Economic efficiency of input utilization and business analysis of fishing gear 'cantrang' at fisheries management area 712 in Indonesia

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Abstract. In order to optimize the input utilization, the technico-economic efficiency of fishing operations is commonly assessed by employing various production function models. 'Cantrang' is the local Indonesian name for a fishing gear resembling a modified trawl. Regarding the contribution of mechanized 'cantrang' to the total marine fish production of Indonesia, an attempt was made to assess the input-output relationship in 'cantrang' operations at 8 major landing centers at the Fisheries Management Area 712 (FMA-712), using the Cobb-Douglas production function model. The business analysis of the fishing gear 'cantrang' was also conducted. The functional relationship indicated that there was ample scope to enhance the net profit of 'cantrang' gears by increasing the number of fishing days and the area of operation at Banten, DKI-Jakarta, West Java, Central Java, East Java, Lampung, Central Kalimantan and South Kalimantan. Even though the number of days for fishing in a year is not up to the optimum level in all the major centers selected for the study, the existing socio-economic conflicts and inter-sectoral disputes should be addressed, while increasing the number of fishing days with mechanized 'cantrang'. Based on business analysis on 'cantrang' fisheries at FMA-712, the average net present value (NPV) of 'cantrang' fishing gears is 93504200 for Banten, 13400500 for DKI Jakarta, 104900420 for West Java, 100504277 for Central Java, 120845200 for East Java, 16500800 for Lampung, 86500330 for Central Kalimantan and 90200500 for South Kalimantan. This shows that the fishing effort using 'cantrang' fishing gear can continue. An average payback period of 2.69 to 2.90 years was obtained.
Key Words: business, cantrang, Cobb-Douglas model, economic efficiency, production factors.

Introduction. 'Cantrag' is the name of a modified fishing gear with high productivity and which is effective in catching bottom fish. It has three main parts: wings, body and pocket. 'Cantrang' is operated by being towed by a ship or is anchored in waters. In addition, the water bottom, as the operating area, must be flat and muddy or sandy (Bambang 2006). 'Cantrang' has been popularized since the use of trawling was prohibited, especially in the Java Sea and its surroundings. According to Kusnandar (2000), and Sutanto (2005), the use of 'cantrang' is profitable for fishermen because the time of capital return to manufacture 'cantrang' fishing units (payback period) is relatively short. 'Cantrang' is widely used in northern Java waters. The reason for using 'cantrang' is that it is easy and cheap to manufacture, so that it has a fairly rapid development (Leo 2010). According to Adhawati et al (2017), the 'cantrang' has a big contribution to the welfare of locals.

The results of Sutanto (2005) show that the fishing time for 'cantrang' is 74.4 hours on average, relatively shorter than for gillnets (104.60 hours at sea). Bintoro & Sukandar (2011) found that 'cantrang' can produce a high catch; however, 'cantrang' is categorized as environmentally unfriendly, due to the fact that it does not select the catch size or species and can disturb the substrate. This was also noted by Najamuddin et al (2017), who stated that environmentally friendly fishing gear does not produce negative impacts to the environment, does not destroy the substrate, and does not pollute. More emphasized in the fisheries effort, economic considerations and sustainable management are needed (Squires 1987).

Based on this consideration, the government of Indonesia, through the Ministry of Marine Affairs and Fisheries, issued a policy to prohibit the use of trawls and seine nets in all fisheries management areas through the ratification of the Regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 2 of 2015. Regulations have an impact on the socio-economic status of fishing communities. Currently, the life of the fishing community is more complicated partly due to the presence of the ministerial regulation No. 2/2015, the prohibition of 'cantrang' and the pressure of the coronavirus pandemic, so that their economic life declines.

Estimation of technico-economic efficiency of fishing operations is a necessary prerequisite for improved utilization and optimum substitution of inputs to enhance production. Commonly employed methods for this estimate are the production function and production frontier analyses, which are based on a combination of input and output controls (Salvanes & Steen 1994; Pascoe & Robinson 1998; Pascoe et al 2001). Production function defines the relationship between the level of inputs and the resultant level of outputs. It is estimated from observed outputs and input usage and indicates the average level of outputs for a given level of inputs (Schmidt 1986). In fisheries, several estimates have been made on the production functions at either individual boat level or total fishery level to understand the elasticities (Berkes et al 2001).

