International Journal of Food and Agricultural Economics
ISSN 2147-8988, E-ISSN: 2149-3766
Vol. 4 No. 2, 2016, pp. 39-50

TECHNICAL EFFICIENCY AND THE TECHNOLOGY GAP IN WETLAND RICE FARMING IN INDONESIA: A METAFRONTIER ANALYSIS

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Abstract

Diversity in the characteristics between regions is why different kinds of technology are used in wetland rice farming in Indonesia. These differences lead to a technology gap which then makes it nearly impossible to compare the maximum production sizes (the frontiers) of each region. This study is aimed to observe the factors that affect production, efficiency, and the technology gap in wetland rice farming using the data from 4,203 wetland rice farmers in 4 regions in Indonesia which were obtained from the Cost Structure of Food Crops Production Survey 2011 conducted by the BPS-Statistics Indonesia. This study was conducted using a metafrontier analysis to prove that the efficiency level in the 4 regions could not be compared to each other. In general, all the coefficients of the production function variables were positive and significant, as expected. The size of the harvested area was the strongest factor in influencing wetland rice production. The ten socio-economic variables in this study had various effects on the inefficiency of rice farming in each region. This study also demonstrated that the use of technical efficiency measurements taken based on their respective region's frontier would lead to biased and misguided policies; therefore, special notes are required in the analysis.

Keywords: *Efficiency, metafrontier, technology gap, wetland rice farming*
JEL Codes: Q12, Q16, Q18, Y40

1. Introduction

The production process can be judged technically inefficient if it is unable to yield the maximum productivity, which means that the utilization per unit input bundle does not result in maximum production (the frontier). The inefficiency issue is suspected to be the reason for farmers' low income and welfare because according to Saptana (2012), a high efficiency level in agribusiness strongly determines the farmers' welfare level.

Rice is still the staple food in Indonesia even though there are a few areas in Indonesia where they consume other staple foods. To this day, the people's dependence on rice is very strong; up to 95% of the Indonesian people consume rice as their staple food, even though Indonesia has 77 foods that have similar or a higher content of carbohydrate than rice. Because of the rapid population growth and the huge consumption of rice in Indonesia in addition to the fact that the international rice market is a thin market -rice producing countries are also rice consumers- Indonesia cannot rely on imported rice alone to fulfill the domestic demand for rice. Therefore, self-sufficiency policies and food diversification are important alternatives.

In general, the productivity of wetland rice in Indonesia has increased, even though in the past few years it has had a tendency to leveling-off. According to Tinaprilla (2012), the leveling-off of the productivity is thought to be caused by nutrient imbalances in the soil and the depletion of organic matter in soil as a result of overusing inorganic fertilizers and pesticides. On the other hand, clearing new farmland is more difficult because the cost for clearing new paddy fields and rehabilitating irrigation networks is expensive (Tinaprilla, 2012). As long as the food diversification programs do not succeed, the need for a supply of rice as a staple food is crucial. An important alternative to be considered to ensure the availability of rice is to increase land productivity through intensification or technology improvements and increasing rice farming efficiency.

The regions that are rice production centers in Indonesia that need to be considered in the intensification program are Sumatra, Java, and Bali. In these regions, the challenge to maintain paddy field use is escalating because it must compete with other agricultural commodities which are relatively more profitable; moreover, there is shifting in land use as a result of demands of industrialization and population growth. Meanwhile, regions other than Sumatra, Java, and Bali such as Kalimantan, Sulawesi and Eastern Indonesia are potential for extensification programs, but if extensification programs are applied in these regions, it will also face challenges in the form of high costs of clearing new farmland, establishing irrigation networks, and also the presence of trade off with other more promising agricultural commodities and the concern for preserving the forests for carbon trading.

