

Estimation of Production Function in Fishery on the Coasts of Caspian Sea

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Abstract—This research was conducted for the first time at the southeastern coasts of the Caspian Sea in order to evaluate the performance of osteichthyes cooperatives through production (catch) function. Using one of the indirect valuation methods in this research, contributory factors in catch were identified and were inserted into the function as independent variables. In order to carry out this research, the performance of 25 Osteichthyes catching cooperatives in the utilization year of 2009 which were involved in fishing in Miankale wildlife refuge region. The contributory factors in catch were divided into groups of economic, ecological and biological factors. In the mentioned function, catch rate of the cooperative were inserted into as the dependant variable and fourteen partial variables in terms of nine general variables as independent variables. Finally, after function estimation, seven variables were rendered significant at 99 percent reliably level. The results of the function estimation indicated that human resource (fisherman quantity) had the greatest positive effect on catch rate with an influence coefficient of 1.7 while weather conditions had the greatest negative effect on the catch rate of cooperatives with an influence coefficient of -2.07. Moreover, factors like member's share, experience and fisherman training and fishing effort played the main roles in the catch rate of cooperative with influence coefficients of 0.81, 0.5 and 0.21, respectively.

Keywords—Production Function, Coefficient, Variable, Osteichthyes, Caspian Sea

I. INTRODUCTION

POPULATION growth and food security for residents of the Earth is the main challenge human societies are facing today in the 21st century. Water resources are one of the main food providing resources for human which plays a large part in families' food diet. Given the development of technology and improvement in fishing equipments and tools, great changes occurred in this field which turned fishing from its traditional state into an industry in a way that millions of people in the world and thousands of people in Iran make a living with fishing.

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Caspian Sea, as the largest lake in the world and one the most important water resources in the country, is one of the largest provider of protein and a job creator for a host of active human resources in northern provinces of Iran with 14,000 tons of different types of osteichthyes caught annually[8]. The Caspian Sea utilization system is defined by the Fisheries Organization according to certain criteria and regulations in the form of beach net cooperatives [9]. The fishing season starts from October each year and lasts till the end of next March. Many different factors are involved in the fishing process which can be divided into three groups of economic (capital and workforce), ecological (weather conditions) and biological (aquatic reserves, propagation and reproduction rate) factors [4]. As it was noted earlier, the incremental development of this industry requires this business to be cared for and studied more than before. In this research, contributory factors in fishing were first identified and then the effect of each factor was studied through production (catch) function estimation.

A. Production Function Approach

This approach, which is also called the productivity change approach, the approach to effect production or environment valuation as an entity, tries to find the relation between environmental characteristics and output level of an economic activity [5]. This approach is widely used especially to evaluate the effects of changes in environmental quality on agriculture and fishery [1]. If Y is the activity output, ENV is the involved environmental variables and x_i : ($i=1, 2, 3, \dots, n$) are other entities in production, the production function will be as follows:

$$Y = f(x_i, ENV) \quad (1)$$

A group of factors, whether natural or human-related, come together in fishing activity to bring about fishing process and they finally lead to goal or optimum catch. These factors can be economic, ecological or biological [10]. The mathematical form of the production function is as follows:

$$Y_t = f(E_t, X_t, S_t) \quad (2)$$

The above function indicates that catch is affected by effort or activity, reserve quantity and the particular features of fish:

Y as a dependant variable, shows the catch rate in the period (t)

E shows the effort-activity factor which includes the number of fishers, fishing days and etc.

X shows the fish reserve quantity.

S shows the particular features of fishing effort which is different among cooperatives like beach net opening size, fishers' skill, fishing tool quantity and etc.

B. The Review of Literature

T. Bell used Shiffer's model to calculate lobster equilibrium in New Zealand waters in 1972. He considered lobster fishing to a function of the number of spread beach nets in a single year and the annual average water temperature in the residence. At the end, both variables were significant with a 96 percent reliability coefficient.

Using the cross sectional data of 1968, 1971 and 1975, E. A. Jorendal estimated the salmon catch (production) function in the Northern Sea. He considered the catch (production) function of each boat to be a function of variable entities, reserve quantity in the beginning of the year and fixed entities which denoted the particular features of the fleet. He inserted several factors like the length, width and depth of the boat, manufacturing year, engine power, boat structure type (wooden, fiberglass) into the model.

