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Assessing economic efficiency of oil palm production in Aoluek district, Krabi province

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The research focused on describing socio-economic characteristics and production in oil palm farming of farmers and assessing economic efficiency of oil palm production as well as investigating main factors effecting economic efficiency of oil palm production in Aoluek district, Krabi province. Detailed survey data obtained from a sample of 150 oil palm farmers were selected using a simple random sampling technique. Stochastic frontier analysis and multiple regression were used for data analysis. The results showed that most of the surveyed farmers were late middle-aged male with an average land holding size for oil palm plantation was 29 rai. An average economic efficiency of oil palm production was 0.95. The main factors positively effecting economic efficiency were farmer's experience, extension visits, oil palm production system, and source of seedlings. On the contrary, grouping for bargaining power formation had statistically significant negative effect on economic efficiency.

Keywords: economic efficiency, oil palm, stochastic frontier

Introduction

Oil palm farming is a dominant rural economic as well as important activity in Thailand. Thailand is ranked third in the world for producing palm oil (1.70 million ton). Indonesia is the leader of the world (28.50 million ton), while Malaysia is the second (19 million ton) (Foreign Agricultural Service, 2013). In 2012, oil palm farming utilizes land equal to 4.32 million rai (1 rai is equivalent to 0.16 hectare) and it produces 11.33 million ton of oil palm fruit bunch (Office of Agricultural Economics, 2013a). The average actual yield of the oil palm is 2.84 ton per rai (Office of Agricultural Economics, 2013a). In the same time, domestic demands for palm oil are equal to 1.61 million ton (Office of Agricultural Economics, 2013b).

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Oil palm production is constrained by bio-physical and economic bottlenecks. The bio-physical constraints consist of frequent floods, irregular pattern of rainfall, low soil fertility, and pest menace, while the economic constraints are high cost of production, low productivity, instability of oil palm fresh fruit bunch price, agricultural labor shortage and higher wages due to the high opportunity cost of labor in other activities. In addition, technological constraints like low yielding varieties and accelerated conversion of oil palm land to rubber farms are other major threats.

Presently, the significance of international trade has been increasingly high and unavoidable because it is considered to be an important economic tool to expand trading opportunities, to create economic alliances, and to enhance competitiveness of domestic goods and services. The attempt for having ASEAN Economic Community (AEC) directly effects Thai oil palm farmers. The Thai oil palm farmers will be negatively affected because they have to adjust their production in order to reduce cost of oil palm production to compete with imported goods which are cheaper.

Aoluek district is a district of Krabi province which is considered as economic zone for oil palm production of Thailand. In, 2011, oil palm was grown covering 182,930 rai (18.36% of the total oil palm planted areas of Krabi province). At the same time, oil palm households existed 5,030 household (22.42 percent of the total oil palm households of Krabi province) with an average land holding size for oil palm plantation is 36.37 rai per household (Krabi agricultural office, 2011) which was considered smallholder farmers. Most smallholder oil palm farmers faced high cost of production especially cost of chemical fertilizers. Thus, their production efficiency was still low compared with mid-sized estates and large estates.

Due to above constraints and problems, they may lead to be unsustainable oil palm production systems. Therefore, oil palm farmers must prepare with readiness to increase their competitive capacity. Economic efficiency of oil palm production can help to reduce cost of production, and would result in boosting sustainability of oil palm farming in Aoleuk district, Krabi province. This research attempts to describe socio-economic characteristics and production in oil palm farming of farmers and to assess economic efficiency of oil palm production as well as to investigate main factors effecting economic efficiency of oil palm production in Aoluek district, Krabi province. The expected outcome of this research is to formulate recommendations for improving farm performances for reaching the best practice and sustaining oil palm production systems in the research area and other area with similar characteristics.

Materials and methods

Primary data of this research based on farm level cross-sectional data of the crop year 2011. The sample size was considered according to sampling error at 5 percent, which calculated using formula with simple random sampling (Thompson, 1992). The actual samples of 150 farm households were collected. They were selected using simple random sampling technique. Structured questionnaire was used for interviewing individual oil palm farmers.

