Technical Efficiency of Rice Farm Production in Aceh Province, Indonesia

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Abstract

The purpose of the present paper is to examine the efficiency of Indonesian rice production conducted in Aceh Province, by using agricultural census data 2013 with a sample of 1,029 characteristics of farm households. The analysis model used is stochastic frontier analysis (SFA)) approach and the estimation result obtained that rice production factors such as wages of farm workers, harvested area, fertilizer, and seeds have not been technically efficient. Furthermore, the economical scale of rice production in Aceh Province is decreasing return to scale that coherent with the results of the efficiency test.

Keywords: efficiency, farmer household, stochastic frontier analysis, economic scale.

Introduction

Rice is a strategic commodity for staple food as well as a source of livelihood for most of the population in Indonesia including Aceh Province. Rice farming activities are generally dominated by rice farmers' households in cultivating their own rice fields or others (BPS, 2014). The main problem facing these commodity farmers in terms of production, based on the 2013 Agricultural Census is a relatively high increase in production costs in addition to unpredictable pest attacks (BPS, 2014). This condition can trigger inefficient production process which in turn will disrupt the stability of rice production.

The province of Aceh, earlier than Indonesia rice self-sufficiency in 1984-1985 was primarily a region producing rice surplus (Hasan, 1976). However, with the increase in production costs, it will have the impact on farmers on production inefficiencies as producers in generating revenues and also rice consumers. The causes of occurrence in some cases can be identified as technological gaps, increased production costs, aging factor and distribution of irrigation channel (Xu & Jeffrey, 1998; Trewin, 1995; Saiyut, et. al, 2017; Seok, et al., 2018; Pedroso, et al., 2018). Based on the previous results of studies of inefficiency factors of rice production in some regions or countries are the gap between the results of technology with the potential and actual production yield obtained by farmers, therefore gap occurs as the ability of farmers in applying technology applications will vary between farmers with others (Ainembabazi et al., 2017; Fuwa, et al., 2007).

Agricultural technology can improve production and consequently rising production costs such as fertilizer, superior seeds and pest control, especially in the case of rice production in Indonesia (Squire & Tabor, 1991; Trewin et al., 1995). Therefore, the government intervened by subsidizing some production components such as

fertilizers, pesticides and some other components. In this study, we examine how production costs components in relation to the technical efficiency of rice yield in Aceh Province. This paper organized as follows: first theoretical framework and model analysis; second, analysis model of inefficiency of rice production and description of data used; third, results and discussion; the last, conclusion.

Framework and Model Specification

The efficiency measurement approach, as Farrell (1957) points out, consists of two components, first technical efficiency that reflects famers' ability to achieve maximum output. Measurement of the technical efficiency referred to the ratio of potential rice production with actual rice production which derived from the *stochastic frontier analysis* (SFA) model (Xu & Jeffrey, 1998). The SFA model was first developed by Aigner, et al., (1977); Meeusen & van Den Broeck, (1977); and Battese & Corra, (1977). The difference between the three authors is the model and distribution assumptions which are being used. In this study we used the exponential in this study we use the exponential distribution as suggested by Griffiths & Hajargasht (2016).

The application of models in rice research is quite diverse in accordance with the conditions and problems that are being faced. The latest use of the SFA model in rice production in previous research can be found in (Saiyut, Bunyasiri, Sirisupluxana, & Mahathanaseth, 2018; Silva, Reidsma, Laborte, & van Ittersum, 2017; Tsionas, 2017; Y. Xu, Zhang, & Zhang, 2018) Squire & Tabor (1991); Roche, (1994) Trewin et al., (1995).

The method of SFA model in agricultural sector such as Seok et al, (2018) on aging and labor efficiency factor in agricultural sector as important factor in sustainable agriculture development in Korea , this research has been done by Saiyut et al. (2017) for a case study in Thailand; then research with evaluation approach of production system in order to develop farming from production to business development from commodity of production (Xu et al., 2018) ; research with multiple output approach from socio-economic factors (Shavgulidze, et al., 2017) . In this research paper model specification is single output and multiple input oriented approach of the rice production.

The functional form of the production model used in this article which consider two conditions: first, the flexibility of functions with sufficient parameters to describe the conditions of farmer production; and second, fit in economic theory, *parsimonious* simple and easiest to apply (Coelli et al., 2005).

