Measuring the Technical and Scale Efficiency of Maize Production in Thailand: The Case of Mae Chaem District, Chiang Mai

Nuzzree Watcharasakonpong[1*] Poon Thiengburanathum[2]

1. School of Logistic Engineering and Supply Chain Management, Department of Industrial Engineering, Chiang Mai University, PO box 50200, Chiang Mai, Thailand
2. Department of Civil Engineering, Chiang Mai University, 239 Suthep Street, Chiang Mai 50200, Thailand

Abstract

This paper aims to measure the technical efficiency(TE) by identifying sources it for maize production in Mae Chaem District, Chiang Mai, Thailand and to explain estimated TE by farmer characteristics. Data Envelopment Analysis was employed to estimate farmer (DMU) score of technical efficiency both of the constant return to scale (CRS) and the variable return to scale (VRS) were applied to the study based on input oriented, a relative efficiency index in production. Then, Tobit regression model was used to clarify the variation in technical efficiency scores by determining major farmer's characteristics as an element factors behind. A total 103 Maize farms were selected for the study dividing into 2 groups by 52 farms were non-burn farm and 51 farms were burned farm. The result showed that group1 has more average efficiency than group2 by 7% under the constant return to scale and 1% under the variable return to scale. The scale efficiency result show that majority of both of farmer group were operated with increasing return to scale. Tobit regression result shows that farm's characteristics such as farm experience, burn, family size have statistically significantly affected by 0.53, -7.2 and 1.36 percent to technical efficiency under constant return to scale, the technical efficiency under variable return to scale was influenced by farm experience and family size by 0.61 and 1.10 percent respectively.

Keywords: Non-Parametric, Data Envelopment Analysis, Tobit Analysis, Technical Efficiency, Farmer Characteristics.

1. Introduction

Thailand, one of the Leading Southeast Asia's maize producer, which is heavily oriented toward providing feed for the livestock industry around 7.8 million tons in 2032 (demand forecasted). Thailand has an area under maize cultivation in 2015/2016 was 1.131 million hectares with 4.931 million tons of National Maize Production (table1). Maize was also ranked as important crop number seven form total Thailand crop. Thailand can grow maize two times annually, the yield of maize, mainly to be used as raw material in the animal feed industry. Maize production has continued to grow as the growth of the livestock sector, especially chickens and pigs, with the demand for maize as an ingredient of animal feed 4.3 million tons per year or 94 percent yield of maize in the country. In Thailand, there are 640 feed factories in service which have a capacity of 17 million tons of process expectation in next 10 years. Thailand feed industry also imports maize form Lao PDR (Department of Foreign Trade, 2015), Cambodia and other neighboring country. Other 6% of maize yield will be used in other areas such as industry, flour, maize meal and vegetable oil, cosmetics. From table 1, Thailand has maize cultivated area totally 1,131,757.92 hectares and 4,729,527 tons of maize including 756,724.26 hectare produced 3,298,579 tons (70%) from northern part, 238,163.84 hectare produced 970,124 tons (20.51%) from North-Eastern and 110,047.52 hectare produced 430,184 tons (9.49%) from Central Part. Maize becomes an important crop of the Northern region since 1982, Thailand begun maize supporting policy in National Social and Economic Development Plan No.5. However, many recent studied show the negative impact on maize farmer such as a high price of inputs (Fertilizer, Pesticide, Seed and labor cost), an increasing of farmer debt (Talerngsri and Pongkitworasin, 2012). According to investigated research area stated that maize becomes a popular crop in Mae Chaem district since 1995 with 23,180.84 hectares and 8,507 household farms from total 13,010 household farms. This indicates more than 65% of Mae Chaem farmer has involved occupation in maize. In 2015/16 Mae Chaem district has maize cultivated area 15,697.76 hectare and 70,775 tons of maize which can produce 4,508 kg of maize per 1 hectare. From table 2, Maize has become an important crop instead of cabbage, carrot, and garlic with 552.86 percent of enlarging in 16 years. Data showed in 2009 with the highest volume of maize production by 86,095 tons. In 2009, an average F.O.B maize price on Thailand equals 7.32 baht per kilogram but in a previous year was 9.24 baht per kilograms some reports indicated that the highest volume of maize in 2009 caused farmer decided to expand harvest areas because of 2008 maize price. While shallot, paddy rice, and sticky rice have expanded between -4.5 percent and 41 percent.

