TECHNICAL, COST AND ALLOCATIVE EFFICIENCY OF RICE, CORN AND SOYBEAN FARMING IN INDONESIA: DATA ENVELOPMENT ANALYSIS APPROACH

Rosihan Asmara[1,*], Fahriyah[1], Nuhfil Hanani[1]

[1]Faculty of Agriculture, University of Brawijaya, Malang, East Java, Indonesia

*corresponding author: rosihan@ymail.com

ABSTRACT: This study aimed to analyze technical, cost and allocative efficiency, and to analyze the influence factors on the rice, corn and soybean farming in Indonesia. It used Data Envelopment Analysis (DEA) aiming to minimize the cost of inputs. The results show that the propotion of efficient allocative efficiency levels are about 10.20% for rice farmers, 12.28% for corn farmers and 4.55% for soybean farmers. Additionally, the proportion of farmers having technically efficient are 26.53% for rice farmers, 26.32% for corn farmers, and 36.36% for soybean farmers. The lower allocative efficiency shows that farmers face much difficulty in considering input prices and input allocations in their productions. Moreover, the most dominant factors affecting the technical (TE) and cost (CE) efficiency in rice, corn and soybean farming are land area and extension frequency. Those are definitely important factors in improving farming efficiency. Spesifically for extension program, this study confirms empirically that extension is still one of imperative factors should be considered in agriculture development in Indonesia.

Key words: technical efficiency, Paddy, Maize, Soybean, Data Envelopment Analysis

INTRODUCTION

Rice, corn and soybean are strategic food commodities in Indonesia and farmers mostly cultivate them as the main source of income and the livelihood in rural areas. Considered from the food consumers, rice and corn are especially the major sources of carbohydrates, while soy is the protein source.

Given the importance of these food commodities for consumers and producers, they are determined as the political commodities. Food scarcity will cause food prices to be expensive and affect inflation, which become a political issue then. Therefore, the government attempts constantly to meet the society food demand. If the food availability were unable to be fulfilled by domestic production, then government conducts imports to fill the gap in the market.

Food demands continue to increase in line with the population growth. While production does not meet the food demand, the production deficiency occurs and consumption needs are solved through imports. Data of ASEAN Food Security Information System (2016) showed that in 2013 the value of rice imports was USD 244.623 millions, corn was USD 935.78 millions and soybean reached USD 1116.09 millions. Therefore, Indonesian government launched the food self-sufficiency policy for addressing the issue. This effort goes in line with population, which continue to increase, whereas the world food supply is getting relatively stagnant.

Efforts to increase production in food self-sufficiency achievement should be followed by the improvement of competitiveness so that the product can compete in domestic and international markets. FAO (2016) states that Indonesian food manufacturer level is more expensive than the countries of major producers in the world. The price of rice in Indonesia producer level is 876 USD per ton, while Thailand and Vietnam are only 318 and 299 USD per ton. The price of Indonesian corn is USD 352 per ton, while the United States is USD 271, Argentina is USD 203.271, and Brazil is USD 226 per ton. Indonesian soybean price is USD 800, while the United States is USD 529, Argentina

and Brazil are USD 363.271 and USD 508 per ton, respectively. This situation shows that food production by farmers is still less efficient.

Based on these facts, efforts to increase farmer's production must be accompanied by the increase of farming efficiency, one of which is to conduct technical and allocative efficiency by optimally using farm inputs. Therefore, it is important to do a study on technical and allocative efficiency of food farming in Indonesia, as well as the necessity to identify factors affecting technical efficiency in rice farming. This study used Data Envelopment Analysis (DEA) with the main objective of minimizing the production cost, so that the technical, cost and allocative efficiency would be obtained. The result of study is intended to provide appropriate information to increase productivity and to support rice self-sufficiency program.

RESEARCH METHODS

Sample of this study was collected using multistage sampling. Three regencies in East Java were selected. They are Jember, Tuban, and Banyuwangi regencies. Each of them is the center of rice, corn and soybean productions. In each regency, one district and one village were randomly selected based on the center of food crops in the locations. Then in each village, farmers were randomly determined as sample. The selected regencies as samples were Jember with 49 paddy farmers, Tuban with 57 corn farmers, and Banyuwangi with 44 soybean farmers.

Data Envelopment Analysis (DEA) was applied to measure the efficiency among farmers and the efficiency across enterprises (Coelli et al, 2005), which is cross-section data. DEA is also applicable for time series as conducted by Xiao (2011).

To determine the technical efficiency for i-th farmers, then we used the liner program as follows:

Minimize $_{\theta\lambda}$ θ
Subject to:
$$-yi + Y\lambda \geq 0$$
$$\theta xi - X\lambda \geq 0$$
$$N1'\lambda = 1$$
$$\lambda \geq 0$$

Where θ is the score of the technical efficiency (TE), yi is the production number of i-th farmers, xi is vector $Nx1$ from the number of inputs for i-th farmers, Y is vector $1xM$ for production, X is matrix NxM from the number of inputs used, λ is

the vector of weighted MX1 and θ is scalar. The technical efficiency was identified by the CRS (constant return to scale) approach. In order to search for the cost efficiency (economy), then the model of linear programming was formulated in the form of minimizing production costs.

