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Economic appraisal of offshore fisheries: A study on trawl fishing operations in Pakistan

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This study attempts to show the effects and relative contributions of the different fisheries factors affecting the revenues for a sample of commercial offshore trawling vessels operating in the Exclusive Economic Zone (EEZ) of Pakistan. In this study, the level of relative contribution of each determinant is estimated by using the Standard Multiple Linear regression (SMLR) with standardized regression coefficients and correlation methods. The data were collected through the survey questionnaire and direct interviews with the boat owners and fishermen. The estimated standard beta regression coefficient values for the catch ($ß_1$=0.253), horsepower ($ß_2$=0.26), fishing days at sea ($ß_3$=0.316) and skipper or captain's fishing experience ($ß_4$=0.32), respectively. Similarly, the catch contributes (R^2=17.7 %), horsepower (R^2=18.2 %), fishing days (R^2=22.5 %) and skipper (R^2=23 %) on the revenue. Moreover, the correlation values for the catch ($r_{(\text{Revenue, Catch})}$ = 0.70), horsepower ($r_{(\text{Revenue, Horsepower})}$ = 0.698), fishing days ($r_{(\text{Revenue, Fishing Days})}$ = 0.713) and skipper ($r_{(\text{Revenue, Skipper})}$= 0.718) indicates the strong positive relationship of each variable on the revenue. In conclusion, the skipper fishing experience and individual skills have a very strong influence on the maximizing of total earnings of trawling vessels.

[**Keywords:** Economy; Relative contribution; Revenues; Offshore trawling vessels; Correlation; Standard Multiple Linear Regression (SMLR)]

Introduction

Fishery is considered to be the common property for all and played shared beneficial roles in natural resource management from an economic point of view[1]. Pakistan is gifted with fishery resources that have an enormous potential for development and growth. By the declaration of the Exclusive Economic Zone (EEZ) state in 1976, the Pakistani coast stretched out from baseline waters up to 200 nautical miles which primarily covered the two major provinces of the country, namely Sindh and Baluchistan with an area of 1100 km from India to Iran[2] (Fig. 1). Commercial fishing in Pakistan began right after the independence with only one fishing trawler inherited after the partition of sub-continent[3]. Later, in 1958, the induction of modernization of large fishing vessels, the operational trawl fleet rapidly increased up to more than 3000 trawlers in 2002. Therefore, the fishery plays a major role in the economy of the country and a common fishermen[4]. However, the revenues and costs are the main components to determine the economic performance of fishing operations[5]. Comparatively, several factors in fisheries affecting the revenue or profit which can be fixed (vessel size, engine and gear), varying (fishing days at sea and crew size) and intangible (skipper skills and boat technology)[6]. Furthermore, it is a common phenomenon that a profitable fishery attracts more peoples to join resulting in the lower profits and reduced economic performances[7]. Moreover, several studies also indicate the profitability of offshore fisheries[8-9], while other studies revealed the importance of revenue generation from trawling vessels in terms of technical efficiency[8-13]. Prior to this, the fisheries of developing countries are still in the struggling phase to produce the latest information on the operating costs of fishing and earnings from fish harvesting. Therefore, the fisheries managers and administrators in these countries are fully concerned that without the credible and realistic information about the economic aspects of fisheries, it would be a difficult task to develop and implement a thought-provoking and long-run management policies within the fishing industry[14]. Similarly, the work of Cunningham[15] also discusses the improvement of fisher's income and the factors affecting the revenues from a management point of view.

