Measurement of Technical Efficiency of Durian Production in Thailand: An Application of Data Envelopment Analysis Approach

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ABSTRACT

The purpose of this paper is to investigate and measure the technical efficiency of durian production in each province of Thailand using the data envelopment analysis (DEA) during the period 2012-2016. The findings indicate that the technical efficiency of Thai durian production revealed favorable results from 2012 to 2016 but still needs to be improved since the technical efficiency score is not close to 1.000. On the other hand, Chanthaburi province had the highest mean efficiency score and was recognized as the best province for Thai durian production. Moreover, the study found that Phuket province had lowest mean technical efficiency score of Thai durian production, which therefore should be increased the quantity of the outputs and inputs. Therefore, the results of this study can provide important information to farmers, agricultural planners and government agencies to help increase the technical efficiency levels of durian production in Thailand.

Keywords: Data envelopment analysis; Durian production; Technical efficiency; Thailand

Introduction

Durian is well known in Southeast Asia as being "King of Fruits". According to the Office of Agricultural Economics (OAE), Thailand is the largest durian producer in the world and durian production in 2016 was 656,777 tons. Moreover, Thailand is the leading exporter of durian in the world, and the major export markets are Taiwan, Hong Kong, Malaysia, China and United States. According to National Statistical Office of Thailand, the planted area is more than 0.1 million hectares and the total harvested area has increased continuously. Major production areas of durian are eastern region and southern region of Thailand. Durian production involved 0.3 million families of farmers, which accounts for more than 1 million people across the country and includes entrepreneurs, laborers, and government officials (OAE, 2016). In addition, durian production plays an important role in Thailand's economy and society. In the past, numerous studies have examined the economic efficiency and aggregate levels of Thai agriculture (Krasachat, 2004). However, a very few studies have focused on the technical efficiency (TE) of Thai durian production in each province. Durian production in each area of Thailand is different and unstable ground, resulting in different production efficiency. Therefore, this study aims to investigate and measure the TE of durian production in each province of Thailand from 2012 to 2016 by using data envelopment analysis (DEA) model.

DEA is a non-parametric method to measure the TE and productivity of decision-making units (DMUs) according to multiple inputs and outputs (Hadad, Friedman, Sinuany-Stern, & Ben-Yair, 2008; Sexton, 1986). Previous studies have reported that the basic factors of production, such as, land, labor and capital have been considered as assessment parameters of sustainable development (Longpichai, Perret, & Shivakoti, 2012; Parichatnon, Maichum, & Peng, 2017; Van Passel, Van Huylenbroeck, Lauwers, & Mathijs, 2009). Wijnhoud, Konboon, and Lefroy (2003) found that the inputs and outputs variables are important socio-economic factors and impact on the long-term sustainability. Thus, the measurement of efficiency score depends on inputs and outputs variables, which is consistent with numerous studies. In addition, previous research has suggested that performance measures are derived from the difference in the labor force, fertilizers, pesticides and machinery to produce durian fruits in different areas (Parichatnon et al., 2017; Rahman & Rahman, 2009; Sherlund, Barrett, & Adesina, 2002). Krasachat (2012) measured the efficiency of organic durian farms in Thailand and had one output (quantity of durian) and three inputs (land, human labor and total costs). Son, Coelli, and Fleming (1993) applied DEA model for analysis of the agricultural performance in Vietnam. Mohammadi et al. (2015) used DEA to measure the TE of agricultural farm and had one output variable (quantity of farm produce) and had eight input variables (fertilizer, chemicals, seed, labor, machinery, diesel, electricity and water). Furthermore, Krasachat (2014) studied the effects of socio-economic factors of farms and farm management factors by using DEA approach and Tobit regression model. The results found that durian

quantity, land, labor force and other inputs have a major influence on efficiency performance of durian farm.

Research Methodology

DEA model

DEA is the most widely used technique in agricultural economics (Meeusen & Van den Broeck, 1977). DEA was developed by Charnes, Cooper, and Rhodes (1978) and was based on constant returns to scale (CRS) and was subsequently expanded by Banker, Charnes, and Cooper (1984) to accommodate technologies that exhibit variable returns to scale (VRS). According to Coelli, Prasada Rao, O'Donnell, and Battese (2005), the advantage of using this technique is that it can evaluate the performance of individual DMUs. In this study, we used CCR (Charnes Cooper and Rhodes) model developed by Charnes et al. (1978), which, based on CRS model. Moreover, we also used the DMU to refer to any entity that has been evaluated for its ability to convert inputs into results. This study selected n (n = DMUs = 22 provinces) to evaluate the TE of Thai durian production. Thus, to evaluate each DMU we propose to use the equation as follows (Charnes et al., 1978):

$$TE_q = \frac{\sum_{r=1}^{t} u_r y_{rq}}{\sum_{i=1}^{m} v_i x_{iq}} \qquad (1)$$

Here, TE_q is technical efficiency of firm q using m inputs to produce t outputs; y_{rq} is the quantity of output r produced by firm q; x_{iq} is the quantity of input i consumed by firm q; u_r is the weight of output r; v_i is the weight of input i. All data are run through the linear program with the input and output matric. The TE scores are ranked from 0 to 1.000.

