International Journal of Economic Research

ISSN : 0972-9380

available at http: www.serialsjournals.com

Volume 14 • Number 15 (Part 4) • 2017

Technical Efficiency in Rice Production of the Farmers in Cooperatives: A Study in KienGiang Province, Mekong Delta, Vietnam

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ABSTRACT

This study aims to estimate technical efficiency in rice production and analyze the factors affecting technical efficiency in rice production in KienGiang Province, Mekong Delta, Vietnam. Data were obtained from 276 rice farmers under four cooperatives in Chau Thanh District. Cobb-Douglas stochastic frontier model was applied. The findings show that the farmers occupy, on average, 1.6 ha of rice land per household. The average rice yield was 6.66 tons per ha in summer-autumn crop. The farmers achieved, on average, 92.4% technical efficiency in rice production. The farm size, potassium active and labor hours affect positively the technical efficiency. It was also found that farmers, who have higher experience in rice production and attended in many technical training classes, have obtained higher technical efficiency. However, farmers who joined cooperatives for a long time, but did not join in cooperative activities, cannot improve the technical efficiency.

Keywords: Technical efficiency, Rice production, Cooperative's farmers, Vietnam.

1. INTRODUCTION

Vietnam had about 4.1 million ha of rice land and total rice output reached about 45 million tons in 2014 (General Statistics Office of Vietnam, 2015). Mekong Delta is the largest rice production region which contributed about 56% of total rice output and 90% of total rice export in Vietnam (General Statistics Office of Vietnam, 2015). KienGiang is the largest rice production province under Mekong Delta, which produced about 4.5 million tons of rice in 2014 (General Statistics Office of Vietnam, 2015). Chau Thanh is one of large rice production districts in KienGiang Province, which is affected by flood and salinization as it is a neighboring sea district. Several anti-flood and salty water boundary systems were built to protect rice

production in the district. However, when there is a continuous heavy rainfall and the outside water level is higher than the inside of rice field, an individual farmer cannot protect his field by continuously pumping water out of the field. In order to solve the problem, a number of farmers in a region link together and establish cooperatives. Currently, Chau Thanh District has 10 rice cooperatives and 168 pump collective groups, which meet water pumping requirements for 82% of the flood affected rice production area (Chau Thanh Agricultural Division, 2016). The cooperatives help farmers store and supply water in drought and salinity intrusion period. Besides, the cooperatives offer other services such as plowing land, providing seed, harvesting and transferring technology for the members. In this way, the cooperatives help the members sow at right season schedule, limit pesticide usage, reduce production costs, and increase productivity in their rice production.

The cooperatives provide basic conditions for the members to produce three rice crops per year. However, this type of intensification in rice production degrades soil fertility seriously. Moreover, closed boundary served for producing three rice crops limits alluvial reception from flood. This leads to reduce essential nutrients for rice production and increase the toxics in soil (Dang and Danh, 2008). As a result, the farmers use large amount of fertilizers and pesticides to get high productivity. However, this excessive use of fertilizers and pesticides reduce the technical efficiency in rice production. The estimation of rice production efficiency is essential for planning of local socio-economic policies because it provides quantitative efficient measures and assesses possibilities of inefficient factors in rice production (Huy, 2009). It is worthwhile to mention that in Chau Thanh District the summer-autumn crop had lowest productivity among the three rice crops, about 5.56 tons/ha in 2015 (Chau Thanh Agricultural Division, 2016).

This study aims to assess characteristics of the rice farmers and problems in rice production in the cooperatives in KienGiang Province, Vietnam. The study also estimates technical efficiency in rice production and analyzes the factors affecting technical efficiency in rice production in the summer-autumn crop.

2. MATERIALS AND METHODS

Study Area, Survey Design and Data Collection

The study was conducted in Chau Thanh District under the KienGiang Province, Vietnam (Figure 1). Chau Thanh is one of largest rice production districts in the Province. The district has 10 agricultural cooperatives which are divided in two regions. The study selected two cooperatives from each region. The selected cooperatives are: Minh An, Kenh-18, Tan Hung, and Hoa Thuan-1. There were a total of 623 rice farmers in these four cooperatives during the survey (Table 1). To determine the sample size, the study used Taro Yamane (Yamane, 1967) formula as follows:

