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An Economic Analysis of Fisheries Through Production Function Approach

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Abstract: This research was conducted at the southeastern coasts of the Caspian Sea in order to evaluate the performance of Osteichthyes cooperatives through production 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 2010 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 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.

Key words: Production Function · Coefficient · Variable · Osteichthyes · Caspian Sea

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.

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 [1]. The Caspian Sea utilization system is defined by the Fisheries Organization according to certain criteria and regulations in the form of beach net cooperatives [2]. 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 [3]. As it was noted earlier, the incremental development of this industry requires this business to be cared for and studied more than before.

The main goal of this research is first to identify the contributory factors in catch and later to determine the effect coefficient of each factor in the fishing process through estimating the production function in order to cause productivity and catch increase through considering the results and other factors, developing the effective factors and improving the weak ones.

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.

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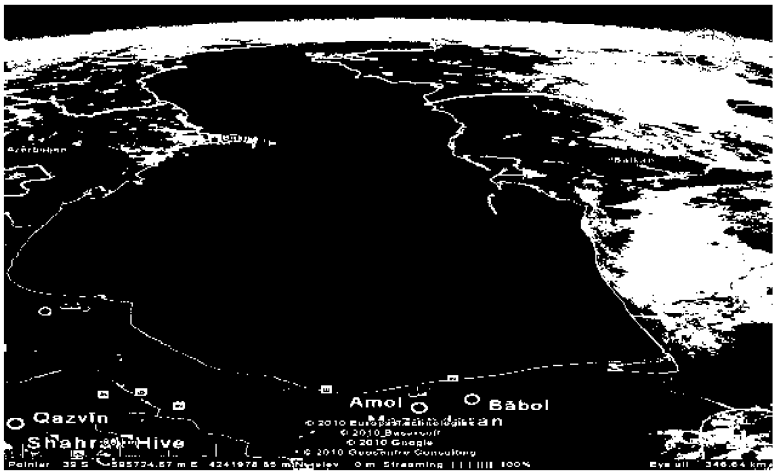

Fig. 1: Southern coasts of Caspian Sea

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 [4].

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 [5].

Caspian Sea: Caspian Sea has 1200-1039 km long, 435km wide and 378-390 thousand square kilometer large. Caspian Sea is the largest lake in the world as the most important water resource in the country. It contains 76-78 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 (Fig. 1). Generally, there are 154 species and subspecies of fish in three groups of Osteichthyes, cartilaginous and shag fish living in the Caspian Sea [6]. 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.

MATERIALS AND METHODS

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 [7]. This approach is widely used especially to evaluate the effects of changes in environmental quality on agriculture and fishery [8]. If Y is the activity output, ENV is the involved environmental variables and x_i: (i=1, 2, 3… 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 [9]. 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.

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 [10]. 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.

Cochran Formula was used to decide on the number of needed samples through the random sampling method as follows:

$$n = \frac{Nt^2s^2}{Nd^2 + t^2s^2}$$

In this formula:

n : The number of needed samples
N : The total number of available samples in the society
t^2 : Student t distribution
S^2 : Sample variance
d^2 : Statistical error

The variance of the samples had to be determined or calculated through a preliminary sampling in order to be able to use the above formula. Finally, 350 questionnaires were filled using the above formula and were then analyzed by E-views 7.0 which led to the estimation of the desired production function.

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:

Table 1: Variables and Coefficients

Variables	Coefficient	Std. Error	t- Statistic	Prob.
C	1.480	5.726199	0.258656	0.8007
NL	1.760	0.192922	9.138071	0.0262
P	0.500	0.013533	4.186559	0.0015
I	0.810	0.316148	2.587514	0.0252
P2	0.100	0.021708	4.939925	0.0004
E	0.210	0.067963	3.098065	0.0101
ND	- 2.070	1.169690	-1.775710	0.1034
P3	0.030	0.009801	3.149850	0.0092

$$Y = 1.48+1.76 \text{ Ln (NL)}+0.5 \text{ Ln (P)}+0.81 \text{ Ln (I)}+0.1 \text{ Ln (P}_2\text{)}+0.21 \text{ Ln (E)} -$$

