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Fish demand in Egypt: An analysis using Almost Ideal Demand System (AIDS)

MOHAMMED AL-MAHISH¹, HANADY ABD EL-RADI^{1,2} AND HAFSA MURSI^{1,3}

¹Department of Agribusiness and Consumer Science, College of Agriculture and Food Science, King Faisal University AlAhsa - 31982, Saudi Arabia

²Agricultural Economic Research Institute, Cairo, Egypt

³Department of Agricultural Economics, Ain Shams University, Egypt

e-mail: malmahish@kfu.edu.sa

ABSTRACT

Egypt has a vast water area of about 13 million acres, and the amount of fish production capacity reached 1.82 million t in 2017. This represents an increase by 6.8% compared with 2016; however, the increase in population growth rate has caused a shortage in meeting consumers' needs by about 15.47%. This research aims at estimating demand elasticity for Tilapia, Bayad, and Catfish in Egypt as they are the most important fish items prevalent in the Nile River. The results show that the demand for fish in Egypt is price inelastic. This means that price changes have a small impact on the quantity demanded of fish. In addition, tilapia was identified as a necessary fish item in Egypt. The Hicksian cross-price elasticities identified tilapia and bayad as substitutes for catfish.

Keywords: Almost Ideal Demand System, Demand elasticity, Fish demand

Fish is one of the most important sources of animal protein, and consists of nearly 18.5% protein in wet weight, compared to 16.8% for beef, 13.6% for eggs and 3.8% for milk. Fish protein is easily digested and absorbed due to high level of essential amino acids and unsaturated essential fatty acids (AOAD, 2005). Both natural and cultivated fish resources are considered as main sources of animal protein.

Egypt has a vast water area of about 13 million acres including marine fisheries, lake fisheries, Nile River fisheries, canals, valleys and 300 thousand acres of fish farms in 2017. The production from fish farms had contributed about 79% to the total fish production in 2017. On the other hand, domestic fish production had increased from 889.3 thousand t in 2005 to about 1.82 million t in 2017 and the self-sufficiency had increased from 82.3% in 2005 to about 85.6% in 2017. Among the most important fish items that are endemic in the Nile River are tilapia (*Oreochromis* spp.), bayad (*Bagrus bajad*) and catfish (Siluriformes). The share of these items in Nile River fisheries production was about 62% of all fish production in 2017 (CAPMS, 2018).

Egypt is one of the 36 countries that suffered from malnutrition in 2015 (UNICEF, 2019). The problem of malnutrition had occurred due to the lack of local production to meet consumers' needs. An individual needs about 20 g of animal protein per day or 7.3 kg per year;

this can be achieved if an individual consumes about 33 kg of beef or 45 kg of fish in order to effectively combat malnutrition (FAO, 2014). Also, the increase in population growth rate led to a shortage in meeting consumers' needs in red meat, poultry meat, or fish meat by about 6.51, 23.5 and 23.54% respectively (CAPMS, 2018). Fisheries and aquaculture sectors can help confront the problem of undernourishment. Demand elasticities of food items are useful in analysing how policy changes affect food markets or economic welfare. Therefore, the present study was undertaken with an aim to measure fish demand in Egypt.

Almost Ideal Demand System (AIDS) was used to analyse the fish and meat demand in Egypt by several authors (El-Batran and Ismail, 2002; Alboghdady and Alashry, 2010; El-Batran, 2012; Khalel and Mohamed, 2015; Amin and Elfatah's, 2016; Ahmed and Mekkawy, 2016; Mashaal, 2018). Nasser (2015) estimated consumption function of fish in Egypt, from 2002 to 2013, using multiple-regression and found that fish consumption is affected negatively by individual income and positively by number of population. Soliman and Hamed (2014) estimated demand elasticity of fresh fish and other animal meat for both rural and urban consumers in Egypt based on the 2009 household budget survey.

Hegazy and Hakem (2011) indicated that there is an upward trend, over time, in retail price of fish with

an annual change rate of 0.16 LE kg⁻¹ from 1990-2009 and fish retail price increased from 6.4 LE kg⁻¹ in 1990 up to 13.2 LE kg⁻¹ in 2009. The literature review shows a research gap of economic studies focusing on fish demand in Egypt, especially. Therefore, this paper contributes to the literature by focusing on the demand for the most popular fish species in Egypt since most of the works published analysed the demand for fish in Egypt as part of other meat items.

The available data is annual data from 1997 to 2017. The data was collected from the Egyptian Agency for Public Mobilisation and Statistics, represents quantity and retail prices in Egyptian pound of tilapia (locally known as *bulti*), bayad and catfish (locally known as *qaramit*). The first step in the analysis was to conduct a unit root test. Table 1 shows the results of the Augmented Dicky Fuller test.