Descriptive statistic analysis was used to describe socio-economic characteristics and production in oil palm farming of farmers, i.e. percentage and mean. Economic efficiency of farmers was measured using stochastic frontier analysis which was single output, but using various inputs. Cobb-Douglas form was specified in order to estimate parameters and calculate economic efficiency scores because it had the best fit in explaining the relationship between independent variables and dependent variable, and consistent with the theory more than the other forms (Kobb and Smith, 1980; Taylor and Shonkwiler, 1986; Battese, 1992; Brovo-Ureta and Pinheiro, 1993; Kumar, 2001; Wiboonponse and Sriboonchitta, 2001; Songsrirote and Singhapreecha, 2007). The parameters were obtained using maximum likelihood estimation (MLE) and inefficiency effects were assumed as half normal, reflecting the belief that most oil palm farmers are relatively high production efficiency. Stochastic production frontier and stochastic cost frontier were shown in equation (1) and (2), respectively.

$$\ln TQP_i = b_0 + b_1\ln(ARP_i) + (b_2\ln(LAB_i) + (b_3\ln(QCH_i) + v_i - u_i \quad (1)$$

Where

TQP was total output of oil palm measured in kilogram per year,

ARP was area under oil palm plantation measured in rai,

LAB was labor used measured in man-day per year, and

QCH was quantity of chemical fertilizers used measured in kilogram per year.

The stochastic production frontier in terms of output oriented measure based on Timmer (1971) index of technical efficiency (TE) which was ratio of observed output (Y) to frontier maximum feasible output (Y^*), given a set of inputs.

$$TE = \frac{Y}{Y^*} = e^{-u_i} = \exp(-u_i)$$

Technical efficiency has values in the range of 0 and 1. Technical efficiency was equal to one, it meant oil palm farmer can produce oil palm at the highest output on production frontier and if value of technical efficiency was less than one, it meant oil palm farmer can produce oil palm at lower output than production frontier. The technical efficiency was converted into a percent multiplying this equation by 100.

$$\ln COS_i = b_0 + b_1 \ln WAG_i + (b_2 \ln) PCH_i + (b_3 \ln) TQP_i + (v_i + u_i \qquad (2)$$

Where

COS was cost of oil palm production measured in baht per year,

WAG was wage measured in baht per time,

PCH was prices of chemical fertilizers measured in baht per kilogram,

TQP was total output of oil palm measured in kilogram per year.

Cost efficiency (CE) or economic efficiency (EE) was ratio of frontier minimum feasible cost (C^*) to observed cost (C) and allocative efficiency (AE) was ratio of economic efficiency to technical efficiency (Bravo-Ureta and Rieger, 1991; Ajao *et al*., 2012; Khan, 2012).

$$EE = \frac{C^*}{C} = e^{u_i} = \exp(u_i)$$

$$AE = \frac{EE}{TE}; 0 \leq AE \leq 1$$

Economic efficiency has values in the range of 0 and 1. Economic efficiency was equal to one, it meant oil palm farmer can produce oil palm at the lowest cost on cost frontier and if value of economic efficiency was less than one, it meant oil palm farmer can produce oil palm at higher cost than cost frontier. The economic efficiency was converted into a percent multiplying this equation by 100.

Multiple regression analysis was applied to investigate main factors effecting economic efficiency of oil palm production. Maximum likelihood estimation (MLE) was employed to estimate the coefficients. The equation could be written as follows:

$$EE = b_0 + b_1GEN_i + b_2AGE_i + b_3STA_i + b_4EDU_i + b_5FHI_i + b_6EXP_i + b_7MEM_i + b_8GRO_i + b_9DEB_i + b_{10}BAR_i + b_{11}FVI_i + b_{12}SYS_i + b_{13}SOU_i + b_{14}APT_i + b_{15}FFE_i + U_i$$

Where

EE was economic efficiency of oil palm production which varied between 0 to 1,

GEN was farmer’s gender as a dummy variable, 1 for female and 0 was otherwise,

AGE was age of farmer measured in year,

STA was farmer’s marital status as a dummy variable, 1 for farmer got married and 0 was otherwise,

EDU was years of attending in formal school, FHI was farm household income of farmer measure in baht per year,

EXP was years of farmer’ s experience in oil palm cultivation,

MEM was number of household member measured in person,

GRO was member of group as a dummy variable, 1 for farmer was group membership and 0 was otherwise,

