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TECHNICAL EFFICIENCY CHANGE OF RICE FARMERS IN THE CROPPING SEASONS OF CHIANG MAI PROVINCE, THAILAND

Pratama Anugrah Rizki
Department of Tropical Agriculture and International Cooperation, National Pingtung University Science and Technology, Taiwan & Department of Agribusiness, Faculty of Agriculture, University of Islam Malang, Indonesia

Anupong Wongchai
Department of Agricultural Economics and Development, Faculty of Agriculture, Chiang Mai University, Thailand

Peng Ke Chung*
Department of Agribusiness Management, National Pingtung University Science and Technology, Taiwan

*E-mail: kchung@mail.npust.edu.tw

ABSTRACT
Rice has become an important economic crop due to the biggest main staple food in South-East Asian countries. However, rice farmers usually faced several complications including low production efficiency because of the high transactional cost of accessing inputs. Therefore, the purpose of this study was to measure technical efficiency changes and then decompose these changes into several levels of efficiency. The data was collected from November 2021 until June 2022 from three cropping seasons containing 200 observations from 4 districts in Chiang Mai Province, Thailand. Stochastic production frontiers with the Cobb-Douglas functional model were used to analyze technical efficiency (TE) levels. The results indicated that the average TE for rice farmers of 76.30% and the average TE change of - 0.007% in all cropping seasons. Moreover, the findings also revealed that fertilizer and material costs had negatively and significantly impacted farmers' efficiency. By contrast, years of education, labor, and water costs had positively and significantly affected farmers' efficiency. This study suggested that additional investments in research and improved technologies could be further promoted to increase rice productivity and the level of farmers' efficiency.

KEY WORDS
Cropping season, rice productivity, stochastic production frontier, technical efficiency change.

Rice cultivating in in Asia and Africa is ruled through smallholder farming households, which cultivated 94% of the countrywide cropped area in 2013–2014 (CSA, 2014). A huge majority of rice farmers living in rural areas are deriving their livelihoods from agriculture. increase in rice farming became one of the essential drivers of the country wide financial increase recorded in South-East Asia countries in a decade (Tefera *et al.*, 2013). Total of rice production account for roughly 60% of rural employment and 80% of overall cultivated area (Alemu *et al.*, 2018). In the crop production sector, rice is the dominant food grain and the main staple food.

In Thailand, the potential to growth rice productivity is very excessive because it has been proven and found out by current extension activities in different areas. Moreover, population growth, low productiveness because of loss of knowledge transfer, and reducing availability of arable land are the main contributors to the modern food scarcity (Jierwiriyapant *et al*., 2012). In Chiang Mai Province, generally rice productivity are very low and the increase in agricultural output has slightly saved pace with the population increase. Furthermore, the inefficient of agricultural systems and variations within the efficiency of

production specially in rice cropping discourage farmers to provide more (Beshir, 2014). Earn profits in rice production through improvement of farmers' performance are getting essential in recent times.

The opportunities to increase rice production by bringing additional production inputs or by increasing the utilization of physical resources have been diminishing. In addition, removing of farmers' inefficiency can be greater more effective than introducing new technology as a method of growing agricultural output and farmers' profit (Cañete *et al.*, 2013). The rice farmers in the Chiang Mai Province have low profit, land ownership ranges between 0.5 and 1.5 hectares, output productivity is low, limited access to government facilities and infrastructures, and food necessities are not completely met (Parichatnon *et al*., 2015).

Most of rice farmers in Chiang Mai Province primarily based farming activities have additionally remained conventional and non-business oriented. As the consequence, that kind of agricultural system is not able to maintain the population growth with the stapple food demand (Pornpratansombat *et al*., 2011). The analysis of efficiency in rice production is an essential problem for agricultural sustainability and development; it offers beneficial information for creating applicable choices within the use of these scarce resources and for reformulating agricultural regulations (Ogada *et al*., 2014). Furthermore, considering social development is dynamic, it is important to update the information based on the current situations about farmers and other agricultural issues.

Therefore, the objectives of this study were to measure the technical efficiency of rice production in Chiang Mai Province, provide perspectives on the optimum management of production input combinations under current cultivation practices, and evaluate the factors that affect farmers' technical efficiency. Furthermore, the findings of this study are considered to be beneficial to organic rice farmers as well as to the development of rice production in Chiang Mai Province, Thailand.

