International Journal of Agriculture and Biosciences 2024 13(1): 30-33.
https://doi.org/10.47278/journal.ijab/2024.083

RESEARCH ARTICLE

eISSN: 2306-3599; pISSN: 2305-6622

Determinants of Fish Supply in Egypt: An Analysis Using Translog Error Correction Model

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ABSTRACT

This paper aims to measure the responsiveness of quantity supplied of fish in Egypt to changes in fish prices, aquaculture farm size, and fishmeal prices. Given the limited data availability, this paper uses time series data of three highly consumed fish species, namely Nile Perch, Nile Tilapia, and African Catfish in Egypt as a case study. The translog revenue function was developed in error correction format and used to estimate own-supply price elasticities and cross-supply price elasticities. The results showed that the own-price supply elasticities for fish in Egypt are price inelastic as expected due to biological factors associated with fish production that restrict quantity supplied to respond in proportion with fish prices increase. Interestingly, cross-price elasticities show that Nile perch and Nile Tilapia as well as Nile Perch and African Catfish are considered substitutes in production. However, African Catfish and Nile Tilapia are complements in production. Surprisingly, the aquaculture farm size was not a significant determinant of fish supply in Egypt in the short-run. Thus, the paper recommends that decision makers in Egypt need to develop a sustainable aquaculture production system that contributes significantly to fish supply not only in the short run but also in the long run.

Keywords: Fish Supply; Supply Elasticity; Error Correction Model.

Article History
Article # 23-545
Received: 08-Dec-2023
Revised: 10-Jan-2024
Accepted: 20-Jan-2024

INTRODUCTION

Fish is a significant part of Egyptian diet contributing to 38 percent of total animal protein and is a good source of micronutrients. Fish per capita consumption reached over 20 kg person per year in 2020 (Tran et al., 2022). The Egyptian fisheries sector is a major pillar in food security and economic and social development (Hassan et al., 2019). Over the last 20 years, fish consumption increased rapidly in Egypt, exceeding beef and poultry consumption resulting in an increase in the demand for domestic production of fish. Official statistics showed that wild fish catch rates reached the highest level in 2000 and hence further increase in fish production should come from aquaculture (Kaleem and Sabi, 2021). Aquaculture industry in Egypt is one of the largest in Africa with domestic production capacity reaching approximately more than 2 million tons in 2019, representing 80 per cent of total domestic fish supply (Kaleem and Sabi, 2021; Tran et al., 2022). The fish farms are located in different parts of Egypt including seas, lakes, fresh water of the Nile River and man-made artificial lakes such as Lake Nasser and Lake Al Raayan.

Despite the large area occupied by fisheries in Egypt, fish production is still low. The area suitable for fishing in the Red Sea is about 4.5 million feddan, and its beaches extend a thousand kilometers. The area suitable for fishing in the Mediterranean is about 6.8 million feddan, and its shores extend for a length of 1,000 km. Marine fisheries occupy the second rank among the sources of fish production in Egypt. The Mediterranean fisheries constitute about 11% of the total fish production. The area extending east of Alexandria to Port Said with a length of 360 km. It is distinguished by the wideness of its continental shelf (16-72 km), while the Gulf of Suez and the Red Sea produce about 8.81% of the total production annually. Natural lakes such as Bardawil, Lake Qarun, Port Fouad, Bitter Lakes, Burullus, Manzala, Idku and Mariout are among the most fertile and richest lakes in the world in terms of fish production. The mild climate and good natural conditions make these lakes among the most fertile natural lakes for important species such as mullet, toubar, bream, seabass, lute, snake and shrimp. Despite the availability of natural conditions that guarantee the abundant fish production, the production is affected by dense vegetation of reeds and factors such as water pollution. Industrial lakes such as

Cite this Article as: Al-Mahish M, Kinawy A, Ahmed H and Brizmohun R, 2024. Determinants of fish supply in egypt: an analysis using translog error correction model. International Journal of Agriculture and Biosciences 13(1): 30-33. https://doi.org/10.47278/journal.ijab/2024.083