The objective of the present study is to estimate the output elasticities associated with selected inputs and to find out the potential of optimum utilization of inputs for enhanced production and business analysis of 'cantrang' fishing at the fisheries management area 712 (FMA-712), which covers the provinces of Banten, Lampung, Jakarta, West Java, Central Java, East Java, Central Kalimantan and South Kalimantan. The results of this research could be taken into consideration by the government for new policies.

Material and Method

Data collection methods and determination of samples. This research was conducted in FMA-712, from 2018 to 2019 (Figure 1). In Indonesia, there are 11 fisheries management areas, FMA numbers 571, 572, 573, 711, 712, 713, 714, 715, 716, 717 and 718. The area is located in the waters of the northern part of Java Island. The total area of FMA-712 is 414461.87 km^2 (Sutanto et al 2005).

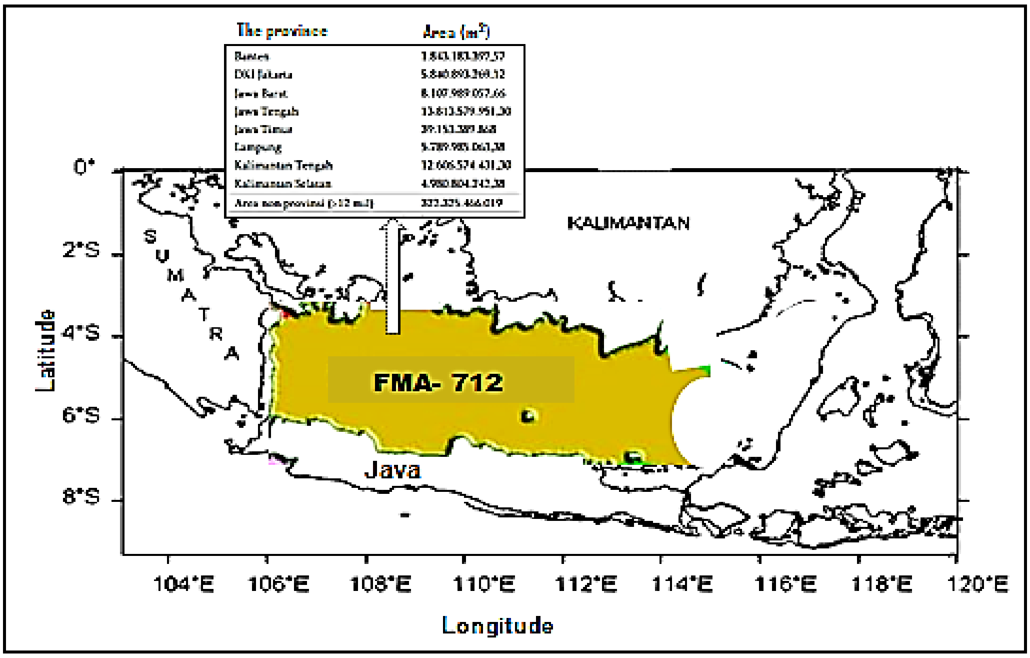

Figure 1. Fisheries Management Area-712.

Data collection methods used in this study were interviews, literature study and documentation. The data needed in this study includes primary and secondary data. Primary data collection is done by interview and observation. The sampling method used in this study is the purposive sampling method. According to Kuncoro (2009), the purposive sampling method is sampling with certain considerations. This research is intended with certain considerations towards 'cantrang' fishermen in each province. The number of respondents for each province was 30 people. The number of respondents was determined by the following Slovin formula (Kuncoro 2009):

$$n = \frac{N}{1 + N(e^2)}$$

Where: n - the number of 'cantrang' fishermen used as respondents; N - the number of 'cantrang' fishermen in the harbor; e - maximum acceptable error (0.1).