1.1 Haze and Pollution Problem Alleged on maize.

Haze becoming a serious problem in northern of Thailand since 2007, The haze seasoning begun from March to May every year. In 2015, Northern part of Thailand has 15,950 times of hotspots. Chiang Mai has a significant share of 2,119 times of hotspot in the haze problem (Forest Fire Control Division National Park, 2015) and more than 319 hotspots in Mae Chaem district (Department of Pollution Control, 2015). There are many causes of hotspot including agriculture waste burning, crop preparation, forest's fire and etc. Maize was alleged as the cause of haze problem from burning agriculture waste and pre-land planting. Since maize has a huge involve as the main occupation and allegation in causing of haze problem. It's very important to find out if the burned farms and non-burned-farm are working efficiently or not as a big research question. This study points out the source of inefficiencies of crop maize production in Mae Chaem district which the result can offer a big context in determining policies and also might guide as a decision supporting tools to figured out the maize-haze solution for the future.

2.Research Methodology

A two stage Data Envelopment Analysis was applied into this study. For the first stage, measuring technical efficiency of maize producer. Second stage, explanatory variable which assumed to affected the technical efficiency will be estimate by Tobit Regression Analysis.

2.1 Literature Review

From the statement of introduction, based on the research question that "Does the maize production in research area good or bad?" and "How the maize productivity situation is". The consequence of burning agriculture affects to people in Chiang Mai. Recently report indicated that maize are highly implicated to Mae Chaem's farmers. There are many suggestions to farmer such as terminate maize production, avoiding burn agriculture process. This is study concern maize as part of farmer's life. The question can answer by measure current efficiency in maize production. The degree of inefficiency in resource utilization give alternative aspect to analysis whether if the farmer cannot change the crop and still planting maize. Efficiency analysis consider as an identifying tool.

Efficiency analyses are convenience for integrate efficiency describing exogenous variable (Karimov, 2014). In the previous studies, there are many studied indicated farm experience has positive relation to technical efficiency such as Endras Geta (2013), Ogunniyi (2012), Kane *et.al.* (2012), Yusuf (2007), Khai *et.al.* (2008) state that "the variable farm experience showing that farmer with greater farming experience will have better management skills and higher efficiency. Thus, the increasing of farm experience could increase technical efficiency. The positive relationship between farm experience and technical efficiency was also founded by (Parikh, 1995) conducted the studies on Pakistan farmer. After 1 year later, Coelli and Battese (1996) was found the same result in Indian farmer. In the contrast, Ajibefun *et.al.* (2006), Seyoum *et.al.* (1998), Amaza and Maurice (2005), Wakili (2012) and Karimov (2014) found that the older farm was more inefficient, these were conducted in Nigeria. Farmer's age and experience still discuss in efficiency measurement literature now a day.

Family size had been mostly reported with negative relation with farmer technical efficiency (Okike, 2000) in the other words, a larger family size causing technical inefficient on farmer. Yusuf (2007) found that family size has negative influence on technical efficiency. (Ogunniyi, 2012) reported that family size was negative influence and statistically significant on technical efficiency under a constant return to scale. Geta *et.al.* (2013) was consider this factor in the model and also found a negative relation but not significant. However, (Ingram, 1994) and (Pender, 2004) reported that more densely household could enable them to increase crop production. In the other word, they found a positive relationship between family size and technical efficiency.

Farm size in previous studies was found both of negative and positive relationship with technical efficiency. In case of negative relationship. In 1994, Frisvold and Ingram found the smaller farm were operated more efficiency than larger farm in Sub-Sahara Africa. According to Pender (2004) farm size was negatively affected on farmer's technical efficiency in Uganda. 5 years later, Brambilla *et.al.* (2009) conducted the study in Zambia, results show small farm tend to be efficient more. Although, there are positive relationship between farm size and technical efficiency reported in the study, Budak *et.al.* (2005) found that farm size was positively associated with technical efficiency, the study conducted in Turkey. In a similar way, Sharma, Leung *et.al.* (1999), Geta (2013), Tipi (2009), Bagi (1982) confirm the same result in their study.

