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EFFICIENCY ANALYSIS TOWARDS EXOGENOUS VARIABLES: FISHERY PRODUCTION IN MALAYSIA

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Abstract: Fishery contributes to a wide range of employment and economic benefits for individuals and the country. Unfortunately, the global fish stock has been fully exploited and the sign of recovery from it is tremendously low. It can be observed that the current condition of the fishery production should be taken seriously since there is a problem in the efficiency level. Therefore, this research is conducted to investigate the relationship of exogenous variables towards the efficiency level of fishery production. The Panel Tobit Regression is applied. Based on the data collected which involve 13 states in Malaysia from the year 2004 until 2014, efficiency result shows that Perak is the most efficient state throughout the year 2004 to 2014 with a mean score of 0.9440, followed by Perlis and Pahang with efficiency mean scores of 0.9036 and 0.8001 respectively. The least efficient state for the 11 years period was Negeri Sembilan with efficiency mean score of 0.1470. Panel Tobit Regression is applied to find the relationship of efficiency score for 13 states in Malaysia with exogenous variables. Tobit characteristic applied in the model as the efficiency score is based on censored data with lower and upper limit of zero and one. The result shows temperature and total rainfall are positively affecting the efficiency score. Meanwhile, the wind speed shows a negative relationship with the efficiency score. Overall, this research has successfully demonstrated the effect of exogenous variables on the efficiency score of fishery production. The findings may give some reference for the policy maker to revise the current policy by considering the exogenous factors in calculating fish revenue.

Keywords: Efficiency, Panel Tobit Regression and Fishery production.

I. INTRODUCTION

Fish contributes to the portion for protein. Fishery productions give broad opportunity in employment as well as economic benefits to the country. In 2014, Malaysia incur loss amount of RM 0.5 Million due to the decrease numbers of total marine fish landed for about 24,772 metric tons in 2014 as compared to the previous year which lead to huge impact on the Malaysian economy [1]. By the year 2030, Fishing Future Organization has predicted, the direct human consumption will exceed around 232 million metric tons, however, only 170 million metric tons able to be produced as on the current trajectory of the fishery production system. Therefore, there is a shortage of 62 million metric tons if none of alternative action done to cater this severe problem. Due to the situation, three different alternatives are suggested by Fishing Future Organization – reduce waste, improve fisheries and increase the numbers of aquaculture products [2].

Several studies are conducted to investigate the effect of exogenous variables towards fishery production through implementation of multiple types of DEA by [3],[4] and

[5]. The environment factors are introduced as part of the exogenous variables in fishery production such as determinants of ambient water quality of the aquatic by [4] and ozone layer depletion potential by [5]. In Malaysia, [6] and [7] have introduced the Tobit Regression method to determine the effect of input resources towards the fishery production. Other than that, [8] introduced DEA methods in early stage and later incorporate with window analysis using Ordinary Least Square method to foresee the research objective.

Efficiency can be defined as the degree of vessel performance at maximum level using the similar level of input as stated by [9] and [10]. Application of Data Envelopment Analysis (DEA) is widely used in multiple sectors such as banking, hospitality and agriculture sectors. For instance, researcher by such as [11] implemented Panel Tobit Regression to identify factors that influenced efficiency level of public universities. [12] and [13] also used Panel Tobit Regression in banking sector to investigate the factors that contributes to bank efficiency in their country. Nowadays, global fish stock has been fully exploited and the sign of recovery is tremendously low. The current condition of fishery production should be taken seriously since there is problem in the efficiency level. Hence, this study aims to determine the effect of exogenous variables towards fishery productions efficiency in Malaysia. The findings may give some reference for the policy maker to revise the current policy by considering the exogenous factors in calculating fish revenue.

II. METHODOLOGY

A. *DataSources*

This study used data collected from 13 states in Malaysia which is used as Decision Making Units (DMUs) in DEA and involved data from period 2004 until 2014. The scope of the study covers all the Malaysian Fishery Water Zone and all fishery districts registered under the Department of Fishery Malaysia exclude Labuan. All data sources are taken from both Department of Fishery Malaysia and Malaysian Meteorological Department.

