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Efficiency Differences on Rice Production Between Thailand and Vietnam Using Meta-frontier

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Abstract -A decade ago, Vietnam has been the main competitor of Thailand that has an advantage over Thailand in terms of potential for rice production, the yield of rice was almost two times higher than Thailand. Meta-frontier was used to analyze and compare the efficiency in rice production of Thailand and Vietnam. Therefore, this research aimed to analyze technical efficiency in rice production of both countries using Meta-frontier and analyze technology gap ratio. The research used data on rice production of both countries collected from 2007 – 2016. The results found that the technical efficiency scores in rice production of Thailand and Vietnam were 0.797 and 0.877, respectively. The results from comparing efficiency under Meta-frontier, Vietnam had more efficiency in rice production than Thailand. The results of technology gap ratios of Thailand score were at 0.990, while it was 0.982 for Vietnam. This research suggested that Thailand should develop varieties of rice breeding that makes yield of rice higher and should provide appropriate technology to farmers to enhance their productivity. For the suggestion of a policy of Thailand, Thailand should set a clear policy to help farmers in rice production and should study policy of Vietnam to help farmers to improve their rice production, and then apply to Thailand.

Keywords – Rice Production, Meta-frontier, Technology Gap Ratios

1. INTRODUCTION

Rice is one of the leading food crops that is consumed by most of population in the world. More than 90 percent of the world's population who have been consuming rice lives in Asia. Since the Asian people are the majority group of the world, it leads to the highest number of rice production, rice consuming, and rice trading are in Asia. Moreover, the highest number of rice production's countries are also in Asia. The countries with the most rice cultivation are in Asia, including China, India, Indonesia, Vietnam, and Thailand (Agricultural Research Development Agency, 2013).

In the part of rice cultivation of Thailand, rice is one of the leading food crops that affects economic productions of Thailand. Thailand exports many tons of rice to many countries. However, it has been about 10 years ago that Vietnam has been the main competitor of Thailand that has

more efficiency on rice production. Vietnam can produce a greater number of rice production with using lower manufacturing cost. Because of the development and improvement of rice production's process of Vietnam, the country can increase the number of the rate of rice's exportation. Because of this, Thailand will loss many market shares in the long run (Mekchai, 2014).

During the year 2007-2016, Thailand had rice yield in the average of 484 kilogram per rai comparing with Vietnam, the average of rice yield was 874 kilogram per rai. Thailand has rice cultivation areas more than Vietnam about 20 million rai, but Vietnam has higher rice yield by almost 2 times (FAO, 2017). From rice production and area harvested information, it cannot be concluded that Vietnam has more efficiency on rice production than Thailand. The reason is that each country has different factors such as geography, production technology as well as the difference of wisdom and social concept.

From basic efficiency hypothesis that different countries must be under the same technology sets, so it can be compared with each other. The theory is consistent with this assumption is the theory of Meta-frontier which has been presented for the first time by Hayami and Ruttan (1970). This concept of measuring economic efficiency received a lot of interest in the present because from the principle of different countries having the potential to reach the same or similar technology, can be used to compare the efficiency of production.

From this reason, the efficiency differences on rice production between Thailand and Vietnam is studied using Meta-frontier to analyze technical efficiency, together with analyze technology gap ratios of both countries. The focus of this research is to compare efficiency in Rice production of the two countries by using Meta-frontier. Therefore, the objectives of this research are to analyze technical efficiency in rice production of Thailand and Vietnam, as well as to analyze technology gap ratios in rice production. The results will be used as a guideline to develop efficiency in rice production of both counties in the near future.

2. Literature Review

Ferjani and Latruffe (2009) studied small dairy farms in Switzerland and French using Meta-frontier. Data was collected from 300 farms in 1990 – 2004. The variables were used in this study such as Milk produced, Number of livestock units, Labor and number of farms. The results showed that the average score for the French farms was 0.777 and Swiss farms was 0.802. Under the Meta-frontier, the average score of French farms was 0.770 and Swiss farms was 0.754. This results suggested that the productivity gap and the efficiency differential between Swiss and French farms were due to higher proportion of family labor and larger Swiss farms with lower labor per livestock unit.

Mariano et al. (2010) studied farm-level efficiency and technology gap ratios on rice farming in Philippines using Meta-frontier. This study divided in four agroclimatic zones. First type, climate has two seasons, dry and wet. Second type is no dry but minimum rainfall. Third type has no very maximum rain and last type has rainfall all year. The results of the production frontiers were not different in agroclimatic zones. The mean TGR was high in every zones ranged from 0.83 to 0.87. Farmers in zone 3 were the most productive group and follow by farmers in zone 2. It showed that rice producers in Philipines can adapt crop strategies to use in different conditions.

