Demand Analysis for Fish in Tunisia: An Empirical Approach

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Abstract- The aim of this paper is to analyze and determine the factors influencing fish demand in Tunisia during the 1975-2000 period. A Box-Cox transformation is used to select the appropriate functional form between linear and double-log models. Results indicate that the double-log form fits better the data and is used for the empirical analysis. Calculated elasticities from static model show that fish demand is price-inelastic and that fish can be considered as a normal good. However, the dynamic analysis using Houthakker-Taylor model suggests that fish consumption in Tunisia depends on consumers psychological-buying habits. Finally, the values of the short and the long-run elasticities indicate that per capita consumption of fish in Tunisia is growing, but at a slowing rate.

Key-words: Fish demand, Box-Cox transformation, double-log model, Tunisia.

JEL: D12, C22.

I. Introduction

Food demand analysis is a subject of great interest given its importance for food policy and marketing decisions. Policymakers, now more than ever, need estimates of social welfare and market adjustment indicators under alternative policies in order to understand the nature of food demand and market structure. In this context, and despite the importance of the fish sector to the economy, the market structure for fish products in Tunisia is not well understood. The effects of price changes and other socio-economic variables on market demand have not been researched. It's not until recently that a couple of food demand studies have been undertaken in Tunisia providing insights into the effect of conventional factors, i.e., price and income, on food demand (Dhehibi and Gil, 1999; Ben Kaabia et *al*., 2000; Laajimi and Dhehibi, 2001; Laajimi et *al.*, 2003). Dealing with food consumption, Dhehibi and Gil (2003) showed that, in Tunisia, daily per capita calorie intake has substantially increased in the last 25 years, following an annual growth rate of 1.6%. The proportion of calories coming from animal products is still very low and hardly reaches 10% of total calorie intake, due to the null consumption of pork and the relatively high price of meat and fish products in comparison to other food products.

According to the National Statistics Institute of Tunisia, food expenditure represents a high percentage of total family expenditure. In 2000, Tunisian households allocated 38% of their budget to food products and the consumption of animal products (meat, fish, milk and dairy, and eggs) has increased during the period 1975-2000. In 1975, this food group represented around 20% of total food expenditure while in 2000 this percentage reached 38%. It is noteworthy that the importance of this percentage is due to increased fish budget share into animal food group. The relative importance of fish increased from 22% of total animal food expenditure in 1975 to 31% in 2000. On another note, the fish sector in Tunisia is an important contributor to the economy in terms of protein production, employment and income generation. In the year 2000, this sector produced around one million tons of fish, accounting for 8% of agricultural gross product. Fish production, which grew at an annual rate of 6.46% during the 1975-2000 period, has neared the relatively rapid growth of 6.86% in the overall agricultural sector. Fish products, which are also important as a source of foreign exchange, accounted for 15.36% of agricultural exports.

Given the above, the objective of this paper is to analyse and determine the factors influencing fish demand in Tunisia. Furthermore, this paper presents empirical evidence about fish consumption behavior in the country. In this sense, and to the authors' knowledge, this paper constitutes the first attempt to empirically estimate fish demand elasticities in Tunisia. The rest of paper is organized as follows. The next section briefly describes the theoretical model of fish demand in Tunisia. Section 3 is devoted to a description of the econometric framework. Empirical results are summarized in section 4. Finally, some concluding remarks and policy implications are outlined in section 5.

II. Theoretical framework

According to Deaton and Muellbauer (1989), the composite commodity theorem holds that groups of fish products can be treated as a single good because the prices of different species and products of fish tend to move together. Cheng and Capps (1988) showed that the aggregation of food demand analysis can generate substantive information such as own and cross price, and income elasticities, and other dynamic aspects of consumer market behaviour. In microeconomic theory, the behavioural axioms of the individual consumer are such that he makes his choice of a commodity bundle in order to maximize his satisfaction subject to a budget constraint.