The results of the Augmented Dicky Fuller test clearly shows that the variables are not stationary at p<0.05. However, all the variables are difference-stationary, especially when the drift term or a trend is included. Most of the variables that were not significant at p<0.05 were found to be significant at the p<0.1. This fact should be taken into account prior to selecting the demand model. As a result, the optimal model to estimate in case of non-stationary data, is either the error corrected AIDS model (Karagiannis *et al.*, 2000; Nzuma and Sarker, 2010; Singh *et al.*, 2011; Rathnayaka *et al.*, 2018) or differential demand models such as Rotterdam Demand model, CBS demand model, NBR demand model, or the first-difference linear AIDS (FDLAIDS). Thus, for the current study, FDLAIDS has been selected since it has almost the same independent variables as in the Rotterdam model and the same dependent variable as the NBR model. The FDLAIDS model is expressed below (Neves, 1994):

$$dw_i = \beta_i (d \ln x - d \ln P) + \sum_j y_{ij} d \ln p_j \dots\dots\dots(1)$$

where w_i is the budget share for good i, p_j is the price for good j, x is the total expenditure and lnP is Stone price index.

However, Okrent and Alston (2011) stated that the estimating form of the FALAIDS model is expressed as follows:

$$dw_i = \beta_i d \ln Q + \sum_{j=1}^n y_{ij} d \ln p_j \dots\dots\dots(2)$$

where, dlnQ = + $\sum_{i=1}^3 w_i d \ln q_i$ is the Divisa volume index and q_i is the quantity of fish item i.

Moreover, the microeconomic theory requires the FDLAIDS model to comply with the following parametric assumptions:

$$\text{Homogeneity requires } \sum_{j=1}^n y_{ij} = 0 \dots\dots\dots(a)$$

$$\text{Symmetry requires } y_{ij} = y_{ji} \dots\dots\dots(b)$$

$$\text{Adding-up } \sum_{i=1}^n y_{ij} = 0 \sum_{i=1}^n \beta_i = 0 \dots\dots\dots(c)$$

The Marshallian price demand elasticities and expenditure elasticities for the FDLAIDS model has been calculated as given below:

$$\text{Marshallian Price elasticity: } n_{ij} = \frac{y_{ij} - \beta_i w_j}{w_j} - \delta_{ij} \dots\dots\dots(3)$$

$$\text{Expenditure /income elasticity: } n_i = \frac{\beta_i}{w_i} \dots\dots\dots(4)$$

where δ is kronecker delta which equals 1 when i=j and zero otherwise. On the other hand, the Hicksian elasticities are computed using the Slutsky equation.

$$\epsilon_{ij} = n_{ij} + w_j n_i \dots\dots\dots(5)$$

As stated by Barnett and Seck (2008), the AIDS model allows more flexibility in testing the negative semi-definiteness of the Slutsky matrix compared to the Rotterdam model. Thus, the Slutsky matrix is negative semi-definite for the case of the three Egyptian fish items, if the following conditions are met:

$$\epsilon_{11} < 0 \text{ and } \det \begin{bmatrix} \epsilon_{11} & \epsilon_{12} \\ \epsilon_{21} & \epsilon_{22} \end{bmatrix} > 0 \dots\dots\dots(6)$$

Bewley, Young and Colman (1987) indicated that the single R² is inappropriate for the case of system of equations; further, they suggest an equation that provides the required R².

$$R_L^2 = 1 - \frac{1}{1+LR/[T(n-1)]} \dots\dots\dots(7)$$

Table 1. Augmented Dicky Fuller Test

Series Variable	I(0)			I(1)		
	No Trend	Trend	Drift	No Trend	Trend	Drift
Bayad Retail Price	1.621	-2.203	1.621	-3.848*	-4.599*	-3.848*
Tilapia Retail Price	2.553	-1.257	2.553	-2.357*	-4.055*	-2.357*
Catfish Retail Price	3.318	0.474	3.318	-2.509	-4.262*	-2.509*
Bayad Retail Budget Share	-1.507	-1.507	-1.507	-4.937*	-5.351*	-4.937*
Tilapia Retail Budget Share	-1.974	-1.769	-1.974*	-4.819*	5.337*	-4.819*
Catfish Retail Budget Share	-1.019	-2.256	-1.019	-4.201*	-4.091*	-4.201*

*Represents rejection of the null hypothesis of a unit root at p<0.05.

where T is the total number of observations, n is the number of food items, R^2_L is the alternative R^2 that is suggested for the case of systems of equation, LR is twice the difference between the log-likelihood of the model and the log-likelihood of the dependent variables on the constant term.

