Technical Efficiency and Technology Gap in Indonesian Rice Farming
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Abstract
This study aims to estimate the technical efficiency and technology gap in Indonesian rice farming, and analyze its determinants. An analysis of DEA Metafrontier and Tobit regression was applied respectively for the first and second objective. The data is based on farm level data of fifteen rice–producing provinces in Indonesia. The result showed that the technical efficiency based on metafrontier estimation is slightly lower than the technical efficiency based on regional frontier estimation, indicating the existence of technology gap which is quite small. Net income, education, and irrigated rice field found related to the technical efficiency and technology gap. Meanwhile, the effect of other factors on the technical efficiency and technology gap is ambiguous. Hence, this study suggests that these three factors should be considered in the policy to increase technical efficiency and to reduce the technology gap in Indonesian rice farming.

Keywords
Rice farming, technical efficiency, technology gap, DEA metafrontier, Tobit regression.

Introduction
Technical efficiency of rice farming in Indonesia has been investigated by many researchers based on frontier production function estimation. As examples, Widodo (1986) showed that the average technical efficiency of rice farming in West Java is 0.73-0.76, while in Yogyakarta is 0.85-0.86. Squires and Tabor (1991) find that the average technical efficiency of rice farming in Java and off Java is 0.697 and 0.704 respectively. According to Llewelyn & Williams (1996), the average technical of rice farming in East Java is 0.87. Fabiosa et al. (2004) showed that the average technical efficiency in West Java is 0.66, while in East Java and Central Java are 0.72 and 0.76 respectively. Study conducted by Brazdik (2006) in West Java showed that the average technical efficiency of rice farming in this region is around 0.60-0.77. A Study by Kusnadi (2011) used a sample of 802 farmers based on PATANAS survey data showed that the average technical efficiency of rice farming in Indonesia is around 0.92. Makki et al. (2012) showed that the average technical efficiency of rice farming in the province of South Kalimantan is 0.78. Furthermore, Suharyanto et al. (2013) showed that the average technical efficiency of rice farming in the province of Bali is 0.88.

However, these studies did not take into account the technological gap between the farmers. Thereby, the technical efficiencies are not comparable between the farmers who operate under a given production technology and the farmers which are operating under different production technology. Conceptually, a comparable technical efficiency can be estimated by using metafrontier production function [see Battese and Rao (2002); Battese et al. (2004); O’Donnell et al. (2008); Chen and Song (2008) for a detailed discussion].

A meta production function introduced by Hayami (1969, 1970), Hayami and Ruttan (1969, 1970, 1972) to explain agricultural productivity differences on a global level. Meta production function or potential production function is described as an envelope for less elastic isoquant of agricultural producer groups in different countries with different technologies (Hayami and Ruttan, 1969), or the envelope for individual production curve (Hayami and Ruttan, 1972). The function can be obtained by estimating general production functions or cross country (Hayami and Ruttan, 1970).
The concept of meta production is interesting because it incorporates data from different countries to estimate general production function, thus increasing both the range of independent variables or even the total number of observations, and thereby reducing the possibility of multicollinearity, improving the reliability of the production estimation. In addition, the meta production function can be estimated using intercountry data, although the individual production functions of the countries cannot be estimated using individual country data because the number of observations may not be enough.

Hayami and Ruttan estimate meta production functions using ordinary least squares (OLS) method. Many studies followed the concept and methodology of meta production function estimation [see for example Kawagoe and Hayami (1983); Kawagoe et al. (1985); Lau and Yotopoulos (1971, 1989); Marra and Schurle (1994); Fulginiti and Perrin (1998); Alston et al. (2000)]. Based on the concept of meta production, many studies estimate metafrontier production function to explain the technology gap between producer groups using parametric approach whether deterministic (DFA-MF) or stochastic (SFA-MF), and nonparametric approach Data envelopment analysis (DEA-MF). Kudaligama and Yanagida (2000) estimate DFA-MF and SFA-MF based on the data used by Hayami and Ruttan (1985) by modifying certain variables. The estimation of DFA-MF is conducted by using Minimum Absolute Deviation (MAD) techniques through linear programming (LP) as in Aigner and Chu (1968). Meanwhile, SFA-MF is estimated based on the data of all producers groups, all countries in the same time using a maximum likelihood method. This procedure estimation of SFA-MF is also used by Gunaratne and Leung (2000) to estimate the SFA-MF for black tiger shrimp production systems in Asia.