2.2. Data and Variables.

The number of DMUs is expected to be larger than the product of number of input and output in order to discriminate (Darrat et al.2002; Avkiran,2001) effectively between efficient DMUs. However, the sample size should be at least 2 or 3 times larger than the sum of the number of inputs and outputs (Ramathan, 2003). In this study has the sum of inputs number and output number equals 5 then, 15 farms should be minimum sample size according to suggestion (Ramanathan, 2003). A sample size of 103 farm households randomly selected in the study area based on cross sectional 2014/15 crop the variable burn identified 52 and 51farms for non-burning group and burning group respectively. In Additional, burning refer to the using of burn into land preparing before planting maize. This study employed one output and four inputs were used in the efficiency estimation. The output is maize yield per 0.16 hectare. The inputs including seed quantity, labor cost, chemical-pesticide cost, and fertilizer cost. Table 3 shows the descriptive statistics of the inputs and output while table 4 shows descriptive statistic of farm's characteristic in the study. DEA score calculated by DEAP2.1 suggested by Tim Coelli (1995) estimated the technical efficiency both of CRS and VRS assumption then, the Tobit Regression was used to find out causes of inefficiencies. The explanatory variables such as Farm Experience, Farm Size, Family Size, and Burn were selected in to independent variable and estimate by STATA 12.

2.3. Methodology Approach

2.3.1 Data Envelopment Analysis

There are two ways to measure the production efficiency including parametric and non-parametric method. The non-parametric method was initiated by Farrell in 1957. Data envelopment analysis is non-parametric based on the use of linear programing techniques estimate efficiency and inefficiency from an observed data. An input oriented data envelopment analysis was employed under the assumption of a constant return to scale (CRS) and variable return to scale (VRS) to minimize inputs use of decision-making units (DMUs) which can maintain the current level of maize yield. Then a scale efficiency will be assessed the scale efficiency each DMUs. The linear programing model for constant return to scale used in this study were as follow (Coelli et al. 1998);

$Min_{\theta,\lambda}\, \theta$,

Subject to

$$
\begin{aligned}
&-y_i + Y\lambda \geq 0 \\
&\theta x_i - X\lambda \geq 0 \\
&\lambda \geq 0
\end{aligned}
\qquad (1)
$$

where θ is the TE_{crs} of ith farms and λ perform $N\times1$ constants. Y = output matrix of N farms, X = input matrix of N farm, for the i th farm, inputs and output data are represented by the column vector x_i , y_i respectively. The linear programing model for variable return to scale used in this study were as follow (Coelli et al. 1998);

$Min_{\theta,\lambda}\, \theta$,

Subject to

$$
\begin{aligned}
&-y_i + Y\lambda \geq 0 \\
&\theta x_i - X\lambda \geq 0 \\
&N1/\lambda = 1 \\
&\lambda \geq 0
\end{aligned}
\qquad (2)
$$

Where θ is the TE_{vrs} of ith farm, N1/ λ =1 performs a convexity constraint which assure an inefficient DMU is only benchmarked against DMUs of similar size.

In addition, if a DMU's has existing productivity is equal to the frontier lies on the frontier (=1), it means that DMU is technically efficient. On the other hand, if a DMU has existing productivity unequal the frontier ≠(1), it's mean the DMU is technically inefficient. There are 103 farms in the sampling, wherewith a single output is maize yield and 4 inputs including seed, labor cost, chem-pesticide cost and fertilizer cost.

2.3.2 Scale Efficiency (SE)

Scale efficiency value explains when the use of inputs and increased proportionally, the productivity will increase proportionally as much as they used. For example, if any DMU has an efficient on scale efficiency when the increase of input used for 10% the productivity of that DMU will be increase at 10%. This calls the constant return to scale or "CRS" if DMU can increase their productivity more than 10% after using 10% of input. DMU will be "increasing return to scale or "IRS" but in the other way, if the DMUs can produce the productivity less than 10% after using 10% of input, thus the DMU will be decreasing return to scale or "DRS". Scale Efficiency can obtain from following this; (Dhungana *et al.* 2004)

$$SE = \frac{TE_{crs}}{TEvrs}$$

if, SE = 1 means scale efficient
SE < 1 means scale inefficient (3)