(0.25) (9.13) (4.18) (2.58) (4.93) (3.09)

$$2.07 \text{ Ln (ND)} + 0.03 \text{ Ln (P}_3\text{)}$$

(-1.77) (3.1)

N= 25 $R^2 = 0.9962$ Adj $R^2 = 0.9927$ D.W.T = 1.76

Fisher Quantity: As it can be seen in the above table, the fisher quantity effect coefficient was estimated to be 1.76 in the human force sector. We can state that we will see an increase of 1.76 percent in the catch rate of the cooperatives for a one unit increase in the number of fishers. Generally speaking, it can be concluded that the rise in the number of staff members of the cooperatives has a positive effect on the catch rate. However, this result was not very unexpected as we observed in the data collection stage in the beginning of the research that cooperatives with higher numbers of fishers had quite higher catch rates than others.

It should be mentioned that the issue of productivity should be taken into account as well and the increase in workforce does not necessarily mean a larger catch. The validity of this variable can be tested by the t-statistic which is a detailed test concerning the significance of individual relationships between independent and dependent variables. The t-statistic in this variable was estimated to be 9.13 indicating the significance of this variable. Concerning this variable, we should say that if the t-statistic is more than or equal to ± 1.5, there is a significant relationship between the independent and the dependent variables; otherwise, there is no significant relationship between the variables.

Fisher Experience: Fisher's experience and skill always play an important role in catch and fishing. Hence, two variables, level of education and working background in cooperatives (the number of years someone has worked as a fisher), were chosen as dependent variables. The desired information on fishers' experience collected by questionnaires was inserted into the related software program. We can see a five percent increase in the catch of the cooperatives with a one unit increase in fishers' level of education and working background. The t-statistic in this variable was estimated to be 4.18 showing the significance of this variable. Generally, cooperatives with more fishers and average years of working background than other cooperatives had greater catches. However, the catches in the western coast cooperatives of the region, especially cooperative A, B, C and D, are quite larger (more than two times) than in other cooperatives implying the influence of some other factors except the number of staff members and background like environmental factors, the river bed type and other factors going to be explained later (Fig. 2).

Member's Share or Income: These cooperatives are so structure that the fishers are themselves mainly the share holders or the owners of the cooperatives. The total earned profit (expenses subtracted from the income) is divided among the fishers in each cooperative in the end of the fishing season with regard to each one's share. As we know, each member's earning or share is affected by the catch in a way that each person's share of the sale increases with the rise in the catch. However, we should remember that costs like that of fishing tools and equipments repairs and maintenance, damages caused by environmental factors and the weather are also effective

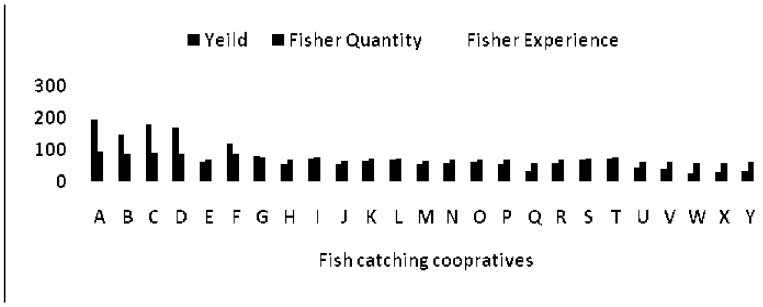

Fig. 2: Number of fishers, average fishers' experience and their effect on catch in each cooperative is shown. It shows that cooperatives with higher fisher quantity and fishers' experience had a higher catch

