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# THE EFFECTIVENESS OF THE PRODUCTION OF HEALTHY RICE IN COMPARISON WITH OTHER RICE VARIETIES IN THE UPPER NORTHERN REGION OF THAILAND

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## *ABSTRACT*

The objective of this study is to examine the efficiency of the production of healthy rice and that of other varieties grown in the upper northern region, by using Meta-Frontier approach in analyzing the rice production efficiency. This study focuses on rice production of farmers by comparing between healthy rice growers and farmers of other rice varieties about 300 and 900 sampling respectively, in the areas of Chiang Mai, Chiang Rai and Phayao. In analyzing the efficiency used one variable of the output, the quantity of rice products and five input variables namely quantity of seeds, cost of soil nourishment fertilizer, cost of weeding, cost of labor in production, and cost of labor for harvesting. The study found that there were more variables for analyzing the efficiency of other rice varieties of rice than those of the healthy rice. Plus, general rice growers had higher production efficiency than healthy rice farmers (0.9439> 0.8604). However, it seems that they should reduce more production factors, particularly labor in production and that in harvesting. Meanwhile, the overall economy of scale had increased while that of each group appeared to be unchanged.

**Contribution/Originality:** This study is one of very few studies which have examined the efficiency of the production of healthy rice and that of other varieties grown in the upper northern region, by using Meta-Frontier approach in analyzing the rice production efficiency.

## 1. INTRODUCTION

Rice is an important economic crop of Thailand. In the 2014/15 crop year, there were 60.79 million rais of rice cultivation throughout the country. The total yield of rice paddy was 26.27 million tons. In 2015, Thailand exported 9.795 million tons of rice to foreign countries, making 155,912 million baht (Department of Foreign Trade, 2016). That is, rice is produced for not only domestic consumption, but also export that makes a lot of income each year for the country. Nonetheless, it is worth noting that rice farmers have faced loss due to the increase of production costs and the uncertainty income. A large number of farmers, as a consequence, turn to other jobs. That tends to cause a decrease in rice growing area in the country.

Even though healthy rice is becoming more in-demand as rice consumers are increasingly concerned more about their health and the environment, jasmine rice is still the most marketable domestically and in foreign countries (Office of Agricultural Economics, 2014). Most of the area for healthy rice cultivation, 80%, is in the northeastern region and another 20% is in the northern region. Besides, the area of healthy rice cultivation

decreased, in 2011, by 0.14 million rais, and by 0.12 and 0.11 million rais in 2012 and 2013 respectively (OAE, 2014). Undoubtedly, the price of healthy rice has increased corresponding to the higher demand. The price of organic paddy is 10% higher than that of general paddy. And, the price of organic rice packed in bags is 20% higher than that of general rice, while the price of healthy rice bagged in foreign countries is 25-30% higher than that of general rice (Kasikorn Research Center, 2013).

The situation, in which the amount of organic rice produced does not seem to meet the demand, has raised a question why rice farmers did not choose to produce more organic rice which had been in relatively high demand. One of the sensible causes might be the inefficiency in the production of healthy rice or the lower return compared to that from the production of other varieties. Therefore, they did not have the motivation to produce organic rice. Due to these reasons, it is interesting to study the efficiency of healthy rice production compared with the production of other varieties of rice.

