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Original Article

The economies scale for fish meat production farms operating in the Musayyib fish market, Iraq, in 2020

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Abstract: Al-Musayyib District is famous for its fish farms due to its location close to Baghdad and the central Euphrates governorates, the availability of water resources, and the expertise of breeders. The research aims to estimate the production and cost function of fish farms, the partial production elasticities, and the total production elasticity of the production function and determine the optimal behavior of the estimated cost function, from minimizing costs, maximizing profit, and determining the optimal production volume. The sum of the partial elasticities of these variables, expressed in the total production elasticity of the estimated function, was 1.273, which is greater than the correct one, meaning that there is an increase in the return to capacity. The number of rearing meals ranged between 1-2, and the design capacity of earthen ponds varies between 10000-480000 m^2, producing 1350-145250 kg/year. 38 kg/year is the quantity at which the average cost reduction is achieved. At the same time, the best normal net profit is achieved, meaning that the profit-maximizing quantity is 5.865 tons/year for production farms in the study area.

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Introduction

Fish is an important source of animal protein that is necessary for human health and to protect humans from diseases of the heart and blood circulation (Mohamed Sayed, 2015). In addition, it is an excellent source of phosphorous, which has a crucial role as it supports the spine and teeth to grow, i.e., every 100 g of fish contains 230-240 mg of phosphorous. Fish meat also contains calcium, magnesium, and iodine, as well as vitamins such as A and D. In addition, fish is the main source of Omega 3, an essential fatty acid for healthy skin, heart, and bones (Hassan, 2010). Iraq has many internal waters suitable for the growth and reproduction of fishes (Arab Organization for Agricultural Development, 1986).

Given the nutritional value of fish meat, the estimation of production and cost functions is of great importance because these functions have extensional and economic applications for an agricultural policy that can lead to increased production and lower costs if breeders are directed to produce according to optimal production rates. Despite the availability of primary resources and available capabilities, Iraq still suffers from several problems that prevent it from benefiting from these resources. This led to fluctuations in fish meat production, the inability to cover the increasing demand for such meat and high production costs. Therefore, efforts and studies must be devoted in the direction that reduces the size of this problem. The research aims to study the reality of fish farm production and costs for the studied sample, estimate partial and total elasticities, calculate capacity returns, and determine the optimal behavior for fish farms. The research assumes that most breeders do not achieve production levels that meet the increasing demand's needs, in addition to the high production costs for fish farmers in the studied sample. The data was obtained through a field survey using the questionnaire form for a selected sample of fish breeders in Babylon Governorate, Musayyib District, and Alexandria District for the summer agricultural season of 2020.

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Materials and Methods

Forty questionnaire forms were distributed randomly to fish farmers, and the data was collected. Then, we have cross-section data for the farms, which were unloaded and analyzed using the SPSS statistical program. Econometrics was used to extract the relationship between the variables using a multiple linear regression model between production as the dependent variable (Yi) (variable) and independent variables (Xi), which are: A is the number of basins X_1, B = the death rate X_2, C = the amount of feed X_3, and D = the number of fish X_4. Since more than one production function model was estimated, the semi-logarithmic function was the most acceptable in terms of the agreement of the variables involved in the economic theory in terms of the parameters' sign, size, and realization of significance. The logarithm ($\log_{10}$) was taken for all the independent variables. Then, the data was analysed to study the relationship between the variables by multiple linear regression of the semi-logarithmic function using the formula of $Yi = B_o + B_i \log X_i + E_i$.

Partial elasticities were estimated for each independent variable (Xi) included in the estimated model, and then the total elasticity was estimated. In addition, capacity returns are calculated based on estimating the total elasticity of the semi-logarithmic production function for fish farms. The analytical and applied aspects were based on measuring the effect of all the independent variables (X_i) combined on fish production, as production is considered the dependent variable (Y_i). The number of ponds, the percentage of deaths, the amount of feed, and the number of fish are considered independent variables. They represent X_i, and the remainder of the equations represent E_i.

