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Analysing Determinant of the Technical Efficiency of Seaweed Operators in Semporna, Sabah, Malaysia

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Abstract: The worldwide seaweed industry is expected to contribute more than RM 20 billion annually as it is useful in food, health and pharmaceutical industries. Seaweed farming is an export-oriented aquaculture subsector that is rapidly spreading specifically throughout the region of South East Asia. The main objective of this study is to identify the technical efficiency factors among the seaweed farms in Semporna, Sabah. Technical efficiency analysis is important because it will give the respondents and agencies a view to study seaweed farm from the current level of efficiency. This study was conducted in Semporna, Sabah and involved 81 respondents. This study used two stage methods whereby, the technical efficiency score first was calculated by using the DEAP 2.1 Software and then regressed with independent inputs. The technical efficiency score demonstrates that seaweed farms in Semporna have efficiency score at average of 69%. It shows that the average seaweed farms were operating at the increasing returns to scale rate which then indicating that the possibility for the farm to increase their yield with the currently available array of inputs and existing technology. On the other hand, the adjusted R^2 is 0.433 indicating all the variables included in this regression model were only able to explain about 43.3% of influence towards the technical efficiency. Only personal control, age, experience and labour inputs were significant to the technical efficiency. This indicates that these factors influencing the farm technical efficiency. The seaweed farming in Malaysia is still under the development phase. Thus, it is important to extend the mini-estates programme and encourage more innovation activities among the public research institutions and local universities.

Key words: Semporna, seaweed, DEA, technical efficiency, multiple regression, development

INTRODUCTION

The worldwide seaweed industry is expected to contribute more than RM 20 billion annually as it is useful in food, health and pharmaceutical industries. Seaweed farming is an export-oriented aquaculture subsector that is rapidly spreading specifically, throughout the Region of South East Asia. In Malaysia particularly, it is expected to be able to produce around 150,000 MT of dried seaweed which valued at RM 1.4 billion in year 2020 (PEMANDU, 2010). The annual growth of seaweed industry has shown a cumulative growth about 34% which is considered as high. However, it is known that only 33% of suitable lands for seaweed farming are being occupied. This phenomenon is seen as an open opportunity for the industry to be experience further development. It is believed that Malaysia can fulfill the market demand by increasing productivity to cater domestic and international needs, since, Sabah coastal areas are blessed with suitable climatic condition for growing seaweed as well as a good infrastructure. Seaweed is further claimed to be as a potential crop to alleviate livelihood of fisherman and coastal community especially for the island's population in Sabah.

The technical input allocation and the ability to manage the farm also have a strong influence over the successful of any agriculture business. The efficient farms evidently show that they can manage to earn higher yield and income than those inefficient farms. So, the government introduces the seaweed mini-estate project under Economic Transformation Programme (ETP) in order to provide an opportunity for seaweed farmers to improve their yield, income and participation in entrepreneurship.

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The main objective of this study is to identify the technical efficiency factors among the seaweed farms in Semporna, Sabah. Technical efficiency analysis is important because it will give the respondents and agencies a view to study seaweed farm from the current level of efficiency. For those who are in higher efficiency group, they can continue their current practice and for those who are categorised in the inefficient group, they can take this opportunity to change their current practice as to improve their efficiency and increase their yield. At the same time, they can allocate their resources wisely, therefore, reducing the cost of production and better time-management. The improvement in both yield and profit will then brought to the life quality improvement among the seaweed operators.

Technical efficiency: The Technical Efficiency (TE) measurement demonstrates as the tool for the Decision Making Unit (DMU) to choose the best practice to maximize the farm output. The DMU is referring to any entity that is to be measured in terms of its ability to transform the inputs into output. The main tools for estimating the DMU best practice are the Data Envelope Analysis (DEA) and Stochastic Frontier Analysis (SFA). Both approaches of DEA and SFA share common characteristics where they identify a frontier or limit on which the relative performance of all utilities in the sample are compared to a benchmarking farm only against the best producer (Ismail *et al*., 2013). In this, it is assumed that if there is a farm that can produce certain amount of output at given inputs, it also expected that another farm which had an equal scale should be able to produce the same amount of output (Coelli *et al*., 1998).

The DEA, is comparing individual DMU to the best of DMU that has the same scale (Karimzadeh, 2012). DEA is a non-parametric concept which used mathematical estimation programming to estimate the TE. In fact, the DEA is based on the inspiring research by Farrell (1957) and improved by Charnes *et al.* (1978). Charnes *et al.* (1978) define the efficiency as the weighted sum of outputs over the weighted sums of input in the constant returns to scale assumption. In DEA itself, there are two most influential models that use the Returns to Scale (CRS) and Variable Returns to Scale (VRS) concept.

