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Technical Efficiency of Paddy Farming in the East Coast of Peninsular Malaysia: A Comparison Based on DEA and SFA

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Abstract
The KADA and IADA KETARA are among important granary areas in Peninsular Malaysia producing paddy for domestic consumption. Both granaries are located in the East Coast of Peninsular Malaysia and involved with the new paddy scheme introduced by the Malaysian Government in 2008 during the world food crisis. This research was conducted to determine the best granary area in terms of technical efficiency (TE) based on two methods; Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The study involved interviewing with 148 paddy farmers using open and close ended questionnaires and the respondents were randomly chosen. The results showed that based on DEA indicator, IADA KETARA recorded the highest TE which is 0.90 while KADA obtained only 0.61. Based on SFA indicator, IADA KETARA indicated 0.84 TE while KADA, 0.67. The results consistently showed the TE scores estimated under DEA (TE-vrs) and SFA methodologies for IADA KETARA is greater than KADA and they are statistically significant at 5% level in both areas. Thus, it can be concluded that IADA KETARA are the best managed paddy farms in terms of technical efficiency compared to KADA.
Keywords: Technical efficiency, paddy granary areas, Data Envelopment Analysis, Stochastic Frontier Analysis

1. Introduction

In Malaysia's economy, agriculture remains as an important sector even though previous policies were in favour of manufacturing sector. This is because agriculture sector contributed 3% to the Gross Domestic Product (DGP) and providing employment for 12% of the population of Malaysia in 2012 (Nor Diana et al., 2013). According to Tey, 2010 Malaysia as a net importer of rice with SSL of about 72% was caught in food security crisis like other developing countries. This is because rice has an important effect on consumption and food security for fulfilling poor customers need in the country, who totally depend on rice as a staple food . Three expected factors that lead to high demand for goods services are the increasing residents, income and the changes of users' appetite which probably bring changes to the local food manufacturing industry. Similarly, the rice consumption is expected to increase from 2.3 million mt in 2010 to 2.69 million mt in 2020 (an increased of about 1.65% per year) due to the anticipated increase in population. The predicted figure is related to the expected increase of total population in Malaysia which is 28.6 million in 2010 to 32.4 million in 2020 (MOA, 2010a).

(MOA, 2011a) The NAP stated that in order to develop the paddy industry in this country, the paddy institution management should be enhanced by bringing into existences of a special unit under MADA, KADA, and IADA. This unit will be responsible to manage the farmers' land under the mini estate paddy scheme. Through this scheme, a sub company which belongs to the farmer will be formed to manage the paddy processing activity and rice processing along the value series consist of the seed production, plantation, harvesting, processing, marketing and distributing.

There are many factors that affect productivity directly or indirectly in any production system. Agricultural output and input are factors that affect growth of the productivity directly. Besides that, the other factors such as declining number of farmers, land conversion and others can affect expansion of productivity of the sector indirectly (Ramaila, 2011). In the growth of productivity, efficiency is a very important element in developing the agricultural economy because of limited resources and reduced opportunities for the development and use of technology (Ali and Chaudhry, 1990). The large economic profit may be achieved due to increased productivity and efficiency through the use of basic limited resources and existing technology.

In order to efficiently utilize limited resources, KADA was fully established in 1972 via Act 69, Kemubu Agricultural Development Authority Act, to manage the water resources, irrigation, and gutter system and the usage of agriculture technology. The aims of KADA are to increase the paddy production and other food production plus enhancing the family socio economic farm level in KADA's region. In terms of Malaysia paddy production, KADA listed at third place with the production over 200 thousands mt (MOA, 2012).

Apart from Kelantan, Terengganu is also one of the rice producing states in the east coast of Malaysia. The paddy granary in this state, which is known as KETARA, covers an area of 5,110 ha. This area contributes 67.0% of the state rice production which produced 40.9 mt of rice. However, this amount can only fulfill about 46.9 % of rice requirement in Terengganu and considered very low (KETARA, 2011). Some of the objectives of KETARA are to increase the production of paddy to 7 mt, in order to increase the monthly income of farmer's household to RM2000.00 and to guide and produce at least 10 entrepreneurs per year in a variety of agribusiness as well as to produce 20 developers to handle processing in order to increase the value of agriculture products (MOA, 2011).