Let $q_1, q_2, ..., q_n$ be the quantities from a commodity bundle (fish spices, in this case) with $p_1, p_2, ..., p_n$ the correspondent prices and Y the consumer income. The consumer maximizes his utility function U expressed as:

$$U = U(q_1, q_2, ..., q_n, Z) \quad (1)$$

Subject to a budget constraint:

$$p_1 q_1 + p_2 q_2 + ... + p_n q_n \leq Y \quad (2)$$

A solution of utility maximization gives the *ith* demand equation in a demand system of n goods as:

$$Q = F_i(P_{it}, Z_{it}, Y_{it}) \qquad i = 1,..., N \qquad t = 1,..., T \quad (3)$$

Where;

Q_{it} = per capita consumption of the *ith* commodity;
P_{it} = price of the *ith* commodity;
Z_{it} = variables affecting fish demand in Tunisia (assumed exogenous);
Y_{it} = per capita income; and
t = time period; $t = 1,..., T$.

According to George and King (1971) and Kusumastanto and Jolly (1997), the demand system specified in (3) may be incorrect in several ways. First, past consumption levels may affect future consumption patterns. Second, shift in consumer's tastes may affect the slope and the position of the demand curve. Third, time lags and logistic delays in catch and distribution may affect availability and hence consumer allegiance for fish products especially when they are consumed fresh. Thus, the static model needs to be revised. In this context and to overcome his limitation, an ad hoc approach has been used to add lagged dependent variables to the ordinary demand function. To this end, the static model can be extended in two approaches: the Houthakker-Taylor State Adjustment Model or the Partial Adjustment Model proposed by Nerlove (1958).

The Houthakker-Taylor approach is based on the fact that past behaviour influences current decisions. However, past behaviour is embodied in the current value of a state variable, which involves habits formed by past consumption. The model is based on two equations.

The first equation, the demand function, in which income, price, and the state of stock variable are exogenous variables and a stock identity, is expressed as:

$$Q_i^j(t) = \alpha + \beta S_i^j(t) + \gamma X^j(t) + \eta I^j(t) + \varepsilon_i \quad (4)$$

Where;

$Q_i^j(t)$: demand for food *i* at time *t* by the *jth* consumer;

$S_i^j(t)$: the state variable for good *i* at time *t*; the *jth* consumer's physical inventory and psychological stock and habits associated with good *i*;

$X^j(t)$: income at time *t* of the *jth* consumer;

$I^j(t)$: price at time *t* of the *jth* consumer; and

ε_i : a random disturbance term.

Then, if $\beta>0$, it indicates an inventory-adjustment effect, and if $\beta<0$, it indicates a habit-formation effect.

The second equation, a stock (physical or psychological) depreciation equation, is expressed as:

$$\Gamma_i^j(t) = Q_i^j(t) - \delta S_i^j(t) \quad (5)$$

Where; $\Gamma_i^j(t)$ is the continuous change in stock around time t, $Q_i^j(t)$ denotes the quantities purchased of good *i* by the *jth* consumer's at time *t*, and $\delta S_i^j(t)$ is depreciation of the stock. The parameter δ is a constant depreciation rate. In the case of habit formation, the parameter δ measure the speed at which the habit dissipates or wears off and simultaneously reflects the rate of physical depreciation.

Sexauer (1977) and Kusumastanto and Jolly (1997) argued that the Houthakker-Taylor specification is the first dynamic demand model which encompasses both inventory effects and the influence of habits arising from past consumption on current demand. The dynamic mechanism in this model is the state variables, which embody the effects of past consumption on present consumer expenditure.