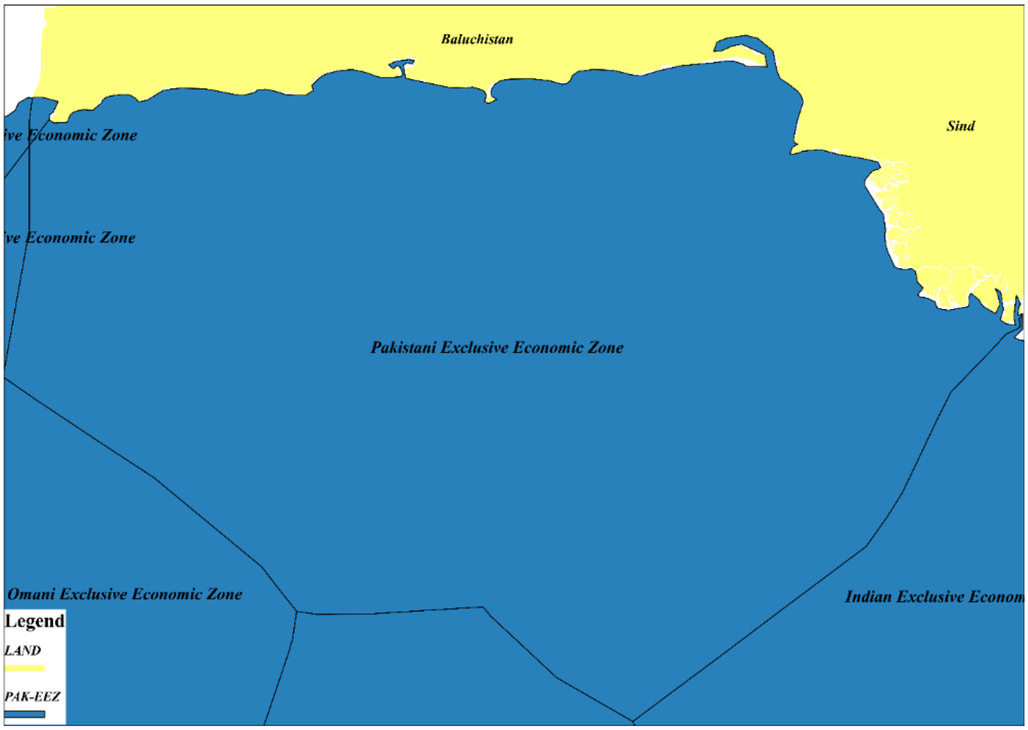

Fig. 1 — Map showing the Pakistani Exclusive Economic Zone (EEZ).

Therefore, the main objective of this paper is to assess the effects and relative contributions of several determinants affecting the fisheries revenue by providing an insightful understanding of the current economic situation of the offshore fisheries in Pakistan. To do this, the Standard Multiple Linear Regression (SMLR) with the estimation of standardized regression coefficients approach is being used to measure the effect of each determinant on revenue[16]. While Pearson's correlation is used to calculate the relative contribution or importance of each input variable in the analysis[17]. However, a few research studies had been done using a similar approach[18-19]. The overall novelty of this paper is to help the fisheries managers and legislative bodies to upgrade the national fisheries policy from economic perspective and provide adequate guidance to common fishermen to utilize the natural resource in a sustainable manner.

Materials and Methods

Data source

The data of vessel features and the composition of offshore fishing fleets included in the present study were drawn from the "Handbook of Fisheries Statistics" compiled by the "Marine Fisheries Department, Government of Pakistan"[20]. However, a comprehensive survey questionnaire was designed to obtain the economic information regarding operating costs of fishing, revenues, total landed catch (tons), crew support, the fishing experience of the captain and the number of fishing days at sea. The data were collected during the close season of fishing activities between the months of June and July 2016 from the landing site of the Karachi Fish Harbor (KFH). Initially, a sample of 100 licensed Pakistani fishing trawler captains was selected as a part of our sampling procedure. From the sample, only 68 respondents have completed the interview. The remaining 32 trawler captains were reluctant to provide the information. Therefore, our final sample size was 68.

Variables selection and analytical tools

In the present paper, the revenue or income of the fishermen is selected as the dependent variable (DV) in terms of Pakistan rupees (Rs). Indeed, the catch, horsepower, fishing days and skipper measures as an independent variables (IV) in terms of tons, HP, number of fishing days at sea and captain fishing experience at the time of sampling. R version 3.4.2 (2017-09-28) statistical software was used for the estimation of z-transformed standardization and bivariate correlation matrix between the variables.

Similarly, the Linear Model (lm) function provides the standardized beta regression coefficients[21]. In addition to this, the QGIS software was used to generate a grid map of Pakistani territorial waters[22].

Standardized Regression Model Equation

In order to quantify the effect sizes or relative importance of independent variables (IV) on the response or dependent variable (DV), we use Simultaneous or Standard Multiple Linear Regression (SMLR) and correlation methods with standardized regression coefficient estimation[23]. Notably, Hunter and Hamilton[24] documented the importance of standardized coefficients and correlations, which has several advantages in regression analysis. By comparing the standardized and unstandardized regression coefficients, they stated that reporting the results of standardized score allows a researcher to establish a scenario that which of the independent variable has the largest relative effect on the dependent variable. However, a prominent debate has fostered on the usefulness of standardized coefficients in the regression analysis by Tukey[25] followed by Kim and Ferree Jr[26] and Pedhazur[27], although the work of Hargens[28] suggested that it is more effective to interpret and represents the variables in terms of scale than choosing between standardized and unstandardized score.