Farmers from different regions, different islands, or different countries will face different production opportunities. Technically, those farmers would make choices from a number of different input-output combinations which are also known as a cluster of different kinds of technology (O'Donnell, Rao & Battese, 2008). Differences in soil fertility, weather conditions, precipitation, and pest outbreaks among regions would affect farming efficiency in each region. The economic level, infrastructure and facilities, quality of human resources, and education level of the farmers which affect technological accessibility and adeptness would also affect the efficiency of the farming (Chen & Song, 2006). Variation among regions in the use of input, production techniques, environmental conditions, *et cetera* are what Villano, Boshrabadi and Fleming (2010) defined as technology gaps. Interregional variation caused by indications of a technology gap lead to the fact that the maximum production size (the frontier) among regions cannot be compared to one another because each region has its own benchmark. Based on their individual production frontiers, each region could believe that they have reached a high efficiency level, whereas if compared to the efficiency level in other regions it might not be efficient yet. This will lead to biased analysis results and conclusions; therefore, a method that could accommodate the interregional technology gap, the metafrontier analysis approach, is required (George E. Battese & Rao, 2002; Chen & Song, 2006; Villano et al., 2010). Due to these conditions and facts, it is very important to conduct a study of the efficiency of wetland rice farming which puts interregional comparison in consideration.

Many studies about agribusiness efficiency using the metafrontier method have been conducted in other countries. Among them is the study by Rao, O'Donnell, and Battese (2003) that studied how to estimate the metafrontier function of the agricultural sector productivity data among regions and groups of regions between countries using the non-parametric data envelopment analysis (DEA) and the parametric framework of stochastic frontier analysis (SFA). Nkamleu, Nyemeck, and Sanogo (2006) studied the agricultural productivity in the continent of Africa between 1971 and 2000 using the metafrontier function technique with the purpose to observe the differences in efficiency and the technology gap in various areas in Africa. The results of the study supported the view that the technology gap plays an important role in explaining the ability of the agricultural sector in a certain area to compete with the agricultural sector in numerous other regions in Africa. The study also has proven that the average technical efficiency of the agricultural sector was nearly always stable and that there was a marginal decline of productivity potential in the 30-year period of observation. Boshrabadi, Villano and Fleming (2007) studied the technical efficiency and the differences in three varieties of pistachios in Iran. In addition to studying the stochastic frontier production using pooled data and the stochastic frontier production of each variety, they also studied the stochastic metafrontier production of the three nut varieties. Using these methods, the technical efficiency score could be corrected using the variety-technology gap ratio (VTGR). The results demonstrated the importance of calculating the differences in the frontier production functions set for different nut varieties because the three methods demonstrated different results. Medhin and Köhlin (2009) used the stochastic metafrontier approach to investigate the role of small-scale soil conservation in the highlands of Ethiopia. The estimated stochastic frontier in plot level and the metafrontier technology gap ratio (TGR) were applied to three soil conservation technology groups and a group of plots without any soil conservation. The results were that plots with soil conservation were more technically efficient than plots without conservation. The metafrontier estimate demonstrated that soil conservation could improve a natural plot's technological position.

A study using the metafrontier analysis has been conducted in Indonesia by Tinaprilla (2012) who studied rice production, technical efficiency and the factors which affected them and allocation efficiency and rice farming economic efficiency. The study was done using the 2010 PATANAS data based on the commodity rice in 5 rice-production center provinces with 592 observations. However, technical efficiency for the metafrontier obtained from this study was much lower in value than the technical efficiency of the regional frontier functions; therefore, it was possible that the conclusion and the policy implications made were biased. In order to assure that the metafrontier estimate functions could encompass the frontier functions of each region, this study uses the linear programming techniques as used in the study conducted by O'Donnell et al. (2008). Another point that sets this study apart is that the division of regions is different and these regions were formed with hypothesis assessments to ensure the presence of interregional technology gaps.

This metafrontier analysis will resolve a number of issues, including: (1) what factors affect the production level and technical efficiency of wetland rice farming in the 4 regions in Indonesia, and what the chances of each region for improving its efficiency are (2) what the national agribusiness' maximum technical efficiency potential is, the condition of each region's efficiency compared to the national maximum efficiency potential, and what the chances of each region are in reaching the maximum national potential.

In general, this study aims to analyze the technology gap in wetland rice farming in Indonesia using the metafrontier production function approach. Specifically, this study aims to:

1. Identify the factors that affect the production level and analyze the efficiency of wetland rice farming in Indonesia.

