Cost Efficiency of RSPO Oil Palm Farms in Thailand

Anuparp Saengsathien[#1], Morrakot Raweewan[#2]

[#]*School of management technology, Sirindhorn Institute of Technology, Thammasat University Thailand*
[1]saengsathien85456@gmail.com
[2]morrakot@siit.tu.ac.th

***Abstract*— According to Roundtable on Sustainable Palm Oil (RSPO), Thailand is the first oil palm producer in the world to achieve independent smallholders RSPO-certified under the RSPO Group Certification in 2012. The purpose of this study is to measure cost efficiency and to identify factors affecting cost efficiency in RSPO oil palm plantation in Thailand. The RSPO record book from 2014 was analyzed using data envelopment analysis method in value-based cost efficiency model of Tone (2002). The estimated cost efficiency of RSPO oil palm farms was found to be 62.66 percent with a minimum of 32.42 percent and a maximum of 100 percent. The result of this study revealed that the important factors affecting positive relationship on cost efficiency are applied empty fresh fruit bunch and paid for water supply.**

***Keywords*— Cost Efficiency, Data Envelopment Analysis, the Roundtable on Sustainable Palm Oil (RSPO)**

I. INTRODUCTION

Oil palm demand is highly increasing in the global market. Oil palm is used as raw material in thousand products currently on the market. The oil palm plantation area in Thailand has been increasing constantly with an average annual growth rate of 11% from 1981 to 2000 and 9% from 2001 to 2010 [1]. The rapid expansion of palm oil plantation worldwide is due to high demand of oil palm that could lead to deforestation, environmental problem and biodiversity. However, no report is found on the negative effect of oil palm plantation expansion in Thailand [2]. Malaysia and Indonesia are the world's main oil palm producers that are continually expanding their plantation areas. Following the increase in oil palm plantation area, some forests were changed into oil palm farms [3]. The United Nations Environment Program (UNEP) then declared oil as the main driver of deforestation in both countries.

Using credible global standards and engagement of stakeholder, the Roundtable on Sustainable Palm Oil (RSPO) has been formed to promote the growth and use of sustainable oil palm products since 2004. In order to create the norm on sustainable oil palm, RSPO targets transformation of the markets. Community enterprise group for sustainable palm oil production (Chonburi), community enterprise group Suratthani, the sustainable oil palm smallholders production (Univanich Plaipraya) and UPOIC Nuakhlong-Khaopanom are the very first groups of independent smallholders to achieve RSPO Certification [2]. These four groups participated in "Sustainable Palm Oil Production" project which took three and a half years from January 2009 to June 2012 [4]. This project aimed to implement the principles of RSPO certification and requirements to smallholder oil palm farmers in Thailand which was supported by German Academy for International Cooperation (GIZ). However, the analysis of cost efficiency and determinant factors for RSPO oil palm has not been proposed in most of the past studies. The main objective of this study is to measure cost efficiency and factors affecting cost efficiency of RSPO oil palm farmers in Thailand, particularly, to examine the impact of oil palm sustainable plantation on cost efficiency.

In previous studies, various literatures [5, 6] employed traditional cost efficiency model proposed by Färe et al. (1985) to estimate cost efficiency. B.H. Gabdo (2013) [5] applied DEA to measure cost efficiency and allocative efficiency of smallholder livestock-oil palm integration farms in Johor, Malaysia. The DEA method in traditional cost efficiency model by Färe et al. (1985) was employed. The result revealed that in order to improve cost and allocative efficiency, livestock-oil palm integration farmers should carefully purchase production input at cheaper rate and be prudent. Ibitoye et al (2011) [7] examined factors influencing oil palm production in Ondo state using regression analysis. The result obtained from regression analysis revealed that only two variables have significant relationship with the fresh fruit bunch production including level of education attained and number of times the respondents attended training. In South Sumatra Indonesia, Malini and Aryani (2012) [8] analyzed the efficiency level of plantation and compared the income of RSPO certified and without RSPO certified using applied mathematical calculations and statistical methods. The result revealed that smallholder farmers in oil palm plantation with RSPO certified have higher income than without RSPO certified. Both land expansion and capital influence oil palm plantation with RSPO certified while only land expansion has an influence on the plantation without RSPO certified. However, this study, to our knowledge, is the first to employ DEA method in value-based cost efficiency model of Tone (2002) [9] to estimate cost efficiency at farm level in Thai agriculture. The next section considers data collection and specification of the model. Then, result is presented and discussed. The final part presents conclusion of this study.