The Partial Adjustment Model (Nerlove, 1958) assumes that the economic agent partially adjusts to the equilibrium values determined by static maximum (or minimum) conditions. In the case of the consumer, the equilibrium values are the quantities defined by the static demand equation. Phlips (1990) indicates that the adjustment is partial because the presence of inertia, earlier commitments or lack of information. The equation defining the equilibrium values is defined as follows:

$$Q_t^* = a + b X_t + \varepsilon_t \quad (6)$$

Where Q_t^* represents the desired values and X_t the variables which determine these values. The current value of Q is supposed to adjust to its equilibrium value according to:

$$Q_t - Q_{t-1} = \xi\left(Q_t^* - Q_{t-1}\right) \quad 0< \xi <1 \quad (7)$$

Where ξ, the adjustment coefficient, measures the proportion by which the difference between the equilibrium value Q_t^* and the realized value Q_{t-1} is reduced during period t. When ξ=1, the current value of Q is equal to its equilibrium value ($Q_t = Q_{t-1}$), the adjustment is total and immediate, indicating that the dynamic model is the same as the static model. The model implies that the adjustment coefficient ξ is 0< ξ <1. On combining equations (6) and (7), the distributed lag model based on geometric distribution is reconstructed, as follows:

$$Q_t = \xi a + \xi b\, X_t + (1-\xi)\, Q_{t-1} + \xi\, \varepsilon_t \quad (8)$$

The static coefficient b appears as the long-run coefficient, while the product ξb measures the short-run reaction. However, b is the long-run marginal propensity to consume, and ξb is the short run propensity to consume because equation (6) is considered as a consumption function.

III. Econometric issues

III.1. Data

Data come from different sources. Information about quantities is obtained from the Food Balance Sheets published by the Ministry of Agriculture in Tunisia. Annual price series for each commodity are obtained from the *Bulletin Mensuel de Statistique* (Monthly Statistical Bulletin) published by the *Institut National de la Statistique* (National Statistics Institute, INS). The following products have been considered: 1) fish[2]; 2) beef; 3) lamb; 4) poultry; and 5) eggs. The sample period covers yearly data from 1975 to 2000.

Table 1. Descriptive statistic of variables used in the demand function for fish in Tunisia, 1975-2000.

Variables	Notation	Unit of Measurement*	Mean	Standard deviation
Fish consumption	QF	Kg/cap/yr	8.8545	1.336
P_{Fish}	PF	DT/kg	1.7186	1.003
P_{Beef}	PB	DT/kg	2.5677	1.658
P_{Mutton}	PM	DT/kg	3.1662	1.896
$P_{Poultry}$	PP	DT/kg	1.0185	0.4249
P_{Eggs}	PE	DT/kg	0.7706	0.2828
Income	Y	DT/cap/yr	1218.0	183.189

Notes:

1.: *: All monetary units were converted to real Tunisian Dinar by dividing nominal values with the corresponding consumer price index figures (1990=100).

2.: 1€ = 1.55 DT.

III.2. Model specification

[2] For this group, a weighted average of different types of fish is used to determine the aggregated price and quantity.

Economic theory does not provide criteria to choose *ex ante* among functional forms. Thus, the criteria in choosing between alternative functional forms takes into account consistently with theory ease to estimate and fit the data well. In this study, two specifications (linear and double logarithmic) are used to estimate fish demand consumption in Tunisia. The decision to choose which one to retain is made once the two demand models have been estimated and theoretical consistency and statistical inferences are checked.

The statistical models for fish demand in Tunisia are defined as follows:

The linear model:

$$Q_{Ft} = \alpha_0 + \alpha_1 P_{Ft} + \alpha_2 P_{Bt} + \alpha_3 P_{Mt} + \alpha_4 P_{Pt} + \alpha_5 P_{Et} + \alpha_6 Y_t + \varepsilon_t \quad (9)$$

The double logarithmic model

$$LnQ_{Ft} = \alpha_0 + \alpha_1 LnP_{Ft} + \alpha_2 LnP_{Bt} + \alpha_3 LnP_{Mt} + \alpha_4 LnP_{Pt} + \alpha_5 LnP_{Et} + \alpha_6 LnY_t + \varepsilon_t \quad (10)$$

Where Q_{Ft} denotes annual per capita fish consumption (kg); P_{Ft}, P_{Bt}, P_{Mt}, P_{Pt}, P_{Et} are real average price of fish, beef, mutton, poultry and eggs, respectively (DT/Kg). Y_t is the real annual per capita income (DT).