Table 2 reveals that on average, bayad constitutes almost 58% of Egyptian consumers' budget, followed by tilapia and catfish with 28 and 14%, respectively.

The FDLAIDS model, as specified in equation (2) was estimated using the full information maximum likelihood (FIML) since it is insensitive to the deleted equation from the system (Barten, 1969; Brown, Lee and Seale, 1995). Moreover, symmetry and homogeneity restrictions were imposed in the estimation and the adding-up condition is maintained in the model. The model was estimated with the catfish equation dropped to avoid singularity in the

variance-covariance matrix. Table 3 shows the estimated parameters. The estimated Marshallian elasticities are given in Table 4 and the estimated Hicksian elasticities are given in Table 5.

The Marshallian own-price elasticities have the correct negative sign. This result shows that the demand for fish in Egypt is price inelastic, which confirms the fact that demands for food in general is price inelastic. Also, the Hicksian own-price elasticities are inelastic with negative sign. Moreover, income elasticities shows that tilapia is a necessary good. On the other hand, bayad and catfish have unitary income elasticities which indicates that their preference relation is homothetic (Chipman, 1974). The Marshallian cross-price elasticities show that all the fish items are cross-complements. The Hicksian cross-price elasticities show that tilapia and catfish consumption are net substitutes for catfish consumption.

Table 2. Descriptive statistics of key variables used in our model

Variable	Average	Standard Deviation	Minimum	Maximum
Bayad Retail Budget Share (w1)	0.584	0.067	0.457	0.651
Tilapia Retail Budget Share (w2)	0.277	0.045	0.228	0.376
Catfish Retail Budget Share (w3)	0.139	0.026	0.102	0.182
Bayad Retail Price (RP1)	19.647	10.467	9.580	47.890
Tilapia Retail Price (RP2)	13.473	7.279	7.220	33.000
Catfish Retail Price (RP3)	9.426	4.089	5.790	21.000

Table 3. Parameter estimates

Equation	Retail Model				
	Intercept	γ_{i1}	γ_{i2}	γ_{i3}	β_i
dw_1	0.004 (0.003)	0.395*** (0.071)	-0.253*** (0.052)	-0.142*** (0.029)	0.007 (0.058)
dw_2	-0.003 (0.004)		0.260*** (0.048)	-0.008 (0.039)	-0.008 (0.058)
dw_3				0.149	0.001

Note: R^2 :0.603***, **,* denote significance level at the 1, 5 and 10% levels. Figures in parenthesis indicate standard errors.

Table 4. Estimated Marshallian (Uncompensated) Elasticities

Fish Item	Marshallian (Uncompensated) Elasticities			
	Income	Bayad	Tilapia	Catfish
Bayad	1.011*** (0.081)	-0.612*** (0.081)	-0.256*** (0.065)	-0.143*** (0.032)
Tilapia	0.971*** (0.209)	-0.236* (0.118)	-0.732*** (0.073)	-0.146 (0.058)
Catfish	1.010*** (0.115)	-0.148* (0.083)	-0.010 (0.057)	-0.852*** (0.026)

***, **, * denote significance level at the 1, 5 and 10% levels. Standard errors in brackets.

Table 5. Estimated Hicksian (Compensated) Elasticities

Fish item	Retail model		
	Bayad	Tilapia	Catfish
Bayad	-0.016 (0.089)	0.034 (0.076)	-0.007 (0.089)
Tilapia	-0.319** (0.113)	-0.481*** (0.161)	-0.106 (0.165)
Catfish	0.446*** (0.045)	0.279*** (0.082)	-0.703*** (0.123)

***, **, * denote significance level at the 1, 5 and 10% levels. Figures in parenthesis indicate standard errors.

The demand for tilapia, bayad and catfish in Egypt was estimated using the first-difference AIDS model. The results indicated that the demand for tilapia, bayad and catfish is price inelastic. The expenditure elasticities show that the preference relation for bayad and catfish is homothetic and tilapia is a necessity fish item. The estimated Marshallian cross-price elasticity shows that tilapia, bayad and catfish are gross complements. Whereas, Hicksian price elasticity shows that bayad is a net complement for tilapia. Conversely, tilapia and bayad were found as net substitutes for catfish. The results of this paper are beneficial to researchers and policy makers who are interested in evaluating the impact of exogenous variables on fish demand. The impact of these variables on fish prices and quantity in Egypt can be examined by utilising the estimated elasticities.

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