DEB was farm debts as a dummy variable, 1 for farmer was debtor and 0 was otherwise,

BAR was grouping for bargaining power formation as a dummy variable, 1 for farmer participated grouping for bargaining power formation and 0 was otherwise,

FVI was extension visits measured in time,

SYS was oil palm production system as a dummy variable, 1 for oil palm and other crops farming system and 0 was otherwise,

SOU was source of seedlings as a dummy variable, 1 for private companies and 0 was otherwise,

APT was years of oil palm trees,

FFE was number of fertilization measured in time per year, and

U was stochastic disturbance term.

These variables were expected to explain economic efficiency of oil palm production. The sign of the variables in economic efficiency model was very important in explaining level of economic efficiency of farmers. A negative sign on coefficient implied that variable had an effect on decreasing economic efficiency, while a positive coefficient signified effect of increasing economic efficiency. t-test was applied to test for differences of technical efficiency, allocative efficiency, and economic efficiency scores between monocropping (oil palm farming system) and mixed cropping (oil palm and other crops farming system).

Results

More than half of the sampled farmers were male. However, practically all housewives assisted their husbands in some activities of oil palm production. An average age of the farmers was 48.35 years old. Almost all farmers got married. Half of the farmers obtained the lowest educational level (primary school); an average duration of schooling of whole samples was 7.95 years. It was likely that they would have a limited knowledge for oil palm management.

Oil palm farming can be regarded as their major occupation (primary source of income) and rubber as a minor occupation. It is clear that most farmers depend for their income on oil palm and rubber. Some farmers received off-farm income such as temporary hired labor in towns or cities. The average farm household income was 525,303.33 baht per year. 33.34 percent of the farmers have had experiences in oil palm farming for more than 20 years. The farmers had an average of 17.71 years of experiences in oil palm farming.

The average farm family of the farmers was of medium size, which meant that it consisted of 4 members per household. Half of household members or approximately two persons were household labors working in oil palm farming. 40 percent of the farmers were members of village saving groups, while 36.67 percent were members of agricultural cooperatives. Only 2.67 percent of the farmers were village fertilizer group.

Results concerning on farm debts showed that 60.67 percent of the farmers have had debts and most of them were borrowing money for oil palm farming purposes from institutional and non-institutional sources. The average amount of debts of the farmer was 123,000 THB or approximately 4,100 USD on the average (1 USD is approximate 30 THB). It is clear that credit plays an important role in oil palm farming.

43.33 percent of the farmers grow only oil palm (do not engage in other activities), and the remaining 56.67 percent grow oil palm and other crops (rubber, fruits and vegetables). Oil palm systems of the farmers can be classified into 7 systems that are; (1)oil palm and rubber farming system, (2)oil palm farming system, (3)oil palm and vegetables farming system, (4)oil palm and fruits farming system, (5)oil palm, rubber and vegetables farming system, (6)oil palm, rubber and fruits, and (7)oil palm, rubber, vegetables and fruits farming system.

All farmers are commercial oil palm producers. Most of them are smallholder farmers. On a per household basis, the farmers owned on average 39.30 rai. The average land holding size for oil palm plantation was 29.08 rai, which was higher than the average farm size of the country (25.42 rai) and of the southern region (23.59 rai) (Office of Agricultural Economics, 2012). All farmers were farming on their own land. Land ownership has influences on investment incentives and the availability of resources to finance farm investment as well as land improvement investment (Feder and Onchan, 1987). The most popular land title among them was Chanod (42.68%). Nor Sor 3 was more common (33.76%). However, some oil palm plots of the farmers had no land title.

Most oil palm plots are in plain and highlands areas which have loam and sandy loam. Land suitability and rapid yield were main reasons why the farmers chose oil palm plantation. 67.33 percent of the farmers intend to expand area under oil palm plantation. Most farmers grow *tenera* variety because its palm fruits contain the most oil. Generally, the *tenera* grown is called according to trademark name or its origin, i.e. Costa Rica and Surat Thani 1. On most plots, 22 oil palm trees per rai were generally planted. Nearly all farmers depend only on rainfall as water source for oil palm production (97.34%). Even though irrigation can significantly improve oil palm yield, most farmers have not yet applied such system. This is due to lack of water supply and high investment cost.