$$n = \frac{N}{1 + N(e)^2}$$

where,

Population size (N) = 623,

Level of error (e) = 5% (the confidence level is 95%),

Representative sample size (n) = 243

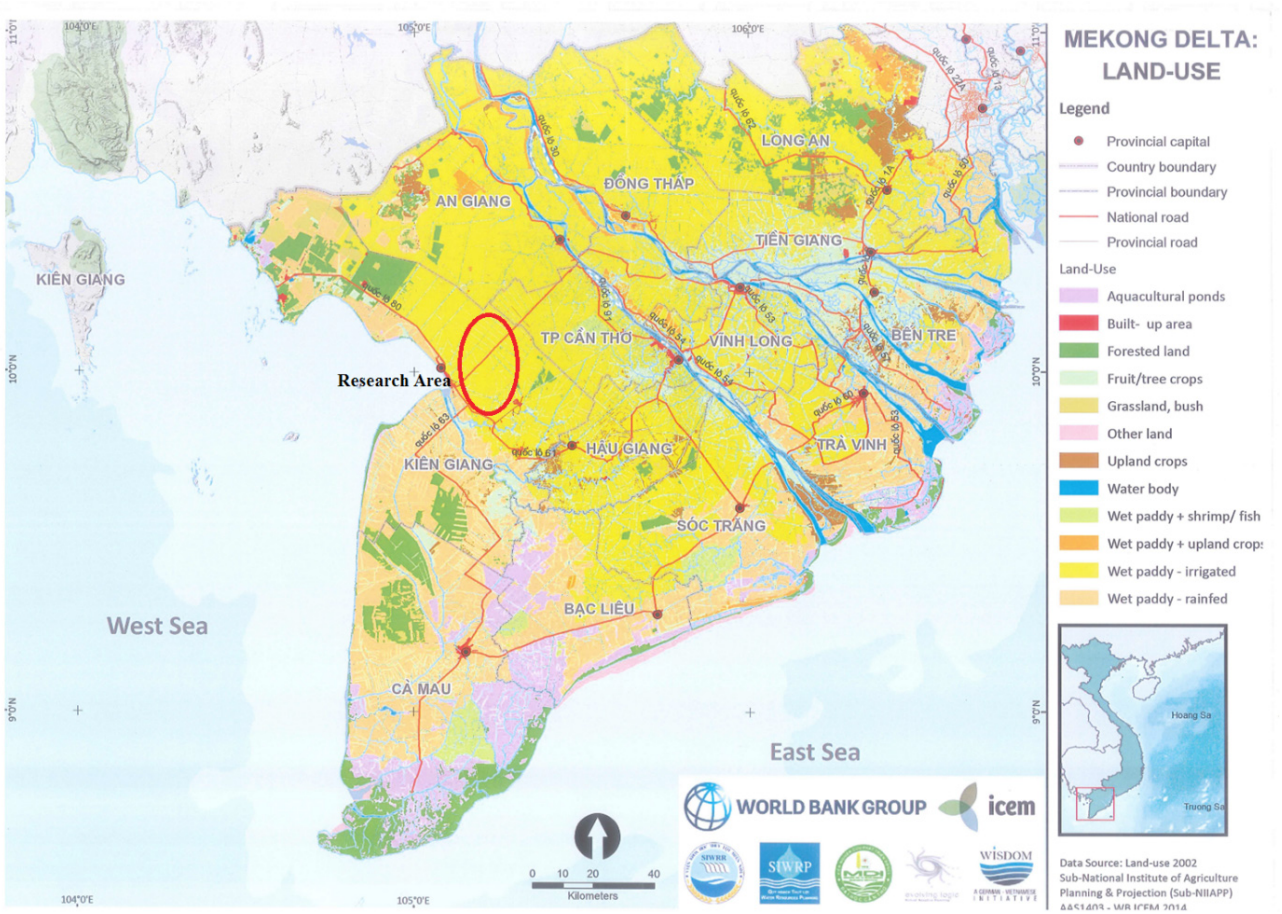

Figure 1: Map of Mekong Delta region and the research area
Source: **http://mekong-cuulong.blogspot.com/2016/03/10-ban-o-cua-ong-bang-song-cuu-long.html**

The study surveyed 70 rice farmers in each of the selected cooperatives. However, there were four incompliance observations. Therefore, the real sample size for the study is 276 (Table 1). To represent the population in the study area, the respondents were selected based on different criteria such as location, whole land size, experience in rice production, kind of variety, and number of crop per year. In order to get reliable data and information, the survey was conducted after the farmers finished their rice crop. The study conducted the surveyed at the summer-autumn crop in 2016, which produced during June and October 2016.

Table 1
Basic profile of the surveyed cooperatives

Cooperative	*Foundation year*	*Rice area (ha)*	*Population size (farmers)*	*Sample size (farmers)*	*Percent*
Hoa Thuan-1	2006	380	190	68	24.6
Kenh-18	2013	222	160	70	25.4
Tan Hung	2007	320	141	70	25.4
Minh An	2005	105	132	68	24.6
Total		1,027	623	276	100.0

Data Analysis

The study applied descriptive statistics to analyze socio-demographic characteristics of the respondents (such as age, education level, and experience in rice production) as well as the features of rice production (for example, rice land area, rice variety, source of seed, rice production technique, participating technical training class, input and output quantity, cost, revenue, estimated profit, and rice production problems).