TABLE I: INPUT AND OUTPUT VARIABLES

	Variables	***Description***
Input(controlled)	Number of Fishermen	Number of workers used for fishing activities based on licensed fishing vessel for each state in Malaysia
	Number of Fish Vessels	Number of vessel based on engine power of the boat for each states in Malaysia
Input(exogenous)	Temperature	Average temperature reading for each state in Malaysia(˚c)
	Windspeed	Average wind speed reading for each state in Malaysia (m/s)
	Rainfall	Average rainfall reading for each state in Malaysia (mm)
Output	Landing of Marine Fish	Number of metric tons produce per year for each states in Malaysia
	Fishery Revenue	Value of capture fisheries per year (RM Millions) for each states in Malaysia

B*. Theoretical Framework*

Generally, efficiency can be defined as the utilization of input resources by evaluating the output production obtained with the provided input resources. According to Pascoe and Tingley (2007), efficiency can be defined as the degree of vessel performance at maximum level using the similar level of input. On the other hand, for the technical efficiency can be reviewed as the difference in the actual and potential output measured when the fixed and variable input is constant under the same level of observation [14]. The underutilization will happen when the input is not fully utilized due to problem arise such as age of vessel, method of fish landing, the number of fishermen and others [9]. The estimation is suitable for small sample size and requires minimal number of observations [15]. According to [10], DEA is a non-parametric approach which generally based on linear programming technique. Besides, DEA able to eliminate any external factor as well as random error that occur within the efficiency measurement [4].Theefficiency measurement in this study is to indicate the rate of efficiency in fishery production by finding thetotal input contributing towards the production against the output received such as fish landing in metric tons per year.

C. *Model Specification*

The Panel Tobit regression is used to investigate the effect of exogenous variables towards the efficiency of fishery production in Malaysia. Panel regression is acting as an alternative model which bounded only the positive probability at the end of interval and carry similar characteristic of basic DEA model value in the interval of [0, 1]. Furthermore, the Panel regression model involved with the combination of basic Ordinary Least Squares (OLS) model with the time series model characteristic. Therefore, this study used Panel regression model as the model allow cross sectional data with time series characteristic. The general form of Panel regression as follows

$$y_{it} = \alpha + X_{it}^{'}\beta + u_{it} \quad (1)$$

$$u_{it} = \mu_i + \gamma_{it} \quad (2)$$

Where value y_{it} indicate the efficiency score of fishery production for each state in Malaysia,*i* and at specific time from year 2004 until 2014,*t*. While $X_{it}^{'}$ represent the exogenous variable for *i*-th states in Malaysia at time, *t*. Whereas, u_{it} represent disturbance term for *i*-th states in Malaysia at time *t*.

Since the Panel Tobit regression follow Tobit regression model as stated in [16], the independent variable of efficiency score of fishery production, y_{it} will be using the general regression form as follows,

$$y*_{it} = \sum_{k=1}^{n} \beta_{k_{it}} X_{k_{it}} + u_{it} \quad (3)$$

$$y_{it} = \left[\frac{1 + \text{sign}\,(y*_{i})}{2}\right] * \quad (4)$$

$$sign(y_{it}*) = \begin{cases} 1; & y_{it}*\geq 0 \\ -1 & y_{it}*<0 \end{cases} \quad (5)$$

Where the value of y_{it} indicate the efficiency score of fishery production for each state in Malaysia, i and at specific time from year 2004 until 2014, t. $X_{k_{it}}$ represent each exogenous variable for *i*-th states in Malaysia at time, t while X_1 represent the vector of average temperature, X_2 represent the vector of average windspeed reading and X_3 represent the vector of the exogenous variables (total rainfall). u_{it} is the disturbance term for *i*-th states in Malaysia at time *t*.

III. RESULTS

Initially, there are four models to be included in the analysis. The models are as stated in Table 2,

TABLE II: DEA MODELS

Model Type	*Description*
Model 1	Number of fishermen against total fish landing
Model 2	Number of fish vessels against total fish landing
Model 3	Number of fishermen against total fish revenue
Model 4	Number of fish vessels against total fish revenue

Based on correlation test between models and size of operations, Model 3 has the least relationship towards the size of operation as compared to the other models. Therefore, Model 3 is chosen as the main model to evaluate the efficiency score as it has the most insensitive relationship. Model 3 involves the number of fishermen as the input variable against total fish revenue.

TABLE III: CORRELATION TEST OF DEA MODELS WITH SIZE OF OPERATIONS

Size of Operations	*Model 1*	*Model 2*	*Model 3*	*Model 4*
No of Fishermen	0.153101	-0.01395	0.004283	-0.06964
No of Fish Vessel	0.041036	-0.19105	-0.09024	-0.24847

Table 4 show the frequency table for the top three states with highest efficiency score of fishery production from year 2004 till 2014 using Model 3. The highest frequency obtains the efficiency score of 1 is Perak with total of 5 times throughout 11 years from year 2005, 2006, 2007, 2013 and 2014. Next, Perlis has obtained efficiency score for 4 consecutive years from year 2009 till 2012. As for Pahang, it obtained the efficiency score of 1 twice for year 2004 and 2008.