Data and Variables

We analyzed durian production in Thailand from 2012 to 2016. Therefore, the study used the secondary data collected from surveys by various Thai governmental agencies: Office of Agricultural Economics, Department of Internal Trade and Ministry of Labor. The research area covered 22 provinces across four regions in Thailand, namely Chanthaburi, Chumphon, Krabi, Nakhonnayok, Nakhonphanom, Nakornsrithammarat, Narathiwat, Nonthaburi, Pattani, Phangnga, Phatthalung, Phuket, Prachinburi, Ranong, Rayong, Satun, Songkhla, Suratthani, Trang, Trat, Uttaradit and Yala. This study analyzed a total of six inputs, namely planted area (X1), harvested area (X2), human labor (X3), machinery (X4), fertilizer (X5) and pesticide (X6), and one output, namely quantity of durian (Y). Data descriptions can be seen in Table 1. Data analyses were conducted using data envelopment analysis program (DEAP 2.1) and statistical package for social sciences (SPSS 23.0). Descriptive statistics of the variable items are presented in Table 2. The results showed that on average, planted area was 107,762.08 ha, while the harvested area was 94,854.40 ha, human labor had a very high number at 1,428.93 hr/ha, machinery was 32.55 hr/ha, fertilizer was high at 18,357.73 tons and also pesticide was 2,130.42 tons in durian production sector. Furthermore, the average of durian quantity was 552,912.30 tons.

Table 1. Data descriptions of variables items and resource

Variables	Unit	Definition	Source
Inputs			
Planted area	hectare (ha)	Agricultural land that is used for durian growing.	Mohammadi et al. (2015)and Krasachat (2014)
Harvested area	hectare (ha)	Total area for durian production.	Tung (2014) and Krasachat (2012)
Human labor	hour per ha (hr/ha)	The workers who are 15-60 years old and engaged in durian production.	Krasachat (2014) and Rahman, Wiboonpongse, Sriboonchitta, and Chaovanapoonphol (2009)
Machinery	hour per hectare (hr/ha)	The total power of farm machinery.	Nassiri and Singh (2009) and Rahman and Rahman (2009)
Fertilizer	tons	Total number of the chemical fertilizers used in durian-farming production.	Mailena, Shamsudin, Radam, and Latief (2014), Nassiri and Singh (2009) and Dhungana, Nuthall, and Nartea (2004
Pesticide	tons	Total number of substances that are intently used for destroying, mitigating and preventing any pest. Pesticides included insecticides, herbicides, fungicide and bactericides.	Mailena et al. (2014) and Tung (2014)
Output			
Quantity of durian	tons	Total durian quantity of all the production.	Krasachat (2014), Krasachat (2012)

Table 2. Descriptive statistics of the variable items

Variables	Unit	Average	Standard deviation	Maximum	Minimum
Inputs					
Planted area	hectare (ha)	107,762.08	98,802.40	208,389.30	5,290.38
Harvested area	hectare (ha)	94,854.40	91,470.65	130,842.59	3,365.90
Human labor	hour per ha (hr/ha)	1,428.93	1,093.32	3,491.60	340.52

Machinery	hour per hectare (hr/ha)	32.55	13.09	54.85	12.31
Fertilizer	tons	18,357.73	14,658.03	43,930.35	2,540.12
Pesticide	tons	2,130.42	1,185.22	4,320.15	643.00
Output					
Quantity of durian	tons	752,912.30	602,450.12	653,921.31	58.39

Results and Discussion

The efficiency measure was assessed through DEAP 2.1 software to analyze TE level of Thai durian production in 22 provinces. Consequently, Table 3 shows that the efficiency scores of Thai durian production. The results found that the average TE score of durian production from 2012 to 2016 was 0.652, standard deviation was 0.177, average maximum of TE score was 0.978 and average minimum of TE score was 0.362, respectively. It can be seen that average TE scores are relatively moderate, thus, it is necessary to improve the operational efficiency of durian production in Thailand.

Regarding TE in each year, we found that the average TE score in 2012 was 0.637; it also found that the Chanthaburi province had the highest efficiency (0.957) and Nakhonnayok province had the lowest efficiency (0.339). In 2013, the results shows that the average TE score was 0.642, and Chanthaburi province had a high efficiency score (0.970) and Phuket province had a low efficiency score (0.362). Durian production in 2014 had an average TE score of 0.648; Chanthaburi province revealed the highest average score at 1.000 and Phuket province performed the lowest average score of 0.340. The average TE score of Thai durian production in 2015 was 0.664; Rayong province had very high scores at 1.000 and Nonthaburi province had the lowest score at 0.378. Moreover, the average efficiency score of all data in 2016 was 0.669; Chanthaburi province had a good efficient performance (0.962) and Nonthaburi province had the worst efficiency TE score (0.391). Therefore, it is summary that Thai durian production in 2016 had a better average TE score than the other years.