Results and Discussions

Estimating the semi-logarithmic production function: More than one production function model was estimated, and the semi-logarithmic model was adopted because it best represents the relationship between production and its components of the independent variables. The method of least squares was used. Ordinary OLS is one of the most applied methods in estimating the econometric model due to its important characteristics, including the efficiency of the variance size and impartiality (Al-Saifo, 1988). For the estimated function, the formula of $Y = b_0 + b_1 LnX_1 + b_2 LnX_2 + b_3 LnX_3 + b_4 LnX_4 + E_i$ was used, where X_1 = the number of basins, X_2 = percentage of death, X_3 = the amount of feed, X_4 = the number of fish, and E_i = the random variable.

The estimated model was acceptable and can be relied upon in interpreting the studied function (Table 1). The estimated function was tested based on three statistical, economic, and standard criteria, and it did not suffer from any problem related to second-order problems and the opposite of the corrected determination coefficient ($R^{/2}$). The explanatory power of the estimated models was 0.77, which means that 77% of the changes occurring in the dependent variable (production) are due to the change in the independent variables (production elements), and 23% of changes in the dependent variable due to random factors, or due to the deletion of some variables from the estimated model. The estimated parameters were consistent with logic, economic, and statistical significance, except for some variables, such as the number of meals, academic achievement, and years of experience. Therefore, it was decided to exclude them from the estimated function.

We find that the estimated parameter of the number of basins (X_1) had a positive sign (38862.20), was significant (P>0.05), and agreed with the principle of economic theory. The percentage of deaths (X2) showed a negative sign (51291.88) and was significant (P>0.05), which is consistent with the principle of economic theory (Table 1). The sign of the estimated value of the number of fish parameters (X_4) was negative, amounting to 28088.41 (P>0.01), which is in agreement with the principle of economic theory. In addition, the function as a whole was significant (P>0.01), based on the (F) test, estimated as 13.042 compared to the tabular value of 3.29. The value of (d*) Durbin Watson calculated as 1.463, which is greater than the value of (d_l), which is equal to (1.285), and smaller than the value of (d_u), which was equal to 1.721 at the level of 0.05.

Table 1. The results of estimating the semi-logarithmic production function for fish breeders.

code	The estimated parameters of the function	independent variables
C	-114391.7 (-1.093)*	Constant
X_1	38862.20 (1.857)**	The number of basins
X_2	-51291.88 (-1.840)**	Percentage of death
X_3	272679.1 (3.630)**	The amount of feed
X_4	-280884.1 (-3.188)**	The number of fish.
	0.77	R^2
	0.71	$R^{\backslash 2}$
	1.463	D.W
	13.042	F*

The numbers in brackets indicate the t-test values. *, **, significant at the level of 0.05, and 0.01.

Estimation of partial production elasticities and total production elasticities of the production function: The estimated semi-logarithmic production function was as follows: $Y = -114391.7 + 38862.20\ LnX_1 - 51291.88\ LnX_2 + 272679.1\ LnX_3 - 80884.1\ LnX_4$.

It was done, depending on the estimated parameters, by calculating both the partial production elasticity and the total production elasticity by relying on the mathematical formula (Kazim, 2002) of $Ep = bi / Y^{\backslash}$, where Ep = production flexibility, bi = estimated parameter, and $Y^{\backslash}$= Arithmetic mean. After applying the equation, the estimated semi-logarithmic function was obtained: $Y=114391.7 + 1.368\ LnX_1 - 1.806\ LnX_2 + 9.602\ LnX_3 - 7.891\ LnX_4$.

By estimating the partial production elasticity, it was positive for some variables and negative for others, as the production elasticity for the variable of the number of ponds (X_1) amounted to 1.368, being greater than 1, the correct one; this means that the use of this resource falls in the first stage of production and increasing this productive resource by 1% will lead to an increase in output by 1.368%. The elasticity of production for the variable of the percentage of deaths (X_2) had a value of -1.806, indicating that it is used in the third stage of production, i.e., an increase in this productive resource by 1% will decrease production by 1.806%.