Data analysis model. The data analysis model uses the Cobb-Douglas production function analysis to analyze the magnitude of the influence of the utilization of production input variables in generating income output and production volumes of fishermen (Hannesson 1983). The variables used in this study are independent variables of production factors that affect income and production volume of 'cantrang' fishermen. These variables are business capital (K), labor (L), ships (V), machinery main ship (E1), axle engine (E2). Dependent variables (Y) were the income of 'cantrang' fishermen (Y1), and the production volume of fishing effort using 'cantrang' (Y2), in the ports of 8 provinces: Banten, Jakarta, Lampung, West Java, Central Java, East Java, Central Kalimantan and South Kalimantan. The number of fishing days, quantity of fuel used, and repairing and maintenance charges per year per unit were used in the model. The production function used to evaluate the economic efficiency of input utilization in 'cantrang' operations is presented below:

$$Y = a * X_1^{b1} * X_2^{b2} * X_3^{b3}$$

Where: Y - gross output in kg; a - constant value; X_1 - number of fishing days per unit in a year; X_2 - quantity of fuel used in a year per unit; X_3 - annual repairing and maintenance charges per unit; b1, b2, b3 - regression coefficients.

Marginal value productivity (MVP) was computed for all the explanatory variables X_1, X_2, X_3. The MVP of a particular input is the gross returns for the increase in one more unit of that input, while other inputs remain constant. It was obtained by multiplying the regression coefficients of explanatory variables with the ratio of geometric mean (GM) of gross returns to geometric mean of given input. Efficiency in production is the ratio of output and input, related to achieving maximum output with a number of inputs. If the ratio of output is large, the efficiency is higher. Efficiency is the use of the best inputs in producing outputs (Susantun 2000).

Analysis of the feasibility of 'cantrang' capture fisheries effort. Effort analysis is carried out through the net present value (NPV), benefit cost ratio (PI), internal rate of return (IRR) and payback period (PP) analyses. These described the feasibility of 'cantrang' capture fisheries in FMA-712, namely the business analysis using the discounted criterion method, due to differences in inflation or interest rates that occur.

NPV is the difference between the present value of the investment and the present value of net cash receipts (operating cash flows and terminal cash flows) in the future. To calculate the present value, it is necessary to determine the relevant interest rate. In this method, the discount rate is a factor of 18%, according to the average daily bank interest rate. The NPV can be determined by the formula:

$$NPV = \sum_{t=1}^{n} \frac{CFt}{(1+i)t} - Co$$

Where: CFt - cash flow per year in period t; Co - initial investment in year 0; I - interest rate; t - year in which the investment took place; n - number of years.

The decision making is as follows: if NPV is higher than 1, then the business is feasible; if NPV is 0, then the business can be feasible; if NPV is less than 1, then the business is not feasible.

The benefit cost ratio was determined by the following formula:

PI = present value of cash flow/initial cash flow

The decision making should be as follows: efforts could be feasible if PI is higher than 1, are inappropriate if PI is less than 1.

The internal rate of return was determined by the following formula:

$$IRR = \frac{i_1 + NPV_1}{NPV_1 - NPV_2}(i_2 - i_1)$$

Where: i_1 - interest rate 1; i_2 - interest rate 2; NPV_1 - NPV at an interest rate i_1; NPV_2 - NPV at an interest rate i_2.

The payback period is an investment valuation method based on the payment of investment costs by profits or, in other words, the time needed to return the invested capital.

Results and Discussion. Production function analysis using Cobb-Douglas model indicated that there was ample scope to enhance the net profit of 'cantrang' by increasing the number of fishing days and area of operation. Input variables such as number of fishing days per unit and the quantity of fuel used in a year were significant in all the eight landing centers.

Estimation showed that a 1% increase in the number of fishing days would result in an output increase by 0.69% at Banten, 0.78% at Jakarta, 0.69% at west Java, 0.72% at Central Java, 0.78% at East Java, 0.64% at Lampung, 0.73% at Central Kalimantan and 0.78% at South Kalimantan. The fuel consumption was also a significant variable. An increase in oil expenditure by 1% would increase the gross output by 0.42% at Banten, 0.41% at Jakarta, 0.53% at West Java, 0.48% at Central Java, 0.59% at East Java, 0.70% at Lampung, 0.61 at Central Kalimantan and 0.38% at South Kalimantan (Table 1). For the above model, the profit is maximum, when the marginal revenue (MR) is equal with the marginal cost for X (MC).