MATERIALS AND METHODS OF RESEARCH

The survey in this study was conducted from November 2021 until June 2022 and the respondents of this study were rice farmers who had a member of the farmer association. We decided to apply multistage random sampling to collect the rice farmer data, first step of this study purposively determined Chiang Mai Province as the research location due to one of the centers of rice production in Thailand. In the second step, four districts were selected by considering the number of rice production such as Chiang Dao, Mae-On, San Kamphaeng, and Samoeng. Third, we created the rice farmer list and randomly selected 200 rice farmers with 50 farmers from each district. Then, we created a structured questionnaire by considering detailed information from the government, related agricultural institutions, and the previous study to conduct the research.

The technical efficiency of rice production on farmers was analyzed by using the Stochastic Frontier Analysis (SFA) to evaluate the efficiency level of organic rice farmers or with a single output and multiple inputs by using the Cobb-Douglas model approach (Karimov, 2013). The concept of the Cobb-Douglas model is a long-term model that describes the relationship between the rate of growth in output and the rate of increase in production inputs, all the input variables are changeable and constrained to change in the long run as a result of a certain growth in scale (Mussa *et al*., 2012). The model for measuring the technical efficiency based on Coelli (2002) is as follows:

$$lnY_{it} = \beta_0 + \beta_1 lnLa + \beta_2 lnSDc + \beta_3 lnFLc + \beta_4 lnHLc + \beta_5 lnPTc + \beta_6 lnFTc + \beta_7 lnFUc + \beta_8 lnCLc + V_{it} - U_{it} \quad (1)$$

Where: Y_{it} is the total rice production; *β* are estimated parameters of the production function, their subscripts are according to the variables; *La* is the land area (Ha); *SDc* is the seedling cost; *FLc* is family labor cost; *HLc* is hired labor cost; *PTc* is the pesticide cost; *FTc* is the fertilizer cost; *FUc* is the fuel cost, and *CLc* is the crop loss cost is measured in baht. V_{it} - U_{it} is the error term.

This study used the Technical Efficiency Change (TEC) model specification to measure the farmers' efficiency change between three periods of the rice cropping season. The TEC specification model form can be expressed as (Kumbhakar and Lovel, 2000):

$$TEC = \ln \qquad (2)$$

Where: all the components must be the natural logarithm and the TE between two periods of time, denoted by TE_t is the average efficiency score in the cropping season *t* and TE_{t-1} is the average efficiency score in the previous cropping season of *t.*

RESULTS AND DISCUSSION

The summary statistics of the socio-economics variables for rice farmers are shown in Table 1. The overall situation of the rice farmers' production system was obtained through deep interviews with 200 sample organic rice farmers in Taiwan and the findings of this study are as follows.

Table 1 – Descriptive statistic of organic rice farmers in Taiwan

Variables	Mean	Std Deviation
Age (year)	48.51	13.13
Farming experience (year)	28.50	17.29
Education (year)	11.32	6.51
Land area (ha)	1.93	2.80
Productivity (kg/ha)	6148.44	6074.38
Seedling cost (baht)	9462.08	2628.80
Fertilizer cost (baht)	20143.95	10769.97
Pesticide cost (baht)	1512.95	2132.51
Fuel cost (baht)	46296.63	8576.57
Family labor cost (baht)	18696.83	10463.66
Hired labor cost (baht)	64993.42	13007.17
Crop loss cost (baht)	987.53	2471.61

The average age of rice farmers was 48.51 years old, and most of them were of productive age since farmers aged between 25 and 50 years old have more ability and experience to work in the agriculture sector (Obasi, 2013). Furthermore, the farmers averaged 28.50 years experienced in rice farming activity, and according to Fakkhong (2015), farmers who have farming experience of more than 10 years have more capability to improve farming efficiency. Moreover, the average farmers' education was 11.32 years indicating this level of education has become the main factor to adopt and improve the efficiency of technology transfer in agriculture (Rasyid *et al.*, 2016). The average land area of 1.93 ha agreed with Ibrahim (2012) who reported that farmers who owned larger land areas have an opportunity to be more technically efficient than smaller land areas because they have more capacity to expand their farmland area and maximize output production. The distribution of output and inputs variables for rice production was 6148.44 kg/ha, this volume of rice productivity is higher in the whole country. According to OEA (2020), the national rice productivity was 5763.21 kg/ha. Furthermore, the average amount of seedling cost was 9465.08 baht, followed by fertilizer cost of 20143.95 baht, pesticide cost of 1512.95 baht, the fuel cost of 46296.63, crop loss cost of 987.53 baht, family labor and hired labor costs were 18696.83 baht and 64993.42 baht.

This section discussed the result of the Maximum Likelihood Estimation (MLE) that summarized factors affecting farmers' technical efficiency (Table 2). The results indicated that education was positively significant in farmers' technical efficiency, followed by family labor and farming experience. In contrast, fertilizer and fuel costs were negatively significant to farmers' technical efficiency.

