Technical efficiency analysis of rice farmers in Ngawi District, East Java Province

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Abstract. The use of inputs in rice farming which is still based on the experience of farmers influences the level of technical efficiency of farmers. This study aims to analyse the technical efficiency of rice farming in Ngawi District, East Java Province. The method used to analyse technical efficiency is Data envelopment Analysis (DEA) VRS models and tobit regression analysis to determine the factors that influence the technical efficiency of farmers. The respondents used in this study were 88 rice farmers. The results of the study show that there are 60 (68%) farmers who are technically efficient and there are 28 (32%) farmers who are technically inefficient. tobit regression results indicate that there are 6 variables that have a significant effect on technical efficiency including; age, education level, experience, number of families, spacing and quality of seeds. This implies that there is a need for equal distribution of information related to the use of rice production inputs.

1. Introduction
Rice is the staple food for more than 95 percent of Indonesia. Rice farming provides employment and as a source of income for 21 million farm households. In addition, rice is also a very strategic political commodity, so that rice production in the country to be a benchmark as the success of agricultural development. Indonesia is known as the rice-producing countries world number three as many as 70.8 million tons, after China and India are respectively 206.5 million tons and 153.8 million tons. Indonesian rice production contributes to the global rice production is 9.76%. However, Indonesia is also still the country's fourth largest rice importer after China, the Philippines, and Bangladesh, respectively: 2.5; 1.9; 1.3 and 1 million tonnes [1]. This phenomenon occurs because of the lack of domestic rice supply, and also due to the consumption of rice of Indonesia's population is relatively high, for the development of a population which is very rapid and per capita consumption is also very high, reaching 98 kg/capita/year [2]. Therefore, the government must continue to make efforts to achieve rice self-sufficiency quickly.

The use of production inputs becomes essential as a basis for running the PTT program implemented by the government. The level of production efficiency needs to be done to help farmers to achieve the optimization of production. Efforts that can be done is to calculate the level of technical efficiency of rice farming. The concept of technical efficiency to provide information regarding the use of minimal inputs in order to produce a specific output. Efficiency measurement is done by calculating the cost minimization of the use of inputs in farming to achieve a certain output. One concept to calculate the technical efficiency of farmers is Data Envelopment Analysis approach [3-7].
Previous study shows that farmers in Indonesia are being over utilized the uses of fertilizer and labour and this caused technical inefficiency [8].

Data Envelopment Analysis (DEA) created as a performance evaluation tool activity that requires one or more inputs and produces one or more output. In a simple measurement is expressed by the ratio of output to input. DEA has the advantage: 1) Identification of sources and levels of inefficiency for each input and output sector in the entity; 2) Identification of members and efficient set of benchmarks used to evaluate performance and identify inefficiencies [9].

Rice production centre in East Java is inseparable from the existence of Ngawi. The district is the largest area of rice fields number 4 in East Java, so that the area can be regarded as the granary. Besides The district has rice cropping intensity (IP 300) The most widespread in East Java. One area in Ngawi is growing rice, IP 300 is in District Widodaren. This district has an area harvested third-largest Ngawi district that is 12,805 hectares. In addition, the sub-district has the highest Investment Index compared to another sub-district that is equal to 281. But unfortunately, in the use of factors of production is still much to rely on experience and information from other people who are still in question related to efficiency. To solve these problems, this study aims to analyse the level of technical efficiency of rice farming rice fields IP-300 in Widodaren District with Data Envelopment Analysis (DEA) approach.

1.1. Literature review
Technical efficiency is related to the production of output given some input: a production plan is technically efficient if there is no way to produce more output with the same input or to produce the same output with less input [10]. Farmers will be efficient if the increase in output obtained through the reduction of at least one other input. Therefore, farmers who have technically efficient will be able to produce the same output with at least one fewer input or by using the same input will be capable of producing at least one output is more.