2. Measure and analyze the technology gap in wetland rice farming in Indonesia.

2. Study Methodology

2.1. Data Sources and Study Scope

This study uses secondary data, the results of the Cost Structure of Food Crops Production Survey 2011 conducted by the BPS-Statistics Indonesia. The data analyzed were obtained from 4,203 respondents, wetland rice farmers from 148 regencies in 13 provinces which are wetland rice production centers, Aceh, North Sumatra, West Sumatra, South Sumatra, Lampung, West Java, Central Java, East Java, Banten, Bali, West Nusa Tenggara, West Kalimantan, and South Sulawesi Provinces. The type of food crop dealt with in this study was only wetland rice. In line with this study's aims which are related to the intensification program, the regions in this study were grouped into Sumatra, Java, Bali and Other Regions. Pertaining to efficiency and the technology gap in wetland rice farming, the variables used in this study were: (1) The output in the form of the amount of wetland rice production; (2) Input: the area harvested, fertilizers, seed, and labor; (3) The characteristics of the farmers: gender, age, education; (4) The characteristics of the agribusiness: the planting period (sub-round), the land ownership status, funding, government aid, the use of soil-tilling equipment; and (5) Institution: expansion, farmer group membership.

The limitation in this study is that the data used is secondary data; therefore, the analysis conducted was limited to the variables available from the Cost Structure of Food Crops Production Survey 2011 data. The discussion is limited to the results of the production, efficiency and technology gap analyses with the metafrontier production function approach.

2.2. Modeling

2.2.1. Stochastic Frontier Production Function

The production function which will be used in this study use is the Cobb-Douglas production function. There are a number of reasons for using the Cobb-Douglas production function: its form is relatively simple, it can be transformed into a linear additive form, and it rarely causes problems. Many previous studies related to the stochastic frontier production function recommend the use of the Cobb-Douglas production function. This production function model was initially proposed separately by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). The error term in their model consists of two components, and as a result, this model was dubbed the "composed error model" by Jondrow, Lovell, Materov and Schmidt (1982), Abedullah, Kouser and Mushtaq (2007), Usman, Ilu and Sa'adatu (2013) and other researchers. This model is presented below:

$$\ln y_i = \beta_0 + \sum_m \beta_m \ln X_{mi} + \varepsilon_i \qquad (1)$$

where y_i denotes the output for the *i*th firm (farmer); X_{mi} denotes the vector of input *m* used by the *i*th farmer; β denotes the parameter coefficient vector; ε_i denotes the error term of the *i*th farmer.

The error term ε_i in this stochastic frontier function consists of two elements, v_i and u_i. The element v_i is an output variation caused by external factors (such as climate, pest outbreaks, natural disasters, *et cetera*) which cannot be controlled by the farmer, the distribution is symmetrical and normal, $v_i \sim N(0, \sigma^2_v)$. Whereas u_i reflects the inefficiency component which is the error term component which is internal (controllable) and is usually related to the farmer's managerial capability in managing his/her agribusiness. This component's distribution is asymmetrical (one sided), $u_i \geq 0$. If the production process is efficient (perfect), the output will overlap with the maximum production potential (the frontier) for the best practice. In this case, there is no inefficiency, which means that $u_i = 0$. On the other hand, if $u_i > 0$, meaning it is below the potential, it is stated that there is inefficiency in the agribusiness. The distribution is half normal ($u \sim |N(\mu_i, \sigma^2_u)|$).

Referring to the study by George E. Battese, Rao, and O'Donnell (2004), for a number of N farmers in a given region who farm wetland rice using an array of inputs, the general form of the stochastic frontier production function of the *i*th farmer in the *j*th region is expressed by

$$Y_i = f(x_{i(j)}, \beta_{(j)})e^{v_{i(j)} - u_{i(j)}} \equiv e^{x_i\beta_{(j)} + v_{i(j)} - u_{i(j)}} \qquad (2)$$

with $i = 0, 1, 2, ..., N_j$ and $j=1, 2,..., J$

The form of equation (2) assumes that the exponents of the frontier production function are linear in the parameter vector $\beta_{(j)}$, and x_i is a vector (or the transformation) of the *i*th farmer's inputs.

Based on the input and output data of wetland rice farming in the *j*th region, an estimate of the frontier production function parameters, both the estimate using the Ordinary Least Square (OLS) method and the estimate using the Maximum Likelihood Estimation (MLE). According to Greene (2002), the unbiased estimation method is the MLE. The stochastic frontier model estimation is conducted through a two phase process. The first phase uses the OLS method to estimate the parameter for production inputs (β_i) and the second uses the MLE method to estimate the whole production factor parameter (β_i), and the variant of the two error term components v_i and u_i (σ^2_v and σ^2_u).