In his research entitled "the study of contributory factors in the catch of beach net cooperatives in the southwestern coasts of the Caspian Sea", S. Mostafazade studied 23 beach net cooperatives in Gilan province in 1990. He considered catch a function of beach net pulling, workforce, capital, fishing place status and reserve quantity. After estimating the linear function from 34 distributor variables, he found that seven variables were significant at 99 percent reliability level [7].

In his doctoral thesis in 2002, A. Mortazavi estimated shrimp production and supply function in Iran. He selected production rate as dependent variable and regarded factors like feeding, shrimp seedlings quantity, workforce quantity and fuel and energy amount as independent variables [6].

II. MATERIALS AND METHODS

A. Caspian Sea

Being 1200-1039km long, 435km wide and 378-390 thousand square kilometer large, Caspian Sea in the largest lake in the world as the most important water resource in the country. It contains 2009 thousand cubic meter of water which forms 44 percent of the total water amount of world lakes and is fed by 130 small and large rivers which enter the sea mainly from the southern section. Generally, there are 154 species and subspecies of fish in three groups of Osteichthyes, cartilaginous and shag fish living in the Caspian Sea [2]. Some famous osteichthyes include carps, kutums, mullets ... etc. as it was mentioned, Osteichthyes fishing by beach net cooperatives is done according to certain criteria and regulations under the supervision of Iranian Fisheries

Organization. Cooperatives have predefined structures and responsibilities with certain financial performance. 25 cooperatives in the southeastern coasts of the Caspian Sea extending from the Amir Abad Port fishing ground to Ashoradeh region inside Miankale Wildlife refuge were studied in this research.

B. Research Methodology

The stages of carrying out this research are listed below:

Stage one: studying the theoretical principles and reviewing the related literature in and out of Iran

Stage two: visiting the area and talking with managers and fishers of the cooperatives and also beach net fishing experts

Stage three: identifying the contributory factors in catch and determining variables

Stage four: designing and providing questionnaires and conducting the pretest stage

Stage five: collecting necessary information through questionnaires and related organizations

Stage six: analyzing data by E-views software

As it was mentioned in research stages, the area was visited after studying the theoretical principles and the related literature and managers, fishers and experts of beach net fishing were talked with and interviewed. This stage is regarded as one of the most important and influential stages of the research since all contributory factors in fishing were identified and independent variables had to be selected and inserted into the model among contributory factors.

After studying and talking with fishers and experts, factors were divided into three groups of economic factors like capital, workforce and fishing tools, ecological tools like weather, beach net pulling quantity and fishing days and biological factors fish reserves quantity, propagation and reproduction rate and releasing rate. Finally, 14 specific variables in the form of 9 general variables including qualitative and quantitative ones were selected as independent variables and were inserted into the model among fishing factors and variables with regard to existing limitations [3]. Therefore, catch quantity (Q) is the dependant variable which is a function of below independent variables:

$$Q = f(NL, P, LE, I, K_1, P_2, E, ND, P_3) \quad (3)$$

NL as the number of human force (number of fishers), P as experience and head fisher background, LE as fisher's experience and skill, I as the income or member's annual share, K_1 as the capital of the cooperative, P_2 as the fishing tools and equipments (beach net, boat, tractor and etc), E as the beach net pulling number (fishing effort), ND as the number of days in which there is no fishing due to bad weather conditions like storm and wind and P_3 is the presence of port and power plant in the area are selected as independent variables in this research.

After variable determination, data collection was done through two ways i.e. related organizations and offices and questionnaires. Then, collected data was analyzed by E-views 5.0 software and the related production function was estimate.

III. RESULTS

We inserted nine general variables which included fourteen specific variables in order to estimate the production function. After estimating the function, we found that seven variables became significant at 99 percent reliability level but two variables didn't which were removed from the model (Table. 1). The osteichthyes production function of the southeastern coasts of the Caspian Sea is as follows:

$$Y = 1.48 + 1.76 \ln(NL) + 0.05 \ln(P) + 0.81 \ln(I) \\ (0.25) \quad (9.13) \quad (4.18) \quad (2.58)$$

$$+ 0.1 \ln(P_2) + 0.21 \ln(E) - 2.07 \ln(ND) + 0.03 \ln(P_3) \\ (4.93) \quad (3.09) \quad (-1.77) \quad (3.1)$$

$$N = 25 \quad R^2 = 0.9962 \quad \text{Adj } R^2 = 0.9927 \quad D.W.T = 1.76$$

TABLE I
VARIABLES AND COEFFICIENTS

Variables	Coefficient	Std. Error	t-Statistic	Prob.
C	1.48	5.726199	0.258656	0.8007
NL	1.76	0.192922	9.138071	0.0262
P	0.5	0.013533	4.186559	0.0015
I	0.81	0.316148	2.587514	0.0252
P ₂	0.1	0.021708	4.939925	0.0004
E	0.21	0.067963	3.098065	0.0101
ND	-2.07	1.169690	-1.77571	0.1034
P ₃	0.03	0.009801	3.149850	0.0092