In the first step, the two empirical models are estimated using Generalized Least Squares (GLS). In order to get the appropriate specification, the Box-Cox transformation procedure is then applied (Maddala, 1977; Johnston, 1984; and, Green, 1990).

In the second step, the Houthakker-Taylor model is used to estimate habit formation and inventory adjustment effects. The unobservable state variables can be eliminated by substitution, which leads to the following demand equation:

$$Q_{Ft} = L_0 + L_1 Q_{Ft-1} + L_2 X_t + L_3 X_{t-1} + L_4 \Delta P_{Ft} + L_5 P_{Ft-1} + \varepsilon_t \quad (11)$$

The estimated coefficients (the Ls) are composite terms from witch the structural parameters may be derived (Houthakker and Taylor, 1970; Sexauer, 1977; and, Kusumastanto and Jolly, 1997); the Δ indicates that the variable is in first difference. From equation (11), the value of the coefficient β can be estimated using the following formula:

$$\beta = \frac{2(L_1 - 1)}{L_1 + 1} + \frac{L_3}{L_2 - 0.5 L_3} \quad (12)$$

Given the importance of elasticities for policy analysis and the fact that no distinction can be made between the long and the short run in the Houthakker-Taylor model, the partial adjustment model is used to estimate these parameters.

The partial adjustment specification used for short-run model is:

$$Q_{Ft} = \tau A + \tau B P_{Ft} + \tau C P_{Bt} + \tau D P_{Mt} + \tau E P_{Pt} + \tau F P_{Et} + \tau G Y_t + (1-\tau) Q_{Ft-1} + \varepsilon_t \quad (13)$$

Or;

$$Q_{Ft} = \psi_0 + \psi_1 P_{Ft} + \psi_2 P_{Bt} + \psi_3 P_{Mt} + \psi_4 P_{Pt} + \psi_5 P_{Et} + \psi_6 Y_t + \psi_7 Q_{Ft-1} + \varepsilon_t \quad (14)$$

Where; $\tau A=\psi_0$; $\tau B=\psi_1$; $\tau C=\psi_2$; $\tau D=\psi_3$; $\tau E=\psi_4$; $\tau F=\psi_5$; $\tau G=\psi_6$; and $(1-\tau)=\psi_7$. The long-run demand coefficients can be estimated by dividing ψ_0, ………, ψ_7 by one minus the coefficient of lagged demand ($1-\psi_7$) recognized as the "adjustment coefficient".

IV. Empirical results

According to the procedure for estimation of both models, the adjusted R^2 for the linear model is 65%, while the R^2 for the double-log model is 75%. Hypothesis testing for overall significance of the regression using the F-test indicated that there is a significant relationship between per capita consumption of fish and the explanatory variables for both models. The individual t-test shows that most partial regressions in linear and double-log models are statistically different from zero (Table 2). Moreover, the Goldfeld-Quandt test was used and no heteroscedasticity is detected in both models. Since the results of hypotheses testing were satisfied, both models appeared to be acceptable.

Table 2. Estimated coefficients of linear and double-log models and elasticities of the demand for fish in Tunisia, 1975-2000.

Variables	Linear		Double-log coefficients
	Coefficients	Elasticities	
Intercept	1.94**		-1.26
P_{Fish}	-1.97*	-0.38	-0.18**
P_{Beef}	-1.55**	-0.45	-0.59**
P_{Mutton}	1.35*	0.48	0.41*
$P_{Poultry}$	2.17	0.25	0.22*
P_{Eggs}	3.24*	0.28	0.18
Income	0.0043*	0.59	0.51**
F ratio	216.23**		245.013**
R^2	0.65		0.75

Note: *, **, *** significant at the 10%, 5%, and 1% level, respectively.

