

DEMAND FOR RED MEAT, POULTRY AND FISH IN TUNISIA: A GENERALIZED ADDILOG DEMAND SYSTEM

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Food demand analysis is a subject of great interest given its implications for food policy and marketing decisions.

Policymakers now need estimates of social welfare and market adjustments under alternative policies in order to select the most beneficial alternatives.

However, only a few studies have been carried out in Tunisia on food demand (Merhaban, 1992; Fuglie, 1994; Lahiani, 1996, among others). This paper in this sense aims to provide a starting point for discussion an applied demand models in Tunisia.

The estimation of food consumption parameters using dynamic demand systems has gained increasing support as consumer behaviour is not static. Previous research has shown that lagged values of some of the variables involved exert an important influence on current consumption. In some cases, economic studies of food demand often show that consumers do not adjust instantaneously to changes in prices, income and other determinants of demand. Psychological causes of consumer inertia, which include habit formation and persistence, institutional factors, such as inventory adjustment and intertemporally separate budgeting, contribute to observed lagged effects in consumer's decision making (Brown, 1952; Houthakker and Taylor, 1970; Blundell, 1988; Kesavan *et al.*, 1993). It seems that the assumption of consumer's instantaneous adjustment is very restrictive. A standard procedure for incorporating dynamic processes is to assume

ABSTRACT

This paper provides an analysis of red meat, poultry and fish demand in Tunisia using multi-equational econometric systems with time series data. Different dynamic versions of the GADS (Generalized Addilog Demand System) are specified and estimated. Results from functional form tests indicate that the model in Error Correction Form fits better the data and is used for red meat and fish demand analysis. Results shown that demand is responsive to prices and total expenditure on meat and fish. Calculated elasticities, based on the estimated model with both homogeneity and symmetry imposed, indicate that both poultry and mutton and goat meats are revealed as necessity goods. Substitution effects are mainly present showing the strong competition among the several types of meats. Comparison with other studies has showed the benefits from using desaggregated data when estimating demand relations.

RÉSUMÉ

Dans ce travail on décrit l'évolution de la consommation des viandes et des poissons en Tunisie. Pour analyser la structure de la demande de ces produits, divers versions dynamiques du modèle GADS (Generalized Addilog Demand System) ont été spécifiés, en se basant sur des données de séries chronologiques. Le résultat de la sélection entre les différentes formes fonctionnelles a permis de retenir le modèle GADS sous la forme de Modèle de Correction de l'Erreur (ECM). Les résultats de l'estimation ont montré que la demande de viandes et de poissons répond aux variations de prix, aussi bien aux dépenses totales dans ce groupe de produits. A l'exception de la viande de volaille, qui est révélé comme étant un bien de première nécessité, les viandes ovines ont des élasticités plus proches de l'unité et sont donc considérées comme étant des biens normaux, tandis que la viande bovine et les poissons sont considérés comme des biens de luxe. Les élasticités prix directes ont montré que toutes les catégories des viandes et des poissons ont une demande élastique.

an adjustment process, with focus only on short-run dynamics. An alternative for identifying the appropriate model specification for demand is to develop a relatively general framework incorporating the alternative hypotheses related to dynamic adjustment and allowing for direct estimation of long run coefficients (Anderson and Blundell, 1983a). The purpose of this paper is to present empirical evidence about red meat, poultry and fish consumption behaviour in Tunisia. Several static and dynamic versions of the Generalized Addilog Demand System are estimated using Tunisian aggregate annual time series data from 1973 to 1994. The applicability of restrictions suggested from demand theory are tested and expenditure and Marshallian and Hicksian price

elasticities are computed. This application of the GADS model to this group of food demand in Tunisia is especially attractive because there is no empirical evidence available about meat and fish demand in that country. The paper is organised as follows. First, some descriptive statistics on the evolution of meat and fish consumption in Tunisia are presented. In section 2 the Generalized Addilog Demand System is described, its theoretical properties are shown and how to introduce dynamics is discussed. Next, the estimation method and results are presented. Finally, in Section 5 some concluding remarks are outlined.