Table 1

Estimated production function of mechanized 'cantrang' in 8 landing centers at Fisheries Management Area 712 (Y=0.68901)

Parameters	*Banten*	*Jakarta*	*West Java*	*Central Java*	*East Java*	*Lampung*	*Central Kalimantan*	*South Kalimantan*
b1	0.690**	0.780**	0.690**	0.720**	0.780**	0.640**	0.730**	0.780**
b2	0.420**	0.412**	0.530**	0.480**	0.590**	0.700**	0.610**	0.380**
b3	0.024 NS	-0.112 NS	0.026 NS	0.024 NS	0.112 NS	0.040 NS	0.054 NS	0.064 NS
R^2	86.4	75.0	88.0	73.0	87.2	75.8	75.0	87.5

Note: b1 - production coefficient; b2, b3 - regression coefficients; R^2 - coefficient of determination; ** - significant ($p<0.05$); NS - not significant.

MR=(Y/Xi)×PY and MC is the acquisition cost for one unit of Xi. Hence, bi×(Y/Xi)×PY=PX. The optimum level of Xi=bi×Y×(PY/Xi), where b_1 is the production coefficient. Y is the average annual output, Xi is the average annual input used, PY is the price of output and PX is the price or acquisition cost of input Xi. By testing the coefficient of determination (R^2), the goal is to find out how far the relationship of independent variables is to the dependent variable (Y). In Banten province, it was 0.864, which means that 86.4% of the production factors are used, while the remaining 13.6% are other factors that have not been taken into account. Likewise, in Jakarta, it is 75%, for West Java it is 88%, for Central Java it is 73%, for East Java it is 87.2%, for Lampung it is 75.8%, for Central Kalimantan it is 75% and for South Kalimantan it is 87.5%, respectively.

It is obvious from Table 2 that the inputs for which the ratio of the marginal value productivity to acquisition can be increased are more than one. At the Jakarta landing center, fishing days in a year can be increased from the average level of 193 to 204, to obtain a maximum profit. The annual oil consumption can be increased to the optimum level of 54672 L, from the average of 39814 L. In Lampung province, fishing days can be increased by increasing the average level of fuel from the average of 38810 L to 58400 L. Maintenance and repairing expenditures had a negative MVP indicating that reducing the maintenance and repairing charges can increase gross returns.

Table 2

Regression coefficients, marginal value productivity (MVP), geometric means and ratios of MVPs to their factor costs obtained through the Cobb-Douglas production function analysis

Variables	*Regression Coefficient*	*MVP of outputs (Rp)*	*Geometric mean*	*Acquisition cost (Rp)*	*Ratio of MVP to acquisition cost*
Banten					
Y	-	-	631685 kg	-	-
X_1	0.690	47616756	192 days	46900000	1.018
X_2	0.420	60600960	32064 L	45000000	1.135
X_3	0.024	1056	Rp 44000	900	1.173
Jakarta					
Y	-	-	307256 kg	-	-
X_1	0.780	54107990	193 days	53200450	1.017
X_2	0.312	55898856	39814 L	45000000	1.242
X_3	-0.112	-327.6	Rp 85000	900	-0.364
West Java					
Y	-	-	537239 Kg	-	-
X_1	0.690	47104780	198 days	46900850	1.004
X_2	0.530	92561850	38810 L	45000000	2.056
X_3	0.026	1300	Rp 50000	900	1,444
Central Java					
Y	-	-	590400 kg	-	-
X_1	0.720	51757344	200 days	49120400	1,054
X_2	0.480	83592000	38700 L	45000000	1.298
X_3	0.024	1.449	Rp 44500	900	1,197
East Java					
Y	-	-	87800 kg	-	-
X_1	0.780	56911512	203 days	49800400	1.143
X_2	0.590	105669000	39800 l.	45000000	1.073
X_3	0.112	7907	Rp 50600	900	1.797
Lampung					
Y	-	-	281310 Kg	-	
X_1	0.640	73181500	204 days	68400500	1.070
X_2	0.700	125370000	39800 L	45000000	1.134
X_3	-0.140	-45.8	50200 Rp	900	-0.466
Central Kalimantan					
Y	-	-	590340 Kg	-	-
X_1	0.730	51054010	194 days	45400900	1.124
X_2	0.610	100467000	36600 L	45000000	2.232
X_3	0.054	3261	Rp 60400	900	3.623
South Kalimantan					
Y	-	-	610400 kg	-	-
X_1	0.780	57752569	206 days	46850400	1.232
X_2	0.380	66775500	39050 L	45000000	1.042
X_3	0.064	3865	Rp 60400	900	4.294

Note: Rp - Indonesian Rupiah; the exchange rate USD to Rp in 2019 was considered 1:14980. Y - gross output in kg; X1 - number of fishing days per unit in a year; X2 - quantity of fuel used in a year by a unit; X3 - annual repairing and maintenance charges per unit.