Minimize λ, xi^* $w_i'x_i^*$
subject to
$$-yi + Y \lambda \geq 0,$$
$$xi^* - X \lambda \geq 0$$
$$N1' \lambda = 1$$
$$\lambda \geq 0$$

Where w_i is the vector of input prices from farmers and $xi *$ (calculated by linear programming) is the vector which was minimized from the cost of input total of i-th farmers. The economic or cost efficiency (CE) for i-th farmers was obtained by dividing the farmers' optimal cost as defined in equation (3). Meanwhile, the allocative efficiency (AE) was calculated by dividing the economic efficiency or cost (CE) with the technical efficiency (TE) as follows:

CE = wi'x * / wi 'xi   …………………….…..
AE = CE / TE   …………………………...

In order to examine the factors affecting the efficiency, we used the following equation:

$$TE = u_i = \alpha_0 + \sum_{j=1}^{10} \alpha_j Z_{ij} \ ……………….$$

TE is the level of technical efficiency, while Zij are factors affecting the technical efficiency which consists of 10 variables, namely: age, sex farmers, education, number of family member, land area, land ownership, variety, origin of seeds, extension frequency, demonstration plot farming.

As the obtained variable of efficiency was not normally distributed due to its value between 0 and 1, the OLS would potentially produce inconsistent estimation. Therefore, this study used the Tobit regression model which was estimated by Maximum Likelihood Estimator (MLE).
………………. (1)

RESULTS AND DISCUSSION

Table 1 represents TE, AE and CE. The level of TE on average is lower than that found by Ngeno et al (2012). The average TE of rice farming was 0.68, lower than corn (0.73) and soybeans (0.81), as well as CE of paddy rice farming which was the lowest (0.42), and followed by soybeans 0.48. Since AE was the division of TE and CE as in equation (4), it was obtained 0.61 for rice, corn 0.75, and soybean 0.45.

Table 1. Average of technical efficiency (TE), efficiency cost (CEK), and allocative efficiency (AE) of rice, corn and soybean farming

Comodity	TE		AE		CE	
	Mean	Std	Mean	Std	Mean	Std
Rice	0.68	0.23	0.61	0.21	0.42	0.23
Corn	0.73	0.18	0.75	0.11	0.55	0.18
Soybean	0.81	0.17	0.59	0.17	0.48	0.19

Based on Table 2, the percentage of farmers in the range of 0.90-1.0 of TE are only about 26% of corn and rice farmers and 36% of soybean farmers in that range. Similarly, CE for the commodities were 4% of rice farmers was efficient on the range mentioned above, technically efficient of corn farmers are 7% and that of soybean farmers are 2%.

The farmers' allocative efficiency have the lower level. For the range efficiency of 0.90-1.00, rice farmers in that range for rice, corn, and soybean are about 10.20%, 12.28% and 4.55%, respectively. This situation described that the efficiency of food farming in Indonesia still need much improvement.

Table 2. Distribution of Technical Efficiency (TE), Efficiency Cost (CEK) and Allocative Efficiency (AE) in Rice, Corn and Soybean Farming

Distribution of Efficiency	TE			CE			AE		
	Rice	Corn	Soybean	Rice	Corn	Soybean	Rice	Corn	Soybean
<0.30	6.12	0.00	0.00	44.90	5.26	11.36	4.08	0.00	4.55
0.31-0.40	8.16	1.75	0.00	8.16	15.79	27.27	16.33	0.00	4.55
0.41-0.50	6.12	7.02	4.55	20.41	22.81	27.27	14.29	0.00	29.55
0.51-0.60	20.41	15.79	11.36	10.20	28.07	6.82	18.37	8.77	11.36
0.61-0.70	14.29	26.32	13.64	2.04	5.26	13.64	10.20	31.58	29.55
0.71-0.80	10.20	19.30	9.09	4.08	8.77	6.82	14.29	28.07	11.36
0.81-0.90	8.16	3.51	25.00	6.12	7.02	4.55	12.24	19.30	4.55
0.90-1.00	26.53	26.32	36.36	4.08	7.02	2.27	10.20	12.28	4.55

The factors affecting efficiency in this study were focused on TE and CE, while the affecting factors in AE was not required since they were the division between CE and TE. Factors on education and land area influenced TE of rice farming, while in corn farming the influencing factors were the number of household members, land area, land ownership status, extension frequency, and the presence of demonstration plot. In soybean farming, the influencing factors were the status of land ownership and extension frequency (Table 3).