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Lake Nasser, which has an area of about 1.2 feddan, is the largest body of fresh water. It includes the fishing areas of the High Dam Lake in Aswan, and it is also considered one of the largest artificial lakes in Africa. More than 50 species of fish belonging to 15 families live in those lakes. The most important of which are Nile tilapia, Galilean tilapia, Samos (egg shell), whitefish, Alraba, shawl, and Lepis. Fresh water includes the Nile River and its branches, canals and drains, with a total area of 178 thousand feddans (Elkholy, 2021).

The concept of supply response describes the responsiveness of quantity supply to changes in product prices as well as supply shifters. Past research work on the determination of factors affecting supply response relied on traditional statistical methods using unstable time series data, which ignored the unit root and the degree of cointegration between variables. The aim of this paper therefore is to test for cointegration and to estimate error correction model in order to examine fish supply response and identify the most important non-price factors influencing fish supply response in Egypt. The short-run and long-run own-price and cross-price elasticities for three types of fish are determined. The findings from this study support future price setting policies that are necessary to increase the supply of fish in the Egyptian market.

After a thorough analysis of prevailing theoretical frameworks to study agricultural supply response, error correcting models were found to be the most useful (Ocran and Biekpe, 2008). In an analysis of UK pig supply, Hallam and Zanoli (1993) stated that the error correction model is a valid model and is better than the partial adjustment model, both theoretically and empirically. Furthermore, several studies support the superiority of the error correction model approach, which does not restrict the short run movment of prices and quantities (McKay et al., 1999; Thiele, 2000). Using the error correction model applied to selected crops, the aggregate supply response in Algerian agriculture was price inelastic (Benmehaia, 2021). Ali et al. (2017) estimated maize supply response for the period 1980-2014 using the error correction model. The main factors influencing maize supply response are maize price, water, and sunflower prices. The elasticity values from the VECM are less than one implying that the supply of this crop could be described as inelastic.

This study uses the translog revenue function to investigate supply relationships. The study is a good addition to the agricultural economics literature because it shows how translog supply model can be estimated in error correction format. The approach used is common in fisheries and other industries that treat the input variables as given due to biological factors of production (Ocran and Biekpe, 2008).

MATERIALS & METHODS

Time series data used for this study consist of 21 observations from 1997 to 2017, obtained from the Egyptian Agency for Public Mobilization and Statistics. The main key variables used are fishmeal price, aquaculture farm size, quantity, and wholesale prices of three fish species, namely Nile Perch, Nile Tilapia, and African Catfish, domestically known as Bayat, Bulti, and Qaramit. Thus, the domestic names of those fish species will be used throughout the paper. Table 1 provides summary of key variables in logarithms.

Prices of all fish species are in Egyptian pounds, quantities are in kilogram, aquaculture farm size are in Feddan and were converted to hectare, and fishmeal prices are international fishmeal prices in US dollar converted to Egyptian pound.

The mentioned key variables data are time series data, and hence no stationarity are expected in the Egyptian fish data. Thus, we conducted KPSS stationarity test (results available upon request), and we reject the null hypothesis of stationarity for all the key variables. However, the results showed that all the data are stationary at the first deference. As a result, we proceed with cointegration test to reveal the existence of long-run relationship. For this purpose, we use Engle and Granger (1987) two step-cointegration method. This method relies on estimating two regression models. The first step is to estimate the following translog revenue function (Asche and Hannesson, 2002):

$$R(p,x) = a_0 + \sum_i b_i \ln p_i + \sum_i \sum_j c_{ij}\, lnp_i lnp_j + d_0 \ln x + \sum_i d_i\, lnp_i \ln x_i \quad (1)$$

If we take the partial derivatives of the revenue function (1) with respect to p_i, we obtain the following share equation:

$$S_i = b_i + \sum_j c_{ij}\, lnp_j + d_i \ln x_i \quad (2)$$

In order to comply with microeconomic theory, the following restrictions were imposed in the estimation:

Adding-up $\sum_i b_i = 1,\ \sum_i c_{ij} = 0,\ \sum_i d_i = 0$ (3)

Homogeneity $\sum_i c_{ij} = 0$ (4)

Symmetry $c_{ij} = c_{ji}$ (5)

Equation (2) was estimated using seemingly unrelated regression method with Qaramit equation excluded to avoid singularity in the variance-covariance matrix. The residuals of equation (2) were tested to reveal the existence of long-run relationship. The null hypothesis for this test is as below:

H_0: The series are not cointegrated (residuals are nonstationary).

The results of the cointegration test in Table 2 reject the null hypothesis that the residuals of Bayat and Bulti share equations have unit root. As a results, the series of Bayat and bulti share equations are cointegrated. In the second step, we estimate the following share equations of the translog revenue function in error correction format by adding the residuals from equation (1) as explanatory variable:

$$\Delta S_{i_t} = \beta_0 + \beta_{ij} \Delta\, lnp_{j_{t-1}} + \beta_i \Delta \ln x_t + \lambda \hat{e}_{it-1} + u_t \quad (6)$$

The short-run own supply price elasticities and cross supply price elasticities are calculated as below, respectively:

$$\varepsilon_{ii} = \frac{c_{ii}}{S_i} + S_j - 1 \quad (7)$$

$$\varepsilon_{ij} = \frac{c_{ij}}{S_i} + S_j \quad (8)$$

The long-run parameters are obtained by taking the negative of short-run parameters and dividing it on the error correction term parameter (Nzuma and Sarker, 2010). Once the long-run parameter is obtained, we use elasticities formulas (7) and (8) to obtain the long run elasticities.

Table 1: Summary Statistics

Variable	Minimum	Maximum	Mean	Standard Deviation
Log Bayat Price	2.045	3.812	2.719	0.552
Log Bulti Price	1.902	3.230	2.335	0.386
Log Qaramit Price	1.477	2.944	1.960	0.444
Log Bayat Quantity	1.971	3.689	2.659	0.554
Log Bulti Quantity	1.850	3.102	2.280	0.387
Log Qaramit Quantity	1.425	2.820	1.898	0.426
Log Aquaculture farm size	9.751	11.926	11.345	0.669
Log Fishmeal Price	0.326	2.221	1.619	0.830

Table 2: Cointegration Test

Equation	Critical value at 1% level	tau statistics	Decision
Residuals of Bayat Share equation	-3.96	-4.791	Reject null hypothesis
Residuals of Bulti Share equation	-3.96	-5.353	Reject null hypothesis

Table 3: Parameters of Translog Supply Error Correction Model

Bayat Share Equation	Parameters	Bulti Share Equation	Parameters
Intercept	0.001	Intercept	-0.0007
	(0.003)		(0.003)
Bayat Price	0.412***	Bayat Price	-0.277***
	(0.048)		(0.044)
Bulti Price	-0.277***	Bulti Price	0.287***
	(0.044)		(0.045)
Qaramit Price	-0.134***	Qaramit Price	-0.010
	(0.015)		(0.014)
Aquaculture farm size	0.004	Aquaculture farm size	-0.004
	(0.005)		(0.005)
Fishmeal Price	-0.009	Fishmeal Price	0.003
	(0.014)		(0.014)
Input Interaction Term	0.016	Input Interaction Term	-0.037
	(0.031)		(0.030)
Error Correction Term	-0.862***	Error Correction Term	-0.923***
	(0.191)		(0.179)
Adjusted R^2	0.82	Adjusted R^2	0.78

Note: *** indicate significance at the one percent level.