2. Methodology

2.1 Study Area and Data sampling

Two granary areas in East Coast of Peninsular Malaysia which is KADA in Kelantan and IADA KETARA in Terengganu were covered in this research. The distance between these two granaries is about 55 km. The source of the data used in this study is primary data. The data were obtained by interviewed with paddy farmers using the structured questionnaires. The data was based on the 2013 cropping season and surveyed by trained enumerators under the supervision of the researcher. The data sampling in this research was taken randomly from the whole paddy farmers in both states. The questionnaire has been designed to gather the information on output, input, and some major socio-economic characteristic of the farmers. The information of input involved were farm size, amount of fertilizer, pesticide, seed, fuel and total working hour. The data will be used to estimate the technical efficiency of paddy farming in both states.

2.2 Theoretical framework of Technical Efficiency

2.2.1 Data Envelopment Analysis

The DEA method is created based on a model of linear programming in different scales to describe the technical efficiency levels; for example in cases of constant or variable returns to scale. The DEA in particularly can be estimated either with the assumption of Constant Returns to Scale (CRS) or with the assumption of Variable Returns to Scale (VRS). The technical efficiency defined by the DEA method either for constant or variable returns to scale can be calculated based on output orientation, hence resulting in a model that attempts to maximize outputs holding the observed amount of any input constant, or based on input orientation hence resulting in a model whose objective is to minimize inputs, keeping the observed amount of any output constant (Coelli et al. 2005).

The main advantage of this technique is that it considers various factors and does not need parametric assumptions as in traditional multivariate methods. On the other hand, there are a few critical factors one must consider in the application of DEA models (Talluri, 2000). The efficiency scores could be very susceptible to changes in the data and depend seriously on the number and type of input and output factors considered. The DEA is criticized because it is deterministic in nature and hence does not allow for the impact of measurement error and other random noise that can influence the estimated frontier (Schmidt 1985; Coelli 1995; Sharma et al.1999).

In this research, the input oriented of DEA method was used. This method is based on variable returns (VRS) to scale assumption as outlined by Coelli (1998). In this orientation, technical efficiency measure tackle the question how much inputs can be proportionally reduced without changing the output quantity produced. The input-oriented VRS in DEA linear programming models were applied to calculate the technical efficiency.
The envelopment form of the minimization problems is as follows:

$$\begin{aligned} &Min_{\theta,\lambda}\theta, \\ &\text{Subject to } -y_i + Y\lambda \geq 0, \\ &\theta x_i - Y\lambda \geq 0, \\ &NI'\lambda = 1, \quad \text{(VRS constraint)} \\ &\text{and } \lambda \geq 0 \end{aligned}$$

Where subscript i represents the *ith* farm; θ is the TE score having values ranging from 0 to 1; λ is a *NX1* vector of constants (weights) which defines the linear combination of the peers of the ith; Y is a vector of output quantities and X is a vector of observed inputs.

2.2.2 Stochastic Frontier Analysis

Aigner et al. (1977) and Meeusen and Van Den Broek (1977) has develop the stochastic production frontier model to estimate the technical efficiency of the production system. Since then it has been used by many authors to estimate the productive efficiency of a variety of agricultural production processes, such as factor productivity of industry, farms, crops and livestock.

The main advantage of the stochastic frontier production function model is the introduction of a disturbance term instead of noise, measurement error and exogenous factor further than the control of the production unit. This advantage of the stochastic frontier model is appropriate for efficiency measurement in agricultural production processes owing to agriculture's uncertainty in production (Wakili, 2012). The Stochastic

frontier production model is accepted by many researchers because of its flexibility and the ability to directly marry economic concepts with modeling the reality in production (Charles et al., 2011).
In this study, the SFA can be written as follows:
$Y= f (X_1, X_2, X_3, X_4, X_5)$
Where, Y= Total output per season in mt
X_1= Total amount of seed used (kg)
X_2= Total amount of fertilizer used (kg)
X_3= Total amount of pesticides used (ml)
X_4= Total amount of fuel used (l)
X_5 = Labor cost in hour

The stochastic Frontier Regression model is estimated using the maximum likelihood estimation (MLE) technique and the software by Coelli (1995) was chosen based on parameters estimated in this research and the model specification was expressed as:
$Y_i = \beta X_i + (V_i - U_i)$, i= 1,….,N

Where Y_i is the output, X_i is the input variables and βs are the parameter to be estimated. The V_i is random variables which are assumed to be identical and independently normally distributed. The V_i is considered to be independent of the U_i which are not negative random variables and assumed to account for technical inefficiency in production. The Ui are considered to be independently distributed as truncations at zero of the N (mi, σ_u^2) distribution, and assumed as follows:
$M_i = z_i \delta$
Where z_i = px 1vector of variables which may influence the efficiency of a farm and
δ = 1xp vector of parameters to be estimated.