2.3.3 Tobit Analysis Model.

The Tobit model was purposed in 1958 by James Tobin, the model was known as censored or truncated regression models. Since the technical efficiency score are range between 0.00-1.00, (Maddala,1983) states that the estimation with the ordinary least squares (OLS) regression on DEA score or one sided Tobit regression will affect by biased parameter since the OLS assume a normal distribution and homoscedastic variable. Hence, this study applied the two-limit Tobit regression to explore the source of efficiency score and explanatory variables such as farm experience, Farm size, Burn Process, and Family size. The two-limit Tobit regression can define as; (Tobin, 1958)

$$y_i^* = \beta_0 + \sum \beta_m X_{jm} + \mu_i$$

$$y_i = 1$$

$$y_j^* \begin{cases} if\ y_i^* \leq 0 \\ if\ 0 < y_i^* \leq 1 \\ if\ \ y_i^* \geq 1 \end{cases}$$

0 (4)

Where y_i^* is latent variable, β is a vector of unknown parameters to be estimate, X_{jm} is a vector of explanatory variable m for farm j and $\mu_j$is an error term which is independently and normally distributed by mean zero and variance σ^2, stand for y_i represented by the observed variables (efficiency index)
2.3.4. The application of Tobit regression in this study.

$$y_i^* = \beta_0 + \beta_1 Fexp + \beta_2 Fsize + \beta_3 Burn + \beta_4 Famsize + \mu_j \quad (5)$$

Where y_i^* is a efficiency index, β are the unknown parameters to be estimate. The variable Fexp is the number of farmer's experience in maize production, Fsize is the number of total land cultivated, Burn is the dummy variable which take a value of 1 if farmer has burned process in land preparing otherwise 0, Famsize is total number of people in the farmer's household. Maximum likelihood estimates following by (Maddala,1999) all parameter for Tobit regression were calculated by STATA v.12.0.
2.3.5 Marginal Effect

For the two-limit Tobit model, regression coefficients cannot infer such a traditional regression coefficient which give a degree of marginal effects of change in the explanatory variables on expected value of dependent variable. There are 3 conditions for marginal effect according to (Gould, 1989) firstly, the unconditional expected value of the dependent variable following this; (Maddala, 1999)

$$\frac{\partial E(y)}{\partial x_j} \quad (6)$$

secondly, the expect value of the dependent variable conditional upon being between limit;

$$\frac{\partial E(y^*)}{\partial x_j} \quad (7)$$

finally, the probability of being between limits.

$$\frac{\partial[\varphi(Z_U)\text{-}\varphi(Z_L)]}{\partial x_j} \quad (8)$$

The marginal effects on above equations were estimate by STATA v.12.0

3.Result and Discussion

3.1 Descriptive statistic result in the study.

3.1.1. The summary of variable in this study

The summary of statistics of variable for the production frontier estimation is presented on table 3. The table reveals that group 1 has the average output per 0.16 hectare of maize is 1,147.65 kg. with a standard deviation of

401.22 kg per 0.16 hectare, the average of using seed, labor cost, chem-pesticide cost, fertilizer cost are 4.19 kg, 1,019.62 baht, 833.17 baht, 2,117.50 baht per 0.16 hectare respectively. The greatest variation existing for inputs rank from fertilizer cost, labor cost, pesticide and seed.

Group2 has the average output per 0.16 hectare of maize is 790.35 kg, with standard deviation of 238.12 kg per 0.16 hectare, the average of using seed, labor cost, chem-pesticide cost, fertilizer cost was 4.02 kg, 434.92 baht, 1,042.82 baht and 2,440.74 baht per 0.16 hectare respectively. The greatest variation existing for inputs used rank form fertilizer cost, pesticide cost, labor cost and seed.

As it seen on the table 3, indicate that group1 has maize yield more than group2 by 353.3 kg per 0.16 hectare and used input less in pesticide and fertilizer, in the other way group 2 has used input less than group1 in labor and seed. An average maize production cost of group 1 is cheaper than 1.98 baht and group 2 cheaper than 0.42 baht per kg when comparing with cost of maize production in Phetchabun province (Khampian, 2014).