By referring to VRS concept, Coelli *et al.* (1998), explain that the convexity constraints act as the restriction that makes the comparison only of farm of similar size, output by performing a convex hull of intersecting planes, so, the data enveloped more tightly. Whenever, the DEA frontier or surface is determined, the efficiency measurement are calculated relative to this surface and it identifies the efficient production DMU which belong to the surface or equal to 1 and otherwise, it is considered as inefficient DMU (Coelli *et al*., 2005). The main advantage of the DEA is its generality. It can accommodate multiple input and output and does not require input or output price in order to iidentify the best practice production frontier. It also assumes there are no random effects in the production and does not require the specification of the production function (Mailena *et al*., 2014). Grifell-Tatje and Lovell (1996) also claimed that it uses less data demanding than econometrics methods because it does not require a large sample size.

MATERIALS AND METHODS

This study was conducted in Semporna, Sabah. The population sample size was involved 81 respondents. The technical efficiency study used two stage methods whereby, the technical efficiency score first was calculated by using the DEAP 2.1 Software. The software has provided direct technical efficiency for both Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) score for an individual farm, therefore, making it to be more convenient to use. Thus, the result of characteristics of the farms can be summarised in a straightforward manner (Table 1). Secondly, the multiple regression analysis was estimated using the SPSS statistical package software (Table 2). This objective is to

Table 1: The individual seaweed operator's Technical Efficiency (TE) score

DEA interval	TE_{VRS}[1] (n (%))
0.300-0.399	8 (9.9)
0.400-0.499	12 (14.8)
0.500-0.599	8 (9.9)
0.600-0.699	11(13.6)
0.700-0.799	11 (13.6)
0.800-0.899	**16 (19.8)**
0.900-0.999	**4 (4.9)**
1.000	**11 (13.6)**
Total n (%)	81 (100)
Minimum score	0.323
Maximum score	1.000
Mean	0.690

[1]using DEAP 2.1 Software; Survey data; Bold values are significant

Table 2: Results of multiple regression analysis for independent variables and TE_{VRS}

Variables	Coefficients
Constant	0.656
Entrepreneurial attitude orientation	
Personal control (x_3)	0.219**
Socio-demographics	
Age (x_5)	-0.744*
Experience (x_8)	0.384*
Household person (x_9)	-0.123
Technical inputs	
Land (x_{11})	0.400
Seed (x_{12})	0.126
Labour (x_{13})	-0.257**
R^2	0.483
Adjusted R^2	0.433
ANOVAs F-value	9.733*
Durbin-Watson	2.253

*Significant at 1%; **Significant at 5%; Survey data determine the technical efficiency involving two procedures, first by estimating the Technical Efficiency on constant Return to Scale (TE_{VRS}) and second by regressing it towards the independent variables.

RESULTS AND DISCUSSION

Descriptive analysis: Table 3 is a representation of both male and female respondents at 76.5 and 23.5%, respectively. The gender mean and standard deviation is 0.77 and 0.462, respectively. The results show that the males outnumbered the females indicating that there is a significant gender-bias. The respondent's age is between 17-76 years old and the average age group is of 44.14 years old. The result also shows that the younger age group 29 years old and below only represents 6.2% of the respondents.

Table 3 also indicates that majority of the seaweed operators had primary education (51.8%), followed by those who did not attend formal education (24.7%) and secondary education (23.5%). It is shown that the majority of the respondents involved in the seaweed cultivation were among married men. The breakdown of the seaweed operator's household showed that more than half (51.9%) were from the family group of 6-8 persons.

Table 3: Socio-economics characteristics

			Inventory score	
Variables	n	Percentage	M	SD
Gender			0.77	0.462
Male	62	76.5		
Female	19	23.5		
Age group (Years old)			44.14	11.680
Below 29	5	6.2		
30-39	28	34.6		
40-49	21	25.9		
Above 50	27	33.3		
Education levels			0.99	0.698
No formal education	20	24.7		
Primary school	42	51.9		
Secondary school	19	23.5		
Households person			6.10	1.692
3-5	30	37.0		
6-8	42	51.9		
9-11	9	11.1		
Other occupation			2.31	1.463
Fishermen	40	49.6		
Seaweed operators	22	27.2		
Farmer	8	9.9		
Business owner	7	7.4		
Others	5	6.2		
Household income			630.86	163.471
RM 300-500	26	32.1		
RM 501-701	36	44.4		
RM 702-902	19	23.5		
Experience in seaweed cultivation (Years)			11.85	5.459
<10	42	51.9		
10-15	27	33.3		
Above 16	12	14.8		

The years of experience among the seaweed operator was divided into three groups represented by 51.8% of <10 years group, 33.3% of the 10-15 years group and 14.8% of those experienced more than 16 years.

