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IMPACT OF ATTENDING TRAINING COURSE VARIABLE ON TECHNICAL EFFICIENCY OF OYSTER MUSHROOM PRODUCTION IN QUANG TRI PROVINCE

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Abstract: The study based on the cross-sectional data of 94 oyster mushroom farms in Quang Tri province to measure their technical efficiency at the farm level and identify the impact of attending a training course variable on it by using the two-stage Bootstrapped Data Envelopment Analysis. The empirical results confirm that attending a training course is an important factor affecting the technical efficiency of oyster mushroom farms in the study area. The farms that attended a relevant training course were more efficient than those did not. Moreover, they also show that the gender of the farmers, the source of irrigation water, the duration of oyster mushroom production, and the number of oyster mushroom crops cultivated on this current farm had a significant correlation with the technical efficiency. Compared with the best practice farms in this sample, in order to be efficient, the oyster mushroom farms in the study area should use fewer inputs to produce the current level of output. Especially, farmers should attend relevant training courses, and the local authorities should organize more training courses to improve the current level of efficiency of those farms. In addition, the impacts of gender of the farmers, source of irrigation water, duration of production and number of crops should also be included in the content of the up-coming training courses.

Keywords: technical efficiency, oyster mushroom, training course, Bootstrapped Data Envelopment Analysis

1 Introduction

The oyster mushroom production has been considered as a mean of not only taking advantage of by-products of the agriculture production but also giving job opportunities and increasing the return to farmers (Nair, 2009). It has been known as a simple industry because it does not require a large and fertile land as well as high skill workers, but its net benefit ratio is relative high with 38.6 % of the total value of production (Au, 2017). However, although started in Quang Tri province a long time ago, the production has just spontaneously developed in a few recent years with a mainly small scale. This might be due to lack of information on its efficiency and especially the lack of technical knowledge or instruction of how to cultivate oyster mushrooms efficiently, which might be derived from a relevant training course. Many farms have produced oyster mushrooms mainly based on the experience obtained from others because there have still been few training courses related to cultivating oyster mushrooms, and its important role has not yet been aware in the study area. Therefore, in order to propose persuasive information to the farmers, extension officers as well as local authorities, this paper aims to identify the impact of attending a training course variable on the technical efficiency of

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oyster mushroom production in Quang Tri province using the two-stage Bootstrapped Data Envelopment Analysis.

2 Data and methodology

Methodology

Bootstrapped Data Envelopment Analysis model

Coelli et al. (2005) reported that efficiency can be considered in terms of input orientation or output orientation. The input-orientated efficiency finds out a target point maximizing the proportion reduction in inputs or produces a given level of output from an optimal combination of inputs. Meanwhile, the output-orientated efficiency finds out a target point that maximizes the proportional augmentation in outputs or produces the optimal output from a given set of inputs. Because oyster mushroom farmers seem to have more control over their inputs than outputs, the Data Envelopment Analysis input-oriented model is more appropriate in this study. Moreover, the result of testing for the return to scale of 94 oyster mushroom farms based on the study of Simar & Wilson (2002) showed that the DEA model of those samples should be under the constant return to scale (CRS) (Léopold Simar & Wilson, 2002). Therefore, the DEA model for estimating the technical efficiency in this study is

$$\text{Min}_{\theta,\lambda}\theta,$$

Subject to

$$-y_i + Y \cdot \lambda \geq 0,$$
$$\theta \cdot x_i - X \cdot \lambda \geq 0,$$
$$\lambda \geq 0$$

where θ is the technical efficiency (TE) score having a value ranging from zero to one ($0 \leq \theta \leq 1$). A farm is technically efficient and on the frontier if θ is equal to one. Y is the vector of output quantities and X is the vector of inputs. The first constraint of the above model guarantees that the output produced by the ith farm is less than that on the frontier. The second constraint limits the relative decrease in the input use when θ is minimized to the input use realized with the best-observed technology.

However, the result of DEA estimation is claimed to be biased because of missing taking into account of the random error due to its deterministic nature (Simar & Wilson, 1998; Simar & Wilson, 2000). However, Simar and Wilson used the smoothed bootstrap procedure to correct this bias and even estimate its confident interval. This study, therefore, employs the data envelopment approach with the smoothed bootstrap procedure introduced by Simar and Wilson (1998).

In order to confirm the difference in the mean values of two groups, a two-sample t test has been normally applied in many studies. Nevertheless, the t–tests are fairly robust against departures from the normal distribution (Dalgaard, 2008), which is not used in this non-parametric method Data Envelopment Analysis. Therefore, a nonparametric two-sample Wilcoxon test is more appropriate and was used in this study for this purpose.