3. Results and Discussion

3.1 Demographic

Table 1: Socio-economic characteristic of rice farmers

		KADA		IADA KETARA	
	Factor	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)
Gender	Male	122	98	42	87.5
	Female	2	2	6	12.5
Race	Malay	124	100	48	100
	Chinese	0	0	0	0
	Indian	0	0	0	0
Age	20-29	5	4	2	4
	30-39	17	14	8	17
	40-49	32	26	8	17
	50-59	42	34	18	38
	60-69	24	19	11	23
	70-79	4	3	1	2
Education	No formal education	15	12	10	21
	Primary school	22	18	21	44
	Secondary school	69	56	16	33
	Higher education	18	15	1	2
Marital status	Single	7	6	3	6
	Married	117	94	44	92
	Widow/er	0	0	1	2
Household size	1 to 3 people	29	23	14	29
	4 to 6 people	63	51	20	42
	7 to 9 people	27	22	11	23
	more than 10 people	5	4	3	6
Experience in paddy production					
	1 to 10 years	41	33	13	27
	11 to 20 years	36	29	15	31
	21 to 30 years	32	26	12	25
	31 to 40 years	9	7	4	8
	41 to 50 years	5	4	4	8
	51 to 60 years	1	1	0	0
Training/ conference/ course attended in last 3 years					
	yes	59	48	16	33
	no	65	52	32	67
Land ownership	Own	1	1	10	21
	Rent	79	64	23	48
	Own and rent	44	35	15	31

The participation of male farmers in both granary areas is higher than female farmers. KADA has shown the highest percentage of male farmers with 98%. The participation of female farmers can be seen higher in IADA KETARA compared to KADA which is 12.5% or 6 out of 48 farmers. Based on Table 1, it is noted that the paddy planting activities in each granary are dominated by the Malays as 100% of the farmers at KADA and IADA KETARA are Malays. The analysis of farmers' age had shown that the highest percentage belongs to the age which ranges from 50-59 while 56% of the farmers in KADA have completed secondary school. The IADA KETARA is noted to have the highest percentage in terms of education level at primary school with 44%. This number clearly emphasize that the level of farmer's education is at a medium level.

Based on Table1, it is noted that most of the farmers in the study area are married. For KADA, it is recorded that 96% of the farmers are married and the same also goes for IADA KETARA which recorded 94%. Married farmers are expected to be more committed in producing paddy because they have family members to take care of and the family members can also help them in planting paddy. For the family size, both granary areas have recorded a higher percentage for a household of 4 to 6 people. KADA has recorded 51% and IADA KETARA 42%. In both granary areas studied, it is noted that farmers planted paddy in two kinds of land ownership. It was either in their own land or it was on rented land. It is noted that KADA and IADA KETARA showed a higher percentage of farmers leasing other people's land which is 64% and 48% respectively. The results also showed that the number of farmers that used their own land to plant paddy is very low, for example in KADA only 1% of the farmers used their own land to plant paddy.

The analysis also showed that all of the farmers have experience in planting paddy. For IADA KETARA, those with 11 to 20 years experience showed a higher percentage which is 32% while for KADA, the highest percentage for years of experience recorded the shortest length of experience which 1 to 10 years at 33%. In terms of attending training, class or seminar, KADA and IADA KETARA also have a higher percentage of farmers not attending any training, seminar or class which is 52% for KADA and 67% for IADA KETARA. The reason that the farmers are not attending any training, seminar or class is probably because of lack of advertisement and knowledge about the importance of attending the seminar to increase the production of paddy.

3.2 Descriptive Analysis of Production

The average area of farmer's paddy field in KADA is 8.25 hectare while the average area is 2.7 hectare in IADA KETARA. Table 2 showed the farmers at KADA had allocated 27% or RM477.00 for labour costs, 20% to pay rent and land taxes, 22% for harvesting cost and 17% or RM292.00 to buy seeds. For IADA KETARA, 28% or RM494.00 was used to pay rent and land taxes, 23% was spent on harvesting cost and 19% or RM342.00 was used to pay workers. This is because most of the farmers in the IADA KETARA run the farm activities on their own, and sometimes assisted by their family members.

Table 2: Descriptive statistics for input variables

	Size	seed/ha	Fertilizer/ha	Pesticides	Fuel/ha	Workforce/ha
	ha/farmer	kg	kg	l	l	hour
KADA	8.25	136.8	477.29	1.65	41.57	62.17
IADA KETARA	2.7	152.13	486.74	9.29	18.9	56.97

3.3Technical efficiency

Based on Table 3, farms in IADA KETARA produced the highest mean technical efficiency (TE-vrs) of 0.901 compared with KADA produced the technical efficiency (TE-vrs) only 0.607 respectively. This implied technical efficiency of 90.1% for IADA KETARA while for KADA only 60.7% and inefficiency of 9.9% for IADA KETARA and 39.3% for KADA respectively.