## 2. REVIEW OF LITERATURE AND RELATED THEORIES

### *2.1. Performance Measurement Concept*

Production efficiency studies have expanded rapidly in the 20th century (Berger and Humphrey, 1997). Estimates of both efficiency and inefficiency rely on many tools such as Stochastic Frontier Analysis (SFA), X-efficiency theory, and Data Envelopment analysis (DEA). Parametric analysis using DEA does not require the selection of frontier function models, but the linear combination, between the groups of production inputs and the corresponding outputs which will encircle the data of the entire sample groups, is adopted. Subsequently, misspecification will not occur. In addition, DEA analysis is a linear programming method for an accurate frontier estimation consistent with the production possibility frontier (Charnes *et al.*, 1995). It is also quite flexible in terms of the production inputs which may have different measurement units or characteristics. Only one value of production efficiency will be obtained (Stanton, 2002). An interesting feature of this method is that it allows comparison of production inputs that are different in the production process. Moreover, the simple concept of the DEA approach in mathematics is that the efficiency of the decision-making unit (DMU) uses n different inputs to obtain m outputs, which are measured in the form of the ratio of weighted outputs per weighted inputs. Additionally, the technical efficiency value obtained must be between 0 and 1. The DEA equation must apply constant returns to scale (CRS) or variable yield to scale (VRS). The concept of DEA created from one input and one output is shown in the Figure 1.

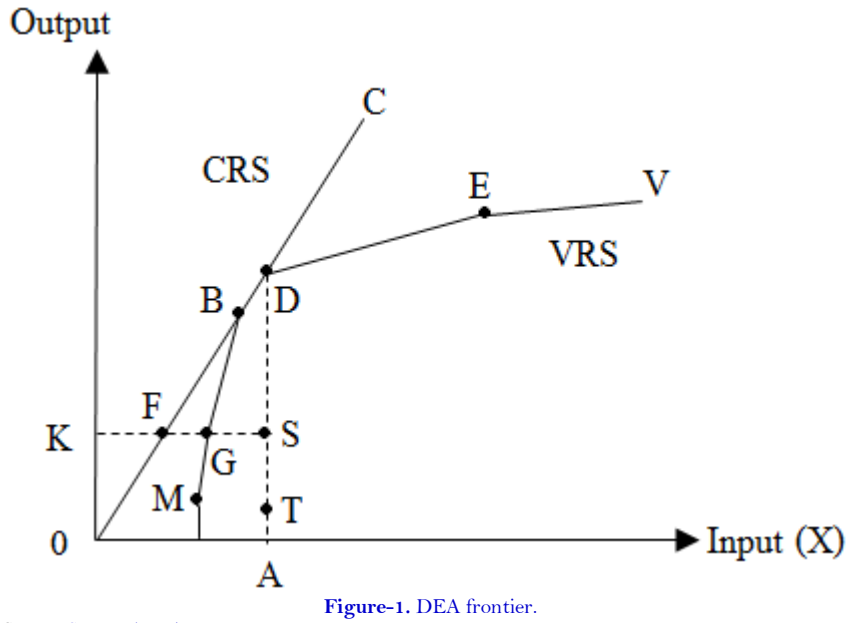


**Figure-1.** DEA frontier.

**Source:** Stanton (2002).

Production can be demonstrated via the relationship, between production inputs and production outputs, called Production Function, which shows the amount of product varying according to the inputs used in the production. In determining returns to scale, the effect of changes in all factors simultaneously will be analyzed to see how they affect the amount of product.

1) When the proportion of the increase in all factors is equal to the proportion of the increase in the product, it is considered constant returns to scale (CRS). To clarify, if doubling the amount of all inputs at the same time also double the amount of product, it means that returns to scale is constant.

2) When the proportion of the increase in product is greater than the increase in all production inputs, it is regarded increasing returns to scale (IRS).

3) When the yield increases less than the proportion of the increase in all production inputs, it is considered decreasing returns to scale (DRS).

## 3. STUDIES ON PRODUCTION EFFICIENCY

There are several of studies on production efficiency using various methods of analysis. Some of the most popular method used by researchers are stochastic frontier analysis (SFA) and data envelopment analysis (DEA). Toshiyuki (1999) examined the ranking test of non-parametric analysis employing DEA, and also studied index measurement with DEA slack adjustment and the application for cooperation in Japanese agriculture. In addition, Toshiyuki and Mika (2001) studied DEA slack adjustment to analyze time series data by examining technical efficiency of Japanese electric power industry during the years 1984-1993. Moreover, Palee (2012) conducted the analysis of technical performance of glutinous rice production in Hang Dong District and San Pa Tong District, Chiangmai Province, with the application of stochastic production frontier. Also, Jutarat (2002) studied technical performance of soybean production in the rainwater area of the lower northern part of Thailand by adopting stochastic production frontier in the analysis as well, to determine the technical productivity of farmers and study the relationship between yield per rai of farmers and various production inputs. Furthermore, Arayaratanakun (2003) applied the stochastic production frontier model and used maximum likelihood estimation method to study technical efficiency of the production of cut orchid flowers.