3.1.2. Farm's characteristics in this study.

Farmer in group1 has experience in maize farming between 3-30 years with average 12.82 years while group2 has 3-25 years and 14.49 years. This indicated that farmer in group 2 has average experience of maize farming more than 1.67 years, The average of farm size of group 1, group2 equal 14.60 rai and 23.04 rai respectively. The average family size is 6.35 and 6.41. however, the variable burn is dummy variable describe the use of burning process in land-prepare and agriculture's waste if yes equal 1, 0 if otherwise.

3.2 Technical Efficiency of Maize Producer between sample group.

The efficiency score for group 1 range from 22.26% to 100%. Including 15.38% of farms are operating efficiently and 84.61% of farm are operating inefficiently with constant return to scale condition. For group 2, the efficiency score range from 60.01% to 100%. Including 11.76% of farms are operating efficient and 88.23% are operating inefficient with constant return to scale condition.

The efficiency score for group 1 range from 66.60% to 100%. Including 26.92% of farm was operated efficiently and 73.07% was operated inefficiently with variable return to scale. For group 2, the efficiency score range from 55.50% to 100%. Including 23.53% of farm was operated efficiently and 76.47% was operated inefficiently.

The result from DEA estimation pointed out on an average technical efficiencies of group 1 were equal 67.65 and 87.69 percent under constant return to scale and variable return to scale respectively. Group 2 were equal 60.01 and 86.42 percent under constant return to scale and variable return to scale respectively. This indicated that group 1 has better technical efficiency score TEcrs, technical efficiency score TEvrs than group 2 by 7.64 and 1.27 percent respectively.

Technical efficiency level in this study is higher than efficiency reported by others in case of maize production; (Budak, 2005) with 84.3 percent in turkey, Abdulai and Eberlin (2001) with 65.7 percent in Nicaragua, Zaibet and Dharmapala (1999) with 48 percent in Oman, (Ogunniyi, 2012) with 65 percent in Nigeria, (Endras Geta, 2013) with 40 percent in Ethiopia, (Gilles Quentin Kane, 2012) with 67.8 percent in Cameroon. However, we do not found non-parametric maize technical efficiency research in Thailand. Whereas, found parametric estimate by Nonthakot and Villano (2009) reported maize technical efficiency in Nan province equal 86 percent, this indicate technical efficiency in this study resembling to their study. A Spearman's correlation was run to assess the relationship between Technical efficiency) CRS (index and Technical efficiency VRS index. In table 6, in order to examine agreement between results obtain from DEA. The correlation coefficient is moderately positive significant less than 1 percent level. This indicated an agreement between two approach.

3.2.1 Maize input slack.

On the table 7, For group 1, the greatest input excess is seed used, Pesticides cost and labor cost, the result show group 1 can reduce seed use, pesticides cost and labor cost by 10.75, 4.89 and 4.40 percent respectively by these amount to obtain the same level of output.

For group 2, the greatest input excess is seed used, Pesticides cost, Labor cost and Fertilizer cost, which could reduce by 10.45, 8.15, 2.06, 1.68 percent respectively. These reducing amount to obtain the same level of output. This similarly to report in Oyo State, Nigeria by (Ogunniyi, 2012) which point out the greatest input excess was seed used.

3.3 The scale efficiency result (Table.8)

The average scale efficiency in group 1 is 76.41% and group 2 is 68.99% this indicated that group 1 has a better scale efficiency than group 2. The characteristic of return to scale in Table 6, show that maize farm in group 1 including 15 farms are constant return to scale, 35 farms are increasing return to scale and 2 farms are decreasing return to scale. Maize farm in group 2 shows the different return to scale characteristic of 51 farms by 13 farms are constant return to scale, 32 farms are increasing return to scale and 6 farms are decreasing return to scale. These result can state that most of maize producers in the study are facing increasing return to scale. Therefore, they could reduce inefficiency by increasing farm size more than present size.