Technical efficiency score: The DEA findings summarize in the Table 1 are using Variable Returns to Scale (VRS) concept. It is revealed that, the seaweed operators in Semporna as having a medium efficiency since the TE score mean is 0.690. The TE ranged between 0.32-1.0 whereby, around 38.3% seaweed operators manage to exceed at least 0.80 score while 61.7% fail to do so.

The technical efficiencyreflects the farm's production changes if the equal allocation of inputs changes. The technical efficiency score demonstrates that seaweed farms in Semporna have efficiency score at average of 69%. The number of farms that exhibits 100% technical efficiency is 11 farms demonstrated that only 13.6% of respondents are efficient in allocating and managing their farm while the rest is inefficient. It shows that, the average seaweed farms were operating at the increasing returns to scale rate which then indicating that the possibility for the farm to increase their yield with the currently available array of inputs and existing technology as suggested by Iliyasu *et al.* (2014). The result also suggests that the farm should consider to expand their area with better resources allocation and farm management. Therefore, the farm can be operated within the efficiency scale.

This finding is also contrasting with the study conducted by Seo and Song (2009) which found that half of the seaweed farms in the Republic of Korea were operating in efficient manner. Seaweed farming had been long establish in Korea and in fact, they are the second largest seaweed producer in the world. This might explain why their high efficiency score on seaweed farms. Furthermore, this present result is also lower if compared to the seaweed farms study in Indonesia which denotes their farm capacity to produce high yield. In comparison to Indonesia, Malaysian seaweed serves as additional income among the coastal community in Semporna, hence, they are not fully utilised their time and effort to seaweed farming. On the contrary, in Indonesia, seaweed cultivation is seen as an industry that serves as its main income for its coastal people. The dependency of Indonesian coastal community towards seaweed farming industry is due to the depletion of fishing resources. Additionally, it does not require high capital and fast return on investment. The present finding is plausible as the respondents are complaining about the pest, disease outbreak and cyclone occurrence which affect their seaweed production. Respondents also claim that they need to do replanting as to maintain their earnings.

Possibly, this is a reason for explaining lower TE among the farms. This is supported by Hurtado *et al.* (2013) who stated that the pest, disease outbreak and cyclone become a large problem in seaweed farming as they reduce the quality and quantity of yield. This suggests that some farms input's and management require improvement, so that, technical efficiency gap can be narrowed. Solis *et al.* (2009) suggest that respondents must manage their inputs combination significantly to reach the technical efficiency of a farm. Other than increasing the farm size, the inputs improvement can also be done by considering better allocation of seeds and management practices. Pest occurrence and disease infestation indicate the needs for a resistance seedlings and proper farming management to increase the efficiency. In the study area, researchers are well aware of the inefficiency that might be associated with age and education. Currently, this industry is mostly dominated by 38-58 years old respondents who possess lower education level (e.g., no formal education and primary school) as shown in Table 2. This exhibits that the young, healthier and educated individuals as uninterested to research in the seaweed farms. Susilowati (2004) explains further that the younger, healthier and educated individuals will prefer to work in the off-farm industry.

Determinants of technical efficiency: The result of the regression (Table 2) shows that adjusted R^2 is 0.433 indicating all the variables included in this regression model were only able to explain about 43.3% of influence towards the technical efficiency. In fact, there is about 56.7% of other variables that might affect the technical efficiency was not included in this regression model. The personal control and experience show a positive and significant relationship with the technical efficiency. On the other hand, the labour and age has opposite relationship with the technical efficiency. Regardless of the low adjusted R^2 result, the ANOVAs value of $F(7, 72) = 9.733$ $p<0.05$.

The result shows four of these inputs were significant to the technical efficiency. This indicates that these factors influencing the farm technical efficiency. For instance as these factors added (except the age factor) the technical efficiency were also increases. The insignificant inputs were household person, land and seed. The insignificant determinant shows that the outcome of the change of that input was too small to influence the technical efficiency. Overall, the adjusted R^2 is at 43% indicating more than half of the inputs that might influence the technical efficiency which had been exclude in this regression study.