Moreover, all of the data analyses were done in the R software, the standard error (SE) values of which are not included in its default descriptive statistics (Dalgaard, 2008). Therefore, following the recommendation of Dalgaard (2008), the median, first quartile (1st Qu.) and third quartile (3rd Qu.) are used instead of SE in this study.

Determinants of technical efficiency

In the second stage, following Simar and Wilson (2007), this study employed the double bootstrap method (Algorithm 2) to identify the determinants of efficiency (Léopold Simar & Wilson, 2007). Therefore, the bias-corrected reciprocal of efficiency scores were regressed on a set of explanatory variables using bootstrapped Truncated regression:

$$\bar{\bar{\delta}} = \alpha + Z_i \cdot \beta + \varepsilon_i, \qquad i = 1, \dots, n$$

where $\bar{\bar{\delta}}_i$ is the bias-corrected reciprocal of DEA technical efficiency scores, α is the constant term, β is the vector of parameters, Z_i is the vector of specific variables and ε_i is the statistical noise, $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$ with left truncation at $1 - Z_i \cdot \beta$. Hence, those variables with a negative (positive) coefficient sign will have a negative (positive) impact on the technical efficiency.

Data and variables

Primary data of this study were based on the farm level cross-sectional data of oyster mushroom farms in Quang Tri province. The sample size was 94 households. This sample was divided into two groups: one attended the training course of cultivating oyster mushrooms with 54 households and the other did not with 40 households.

In the Data Envelopment Analysis model, the yield in kilograms was taken as an output with two main inputs: seedling in bags and labor in working hours. In the truncated regression model, the bias-corrected reciprocal of the DEA technical efficiency score was regressed on farmers' characteristics including gender (a dummy variable taking 1 if a farmer was female and 0, otherwise), experience (years) and dummy attending training course (a variable taking 1 if a farmer did not attend any relevant training courses and 0 if they did), production characteristics including materials used for seedling bags (a dummy taking 1 if they were straw and 0 if they were sawdust), source of irrigation water (the dummy variable taking 1 if it was from the water supply factory and 0 if it was from wells), duration of oyster mushroom production (months), farm area (m^2), and number of crops cultivated on this current farm (crops).

3 Result and discussion

The summary of the descriptive statistics of inputs and output of those two groups used in the Bootstrapped Data Envelopment Analysis model and variables used in the Truncated regression model is shown in Table 1.

The data of Table 1 reveal that there is a significant difference in inputs and output of oyster mushroom production between the two groups: attending and not-attending training courses. However, there is not much difference in farmer's characteristics and production characteristics between them. Generally, the former group used less seedling bags but more labor working hours than the latter. On average, the farm that attended a relevant training course utilized 1,394 seedling bags and spent 843 hours on watering making a production of

1,213 kilograms of oyster mushrooms while the other utilized 5,350 seedling bags and spent almost 500 hours on watering for 2,188 kilograms of output.

Table 1. Inputs and output of oyster mushroom production per farm in Quang Tri province

	Attending training course						Not attendingtraining course						*p*-Value of Wilcox test
	Min	1st Qu.	Median	Mean	3rd Qu.	Max	Min	1st Qu.	Median	Mean	3rd Qu.	Max	
Bootstrapped DEA model													
Inputs													
Seedling (Bag)	400	700	900	1,394	1275	10,000	500	1200	3,000	5,350	7,250	25,000	0.000***
Labor (Hours)	290	500	630	843.3	835	4,218	72.7	229.6	315.6	499.8	710.5	1,783.3	0.001***
Output													
Production (Kg)	350	515	700	1,213	1075	9,000	196	715	1,180	2,188	4,000	6,600	0.005***
Truncated regression model													
Farmer's characteristics													
Experience – X_1 (Year)	2	4.3	8.0	7.8	11	14.0	1.0	5.8	8.0	7.9	10.3	15.0	
Gender – D_1 (Female = 1)	-	-	-	24.0	-	-	-			20.0		-	
Attending training course – D_2	-	-	-	54.0	-	-	-			40.0		-	
Production's characteristics													
Materials of seedling bag – D_3 (Straw = 1)	-	-	-	40.0	-	-	-			22.0		-	
Irrigation water – D_4 (from factory = 1)	-	-	-	22.0	-	-	-			24.0		-	
Duration of production – X_2	3	6.0	7.0	7.8	10	12.0	5.0	5.0	7.0	7.1	8.0	12.0	
Area – X_3	25	36.3	50.0	59.4	68.8	200.0	18.0	30.0	55.0	87.1	100.0	500	
Number of crops – X_4	2	3.0	3.0	4.7	6.8	10.0	1.0	4.0	6.0	6.4	8.0	13.0	

The technical efficiency and its confident interval were estimated and corrected based on the above data and employing Bootstrap input-oriented Data Envelopment Analysis under the constant return to scale, and the results are presented in Table 2.