Rao et al. (2003) estimate DEA-MF and SFA-MF based on FAOSTAT data which consists of 97 major agricultural producing countries in the world. According to Rao et al. (2003), metafrontier function is an envelop to deterministic component of stochastic estimation for different regions. A similar definition can be seen as examples in Battese et al. (2004), Chen & Song (2008), O’Donnell et al. (2008), and Moreira and Bravo-Ureta (2010). The estimation of SFA-MF use linear programming and quadratic programming techniques. Battese et al. (2004) also apply this estimation procedure for textile industries in Indonesia. Chen and Song (2008) use the same procedure to explain efficiency and technology gap of agriculture in China.


Empirically, SFA-MF and DEA-MF are the most widely use to investigate technical efficiency and technology gap in related studies. However, a study conducted by O’Donnell et al. (2008) which is applying both the approaches by using the same sets of data showed that technical efficiency and technology gap based on the estimation of DFA-MF and DEA-MF is greater than technical efficiency and technology gap based on SFA-MF estimation. In addition, the regional technical efficiency is greater than meta technical efficiency. This study employs DEA-MF. Because of DEA use linear programming technique, so that frontier estimated based on all observation data (pooled data) using DEA is already the metafrontier. The next section of this papers sequentially will discuss materials and methods, results and discussion, and conclusion.

Materials and methods

This study covered of fifteen rice-producing provinces in Indonesia. All the fifteenth of provinces will be grouped into five rice-producing regions, namely Sumatera, Java, Bali and Nusa Tenggara, Kalimantan, and Sulawesi. Total number of observation is 5537 rice farmers. Data used in this study is taken from a survey on the cost structure of rice farming conducted by the Central Bureau of Statistics of the Republic of Indonesia (BPS) in 2008.

An output-oriented DEA model assuming variable returns to scale (VRS) is used to estimate production frontier. The model was adopted from O’Donnell (2008):
where $y_i$ = the quantity of output in the form of dry grain harvest (in kilograms) of the $i$-th farmers; $x_i$ = $N \times 1$ vector of input quantities for the $i$-th farmers. These inputs consist of harvested area (in square meters), seeds (in kilograms), fertilizer (in kilograms), and labor (in person days); $Y = L_k \times 1$ vector of output quantity for all $L_k$ farmers; $X = N \times L_k$ vector of input quantities for all $L_k$ farmers; $j = an \ L_k \times 1$ vector of ones; $\lambda_i = an \ L_k \times 1$ vector of weights; $\phi_i = a$ scalar.

Solving the linear programming of equation (1) for each region separately will obtain the technical efficiency score for each farmers relative to regional frontier. The value of $\phi - 1$ shows the proportional increase in output that can be achieved by the $i$-th farmers with inputs held constant. The technical efficiency defined as $1/\phi$ with value between 0 and 1.

A convex metafrontier can be estimated by apply DEA model such as in equation (1) based on pooled data observation of inputs and output for all $L = \sum L_k$ farmers in all regions (O’Donnell et al., 2008). The optimum solution of DEA metafrontier generates technical efficiency score for each farmers relative to regional frontier. The value of $\phi - 1$ shows the proportional increase in output that can be achieved by the $i$-th farmers with inputs held constant. The technical efficiency defined as $1/\phi$ with value between 0 and 1.

Technology gap is measured by metatechnology ratio (MTR). The ratio is defined as technical efficiency based on DEA metafrontier divided by technical efficiency based on regional frontier (O’Donnell et al., 2008; Battese et al., 2004). The value of MTR is between 0 and 1. MTR closer to 1 indicates that the maximum output achieved by farmers is closer to metafrontier output, meaning that technology gap between regional technology adopted and metatechnology is very small.