The production efficiency of agricultural households depends on the following factors.

1) Household characteristics, ages and numbers of household members (Ajibefun *et al.*, 1996; Coelli and Battese, 1996) and levels of education of agricultural household members have a positive effect on the production efficiency of agricultural households (Seyoum *et al.*, 1998; Helfand, 2003; Omononona *et al.*, 2010; Saima *et al.*, 2010). Nevertheless, there are arguments from Bates and Flordeliza (2010) claiming that levels of education has no effect on household productivity. Last but not least, household size (Battese *et al.*, 1996; Nyemeck *et al.*, 2001) and long agricultural experience have a positive effect on production efficiency (Ben, 2000).

2) Having a large agricultural area seems to help increase production efficiency and returns to scale (Jabbar and Akter, 2008; Saima *et al.*, 2010). However, if households divide their land and reduce the cultivating area, that will cause the lack of production efficiency due to waste of production inputs. Besides, the location of farms, specifically the distance between residence and farms and the distance between residence and distribution areas, has a negative effect on production performance (Lyubov and Jensen, 1998; Bates and Flordeliza, 2010). Additionally, it was stated that using labor suitable for production could increase production efficiency (Ajibefun *et al.*, 1996; Lyubov and Jensen, 1998; Bates and Flordeliza, 2010) whereas, moving to work in cities had a negative effect on production efficiency of agricultural households (Joel, 2005).

3) If farmers have formed a cooperative group or agricultural group with funding in the community (Omononona *et al.*, 2010) and have access to loans for production in the community (Joel, 2005; Saima *et al.*, 2010) or have been educated to increase their production experience (Omononona *et al.*, 2010) their household productivity will increase as well.

### *3.1. Objective*

To determine the efficiency of healthy rice production and other varieties of rice mostly grown in the upper northern region of Thailand.

### *3.2. Research Framework*

This study focuses on rice production of farmers by comparing between healthy rice growers and farmers of other rice varieties in the areas of Chiang Mai, Chiang Rai and Phayao, as the top three rice growing areas in the upper northern region of Thailand.

### *3.3. Research Methods*

Step 1 Determine the production efficiency of farmers' households (TEF):

Production efficiency of farmers' households is analyzed by using the non-parametric model based on DEA (Coelli, 1998). The analysis of household production efficiency will be output-oriented, as farmers have to produce the highest amount of production under limited production factors, with the following models.

Z is the total efficiency score of all farmers' households. $y_{rj}$ is the product r of household j , and $\mu_r$ is weighted value of product r when r = 1, 2, …, s. $x_{ij}$ is input i of household j. $v_i$ is weighted value of input i when i = 1, 2, ..., m.

Step 2 Identify the rice production efficiency of the farmers (TEF) by classifying the efficiency into 5 levels Table 1. In addition, the efficiency of the production of healthy rice and of other varieties of rice will be compared.

**Table-1.** The levels of production efficiency.

| Level of efficiency | Meaning |
|---|---|
| 0.8001-1.0000 | Highest efficiency |
| 0.6001-0.8000 | High efficiency |
| 0.4001-0.6000 | Medium efficiency |
| 0.2001-0.4000 | Low efficiency |
| 0.0000-0.2000 | Lowest efficiency |

**Source:** Cheamuangphan *et al.* (2013).

## 4. RESEARCH RESULTS

### *4.1. Data Used in the Study*

In analyzing the efficiency of healthy rice production and general rice production, one variable of the output, the quantity of rice products ($Y_1$) was used. It was found that the average amount of general rice produced was 35,000 kilograms, the highest, while the lowest yield was 1,200 kilograms. The average quantity was 6,993.47 kilograms. For organic rice, the highest yield amounted to 13,440 kilograms, while the lowest yield totaled 620 kilograms. The average quantity of yield was 4,297.57 kilograms. The study also used five variables, namely quantity of seeds (X1), cost of soil nourishment fertilizer (X2), cost of weeding (X3), cost of labor in production (X4), and cost of labor for harvesting (X5).