More than 80 percent of the farmers used hired laborers. The most popular activity utilizing hired labor was harvesting. Harvesting cycles varied a lot, namely from 15-30 days. However, most farmers harvested oil palm within recommended period of 15-20 days. On average, the harvesting cycle was 11.03 days or 1.47 time per month. Severe problems of oil palm production were (1) low output price, which was related to low negotiation power of the farmers, (2) low soil fertility, which was related to low knowledge of soil management, and (3) high cost of chemical fertilizers, which was uncontrollable input.

Technical efficiency conditioned on the composed error ($e_i = v_i - u_i$) and evaluated using the estimated parameters presented in Table 1. Statistically significant variable effecting total output of oil palm was only area under oil palm plantation. The estimates of lamda (λ) and sigma (σ) were 1.01 and 0.61, respectively. These were large and significantly different from zero, indicating a good fit and correctness of the specified distribution assumption.

The stochastic frontier results of cost of oil palm production found that only sigma was significantly different from zero, but lamda wasn't significant and its value was less than unity, indicating the fact that the one-sided error (u_i) didn't dominate the symmetric error (v_i). This implied that inefficiency effects didn't exist among the farmers. In addition, it wasn't significantly different between the two (ordinary least squares (OLS) and MLE) cost function estimates. Therefore, multiple regression was used to estimate parameters presented in Table 2. Statistically significant variables effecting cost of oil palm production were wage and total output of oil palm. The regression model with these explanatory variables could explain correctly 74.20 percent of the variation in cost of oil palm production.

Table 1. Stochastic frontier results of oil palm production

Variable	Coefficient	Standard error	t-statistic	Prob.
Constant	7.15	0.38	19.00	0.00
ln(ARP)	0.86	0.09	9.79	0.00
ln(LAB)	0.13	0.09	1.49	0.14
ln(QCH)	0.01	0.06	0.22	0.82
λ	1.01	0.19	5.21	0.00
σ	0.61	0.04	13.65	0.00
Sigma-squared (v): σ_v^2 = 0.1867 Sigma-squared (u) : σ_u^2 = 0.1887 Log likelihood = -112.95				

Note: $\lambda = \frac{\sigma_u}{\sigma_v}$ and $\sigma = \sqrt{\sigma_u^2 + \sigma_v^2}$

Table 2. Multiple regression results of cost of oil palm production

Variable	Coefficient	Standard error	t-statistic	Prob.
Constant	0.65	0.75	0.87	0.39
ln(WAG)	0.49	0.06	8.20	0.00
ln(PCH)	-0.07	0.18	-0.38	0.70
ln(TQP)	1.04	0.05	19.41	0.00
R = 0.8614 R^2 = 0.7420 Adjusted R^2 = 0.7367 Durbin-Watson statistic = 1.70 F-statistic = 139.9541***				

Note: *** is $p \leq 0.01$

The results revealed that technical efficiency of the farmers range from 88.10 percent to 99.99 percent. An average technical efficiency score of 97.83 percent with a standard deviation of 1.88 percent (Table 3). This implied that, although the farmers were relatively technical efficient, it was clear that there were opportunities that existed to increase technical efficiency by an average of 2.17 percent through minimizing technical inefficiency. In other words, the farmers could potentially decrease their inputs by approximately 2 percent and still attain existing level of output. There were no statistically significant differences in technical efficiency between these two oil palm production systems (Table 4).

Allocative efficiency of the farmers range from 79.26 percent to 99.95 percent. An average allocative efficiency score of 96.81 percent with a standard deviation of 2.64 percent. This implied that, although the farmers were relatively allocative efficient, it meant that there were opportunities that existed to increase allocative efficiency by an average of 3.19 percent through minimizing cost of oil palm production. In other words, the farmers could potentially decrease their input costs by approximately 3 percent and still attain existing level of output. There were no statistically significant differences in allocative efficiency between these two oil palm production systems.