Tobit regression models was used to determine effects of the number specific factors on the technical efficiency and technology gap separately. The model is adopted from Chavas and Aliber (1993), Chavas et al. (2005), and Chen and Song (2008) by a modification in variables used. General specification Tobit model is written as:

$$Y_i = \beta_0 + \beta_1 INCOME_{i} + \beta_2 AGE_{i} + \beta_3 EDU_{i} + \beta_4 SIZE_{i} + \beta_5 SEED_{i} + \beta_6 FIELD_{i} + \beta_7 PEST_{i} + \beta_8 GOV_{i} + \beta_9 CREDIT_{i} + \beta_{10} SOM + \beta_{11 JAVA} + \beta_{12 KAL} + \beta_{13 SUL} + e_i$$

where $Y_i$ is the technical efficiency and MTR respectively obtained from the DEA estimation; $\beta$ is unknown parameter to be estimated; $e_i$ is an error term, assumed $e_i \sim iid \ N(0, \sigma^2)$; $INCOME$ = net income from rice farming (in log); $AGE$ = age of farmers (in year); $EDU$ = formal education (D = 1 for senior high school & the higher education, otherwise D = 0); $SIZE$ = land size (in log); $SEED$ = type of seed (D=1 for high-yielding certified seed, otherwise D = 0); $FIELD$ = irrigated rice field (D=1 for cultivation in irrigated rice field, otherwise D = 0); $PEST$ = pests and diseases (D = 1 if there were pests and diseases, otherwise D = 0); $GOV$ = government assistance (D = 1 for farmers who gets production input assistance free from government, otherwise D = 0); $CREDIT$ = farmers’ access to credit (D = 1 if farmers don’t experience difficulty to obtain credit from formal financial institutions, otherwise D = 0). $SUM, JAVA, KAL, SUL$ respectively is regional dummy variable for Sumatera, Java, Kalimantan and Sulawesi. Parameters are estimated by maximum likelihood method using Eviews software 7.1 version. Since the dataset does contain capital variable we assume capital separability in the interval of our analysis.

Results and discussion

1. Descriptive statistics of variables

Table 1 represents summary statistics of variables. The first five variables in Table 1 are the output and inputs used in the DEA models. Meanwhile, nine other variables are the specific factors in rice farming used in Tobit models to explain the variation in technical efficiency and technology gap between the farmers.
2. Technical efficiency and technology gap

Table 2 reports summary statistics of the regional technical efficiency (TE-K), meta technical efficiency (TE-MF) and metatechnology ratio (MTR) obtained from DEA estimation. The TE-K, TE-MF and MTR are varying between the regions. The average of TE-K is 0.767 in Java and 0.807 in Bali & Nusa Tenggara, for example, indicate that the maximum output obtained using the production inputs with the existing technology in Java, and Bali is around 77% and 80% of the output potential in both regions respectively. Meanwhile, the average of MTR 0.838 in Java and 0.870 in Bali & Nusa Tenggara indicate that the maximum output which achieved in Java and Bali & Nusa Tenggara using the production inputs in those regions respectively with metatechnology is approximately 87% and 72% of the maximum output represented by metafrontier.

In all regions, the TE-MF is slightly lower than
the TE-K. For example, the average TE-MF 0.630 for Java is lower than the average TE-K 0.767 for this region. Based on TE-MF, it can be said that the technical efficiency in Bali and Nusa Tenggara region is the highest compared to any other region. In contrast, technical efficiency in Kalimantan is the lowest than in any other regions.

Based on the DEA estimation of regional frontiers, metafrontier and metatechnology ratio, TE-K, TE-MF and MTR for fifteen provinces covered by the five groups of region can also be obtained. Descriptive statistics of the TE-K, TE-MF and MTR by province are presented in Table 3. In this context, the table 3 is basically describing

<table>
<thead>
<tr>
<th>Region</th>
<th>Statistics</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sumatera (n = 1259)</td>
<td>TE-K</td>
<td>0.768</td>
<td>0.167</td>
<td>0.270</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>MTR</td>
<td>0.818</td>
<td>0.102</td>
<td>0.489</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>TE-MF</td>
<td>0.624</td>
<td>0.140</td>
<td>0.227</td>
<td>1.000</td>
</tr>
<tr>
<td>Java (n = 3273)</td>
<td>TE-K</td>
<td>0.767</td>
<td>0.139</td>
<td>0.270</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>MTR</td>
<td>0.838</td>
<td>0.132</td>
<td>0.579</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>TE-MF</td>
<td>0.630</td>
<td>0.096</td>
<td>0.225</td>
<td>1.000</td>
</tr>
<tr>
<td>Bali &amp; Nusa Tenggara (n = 243)</td>
<td>TE-K</td>
<td>0.807</td>
<td>0.136</td>
<td>0.519</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>MTR</td>
<td>0.870</td>
<td>0.077</td>
<td>0.587</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>TE-MF</td>
<td>0.698</td>
<td>0.118</td>
<td>0.489</td>
<td>1.000</td>
</tr>
<tr>
<td>Kalimantan (n = 287)</td>
<td>TE-K</td>
<td>0.787</td>
<td>0.138</td>
<td>0.445</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>MTR</td>
<td>0.717</td>
<td>0.138</td>
<td>0.457</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>TE-MF</td>
<td>0.563</td>
<td>0.150</td>
<td>0.380</td>
<td>1.000</td>
</tr>
<tr>
<td>Sulawesi (n = 475)</td>
<td>TE-K</td>
<td>0.801</td>
<td>0.114</td>
<td>0.444</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>MTR</td>
<td>0.846</td>
<td>0.060</td>
<td>0.573</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>TE-MF</td>
<td>0.678</td>
<td>0.115</td>
<td>0.402</td>
<td>1.000</td>
</tr>
<tr>
<td>National (N=5537)</td>
<td>TE-K</td>
<td>0.773</td>
<td>0.144</td>
<td>0.270</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>MTR</td>
<td>0.829</td>
<td>0.123</td>
<td>0.457</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>TE-MF</td>
<td>0.633</td>
<td>0.116</td>
<td>0.225</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Source: DEA estimation