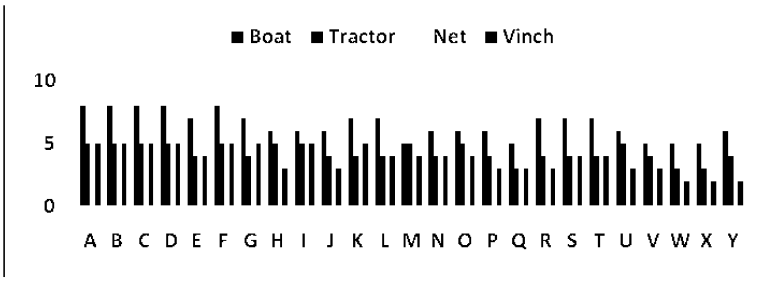

Fig. 3: Utilized fishing tools in cooperative

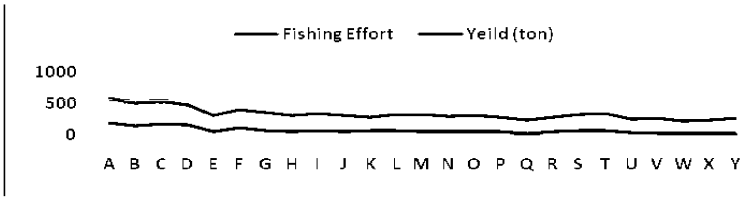

Fig. 4: The relation between fishing effort and catch rate. Cooperatives with higher fishing effort had a higher catch rate

in each member's share. Regarding the selection of this factor as an independent variable in estimating the function, it was assumed that each fisher has done their best to increase their share and the cooperative achieved a greater catch as a result. Having estimated the desired function, the effect coefficient of the member's share variable was estimated to be 0.81 and therefore, the results conform to the existing expectations. The t-statistic also indicates the significance of the income variable (t=2.58).

Fishing Tools and Equipments: In addition to human factors, some other factors like capital are always effective in the catch quantity too. Fishing tools and equipments form a main part of the capital of the cooperatives. In this research, fishing tools and equipments including tractor net, boat, winch etc were separately inserted into the model but did not prove significant due to co-linearity. The main cause of the co-linearity is the close numbers of the mentioned tools and equipments in most cooperatives. In other words, the numbers of nets, boats and tractors are the same in most cooperatives. A general variable which showed the results of the significance of the mentioned variable was inserted into the model to resolve the co-linearity with the index determination for each fishing tool or equipment separately (Fig. 3). The effect coefficient for fishing tools and equipments was estimated to be 0.1 which indicates that we will have a one percent increase in the catch for each unit of increase in fishing tools i.e. there is a positive relationship between fishing tools and the catch. The t-statistic in this variable was calculated to be 3.09 signifying the significance of this variable in the catch of those cooperatives.

Beach Net Pulling Quantity or Fishing Effort: One of the key factors considered in the beginning of the research was the number of fishing attempts in each unit. The number of fishing attempts means the number of net spreading and collecting operations leading into catch in the end. More the number of fishing attempts in normal conditions are, greater the final catch will be. It was expected that this variable has a significant relationship and a high effect coefficient while the results were below expectations. The net pulling or fishing attempt coefficient was estimated to be 0.21 in the estimated production function in a way that the catch increased by 0.21 percent with a one unit increase in the fishing attempt. As it was mentioned earlier, there is a direct relationship between net pulling (fishing attempt) and the catch according to our expectations; however, this variable has a lower effect coefficient than other variables. The t-statistic in this variable was determined to be 3.09 confirming its significance. Figure (4) shows the relationship between the number of fishing attempts and the product quantity of the 25 involved cooperatives. The significant relationship between these two variables can be observed in the quite equal distance between the two curves.

The Number of Days Without Fishing (Bad Weather Conditions): Weather and environmental conditions can be never neglected in fishing operations. Factors like wind, storm, rain and some others affect the fishing and net casting process. Unfortunately, this variable is a qualitative one and the related data cannot be inserted into the model directly and as raw data. The number of days fishing was cancelled due to bad weather conditions was inserted into the function as the target data for each

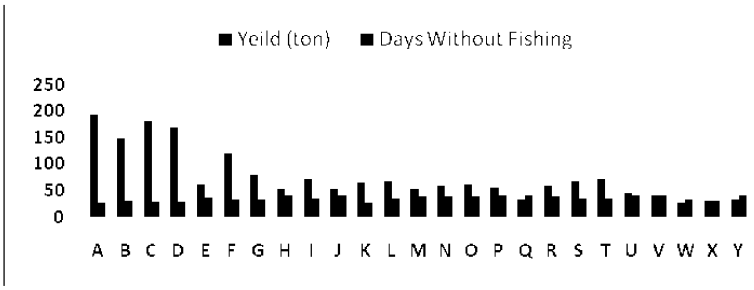

Fig. 5: Unfavorable and stormy weather condition decreased catch rate in cooperatives.