The general Cobb-Douglas production function using four input variables for the *j*th region after being transformed into the linear logarithm can be written as

$$\ln Y_i = \beta_{0(j)} + \beta_{1(j)}\ln X_{1i} + \beta_{2(j)}\ln X_{2i} + \beta_{3(j)}\ln X_{3i} + \beta_{4(j)}\ln X_{4i} + (v_{i(j)} - u_{i(j)}) \qquad (3)$$

where Y_i denotes the amount of wetland rice production (tons), X_{1i} denotes the harvest area (hectare), X_{2i} denotes the amount of labor (man days), X_{3i} denotes the dummy for seed (1-non-local 0-local), X_{4i} denotes the amount of fertilizer (kg), β_0 denotes the intercept, β_1, β_2, β_3, and β_4 are the parameter estimation coefficients, $v_i - u_i$ denotes the error term (v_i is the random effect, and u_i is the non-technical efficiency effect in the model), i denotes the *i*th farmer, and j denotes the *j*th region. The *i*th farmer's technical efficiency (TE) in the *j*th region (George E Battese & Coelli (1988); O'Donnell et al. (2008)) can be calculated using

$$TE_i = \frac{Y_i}{e^{x_i\beta_{(j)} + v_{i(j)}}} = e^{-u_{i(j)}} \qquad (4)$$

The value of technical efficiency is between zero and one, $0 \leq TE_i \leq 1$. Technical efficiency is the reverse of technical inefficiency; therefore, the value of technical inefficiency is $1-TE_i$. The firm's (the farmer) efficiency is defined as the a farmer's actual productivity compared to the maximum potential productivity (Farrell, 1957).

The technical inefficiency function using the ten socio-economic variables deemed to have an influence on the *i*th farmer in a given region's inefficiency in wetland rice farming in this study can be written as

$$u_i = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 + \delta_5 z_5 + \delta_6 z_6 + \delta_7 z_7 + \delta_8 z_8 + \delta_9 z_9 + \delta_{10} z_{10} + w_i \qquad (5)$$

where u_i denotes the technical inefficiency effect, z_1 denotes the dummy for the farmers' gender (1-Male 0-Female), z_2 = age (years), z_3 = duration of formal education proxied by the highest diploma owned (0-None/did not graduate from elementary school 6-elementary school 9-junior high school 12-senior high school 14-D1/D2 15-Academy/D3 17-bachelor degree D4/S1 20-master/doctorate degree), z_4 denotes the dummy for soil tilling (1-Uses a tractor 0-Does not use a tractor), z_5 denotes the dummy for access to credit (1-received credit 0-did not receive credit), z_6 denotes the dummy for receiving grants or subsidies (1-yes 0-no), z_7 denotes the dummy for receiving extension (1-yes 0-no), z_8 denotes the dummy for farmer group membership (1-yes 0-no), z_9 denotes the dummy for the planting season/sub-round (1-Rain Season (January to April) 0-Dry Season (May to August)), z_{10} denotes the dummy for land ownership status (1-owned by the farmer 0-not owned by the farmer), w_i denotes the random variable, and δ_1, ..., δ_{10} denote the estimate parameters of the inefficiency variable.

2.2.2. The Metafrontier Production Function and Technology Gap

The term *metafrontier* was first introduced by George E. Battese and Rao (2002) based on the study by Hayami and Ruttan (1969) who used the term *metaproduction* as an envelope term that includes all existing production functions. George E. Battese and Rao (2002) used the metafrontier production function to investigate the technical efficiency of firms in different groups which could possibly have dissimilar technology. There are a number of approaches that could be used to conduct estimation in relation to frontier production. However, efficiency estimates in stochastic frontier models usually assume that the production technology used is the same for all of the farming in every region, while the different characteristics among regions could lead to the use of different technology in the regions. The unobserved technology gap is considered inappropriate as an inefficiency factor if the variations in production technology is not put in consideration (Villano et al., 2010). This study uses the metafrontier analysis as in George E. Battese et al. (2004) to overcome the gap in a given region in its agricultural production frontier and to obtain each region's comparable technical efficiency. The metafrontier analysis was used not only because of its ability to conduct estimates of the parameters within the frontier production function and technical efficiency but also because of its ability in performing an estimation of the technology gap ratio.