Table 2: Summary statistics of the technical efficiencies and metatechnology ratios by region.

<table>
<thead>
<tr>
<th>Province</th>
<th>n</th>
<th>TE-K</th>
<th>MTR</th>
<th>TE-MF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Nanggroe Aceh Darussalam</td>
<td>155</td>
<td>0.739</td>
<td>0.184</td>
<td>0.813</td>
</tr>
<tr>
<td>North Sumatera</td>
<td>390</td>
<td>0.772</td>
<td>0.129</td>
<td>0.870</td>
</tr>
<tr>
<td>West Sumatera</td>
<td>212</td>
<td>0.648</td>
<td>0.198</td>
<td>0.749</td>
</tr>
<tr>
<td>South Sumatera</td>
<td>261</td>
<td>0.836</td>
<td>0.144</td>
<td>0.776</td>
</tr>
<tr>
<td>Lampung</td>
<td>241</td>
<td>0.813</td>
<td>0.141</td>
<td>0.844</td>
</tr>
<tr>
<td>West Java</td>
<td>1116</td>
<td>0.707</td>
<td>0.119</td>
<td>0.861</td>
</tr>
<tr>
<td>Central Java</td>
<td>958</td>
<td>0.907</td>
<td>0.061</td>
<td>0.662</td>
</tr>
<tr>
<td>East Java</td>
<td>990</td>
<td>0.695</td>
<td>0.116</td>
<td>0.971</td>
</tr>
<tr>
<td>Banten</td>
<td>209</td>
<td>0.784</td>
<td>0.113</td>
<td>0.892</td>
</tr>
<tr>
<td>Bali</td>
<td>89</td>
<td>0.862</td>
<td>0.091</td>
<td>0.839</td>
</tr>
<tr>
<td>West Nusa Tenggara</td>
<td>154</td>
<td>0.775</td>
<td>0.147</td>
<td>0.889</td>
</tr>
<tr>
<td>West Kalimantan</td>
<td>110</td>
<td>0.764</td>
<td>0.170</td>
<td>0.871</td>
</tr>
<tr>
<td>South Kalimantan</td>
<td>177</td>
<td>0.801</td>
<td>0.111</td>
<td>0.621</td>
</tr>
<tr>
<td>Central Sulawesi</td>
<td>84</td>
<td>0.803</td>
<td>0.161</td>
<td>0.829</td>
</tr>
<tr>
<td>South Sulawesi</td>
<td>391</td>
<td>0.800</td>
<td>0.101</td>
<td>0.681</td>
</tr>
</tbody>
</table>

Source: DEA estimation

Table 3: Summary statistics of the technical efficiencies and metatechnology ratios by province.
the distribution of the TE-K, TE-MF and MTR regions to the province. Therefore, the interpretation of the score TE-K, TE-MF and MTR is not different from the previous paragraph.