Given the above, the methodology of Box-Cox regression analysis was used to choose the model that fits better the data. Based on the smaller residual variance, it was decided that the double-log function is more appropriate than the linear model. The mean square error and χ^2, are presented in table 3. Hence, the double-log model is retained to analyze fish demand in Tunisia.

Table 3. The value of mean square error and χ^2 obtained from Box-Cox regression.

	MSE	χ^2
Linear	0.00053	3.65**
Double-log	0.00021	0.12

Note: **: significant at the 5% level.

Table 2 presents short-run elasticities, evaluated at sample mean. The parameters satisfy economic expectation in that the sign of own-price elasticity of fish demand is negative; indicating that if the real price of fish increases the average per capita consumption of fish decreases. The estimated own-price elasticity of demand is –0.18 implying that fish demand is inelastic. That is, if the real price of fish increases by 1%, the quantity of fish demanded will decrease by 0.18%.

The cross-price elasticity of fish with respect to price of beef is –0.59, indicating beef is a good complementary product for fish. If the real price of fish increases by 1%, the quantity demanded for beef will decrease by 0.59%, while, the quantity for mutton, poultry and eggs will increase by 0.41%, 0.22% and 0.18%; respectively, indicating that these products are good substitutes for fish. Beef is not a good substitute for fish. This can be explained by the relative high price of beef compared to poultry and eggs and the nature of mutton product in terms of divisibility for low-income consumers. The income elasticity of demand for fish is 0.51. The value is less than unity, indicating an income inelastic demand for fish, which can be considered as a normal good from the expenditure point of view. With a rate of growth in per capita income of 1.8% per year during 1995-2000, the average consumption of fish per capita is expected to grow by 0.9% per year.

In the dynamic model analysis, all variables in the Houthakker-Taylor model are significant at the 10% level. The empirical results concerning the variables β (inventory-habit coefficient),γ (short-run marginal propensity to consume) and γ’ (long-run marginal propensity to consume), are presented in table 4. The value of β=0.823 indicates a habit formation effects which means that past purchases influenced present purchases and that fish is a non durable good. This value explains that fish consumption in Tunisia is related to a psychological fish-buying habit. This result supports the observed phenomenon of higher consumption of fish in costal areas and high income consumers.

Table 4. Estimated coefficients of the Houthakker-Taylor model of the demand for fish in Tunisia, 1975-2000.

Variables	Coefficients	t-ratios
Intercept	-0.134*	-1.75
Q_{FT-1}	0.727**	3.570
X_t	0.338*	1.676
X_{t-1}	-0.230*	-1.7415
ΔP_{Ft}	-0.132*	-1.877
P_{Ft-1}	-0.048*	-1.820
F ratio	320.54**	
R^2	0.79	
β	0.823	
γ	0.338	
γ’	1.23	
δ	1.32	

Note: *, **, *** significant at the 10%, 5%, and 1% level, respectively.

The depreciation rate (δ) shows that the rate at which this habit is depreciated. With a δ value of 1.32 this habit is eroding quite rapidly. The short-run propensity to consume is relatively low (0.33), which is consistent with lower growth of fish consumption. Hence, in the long-run the marginal propensity to consume is higher (1.23) which means promising growth in fish consumption for the future. The expected increase in consumption in the future is not only because of habit, but is also due to the increase in per capita income.

The analysis of the results derived from the partial adjustment model serves to capture the dynamic adjustment process between the consumer's current demand response and long-run equilibrium or desired demand. The application of this model also provides a convenient method of deriving the long-run demand parameter and elasticities based on the estimated coefficients of the short-run demand equation. Results from table 5 show that the level of statistical significance and explained variance of the partial adjustment model is high in most of the regressions.

