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Technical Efficiency of Paddy Farming in Peninsular Malaysia: Applications of Data Envelopment Analysis

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Abstract
Rice is the staple food for most of the people in the world. Rice also served as a basic food for Malaysian people. More than 300,000 people in Malaysia are paddy farmers and involved in small scale cultivation. Rice production especially in the granary area is expected to increase after the new incentive scheme was introduced by the government as a lot of budget had been spent for this incentive. In addition, the paddy farmers have faced the increase in cost of rice production almost in every year. This study was conducted to measure the technical efficiency of paddy farming in the East Coast and West Coast of Peninsular Malaysia which are MADA, KADA, IADA Penang and IADA KETARA by using Data Envelopment Analysis (DEA). The data were obtained by interviewing the paddy farmers using the well-structured questionnaires. The interviewed farmers were chosen randomly from the whole paddy farmers of each agency. For this function, this study has applied a non-probability sampling method that is a purposive sampling technique. The result showed that the IADA KETARA recorded the highest value which is 0.901 followed by MADA with 0.843, IADA Penang with 0.836 and KADA 0.607. The value of output slacks is zero and only for IADA KETARA. The KADA area operated with 0.017 as minimum output slacks, IADA-Penang with 0.332 as maximum output slacks and MADA was in the middle of the two with 0.159 output slacks. These showed the average level of shortfall in paddy production in the three granary areas.
Keywords: Rice Production, Technical Efficiency, DEA, Malaysia

1. Introduction

Malaysia is a country that produces rice and also import rice from other rice producing countries to meet the needs of the community as rice is the staple food for Malaysian. Currently, Malaysia does not export rice to other countries as the rice production in Malaysia is still limited to cater local needs. Nowadays, Self Sufficient Level (SSL) of all food commodities is projected to increase except rice in which the SSL is maintained at 70%. However, this issue will be reviewed from time to time with regards to security of rice supply in the country, global rice market scenario and the relative cost of imports.

In 2008, the price of rice in the world market had increased dramatically and this scenario has leads all countries in the world including Malaysia to start giving special attention to the food security issue. Similarly, the risen in the world food prices was visible through the food consumer price index from 100 in 2005 to 124.1 in 2010. This issue was expected to get worse as a result of climate change, scarce factor of production and an increase in input prices, and the competitive use of food for biofuel production (MOA, 2011). Moreover, the growth of population and rising of incomes had also give impact in the increase of food demand and this putting pressure on local food production industry. Rice consumption was expected to increase from 2.3 million metric tons in 2010 to 2.69 million metric tons in 2020 as a result of increasing number of population.

Reduction of land for food production is also an issue that should not be underestimated. According to statistics released by the Ministry of Agriculture, the total area of agricultural land for food production has declined by 0.8% per annum in the period of 2000 to 2010 and it is expected to decline by 0.9% per annum in the period of 2011 to 2020. This decline is due to the conversion of food crops to oil palm plantations and the development of residential and industry areas. Although to open a new area for rice cultivation is no longer recommended, the Government has taken other initiatives to ensure that the nation's food supply remains sustain. The initiatives include increasing food production through optimal use of land, sustainable intensive farming and large-scale cultivation of rice in a rice bowl.

With these initiatives, the Government expects the rice production to rise from 2.55 million metric tons in 2010 to 2.91 million metric tons in 2020, a growth of 1.3% per annum. Production at these levels will be achieved through increase of productivity of 4.0 tons/ hectare in 2010 to 5.0 tons/ hectare in 2020.

Deshpande and Bhende (2003) stated that the productivity increment is the only way out to fill the existing gap between demand and supply of food production, as the scope for further expansion of the area is very limited to meet out the requirement of ever increasing population in future. The productivity can be increased through introducing new technologies, adoption of existing technologies and efficient use of available resources. However, introducing of new technologies would be meaningless if the existing technologies are still not being use to their full potential (Kalirajan *et al*., 1996).

This study was done to estimate the technical efficiency of four granary areas which are MADA, KADA, IADA Penang and IADA KETARA based on Data Envelopment Analysis (DEA). Increasing the efficiency in production assumes greater significance in attaining potential output of the farms. Furthermore, the examination of existing gap between the potential and actual yields on the farm, given the technology and resource endowment of farmers, would provide a better understanding of the yield gap along with the causative factors. Thus, technical efficiency is an indicator of productivity differences across farms (Umanath and Rajasekar, 2013).