Before putting the variables into the regression analysis, each independent variable, including dependent variable standardized (centered and scaled) at the level of z-score. To do this, each value subtracted from its sample mean and then divided by the sample standard deviation[29]. The equation of standardized variables can be written as follows:

$$\text{Standardized Variable } (Z) = X - \overline{X} / S_x \quad (1)$$

Now, by substituting the sample variables into the equation

$$Z_{(Revenue)} = \text{Revenue} - \overline{\text{Revenue}} / \text{SD (Revenue)} \quad (i)$$

$$Z_{(Catch)} = \text{Catch} - \overline{\text{Catch}} / \text{SD (Catch)} \quad (ii)$$

$$Z_{(Horsepower)} = \text{Horsepower} - \overline{\text{Horsepower}} / \text{SD (Horsepower)} \quad (iii)$$

$$Z_{(Fishing\ Days)} = \text{Fishing Days} - \overline{\text{Fishing Days}} / \text{SD (Fishing Days)} \quad (iv)$$

$$Z_{((Skipper)} = \text{Skipper} - \overline{\text{Skipper}} / \text{SD (Skipper)} \quad (v)$$

Then, by inserting these new standardized variables in the regression model, we obtain

$$Z_{iY\ (Revenue)} = \beta_1 * Z_{i1\ (Catch)} + \beta_2 * Z_{i2\ (Horsepower)} + \beta_3 * Z_{i3\ (Fishing\ Days)} + \beta_4 * Z_{i4\ (Skipper)} + E^*_i \quad (2)$$

Where; Z_{iY} = Value of predicted or explained variable (Revenue) at z-score

β_1 = Standard (Beta coefficient) for variable Catch

β_2 = Standard (Beta coefficient) for variable Horsepower

β_3 = Standard (Beta coefficient) for variable Fishing Days

β_4 = Standard (Beta coefficient) for variable Skipper Experience

Z_{iz} = First independent variable (Catch) at z-score

Z_{i2} = Second independent variable (Horsepower) at z-score

Z_{i3} = Third independent variable (Fishing Days) at z-score

Z_{i4} = Fourth independent variable (Skipper experience of fishing) at z-score

E^*_I = Error term

From equation (2), it is evident that as a result of the standardization, no information is missing and the original metrics can be retrieved by providing original mean and standard deviation[30]. Moreover, the standard beta weights to calculate the relative contribution of each independent variable (IV) on the dependent variable by using Pearson's correlation values[17]. The equation for calculating decomposed values of relative importance can be written as follows:

$$R^2 = ß * r$$

Where;

ß = Beta regression coefficients of the independent variables (IV)

r = Pearson's correlation values between dependent and independent variables

Results

The overall summary statistics of the variables for the quantitative analysis are presented in Table 1. From Table 1, it is observed that the per trip total average revenue generated by offshore operating trawlers are 12, 85000 rupees, an annual catch of 126 tons and the average vessel speed of 312 HP. Whilst, the operational fishing days at sea and the captain's experience showed a low variation among the other parameters of the data. To illustrate the results, estimated standard regression coefficients

Table 1 — Summarizes the descriptive statistics for sample boats

Statistic	N	Mean	Median	Min	Max	St. Dev	Range
Revenue	68	12,85000	12,74520	12,2120	22,87639	631425.9	21,65519
Catch	68	125.735	126	120	131	3.598	11
Horsepower	68	311.926	311	300	320	5.976	20
Fishing Days	68	166.397	167.5	160	170	3.149	10
Skipper	68	16.382	16	12	20	2.580	8

Note: Revenue = Rupees per trip, Catch = Metric tons per year, Horsepower = HP, Fishing Days = Number of days at sea per year, Skipper = Fishing experience of captain in years