3. The determinants of technical efficiency and technology gap

The maximum likelihood estimation results of such determining factors to the TE-K, TE-MF and MTR are shown in Table 4.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Symbol</th>
<th>TE-K</th>
<th>TE-MF</th>
<th>MTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td></td>
<td>0.6660***</td>
<td>0.3730***</td>
<td>0.6436***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0231)</td>
<td>(0.0185)</td>
<td>(0.0208)</td>
</tr>
<tr>
<td>Net income</td>
<td>INCOME</td>
<td>0.0313***</td>
<td>0.0680***</td>
<td>0.0515***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0034)</td>
<td>(0.0027)</td>
<td>(0.003)</td>
</tr>
<tr>
<td>Age</td>
<td>AGE</td>
<td>0.0009***</td>
<td>-0.0001***</td>
<td>-0.0008***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0002)</td>
<td>(0.0001)</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>Education</td>
<td>EDU</td>
<td>0.0542***</td>
<td>0.0411***</td>
<td>0.0094***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0038)</td>
<td>(0.0028)</td>
<td>(0.0036)</td>
</tr>
<tr>
<td>Land size</td>
<td>SIZE</td>
<td>-0.0253***</td>
<td>-0.0322***</td>
<td>-0.0169***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0035)</td>
<td>(0.0029)</td>
<td>(0.0032)</td>
</tr>
<tr>
<td>Type of seed</td>
<td>SEED</td>
<td>0.0799***</td>
<td>0.0316***</td>
<td>-0.0411***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0036)</td>
<td>(0.0024)</td>
<td>(0.0034)</td>
</tr>
<tr>
<td>Irrigated rice field</td>
<td>FIELD</td>
<td>0.0480***</td>
<td>0.0498***</td>
<td>0.0122***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0034)</td>
<td>(0.0024)</td>
<td>(0.0033)</td>
</tr>
<tr>
<td>Pests &amp; diseases</td>
<td>PEST</td>
<td>-0.0631***</td>
<td>-0.0325***</td>
<td>0.0169***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0035)</td>
<td>(0.0025)</td>
<td>(0.0034)</td>
</tr>
<tr>
<td>Government assistance</td>
<td>GOV</td>
<td>0.0607***</td>
<td>0.0355***</td>
<td>-0.0135***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0038)</td>
<td>(0.0027)</td>
<td>(0.0035)</td>
</tr>
<tr>
<td>Access to credit</td>
<td>CREDIT</td>
<td>-0.0391***</td>
<td>-0.0146***</td>
<td>0.0167***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0034)</td>
<td>(0.0024)</td>
<td>(0.0033)</td>
</tr>
<tr>
<td>Sumatera</td>
<td>SUM</td>
<td>-0.0192***</td>
<td>-0.0570***</td>
<td>-0.0537***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0071)</td>
<td>(0.0062)</td>
<td>(0.0056)</td>
</tr>
<tr>
<td>Java</td>
<td>JAVA</td>
<td>-0.0297***</td>
<td>-0.0328***</td>
<td>-0.0071</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0067)</td>
<td>(0.0057)</td>
<td>(0.0055)</td>
</tr>
<tr>
<td>Kalimantan</td>
<td>KAL</td>
<td>-0.0025</td>
<td>-0.1176***</td>
<td>-0.1505***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0082)</td>
<td>(0.0086)</td>
<td>(0.0092)</td>
</tr>
<tr>
<td>Sulawesi</td>
<td>SUL</td>
<td>0.0268***</td>
<td>0.0128*</td>
<td>-0.0158***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0077)</td>
<td>(0.0068)</td>
<td>(0.0061)</td>
</tr>
</tbody>
</table>

| Likelihood ratio | 2937.421*** | 3170.937*** | 913.6276*** |

Notes: the number in the parentheses is standard error; *** and ** indicates statistically significant at 1%, 5%, and 10% level of significance, respectively.

Source: own calculation

Table 4: Maximum likelihood estimation results for Tobit models.

Net income from rice farming has a positive and significant effect to the TE-K, TE-MF and MTR mean that the TE-K, TE-MF and MTR will increase as the net income increase. The age of farmers has a positive and significant effect on the TE-K which support the previous studies [such as Llewelyn and Williams (1996); Fabiosa et al. (2004); Kusnadi et al. (2011); Suharyanto et al. (2013)]. This suggests that old farmers are more efficient than young farmers because their experiences in rice cultivation are more than young farmers. In contrast, effect of age to the TE-MF and MTR is negative. This situation may occur because of the old farmers are usually reluctant to adopt and use the new technologies or more efficient production methods.