The highest amount of seeds used was 360 kilograms, which was the amount used by general rice farmers, while the lowest quantity of seeds used was 7 kilograms, used by organic rice growers. The average seed quantity equaled 78.46 kilograms. Plus, by considering the cost of soil nourishment fertilizer (X2), the highest cost was up to 34,000 baht. However, some organic rice farmers had not used soil fertilizers. That caused the average soil fertilizer cost to be equal to 4,055.65 baht. Moreover, the highest cost of weeding (X3) amounted to 8,720 baht. Some general rice growers and organic rice growers did not face such cost. That resulted in an average soil fertilizer cost of 307.32 baht. When considering the labor cost of production (X4), it was revealed that the highest value was 78,400 baht and the lowest cost totaled 400 baht, resulting in an average labor cost of production equal to 5,196.57 baht. Meanwhile, the highest labor cost of harvesting (X5) amounted to 7,810 baht. The minimum use was 500 baht. This made the average labor cost of production equal to 1,772.28 baht.

### *4.2. The Efficiency Level of Rice Production*

Based on the analysis of rice production efficiency between rice, the general rice production appeared to be more effective than the healthy rice production, as proved by the average of the technical efficiency (TE) of general rice production of 0.9439, whereas the average technical efficiency (TE) of the healthy rice production equaled to 0.8604. Most farmers of each type of rice cultivation had the highest level of efficiency. followed by the high and the medium level respectively as in Table 2. Since10 farmers, representing 3.33 percent of the healthy rice farmers, had low production efficiency, the overall level of the healthy rice production efficiency turned to be lower than the general rice production. However, when analyzing the production efficiency of both groups of farmers altogether, it was found that the overall production efficiency was at the highest level with the average TE equal to 0.9072 Table 2.

**Table-2.** Level of efficiency.

| Efficiency | | General Rice | | | Healthy Rice | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Level of Eff. | Meaning | Amount | Percent | Average TE | Amount | Percent | Average TE | Amount | Percent | Average TE |
| 0.8001-1.0000 | Highest | 552 | 92.00 | 0.9644 | 224 | 74.67 | 0.9495 | 759 | 84.33 | 0.9603 |
| 0.6001-0.8000 | High | 44 | 7.33 | 0.7178 | 44 | 14.67 | 0.6932 | 87 | 9.67 | 0.7053 |
| 0.4001-0.6000 | Medium | 4 | 0.67 | 0.5980 | 22 | 7.33 | 0.5310 | 42 | 4.67 | 0.5376 |
| 0.2001-0.4000 | Low | - | - | - | 10 | 3.33 | 0.3254 | 12 | 1.33 | 0.3073 |
| 0.0000-0.2000 | Lowest | - | - | - | - | - | - | - | - | - |
| Total | | 600 | 100.00 | 0.9439 | 300 | 100.00 | 0.8604 | 900 | 100.00 | 0.9072 |

**Source:** Calculation.

## 5. EXCESS INPUTS IN PRODUCTION

It was found that the 416 general rice growers should reduce excess inputs. The number represents 69.33 percent of all general rice growers. 228 farmers or 38.00 percent who should reduce two production factors. Also, 136 rice growers, accounting for 22.67 percent, should reduce one factor, while there 52 farmers, or 8.67 percent, should reduce three excess factors. Moreover, most organic farmers, 94 people or 31.33 percent, should reduce only one factor. Simultaneously, 54 organic rice growers or 18.00 percent, and three factors should be reduced among six farmers, representing 2.00 percent of the total number.