Table 5. Estimated coefficients of the partial adjustment model of the demand for fish in Tunisia, 1975-2000.

Variables	Linear		Double-log	
	Short-run	Long-run	Short-run	Long-run
Intercept	1.201	2.89	1.19	3.20
P_{Fish}	-2.19**	-5.27	-0.37**	-0.98
P_{Beef}	-0.29	-0.71	-0.09	-0.25
P_{Mutton}	0.48	1.17	0.22*	0.59
$P_{Poultry}$	1.94*	4.65	0.21*	0.55
P_{Eeggs}	2.48	5.99	0.10	0.23
Y	0.001	0.003	0.273	0.73
$LagQ_F$	0.58**	0.58	0.63**	0.63
F ratio	235.17**		476.05**	
R^2	0.74		0.87	

Note: *, **, *** significant at the 10%, 5%, and 1% level, respectively.

The coefficient of adjustment (ξ) on logarithmic transformation is 0.374. This value indicates that there is a slow adjustment process between the consumer's current and desired long-run demand. Given the relatively slow adjustment process, the difference between the short-run and long-run elasticities can be justified (Table 6). In general, it is shown that the long-run elasticities are about third as large as the short-run elasticities, which means that the demand for fish in Tunisia is increasing at a decreasing rate.

Table 6. Estimated price and income elasticities (short-run and long-run) of demand for fish in Tunisia, 1975-2000, obtained from the partial adjustment model.

Elasticities						
			Cross-price			
	Own-price	Income	Beef	Mutton	Poultry	Eggs
Double-log						
(a) Short-run	-0.367	0.273	-0.092	0.222	0.205	0.102
(b) Long-run	-0.981	0.733	-0.246	0.593	0.548	0.272

V. Concluding remarks and policy implication

The objective of this paper is to analyse fish demand in Tunisia and the factors influencing it during the period 1975-2000.

Results indicate that there is a significant relationship between per capita consumption of fish with the price of fish, beef, mutton and poultry. Calculated demand elasticities indicate that the own-price elasticity of fish demand stands at –0.18, meaning that the quantity of fish was price inelastic. By looking at this value, it seems that producers are facing an inelastic demand function for fish on the domestic market. However, an increased investment in the fish sector should be carefully monitored taking into account that an increase in supply is likely the result of a fall in fish revenue.

Another factor considered important to increasing fish consumption is per capita income. In this regard, the value of the income elasticity of fish demand is 0.51, indicating that fish is a normal good and that an increase in income will contribute significantly to increasing fish consumption in Tunisia. As regards to cross-price elasticities, mutton, poultry and eggs are considered good substitutes for fish, while beef is a complementary good.

The value of the inventory-habit coefficient β is positive, implying that consumption of fish in Tunisia depends on psychological food-buying habits, which means that past purchases influence present purchases. An implication of this result is to encourage necessary to encourage domestic consumers to eat more fish using techniques such as advertising, especially in urban areas, to influence their preferences towards fish consumption.

The dynamic analysis showed sizeable differences between the values of γ - short-run marginal propensity to consume and γ' - long-run marginal propensity to consume. The magnitude of the long-run marginal propensity to consume indicates that the demand for fish in Tunisia will increase. Furthermore, the low value of adjustment coefficient is an indicator that per capita consumption of fish in Tunisia is increasing but at a decreasing rate. The increase in income and a positive change in habit or preference towards fish are important factors to increasing fish consumption in Tunisia.

Results obtained in this study apply to the sample period and the group of fish products considered. The use of cross section combined with yearly data and improvement of data collection at a more disaggregated level (more fish categories) could provide more definitive answers to understanding the key demand factors for fish products in Tunisia. Finally, it would be more interesting from a policy-maker point of view to analyze the influence of socio-demographic characteristics of consumers on fish demand. Further model development including these variables is very important for supporting government decisions.

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