2. Methodology

2.1 Study Area

In this study, four granary areas were chosen which are; MADA in Kedah and IADA Penang in Penang will represent the West Coast and the East Coast is represents by KADA in Kelantan and IADA KETARA in Terengganu.

2.2 Data Collection

All the data collected in this study were based on personally interview by using open ended questionnaire. The respondents involved are the paddy farmers and they were selected randomly. The questionnaire covered few important aspects of production which are farm size, total seed used, total fertilizer applied, total pesticides applied, total fuel used and total working hour involved. The output variable considered for this study is the paddy yield. Aside that, the data on the socio economic variables such as family members, the age of household, the schooling year and the paddy area of the sampled farmer was also collected to explore their influence on the estimated cost efficiencies of the paddy farms.

2.3 Analytical Framework and Model Specification

In this study, the DEA was chosen to measure the technical efficiency of the granary area. In DEA analysis, there are two oriented approaches which are input oriented approach and output oriented approach. Input oriented approach referred to how much input levels can be reduced in maintaining the same level of output. On the other hand, output oriented approach referred to how much output levels can be proportionally increased without altering the input levels. This study involved input oriented based on variable returns (VRS) to scale assumption as outlined by Coelli (1998).

In this oriented approaches, technical efficiency measure tackled the question on how much inputs can be proportionally reduced without changing the output quantities produced. The input-oriented VRS DEA linear programming models were applied to calculate the technical efficiency.

The envelopment form of the minimization problems is as follow:

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

Where subscript I presents 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 lake; Y is a vector of output quantities and X is a vector of observed inputs. The software used to analyze the technical efficiency for this study was computer software DEAP version 2.1 produced by Coelli (1998).

3. Result and Discussion

3.1 Summary Statistics of Granary Area Studied

Table 1 presented the summary statistic of sample farms observed in this study. Based on the table, the highest mean of production was noted by MADA with 5.05 ton per hectare followed by IADA Penang with 4.83 ton per hectare. The third placed was indicated by IADA KETARA with mean yield of 3.7 ton per hectare and MADA noted the lowest yield with 3.62 ton per hectare.

In this research, six inputs were involved. For utilization of seed, farmers in IADA Penang were noted to apply the least amount of seeds as they only recorded to applied 102.79 kg/ ha. The highest utilization of seed was noted by IADA KETARA in which 152.13 kg/ ha of seeds was used. MADA and KADA noted to have similar amount of seed applied as both recorded 131.62 kg/ ha and 135.83 kg/ ha of seed used respectively. For MADA,

even though the mean amount of seed applied is not the highest, but the maximum amount of seed per hectare applied is the highest compared to other granary areas. This followed by IADA KETARA, IADA Penang and lastly KADA. However, MADA also recorded to have the lowest of seed applied per hectare with only 41.67 kg/ha while the highest was noted by IADA KADA with 58.97 kg of seeds per hectare.

The study also found that the farmers in IADA Penang had applied fertilizer higher than other granary areas as 504.44 kg of fertilizer were applied per hectare followed by IADA KETARA with 486.74 kg of fertilizer per hectare. MADA and KADA noted similar amount with 474.69 kg and 473.92 kg per hectare respectively. The maximum amount of fertilizer applied per hectare was recorded by farmer in IADA Penang with 979.25 kg of fertilizer were applied per hectare. The lowest amount of fertilizer applied was noted by farmer in KADA with only 16 kg fertilizer was used per hectare.

For the application of pesticides, the highest mean amount was indicated by farmers in IADA KETARA with 9.29 liter was applied for every hectare compared to MADA, KADA and IADA Penang with only 1.44, 1.63 and 2.59 l/ha was applied respectively. In every granary, minimum amount of pesticide applied was zero and the maximum amount was recorded by farmer in IADA KETARA with 127.5 l/ha. Based on the interview, the main problem of pest in IADA KETARA was rat and a lot of amount of pesticides was used to solve this problem.