For Banten fishery harbor, fishing days in a year can be increased marginally from the average of 192 to 194 to get the maximum profit. Annual oil consumption can also be increased to 43139 L from 32064 L and maintenance and repairing expenditure from 44000 Rp to 47250 Rp. At this landing center, 'cantrang' units are operating almost at the optimum level, so that there is no scope for further increase in the number of fishing units or number of fishing days for the existing units. At West Java, the fishing days in a year can be increased from the average level of 198 to 220 to obtain maximum profit. The annual oil consumption can be increased to the optimum of 40800 L from the average of 38810 L, and repairing and maintenance expenditure from 50000 Rp to 64895 Rp. At Central Java, East Java, Central Kalimantan and South Kalimantan, the fishing days in a year can be increased. The repairing and maintenance expenditure are 44500, 50600, 50600 and 50600, respectively.

Business feasibility analysis. The NPV for 'cantrang' fishing gear has an average value of 93504200 for Banten. In DKI-Jakarta province it is 13400500, in West Java it is 104900420, in Central Java it is 100504277, in East Java it is 120845200, in Lampung it is 16500800, in Central Kalimantan it is 86500330 and in South Kalimantan it is 90200500. The values indicate the NPV in a fishing effort using a positive or more than zero fishing gear. This shows that the fishing effort using 'cantrang' may be feasible if it is continued.

The values of the benefit to cost ratio in the business fishing with 'cantrang' for the 8 provinces are ranging between 1.02 and 1.42. Based on the B/C ratio of the business fishing, 'cantrang' is a feasible fishing gear, producing a benefit to cost ration higher than 1.

The internal rate of return for 'cantrang' is above the discount factor of 18%, so it can be said that the 'cantrang' fishing business is feasible to continue. The 'cantrang' effort in the 8 provinces was characterized by an IRR ranging from 23.74% to 33.80%. The rate of return on capital for businesses is categorized as quick if the value of the payback period is less than 3 years. If the PP value is more of 3 years, but less than 5 years, it is a moderate rate of return. If the payback period value is more than 5 years, the rate of return is slow (Riyanto 1991). In capture fisheries business using 'cantrang', an average payback period of 2.69 to 2.90 years was obtained. This means that fishermen can return all business capital in less than one year, according to interviews with fishermen.

A common feature of all the production function analyses is the reliance of independent inputs to optimize the output levels. This approach has generally been common for the estimation of most production functions in several industries. However, unlike many other industries, fisheries are characterized by many mutually dependent inputs and the optimization of one variable eventually alters the other variable. For example, if the number of fishing days increases, the fuel consumption also increases proportionately. This makes the production function analysis a rather difficult task in fishing operations.

Marine fisheries of Indonesia reached maximum levels of production in the inshore areas by the end of 2018s, which has shifted the subsequent fisheries developments towards the expansion of offshore and deepsea fisheries (MAFM 2019). The annual catchable potential of marine fisheries of Indonesian waters is estimated at 9.9 million tons including 3.9 mt from inshore and 6 mt from offshore waters (MAFM 2019). However, the catch from the inshore waters reached the estimated potential during 2013–2019 (Ardiyani 2019). While Indonesia has the potential to exploit offshore fishery resources, the majority of gillnets, 'cantrang' and 'payang' fishing gears are currently operating from inshore waters. This would further put pressure on the inshore fishery resources, considering the fact that many valuable fishery resources, like pelagic fish. The reality of the potential of fisheries in Indonesia comprises 1992 million tons per year (20%) in FMA-718 (Arafura Sea), 1228 million tons per year (12%) in FMA-572 (west of Sumatera, India Ocean and Sunda Strait) and 1143 million tons per year (12%) in FMA-711 (Karimata Strait, Natuna Sea and South China Sea). Most of the fish resources (49%) including FMA-712, were in the status of overfishing (MAFM 2019).