Technical efficiency relates to the ability of a company to produce at the frontier curve isoquant, [11] stated that the technical efficiency shows the ability to minimize the use of inputs in the production of a specific output vector or the ability to achieve maximum output from a particular input vector. A farmer is technically more efficient if they can produce higher outputs by the same number of inputs. Technical efficiency associated with behavioural objectives to maximize output [12]. Farmers called technically efficient if it has been producing at the level of its production limit where it can’t be achieved due to various factors such as bad weather, the presence of plant pests or other factors that cause the production is under the limit expected [12].

2. Materials and methods

2.1. Sampling method
Simple Random Sampling is the method that used in this study. Sampling was done by using Slovin formula. From these calculations are obtained samples of 88 farmers. The data used in this study are primary data, consisting of socio-economic conditions of the respondents, the performance of farming, use of production inputs, farm income, farmers’ membership on agriculture programs and other information. The data is used to be able to determine the level of efficiency and the factors that influence the technical efficiency of paddy rice farm IP -300i.

2.2. Data Envelopment Analysis (DEA)
The approach used in this study is the Data Envelopment Analysis (DEA). VRS helps us to be able to measure the relative efficiency without assuming the inputs are controllable [13]. The assumption of this model is that the ratio between the input and output additions are not the same (variable return to scale). It means, changes in the input and output of a DMU take place in a linear manner, that allowed the increase (increasing returns to scale/IRS) and decline (decreasing returns to scale/DRS) the efficiency [14,15]. Thus, this method involves the analysis of multi-input, multi-output, and variable
return to scale. Input variables used are seeds, organic fertilizer, urea, fertilizers SP 36, Fertilizers phosphs, ZA fertilizer, Leaf Fertilizers, Pesticides Solid, Liquid Pesticides, Labour and Irrigation. While, the variable output used in this study is the production of rice.

2.3. Tobit regression model
Tobit regression was first proposed by [16] which assumes that the dependent variable of limited value (censored), only independent variable that is not limited to, all variables (both smoking and non-smoking) was measured properly, there is no autocorrelation, Heteroscedasticity and multicollinearity and use appropriate mathematical models [17].

The value of technical efficiency with DEA analysis generated in this study is 0:00 to 1:00, where the use of regression tobit will explain the relationship between the level of technical efficiency and the characteristics of the respondent farmers. Factors affecting the technical efficiency adapted to conditions of the respondents in the study site, Factors that supposed to influence the technical efficiency of rice farming IP-300 in District Widodaren namely age (AGE), education (EDU), the experience of farming rice (EXP), the number of dependents (FAM), the membership of farmers in SLPTT program (PROG) and use organic fertilizer (ORG). Tobit models used in this study are as follows:

\[
TE = \beta_0 + \beta_1 \text{AGE} + \beta_2 \text{EDU} + \beta_3 \text{EXP} + \beta_4 \text{FAM} + \beta_5 \text{PROG} + \beta_6 \text{ORG} + \beta_7 \text{MT} + e
\]  

Where:
- \(TE\) = Technical Efficiency
- \(\text{AGE}\) = Age (Years)
- \(\text{EDU}\) = Education (Years)
- \(\text{EXP}\) = Experience (Years)
- \(\text{FAM}\) = Number of Dependents Family (Life)
- \(\text{PROG}\) = Membership Program SLPTT = (1: Members and 0: no members)
- \(\text{ORG}\) = Organic Fertilizer (1: Using and 0: do not use)

3. Results and discussion
3.1. Technical efficiency analysis
Table 1 presents the farmers who have technical efficient with CRS and VRS models. Where farmers have technical efficient on a scale of CRS as many as 33 farmers, while farmers who have technically efficient in VRS scale of 60 farmers.

| Scale efficiency | Number of farmers | Percentage (%) |
|------------------|-------------------|----------------|
| CRS              | 33                | 38%            |
| VRS              | 60                | 68%            |