Table 3. Factors Affecting Technical Efficiency (TE) in Rice, Corn and Soybean Farming

Variable	Rice			Corn			Soybean		
	Coef.	Std. Err.	t	Coef.	Std. Err.	t	Coef.	Std. Err.	t
Age	-0.003	0.002	-1.610	0.001	0.001	0.870	0.001	0.002	0.330
Sex	-0.103	0.066	-1.570	-0.013	0.025	-0.520	-0.079	0.062	-1.290
Education	0.017*	0.007	2.410	0.004	0.005	0.840	0.008	0.005	1.730
ART total	-0.002	0.023	-0.090	-0.024*	0.009	-2.640	-0.005	0.011	-0.430
Land area	0.084*	0.033	2.560	0.168**	0.025	6.780	0.068	0.066	1.030
Ownership	-0.106	0.059	-1.790	-0.100**	0.025	-4.060	-0.302	0.068**	-4.440

Table 3. Factors Affecting Technical Efficiency (TE) in Rice, Corn and Soybean Farming (Continued)

Variable	Rice			Corn			Soybean		
	Coef.	Std. Err.	t	Coef.	Std. Err.	t	Coef.	Std. Err.	t
Varieties	0.069	0.070	0.990	-0.040	0.025	-1.590	0.000	0.033	0.000
Seed origin	0.055	0.085	0.640	0.035	0.049	0.720	0.036	0.036	0.990
Extension frequency	0.002	0.019	0.090	0.045**	0.007	6.660	0.018	0.007*	2.580
Demplot	0.024	0.058	0.410	0.092*	0.035	2.620	0.077	0.053	1.460
Intercept	0.593	0.252	2.350	0.556	0.071	7.780	0.747	0.173	4.310
Log likelihood		17.821			61.742			36.337	

Notes: ** significant at α = 0.01, * significant at α = 0.05

Factors affecting CE in rice farming were education, number of household members, and the land area. In corn farming, the influencing factors were the number of household member, land area, land ownership status, extension frequency, while in soybean farming the factors affecting the cost efficiency were land area and extension frequency (Table 4)

Table 4. Factors Affecting Cost Efficiency (CEK) in Rice, Corn and Soybean Farming

Variable	Rice			Corn			Soybean		
	Coef.	Std. Err.	t	Coef.	Std. Err.	t	Coef.	Std. Err.	t
Age	0.000	0.002	-0.240	-0.001	0.001	-0.600	-0.004	0.002	-1.900
Sex	0.070	0.051	1.350	-0.025	0.036	-0.690	-0.158	0.082	-1.920
Education	0.012*	0.006	2.160	0.002	0.007	0.220	0.005	0.006	0.840
ART total	0.046*	0.018	2.530	-0.029*	0.013	-2.260	-0.007	0.015	-0.480
Land area	0.162**	0.026	6.300	0.179**	0.035	5.160	0.322**	0.088	3.660
Ownership	-0.068	0.047	-1.470	-0.087*	0.035	-2.510	-0.063	0.091	-0.690
Varieties	0.004	0.055	0.080	-0.074	0.035	-2.120	0.102	0.044	2.330
Seed origin	-0.001	0.067	-0.010	0.007	0.069	0.100	0.042	0.049	0.850
Extension frequency	0.001	0.015	0.050	0.037**	0.009	3.950	0.024*	0.009	2.520
Demplot	0.019	0.046	0.420	0.087	0.049	1.770	-0.101	0.070	-1.430
Intercept	-0.064	0.197	-0.320	0.551	0.100	5.500	0.424	0.232	1.830
Log likelihood		29.760			43.225			24.143	

Notes: ** significant at α = 0.01, * significant at α = 0.05

Based on the analysis, as shown in Tables 3 and 4, the general fact, which can be obtained is that the most dominant factors affecting TE and CE in rice, corn and soybean farming are factors of land area and extension frequency. The larger the cultivated land, or the more the extension frequency is, the higher farming efficiency (TE and CE) will be. Therefore, increasing land used for the farming and the extension on technological innovation are required to increase the efficiency of farming crops.

CONCLUSION

The average technical efficiency (TE) of rice farming is 0.68, corn 0.73 and soybean 0.81, while the cost efficiency (CE) in rice farming is 0.42, corn 0.55, soybean 0.48. It is estimated that only about 10.20% of rice farmers, 12.28% of corn farmers and 4.55% of soybean farmers operate in allocative efficient conditions. This situation provides a description that improving the efficiency of food farming in Indonesia is still very possible to accomplish.

Factors on education and land area influence the technical efficiency and cost (TE and CE) of rice farming. In maize farming, the affecting factors are land area, status of land ownership, frequency of extension; whereas, in soybean farming the influential factors are status of land ownership and frequency of extension. The required policy to improve the efficiency of crop farming in Indonesia is the shared management to scale up businesses, as well as the increased frequency on the extension of technology innovation.

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