Table 3. Level of production efficiency of farmers

Level	Technical efficiency		Allocative efficiency		Economic efficiency	
	number	percentage	number	percentage	number	percentage
Low (≤ 0.50)	0	0.00	0	0.00	0	0.00
Moderate (0.51-0.75)	0	0.00	0	0.00	0	0.00
High (> 0.75)	150	100.00	150	100.00	150	100.00
Maximum	0.9999		0.9995		0.9959	
Minimum	0.8810		0.7926		0.7781	
Average	0.9783		0.9681		0.9470	
S.D.	0.0188		0.0264		0.0300	

Table 4. Comparison of production efficiency level of farmers classifying production system

Production system	Average	S.D.	t-test		95% Confidence level
			t-statistic	Prob.	
Technical efficiency					
Monocropping	0.978	0.017			-0.007-0.006
Mixed cropping	0.979	0.020	-0.13	0.89	
Allocative efficiency					
Monocropping	0.966	0.033	-0.81	0.42	-0.013-0.005
Mixed cropping	0.970	0.020			
Economic efficiency					
Monocropping	0.945	0.034	-0.84	0.40	-0.014-0.006
Mixed cropping	0.949	0.027			

Note: Monocropping farmers were 65 persons and mixed cropping farmers were 85 persons.

Economic efficiency of the farmers range from 77.81 percent to 99.59 percent. An average economic efficiency score of 94.70 percent with a standard deviation of 3.00 percent. This implied that, although the farmers were relatively economic efficient, it was clear that there were opportunities that existed to increase economic efficiency by an average of 5.30 percent through improving their technical and allocative efficiencies. In other words, the farmers could potentially decrease their overall cost of oil palm production by approximately 5 percent and still attain existing current output level. The best practice farmer operated at 99 percent, while the least practice farmer was found to operate at 78 percent. There were no statistically significant differences in economic efficiency between these two oil palm production systems.

Across all farms, Statistically significant variables effecting economic efficiency were farmer's experience, grouping for bargaining power formation, extension visits, oil palm production system, and source of seedlings (Table 5). Farmer's experience, oil palm production system, and source of seedlings had statistically significant effects on economic efficiency of oil palm production at the 10 percent significance level. In addition, grouping for bargaining power formation and number of extension visits had statistically significant effects on economic efficiency of all farms at the 5 percent significance level.

Table 5. Factors effecting economic efficiency of oil palm production

Variable	Coefficient	Standard Error	t-statistic	Prob.
constant	0.9076	0.0424	21.4083	0.00
GEN	-0.0041	0.0068	-0.6029	0.55
AGE	-0.0002	0.0004	-0.5619	0.57
STA	0.0111	0.0156	0.7147	0.47
EDU	-0.0005	0.0012	-0.3936	0.69
FHI	-0.000000004	0.000000005	-0.7642	0.44
EXP	0.0009	0.0005	1.6731	0.09
MEM	-0.0010	0.0029	-0.3752	0.71
GRO	-0.0007	0.0066	-0.1058	0.92
DEB	0.0064	0.0068	0.9434	0.35
BAR	-0.0500	0.0212	-2.3589	0.02
FVI	0.0032	0.0016	1.9499	0.05
SYS	0.0112	0.0069	1.6307	0.10
SOU	0.0109	0.0070	1.5589	0.12
APT	-0.0008	0.0006	-1.2488	0.21
FFE	-0.0039	0.0043	-0.8948	0.37

R = 0.3812 R^2 = 0.1453 Adjusted R^2 = 0.0425 Log likelihood function = 261.5621

Farmer's experience had a positive effect on increasing economic efficiency of oil palm production. It implied that an increase in farmer's experience by 1 year would lead to an increase in level of economic efficiency by 0.0009. Experience had an important and positive effect on farmer's management decisions. Long years of experience or more experience in oil palm management helped oil palm farmers to improve adoption of modern techniques. This would lead to effectively allocate inputs, thereby allowing them to operate at higher level of efficiency.

One of the variables most worth mentioning in relation to economic efficiency of oil palm production was grouping for bargaining power formation.

A negative relationship and statistically strong significant effect economic efficiency and grouping for bargaining power formation. It implied that the farmer participated grouping for bargaining power formation would lead to a decrease in level of economic efficiency by 0.0500. Conflict and cheating may occur within group. As a result, the farmers had a low confidence in group performance. Most farmers used to sell oil palm fruit bunch by themselves.