The data in Table 2 show that oyster mushroom farms that attended a relevant training course are much more efficient than the farms that did not, and the difference is statistically significant. The 95 % confident interval for the technical efficiency of the group attending a training course is between 0.68 and 0.72 (with the mean value of 0.69); and for the group not-attending a training course this interval is between 0.43 and 0.56 (with the mean value of 0.48), indicating that these oyster mushroom farms are substantially inefficient. The attending and not-attending training course farms used higher inputs than the best practice farms, corresponding to 31 % and 52 %, respectively. Besides overusing inputs, what are the factors affecting their technical efficiency?

Table 2. Technical efficiency of oyster mushroom farms in Quang Tri province

Statistics		Attending training course	Not-attending training course	*p*–value of Wilcox test
Min		0.3354	0.0546	
1st Qu.		0.6277	0.2990	
Median		0.7048	0.5254	
Mean		0.6901	0.4786	9.323e-06***
Max		0.9785	0.8869	
Confident interval	Lower	0.6771	0.4310	
	Upper	0.7198	0.5567	

Table 3. Determinants of technical efficiency of oyster mushroom farms in Quang Tri province

Statistics	Coefficient	Confident interval	
		Lower	Upper
Intercept	-66.23025099***	-111.03118367	-37.3964132
Farmers' characteristics			
Experience – X_1	-0.22623032	-2.44563287	1.7323459
Gender – D_1	-15.77106221***	-39.61546229	-5.4662854
Attending training course– D_2	58.54230114***	38.01462508	91.1345553
Production characteristics			
Materials of seedling bag – D_3	5.28079541	-6.07545108	16.8713303
Irrigation water – D_4	-23.92141662***	-45.01094531	-13.1057612
Duration of production – X_2	-4.67384883***	-9.65399609	-2.0865221
Area – X_3	0.02606816	-0.06135763	0.1098706
Number of crops – X_4	2.57384074**	0.27772390	7.0266691

*, **, *** Indicate the significance at 10, 5 and 1 % levels, respectively.

The determinants of technical efficiency of oyster mushroom farms in Quang Tri province are shown in Table 3. The results of bootstrap truncated regression on farmers' characteristics and production characteristics to identify the determinants of technical efficiency were found. Notably, the coefficient of farmers attending a training course was found to be positive, and this factor was a statistically significant dependent variable. This implies that Attending training course was an important factor affecting the technical efficiency. This shows that the attending training course group was more efficient than the not-attending training course group. Therefore, this again confirms the result of the comparative analysis shown in Table 2.

Moreover, data in Table 3 also show that Gender of farmers, Source of irrigation water, Duration of oyster mushroom production, and Number of oyster mushroom crops cultivated on this current farm also had a significant relationship with technical efficiency. Among them, only the last variable positively affected the technical efficiency, while the others had the negative effect.

The negative and statistically significant coefficients of farmers' gender and source of irrigation water imply that male-operated farms were less efficient than female-operated ones, and the oyster mushroom farms using irrigation water from the factory were more efficient than those using irrigation water from the well. The results interpreted that water from the factory is always treated and filtered while water from the well is completely natural, untreated and unfiltered. It is not sure that water from wells can qualify the growth of oyster mushrooms in a good condition when all relevant technical documents noticed that oyster mushrooms require clean water for irrigation.

The coefficient of the duration of oyster mushroom production in the last crop shows that the longer the crop lasted, the more efficient the farms were. However, the more crops they cultivated on this current farm, the less efficient they were.

4 Conclusion and recommendation

In the current study, the two-stage Bootstrapped Data Envelopment Analysis was employed to measure the technical efficiency of oyster mushroom farms in Quang Tri province and identify the important role of attending training courses. The results showed that farms attending a relevant training course were more technically efficient than those did not. The mean technical efficiency of those two groups was 0.69 and 0.48, respectively. This significant difference was also confirmed by the result of the Bootstrap Truncated regression in the second stage. Besides, Gender of the farmer, Source of irrigation water, Duration of oyster mushroom production, and Number of oyster mushroom crops cultivated on this current farm also had a significant correlation with the technical efficiency.

Based on the results, the recommendations can be made. Because of the importance of attending training courses, the local authorities should organize more short courses of training how to cultivate oyster mushrooms efficiently in this study area. These training courses should include the content of encouraging farmers to use irrigation water from the factory instead of from a well, lasting the duration of oyster mushroom production as long as possible, but reducing the number of crops cultivated on the current farm. Moreover, due to the usefulness of the training courses, the farmers in Quang Tri province should do by themselves and be encouraged to join in such training courses to make their mushroom farming more profitable.

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