3.4 Determinants of Technical Efficiency.

As the report by table 9. The Tobit regression model indicated that an important variables affecting the technical efficiency were farm experience, burn and family size. Farm experience was statistically significant at positively to the technical efficiency of maize farmer at less than 10 percent level of significance. In meanwhile, burn was statistically significant but at negative to technical efficiency of maize production. Family size also statistically significant at positively to the technical efficiency at less than 5 percent level of significant.
Farm Experience and family size have positive relationship with technical efficiency. Hence, the more farm experience and family size have increased maize productivity and technical efficiency their production. The relationship between burning procedure and technical efficiency in maize production was negative and statistically significant. Thus, burning is crucial to decrease technical efficiency in maize production.

Table 10, show farm experience and Family size have positive relationship with technical efficiency (VRS) Hence, the more farm experience and family sizes have increased maize productivity and technical efficiency VRS. As the result on table 9 and 10 reveal that farm experience has positive correlate both of technical efficiency CRS and VRS these results consist to (Battese, 1996) (Endras Geta, 2013) (Gilles Quentin Kane, 2012) (Ogunniyi, 2012) (Parikh, 1995) (Yusuf S.A, 2007) Khai *et.al.* (2008) also reported that positive relationship between farm experience and farm's technical efficiency in their studies. Family size was report positive relationship with technical efficiency, consisting with (Ingram, 1994) (Pender, 2004) who reported the same result in their studies.

3.5 Marginal Effect on Technical Efficiency

3.5.1 Marginal effect of change in explanatory variable for Technical Efficiency CRS.

The result from Tobit regression show a unit change in farm experience variable increases the probability of a maize producer being efficient by about -0.4 percent and the mean level of efficiency by 0.53 percent with an overall increase in the probability and level of technical efficiency by 0.6 percent. This unit change in the farm experience bring 0.6 percent increase to the expected value of unconditional technical efficiency. Family size's unit changes would increase the probability of maize producer being efficiency by -1 percent and the expected valued technical efficiency by 1.36 percent and bring about 1.75 percent increase to the unconditional technical efficiency. A change in the dummy variable represent the using of burning in pre-planting varies form 0 and 1 would increase the probability of maize producer to fall on efficiency by 5 percent and decreasing the expected condition technical efficiency about -7 percent and by -9 percent for unconditional expected value of technical efficiency. (table 10)

3.5.2 Marginal effect of change in explanatory variable for Technical Efficiency VRS.

As the result in table 12, A unit change in farm experience variable can decrease the probability of maize producer being efficient about 0.9 percent and the mean level of efficiency by about 0.6 percent and overall increasing in the probability and level of technical efficiency by 0.8 percent and A unit change in Family size would decrease probabilities chance to being between limits about 0.167 percent, and increasing the expected conditional (mean level of efficiency) about 1.104 percent and overall increasing in the probabilities and level of technical efficiency by 1.59 percent.

4.Conclusion

This study was executed in Mae Chaem district, Chiang Mai, Thailand to assess the technical and scale efficiency of maize producer between of non-burn farm and burn farm. The study was based on the cross-sectional data collect 103 randomly select households in 2014/15 crop. The DEA model was applied to determine the level of technical efficiency of each maize producer in the sample. In additional, a two-limit Tobit regression was employed to classify factor determining technical efficiency.
The average technical efficiency was found to be 67.65 and 60.01 percent for group 1 and 2 respectively under a constant return to scale. The average variable return to scale was 87.69 and 86.42 percent. This shows that if average maize farm in the group 1 sample was to achieve the technical frontier, they should decrease 32.35 and 12.31 percent of using input without any reduction of the output produced. In the same way, if average maize farm in group 2 sample was to achieve the technical frontier, they could reduce 39.99 and 13.58 percent of using input without any reduction of the output produced. Both of group have greatest inputs excess were seed used, pesticide, labor, and fertilizer. The correlation between TE(crs) and TE(vrs) is 0.5461, this indicated a moderate relation between both conditions. Scale efficiency (SE) were 76.41 and 68.99 percent. This means non-burn

farms are operating near optimal scale than burn farm. The Tobit regression results show that farm experience, Burn, and Family size were significantly determinant of technical efficiency under a constant return to scale. The technical efficiency under a variable return to scale had a significant affected by 2 factors including farm experience and family size. From above result, confirm that farm experience and family size had a positive relation with both of technical efficiencies while burn process has a negative relation to only technical efficiency under a constant return to scale. As a result of the study, policy maker should focus on maize producer's training and promote non-burn agriculture to farm household which can decrease technical inefficiency in maize production.