The stages of rice production in Indonesia are land cultivation, planting, maintenance, fertilization, pest control, harvesting which include threshing and transport, so that production depends on the following factors (BPS, 2014): labour (x_1), processing machines (x_2), seed (x_3), fertilizer (x_4), pesticides (x_4) as inputs to produce rice production (q) and $\beta_i$are parameters of each input vector.

$$q = \prod_{i=1}^{5} x_i^{\beta_i} \quad (1)$$

In the simplified form of Cobb-Douglas (4) model, which can be written as follows (Pedroso et al., 2018; Xu & Jeffrey, 1998)?

$$q_i = \mathbf{x}_i'\beta + v_i - u_i \;\; ; u \geq 0 \quad (2)$$

Where the component as noise factor is $v_i \sim iid(0, \sigma^2)$ and $u_i \sim \exp(0, \lambda)$ as error term which is associated with inefficiency factor as exponential distribution with mean λ. By

taking logarithm both sides of the equation, the cost equation will be estimated becomes linear so that the equation can be written as follows:

$$\ln q_i = \beta_0 + \sum_k \beta_k \ln x_k + \varepsilon_i \quad (3)$$

Rice production (q_i), the input component of rice production is a vector is a composition of production cost structure consisting of: seed, fertilizer, harvested area, wage of paddy field worker this component is the input cost observed or actual from each farmer. Component is a deterministic component of potential inputs to produce; and is a component of random inefficiency or composed error which consists of the noise factor associated with the technology and the disturbance error associated with inefficiency (Figure 1) (Kumbhakar & Lovell, 2004). The measurement of technical efficiency, following the efficiency calculation procedure by Xu & Jeffrey (1998), derived from equation (1), such as:

$$TE_i = \frac{q_i}{\mathbf{x}'\beta.\exp\{\varepsilon_i\}} \quad (4)$$

Hypothesis which was tested with the likelihood ratio test or *LR* test (Gutierrez et al., 2001). Input efficiency is completed by coefficient test, with hypothesis; alternative hypothesis. Agricultural Census Data 2013 (ST 2013) from the Central Statistics Agency of Aceh is used in this research. With a sample size of 1,029 rice farmers in Aceh Province. To obtain a complete set of data from the census-generated micro data, prior to estimation requires data cleaning to obtain sample of 1,029 farmers applying the completeness, consistency, and accurateness criteria (Sehgal & Bhargava, 2017; Mezzanzanica et al., 2015).

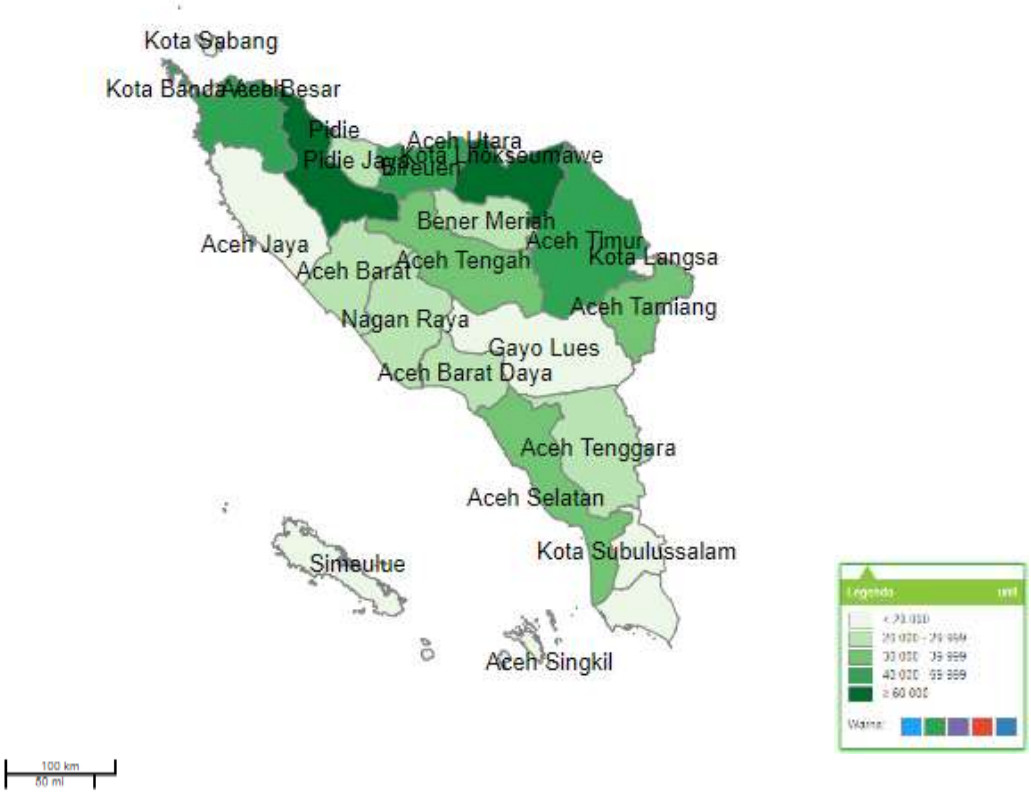

Figure 1. Distribution of agricultural households in Aceh Province
Source: Agricultural Census (ST 2013), Central Bureau of Statistics, 2014.