Furthermore, Figure 1 shows that the TE score of durian production in each DMU. Chanthaburi province had the most efficient durian production from year 2012 to 2016, followed by Rayong province, Trat province, Chumphon province, Suratthani province, Uttaradit province, Nakornsrithammarat province, Phatthalung province, Yala province, Phangnga province, Satun province, Pattani province, Narathiwat province, Ranong province, Krabi province, Trang province, Songkhla province, Prachinburi province, Nakhonphanom province, Nonthaburi province, Nakhonnayok province and Phuket province. The findings from this study suggests that it could be improved the production to increase the efficiency performance of durian production in Thailand.

Table 3. Efficiency scores of the durian production

DMUs	2012	2013	2014	2015	2016	Average
Chanthaburi	0.957	0.970	1.000	0.933	0.962	0.964
Chumphon	0.903	0.883	0.863	0.845	0.891	0.877
Krabi	0.604	0.572	0.564	0.588	0.597	0.585
Nakhonnayok	0.339	0.376	0.397	0.411	0.418	0.388
Nakhonphanom	0.442	0.419	0.398	0.424	0.437	0.424
Nakornsrithammarat	0.708	0.729	0.723	0.737	0.742	0.728

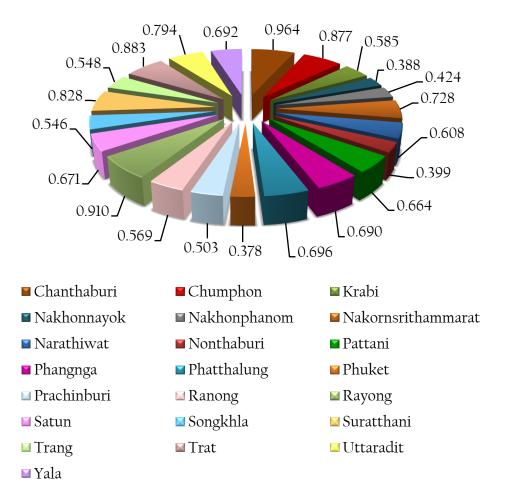|						
Narathiwat	0.611	0.589	0.604	0.612	0.623	0.608
Nonthaburi	0.421	0.398	0.407	0.378	0.391	0.399
Pattani	0.629	0.637	0.652	0.694	0.706	0.664
Phangnga	0.647	0.690	0.713	0.708	0.693	0.690
Phatthalung	0.726	0.698	0.667	0.684	0.704	0.696
Phuket	0.378	0.362	0.340	0.392	0.416	0.378
Prachinburi	0.479	0.480	0.511	0.527	0.516	0.503
Ranong	0.539	0.567	0.575	0.589	0.574	0.569
Rayong	0.867	0.890	0.902	1.000	0.889	0.910
Satun	0.638	0.643	0.678	0.690	0.707	0.671
Songkhla	0.503	0.529	0.548	0.587	0.564	0.546
Suratthani	0.811	0.799	0.771	0.874	0.886	0.828
Trang	0.512	0.529	0.567	0.550	0.581	0.548
Trat	0.832	0.868	0.890	0.901	0.922	0.883
Uttaradit	0.754	0.789	0.805	0.810	0.814	0.794
Yala	0.710	0.704	0.673	0.683	0.690	0.692
Average	0.637	0.642	0.648	0.664	0.669	0.652
Standard deviation	0.174	0.178	0.179	0.180	0.175	0.177
Maximum	0.957	0.970	1.000	1.000	0.962	0.978
Minimum	0.339	0.362	0.340	0.378	0.391	0.362

Figure 1. The technical efficiency score of Thai durian production in each province

Conclusions

This study has measured the TE of durian production from 2012 to 2016 and research areas consisted of 22 provinces in Thailand. For this reason, the DEA model was the main research method for this study. The TE score of Thai durian production revealed favorable results; however, the production still needs to be improved since the TE score is not close to 1.000. In addition, the empirical results indicated that Chanthaburi province had the most effective in Thai durian production from year 2012 to 2016 as compared with other durian producing provinces. This suggests that the Chanthaburi province is best suited for durian production in Thailand. On the other hand, Phuket province had the worst efficiency score for durian production when compared to other provinces in Thailand. The cause could due to overuse of input factors, resulting in low quantity of durian production. Therefore, it caused inefficiency as well as poor production rates. Moreover, this study can provide important information to farmers, planners and government agencies to define strategies that are useful and helpful to increase the efficiency in each province for Thai durian production.

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