Wongchai, Yotimart and Peng (2012) studied efficiency differences in Paddy Rice in Thailand using Meta-frontier DEA. 76 provinces were divided into four regions. The data was collected from the crop year 2001 to 2010/11. The variable used in this study such as arable land, seed, rainfall and fertilizer. The results showed that the Meta-frontier scores were from 0.42 to 0.94. the highest and lowest average scores of Northeast of Thailand and the Central were at 0.97 and 0.88.

Technology gap ratios scores showed that the North's highest average score was at 0.87 and the South's lowest average score was at 0.51. In discussion, Thailand could develop by raising trainings in farmers and decreasing the number of labor and irrigation.

Furthermore, Chebi et al. (2016) did a research on technical efficiency of wheat farms in Sudan using Meta-frontier. The main objective of this study measured technological gap ratios, as well as technical efficiency of wheat farms production in four areas of Sudan; namely River Nile, Northern, Kassala States of Sudan and Gezira. The sample of 951 wheat farms were collected in 2013. The results revealed that the average technical efficiency in group frontiers for River Nile, Northern, Gazira, and Kassala were 0.41, 0.48, 0.52, 0.61. respectively. The technology gap ratios for Kassala, Northern, Gezira and River Nile were 0.50, 0.75, 0.82, and 0.92, respectively. This results suggested that farms in the Northern, Gezira, and River Nile should improve inputs using technologies such as fertilizer, sowing, irrigation, and harvesting.

From the pervious review of literature, most researches used Meta-frontier as an instrument. Each country has different ways in measuring an efficiency of rice production. However, most researches used the similar input variables such as seeds, labor, fertilizer, and farming area. It was found out that the research processes of conducting this research is similar to most researches since they had the same input variables. This leads to have more understanding about the use of an instrument and variables.

3. Material and Methods

3.1 Theory framework

The concept of measuring efficiency of production in different group or different management has been developed by Rao, O'Donnell, and Battese (2004). This concept is called "Meta-frontier", which has taken the basic idea from Meta Production Function by Hayami and Ruttan (1971).

3.1.1 The Meta-frontier

Determine x and y be non-negative real input and output vectors of dimension N*1 and M*1. The meta-technology set includes all input and output combinations shown as the following (Battese, Rao and O'Donnell, 2008):

$$T = \{(x, y): x \geq 0; y \geq 0; x \text{ can produce } y\} \quad (1)$$

This meta-technology set has output and input sets. For example, the output set is defined for any input vector, x, as Equation (2):

$$P(x) = \{y: (x, y) \in T\} \quad (2)$$

This output set as the output meta-frontier. The technology using the output meta-distance function, defined as Equation (3):

$$D(x, y) = inf_{\theta} \left\{\theta > 0: \left(\frac{y}{\theta}\right) \epsilon P(x)\right\}. \quad (3)$$

The distance function obtains its regularity properties from the output set. An observation (x, y) can be considered efficient with respect to the meta-frontier if and only if $D(x, y) = 1$.

3.1.2 Group frontiers

The group of firms is separated into K(> 1) groups and were supposed that resource, other environmental constraints or regulatory may prevent firms in certain groups from choosing from technologically feasible input and output combinations in the meta-technology set. Rather, the input and output combinations available to firms in the *K* th group are included with the group-specific technology set as follow:

$$T^k = \{(x, y): x \geq 0; y \geq 0; x \text{ can be used by firms in group } k \text{ to produce}, y\} \quad (4)$$

the following group-specific output sets and output distance functions represent the K group-specific technologies as Equation (5) and (6):

$$P^k(x) = \{y: (x, y) \in T^k\}, k = 1,2, \dots, K \quad (5)$$

$$D^k(x, y) = inf_\theta \left\{\theta > 0: \left(\frac{y}{\theta}\right) \epsilon P^k(x)\right\}, k = 1,2, \dots, K. \quad (6)$$

If the output sets, $P^k(x)$, k = 1,2,…, K, satisfy standard properties then the distance functions, $D^k(x, y)$, k= 1,2,…,K, also satisfy standard properties.