Table 4: Short-Run Supply Elasticities of Fish in Egypt

	Short-Run Elasticities		
	Bayad	Bulti	Qaramit
Bayat	0.305***	-0.201***	-0.104***
	(0.015)	(0.009)	(0.002)
Bulti	-0.458***	0.367***	0.091***
	(0.020)	(0.016)	(0.003)
Qaramit	-0.472***	0.201***	0.272***
	(0.007)	(0.007)	(0.004)
	Long-Run Elasticities		
Bayat	0.419	-0.278	-0.141
Bulti	-0.545	0.457	0.088
Qaramit	-0.642	0.194	0.413

Note: *** indicate significance at the one percent level.

RESULTS AND DISCUSSION

The results of the error correction model (6) are reported in Table 3. The share equation in (6) was augmented with interaction term between inputs because as aquaculture farm size increases, the price that will be paid on fishmeal is expected to increase.

The error correction terms are below one in absolute value and have the expected negative sign. The adjusted r-squared value show that the models' explanatory variables have explained 82% and 78% of the variation in the share equations of Bayat and Bulti, respectively.

Supply elasticities using equations (7) and (8) are estimated to assess how changes in fish prices affect quantity supply of fish in Egypt and characterize supply relationships among the selected fish species. The results of own supply elasticities and cross-supply elasticities in the short run and in the long run are reported in Table 4.

The results of the estimated own price supply elasticities have the expected positive sign and are inelastic. The long-run own price supply are larger as expected but still inelastic. This fact is attributed to biological and space factors associated with fish production. The own price supply elasticities indicate that a one percent increase in fish price increases fish supply in Egypt by approximately 0.3% in the short run and 0.4% in the long run. The cross-price elasticities show that Bayat and Bulti are considered substitute in production. Also, Bayat and Qaramit are substitute in production. However, Qaramit and Bulti are complements in production. Also, an increase in fishmeal prices has a negative effect of fish production in the short-run. However, this effect is economically significant but statistically insignificant. Surprisingly, the results indicate that the size of aquaculture farms is not a significant determinant of fish supply in the short-run.

Conclusion

The paper aimed to estimate fish supply elasticities in Egypt to help decision maker asses the responsiveness of quantity supply to changes in fish prices and changes in some inputs used fish production. The paper relied on the available annual time series data on the highest consumed fish species in Egypt (Nile Perch, Nile Tilapia, and African Catfish), domestically known as Bayat, Bulti and Qaramit. The results of the unit root test indicates that the data are first difference stationary. Thus, the paper examined the existence of long run relationship among the data through Engle and Granger two step method. The results of the Engle and Granger cointegration test indicate that the residuals are stationary and hence confirm the existence of long run relationship among supply shares, fish prices, and inputs of production. The paper used translog revenue function because it is compatible with microeconomic theory and it was estimated in error correction format. The results of the error correction model showed that the error correction parameters have the desired properties i.e., negative and less than one in absolute value. The estimated own supply elasticities are inelastic and have the correct positive sign indicating that fish supply in Egypt is not sensitive to price changes due to biological factors associated with fish production that prevents quantity supply to respond in proportion to changes in fish prices. Also, the cross-supply elasticities shows that Bayat and Qaramit are substitute in production. Moreover, Bayat and Bulti were found to be substitute in production. Conversely, Bulti and Qaramit were found to be complement in production. Surprisingly, the size of aquaculture farms was not a significant determinant of fish supply in Egypt in the short run. This indicates a strong need to develop a sustainable aquaculture production system that contributes significantly to supplying fish in the Egyptian market not only in the short-run but also in the long-run.

The main limitation of this paper is its reliance on only three of the highest consumed fish species in Egypt due to data availability. Thus, cross-price elasticities with other fish species beside those mentioned were not performed. We recommend future research to estimate supply elasticities of fish in Egypt using cross-sectional data covering the majority of fish species available in Egyptian markets.

Authors' Contributions

MA performed the statistical analysis and results interpretation, AQ wrote introduction and literature review, HA collected and organized the dataset, RB contributed to introduction, literature review, and proofreading.

Conflict of Interest

The authors declare no conflict of interest.

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