The study also employed Stochastic Frontier Analysis (SFA) method to assess technical efficiency in rice production of the cooperatives' farmers in rice production. SFA method had also been applied to identify and examine the factors affecting the technical inefficiency in rice production. SFA method was proposed by Aigner et. al., (1977), and Meeusen and Van Den Broeck (1977). They proposed the production function had an error term with two components: random effects and technical inefficiency.

The proposed model is as follows:

$$Y_i = X_i\beta + (v_i - u_i)$$

where,

Y_i = logarithm of the output

X_i = $k \times 1$ vector of transformation of the input quantities

β = vector of unknown parameters

v_i = random error, and independent of the u_i

u_i = non-negative random variable accounting for technical inefficiency

Several functional forms were used to estimate the input-output relationship. However, if the model has more than three independent variables, the Cobb-Douglas function is preferable to the others (Hanley and Spash, 1993). Therefore, this study used the Cobb-Douglas stochastic frontier model with seven input independent variables:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i} + v_i - u_i$$

where,

Y = Total quantity of rice output (kg)

X_1 = Rice farm size (ha)

X_2 = Quantity of rice seed (kg)

X_3 = Quantity of nitrogen active (kg)

X_4 = Quantity of phosphorus active (kg)

X_5 = Quantity of potassium active (kg)

X_6 = Quantity of pesticide active (g)

X_7 = Quantity of labor (hour)

v_i = random error

u_i = non-negative technical inefficiency effect

The v_i is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$. On the other hand, the u_i is assumed to be independently distributed as truncation at zero of the $N(\mu_i, \sigma_u^2)$ distribution, where μ_i is defined by:

$$\mu_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + e_i$$

where,

Z_1 = education level of the farmer in years of schooling

Z_2 = experience in rice production of the farmer in years

Z_3 = income dummy variable; Z_3 = 1 if rice is main income of household and 0 otherwise

Z_4 = credit dummy variable; Z_4 = 1 if farmer got credit for rice production and 0 otherwise

Z_5 = time of joining cooperatives in years

Z_6 = technical training variable in number of classes in 2016

Z_7 = crop dummy variable; Z_7 = 1 if farmer produces 3 crops per year and 0 otherwise

Z_8 = variety dummy variable; Z_8 = 1 if farmer uses IR50404 rice variety and 0 otherwise

δ_i = unknown parameter to be estimated

The model parameters (β and δ) are based on the maximum likelihood estimation with variance parameters $\sigma^2 = \sigma_v^2 + \sigma_u^2$ (Aigner et. al., 1977) and $\gamma = \sigma_u^{2/}(\sigma_v^2 + \sigma_u^2)$ (Battese&Corra, 1977).The study applied Frontier 4.1 program written by Coelli et. al., (2005) to estimate the stochastic frontier model.

3. RESULTS AND DISCUSSION

Social-demographic Characteristics of the Surveyed Cooperative's Farmers

Table 2 shows the socio-demographic characteristics of the surveyed cooperatives' farmers. The analyses showed that the average age of farmer was 48.3 years. They had educational experience of, on average, 5.6 years. The farmers were engaged in rice production for, on average, 24.7 years. Rice production was the main source of income for most of the households (93.1%). However, a small portion of the households (5.6%) borrowed money from bank for rice production. The average amount of loan per household was 66.7 million VND.

Table 2 also shows the linkages of the farmers with the cooperatives. The findings showed that the farmers have dealings with the cooperative for, on average, 5.7 years. It can be mentioned that farmers must contribute capital to the land use services of the cooperatives to be a member of a cooperative. The amount of capital depends on area of the rice land (about 200,000 VND per ha). It is also mandatory for the members to join technical training classes. In 2016, nearly 70% of the respondent farmers joined at least one technical training class. However, 30.4% of the respondents did not join any technical training class in 2016.

The surveyed cooperatives provide various types of services to their members such as pumping water, plowing land, harvesting and purchasing rice. It is worthwhile to mention that the price of pumping water service provided by the cooperatives are lower than that of private service (200,000 VND per ha). However, the respondents reported that they need more supports and services from the cooperatives. Half of the

surveyed farmers (50%) need fertilizer services, followed by harvesting (49.3%), purchasing rice (34.1%), providing seed (26.8%), and plowing land (25.7%). For example, if farmers buy fertilizers in cash, they would pay at the market price of fertilizers. But the farmers often pay money after harvesting (i.e. nearly three months later from buying the product) due to lack of capital. At that time, they have to pay 3-10% higher price than the original purchase price. Therefore, farmers would like the cooperatives to supply fertilizers with the original price.