The group-specific output sets, $P^k(x)$, k = 1,2,…,K, are subsets of the output set, $P(x)$. Figure 1 shows three groups of the production possibilities available to single-input, single-output firms. The group-k frontier is labelled k-k' and is assumed to be convex (k =1,2,3). If the three groups are exhaustive (i.e., if K=3) then the group-specific frontiers cover all the input and output combinations that could be produced by any single firm, implying the meta-frontier is the non-convex frontier, 1-B-3'. However, if the three groups are not exhaustive, then other input and output combinations may be feasible and the meta-frontier could be the convex frontier, M-M'.

3.1.3 Technical efficiencies and meta-technology ratios

From section 3.1.1 that an observation (x, y) is efficient with respect to the meta-frontier if and only if D(x, y)=1. An output-orientated approach is used to measure the technical efficiency of a pair (x, y) with respect to the meta-technology as follows:

$$TE(x, y) = D(x, y) \quad (7)$$

For example, D(x,y) is equal to 0.7, implying that the output vector, *y*, is 70 percent of the maximum output that could be produced by using the input vector of firm. Technical efficiency was measured the group-*k* frontier as follow:

$$TE^k(x, y) = D^k(x, y) \quad (8)$$

if $D^k(x, y)$ is equal to 0.8, then output is 80 percent of the maximum output that could be produced by using the input vector of firm and group-*k* technology.

The group-*k* output distance function, $D^k(x, y)$, must have a value no less than the output meta-distance function, $D(x, y)$. The meta-frontier envelops the group-*k* frontier. Obtaining a measurement of how close the group-*k* frontier is to the meta-frontier. Specifically, the output-orientated meta-technology ratio for group-*k* firms are shown as follow:

$$MTR^k(x, y) = \frac{D(x,y)}{D^k(x,y)} = \frac{TE(x,y)}{TE^k(x,y)} \quad (9)$$

From examples above, where the technical efficiency of (x, y) with respect to the meta-technology was 0.7 and the technical efficiency with group-*k* frontier was 0.8, the meta-technology ratio was 0.875 (= 0.7/0.8). That means, given the input vector, the maximum output that could be produced by a firm from *k* group is 87.5% of the output that is feasible using the meta-technology.

3.2 Data source and instrument

This research collected data using secondary sources in rice production of Thailand and Vietnam by provinces from 2007 – 2016 such as Office of Agricultural Economics (2017), General Statistics Office of Vietnam (2018) and FAO (2017). This research scoped in 77 provinces of Thailand and 63 provinces of Vietnam.

For an anlysis part of technical efficiency differences and technology gap in rice production between Thailand and Vietnam was used variable data related to rice production in both countries and were analyzed together. There were two steps to determine the technical efficiency and technology gap ratios by using the data from 2007 – 2016 and using Meta-frontier under Data Envelopment Analysis (DEA) approach. Firstly, Meta-frontier DEA was

used to calculate technical efficiency in rice production of Thailand and Vietnam, and Output-orientated approach was used in analyzing data. Secondly, Meta-frontier DEA was used to calculate technology gap ratios in rice production of Thailand and Vietnam and compare technical efficiency in rice production of Thailand and Vietnam.

3.2.1 Construction of Group Frontiers

The region k consists of data on L_k units (k is Thailand or Vietnam). The linear programming (LP) problem is used to construct an output-orientated DEA model as follows (Rao, O'Donnell, and Battese, 2004):

$$max_{\phi,\lambda}\ \phi$$

Such that $-\phi y_i + y_k\lambda \geq 0$

$$x_i - x_k\lambda \geq 0$$

$$\lambda \geq 0$$

(1)

Where

x_i presents the N×1 vector of input quantities for the i-th unit

y_i presents the M×1 vector of output quantities for the i-th unit

X_k presents the N× L_k matrix of input quantities for all L_k units

Y_k presents the M× L_k matrix of output quantities for all L_k units

λ presents a L_k ×1 vector of weights

ϕ presents a scalar

3.2.2 Construction of Meta-frontier

A DEA model is used to construct as a Meta-frontier which based on all collected data for all firms/units. Since a total of $L = \Sigma_k L_k$ units (k is Thailand or Vietnam), the linear progamming model is used with all input matricts and output matrices for all units:

$$max_{\phi^*,\lambda^*}\ \phi^*$$

Such that $-\phi^* y_i + Y^*\lambda^* \geq 0$

$$x_i - X^*\lambda^* \geq 0$$

$$\lambda^* \geq 0$$

(2)

Where

x_i depicts the N×1 vector of input quantities for the i-th unit

y_i depicts the M×1 vector of output quantities for the i-th unit

X^* depicts the N× L matrix of input quantities for all L units

Y^* depicts the M× L matrix of output quantities for all L units

λ^* depicts a L ×1 vector of weights

ϕ^* depicts a scalar

The variables used in this research were divided into two series, Thailand and Vietnam series.