For the elasticity of production for the variable amount of feed (X_3), it showed a value of 9.602, and being greater than one is correct; this means that using this resource is in the first stage of production, and increasing this productive resource by 1% will lead to an increase in production by (9.602%). In addition, for the production elasticity of the variable number of fish (X_4), the value was -9.891, indicating that the number of fish was more than what was required, so the increase in their unaccounted numbers led to the use of this resource to the extent necessary (Overused). Furthermore, this resource is used in the third production stage, making its use uneconomical. This indicates that % increase in this productive resource by 1% will decrease production by 9.891%. For the sum of the partial elasticities of these variables, which are expressed by the total production elasticity of the estimated function, it was found to be 1.273, which is greater than the correct one, and this means that there is an increase in the amount of return to capacity, i.e., an increase in all resources by 1% will lead to an increase in production by 1.273%. The total elasticity of production reflects the possibility of increasing production by increasing the productive resources used in equal proportions.

Estimating the cost function: The cost function is the relationship between what the producer spends in return for obtaining the productive resources used to produce a specific product (Sakkab, 2005). It is an expression of production costs as a function of the amount of output (TC =f(Q)). The cost functions can be calculated using various functions, namely linear, quadratic, and cubic, i.e., $TC = b_0 + b_1 Q$, $TC = b_0 + b_1 Q + b_2 Q^2$, and $TC = b_0 + b_1 Q + b_2 Q^2 + b_3 Q^3$, respectively. For example, the total fish production with the variable (Q) by raising the number of meals from 1 to 2. The annual total costs for each field were considered the dependent variable TC when estimating the cost function. Three functions (linear, quadratic, and cubic) were used. The cubic function was the best, and the results were as TC = 405.150 + 2918.5Q – 2.950Q^2 + 1.125Q^3 (t* (0.104) (8.720) (-3.367) (2.726); $R^{\backslash 2}$ = 0.98, D.W = 1.559, and F* = 939.68).

Economic and econometric analysis: The results of the statistical estimation of the cost function parameters with the three production parameters (Q, Q^2, and Q^3) were significant at 1% because the tabular t-value was 2.624, less than calculated for the three production parameters. The value of F* indicated the significance of the model as a whole, as the tabular F was 6.22 at the 1% significance level. The value of the coefficient of determination $R^{\backslash 2}$ indicated that more than 98% of the variance in the dependent variable is due to the variance in the independent variables. In comparison, less than 2% of the variables are attributed to other factors the model could not explain. It was clear from the cost function above that the signals of all parameters are consistent with the logic of the economic theory. It was necessary to conduct the standard tests for the model to be acceptable and reliable, the most important of which is the problem of multiple linear correlations that cannot be expected because the function is with one variable, the lack of self-correlation, and the instability of variance homogeneity. The two problems were detected according to the tests related to each problem, as follows: D.W test indicated that there was no serial autocorrelation because the value of d* was 1.559, which is greater than d_l (1.285) and smaller than d_u was 1.721 at a 5% significance level, which means: 1.285< d < 1.721 and 1.285< 1.559 < 1.721.

The Park test indicated that there is no problem of instability of variance homogeneity. It included estimating the error square regression equation as a dependent variable and the quantity of output (kg) as an independent variable. The function failed in all standard tests, and the relationship was found as follows: Lnei2 = 1.418+ 0.195LnQ2 (t (0.079) (1.385); R^2 = 0.14, F* = 3.96).