Table 2
Socio-demographic characteristics of the surveyed cooperatives' farmers

Item	*Frequency (n = 276)*	*Percent*
Age (years)		
– ≤ 30	6	2.2
– 31-40	57	20.7
– 41-50	96	34.8
– 51-60	93	33.7
– > 60	24	8.6
Mean	48.3	
Education		
– Illiteracy	12	4.3
– Primary school	134	48.6
– Secondary school	109	39.5
– High school	21	7.6
Mean (years)	5.6	
Experience in rice production (years)		
– ≤ 10	26	9.4
– 11-20	83	30.1
– 21-30	98	35.5
– 31-40	59	21.4
– > 40	10	3.6
Mean	24.7	
Main income source of household		
– Rice	257	93.1
– Non-rice	19	6.9
Loans for rice production		
– Yes	43	15.6
– No	233	84.4
Amount of loan (million VND)*	(*n* = 43)	
– 5-20	14	32.6
– 21-35	8	18.6
– 36-50	12	27.9
– > 50	9	20.9
Mean	66.7	

(*Contd...*)

Item	*Frequency (n = 276)*	*Percent*
Years of joining cooperative		
– 1-5	145	52.5
– 6-10	122	44.2
– > 10	9	3.3
Mean	5.7	
Technical training classes joined in 2016		
– 0	84	30.4
– 1	119	43.2
– 2	63	22.8
– > 2	10	3.6
Mean	1.0	
Existing services provided by cooperatives[Ψ]		
– Pumping water	276	100.0
– Plowing land	87	31.5
– Harvesting	70	25.4
– Purchasing rice	70	25.4
Other services needed[Ψ]		
– Providing fertilizer	138	50.0
– Harvesting	136	49.3
– Purchasing rice	94	34.1
– Providing seed	74	26.8
– Plowing land	71	25.7

[*]1 million VND ⊕ 43.77 USD ⊕ 1,615 Baht (March 2017).
[Ψ]One farmer can give more than one answer.

Features of Rice Production and its Problems in the Study Area

The following sub-sections focus on various features of rice production and the problems in rice production in the study area:

1. ***Rice land and rice production:*** Table 3 shows the profile of rice land and rice production in the study area. The data show that a household in the study area occupies a total of 1.9 ha rice land area. However, the rice production area in the cooperatives is, on average, 1.6 ha per household. Majority of the households (97%) produce two main rice varieties (i.e. IR50404 and OM5451) in summer-autumn crop. All farmers in Kenh-18 and Hoa Thuan-1 cooperatives use variety IR50404. This is a short-time variety and low quality rice. However, variety IR50404 yields high productivity and can be easily consumed. Farmers in Tan Hung cooperatives use only variety OM5451. In Minh An cooperatives, farmers use some other varieties such as OM5451, OM4900, OM6976, and OM7347.

   Majority of the farmers collect rice seed from two sources: owned seed (47.8%) and purchasing form breeding center (43.1%). Some farmers buy the foundation seed for one crop. After harvesting, they used the rice output as certified seed for the next crop. Other farmers buy the

certified seed directly from the breeding center, which has lower price than foundation seed. A lower portion of the famers (7.3%) buy the seed from their neighbors at the market price of rice, when they clearly know about the productivity and quality of the neighbor rice field. Most of the surveyed farmers (96.7%) apply the scattering method for sowing rice. The reason is that scattering method uses more quantity of seed than row seeding method. Similarly, majority of the farmers (96.7%) follow the "1 Must 5 Reduce" (1 Phai 5 Giam) applied program in rice production. "1 Must" means must use the certified seed, and "5 Reduce" means reduce seed quantity, reduce fertilizer quantity (nitrogen), reduce pesticide quantity, reduce water utilization, and reduce post-harvest losses. However, the farmers really follow only "1 Must". A relatively lower portion of the farmers (19.9%) apply the "3 Decrease 3 Increase" (3 Giam 3 Tang) program. "3 Decrease" means decrease seed quantity, decrease pesticide quantity and decrease nitrogen quantity, and "3 Increase" means increase rice yield, increase rice quality and increase economic efficiency. The Integrated Pests Management (IPM) program is practiced by 24.6% of the surveyed farmers. They planted flowers on the rice field dike, and used light traps. Several farmers reported that they had joined the IPM class but they did not apply it because chemical utilization immediately shows efficacy. The farmers visit their rice field, on average, 3.6 days per time.

Table 3 also provides information about the number of rice crops in a year. Majority of the cooperative's farmers (75%) produce three rice crops per year. The farmers in Minh An cooperatives produce two rice crops per year, which constitute 25% of the total respondents. According to the instructions of Chau Thanh Agricultural Division, the farmers in Minh An cooperatives produced three rice crops per year in 2011, 2012 and 2014. However, the efficiency of third crop was found to be low. As a result the cooperatives decided to produce two rice crops only per year.