II. DATA AND METHODS

Data was collected from record books of 66 RSPO oil palm farmer members in Suratthani, Thailand in September 2015. The data of the cost of input-spending and oil palm production in 2014 was gathered. Two set of variables were used in this study; (i) the set of input cost-spending for measuring the level of cost efficiency and (ii) demographic and farm management characteristics, age and location for analyzing the factors affecting cost efficiency. The data were analyzed using IBM ILOG CPLEX Optimization software and MINITAB 17. The data envelopment analysis in value-based cost efficiency model of Tone (2002) was employed to measure cost efficiency of RSPO oil palm farms. Moreover, the factors affecting cost efficiency were also explored using the ordinary least square regression model.

The concept of cost efficiency originated by Farrell (1957) [10] was then further developed using linear programming technique by Färe et al. (1985) [11]. In their study, each oil palm farmer used different kinds of herbicide, fertilizer usages and purchased the inputs with different prices. The cost efficiency DEA model by Färe, Grosskopf, and Lovell (1985), can be limited because this model assumed the same input prices across all decision making units (DMUs) and homogeneous (physical) inputs. In order to keep away from this weak point, the value-based technology in DEA is appropriate to applied then the value-based cost efficiency model of Tone (2002) was employed in this study.

In this study, n observed decision making units (DMUs) are dealt with, each uses m input to produce s output. Let $x_j = (x_{1j},\ldots,x_{mj})^T \in \mathbb{R}^m_{\geq 0}$ and $y_j = (y_{1j},\ldots,y_{sj})^T \in \mathbb{R}^s_{\geq 0}$ be, respectively, the input and output vectors of DMU$_j$, $j \in J=\{1,\ldots,n\}$. Let $cj=(c_{1j},\ldots,c_{mj})^T \in \mathbb{R}^m_{\geq 0}$ be the non-negative price vectors of input of DMU$_j$. The input-spending of each DMU$_j$ is assumed to be $\bar{x}$, where $\bar{x} = c*x$. Here, $*$ is the component-wise multiplication of vectors. The cost efficiency of the evaluated oil palm farm is measured as the ratio of the minimum cost to the actual cost. In the following model of Sahoo et al. (2014) [12], it comprises of cost efficiency model of Färe et al. (1985) and value-based model of Tone (2002):

Cost efficiency model of Färe, Grosskopf, and Lovell (1985):

$$\gamma_0 = Min_{\lambda,x} = \frac{1}{C^0}\sum_{i=1}^{m} c_{io}\ x_i$$

Subject to

$$\sum_{j\in J} \lambda_j x_{ij} \leq x_{i'} \qquad i = 1,\ldots,m,$$
$$\sum_{j\in J} \lambda j\, y_{rj} \geq y_{ro'} \qquad r = 1,\ldots,s,$$
$$\sum_{j\in J} \lambda_j = 1,$$
$$\lambda_j \geq 0, \forall j \in J,$$

Where $C^\circ = \sum_{i=1}^{m} c_{io}\, x_{io}$ is the observed cost of DMU$_o$.

Value-based cost efficiency model of Tone (2002):

$$\gamma_0^{CE} = Min_{\lambda,\bar{x}} \frac{1}{c^0}\sum_{i=1}^{m} \bar{x}_i$$

Subject to

$$\sum_{j\in J} \lambda_j \bar{x}_{ij} \leq \bar{x}_{i'} \qquad i = 1,\ldots,m,$$
$$\sum_{j\in J} \lambda j\, y_{rj} \geq y_{ro'} \qquad r = 1,\ldots,s,$$
$$\sum_{j\in J} \lambda_j = 1,$$
$$\lambda_j \geq 0, \forall j \in J,$$

Where $C^\circ = \sum_{i=1}^{m} c_{io}\, \bar{x}_{io}$ is the observed cost of DMU$_o$.