1) Variables of Thailand

1. Y_{TH} is an output variable that represents rice production of Thailand from 2007 – 2016. The units of measure are tons.

2. x_{TH1} is the first input variable that represents harvested area of Thailand from 2007 – 2016. The units of measure are hectare.

3.x_{TH} is the second input variable that represents seeds of Thailand from 2007 – 2016. The units of measure are tons.

4.x_{TH} is the third input variable that represents fertilizer of Thailand from 2007 – 2016. The units of measure are tons.

5. x_{TH4} is the forth variable that represents household in rice cultivation of Thailand from 2007 – 2016. The units of measure are households.

2) Variables of Vietnam

1.Y_{VN} is an output variable that represents rice production of Vietnam from 2007 – 2016. The units of measure are tons.

2. x_{VN1} is the first input variable that represents harvested area of Vietnam from 2007 – 2016. The units of measure are tons.

3.x_{VN2} is the second input variable that represents seeds of Vietnam from 2007 – 2016. The units of measure are tons.

4. x_{VN3} is the third input variable that represents fertilizers of Vietnam from 2007 – 2016. The units of measure are tons.

5. x_{VN4} is the forth input variable that represents household in rice cultivation of Vietnam from 2007 – 2016. The units of measure are households.

4. Analysis and Result

The following result is relevant to the first objective of this research. The objective was to analyze technical efficiency in rice production of Thailand and Vietnam. Table 1 shows an overview of Thailand's efficiency scores in rice production from 2007 – 2016.

From Table 1, this research shows technical efficiency scores in Thai rice production from 2007 – 2016. The average of technical efficiency scores in Thai rice production is 0.805 that means rice production of Thailand is determined by input variables (harvested area, seed, fertilizer and households in rice cultivation) up to 80 percent on average over the last 10 years. Efficiency scores that shows in Table 1, are considered to effective in high rice production level. The efficiency score in each year of rice production is ranged from 0.7 – 0.8. In 2016, this research showed the highest efficiency score at 0.838 and lowest efficiency score at 0.775 in 2012.

Table 2 reveals an overview of technical efficiency scores in rice production of Vietnam from 2007 – 2016. The Average of efficiency in rice production of Vietnam is 0.893 that means rice production of Vietnam is determined by input variables (harvested area, seed, fertilizer and households in rice cultivation) up to 89 percent on average over the last 10 years. Efficiency scores in Table 2 are considered to affect in high rice production levels. The efficiency score in each year of rice production is ranged from 0.78 – 0.93. In 2011, This research shows the highest efficiency scores is 0.933 that means in this year, Vietnam was determined by input variables up to 93 percent and the lowest efficiency score was 0.78 in 2007. It may conclude that Vietnam has really high efficiency in rice production.

Next part is the results that relevant to the second objective of this research. The objective was to analyze technology gap ratios in rice production of Thailand and Vietnam under Meta-frontier that was divided into 2 parts: Technical efficiency in rice production of Thailand and Vietnam under Meta-frontier and result of Technology gap ratios of Thailand and Vietnam.

Table 3 shows the results of technical efficiency in rice production of Thailand and Vietnam using Meta-frontier during 2007 – 2016. The Table shows the score of technical efficiency in rice production of Thailand under Meta-frontier or same technology with Vietnam.

This research found that if using the efficiency in rice production under the same technology with Vietnam, Thailand has technical efficiency in rice production average in 0.797. This score means under same technology with Vietnam, Thailand can use input variables (area harvested, seeds, fertilizer and labor in rice cultivation) to make rice production about 79 percent of all possibility in rice production. In 2016, Thailand had the highest technical efficiency score in the last 10 years at 0.831. In 2008, Thailand had the lowest technical efficiency score in

the last 10 years at 0.765. In overview of Thailand, Thailand is considered having high efficiency in rice production by using the same technology with Vietnam.

Part of technical efficiency score in rice production of Vietnam under same technology with Thailand shows in Table 4. The results of the scores of technical efficiencies in rice production of Vietnam under Meta-frontier during 2007 - 2016 was at 0.877.