The positive and significant input is personal control and experience. The regression result shows that the personal control factor is significantly contributing to the technical efficiency of the seaweed farms. This is might be caused by the fact where they believe that seaweed farming will help them to get a better quality of life. Din and Md Hussain describes about the individual with the personal control who possess the quality of confidence, committed and have high determination to accomplish their goal or belief. Another reason for explaining the present result is probably due to respondent's low education, deficient skills and physical limitations that hindering them from better career opportunity in other employment, therefore, they are motivated to improve their household economics. Ali *et al.* have found that respondents are more likely to try new farming technology, seeds and practices introduced by the government agencies as it can help to increase their farming efficiency.

The seaweed operator's experience is found to have a strong relationship with technical efficiency. It indicates that when there are more years they involve in seaweed cultivation, the more efficient they will become in managing the seaweed farms. In fact, this present result is also related to other socio-demographic factors such as knowledge and skills. They managed to observe, practise and experiment their farming activities when they spend years performed the same routine which enhance their knowledge and sharpen their skills. Hence, this will improve their ability to becomemore efficient in managing their farms. According to Alemdar and Isik (2008) study on peanut farm, they also identified the association between experience and efficiency. Their findings describe that the more the farmer's deals with peanut farming, the more efficient they will become in managing their farms. On the contrary, Bahari *et al.* has found negative sign on experience among the seaweed operators in Indonesia. The farmers still have the ability to produce high yield even though they are inexperienced in seaweed farming.

The age shows a significant sign in influencing the technical efficiency of seaweed cultivation but in a negative way. The negative sign of age indicates that ageing people in the study area were inefficient when compared to younger people. This present finding is similar with Alemdar and Isik (2008) study who also found that the age is negatively affected the technical efficiency. The possible explanation for this finding is that the younger farmers are more receptive to innovation and exposed to modern technology. This is supported by Murthy *et al.* (2009) as their findings proved that younger farmers were more efficient when compared to their senior farmers. Based on another study by Hossin and Rosli, they acknowledged that younger operators do play a vital role in seaweed farming productivity. The younger are more likely to produce seaweed more than those who are older (50 years and above). This is a relevant evident when considering that seaweed cultivation in the study area are currently practised traditional methods and labour-intensive. Moreover, those young farmers who possess higher education level are more likely to accept the recommendation and willing to try new practices as suggested by the agency. The study also illustrates that elderly people as unable to compete with young people despite having years of experience because this occupation requires healthy and strong men to finish a farm task. This is in agreement with Irmayani *et al.* (2015) study in which young farmers would have better physical conditions and able to do a more effective farming task and management.

Based on the result, labour hours have a negative effect on technical efficiency. The negative sign might be explained by the ineffective utilisation of the working hours in the farm. Possibly, respondents spend too much time on the farm but not completed the task immediately. There is a possibility that this issue has caused the farm to be unable to meet its potential production, therefore, it cannot optimise its profit and become a loss for the respondents. This result contradict with the research conducted by Oladimeji *et al.* (2013) where they found that the increasing in labour use would also increase technical efficiency among the small-scale rice farmers. According to this finding, the increasing labor factor would also increase the output as well. In the present study, the technical efficiency is low probably because of unfavorable sea condition or extreme temperature which might be causing them to delay their research. From the respondent's opinions gathered during the interview session, pest and diseases occurrence also forced them to do a sanitation task and replanting. Consequently, this problem will result in inefficiency of time management in the farm.

The low production will affect the operator's social life as it will causes negative impression on the economic status of the seaweed farming. This will further resulting a great disturbance in the life quality of the operators. It is also creates a financial burden, to cope with the high cost of living. In consequence, some of them will leave this occupation and the industry will not be able to flourish. If this happen, it is a big disadvantage for Malaysian economy as Semporna has a high potential to produce high quality seaweed and can fulfill the global market demand. Since, there is 'no size fit all' programme in economy transformation, it is hope that government will look into these socioeconomic factors and plan an appropriate program to sustain the seaweed industry.

CONCLUSION

The seaweed farming in Malaysia is still under the development phase. Thus, it is important to extend the mini-estates programme and encourage more innovation activities among the public research institutions and local universities. Personal and human development in technical and non-technical areas is also a requirement and can be achieve by providing sufficient training and courses in order to expose them to entrepreneurial skills.

RECOMMENDATIONS

In the future study, the cost of seaweed farming, harvesting cycle, usage of farming mechanisation, types of seaweed practices and fertiliser should be included as one of the determining factors.

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