Referring to the study by George E. Battese et al. (2004), the metafrontier production function model for all the farmers in the 4 regions can be written as

$$Y_i^* \equiv f(x_i, \beta^*) = e^{x_i\beta^*} \quad i = 0, 1, 2, ..., N; \; N = \sum_{j=1}^{4} N_j \tag{6}$$

where β^*denotes the parameter vector from the metafrontier function so that

$$x_i\beta^* \geq x_i\beta_{(j)} \;, j=1,2,...,j \tag{7}$$

This metafrontier production function is an envelope function of the stochastic frontier functions of each region which was developed from the data of all of the farmers in the 4 regions. The metafrontier production function is such a deterministic parametric function that it has a value of no less than the deterministic components of the stochastic frontier functions for the regions. The metafrontier production function is a frontier production function which envelopes all the frontier production functions of each region. The metafrontier function is assumed to be a smooth function and it envelopes the stochastic frontier functions for different regions in an unsegmented way (George E. Battese et al., 2004).

The stochastic frontier production function of *i*th farmers in the *j*th region as in equation (2) can be expressed in the form of a new equation that involves the metafrontier functions in equation (6) as follows

$$Y_i = e^{-U_{i(j)}} \cdot \frac{e^{x_i \beta_{(j)}}}{e^{x_i \beta^*}} \cdot e^{x_i \beta^* + v_{i(j)}} \tag{8}$$

The first form on the right-hand side of equation (8) is the technical efficiency relative to the stochastic frontier for the *j*th region as in equation (4), the second form on right-hand side of equation (8) is the technology gap ratio (TGR) of the *i*th farmer in the *j*th region,

$$\mathrm{TGR}_i = \frac{e^{x_i \beta_{(j)}}}{e^{x_i \beta^*}} \tag{9}$$

The technology gap ratio (TGR) is defined as the ratio between the highest output which a region could achieve and the highest output a region could achieve at the metafrontier at the use of a certain combination of inputs. Because of equation (7), the TGR has a value between zero and one, 0<TGR<1. If a farmer has a TGR=1, that farmer is already at the point where he/she is the most efficient in the farming, meaning that that farmer has already used the input combination and technology which is most optimum, resulting in the most optimum production and is on the metafrontier. The technical efficiency of the *i*th farmer relative towards the potential output at the metafrontier is notated as TE_i^* which is defined as analogous to equation (4), is the ratio between the output of the *i*th farmer relative to the third form on the right-hand side of equation (8) which is the metafrontier output

$$\mathrm{TE}_i^* = \frac{Y_i}{e^{x_i \beta^*_{(j)} + v_{i(j)}}} \tag{10}$$

Based on the equations (8) to (10), the technical efficiency relative to the metafrontier could be obtained through the equation

$$\mathrm{TE}_i^* = \mathrm{TE}_i \text{ x } \mathrm{TGR}_i \tag{11}$$

Because the values of TE_i and TGR_i are between zero and one, the value of TE_i^* is also between zero and one, $0 < \mathrm{TE}_i^* < 1$, but smaller than the TE_i value.

3. Results and Discussion

Before the analysis is performed, referring to the study by Kokkinou (2012), there needs to be a hypothesis test to assess whether there is an inefficiency effect on the stochastic production function of the frontiers in each region, and whether a technology difference exists in each region. This is necessary because if in all of the regions there is neither the inefficiency effect nor any technology difference, the technology gap analysis using the metafrontier analysis is redundant. Based on the results of the analysis which are presented in Table 1, all the regions could be included in the analysis because the LR values of the test of the one-sided error are all higher than the χ^2 values obtained from Table 1 Kodde and Palm (1986) at a significance level of α = 5%. Therefore, the zero hypothesis that there are no inefficiency effects in the stochastic frontier model can be rejected, meaning that there was a significant inefficiency effect in all the regions. Referring to O'Donnell et al. (2008), the next hypothesis test is testing whether there is a technology gap between regions. This is tested by adding up all the log likelihood function $\ln[L(H_1)]$ values of each region and comparing it to the ln[L(H_1)] of the pooled production function of all of the regions. The hypothesis test is classified as rejecting H_0 if $\sum_{j=1}^{4} ln[L(H_1)]_j > ln[L(H_1)]_{pooled}$. The result is the sum of all the log likelihood function values of each region (-753.08) is larger than the pooled value of all regions (-864.33) which means that the zero hypothesis-there is no technology gap in each region-is rejected. From the two hypothesis tests, it is decided that the technology gap analysis using the metafrontier approach can be conducted.