Let γ_0^{CE} denotes the value-based cost efficiency score having a value $0<\gamma_0^{CE} \leq 1$. If the γ_0^{CE} is equal to one, it means that the farm is on the frontier. The vector λ_j is non-negative vector of weights which indicate the linear combination of the peers of the j-th farm. m is the number of inputs, s is number of outputs, n is number of DMUs (j = 1,…,n), $y1$ represents the fresh fruit bunch production output, $\sum_{i=1}^{m} \bar{x}_i$ is the minimum cost which $\bar{x}_1$ represents fertilizer cost, $\bar{x}_2$ represents harvesting cost, $\bar{x}_3$ represents transportation and fuel cost, $\bar{x}_4$ represents hired labor cost and $\bar{x}_5$ represents other input cost. y_{ro} represents r^{th} output for DMU$_o$ (DMU$_o$ represents decision making units under evaluation). To obtain value-based cost efficiency score (γ_0^{CE}) for each farm in the sample, the linear programming problem need to be solved n times. Here, IBM ILOG CPLEX Optimization software was used to execute data envelopment analysis. Most of past literature studies employed the Tobit regression model (TRM) to explore factors affecting efficiency in agriculture field [13, 14, 15]. However, McDonald (2009) [16] argued that DEA efficiency scores is fractional data and not generated by a censoring process. Then, TRM is not appropriate in this situation. According to Banker and Natarajan (2008) [17], using ordinary regression analysis in second stage DEA to explore factors affecting efficiency level will obtain better results than using TRM. The ordinary regression analysis model for this study can be specified as follow:

$$CE_i = \beta_o + \sum_{i=1}^{n} \beta_i z_i + \varepsilon$$

where CE_i denote value-based cost efficiency scores, β_0 is the intercept, β_i are unknown parameters to be estimated and z_i are explanatory variables defined in Table 1, while ε is the error term.

TABLE I DESCRIPTION OF EXPLANATORY VARIABLES

Variables	Description	Unit
Demographic and farm management characteristics variables		
Gender	Dummy (1 = Male, and 0 = Otherwise)	Dummy
Age	Represents age of oil palm farmer	Year
Farm Size	The oil palm plantation area	Hectares

Non-herbicide applied	Dummy (1 = Yes, and 0 = Otherwise)	Dummy
Age variables		
Age of oil palm 3 to 8 years	Dummy (1 = Yes, and 0 = Otherwise)	Dummy
Age of oil palm 9 to 19 years	Dummy (1 = Yes, and 0 = Otherwise)	Dummy
Location variables		
Paid for water-supply	Dummy (1 = Yes, and 0 = Otherwise)	Dummy
Unpaid for water-supply	Dummy (1 = Yes, and 0 = Otherwise)	Dummy
Watercourse	Dummy (1 = Yes, and 0 = Otherwise)	Dummy

III. RESULTS AND DISCUSSIONS

Table 2 and 3 shows the descriptive statistics of variables related to RSPO oil palm farms. The average yield of oil palm plantation is 21.11 ton per hectare. It is higher than an average oil palm yield of 19.54 ton per hectare in southern region as reported by agricultural statistics of Thailand book (2014) from Office of Agricultural Economics Thailand.

On average, the RSPO oil palm farmers spend 8,724 baht per hectare on fertilizer, 8,185 baht per hectare on harvesting, 3,919 baht per hectare on transportation and fuel, 3,432 baht per hectare on hired labor for fertilizer application, grass cutting, frond pruning, herbicide application and 865 baht per hectare on other input costs including herbicide cost, fuel cost for grass cutting or others.

TABLE II DESCRIPTIVE STATISTICS OF OUTPUT AND INPUT VARIABLES

Variables	Mean	Min	Max	S.D.
Output variable				
Fresh Fruit Bunch Production (Ton/ha)	21.11	6.38	52.77	9.25
Production cost input variables				
Fertilizer Cost (Baht/ha)	8,724.33	0	31,241.49	5,137.68
Harvesting Cost (Baht/ha)	8,185.15	2,387.32	21,127.59	3,700.79
Transportation & Fuel Cost (Baht/ha)	3,919.02	512.04	11,680.99	2,268.99
Hired Labor Cost (Baht/ha)	3,432.22	0	9,795.45	2,339.74
Other Input Cost (Baht/ha)	865.48	0	10,023.76	1,948.98

TABLE III DESCRIPTIVE STATISTICS OF EXPLANATORY VARIABLES

Variables	Unit	Mean	Min	Max	S.D.
Gender	Dummy	0.68	0	1	-
Age	Year	48.51	28	80	10.98
Farm Size	Hectares	3.6	0.16	20.41	3.04
Non-herbicide applied	Dummy	0.69	0	1	-
Applied empty fresh fruit bunch	Dummy	0.08	0	1	-
Age of oil palm 3 to 8 years	Dummy	0.28	0	1	-
Age of oil palm 9 to 19 years	Dummy	0.64	0	1	-
Paid for water-supply	Dummy	0.05	0	1	-
Unpaid for water-supply	Dummy	0.08	0	1	-
Watercourse	Dummy	0.36	0	1	-