The high degree of technical efficiency indicated by IADA KETARA suggested that the farms operated at a very high level of efficiency; even though 10% of inefficiency still exists. This indicates that about 10% level of input use will be retracted in the production cycle and given the continuous use of present technology, the same level of paddy output will still be produced if farms were technically efficient. This finding also differs, but is better compared to the result found by Ismail *et al.,* (2013) in the research of technical efficiency of paddy farming in Peninsular Malaysia where the result indicated that TE for West Coast and East Coast based on DEA analysis was only 0.58 and 0.51 respectively. In general, the result showed a wide efficiency range suggesting that the paddy farmers produce with wide variation in yield.

Refering to Table 3, the maximum value of TE-vrs in each granary are 1 while the minimum value of TE-vrs for KADA is 0.15 while IADA KETARA is 0.41. The value of Standard Deviation for KETARA is 0.17 while for KADA, the value is 0.28.

Based on Table 3, the DEA result for KADA showed the inefficiency problem associated with KADA paddy farming; where the mean DEA is 0.61. This finding showed that the paddy farming in KADA is facing critical inefficiency problem and is indeed the most efficient granary area relative to IADA KETARA. Based on this study, even though the mean technical efficiency for KADA is low, 13 out of 124 respondents had the TE-crs value of 1.00 and 27 farmers have the TE-vrs value as 1.00 or fully efficient. This indicated that there are farms that operate fully efficient.

Based on SFA analysis, IADA KETARA indicated 0.835 and KADA, the least efficient with only 0.669.

Based on this result, it can be seen that there was no granary operation at the frontier or fully efficient but the mean SFA value for IADA KETARA is also quite high. Reduction in input utilisation is needed in order to be fully efficient.

Table 3: Frequency distribution and summary statistics of technical efficiency

	KADA				KETARA			
	DEA (vrs)		SFA		DEA (vrs)		SFA	
Efficiency level	No. of farmer	%	No. of farmer	%	No. of farmer	%	No. of farmer	%
0 to 0.199	1	0.8	1	1.00	0	0	0	0
0.2 to 0.499	56	45.2	14	11.00	2	4.2	1	2.1
0.5 to 0.799	29	23.4	88	71.00	11	22.9	15	31.25
0.8 to 1.0	38	30.6	21	17.00	35	72.9	32	66.67
Total No. Farmers	124		124		48		48	
Minimum	0.15		0.02		0.41		0.46	
Maximum	1		0.98		1.00		1.00	
Mean	0.61		0.67		0.90		0.84	
Standard Deviation	0.28		0.18		0.17		0.12	

3.3.1 Statistical Mean Difference in Technical Efficiency under DEA and SFA

The analysis on the statistical mean difference in technical efficiency was determined through a comparison between two important analyses which are DEA and SFA in each granary area separately. In SPSS, there are a few types of t-test available and this research used the independent-samples t-test. From Table 4, it can be seen that the value in the Sig. (2-tailed) column for KADA and IADA KETARA is equal to 0.05; meaning that the TE scores estimated under DEA (TE-vrs) and SFA methodologies in both areas are statistically significant at 5% level.

Table 4: Performance of technical efficiency in each granary area

			T-test for Equality of Means			95% Confidence Interval of the Difference	
Equal variance not assume	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
KADA	-2.0858	246	0.05	- 0.618742	0.0296638	- 0.079326	- 0.044225
IADA KETARA	2.2498	94	0.05	0.66125	0.293916	0.0517543	0.0804956

This result shows that there is a significant difference in the mean TE scores under DEA (TE-vrs) and SFA models in both granary areas. Thus, in all granary areas, the null hypotheses are rejected and the alternative hypotheses are accepted. For KADA, the mean stated was -0.618742, the standard error difference was 0.0296638, t was -2.0858 and the degree of freedom was 246. For IADA KETARA, the mean recorded was 0.66125. The standard error difference was 0.293916 while t was 2.2498 and the degree of freedom was 94.

4. Conclusion

Based on the study of technical efficiency by using the DEA and SFA method, it can be concluded that IADA KETARA recorded the highest TE which is 0.90 for DEA and 0.84 for SFA while KADA noted the lower value which is 0.61 for DEA and 0.67 for SFA. This results meant that the farmer in IADA KETARA have used efficient input in the production process and produce near optimum yield of paddy. This study recommends farmers in KADA and IADA KETARA to improve the level of efficiency by reducing the application of inputs.

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