Fuel also is one of the important inputs as most of the farm activities involved machines that using petrol and diesel to operate. MADA showed as the highest in consumption of fuel with 44.46 l/ha, followed closely by IADA Penang with 43.02 l/ha, KADA with 41.27 l/ha and IADA KETARA with only 18.90 l/ha. In every granary, there are farmers that did not use fuel at all and the maximum consumption amount was recorded by farmer in KADA with 779.22 l/ha.

The study also found that farmers in KADA spent much more time for farm activities compared to other granary areas as 61.73 hours were spent for every hectare. Farmers in IADA KETARA noted as second place with 56.97 hours and farmers in IADA Penang spent the lesser time for farm activities. Both maximum and minimum working hours were recorded by farmer in MADA with 385 hours per hectare recorded as the highest and 1.74 hours per hectare as the lowest.

The average farm size per person for MADA, IADA Penang, and IADA KETARA was 2.91 ha, 4.5 ha, 2.7 ha respectively and KADA indicated as the largest with 8.31 hectare per person. The smallest size was indicated by farmer in MADA with 0.14 hectare, and the largest farm size was owned by farmer in KADA with 48.84 hectare.

3.2 Technical Efficiency of Granary Area Studied

Table 2 showed the technical efficiency in four granary areas which are MADA, KADA, KETARA and IADA-Penang. This study was based on the pure technical efficiency which is the TE-vrs under DEA analysis. As per Table 2 indicated, the farms in IADA KETARA produced the highest mean technical efficiency of 0.901. On the other hand, paddy farms in MADA, IADA-Penang and KADA produced with technical efficiency of 0.843, 0.814 and 0.607 respectively. This implied a technical efficiency of 90.1%, 84.3%, 81.4% and 60.7% and inefficiency of 9.9%, 15.7%, 18.6% and 39.3% for IADA-KETARA, MADA, IADA-Penang and KADA respectively.

It is interesting to note that the results obtained from this study are different compared to the result found by Ismail *et. al*., (2013) in the research of technical efficiency of paddy farming in Peninsular Malaysia as the results of former study indicated that the technical efficiency for West Coast and East Coast based on DEA analysis were only 0.58 and 0.51 respectively.

The high degree of technical efficiency indicated by IADA KETARA suggested that the farms operated at a very high level of efficiency; despite of about 10% inefficiency exist. This indicates that about 10% level of input used 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. In general, the result also showed wide efficiency range which suggesting that the paddy farmers produced with wide variation in yield.

Referring to the Table 2, the maximum value of technical efficiency in each granary are 1 while the minimum value of technical efficiency indicated by every granary are 0.15 for KADA, 0.41 for IADA KETARA, 0.4 for MADA and 0.5 for IADA Penang. The value of standard deviation for KETARA, MADA and IADA Penang are similar which is 0.17 while for KADA the value is 0.28. The DEA result for KADA shows the inefficiency problem associated with KADA paddy farming; with the mean DEA 0.607. This finding showed that the paddy farming in KADA is facing critical inefficiency problem and indeed is the most inefficient granary area compared to the MADA, KETARA and IADA-Penang.

Based on this study, even though the mean technical efficiency (TE) for KADA is low, but, out of 124 respondents, 27 farmers stated the TE value as 1.00 or fully efficient. This indicated that there is a farm that operates fully efficient. TE mean value was low because the minimum mean TE value is very low. Mean technical efficiency score for all granary areas is 0.791. This result implied that the area could become technically efficient if it reduces all of its inputs proportionally by 21%. The analysis suggested that input use could be reduced in order to maintain the current production level. Although some individual farms reported technical efficiency of 1.000, but, none of the granary areas indicate efficient production as there is no granary area reports an average technical

efficiency of 1.000.

3.2.1 Input Slack

The value of output slacks is zero only for IADA KETARA revealed that the granary area produced without any shortfall in output. The granary area in KADA operates with 0.017 as minimum output slacks and IADA-Penang shown to have the maximum output slacks with 0.332. MADA is in the middle with 0.159 output slacks. These show the average level of shortfall in paddy production in the three granary areas.

The input slacks show the quantity by which input could be reduced and still produced the same output. The input slacks provide an accurate indication of technical efficiency of a farm.