This score means under the same technology with Thailand, Vietnam can use input variables (area harvested, seeds, fertilizer and labor in rice cultivation) to make rice production about 87 percent of all possibility in rice production. In 2011, Vietnam had the highest technical efficiency score in the last 10 years at 0.915. In 2007, Vietnam had the lowest technical efficiency scores in the last 10 years at 0.771. An overview of rice production in Vietnam has high efficiency in rice production every year. From the results of technical efficiency in rice production of Thailand and Vietnam under the same technology or Meta-frontier, we can conclude that Vietnam has higher efficiency in rice production than Thailand.

In the part of technology gap ratio, we can calculate from comparing technical efficiency of each country under the same technology. If the comparison results is unequal, the ratio of technology will demonstrate the gap of technology in each country.

Table 5 shows the results of technology gap ratios in Thailand during 2007 – 2016. The scores come from technical efficiency scores in rice production of Thailand in Table 1 compare with technical efficiency score in rice production under Meta-frontier from Table 3. The results found that technology gap ratio of Thailand was in the average of 0.990 that means Thailand has actual different technology but having less or no difference in technology. It can say that Thailand may use the same technology as it is used in Vietnam when measure technology with Thailand and Vietnam.

The results of technology gap ratios in Vietnam during 2007 – 2016 show in Table 6. From Table 6, This research shows scores of technology gap ratios of Vietnam. The scores come from technical efficiency scores in rice production of Vietnam in Table 2 and bring to compare with technical efficiency score in rice production under Meta-frontier from Table 4. The results found that technology gap ratio of Vietnam was in the average of 0.982. The scores show the results that is quite close to Thailand. This means that Vietnam has actual different technology but having less or no difference in technology. It can say that Thailand may use the same technology as it is used in Vietnam when measure technology with Thailand and Vietnam

From the results of technical efficiency scores in rice production from each country by calculated from each frontier, this research found that Thailand had lower technical efficiency than Vietnam. Thailand has technical efficiency score in the average of 0.805, while it was 0.893 for Vietnam. Nevertheless, we cannot compare by using technical efficiency score from each frontier, so we must analyze data using the same technology (Meta-frontier) before comparing productivity in rice production together. The results of technical efficiency in same technology (Meta-frontier) found that Thailand performed technical efficiency score at 0.797 and Vietnam had technical efficiency score at 0.877. It can be concluded that Vietnam has higher efficiency in rice production than Thailand. However, Thailand and Vietnam are considered having high efficiency in rice production.

5. Suggestions

The suggestion part of can be divided into two parts; the production in rice cultivation, as well as the policy in rice production. In the part of

suggestion of production in rice cultivation, the results found that under Meta-frontier, Vietnam has higher efficiency in rice production than Thailand, but it was not a significant difference or nearly efficiency. In fact, a situation in rice production of Thailand and Vietnam reveals that Thailand has less rice production in two times when combining with other factors apart from an analysis of this research. Therefore, based on the fact of the situation of rice production of both countries, the results of this research using Meta-frontier found that Vietnam has more technology in rice production than Thailand, resulting in having more productivity than Thailand.

The suggestions from this research are in the part of improving on yield of rice of Thailand, Thailand should develop varieties of rice breeding, with rice yield higher. Hybrid rice varieties can be considered to use to improve rice production, together with controlling diseases affecting in rice production. Moreover, it should have the training and transferring of advanced technology for farmers to increase rice production. In addition, irrigation should be also considered that it might affect in rice production as Vietnam has a good irrigation. Therefore, Thailand should develop the irrigation system.

For the results of this research and a situation of policy about rice of Thailand and Vietnam, the suggestions in the policy are as follows: From the past to the present policy on rice in Thailand is considered of having no policy that can solve the problem clearly. It may result from having frequent changes of government structure. This will lead to an ineffective policy and the problem is unable to be solved. Therefore, Thailand, should set a clearly policy that can help farmers in term of rice production, or ought to have an education policy from Vietnam where farmers can help develop in good production, and then apply them to Thailand. For example, the policy of three increase and three decrease about variables that puts Vietnam success in rice cultivation. Thailand should also have a policy to solve the problem from a real cause, not policy to solve the last result. If government solves the last result of problem, it will only solve the problem only in the short term. Farmers cannot escape from the real problems.