Results and Discussion

The parameter values of each input of production then equation (2) is estimated by the *maximum likelihood* method. Statistical descriptive results are listed in Table 1, as follows:

Table 1. Summary description statistics of rice factor production

Variable	Observation	Mean	Std. Deviation	Min.	Max
Lq (q)	1.029	8.5392	.7386	5.5684	10.7144
Ln Seeds (x_2)	1.029	8.7842	.5279	7.0031	9.74097
Ln Harvested Area (x_3)	1.029	8.0228	.6097	6.1485	11.0021
Ln Fertilizer (x_4)	1.029	3.8755	.9674	0	6.1093
Ln Wages ((x_5)	1.029	1,0270	5.6908	.8143	9.2591

Source: Agricultural Census 2013, BPS Aceh Province, Indonesia

The estimation results obtained by using exponential distribution and some other components of the technical efficiency statistical test in Table 2. The production cost structure of rice contained from the estimation frontier of rice production in Aceh Province, in total affects the rice production of the harvested area as a representation of the land is the most influential component. The estimation results can be seen from the use of seed and fertilizer to rice production respectively, one of the causes is the government subsidizes these two components of rice production has reduced the potential higher cost of production which cause inefficiency.

The other deterministic frontier component that determines rice production is the wages that farmers spend on the production process from land cultivation, planting, maintenance, harvesting pest control (e.g. threshing and transport) shows a negative effect on rice production. This is an interesting and surprising finding, because this component theoretically has positive effect which in line with Seok's (2018) results that farm worker is the most important factor in agricultural production although it is also explained that the larger number of family members will be more efficient than fewer family members. In the earlier study, Rahman (2011) stated that the difference in the sign of farm worker coefficient occurs due to the application of technology in modern and traditional rice production. As modern rice production, irrigation channel production has been distributed evenly compared to traditional rice production as determinant of these differences as also found by Pedroso, et al., (2018).

The model estimation results show that theoretical consistency in which the production input has a positive sign indicating that the estimated production inputs affect the variation of rice production change in Aceh, this is corresponding to Warr & Yusuf (2014) with the general equilibrium approach in Indonesian rice economy. One of the reasons that can be put forward is that most farmers do their own production process or are assisted by household members so that potential causes, for others statistically the answers given between one farmer and other farmers are quite varied as shown in the standard deviation rate which is quite high compared to the third other components (Table 1).

Table 2. Estimation of stochastic frontier parameter of Aceh Province rice production

Variable	Coefficient	P>|z	z
Ln Seeds (x_2)	.11660 (.0230)	0.000	4.87
Ln Harvested Area (x_3)	.7935 (.0280)	0.000	27.46

Ln Fertilizer (x_4)	.1659	0.000	6.35
	(.0261)		
Ln Wages (x_5)	-.0591	0.001	-3.38
	(.2834)		
Constant	1.2603	0.000	4.45
	(.2834)		
Sigma *v*	0.2164		
	(0.0121)		
Sigma *u*	0.4787		
	(0.0211)		
Sigma2	0.2760		
	(0.0187)		
Lambda	2.2125		
	(0.0293)		
$\sum_{i=1}^{5} \beta_i$	-0.2073		
TE	6.0000		
q (prediction)	8.8923		
q (average)	6611.0410		
Likelihood ratio sigma $u = 0$ χ^2 (01) = 2.7e+02; Prob.> $\bar{\chi}^2$ =0.000			

Note: The dependent variable is the production of rice (lnq)
The number () is the standard error.
Source: Agricultural Census 2013, BPS Aceh Province, Indonesia

Likelihood ratio test gives rejected null hypothesis significantly in other word there is technical inefficiency on rice production by household farmer in Province of Aceh. Another test shows by *TE* from subsequent hypothesis test that alternative hypothesis cannot be rejected that economic scale of rice production is in decreasing return to scale. The result of both tests found where rice production technically is inefficient and showed production scale which tends to decrease, in line with Lee, (2006) which explains more inefficiency occur in small-group Indonesian rice farmers and Pedroso, et al., (2018) added that large farmers are more efficient than small scale farmers in Vietnam rice farmers case. In the case of farmers in Aceh province it is shown that the larger number of farm workers who are mostly supplied from household members will reduce production by 0.0591one season of rice planting.

Conclusion

The results of empirical findings indicate that the inefficiency of rice production in decreasing return to scale as a finding that needs to be followed up appropriately. The sustainability of the input subsidy program needs to be maintained in the short run because it has a positive effect on rice production and vice versa the labor component negatively affects rice production. The limitations of this study are not yet comprehensively exploiting the components of wages or labor in agriculture. The main recommendation is the course of a study on labor cost component of this needs to be organized, other than that the subsidy policy in the short term in maintaining the stability and increasing the efficiency of rice production needs to be preserved evaluated the number and effectiveness.

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