Table 3
Profile of rice land and rice production in the study area

Item	*Frequency (n = 276)*	*Percent*
Total rice land area (ha)		
– < 1	92	33.3
– 1-2	94	34.1
– > 2	90	32.6
Mean	1.9	
Rice land area in cooperative (ha)		
– < 1	101	36.6
– 1-2	115	41.7
– > 2	60	21.7
Mean	1.6	
Rice variety		
– IR50404	138	50.0
– OM5451	132	47.8
– OM7347	4	1.4
– OM4900	1	0.4
– OM6979	1	0.4

(*Contd...*)

Item	*Frequency (n = 276)*	*Percent*
Source of seed		
– Owned seed	132	47.8
– Purchasing from breeding center	119	43.1
– Purchasing from neighbor	20	7.3
– Purchasing from businessman	4	1.4
– Purchasing from extension center	1	0.4
Type of sowing rice		
– Scattering	267	96.7
– Row seeding	9	3.3
Applied program[Ψ]		
– 1 Must 5 Decrease	267	96.7
– Integrated Pests Management	68	24.6
– 3 Decrease 3 Increase	55	19.9
Rice field visit (days/time)		
– 1-2	75	27.2
– 3-4	126	45.7
– 5-6	66	23.9
– > 6	9	3.3
Mean	3.6	
Number of rice crops in 2016		
– 3 crops	207	75.0
– 2 crops	69	25.0
Mean	2.8	

[Ψ]One farmer can give more than one answer.

2. **Input and output of rice production:** Table 4 shows input and output per ha of rice productionin the study area. The analyses revealed that cooperative's farmers use, on average, 196 kg of rice seed per ha. According to the recommendation of the Extension Center, farmer should use 100 kg of seed per ha and not use more than 150 kg/ha. But some farmers use more than 300 kg of rice seed per ha. Farmers use large quantity of seed because they are afraid about the rate of germination, golden apple snail, rat and replanting labor. Similarly, farmers use large amount of nitrogen for branching because of sowing with high density. However, using so much nitrogen leads to several diseases and pests.

   In rice production, farmers use five types of fertilizer: Urea 46-0-0, DAP 18-46-0, Kali 0-0-60, NPK 20-20-15 and NPK 16-16-8. The main ingredients in the fertilizers are nitrogen active (N), phosphorus active (P_2O_5) and potassium active (K_2O). The average use of nitrogen active, phosphorus active and potassium active per ha were 101.46kg, 69.51kg and 48.04kg respectively. Farmers applied fertilizers four times per rice crop. Many kinds of herbicide and pesticide were also used. Each type contains the information about chemical percent on the package. It was found that the farmers used chemical active of nearly 1,959.43 g per ha for rice production. The total labor hour was calculated at 140.4 hours. The average output of rice production was estimated at 6.66 tons per ha in summer-autumn crop.

Table 4
Input and output per ha of rice production in the study area

Item	*Mean*	*Minimum*	*Maximum*	*Std. Deviation*
Input				
Seed (kg)	196.0	100.0	306.7	32.8
Nitrogen active (kg)	101.9	64.8	210.8	13.4
Phosphorus active (kg)	69.5	33.8	127.8	10.5
Potassium active (kg)	48.0	6.4	92.3	14.3
Pesticide active (g)	1,959.4	351.9	8,180.8	941.5
Labor (hour)	140.4	51.0	397.4	57.9
Output (kg)	6,656.9	4,615.4	7,758.6	510.9

3. **Labor hour used in rice production by activities:** Table 5 shows the distribution of labor hour used in rice production by activities. It was found that farmers used a total of 140.4 hours of labor (including family labor and hired labor) for per ha rice production in summer-autumn crop. However, visiting field time was the largest proportion (28.2%) of total labor hour used among the activities. Visiting field time depends on frequency of visiting and the distance of the rice field from house. The farmers also spent a considerable time on spraying the pesticides (23.3 hours/ha), replanting (22.7 hours/ha) and preparing land (19.0 hours/ha). Time for spraying pesticides was comparatively higher because farmers applied pesticides several times in summer-autumn crop. Farmers must embankment and dig the waterways by manpower besides using plowing machine. Time for replanting depends on the death rate of rice field.

   The farmers spent, on average, 7.6 hours per ha for sowing the seed.The findings showed that weeding constitute the significantly lower portion (1.5%) of the total labor hour used by the farmers. For weeding, farmers spray pre-germination herbicide on the rice field after 1-4 days of sowing. Similarly, watering the rice field comprise of significantly lower portion (2.8%) of the total labor hour used for rice production. However, the farmers spend a considerable time (on average, 15.1 hours per ha) to utilize fertilizers in the rice field. The lowest proportion of total labor hour is allocated to drying the rice (1.2%) because most of farmers sell wet rice.