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Table 1: Thailand Maize Area cultivated by Reginal.

Region	Harvest Area	Percent)Area(	Maize Yield)Tons(	Percent
North	756,724.26	66.86	3,298,579	69.74
North Eastern	238,163.84	21.04	970,124	20.51
Central	110,047.52	9.72	430,184	9.095
Other	26,822.30	2.36	30,640	0.647
Total	1,131,757.92	100	4,729,527	100

Source : Office of Agricultural Economic 2016

Table 2 : An important crops yield in Mae Chaem District 2000-2016 unit : tons

Year/Crop	Maize	Shallot	Paddy rice	Sticky Rice	Carrot	Cabbage	Garlic
2000	12,807	20,785	10,550	4,421	38,859	5,285	13,032
2001	13,550	67,828	14,492	5,672	79,674	197,042	30,742
2002	20,115	81,347	9,275	9,757	N/A	272,347	10,850
2003	13,967	22,031	6,780	8,541	13,623	68,636	20
2004	15,703	N/A	6,926	8,093	816	7,024	434
2005	22,000	15,701	1,029	10,071	267	722	672
2006	29,347	31,707	1,546	6,620	479	44,700	495
2007	40,393	61,476	2,082	9,314	N/A	13,545	4,875
2009	86,095	32,466	6,354	8,031	N/A	4,800	390
2010	58,566	12,764	23,007	5,995	N/A	16,426	719
2011	77,449	32,375	681	16,945	N/A	8,580	825
2012	72,608	13,171	23,086	2,050	N/A	2,676	255
2013	76,941	13,225	18,380	6,301	N/A	N/A	83
2014	70,775	11,607	19,262	3,337	N/A	447	412
2015	74,664	15,578	16,984	4,590	N/A	N/A	6,398
2016	70,805	19,837	14,947	6,396	N/A	N/A	N/A

Source : Office of Agricultural District, 2016

Table 3: Summary Statistics for Variable Used.

Description	Group	Unit	Mean	SD	Min	Max
			Group 1			
Output						
Maize Yield	1	Kg	1,147.65	401.22	400	2,500
Input						
Seed	1	Kg	4.19	1.95	2	10
Labor	1	Baht	1,019.62	734.94	0	4,000
Chem-Pesticide	1	Baht	833.17	395.64	300	2,000
Fertilizer	1	Baht	2,117.50	758.93	500	4,000
			Group 2			
Output						
Maize Yield	2	Kg	790.35	238.12	400	2,000
Input						
Seed	2	Kg	4.02	1.86	1.83	10
Labor	2	Baht	434.92	530.52	0	2,000
Chem-Pesticide	2	Baht	1,042.82	565.13	300	2,500
Fertilizer	2	Baht	2,440.74	1,225.61	1,000	7,000

Source: Field Survey, 2015

Table 4 : Descriptive statistic of farm's characteristic

Description	Variable	Unit	Mean	SD	Min	Max
Group 1						
Farm Experience	Fexp	Years	12.82	6.72	3	30
Farm Size	Fsize	Rai	14.60	9.58	3.5	40
Burn	Burn	Dummy	0	0	0	0
Family Size	Famsize	No.	6.35	2.66	2	11
Group 2						
Farm Experience	Fexp	Years	14.49	6.15	3	25
Farm Size	Fsize	Rai	23.04	13.01	4	60
Burn	Burn	Dummy	1	0	1	1
Family Size	Famsize	No.	6.41	2.79	2	11

Source: Field Survey, 2015 Denote; Rai = 0.16 hectare

Table 5: Frequency Distribution, summary of TE Measures

Efficiency Range	Group1 Non-Burn			Group2 Burn Farm		
	TEcrs	TEvrs	SE	TEcrs	TEvrs	SE
0.200-0.299	1	0	1	1	0	1
0.300-0.399	6	0	1	12	0	4
0.400-0.499	7	0	3	10	0	7
0.500-0.599	8	0	8	5	2	11
0.600-0.699	7	4	10	4	6	5
0.700-0.799	5	9	3	7	6	2
0.800-0.899	9	14	7	4	11	8
0.900-0.999	1	11	11	2	14	6
Equal 1	8	14	8	6	12	7
Mean	0.67653	0.87698	0.76411	0.60017	0.86425	0.68998
SD	0.22259	0.10900	0.20336	0.23263	0.12577	0.22311
Max	1	1	1	1	1	1
Min	0.270	0.666	0.270	0.239	0.555	0.281
Total	52	52	52	51	51	51