Table 1. Regional Production Functions and Inefficiency Region, Pooled and Metafrontier

Production variable	Coe	Sumate	Java	Bali	Others	Pooled	Meta
(Constant)	β_0	0.698**	0.911*	0.834*	0.401*	0.751*	0.8931
Area Planted (X_1)	β_1	0.828**	0.875*	0.898*	0.826*	0.858*	0.8417
Amount of Labor (X_2)	β_2	0.044**	0.064*	0.087*	0.085*	0.061*	0.0606
Seed Dummy (X_3)	β_3	0.121**	0.086*	0.150*	0.026	0.087*	0.0167
Amount of Fertilizer	β_4	0.102**	0.058*	0.031	0.136*	0.081*	0.0846
Inefficiency Variable							
Gender Dummy (z_1)	δ_1	-0.085	0.075*	0.135*	0.006	0.052*	0.0000
Age(z_2)	δ_2	0.004**	0.002*	0.004*	0.000	0.002*	0.0000
Education (z_3)	δ_3	-	0.000	-	0.019*	-	0.0000
Tractor Dummy (z_4)	δ_4	-	-	-	-	-	0.0000
Credit Dummy (z_5)	δ_5	0.227**	-0.015	0.040	-	0.009	0.0000
Grant Dummy (z_6)	δ_6	-0.010	0.062*	-0.045	-	0.077*	0.0000
Expansion Dummy	δ_7	0.139**	-	-0.007	-	-	0.0000
Farmer's Group	δ_8	-	-	0.029*	0.120*	-	0.0000
Planting Season	δ_9	0.058*	-0.029*	0.085*	0.234*	0.015	0.0000
Land Status Dummy	δ_{10}	-	0.021*	-	-	-	0.0000
sigma-squared (σ^2)		0.0949	0.0823	0.0987	0.0959	0.0888	9.37E-
gamma (γ)		0.1575	0.0008	0.0616	0.1772	0.0096	0.6100
Σβ		0.97	1.00	1.02	1.05	1.00	0.99
log likelihood function		-	-316.88	-88.96	-122.86	-864.33	11620
LR test of the one-		24.5756	60.817	49.137	42.322	99.437	63.482
$\chi 2$ Kodde & Palm α =		19.0450	19.045	19.045	19.045	19.045	
Technical Efficiency		0.9571	0.9210	0.9262	0.9280	0.9586	1.0000
TGR		0.9404	0.9187	0.8368	0.8830		
TE^M (with		0.9001	0.8462	0.7748	0.8197		

Source: Results of processing
Note: ***=sig. α=1%, **=sig. α=5%, *=sig. α=10%

The results of the data processing presented in Table 1 demonstrate that in general, all the production function variable coefficients have a positive value and are significant at α=1%, except in the region of Bali where the dummy coefficient for non-local seed is significant at α=10% and the variable coefficient of fertilizer is not significant. The area harvested (ha) in all regions is very dominant in affecting wetland rice production, demonstrated by the average elasticity which is higher than 80%, compared to the elasticity of the use of labor and fertilizer. This demonstrates that wetland rice production is quite responsive to the area harvested, and this condition is not unusual because generally a larger area planted would increase the wetland rice production; therefore, if the government wishes to make a policy to increase wetland rice production, one of the main focuses is to increase the area planted.

The results of the data processing also demonstrate that the ten socio-economic variables have a variety of effects on rice farming inefficiency in each region. In general, the education level, use of tractors, availability of credit, availability of expansion, membership in a farmers' group and land ownership status have a negative effect on inefficiency or it could be interpreted that these factors have a positive effect on the efficiency of wetland rice farming. On the other hand, the farmer's gender, age, availability of grants, and planting season generally have a positive effect on inefficiency, meaning that these factors cause wetland rice farming to be inefficient.