Table 5
Distribution of labor hour used in rice production by activities

Item	*Value (hours/ha)*	*Percent*
Total hours	140.4	100.0
– Prepare land	19.0	13.5
– Sowing	7.6	5.4
– Replanting	22.7	16.2
– Weeding	2.1	1.5
– Manure	15.1	10.8
– Spraying	23.3	16.6
– Watering	3.9	2.8
– Harvesting	5.5	3.9
– Drying	1.7	1.2
– Visiting field	39.6	28.2

4. **Cost, revenue and profit of rice production:** Table 6 highlights the cost, revenue and profit of rice production of the cooperatives' farmers. The total cost of rice production per ha was estimated at 17.7 million VND. The analyses showed that the cost for pesticides contributed the greatest portion (25.8%) of the total cost, followed by fertilizer cost (20.2%) and labor cost (19.2%). Harvest and post-harvest cost also accounted for a considerable portion (14.1%) of the total cost. It can be mentioned that some farmers sell their wet rice on field, so they do not pay for post-harvest cost. The farmers spend significantly lower amount of money for watering the rice field which constitute 2.8% of the total cost. In summer-autumn crop, farmers can use the natural outside water by opening the small groove when the level of outside water is higher than the inside field. Later when the level of outside water becomes lower, farmers close the groove and save water in their field. The value of rice produced per ha was estimated at 30.4 million VND.The estimated profit in summer-autumn crop was about 12.7 million VND per ha.

Table 6
Cost, revenue and profit of rice production

Item	*Value (thousand VND/ha)*	*Percent*
Total cost	17,704.2	100.0
Prepare land	1,301.6	7.4
Seed	1,645.9	9.3
Herbicide	216.0	1.2
Fertilizer	3,577.8	20.2
Pesticide	4,574.9	25.8
Watering	490.2	2.8
Harvest and Post-harvest	2,501.7	14.1
Labor	3,396.1	19.2
Revenue	30,365.5	
Estimated profit	12,661.3	

5. **Problems in rice production:** Table 7 focuses on the problems in rice production in the study area. It was found that the farmers encountered many problems in rice production. All of the respondents (100%) reported that they face the problem of climate fluctuation in rice production. The main factors in climate problem are murky weather, poor sunshine and unseasonal rain, which lead to development of brown back hopper and many microorganisms such as fungi, bacteria, viruses. These microorganisms cause wide range of diseases in rice.

   Price fluctuation is another big problem faced by majority of the farmers of (74.3%). Most of the farmers sell their rice through the middleman. Before harvesting period, the middlemen make a contract with farmers at the current market price of rice and deposit a portion of total price of rice to the farmers. If the market price of rice is higher than the contract price at the time of harvesting, the middlemen buy rice from the farmers. However, if the market price is lower than the contract price, the middleman postpone to harvest. They wait for increase in price. Consequently, late harvest leads to yield losses. In some cases, middlemen withdraw their deposit if there is no increase in the market price of rice. In this circumstance, farmers try to sell

their rice at a lower price because they need money to pay for the agricultural store. Moreover, farmers need to pay middleman commission which reduces the farmers' profit more.

A considerable portion of the farmers (25.4%) (particularly in Kenh-18 cooperative) suffers from salinization at the first stage of crop. Salinization leads to lack of fresh water for rice production. However, the cooperatives took initiatives to build the closed boundary to protect their members' rice field. Farmers can use reserved water in the cooperative's canal for rice production during the salinization period. A comparatively lower portion of the farmers (15.6%) suffers from lack of capital at the initial stage of production. Due to lack of capital, the farmers purchase pesticide and fertilizer on credit from the agricultural stores and pay the money after selling their rice. However, the farmers have to pay 3-10% higher than the current market price of pesticide and fertilizer. At the time of harvest, a small portion of the respondents (12.3%) face the problem of shortage of harvesting machine. All of the farmers in a cooperative sow and harvest at the same time. However, the number and operational capacity of harvester are limited and cannot serve all the member farmers at the same time.

Table 7
Problems in rice production

Item[Ψ]	*Frequency*	*Percent*
Climate fluctuation	276	100.0
Rice price fluctuation	205	74.3
Salinization	70	25.4
Lack of capital	43	15.6
Lack of harvesting machine	34	12.3

[Ψ]one farmer can give more than one answer.

6. **Estimation of technical efficiency in rice production:** Table 8 provides information on technical efficiency in rice production among the cooperatives' farmers. The analyses revealed that the member farmers of the cooperatives achieved, on average, 92.4% technical efficiency in rice production. It indicates that the farmers in cooperatives can improve their technical efficiency in rice production up to 7.6%. It was also found that majority of the respondents (70.3%) achieved at least 90% of technical efficiency. However, only 2.5% of the respondents obtained lower than 80% of technical efficiency. The findings of this study can be compared with the previous studies conducted in Mekong Delta, Vietnam. It was revealed that technical efficiency in rice production of the cooperative's farmers is higher than that of general farmers in Mekong Delta, Vietnam (Hien et. al., 2003; Nhut, 2007; Huy, 2009; Tuong, 2010; Thong et. al., 2011; Khai and Yabe, 2011). One of the reasons is that most of farmers in a cooperative apply the same formula for input and technique in their production. However, the technical efficiency in rice production in Mekong Delta tends to increase year by year (Tung, 2013).

7. **Factors affecting the technical efficiency in rice production:** Table 9 highlights the factors that affect technical efficiency in rice production in selected cooperatives. It is important to note that the findings of this study are consistent with some results of Hien et. al., (2003) and Huy (2009). The γ parameter associated with the variance of technical inefficiency effect in the stochastic frontier is significantly different from zero. This means that technical inefficiency in the rice production frontier of farmers in cooperatives exists.