Source: Primary Data 2018

CRS models that assume farmers are operating at optimal scale farmers efficiently obtained a total of 33 farmers (38%). While the VRS models that assume farmers are not operating at optimal scale farmers efficiently obtained as many as 60 farmers (68%). Figure 1 show the proportion of farmers who have been streamlined and are inefficient.
Figure 1 shows that rice farmers are efficient at scale VRS was obtained by 68% and the value is greater than rice farmers CRS efficient on a scale of 38%. It can be concluded that the use of models VRS (Assuming that not all farmers to be operating at its optimum) farmers are more efficient than the model CRS (assuming all farmers have all operating at its optimum). The distribution of technical efficiency value with CRS and VRS models can be seen in figure 2.

In the scale of efficiency farmers who operate on a scale of CRS gained as much as 52 respondents (59%), whereas farmers who operate on a scale of IRS sebanyan obtained 33 respondents (38%) and farmers who operate on a scale of DRS gained as much as 3 respondents (3%). Comparison of farmers who operate on a scale of CRS, IRS and DRS are presented in Figure 3 below. Farmers who operate on a scale of CRS with technical efficiency value of 1:00 (100%) there were 52 respondents or 59%. This implies that the addition of production inputs is used, the same as the proportion of output produced.

Farmers technically efficient and operating at scale IRS obtained a total of 33 respondents (38%). Means that the addition of the inputs used will produce a larger amount of output. farmers who have
been efficient at scale IRS, despite having the technical efficiency values were 1.00, they can still add input because the ratio of the addition of the output to be obtained can be higher than the addition of the inputs used for these farmers.

![Figure 3. Comparison of proportion efficiency scale farmers](image)

Furthermore, to farmers efficiently on a scale of DRS gained as much as 3 respondents or 3%. Farmers who operate on a scale of DRS is not supposed to perform additional input, due to the addition of inputs will generate smaller output number of additional inputs used.

### 3.2. Technical efficiency analysis

Table 1 presents the farmers who have technical efficient with CRS and VRS models. Where farmers have technical efficient on a scale of CRS as many as 33 farmers, while farmers who have technically efficient in VRS scale of 60 farmers.

| Variables  | Average of input slack | The number of farmers excess | The number of farmers excess (%) |
|------------|------------------------|-----------------------------|---------------------------------|
| Seed (Kg)  | 1.853                  | 23                          | 26%                             |
| P O (Kg)   | 49.41                  | 28                          | 32%                             |
| Urea (Kg)  | 7.275                  | 28                          | 32%                             |
| SP 36 (Kg) | 10.837                 | 32                          | 36%                             |
| Phons (Kg) | 15.846                 | 24                          | 27%                             |
| ZA(Kg)     | 4.294                  | 18                          | 20%                             |
| P. Leaf (Kg)| 0.186                 | 26                          | 30%                             |
| Solid Pest. (Kg)| 0.342              | 28                          | 32%                             |
| Liquid Pest. (ltr)| 0.201            | 25                          | 28%                             |
| Labour (HOK)| 5.646                 | 26                          | 30%                             |
| Irrigation (Hour)| 25.884             | 36                          | 41%                             |

Source: Primary Data

For example, in table 2 the average value of slack seed input is equal to 1,853, which means that 23 rice farmers can reduce the use of seeds as much as 1,853 kg without reducing the production of rice.
Another example, the average value of the input slack organic fertilizer that is equal to 49.41. Its means that 28 rice farmers still can reduce the use of organic fertilizers amounted to 49.41 kg without reducing the production of rice. The results of this analysis also explain that farmers efficient can be a reference or peer in the use of inputs for farmers inefficient.