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Table 1. Technical Efficiency scores in Rice Production of Thailand from 2007 - 2016

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Mean
TE	0.793	0.796	0.801	0.807	0.822	0.775	0.800	0.790	0.830	0.838	0.805
SD	0.140	0.142	0.143	0.141	0.130	0.153	0.149	0.133	0.139	0.140	0.141
Min	0.521	0.521	0.533	0.488	0.521	0.498	0.502	0.507	0.499	0.568	0.516
Max	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Source: From the results of the calculation

Table 2. Technical Efficiency scores in Rice production of Vietnam from 2007 – 2016

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Mean
TE	0.780	0.864	0.888	0.895	0.933	0.931	0.924	0.903	0.913	0.904	0.893
SD	0.083	0.069	0.049	0.052	0.048	0.038	0.043	0.058	0.063	0.085	0.058
Min	0.630	0.747	0.797	0.774	0.759	0.842	0.824	0.742	0.708	0.442	0.726
Max	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Source: From the results of the calculation

Table 3. Technical Efficiency score in Rice production of Thailand under Meta-frontier from 2007- 2016

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Mean
TE	0.780	0.765	0.798	0.798	0.815	0.771	0.798	0.785	0.828	0.831	0.797
SD	0.142	0.142	0.144	0.145	0.133	0.154	0.149	0.132	0.139	0.147	0.143

Min	0.506	0.511	0.533	0.420	0.521	0.487	0.502	0.507	0.499	0.498	0.498
Max	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Source: From the results of the calculation											

Table 4. Technical Efficiency score in Rice production of Vietnam under Meta-frontier from 2007- 2016

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Mean
TE	0.771	0.854	0.871	0.885	0.915	0.904	0.892	0.885	0.895	0.897	0.877
SD	0.080	0.072	0.061	0.058	0.061	0.065	0.074	0.775	0.073	0.088	0.071
Min	0.629	0.715	0.743	0.751	0.727	0.735	0.713	0.685	0.701	0.442	0.684
Max	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Source: From the results of the calculation											

Table 5. Technology Gap Ratios in Rice production of Thailand from 2007 - 2016

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Mean
TGR	0.984	0.962	0.997	0.989	0.991	0.994	0.998	0.994	0.998	0.991	0.990
SD	0.027	0.060	0.010	0.027	0.020	0.011	0.005	0.010	0.011	0.036	0.013
Min	0.880	0.698	0.947	0.830	0.888	0.926	0.964	0.946	0.905	0.745	0.933
Max	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Source: From the results of the calculation											

Table 6. Technology Gap Ratios in Rice production of Vietnam from 2007 - 2016

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Mean
TGR	0.988	0.989	0.980	0.989	0.981	0.971	0.966	0.980	0.980	0.992	0.982

SD	0.025	0.025	0.039	0.022	0.023	0.041	0.058	0.040	0.037	0.021	0.031
Min	0.881	0.896	0.830	0.884	0.894	0.808	0.746	0.824	0.854	0.897	0.871
Max	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Source: From the results of the calculation											

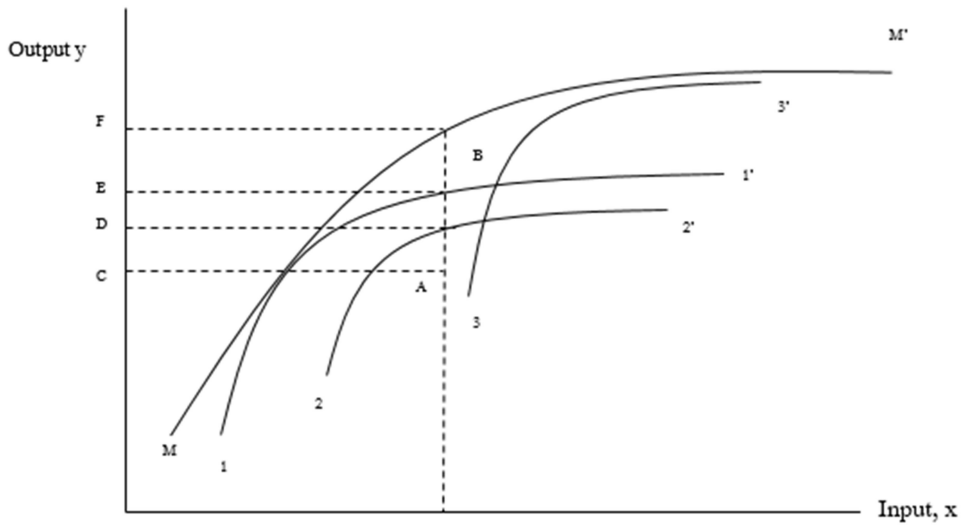

Figure 1: Technical efficiencies and metatechnology ratios
Source: Battese, Rao and O'Donnell (2008)