The frequency distribution of cost efficiency of RSPO oil palm farms is illustrated in Table 4. The result of this study revealed an average cost efficiency of RSPO oil palm farms at 62.66 percent, with a minimum of 32.42 percent and a maximum of 100 percent. This means that cost will be 37 percent on average higher than required if all oil palm farms were operating on the cost efficiency frontier. Only three oil palm farms have cost efficiency score equal to 1. While, 20 oil palm farms amounting to 26 percent possess the lowest cost efficiency score of less than 50 percent. This revealed that RSPO oil palm farms in Thailand achieve low cost efficiency production.

TABLE IV FREQUENCY DISTRIBUTION OF COST EFFICIENCY FOR RSPO OIL PALM FARMS

Cost Efficiency Level	Number of oil palm farms	Percentage (%)
0.01-0.10	0	0%
0.11-0.20	0	0%
0.21-0.30	0	0%
0.31-0.40	7	9%
0.41-0.50	13	17%
0.51-0.60	19	24%

0.61-0.70	17	22%
0.71-0.80	7	9%
0.81-0.90	8	10%
0.91-1.00	7	9%
Total	78	100%
Mean CE (%)		62.66%
Minimum CE (%)		32.42%
Maximum CE (%)		100%

The factors affecting RSPO oil palm cost efficiency were analyzed by using ordinary least square regression. After obtaining cost efficiency values from the value-based cost efficiency of Tone (2002) model, the cost efficiency score were selected as the dependent variables and were regressed against explanatory variables as independent variables including gender of oil palm farmer, age, farm size, non-herbicide applied dummy, applied empty fresh fruit bunch dummy, age of oil palm from 3 to 8 years dummy, age of oil palm from 9 to 19 years dummy, paid for water-supply dummy, unpaid for water-supply dummy, watercourse dummy. Table 5 presents the results of ordinary least square regression analysis for the cost efficiency. The explanatory variables can be classified into three categories: demographic and farm management characteristics variables, age variables, and location variable.

Following the empirical result from regression analysis, two important factors affecting an increase in cost efficiency of RSPO oil palm farm are applied empty fresh fruit bunch and paid for water-supply. These variables show positive coefficient and are statistically related to efficiency indexes at 5 percent level of significance. This means that oil palm farmers who used empty fresh fruit bunch in oil palm plantation and paid for water-supply in dry season have higher cost efficiency than those without. Following a variation in age of palm in sample data of RSPO oil palm farm, the age variables were used to emphasize the age of oil palm tree effect towards cost efficiency. The result revealed that age of oil palm in period of 3 to 8 years has negative coefficient and age of oil palm in period of 9 to 19 years has positive coefficient which corresponds with the nature of oil palm tree. The rapid-increase, yield-peak and decline periods of oil palm were reported in between 3-8 years, 9-19 years and over 20 years [18], respectively. In this study, oil palm with the age of over 20 years in explanatory variable was excluded because of collinearity.

Location variables were introduced to investigate the effect of location of water-supply towards cost efficiency. The result showed that the paid for water-supply has positive coefficient as oil palm trees obtain water-supply in dry season.

TABLE V RESULT OF ORDINARY LEAST SQUARE REGRESSION ANALYSIS

Variables	**Coefficient**	**Standard error**	**t-value**	**p-value**
Constant	0.754	0.13	5.8	0
Gender	-0.0392	0.0461	-0.85	0.397
Age	-0.00177	0.00193	-0.91	0.364
Farm Size	-0.00737	0.0068	-1.08	0.282
Non-herbicide applied	-0.0335	0.0508	-0.66	0.513
Applied empty fresh fruit bunch	0.2049	0.0865	2.37	0.021**
Age of oil palm 3 to 8 years	-0.0164	0.0813	-0.2	0.841
Age of oil palm 9 to 19 years	0.0368	0.0765	0.48	0.632
Paid for water-supply	0.2416	0.0934	2.59	0.012**
Unpaid for water-supply	-0.0301	0.083	-0.36	0.718
Watercourse	-0.0269	0.047	-0.57	0.569