TABLE IV: FREQUENCY TABLE OF EFFICIENCY SCORE FOR MODEL 3

States	*Number of times obtain highest efficiency score*	*Representative Years*
Pahang	2	2004,2008
Perak	5	2005,2006,2007,2013,2014
Perlis	4	2009,2010,2011,2012

The uncontrolled variables are used to evaluate the effect of it towards the efficiency of fishery production. The description of variables uses shown in Table 5.

TABLE.V: VARIABLES IN PANEL REGRESSION MODEL

Dependent variables	Y	Mean technical efficiency score of fishery production
Independent variable	X1	Mean temperature (°c)
	X2	Mean wind speed (meter/sec)
	X3	Total rainfall (mm)

Preliminary test for variables is a must before model is developed. Normality test is one of the best testing to observe the distribution for each variable in the regression model either normally distributed or otherwise. Table 6 shows the result of normality test for variables.

TABLE VI: NORMALITY TEST FOR VARIABLES

Variables	*Mean*	*Median*	*Std Deviation*	*Skewness*	*Kurtosis*	*Probability*
Y	0.5175	0.4987	0.2739	0.2839	1.9851	0.01779
SQRT Y	0.6912	0.7062	0.2001	-0.1425	2.0286	0.0471*
X1	27.7554	27.8500	0.7190	-0.9603	3.3443	0.000012
EXP X1	0.00000000000139	0.00000000000124	0.0000000000779	0.5527	2.8840	0.0252*
X2	1.7317	1.7332	0.3157	-0.1649	2.7025	0.5556*
X3	83,867.54	51,377.70	70,503.52	0.9763	2.6370	0.000008
LOG X3	10.9555	10.8470	0.9203	-0.1295	2.0697	0.0622*

Note: Normal distribution exist if p>0.05

From Table 6, a square root transformation method has been used to transform the dependent variable to normal distribution due to the normality assumption that has to be taken into consideration [12]. Moreover, for dependent variable X1 (mean temperature) and X3 (total rainfall) also has been conduct the exponential and log transformation respectively. The same reason applies as to avoid the violation of regression model and to satisfy the normality assumption. The p-value with more than 95% confidence interval have been used with sign * to show that the variables used to satisfy the normality assumption. Therefore, the variables used for the panel regression model are SQRTY1, EXP X1, X2, and LOGX3. The estimation panel regression model as shown:

$$\sqrt{y_{it}} = a_{it} + \beta_1 e^{x_{1it}} + \beta_2 x_{2it} + \beta_3 log x_{3it} + \varepsilon_{it} \quad (6)$$

Where value y_{it} indicate the efficiency score of fishery production for each states in Malaysia, i and at year, t .$x_{1_{it}}$ represent the mean temperature for i -th states in Malaysia for each year, t,$x_{2_{it}}$ the represent the mean wind speed for i -th states in Malaysia for each year, t , $x_{3_{it}}$ the represent the total rainfall for i -th states in Malaysia for each year, t, andε_{it}represent the error term for i-th states in Malaysia for each year, t.

Besides normality test, the panel root test is used to validate for each variable involves are stationary or otherwise. According to [12], the panel unit root test indicated the test by allowing the unbalanced panel to be part of the testing. Same goes with the multicollinearity test which involved the variance inflation factor (VIF) will be examined for all independent variables of mean temperature (X1), mean wind speed (X2) and total rainfall (X3). Noted that VIF value must be at less than 10 to satisfy the assumption of none multicollinearity exist between the independent variables.

Table 7 shows the test by using level difference and first differencing (with intercept and intercept with trend) as part of the testing as well as the VIF values for independent variables for multicollinearity test.

TABLE VII: UNIT ROOT TEST AND MULTICOLLINEARITY TEST FOR VARIABLES

	Panel		***1st difference***		***VIF***
Variables	Intercept	Intercept & trend	Intercept	Intercept & trend	Centered VIF
Y	0.0325	0.1688	0.0000*	0.0000*	-
EXP X1	0.0012 *	0.0086*	0.0000*	0.001*	1.026191 **
X2	0.0000 *	0.0238	0.0000*	0.0019*	1.013058 **
LOGX 3	0.3423	0.3029	0.0000*	0.0005*	1.013053 **

*p <0.01 or 1% significance level, ** VIF <10

From Table 7, all variables are stationary at first differencing by obtaining the p value must be less than the 1% significance interval. Similarly, the VIF value for each independent variable are at VIF less than 10, therefore satisfy the assumption of not exist the multicollinearity condition in the model. Hence, the model estimation can proceed as panel regression model. The assumption of normality also needs to be evaluated on the residual of the estimation model to ensure the Tobit regression model can be proceeded. Since the p-value for the estimation model is 0.1612, therefore it satisfies the condition of significant at more than 1 % and 5% significance interval.