A. Fisher quantity: Results showed that the effect coefficient of fisher quantity was estimated to be 1.76 in the workforce section which shows that there is a 1.76 time increase in catch with one time increase in fisher quantity. Therefore, we can conclude that the increasing in workforce quantity has a positive effect on catch. This variable can be tested with t-statistics which is a specific test about the significance of individual relations between dependent and independent variables in a way that t was estimated to be 9.13 in the variable of fisher quantity which shows the significance of that variable.

B. Head fisher: Head fisher plays an important role in fishing activity as the leader and guide of fishers. Thereof, education level and experience in cooperative were selected as two variables. The effect coefficient of head fisher variable in catch function was estimated to be 0.05 which shows that there is one unit increase in catch equal to 0.05 percent with the increase in head fisher's education level and experience.

The t-statistic was calculated to be 4.18 for this variable which shows its significance.

C. Member's share or income: As we know, income or member's share is influenced by catch quantity as each member's share of the sale increases with the increase in catch quantity. However, we should not forget that costs of repairing fishing tools and equipment and loss from environmental and weather factors influence a member's share. The effect coefficient of member's share variable was estimated to be 0.81 in production function estimation which means that results conform to existing expectations. The t-statistic indicated the significance of the income variable ($t=2.58$).

D. Fishing tools and equipments: Fishing tools and equipments like tractors, beach nets, boats, winches and etc were inserted into the model in the beginning of this research but didn't prove significantly due to collinearity and a general variable was inserted into the model after determining indices for each fishing tools and equipment individually that results showed the significance of that variable. Its effect coefficient was estimated to be 0.1 which shows that there would be 0.1 percent increase in catch with one unit increase in fishing tools. It means that there is a positive relation between fishing tools and catch quantity. The t-statistic for this variable was calculated to be 3.09 which indicate the significance of this variable in the catch quantity of cooperatives.

E. Beach net pulling quantity or fishing effort: The beach net pulling or fishing effort coefficient was estimated to be 0.21 in the estimated production function in a way that catch quantity will increase for 0.21 percent with one unit increase in fishing effort. Accordingly, there is a direct relation between beach net pulling (fishing effort) and catch quantity. The t-statistic for this variable was calculated to be 3.09 which confirm its significance.

F. The number of days without fishing (bad weather conditions): here, the aim of inserting this model was to show the number of days that different factors like storm, wind and etc prevent from fishing activity in the sea. Results showed that there is a negative relation between the number of days without fishing and catch quantity i.e. fewer these days are, more the catch quantity will be. The effect coefficient and t-statistic were estimated to be -2.07 and -1.77 respectively in this research.

G. The existence of Amir Abad Port and Shahid Salimi Power Plant: In this research, we saw that cooperatives which were nearer to the port and power plant had a greater catch that these results did not conform to expected results in a way that the effect coefficient of this variable was determined to be 0.03 which shows that catch quantity increases for 0.03 unit with one unit increase in distance. After searching a lot to find a reasonable answer to this question, we found that closeness between this area and Tajan River where fish seedlings are released and also suitable fishing site conditions such as

greater depth caused the increase in catch quantity in a way that not only brought the negative effects of the power plant and port to zero, but also increased catch quantity.

IV. CONCLUSIONS

Among existing variables in fishing process, fourteen variables were selected in this research and were inserted into the function in the form of nine main variables that seven variables were proved significant at a 99 percent reliability level and two variables were proved insignificant and were removed from the model. In the estimated production function, human force or fisher quantity had the greatest positive effect and weather conditions had the greatest negative one in the catch quantity of cooperatives. These results were confirmed by the performance report of cooperatives as the cooperative which used more fishers, had larger catch quantity as well and vice versa. It was also true about weather conditions. Concerning capital factors in fishing process, results showed that capital and fishing tools such as tractor, beach net and etc have a positive and significant relation with catch quantity that new and well-working tools can cause the incremental productivity and revenue increase in fishing. All variables like experience, background and fisher and head fisher training which concern human factors were proved significant and positive. Finally, one can conclude that factors like human force, weather conditions and capital have the main roles in catch quantity, respectively.

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