The results in Table 2 shows that education had a positive significant effect on the farmers' efficiency, which indicated that a higher level of education improved the farmers' efficiency because rice farmer could employ the technology innovation and knowledge

transfer enabled an increase in output production (Njikam *et al.,* 2017). Family labor cost positively and significantly affected farmers' efficiency, which agreed with Kerdsriserm *et al.,* (2020), the higher family member as labor in agricultural activity could minimize the production cost than hired labor. Furthermore, farming experience had a significant effect on farmers' efficiency, this finding agreed with Ma *et al.,* (2018), the farmers who had higher experience in farming activity than those who had lower experience could apply more skills and strategies and earned higher output production and better incomes. In contrast, fertilizer cost had a negatively significant effect on the farmers' efficiency, the same finding was reported by Moreira *et al.,* (2016) in that farmers necessarily reduce the cost of chemical fertilizer and use more organic fertilizer to increase their output. Furthermore, the fuel cost had a negatively significant effect on farmers' efficiency and implies that the farmers could increase the rice farming efficiency by reducing the cost of fuel that use in agriculture tools and machines instead of spending the cost on the essential inputs (Missiame *et al.,* 2021).

Table 2 – Factors that affect the technical efficiency

Variables	Parameter	Std Error
Constant	3.497***	0.081
Farming experience	1.298**	0.005
Education	1.634*	0.014
Land area	-0.140	0.013
Seedling cost	0.344	0.087
Fertilizer cost	-2.260***	0.020
Pesticide cost	-1.607	0.007
Crop loss	-0.596	0.121
Family labor cost	4.452***	0.029
Hired labor cost	-0.263	0.089
Fuel cost	-4.544***	0.013
Sigma-squared	7.856***	0.022
Log-likelihood	0.784405	

*Note: ***, **, * means significance at 1%, 5%, and 10% respectively.*

The technical efficiency (TE) data with the Stochastic Frontier Analysis (SFA) with the Cobb-Douglas production model shows in Table 3 and it was found the technical efficiency scores were divided into four categories such as first cropping season, second cropping season, third cropping season, and pooled data (all cropping season). This study found that the average technical efficiency from the first cropping season until the third cropping season was 0.818, 0.778, and 0.793, respectively. The technical efficiency average of pooled data was 0.788. The maximum and minimum technical efficiency scores of pooled data were 0.993 and 0.260, respectively.

Table 3 – Technical efficiency (TE) scores of rice production

Cropping season	First	Second	Third	All seasons
Group of TE	Number of farmers in percentage (%)			
Poor (0.01 – 0.20)	0	0	0	0
Low (0.21 – 0.40)	0.99	2.85	5.7	2.90
Moderate (0.41 – 0.60)	10.89	10.00	15.71	12.03
High (0.061 – 0.80)	28.71	41.42	40.00	35.68
Very high (0.81 – 1.00)	59.40	45.71	38.57	49.37
Technical efficiency score				
Average	0.788	0.758	0.760	0.763
Minimum	0.382	0.261	0.264	0.260
Maximum	0.994	0.989	0.973	0.993
TE Change (%)	0	-0.028	0.006	-0.007

Table 3 shows the average TE in all seasons (pooled) was 0.763 indicating that the farmers within the studied area could optimize their input use by 23.7% to achieve the optimum efficiency level and still produce the same level of production, which agreed with

Attipoe *et al.,* (2020) that the farmers who operated at optimum level could maximize their profit by reducing inputs waste. The technical efficiency in the second cropping season has decreased by 0.028% from the previous cropping season and decreased for all seasons by 0.007%. This situation is caused by the weather condition between the first cropping season and the second cropping season that have negative impacts on the management of water supply in the irrigation system and other inputs by farmers. Generally, the findings of this study are similar to the previous study by Rahman *et al.,* (2008) who investigated the impact of environmental production conditions on productivity and efficiency. Their findings concluded that farmers were unable to adjust to the challenging conditions caused by weather season factors. The condition of the weather events is the consequence of interactions between all of the components that change over time, resulting in complex and highly dynamic flow systems that are very particular to cropping season.

CONCLUSION

In this research, we analyze the technical efficiency of rice in Chiang Mai Province, Thailand. This study found the average technical efficiency of organic rice farmers was 76.30% in three cropping seasons and the average TE change was – 0.007% per cropping season. Fertilizer and material costs had negatively and significantly impacted farmers' efficiency and by contrast, years of education, labor, and water costs had positively and significantly affected productivity growth. The implication of this research is valuable towards improving farmers' efficiency by providing improved technology, technical knowledge, and innovation in rice farming activity.

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