When comparing the production efficiency of both groups of farmers at the same time, it was revealed that the farmers would reduce only up to three production inputs. 333 farmers or 37.00 percent reduced one factor, while 174 farmers or 19.33 percent cut two factors. And, 30 rice growers, accounting for 3.33 percent, reduced three factors. As a result, there were 363 farmers or 40.33 percent of the total number of farmers in both groups who had not reduce excess inputs Table 3.

**Table-3.** Input slack.

| Input | General Rice | | Healthy Rice | | Total | |
|---|---|---|---|---|---|---|
| | Amount | Percent | Amount | Percent | Amount | Percent |
| Reduced 1 input | 136 | 22.67 | 94 | 31.33 | 333 | 37.00 |
| Reduced 2 input | 228 | 38.00 | 54 | 18.00 | 174 | 19.33 |
| Reduced 3 input | 52 | 8.67 | 6 | 2.00 | 30 | 3.33 |
| Number of famer to reduce | 416 | 69.33 | 154 | 51.33 | 537 | 59.67 |
| Number of famer to don't reduce | 184 | 30.67 | 146 | 48.67 | 363 | 40.33 |

## 6. REDUCING EXCESS INPUTS IN PRODUCTION

Based on the evaluation of the rice production efficiency by comparing the use of production inputs among sample groups of farmers, the farmers were suggested that they reduce their production factors to get the same yield. The farmers of each level of efficiency, therefore, should reduce the size of production factors as follows.

### *6.1. Seed Quantity*

4.33 percent of the total number of sample farmers who should reduce the seed quantity. The 32 effective general rice growers with the highest efficiency, representing 5.33 percent, should reduce the seed by an average of 20.80 kilograms, while the farmers who produced healthy rice with the highest production efficiency, 12 cases representing 4.00 percent, should reduce the excess factor by an average of up to 84.14 kilograms. Overall, rice farmers with high and the highest level of efficiency should cut the seeds used in the production by an average of 22.45 and 73.83 kg, respectively.

### *6.2. Soil Fertilizer Cost*

132 general rice farmers, representing 22.00 percent, should reduce the fertilizer cost by an average cost of 2,521.25 baht. Also, four farmers with high productivity, 0.67 percent, should reduce the soil fertilizer cost by an average of 2,849.69 baht, while the average cost of fertilizer should be reduced by 1,133.78 baht among 40 farmers or 13.33 percent of those who produced organic rice. In addition, rice growers with moderate efficiency should reduce the average fertilizer cost by 2,438.81 baht. Overall, farmers with the highest efficiency should reduce the cost by the maximum average of 2,227.43 baht. And, farmers with high and medium efficiency were suggested that they reduce the average cost of soil fertilizer by 106.30 baht and 90.36 baht, respectively.

### *6.3. Weed Removal Cost*

160 rice farmers, accounting for 26.67 percent, should reduce the cost of weeding. Most efficient farmers, 156 cases, representing 26.00 percent, should reduce the cost of weeding by an average of 866.96 baht. The farmers with high efficiency should reduce the cost of weeding by an average of 450.00 baht. Significantly, the organic rice growers had no weeding cost since such cost was for chemicals. Furthermore, when comparing between the two groups of farmers, there were 138 farmers, representing 15.33 percent, who should reduce such factor.

### *6.4. Labor Cost for Production*

Labor cost was a production factor that was necessary to be reduced due to its relatively high number. The general farmers with high level of efficiency should reduce such cost by 8,474.14 baht. 256 farmers with the highest efficiency, 42.67 percent, should reduce the average labor cost by 2,228.63 baht, while the organic rice farmers with the most efficiency should reduce the labor cost by an average of 2,829.36 baht. Moreover, the average labor cost should be reduced by 6,243.23 baht among those with high efficiency, followed by the average labor cost of up to 35,311 to be reduced when considering that among the farmers with medium efficiency. Besides, when comparing between the two groups of farmers, it was discovered that those farmers should reduce the labor cost of production by a maximum average of 11,952.86 baht, which was said to be among the group of farmers with medium production efficiency.