(standardized beta weights) from the simultaneous multiple linear regression (SMLR) are presented in Table 2. The results indicate that the beta regression weights for all the independent variables are significant beyond doubt ($p<0.0001$) at the 5 % level of significance. Likewise, the F-value is also statistically significant ($F=69.4$; df =4), which shows that the combined effect of all the independent variables on the revenue or income of offshore trawling vessels were very strong. The estimated values of the beta regression coefficients for the catch, horsepower, fishing days, skipper were ($ß_1=0.253$), ($ß_2=0.26$), ($ß_3=0.316$) and ($ß_4=0.32$), respectively. Consequently, the beta regression coefficients indicate the relative contribution of each variable on the revenue. For this reason, the skipper has the largest estimated value of standard beta weight ($ß_4=0.32$) than other variables in the model. Therefore, the relative contribution of the skipper is slightly higher in comparison to other variables in the model. The unique contribution of each independent variable on response variable revenue together with the computed values of Pearson correlation 'r' for each variable is represented in Table 3. The variable skipper contributes 23 %, whereas fishing days 22.5 %, horsepower 18.2 % and catch 17.7 % of the relative score on the revenue of offshore trawling vessels. Furthermore, the model explained 81.5 % of the variance in revenue ($R^2 = 0.815$) and the amount of unexplained variance from the model was estimated to be 18.5 % ($1-R^2 =0.185$). Moreover, the results of Simultaneous Multiple Linear Regression (SMLR) with standardized regression coefficients can also be visualized from the path diagram in Figure 2.

Discussion

Information regarding resource dynamics (species and ecosystem) and resource users (socioeconomic aspects of fishermen's and income generation from fishing) is the key to effective fisheries management. By ignoring these two major constraints has led to

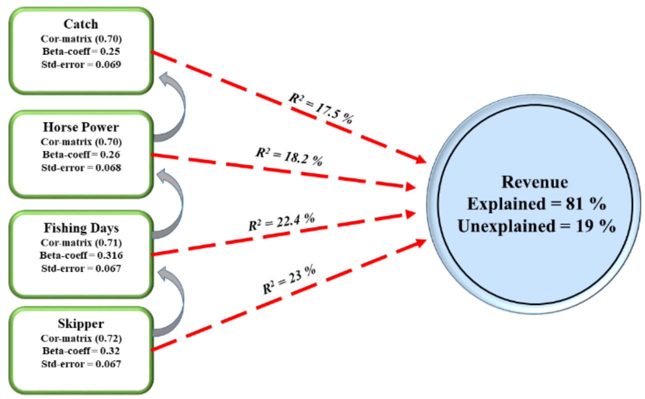

Fig. 2 — Path-diagram of Standard Multiple Linear Regression (SMLR) analysis; cor-matrix indicates correlation values; beta-coeff indicates Standardized beta regression coefficient values; Std-error indicates Standard error; R-squ indicates Relative contribution of each variable in the path representation

management failures[31]. Therefore, over the last twenty years, the focus has been shifted from production level towards upgrading the fisheries management[32]. To the best of our knowledge, there has not been a single study in Pakistan that investigates the factors affecting the economic aspects of trawling vessels.

Effects of catch on revenue

Revenues from fishing are the outcome of the number of catches in tons and ex-vessel price[33]. Therefore, the income significantly increases with an increase in the quantity of the fish landed by trawling vessels or vice versa[19]. Despite the fact that several major factors such as boat congestion in the fishery system, repetitive exploitation of the same fishing grounds with an excessive amount of fishing effort, competition among fishers and inefficient utilization of natural resources resulting in the decline of catch rates and lower income[34]. However, the standardized regression approach showed that the variable catch has a significant effect on the revenue of trawling boats. The low value of the estimated standardized regression coefficient indicates the lowest relative contribution (R^2 =17.5 %) of catch on the revenue in the fisheries of Pakistan. The study is well supported by the foregoing discussion that reduction in landed catches and lower-income was due to some biological and uneconomical utilization of fishery resources.

Effect of horsepower on revenue

Revenue and engine power (HP) were highly correlated. Therefore, the vessel's engine power was considered to be an influential factor to maximize catch rates and profitability of the trawling fleet[35]. Conversely, the fuel consumption is also directly linked to the engine speed (HP). The higher the fuel consumption leading to higher cost and less revenue. Indeed, some studies suggested that from much less horsepower and low fuel burning can also achieve the same catch rates from those vessels precisely designed for higher catch rates and income generation[36]. However, the estimated standardized coefficient of horsepower also has a significant effect with a strong correlation ($r_{(Revenue,\ Horsepower)} = 0.7$) on the revenue (Table 2 and Table 3). Moreover, the relative contribution of horsepower ($R^2 = 18.2$ %) was marginally greater than catch variable in regression analysis, which implies that powerful engines can be useful to increase the catch rates in less time and returning to the landing site early by avoiding the low market prices due to late arrivals[37]. By the same token, the study has well supported the notion that the larger engine power of trawling boats has higher gross revenues owing to the fact that the longer fishing seasons than the smaller boats[38].

