghai	
Very low	(0.0000 – 0.2000)	0	1.0	17.3	4.8
Low	(0.2001 – 0.4000)	0	5.9	1.9	3.4
Medium	(0.4001 – 0.6000)	5.6	14.9	13.5	12.1
High	(0.6001 – 0.8000)	37.0	36.6	34.6	36.2
Very high	(0.8001 – 1.0000)	57.4	41.6	32.7	43.5
รวม		100.0	100.0	100.0	100.0
Average		0.78646 ^{1/}	0.72527 ^{1/}	0.62386 ^{1/}	0.71576 ^{1/}

Source : Calculation

Note : ^{1/} simple average of the total observations**Figure 1** Distribution of technical efficiencies of jasmine and nonjasmine rice

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ใบบอกรับเป็นสมาชิก

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ตำบล.....อำเภอ/เขต.....

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