### *6.5. Labor Cost for Harvesting*

Despite its small number in value, labor cost for harvesting was also to be cut. Based on the analysis, only the general rice farmers with the highest level of efficiency who should reduce their labor cost for harvesting. The average value to be cut totaled 966.23 baht, among 160 or 26.67 percent. Meanwhile, the organic rice growers with the highest level of efficiency should reduce such cost by an average of 1,513.60 baht. Also, the farmers with the high level of efficiency should reduce the average cost of 1369.58 baht. Last but not least, after comparing all sample groups of farmers, it was unveiled that only farmers with the highest level of efficiency should reduce such labor cost by an average of 1124.11 baht.

## 7. ECONOMY OF SCALE

The goal of production of rice growers is to achieve maximum productivity, therefore, farmers need to use efficient production factors with the lowest cost to gain maximum profit. In accordance with the analysis comparing the production efficiency between the two groups of farmers, it was found that the majority of farmers, accounting for 426 people or 47.33 percent, had increasing returns to scale (IRS). Those were farmers with the least and the highest level of efficiency. The increasing returns to scale (IRS) and the constant returns to scale (CRS) amounted to were seen among 351 and 123 rice growers, accounting for 39.00 percent and 13.67 percent of the total number, respectively. When considering each group separately, it was seen that was most general rice growers and healthy rice growers produced had constant returns to scale (CRS). The number of each group were 596 and 186, respectively, representing 99.33 percent and 62.00 percent Table 4. Additionally, there is none of the general rice farmers facing decreasing returns to scale (DRS). Furthermore, 123 organic rice farmers, representing 27.33 percent, had increasing returns to scale (IRS). However, 32 organic rice farmers, accounting for 10.67 percent, had decreasing returns to scale (DRS).

**Table-4.** Economy of scale.

| Level of Efficiency | General Rice | | | Healthy Rice | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | CRS | IRS | DRS | CRS | IRS | DRS | CRS | IRS | DRS |
| 0.8001-1.0000 | 548 | 4 | - | 152 | 42 | 30 | 123 | 303 | 333 |
| 0.6001-0.8000 | 44 | - | - | 18 | 24 | 2 | - | 72 | 15 |
| 0.4001-0.6000 | 4 | - | - | 10 | 12 | - | - | 39 | 3 |
| 0.2001-0.4000 | - | - | - | 6 | 4 | - | - | 12 | - |
| 0.0000-0.2000 | - | - | - | - | - | - | - | - | - |
| Total | 596 | 4 | 0 | 186 | 82 | 32 | 123 | 426 | 351 |
| Percent | 99.33 | 0.67 | 0.00 | 93.00 | 41.00 | 16.00 | 13.67 | 47.33 | 39.00 |

## 8. CONCLUSION

With regard to the analysis of rice production efficiency of the two groups of farmers, it was found that most farmers had the highest production efficiency. Specifically, the general rice farmers had higher production efficiency than the healthy rice farmers. Although the level of performance indicated such result, the amount of excess inputs used by the general rice farmers appeared to be higher. That is because most organic rice growers should reduce only one production factor, whereas most general rice farmers should adjust the production factors down by two factors. Besides, the proportion of those who should reduce their excess inputs was higher than that of the healthy rice farmers. To discuss this in more detail, the production factor that should be reduced the most was labor costs, in production and for harvesting, due to its unnecessarily high numbers which cost excess cost. The average labor cost to be reduced was up to an average of 8,474.14 baht, which was the cost among the general rice growers. Last but not least, the study results showed that when comparing the efficiency of the farmers in the same group, they had constant returns to scale (CRS). On the contrary, when comparing the production efficiency between groups, they had increasing returns to scale (IRS).

### *8.1. Suggestions*

1. Government agencies should train or educate healthy rice farmers in terms of adjusting their production factors in order to lower costs and to generate more returns.

2. Agriculture-related agencies should focus on large-scale production in order to gather groups of farmers to create more bargaining power in the rice market.

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