Source : Model Result

Table 6 : Spearman Correlation Coefficient

	TE-CRS	TE-VRS
TE-CRS	1.00	
TE-VRS	0.5461***	1.00

***significant at 0.01 level 2-taile Source: Data Analysis

Table 7 : Distribution of input slack.

Input	No of farms	Mean Slack	Mean Input	Excess)%(
Group 1				
Seed	13	0.45	4.19	10.75
Labor	6	44.84	1,019.62	4.40
Pesticides	7	40.69	833.17	4.89
Fertilizer	0	0	2,117.50	0
Group 2				
Seed	11	0.41	4.02	10.45
Labor	1	8.95	434.92	2.06
Pesticides	8	84.90	1,042.82	8.15
Fertilizer	5	53.84	2,440.74	2.20

Source: Data Analysis, 2015

Table 8: Characteristic of farms with respect returns to scale)Scales Efficiency(

Sample Groups	Characteristic of return to scale			
	CRS	IRS	DRS	Total
Group 1	15	35	2	52
Group 2	13	32	6	51
Total	28	67	8	103

Note: CRS = Constant Return to Scale, IRS = Increasing Return to Scale, DRS = Decreasing Return to Scale, Source: Model Results

Table 9: Tobit Regression result in determinants of Technical Efficiency CRS

Variables	Coef.	Std.Err	t	$P > \|t\|$
Constant	0.4489054***	0.1047834	4.28	0.000
Fexp	0.007553*	0.0041257	1.83	0.070
Fsize	0.0006147	0.0023218	0.26	0.792
Burn	-0.101818*	0.0531018	-1.92	0.058
FamSize	0.019247**	0.0095135	2.02	0.046
/sigma	0.2477008	0.0192995		
LR chi2)4(	8.95			
Log likelihood	-18.477235			

***,** and * marked as the level of significance at 1, 5 and 10 percent, respectively.

Table 10: Tobit Regression result in determinants of Technical Efficiency VRS

Variables	Coef.	Std.Err	t	$P > \|t\|$
Constant	0.5229883***	0.1254726	4.17	0.000
Fexp	0.0108724**	0.0020289	2.19	0.031
Fsize	-0.0020289	0.0634097	-0.74	0.464
Burn	-0.085194	0.0113813	-1.34	0.182
FamSize	0.0196233*	0.0113813	1.72	0.088
/sigma	0.2899426	0.0250384		
LR chi2)4(	8.53			
Log likelihood	-40.027237			

***,** and * marked as the level of significance at 1, 5 and 10 percent, respectively.

Table 11: The marginal effect on Technical Efficiency CRS

Variable	$\frac{\partial E(y)}{X_j}$	$\frac{\partial E(y^*)}{\partial X_j}$	$\frac{\partial[\varphi(Z_U)\text{-}\varphi(Z_L)}{\partial X_j}$
Fexp*	0.006904	0.005373	-0.0042422
Fsize	0.000562	0.000437	-0.0003453
FamSize**	0.017594	0.013693	-0.0108105
Burn*	-0.092924	-0.072311	0.0571841

Source: Model Result, 2015

Table 12: Marginal Effect on Technical Efficiency VRS Result

Variable	$\frac{\partial E(y)}{X_j}$	$\frac{\partial E(y^*)}{\partial X_j}$	$\frac{\partial[\varphi(Z_U)\text{-}\varphi(Z_L)}{\partial X_j}$
Fexp*	0.0088436	0.0061175	-0.0092762
Fsize	-0.0016503	-0.0011416	0.001731
FamSize**	0.0159619	0.0110413	-0.0167424
Burn	-0.0692412	-0.0479224	0.0724302

Source: Model Result, 2015