Effects of fishing days on revenue

The effect of the number of fishing days has a very strong relationship on the revenue. Besides, even in the effort restricted fisheries, the fishermen can get the economic incentives such as permitted for extra days of fishing at sea to maximize the income by cooperating with the fisheries management authorities[39]. Concerning other studies, research from Paul, Torres *et al*.[40] has measured the significant relationship between improved revenues from the increased number of fishing days. Comparatively, the standardized regression approach in this study also showed a strong significant effect with very strong Pearson's correlation value ($r_{(Revenue,\ Fishing\ Days)} = 0.713$) on the revenue of trawling vessels. Additionally, the higher expected value of the relative contribution of fishing days at sea ($R^2 = 22.5$ %) was estimated, see Table 3.

Effect of Skipper on revenue

The skipper or captain's fishing experience has been the most substantial factor on the technical efficiency of the trawling vessels[41]. Along the similar lines, the work of Bradshaw and Eaton[42] provided the qualitative and quantitative concepts of the term 'skipper effect' in the commercial rock lobster fishery of Tasmania. Correspondingly, the standardized regression approach in our study has demonstrated the strongest relationship between skipper fishing experience and revenue. The obtained values of the standardized beta coefficient ($ß_4 = 0.32$) and Pearson's correlation ($r_{(Revenue,\ Skipper)} = 0.72$) from the analysis pointed out the strong correlation and the noteworthy relationship of captain's fishing experience and increased catch rates and profits of the trawling vessels. Although, in some fisheries, the effect of skipper fishing experience is strong while in some fisheries the effect is weak and near to insignificant[43]. Moreover, the highest value of relative contribution was estimated to be ($R^2 = 23$ %) see Table 3, which implies the strong effect of skipper fishing experience and earnings from the offshore fishing operations in Pakistan.

Table 2 — Regression results using Revenue as the criterion

Variables	*Dependent variable:* Revenue Beta
Constant	0.000 (0.054)
Catch	**0.253***** (0.069)
Horsepower	**0.260***** (0.068)
Fishing Days	**0.316***** (0.067)
Skipper	**0.321***** (0.067)
Observations	68
R^2	**0.815**
Adjusted R^2	0.803
Residual Std. Error	0.443 (df = 63)
F Statistic	69.427*** (df = 4; 63)

Note. * indicates p < .05; ** indicates p < .01; *** indicates p < .001. beta indicates the standardized regression weights, respectively

Table 3 — Computed values of relative contributions and correlations between, catch, horsepower, fishing days, Skipper experience and revenue

Pearson correlation	*Value*	*ß-coefficient*	*Value*Beta-coefficient*	R^2
r (Revenue, Catch)	0.701	0.253	0.1774	**17.7%**
r (Revenue, Horsepower)	0.698	0.26	0.1815	**18.2%**
r (Revenue, Fishing Days)	0.713	0.316	0.2253	**22.5%**
r (Revenue, Skipper)	0.718	0.32	0.230	**23%**
Total				**81.4%**

Note: r = Pearson's correlation, ß-coefficient = Standardized regression coefficients, R^2 = Decomposed values of explained variance (Schumacker 2014)

Conclusion

The present study was designed to determine the effects or relative contributions of several factors or inputs on the revenue generation of the offshore trawling vessels within the fisheries context of Pakistan. Provided that the variables catch, horsepower, fishing days and captain's fishing experience in terms of years are the best indicators to describe the economic proficiency of offshore fishing operations in the territorial waters of Pakistan. However, the presented analysis implies that the relative contributions of catch on revenue were about 17.5 %, horsepower on revenue 18.2 %, fishing days at sea on revenue 22.4 % and skipper experience on revenue was the highest 23 %, respectively. The most noticeable finding to emerge from this study is that the skipper fishing experience is the most important and crucial factor which can be significantly useful to upsurge the financial benefits of the offshore trawling boats. Based on the results, it can be concluded that the commercial fisheries sector of the country has shown some serious weaknesses which can be addressed properly. Declining of catches which costs more a common fisherman than earnings, bycatch and discards, overcrowding of fishing vessels, inefficient and uneconomical utilization of fishery resources and the lack of proper enforcement of fisheries rules and regulations can be an added fatal factors for the future growth and conservation of the natural resource in a sustainable manner. Therefore, we may suggest that a key policy priority should be therefore, to install and plan the long-term implementation of fisheries laws and effective management at every level. Although the study has only examined the technical and economic factors affecting the fisheries revenue, it has certain limitations in terms of the socio-economic relationship between fisheries and fishermen communities. Furthermore, much biological and economic research work will be needed to clearly understand and rectify the issues and problems which are still persisting in the fisheries system of Pakistan.

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