Table 8
Frequency distribution of technical efficiency of rice production

Technical Efficiency (%)	*Frequency*	*Percent*
90-100	194	70.3
80 < 90	75	27.2
< 80	7	2.5
Mean TE	92.4	
Minimum TE	69.9	
Maximum TE	99.0	

Table 9
Estimation of the stochastic frontier function of rice production

Variable	*Coefficient*	*Standard error*	*t-ratio*
Stochastic frontier			
– Constant	8.493***	0.247	34.419
– Farm size (X_1)	0.920***	0.049	18.629
– Seeds (X_2)	-0.047*	0.028	1.700
– Nitrogen active (X_3)	0.017	0.035	0.481
– Phosphate active (X_4)	0.023	0.024	0.951
– Potassium active (X_5)	0.025**	0.012	2.086
– Pesticide (X_6)	0.011	0.009	1.219
– Labor (X_7)	0.057***	0.017	3.295
Inefficiency model			
– Constant	-0.019	0.071	0.263
– Education (Z_1)	-0.004	0.004	1.116
– Experience in rice production (Z_2)	-0.004***	0.001	2.872
– Income dummy (Z_3)	-0.021	0.034	0.628
– Credit dummy (Z_4)	0.006	0.024	0.231
– Years of joining cooperative (Z_5)	0.022***	0.006	3.564
– Technical training in 2016 (Z_6)	-0.029**	0.013	2.181
– Crop dummy (Z_7)	0.199***	0.047	4.216
– Variety dummy (Z_8)	-0.138***	0.037	3.708
Sigma-squared	0.008***	0.002	3.742
Gamma	0.854***	0.054	15.730
Log likelihood function = 377.5			
LR test of the one-sided error = 101.4			

*significant at 10%, ** significant at 5% and*** significant at 1%

The findings show that farm size, potassium active and labor hours have positive effect on technical efficiency. The coefficient of farm size and labor hours (including family labor) are positive in summer-autumn crop at 1%. It indicates that the larger farm size gets higher yield. Farmers regularly visit their rice fields which help increase the yield because they can timely response and quickly deal with pests and diseases. Similarly, the coefficient of potassium active is positive in summer-autumn crop at 5%. It indicates

that usage of more potassium active can bring higher rice yield. However, the magnitude of potassium coefficient is small. Previous studies reported that fertilizer utilization for rice production in the Mekong Delta is higher than other countries and negatively affect the environment and fertility of soil (Hien et. al., 2003; Dang &Danh, 2008). The coefficients of nitrogen active, phosphate active and pesticide are positive and insignificant meaning that these coefficients do not have significant effect on technical efficiency in rice production. In other words, the use of nitrogen active, phosphate active and pesticide has reached to the frontier. Using more nitrogen active, phosphate active and pesticide cannot bring higher productivity. On the other hand, the coefficient of seed is negative at 10% which means that using large amount of seed reduces the technical efficiency.

This study also assessed the factors that affect technical inefficiency in rice production. The factors are education, farmer's experience in rice production, income dummy, credit dummy, years of joining cooperatives, attending technical training class in 2016, crop dummy and variety dummy. It was found that the coefficients of farmer's experience and technical training classes have negative effect to technical inefficiency. It indicates that farmers, who have higher experience in rice production and attended in many technical training classes, have obtained higher technical efficiency. Similarly, the coefficient of variety dummy affects technical inefficiency negatively. It means that farmers using variety IR50404 get higher technical efficiency. On the other hand, the coefficient of crop dummy has positive effect to technical inefficiency indicating that farmers producing three rice crops per year have lower technical efficiency than those producing two rice crops per year. Production of three rice crops per year needs more utilization of input materials (such as fertilizer and pesticide) for each crop. Years of joining cooperatives also affects technical inefficiency positively. Some farmers joined cooperatives for a long time but they did not take part in any activity of the cooperatives. Therefore, joining cooperatives could not help these farmers improve their technical efficiency.

4. CONCLUSIONS AND RECOMMENDATIONS

This study assesses technical efficiency in rice production of the cooperatives' farmers in KienGiang Province, Vietnam. The study also identifies and examines the factors that affect the technical inefficiency in rice production in the province. The findings show that the farmers in the cooperatives occupy, on average, 1.6 ha land area per household for rice production. Most of the households (97%) produce two main rice varieties (i.e. IR50404 and OM5451) in summer-autumn crop. Majority of the farmers (75%) produce three rice crops per year. The average output of rice production was estimated at 6.66 tons per ha in summer-autumn crop. The total cost of rice production was 17.7 million VND per ha. The value of rice output was estimated at 30.4 million VND per ha. The estimated profit in summer-autumn crop was about 12.7 million VND per ha. However, in producing the rice, farmers face many problems such as climate fluctuation, rice price fluctuation, salinization, lacking of capital and harvesting machine.