In this research, high input slack occurred in the following input and in decreasing order: fertilizer, seed, labour and fuel. Fertilizer was indicated as the highest input slack with MADA at 176.76 and IADA Penang with 93.38. These amounts are considered as high. In terms of seed and labour, MADA recorded the highest slacks of 72.6 and 61.35 respectively. In fact, except in fuel in which it recorded the minimum slack. MADA granary area has consistently shown maximum slacks in other production variables. These indicated the levels of excess use of inputs in paddy production; which can conveniently withdraw the production process without affecting level of paddy production. These major input slack items which are fertilizer, seed and labour is quite similar with major input slack indicated by Umanath *et. al*., (2013) in the study of technical efficiency, scale efficiency and economic efficiency of paddy farm in India where the greatest slacks were in women labour use with 51.11% followed by nitrogen fertilizer with 50%, then men labour with 28.89%, potassium fertilizer with 25.56% and lastly seed material with 24.44%.

Based on this result, it is sufficient to state that all input were used excessively in all granary areas. Because of this, every granary area especially those that indicated high input slacks are advised to reduce their inputs especially fertilizer, seed, fuel and also labour as at present, amount of input used are not efficient and eventually are wasteful.

4. Conclusion

Study on the technical efficiency of farm by using the DEA method showed that IADA KETARA noted highest which is 0.9 while KADA noted the lowest value which is 0.607. This results meant that the farmer in IADA KETARA have used efficient input production and produce optimum yield of paddy. IADA Penang showed less efficient in using the input production. Therefore based on this study, it is recommended for the level of efficiency to be improved by reducing excess amount of inputs on one hand and raising output on the other hand and thus farmers could benefit economically.

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Note

Table 1: Summary statistics of sample farm

		Yield (ton/ha)	seed (kg/ha)	fertilizer (kg/ha)	pesticides (L/ha)	Fuel (L/ha)	workforce (H/ha)	farm size(ha)
	mean	5.05	131.62	474.69	1.44	44.46	54.64	2.91
MADA	min	1.44	41.67	470.00	0.00	0.00	1.74	0.14
	max	7.20	277.78	697.27	36.89	630.81	385.07	17.28
	mean	4.83	102.79	504.44	2.59	43.02	40.10	4.50
IADA Penang	min	3.06	52.65	470.00	0.00	0.00	12.15	0.54
	max	7.66	255.53	979.25	17.29	254.18	167.45	19.13
	mean	3.70	152.13	486.74	9.29	18.90	56.97	2.70
IADA KETARA	min	1.21	52.65	470.00	0.00	0.00	16.47	0.61
	max	5.37	262.08	620.08	127.50	117.00	213.14	8.14
	mean	3.62	135.83	473.92	1.63	41.27	61.73	8.31
KADA	min	0.00	58.97	16.47	0.00	0.00	2.46	0.81
	max	9.58	221.13	601.63	14.89	779.22	335.46	48.84

Table 2: Frequency distribution and summary statistics of technical efficiency

Efficiency level	KADA		IADA KETARA		MADA		IADA Penang	
	No. of farmer	%	No. of farmer	%	No. of farmer	%	No. of farmer	%
0 to 0.199	1	0.8	0	0	0	0	0	0
0.2 to 0.499	56	45.2	2	4.2	7	3.5	0	0
0.5 to 0.799	29	23.4	11	22.9	62	31	19	40.4
0.8 to 1.0	38	30.6	35	72.9	131	65.5	28	59.6
Total No. Farmers	124		48		200		47	
Minimum	0.15		0.41		0.4		0.5	
Maximum	1		1		1		1	
Mean	0.607		0.901		0.843		0.814	
Standard Deviation	0.28		0.17		0.17		0.17	

Table 3: Output and input slacks involved in technical efficiency analysis for every granary area investigated

		Mean Input Slacks					
	Mean output Slacks	Farm size	Seed	Fertilizer	Pesticides	Fuel	Labor
KADA	0.017	0.063	18.399	36.951	0.764	38.016	28.825
IADA KETARA	0.000	0.070	39.640	22.147	0.690	30.540	34.768
MADA	0.159	0.364	72.606	176.763	3.303	26.153	61.346
IADA Penang	0.332	0.2	34.53	93.381	4.533	60.645	20.234