3.3. Distribution technical efficiency values of rice farmers
The technical efficiency value of rice farmers by using DEA VRS obtained varying results. The value of technical efficiency using VRS DEA was present in the table 3. From the analysis of rice farmers DEA technically efficient with DEA model obtained by 60 respondents, where farmers are efficient has a technical efficiency of 1.00 and a reference or peer for farmers who have not been efficient. While farmers are not yet technically efficient VRS model with as many as 28 respondents. From the table above it can be concluded that the value of the minimum technical efficiency obtained a value of 0.695 while the value of the maximum technical efficiency was obtained for 1,000. The average technical efficiency values of 0.974.

| No | Technical efficiency | Farmers | Percentage (%) |
|----|----------------------|---------|----------------|
| 1  | 0.50-0.70            | 3       | 3%             |
| 2  | 0.71-0.89            | 10      | 11%            |
| 3  | 0.90-1.00            | 75      | 85%            |
|    | Total                | 88      | 100%           |
|    | Min.                 | 0.695   |                |
|    | Max.                 | 1.00    |                |
|    | Mean                 | 0.974   |                |

Source: Primary Data

3.4. Analysis of factors affecting technical efficiency
Tobit Regression results show six variables that significantly influence the technical efficiency among; age, level of education, experience, family size, spacing land and seed quality. While the field schools, farmer groups and land ownership have insignificant effect on technical efficiency. Age has a positive and significant impact on technical efficiency. it shows the older the farmer, technical efficiency will be higher. However, at some point, when the age of farmers increases, the level of technical efficiency will decrease. This is because at that point the age of farmers has decreased productivity.

The levels of education and experience have a significant and positive effect on technical efficiency. Higher education and the experience of farmers then the value of technical efficiency will increase. This implies that knowledge in farming activities is indispensable to success in farming. This finding is consistent with [5,18,19] where experience and levels of education and training contribute to variations in productive efficiency.

Family size has a significant and negative effect on the technical efficiency. This shows that higher family size can reduce their level of technical efficiency. The Research conducted [20] in Nigerian , found family size has significant and negative relationships with the efficiency of family production.

Land spacing and quality of seeds has a positive and significant impact on technical efficiency. The farmers who pay attention on land spacing and use a good quality seed has a higher level of technical efficiency compared to farmers who do not pay attention on land spacing and seed quality. This result is in line with [21] found that seed quality has a positive influence on the technical efficiency of rice farmers.
Table 4. Tobit regression analysis

| Variable;     | Coef.   | Std. Err | T      | P>|t| |
|---------------|---------|----------|--------|------|
| Age           | 0.002885| 0.001078 | 2.68   | 0.009*** |
| Level of education | 0.007366| 0.003521 | 2.09   | 0.040** |
| Experience    | 0.00285 | 0.000957 | -2.98  | 0.004*** |
| Family size   | -0.02744| 0.007907 | -3.47  | 0.001*** |
| Educational field | -0.00784| 0.014099 | -0.56  | 0.580   |
| Farmers group | -0.02603| 0.028791 | -0.9   | 0.369   |
| Land spacing  | 0.042001| 0.01475  | 2.85   | 0.006*** |
| Seed quality  | 0.10271 | 0.023057 | 4.45   | 0.000*** |
| Land ownership| -0.00641| 0.022422 | -0.29  | 0.776   |
| _cons         | 0.81751 | 0.073623 | 11.1   | 0.000   |
| var (TE)      | 0.003033| 0.000457 | 0.002247| 0.004095|

Log likelihood = 130.24857
Number of obs = 88
LR chi2 = 121.13
Prob > chi2 = 0.0000
Pseudo R2 = -0.3235

* = Significant at 10%. ** = significant at 5%. *** = significant at 1%

4. Conclusions

Based on the research results can be summarized as follows: the first. As many as 68% of respondents have technically efficient and 32% inefficient. Therefore, we can conclude the majority of rice farmers IP 300 in the district of Ngawi already efficient. The second, Factors affecting technical efficiency such as age, experience, plant spacing, seeds quality have significant and positive effect at 1%. Education has positive and significant impact at 5%. And family size and significant negative effect on technical efficiency at 1%.