The analyses revealed that the farmers in the cooperatives achieved, on average, 92.4% technical efficiency in rice production. Majority of the respondents (70.3%) achieved at least 90% of technical efficiency. The farm size, potassium active and labor hours affect positively the farmer's technical efficiency in rice production. It was also found that farmers, who have higher experience in rice production and attended in many technical training classes, have obtained higher technical efficiency. Farmers using rice variety IR50404 get higher technical efficiency than other varieties. On the other hand, the coefficient of

seed is negative at 10% meaning that using large amount of seed reduces the technical efficiency. Farmers producing three rice crops per year have lower technical efficiency than those producing two rice crops per year. Similarly, farmers who joined cooperatives for a long time but did not take part in cooperative activities cannot improve their technical efficiency. Based on the findings, this study suggests some recommendations that might be helpful for the following stakeholders:

1. **For the farmers:** Farmers should change their thinking and pay attention to their main major to get higher efficiency. They should decrease the quantity of seed that would help increase the technical efficiency. Using more potassium active proportion in fertilizer helps to increase the technical efficiency. Besides, farmers should often visit their rice field.
2. **For the cooperatives:** The cooperative management should have at least one member with a "business brain". Most of the managers in the cooperatives are from farmers, who are enthusiasm with their position but lacking of management skills and knowledge how to use computer. The management of the cooperatives should actively contact with the companies to ensure input and output for the farmers.
3. **For the Government:** The government should take initiatives to bring some changes in the Law of Cooperatives, particularly in the article about providing services outside the cooperative not exceed 32%. This limits the capacity of the cooperatives. If the cooperative invests an agricultural machine, this article prolong the payback time of cooperative. Besides supporting the technical training classes, the local government should create a direct communication network between cooperatives and companies. The government also should take initiatives to reduce the role of middle man in selling rice which would help to increase the farmers' profit.

Acknowledgments

The author would like to thank the Faculty of Economics, Prince of Songkla University for supporting the research fund.

References

Aigner, D., Lovell, C. K., Schmidt, p.,1977. 'Formulation and estimation of stochastic frontier production function models', *Journal of Econometrics,* 6(1), 21-37.

Battese, G.E., Corra, G. S.,1977.'Estimation of a production frontier model: with application to the pastoral zone of Eastern Australia', *Australian Journal of Agricultural and Resource Economics* 21(3), 169-179.

Chau Thanh Agricultural Division.,2016.*Report results of the plan in 2015 and orientations in 2016*.Chau Thanh.

Coelli, T. J., Rao, DSP, O'Donnell, C. J., Battese, G. E., 2005. *An introduction to efficiency and productivity analysis*. Springer Science & Business Media.

Dang, N. H.,Danh, V. T.,2008.Overview of agricultural economic development in the Mekong Delta. Economic development of the Mekong Delta in Vietnam, *CDS Research paper*; 2008.

General Statistics Office of Vietnam, 2015.Statistic yearbook of Vietnam in 2014. Hanoi: Statistics Publisher.

Hanley, N., Spash C.L., 1993.Cost-benefit analysis and the environment. Cheltenham: Edward Elgar.

Hien, N.T.M., Kawaguchi, T., Suzuki, N., 'A study on technical efficiency of rice production in the Mekong Delta-Vietnam by stochastic frontier analysis', *Journal of the Faculty of Agriculture,* 48(1/2), 325-357.

Huy, H.T., 2009.'Technical efficiency of rice producing households in the Mekong Delta of Vietnam',*Asian Journal of Agriculture and Development*,6(2), 35-50.

Khai, H.V., Yabe, M.,2011. 'Technical efficiency analysis of rice production in Vietnam', *Journal of ISSAAS,*17(1), 135-146.

Meeusen, W., Van, D.B.J., 1997. 'Efficiency estimation from Cobb-Douglas production functions with composed error', *International Economic Review,* 435-444.

Nhut, Q.M. 2007. *Allocation and cost efficiency analysis of selected farming patterns within and outside boundary irrigated systems in Tri Ton and Cho Moi district, An Giang province (Mekong Delta, Vietnam).* University of Antwerp:Center for ASEAN studies.

Thong, p. L., Xuan, H.T.D., Duyen, T.T.T., 2011.'Comparison of economic efficiency of the summer-autumn and autumn-winter rice crop in Mekong Delta', *Science Journal of Can Tho University,*18(a), 267-276.

Tung, D.T., 2013.'Changes in the technical and scale efficiency of rice production activities in the Mekong delta, Vietnam', *Agricultural and Food Economics,* 1(1), 16.

Tuong, D. M., 2010.'Economic analysis on production of high quality rice in Cuulong delta, Vietnam, *Omonrice*, 17, 174-178.

Yamane, T. 1967. *Problems to accompany statistics: an introduction analysis*. New York: Harper & Row.