Table 2. Technical Efficiency and the Technology Gap in Wetland Rice Farming According to Production Center Regions in Indonesia

Region	Number of Obs.	Average	Min.	Max.	Std. Dev.	Variance
Technical efficiency based on the stochastic frontier production function (TE)						
Sumatra	1352	0.9571	0.6382	0.9867	0.0397	0.0016
Java	1788	0.9210	0.7471	1.0000	0.0531	0.0028
Bali	368	0.9262	0.6348	1.0000	0.0923	0.0085
Others	695	0.9280	0.6792	1.0000	0.0559	0.0031
Technology gap (TGR)						
Sumatera	1352	0.9404	0.7963	1.0000	0.0367	0.0013
Java	1788	0.9187	0.8240	1.0000	0.0213	0.0005
Bali	368	0.8368	0.6320	0.9868	0.0331	0.0011
Others	695	0.8830	0.7239	1.0000	0.0428	0.0018
Technical efficiency based on the metafrontier production function (TE*)						
Sumatera	1352	0.9001	0.5982	0.9700	0.0527	0.0028
Java	1788	0.8462	0.6684	0.9989	0.0531	0.0028
Bali	368	0.7748	0.4578	0.9734	0.0813	0.0066
Others	695	0.8197	0.5625	0.9830	0.0673	0.0045
Analysis of technology gap						

TE Rank			TE* Rank		
1	Sumatera	0.95707	1	Sumatera	0.90010
2	Others	0.92805	2	Java	0.84624
3	Bali	0.92621	3	Others	0.81975
4	Java	0.92096	4	Bali	0.77482

Source: Results of processing

The technical efficiency (TE) value for each region demonstrates that it could be considered efficient in each region if the minimum limit is 90%. The highest average technical efficiency is found in the region of Sumatra region at 95.71% and the lowest is in the region of Java at 92.10%. The maximum technical efficiency (TE=1) occurs in all regions except for Sumatra, and the minimum technical efficiency occurs in the region of Bali. Based on the benchmarks of each region's frontier, this already-efficient condition has implications on each region, making each region satisfied with their wetland rice farming efficiency because the chances to reach a condition of perfect technical efficiency are very slim.

The technology gap in a certain region against the metafrontier can be measured by observing the size of the Technology Gap Ratio (TGR). Based on the average TGR, it can be observed that the region of Sumatra has the smallest technology gap, which means that the use of technology in Sumatra is relatively better than the other regions. Using the TGR values, the technical efficiency (TE) of each region could be corrected and compared because the technology gap aspect is considered, leading to new technical efficiency (TE*) values. It is evident that the technical efficiency value in every region after the technology gap is put in consideration becomes lower than the technical efficiency value which referred to each region’s frontier. The implications are that the national agricultural development policies which are based on the local technical efficiency assessment (without considering the technology gap aspect) could be biased and misdirected because if the minimum limit is 90%, only the region of Sumatra is efficient. In addition, the region of Sumatra that is overlooked because it has been thought to be efficient should actually be given special attention because it is not yet efficient in reality. This means that the regions of Java, Bali and Others still have a chance to improve their technical efficiency. Based on the ranking of the TE* values, it can be seen that the region of Java, which was thought to be the most inefficient, after considering the technology gap aspect, is in the second place after the region of Sumatra, whereas the region of Bali should receive the most attention in improving its technical efficiency because in the ranking is in the last position.

4. Conclusion

The size of land harvested has the most dominant influence on wetland rice production in all the regions in Indonesia, whereas a number of socio-economic variables have a variety of effects on inefficiency. If the minimum limit used is 90%, in general, based on the size of the frontier of each region which does not consider the presence of a technology gap, all the regions in Indonesia are technically efficient; however, if the technology gap is put in consideration, only the region of Sumatra is relatively efficient. Based on this finding, a special explanation that the use of the efficiency value cannot be compared with other regions is needed for the policy implications in a region. For example, the 92.62% efficiency of wetland rice farming in Bali cannot be proclaimed efficient or more efficient compared with other regions because this percentage is based on the frontier benchmark for Bali Island alone. In reality, if the technology gap is put in consideration, the wetland rice farming agribusiness has an efficiency rate of 77.48% and cannot be considered technically efficient if the minimum limit is 90%.

The relatively large technology gap against the metafrontier occurs outside of Sumatra and Java, demonstrating that there exists many opportunities to improve the efficiency of wetland rice farming in those regions. If the presence of the technology gap aspect is put in consideration, a priority scale for the wetland rice farming intensification policy could be developed, starting from the regions that still have many opportunities in decreasing the technology gap and increasing agribusiness efficiency. Based on the results of this study, the priority ranking for the regions in Indonesia that need extra attention in the intensification policy starts with Bali Island, Other regions (aside from Sumatra, Java and Bali), then Java Island and finally Sumatra Island. Therefore, making the decision based on the technology gap aspect in creating a priority scale for agricultural development, especially for wetland rice farming which is based on technical efficiency measures, is more suitable.

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