Determine the optimal behavior: The producer aims to reduce costs and maximize profits through the production process, and it comes through the following steps:

***Cost minimization*:** The farmer's aim in the short term is to reduce costs by achieving two conditions and the first derivative of average variable costs be equal to zero: d AVC /d Q = 0. The condition is sufficient for the positive second derivative of average variable costs: d^2 AVC / d Q^2 > 0. Through the following cost function, we can find the two conditions:

$$TC = 405.150 + 2918.5Q – 2.950Q^2 + 1.125Q^3$$

$$TVC = 2918.5Q – 2.950Q^2 + 1.125Q^3$$

$$AVC = \frac{TVC}{Q} = 2918.5 - 2.950Q + 1.125Q^2$$

To determine the optimal size for the quantity of production in which the average costs are minimized, it is necessary to apply the necessary condition for minimizing costs by taking its partial derivative relative to Q and equating it to zero: d AVC/d Q = -2.950+ 2.125Q = 0 and Q = 2.950 / 2.125 =1. 38. That is, the optimal volume of production that achieves economic efficiency is 1.38 kg/year, which is the quantity at which the average cost reduction is achieved and, at the same time, the best normal net profit is achieved. The actual production volume of the sample farms ranged between (1350-145250) kg/year. d^2 AVC / d Q^2 1. 38 > 0. It is the sufficient condition at which the lowest level of average costs is achieved.

***Profit maximization*:** To reach the volume of output that achieves the greatest profits, two conditions are necessary, and sufficient conditions for the profit function are Π = TR – TC. The necessary condition is that marginal revenue must equal marginal cost.

d Π /d Q = MR – MC = 0, and MR = MC

A sufficient condition is that the second derivative of the profit function must be negative: d_2 Π /d Q^2 < 0, and the necessary condition for the profit function would be:

$$\Pi = P.Q – TC$$

$$\Pi = P.Q - 405.150 - 2918.5Q + 2.950Q^2 - 1.125Q^3$$

$$d\,\Pi /d\,Q\ P -2918.5 +5.9Q - 3.375Q^2 = 0$$

Moreover, by compensation for the value of P = MP, the price of one kilogram of fish meat sold directly to the people, which is equal to an average of

3000 dinars\kg, through (personal interviews with owners of fields and slaughterhouses).

$3000 - 2918.5 + 5.9Q - 3.375Q^2 = 0$

$81.5 + 5.9Q - 3.375Q^2 = 0$

Applying the constitution makes it possible to calculate the amount of production that fulfills the necessary condition for profit maximization: Q = 5.865 tons/year. As for the fulfillment of the sufficient condition, the result of the second derivative will be negative, which is as follows:

$81.5 + 5.9Q - 3.375Q^2 = 0$

$d_2 \Pi / d Q^2 = 5.9 - 6.75Q$

$5.9 - 6.75 (5.865) = -33.688$

That is, the quantity that maximizes profit is 5.865 tons\year for the sample farms in the province of Babylon.

The optimal number of fish that achieves the amount of production that maximizes the above profit can be determined through the relationship between the number of fish entering the culture and the amount of production (kg) achieved through the application of the linear function of N = a + bQ, where N = The number of fish in the rearing ponds, Q = The amount of production achieved (kg) during breeding and a and b = constants. The result was as follows: N = 2529.26 + 0.572Q, t (2.627) (25.507), and $R^{\backslash 2} = 97$, F = 650.60, and D.W = 1.937. By substituting the production amounting to 5.865 kg/year in the above function, the optimal number of maximum profits was obtained as 5884.04 fish.

Conclusions

The corrected coefficient of determination reflected the explanatory power of the estimated model of the production function (0.77), meaning that 77% of the changes occurring in the dependent variable (production) are due to the change in the independent variables (production elements) in the estimation of the function, and 23% of the changes in the dependent variable are due to random factors, or due to the deletion of some variables from the estimated model. The sum of the partial elasticities of these variables, expressed in the total production elasticity of the estimated function, was 1.273, which is greater than the correct unit. This means that the amount of return to capacity increased. The optimal production volume that achieves economic efficiency was 1.38 kg/year, the quantity at which the average cost reduction is achieved while the best normal net profit is achieved. Therefore, the quantity that maximizes profit is 5.865 tons/year for the research sample farms in the Musayyib district. The study proved the opposite of the validity of the hypothesis developed within the methodology.

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