***, **, * denote significance at 1%, 5% and 10%

IV. CONCLUSIONS

The purpose of this study was to measure cost efficiency and to find out factors affecting cost efficiency of RSPO oil palm, especially focusing on the impact of sustainable oil palm plantation. Data were collected from 116 oil palm farms from 66 smallholder farmers of RSPO oil palm farms; data from 78 oil palm farms were analyzed. This study adopted data envelopment analysis method in value-based cost efficiency model of Tone (2002) to measure cost efficiency and used ordinary least square regression to find factors affecting cost efficiency. The efficiency analysis estimated cost efficiency level to be 62.66%.

Demographic and farm management characteristics variables, age variables and location variable were used to investigate efficiency determinants. The regression model showed that applied empty fresh fruit bunch, age of oil palm 9 to 19 years and paid for water supply positively influenced cost efficiency, while gender, age, farm size, non-herbicide applied, age of oil palm 3 to 8 years, unpaid for water-supply, watercourse presented negative relationship with cost efficiency. Most of the explanatory variables in efficiency model revealed the results with expected sign of coefficient.

In conclusion, the results implied that the sustainable oil palm plantation helps enhancing cost efficiency level in Thai oil palm industry. However, this study can be improved in a number of areas. These include employing fractional regression model in the second stage of DEA to explore factors affecting efficiency as well as executing DEA and stochastic frontier analyses then comparing the results.

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REFERENCES

[1] D. Jonas, "Oil palm development in Thailand: economic, social and environmental considerations," in *Oil Palm Expansion in South East Asia: trends and implications for local communities and indigenous peoples*, Forest Peoples Programme, 2011, p. 249.

[2] W. Ubolrat and Y. Nantakrit, "Current Situation of RSPO Standard to Smallholder Farmers in Thailand," *European Journal of Scientific Research*, vol. 113, no. 3, pp. 466–479, 2013.

[3] B. F. Emily, J. S. Matthew, M. Alexandra, D. Finn, A. B. Carsten, F. D. Paul, and P. Ben, "How will oil palm expansion affect biodiversity?," *Trends in Ecology & Evolution*, vol. 23, no. 10, pp. 538–545, 2008

[4] T. Sutonya and K. Sirirat, "Final Report : Impact Study of the Project on Sustainable Palm Oil Production for Bio-energy in Thailand," GIZ Thailand: Project of Sustainable Palm Oil Production for Bio-Energy, Prince of Songkla University and Office of Agricultural Economics, 2012.

[5] B. H. Gabdo, "Estimation of cost and allocative efficiencies under smallholder livestock-oil palm integration farms in Johor, Malaysia.," *Agricultural Journal*, vol. 8, no. 6, pp. 304–307, 2013

[6] E. Gundogmus and Z. Bayramoglu, "Cost efficiency on organic farming: a comparison between organic and conventional raisin-producing households in Turkey," *Spanish Journal of Agricultural Research*, vol. 6, no. 1, 2008.

[7] O. Ibitoye, A. Akinsorotan, N. Meludu, and B. Ibitoye, "Factors Affecting Oil Palm Production in Ondo State of Nigeria," *Journal of Agriculture and Social Research (JASR)*, vol. 11, no. 1,pp. 97–105, 2011.

[8] M. Henny and A. Desi, "Efficiency Analysis of Palm Plantation Plasma Farmers Certified Repo and without Repo on Sustainable Palm Plantation Management in Musi Banyuasin Regency South Sumatera Indonesia," in *IPCBEE*, Kuala Lumpur, Malaysia, 2012, vol. 33, pp. 194–199.

[9] K. Tone, "A Strange Case of the Cost and Allocative Efficiencies in DEA," *The Journal of the Operational Research Society*, vol. 53, no. 11, pp. 1225–1231, 2002.

[10] M. J. Farrell, "The Measurement of Productive Efficiency," *Journal of the Royal Statistical Society. Series A (General)*, vol. 120, no. 3, pp. 253–290, 1957.

[11] R. Färe, S. Grosskopf, and C. A. K. Lovell, *The Measurement of Efficiency of Production*. Boston: Kluwer-Nijhoff Pub, 1985.

[12] B. K. Sahoo, M. Mehdiloozad, and K. Tone, "Cost, revenue and profit efficiency measurement in DEA: A