As all the necessary assumptions satisfied, therefore Panel Tobit with random effect model is chosen by using the Hausmen test. Hausmen Test is used to determine suitable type of panel regression either pooled regression, random effect or fixed effect model as the best model. The Hausmen test show that the p value for estimation model is at 0.2679, thus satisfy the condition of significant at more than 1%.

The result of Panel Tobit regression model is shown in Table 8 by indicates all the exogenous variables give impact towards the efficiency score of fishery production in Malaysia. Mean temperature and mean wind speed are significant at 1 percent significance level where ($p < 0.01$, $p = 0.0009$) and ($p < 0.01$, $p = 0.0000$) respectively. As for the total rainfall is significant at 10 percent significance level where ($p <0.1$, $p = 0.0767$).

TABLE VIII: PANEL TOBIT REGRESSION RESULTS

Independent Variables	***Coefficient***	***p value***
Mean Temperature (EXPX1)	6.58E-14	0.0009***
Mean Wind speed (X2)	-0.214911	0.0000***
Total Rainfall (LOGX3)	0.029422	0.0767*
Intercept (C)	0.655943	0.0016***
Log likelihood	18.72097	
No of Observation -Censored	11	
No of Observation -Uncensored	132	

*, **, *** indicate p value significant at 10%,5% and 1% significant level.

Referring to Table 8, the final Panel Tobit regression model is shown as:

$$\sqrt{y_{it}} = 0.655943 + (6.58 \times 10^{-14}) e^{x_{1it}} - 0.2149 x_{2it} + 0.0294 log x_{3it} + \varepsilon_{it} \quad (7)$$

Where

$y_{it} = efficiencyscorefori - thstatesinMalaysiaforeachyear, t$

$x_{1it} = meantemperaturefori - thstatesinMalaysiaforeachyear, t$

$x_{2it} = meanwindspeedfori - thstatesinMalaysiaforeachyear, t$

$x_{3it} = totalrainfallfori - thstatesinMalaysiaforeachyear, t$

ε_{it} = error term $fori - thstatesinMalaysiaforeachyear, t$

IV. CONCLUSIONS

This study aims to determine the effect of exogenous variables such as temperature, wind speed and total rainfall towards the efficiency of fishery production in Malaysia. The Panel Tobit Regression Model is used to determine the effect of exogenous variables towards the fishery production. Result shows the experimental procedure using inputs and outputs into four different models. Finally, after model validation stage, Model 3 which involved number of fishermen as input variable and the total fish revenue has become the main model to determine the technical efficiency score of fishery production. Based on Model 3, the result show Perak is the most efficient states in Malaysia throughout the year of 2004 till 2014 with the mean score of 0.9440. On the other hand, Negeri Sembilan has represented as the states with most inefficient in the fishery production whereby it only able reaches the mean technical efficiency score of 0.1470. Panel Tobit Regression model with random effect condition is used because it satisfies all the preliminary assumptions such as normality, multicollinearity, stationary and residual. Besides, DEA and Tobit Model have similar characteristic by dealing with carries censored data as well as the variables used are the combination of time series data with cross sectional data condition. Results shows that the exogenous variables of temperature and total rainfall show a positive relationship with the efficiency score of fishery production. As for wind speed, it relatively has an inverse relationship with the efficiency score of fishery production. It is recommended for future research to include different type of controlled variable for inputs and outputs such as in economic overview that incorporate with the operating cost (labor cost, cost of vessel maintenance, etc.) and financial support by Government in term of grand, loan and incentive. By doing so, it can foresee better impact and broaden perspective on evaluating the efficiency level of fishery production. It is recommended to estimate the effect of exogenous variables by using different type of statistical approach such as Partial Least Square Method or any advanced method and compare the result against the impact of exogenous factors in their research. It will be good if the investigation taken place onto the financial prospect. For instance, the volatility of Ringgit Malaysia has become one of the greatest impacts, especially in import and export of the fishery production under international trade.

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