Table 2: The relationship between existence of commercial port and power plant with total catch

Fish Catching Cooperatives	Distance to Port and Power Plant (Km)	Yield (Kg)
A	9.0	193750
B	7.2	148548
C	5.5	180966
D	2.8	168906
E	2.0	607080
F	3.9	120245
G	6.0	787160
H	7.8	533340
I	9.6	707770
J	11.5	526100
K	13.5	661050
L	15.4	676100
M	17.5	530550
N	19.3	578410
O	21.0	606360
P	22.8	554940
Q	24.5	321510
R	26.3	577080
S	28.0	672390
T	29.7	717240
U	31.5	448610
V	33.5	397330
W	35.0	259940
X	37.1	291730
Y	39.0	332270

cooperative in order to solve this problem. Naturally, it was expected that cooperatives more frequently exposed to bad weather conditions had more days without fishing and, accordingly, smaller catches than other cooperatives. The results show that there is a negative relationship between the number of days without fishing and the catch. It means fewer these days are, more the catch will be. The effect coefficient and the t-statistic in this research were estimated to be -2.07 and -1.77 respectively. We can explain that bad weather conditions during the fishing season cause a decrease of over two percent in the catch of the cooperatives (Fig. 5). This effect coefficient is more effective than other variables.

The Existence of Amir Abad Port and Shahid Salimi Power Plant: The presence of a commercial port and a power plant in the involved area increases the possibility of their influence on the catch. Hence, this feature of the area was inserted into the function as an independent variable. Accordingly, the distance between each cooperative and the mentioned installations was calculated on the kilometer scale. Having estimated the function by the software program, the results showed that cooperatives with a shorter distance from the port or the power plant had larger catches than those farther from the two sites. This result did not conform to the expected ones as the effect coefficient for this variable was determined to be 0.03 showing that the catch increased by 0.03 units for each unit of increase in the distance (Table 2). Having searched much for a logical answer to this question, we found that this area was in the vicinity of the Tajan River where larvae are released as well as the suitable conditions of the fishing site like a greater depth caused the increase in the catch in a way that it not only neutralize the negative effects of the port and the power plant, but also increases the catch in the area.

DISCUTION

Among the existing variables in the fishing process, 14 variables were selected in this research and were inserted into the function in the form of nine main variables and seven variables were proved significant at a 99 percent reliability level while two variables were proved insignificant and were removed from the model. In the estimated production function, the human force or the fisher quantity had the greatest positive effect while weather conditions had the greatest negative effect in the catch quantity of the cooperatives. These results were confirmed by the performance report of the cooperatives as a cooperative which used more fishers, had a larger catch quantity as well and vice versa. It was also true about weather conditions. When fishers were surveyed, most of them also regarded bad weather conditions as the most important reason of the fluctuation in catch quantity.

Concerning capital factors in the fishing process, the results showed that the capital and the fishing tools such as net, tractor etc have a positive and significant relationship with the catch quantity and new and well-working tools can cause productivity increase and higher efficiency in fishing. It should be noted that a large portion of the fishing cost goes to repairing and maintaining fishing tools. Therefore, necessary steps should be taken to continuously maintain and monitor the equipments. Concerning the human factors, all the variables like experience and fisher's and head-fisher's training and working background were positive and significant. General and specialized classes and courses on fishery have been held in the past few years by the regional fisheries organization to raise fishers' general knowledge.

Intending to compare the results of this research with similar ones mentioned in the review of the related literature, we can mention two:

- Siavash Mostafazade studied 23 beach net cooperatives in Gilan Province over ten years. Having estimated the linear function of 34 distributor variables, seven variables were proved significant at a 99 percent reliability level. Factors like cold weather, human force and the distance between the cooperatives and the Sefidrood River were determined to be prominent effective factors in catch.
- Estimating the production (catch) function, Mr. Mortazavi inserted such factors as human force, water temperature, water salinity and the consumed energy into the function as independent variables. Four of the nine variables were proved significant at a 99 percent reliability level.

Finally, considering the results of similar researches and also the results of this research, we can say that factors like human force, weather conditions and capital have the greatest effect in the catch respectively.

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