References

[1] FAO 2015 FAO Rice Market Monitor Food and Agriculture Organization of the United Nation. XVII 4
[2] BPS 2015 Badan pusat statistik [Central Bureau of Statistics]
[3] Chemak F, Boussemer J P and Jacquet F 2010 Farming system performance and water use efficiency in the Tunisian semi-arid region: data envelopment analysis approach International Transactions in Operational Research 17 3 pp 381-96
[4] Heidari M D, Omid M and Akram A 2011 Optimization of energy consumption of broiler production farms using data envelopment analysis approach Modern Applied Science 5 3 p 69
[5] Khan A, Huda F A and Alam A 2010 Farm household technical efficiency: A study on rice producers in selected areas of Jamalpur District in Bangladesh European Journal of Social Sciences 14 2 pp 262-71
[6] Khoshroo A, Mulwa R, Emrouznejad A and Arabi B 2013 A non-parametric Data Envelopment Analysis approach for improving energy efficiency of grape production Energy 63 pp 189-94
[7] Picazo-Tadeo A J, Gómez-Limón J A and Reig-Martinez E 2011 Assessing farming eco-efficiency: a data envelopment analysis approach Journal of environmental management 92 4 pp 1154-64
[8] Wibowo R P, Raihan A and Gunawan D 2019 Comparative analysis of technical efficiency between organic and non-organic rice farming in North Sumatera Indonesia IOP Conference Series: Materials Science and Engineering 648 012038
[9] Cooper W W, Deng H, Huang Z and Li S X 2002 Chance constrained programming approaches to technical efficiencies and inefficiencies in stochastic data envelopment analysis Journal of the Operational Research Society 53 12 pp 1347-56
[10] Favero C A and Papi L 1995 Technical efficiency and scale efficiency in the Italian banking sector: a non-parametric approach Applied Economics 27 4 pp 385-95
[11] Kumbhakar S C 2002 Specification and estimation of production risk, risk preferences and technical efficiency American Journal of Agricultural Economics 84 1 pp 8-22
[12] Coelli T A 1996 Guide to DEAP version 2.1: a data envelopment analysis (computer) program. Centre for Efficiency and Productivity Analysis (Armidale: University of New England)
[13] Oyerinde Y and Bankole F 2020 Influence of Constant Returns to Scale and Variable Returns to Scale Data Envelopment Analysis Models in ICT Infrastructure Efficiency Utilization Empowering Businesses With Collaborative Enterprise Architecture Frameworks, ed Iyamu T (USA: IGI Global) pp 158-81
[14] Charnes A, Cooper W W, Golany B, Seiford L and Stutz J 1985 Foundations of data envelopment analysis for pareto-koopmans efficient empirical productions functions Journal of Econometrics 30 pp 91-107
[15] Yaisawarng S and Klein J D 1994 The effects of sulfur dioxide controls on productivity change in the US electric power industry The Review of Economics and Statistics pp 447-60
[16] Tobin J 1958 Estimation of relationships for limited dependent variables Econometrica: journal of the Econometric Society pp 24-36
[17] Hosen M N and Muhari S 2013 Efficiency of the sharia rural bank in Indonesia lead to modified camel Int.Journal of Academic Research in Economics and Management Sciences 2 5 p 34
[18] Nargis F and Lee S 2013 Efficiency analysis of boro rice production in North-Central region of Bangladesh The Journal of Animal & Plant Sciences 23 2 pp 527-33
[19] Page Jr J M 1984 Firm size and technical efficiency: applications of production frontiers to Indian survey data Journal of Development Economics 16 pp 129-52
[20] Alabi A and Aruna B 2005 Technical efficiency of family poultry production in Niger-Delta, Nigeria Journal of Central European Agriculture 6 4
[21] Saeri M, Hanani N, Setyawan B and Koestiono D 2019 Technical efficiency of rice farming during rainy and dry seasons in Ngawi District of East Java Province, Indonesia Russian Journal of Agricultural and Socio-Economic Sciences 91 7