All the coefficients of formal education are positive and significant, indicating that the average TE-K, TE-MF and MTR of the farmers who had senior high school education and higher education is greater than farmers who had junior school education and lower education. The positive and significant effect of formal education on technical efficiency also support previous studies [such as Widodo (1986); Fabiosa et al. (2004)]. Land size has a negative and significant effect on the TE-K, TE-MF and MTR indicate that small farmers are more efficient than the large farmer. Based on literature this case is common in developing countries.

Coefficients of seed types are positive and significant to the TE-K and TE-MF, meaning that the average of TE-K and TE-MF obtained from the use of certified high-yielding seed is greater compared to non certified high-yielding seed. In fact, there are many farmers in Indonesia who do not use certified high-yielding seed due to constraints such as purchasing power, price, and location. This may cause a negative effect of the certified high-yielding seed to the MTR as shown in Table 4. Irrigated rice field dummy variable has a positive and significant effect on the TE-K, TE-MF and MTR. These indicate that the average TE-K, TE-MF and MTR of rice cultivation in irrigated rice field is greater compared to non irrigated rice field. The presence of pest and diseases reduced the technical efficiency of rice farming. However, a decrease in the average TE-K caused by pests and diseases is greater than a decrease in the average TE-MF, and therefore the effect on the MTR is positive.

Government assistance in the form of inputs which are provided free to the farmers has a positive and significant effect to the technical efficiency of rice arming. However, its effect to MTR is negative and significant, meaning that the technology
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gap tends to widened due to not all farmers could access such assistance. Access to credit has a negative and significant effect to the technical efficiency, but its effect to the MTR is positive and significant. However, not all the farmers in Indonesia could access credit because of several reasons, for example, farmers may not have collateral, credit application procedures may be complicated, farmers do not have any information about credit procedures, the distance between the location of farmers and the credit institutions might be quite far (BPS, 2008). Most of these farmers rely on self-financing in operating of rice farming. This situation may cause a negative effect of access to credit on technical efficiency.

Finally, the positive coefficient of Sulawesi for TE-K and TE-MF indicates that rice farming in this region is more efficient to the other regions including Bali & Nusa Tenggara. Furthermore, the negative coefficient of the regional dummy variables showed that the average MTR for the regions is slightly less than the average MTR for Bali & Nusa Tenggara. In other word, this indicates that technology gap of rice farming in Sumatera, Java, Kalimantan and Sulawesi is wider than in Bali and Nusa Tenggara.

Conclusions

The technical efficiency based on metafrontier analysis (TE-MF) can be decomposed into regional technical efficiency (TE-K), and metatechnology ratio (MTR) which measure technology gap. The average TE-MF of rice farming in Indonesia is slightly lower than TE-K, so that the average of MTR is quite high. This indicates that technology gap between the technology adopted by the farmers and the best available technology is quite small. A number of factors have a positive and significant effect on the technical efficiency and technology gap, namely net income from rice farming, education, and irrigated rice field. Land size showed a negative effect on technical efficiency and technology gap. Meanwhile, the effect of other factors such as age of farmers and access to credit on the technical efficiency as well as the effect of seed type and government assistance on technology gap is ambiguous.

In term of policy, an increase in the technical efficiency as well as reduction in the technology gap (or increase in the MTR) is necessary. Therefore, net income, education and irrigated fields should be considered in the policy to increase technical efficiency and reducing the technology gap. Net income obtained by farmers from rice farming should rise not only to improve their standard of living worthily, but also improved their capability to reinvest part of the net income on productive assets for increased rice production. However, the net income can be influenced by a number of factors which are not addressed in this study.

Formal education either general education and vocational education for the farmers should be increased at least up to the senior high school through the 12-years compulsory education program to improve farmers' knowledge on information and technology relating to agricultural practice, make farmers becomes more creative, and innovative. In addition, non-formal education for the farmers is also important to encourage the use a better agricultural practice. Hence, the existence of field school in integrated crop management should be maintained and developed to improve the knowledge and skills of the farmers through direct practice.

Furthermore, the existing irrigated rice field ought to be maintained. Accordingly, the government must be able to prevent the conversion of agricultural land for non-agricultural activities through enforcement of the related laws and regulations. The existing irrigation infrastructures which still function properly must be maintained, while the damaged irrigation infrastructure should be repaired and constructed. These are very important to guarantee the adequate water supply for rice cultivation in normal weather condition, and especially in extreme weather conditions. The construction of irrigation infrastructure is also needed to support the new rice field expansion in areas that have been designated as agricultural areas for food commodity outside Java.

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References