Extension visits had a positive effect on increasing economic efficiency of oil palm production. It implied that an increase in extension visits by 1 time would lead to an increase in level of economic efficiency by 0.0032. Availability of extension services brought benefits to the farmers such as improving their efficiency of oil palm production through exchanging information on production and marketing together and diffusing modern oil palm technology to the farmers. It enabled the farmers to adjust their resources relatively more effectively such as timely availability of fertilizers and herbicides at competitive prices, positively influence their cost of oil palm production. Therefore, the farmers who had accessed to extension services performed significantly better in terms of decreasing cost of oil palm production, earning actual profit, incurring less profit loss and operating at higher farm-level efficiency.

Oil palm production system had a positive effect on economic efficiency of oil palm production. It implied that mixed cropping would lead to an increase in level of economic efficiency by 0.0112. Crop diversification is a strategy to maximize use of land and other resources. It minimizes adverse effects of current system of crop specialization and monoculture for better resource use, lessening of price, and income risks. Based on the findings of this research, mixed cropping have economic efficiency scores higher than monocropping (Table 4).

Source of seedlings had a positive effect on economic efficiency of oil palm production. It implied that seedlings from private companies would lead to an increase in level of economic efficiency by 0.0109. Most private companies have availability of skilled labor and capital resources to invest on improved seedlings. Accordingly, seedlings have been continuously bred for commercial advantage.

Conclusions and recommendations

Aoluek district, Krabi province is an important area of oil palm production of Thailand. The results summarize that most of the farmers were late middle-aged male with high household income. The economic efficiency scores of oil palm production amongst farms were relatively high. Farmer’s experience, extension visits, grouping for bargaining power formation, oil palm production system, and source of seedlings had statistically significant effects on economic efficiency of all farms. The result was consistent with the research of Parikh *et al*. (1995) and Kalirajan and Huang (1996).

Based on this research, the following recommendations are offered:

(1) Due to the findings from field research, most severe problems of oil palm production was low output price. Therefore, Krabi agricultural office should provide more information and train on how to appropriately harvest to gain quality output.

(2) One of severe problems of oil palm production was low soil fertility. Therefore, Aoluek agricultural office and Krabi agricultural office should collaborate to set up mobile unit of oil palm soil testing and frequently give advises to the farmers after having the soil tested results that how to improve their soil quality and recommend how to use the proper combination of inputs especially chemical fertilizers and organic fertilizers. Furthermore, training course on soil management is necessary for the farmers. The knowledge and practical experience could improve their skill in oil palm farming, promote their productivity, and solve their technical problems.

(3) Another severe problem of oil palm production was high cost of chemical fertilizers. This cost is cash expense of oil palm farms. The inefficiency farms should be considered on decreasing of this cash cost by learning from the best practice farms, and then they would increase income from oil palm farming. In addition, farmers as professional farm managers, the planning and evaluation of farm performances are necessary. Therefore, the farmers need to be trained on records keeping systems. This information can again be used for farm improvement.

(4) The maximum economic efficiency score of oil palm production was 99.59 percent. Therefore, Aoluek agricultural office as a main government agency who works closely to the farmers, should provide and disseminate information of the best practice farms or benchmark farms to all farmers in Aoluek district. The officers should stimulate the farmers to improve their oil palm production efficiency.

(5) Extension visits and farmers' experience have a positive effect on economic efficiency of oil palm production. Farmers could reap benefits of extension visits in the form of increased oil palm and decreased cost of oil palm production. Therefore, more personal contact between the farmers and agricultural extension officers should continue and promote for better the economic efficiency of oil palm production. In addition, the agricultural extension system should be strengthened to promote welfare of the farmers.

Moreover, Aoluek agricultural office, Krabi agricultural office and Department of Agriculture Extension (DOAE) should collaborate to boost farm household income by raising productivity through practical on-farm training on use of improved varieties of oil palm and fertilizers, and practices.

(6) Mixed cropping have a positive effect on economic efficiency of oil palm production. It should be encouraged to replace monoculture farming system which was a considered higher risk. Increasing other crops together with oil palm will help create a more diverse income base.

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