From the present analysis for the optimum level of operation, the fishing days at all the 8 centers can be increased from the existing level, excepting Lampung, where the level is almost at optimum. Extending fishing to offshore areas and marginally increasing the number of fishing days with additional fuel utilization would enhance the profit of the 'cantrang' at all the centers. From an economic point of view, the production function indicates that marginal increase in fishing trips with enhanced fuel utilization is required for the optimization of profit. As far as the 'cantrang' sector is concerned, the industry is already moving towards this direction with intensified multiday trawling and extended area of operation. However, the sustainability of fishery resources and sectoral equity in distribution of income warrants appropriate regulatory mechanisms. Hence, in order to optimize the number of fishing days to obtain maximum benefit, the production function analysis for the other major fishing units such as mechanized purse seine, gillnet units and motorized ring seine units should also be carried out. The number of fishing days for all the major fishing units operating from the landing center may then be adjusted accordingly, to obtain maximum profit. The repairing and maintenance expenses at Jakarta and Lampung were beyond the optimum level, and should be reduced for the benefit of operators. Repairing and maintenance of boats is not adequate at Banten, West Java, Central Java, East Java, Central Kalimantan, and South Kalimantan fisheries harbors. The boat owners may have to take proper steps for the timely maintenance of fishing units to increase their net benefit.

During the past decade, there have been some dramatic changes in the economic situation of the domestic fisheries. There has been an upward trend in the price of fuel, fishing gear, and the general cost of fishing operations. However, the price of fish remained the same. An example of the impact of these changes can be seen in the area of Jakarta and Lampung provinces. Variable costs may be reduced in a variety of ways: increasing the productivity of an input, reducing the price of the input, or changing the mix of inputs. Since the determination of input prices is usually defined by market forces, where individual participation is small, this is not a viable alternative.

A review of Indonesian fishery laws and regulations reveals that their primary intent is to prevent and minimize disputes and conflicts among different sectors of the industry. However, most of these regulations are not based on the evaluation of economic efficiency of the fishing operations and do not seem to have included adequate provisions regarding the undertaking of responsible fishing activities, such as imposing mandatory input and/or output controls. Even if there is a provision of increasing the number of fishing days per year for mechanized 'cantrang', the existing sectoral conflicts and disputes would prevent their implementation. In this context, there are many socio-economic problems to be addressed. There is a continuing demand from the motorized and from the traditional sector to reduce the fishing days of mechanized trawlers. A further increase may result in a complex socio-economic crisis among the fishermen population of the country.

The third tool, payback analysis, enables the decision maker to determine the length of time required for the net energy savings to pay back the initial cost. If the calculated payback is greater than the economic life of the investment, it should not be pursued. A simple payback may be calculated by dividing the cost of the project by the net annual savings. The resulting value is the payback number of years (or periods). In the current analysis, however, the simple payback was expanded to allow fuel price escalation, as well as to consider the time value of money.

Conclusions. The fishing effort with the 'cantrang' fishing gear, with the addition of inputs, can still increase fish production, because the value of return to scale is higher than 1, meaning that production has increased returns to scale. In other words, the addition of inputs will produce additional output, more than the previous input units. Thus, the use of inputs is still possible for 'cantrang' fishermen to produce optimal fish production.

Based on business analysis on 'cantrang' fisheries at FMA-712, the average NPV value of the 'cantrang' fishing gear is 93504200 for Banten, 13400500 in Jakarta province, 104900420 in West Java, 10050477 in Central Java, 120845200 in East Java, 16500800 in Lampung, 86500330 in Central Kalimantan and 90200500 in South Kalimantan. The NPV in a fishing effort is positive. This shows that the fishing effort using 'cantrang' is feasible and can continue. The net benefit cost ratio at the 8 provinces ranges from 1.02 to 1.42. The average internal rate of return is 23.74% and the payback period has an average of 2.69 years, meaning that the effort of 'cantrang' fisheries at FMA-712 is further feasible. In capture fisheries business using 'cantrang' fishing gear in the harbors of the eight provinces, an average payback period of 2.69 to 2.90 years is obtained. This means that fishermen can return all business capital in less than one year.

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