THE EVOLUTION OF MEAT AND FISH CONSUMPTION IN TUNISIA

The adequacy of food supplies remains a serious problem in many developing countries. Inadequate food supplies usually cause nutritional problems and might

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result in political and social instability. Food shortages can be eliminated either by increasing food imports or through expansion of domestic food production. Whatever the case, knowledge of food demand, in particular the demand for meat and fish products, are essential for both improved development planning and policy decision making. Since the early 80s the eating habits of Tunisians have changed significantly. The main characteristics of this change are well known and can be summarised as an important increase in the demand for products of animal origin during this period. Animal origin calorie intake has

continuously grown to represent nearly 10% of the total calorie intake in 1994 (FAO, 1995). In terms of macronutrients, this change means a small increase in the quantity of proteins due to the substitution of vegetal origin proteins consumed with those from animal origin. Animal origin products are now an important part of the Tunisian diet. According to the statistics of the Tunisian Ministry of Agriculture, in 1973 the average intake of meat products was 14,5 kilos per person and year. In 1994 this figure had risen to 17.3 kilos per person and year. Tunisia is the only Maghrebian country where this increase has been detected. Nevertheless, the level of meat consumption in Tunisia is lower than that of other Mediterranean countries. We can also highlight the fact that this increase was more important during the 1973-1987 period, while during the period 1987-1994 meat and fish consumption have stabilized. **Figure 1** shows that in the last three decades beef and mouton have been the most important sources of animal food. Fish consumption has decreased during this period but this decrease has been more than compensated by a spectacular growth in poultry consumption. Regarding meat products, it is also noticeable the increase in mouton consumption. Talking now about expenditure levels, it is expected that as welfare increases, households increase their food expenditure less than proportionally (Engel's law). This trend is also observed in the case of Tunisia. In 1975 food expenditure was 41% of total expenditure while in 1995 this figure had decreased to 38% of total expenditure (INS, 1995). The only food products that has experienced an increase in their relative importance on total food expenditure are

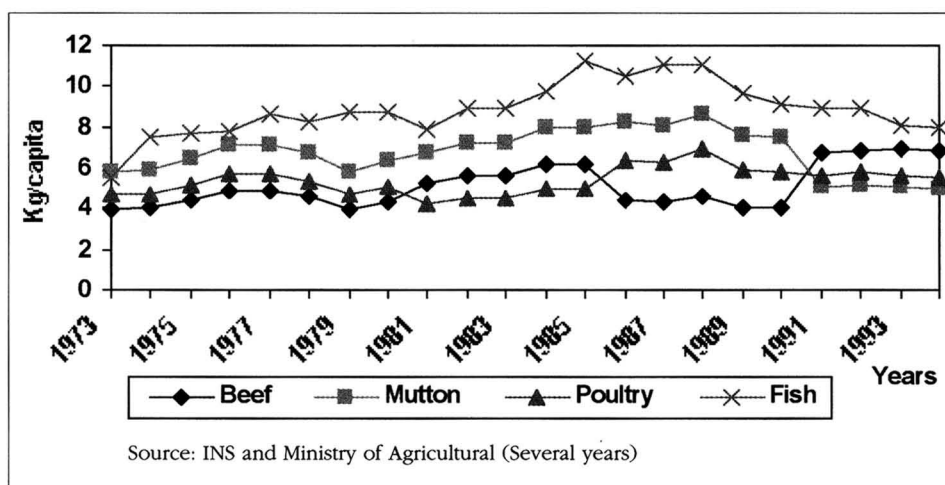


Figure 1 - Quantities of red meat, poultry and fish consumed in Tunisia.

precisely, meat and fish products. If the expenditure structure for the different types of meats is analyzed (**figure 2**) it can be observed that it has been stable for the last twenty years even though cyclical oscillations can be observed, specially for beef and fish, which can be explained by the lack of developed distribution channels. Mouton expenditure is quite stable due to the existing cultural and religious traditions in Tunisia. Regarding prices (**figure 3**), since 1985, there has been an important increase in absolute terms, although, in relative terms, no important variations are observed. The most expensive products, on average, are lamb and beef whose prices are very close to each other. Fish prices are lower as data represent a weighted average of different types of fish, some of them with a traditional low price (sardines, etc.). Poultry prices have been always lower than the rest. Self-consumption of animal products, which had steadily increased up to the early 70s, has shown a constant decrease during the last two decades. It represented around 30% of total consumption in 1975 while in 1995 hardly arrived to a 20% (INS, 1995).

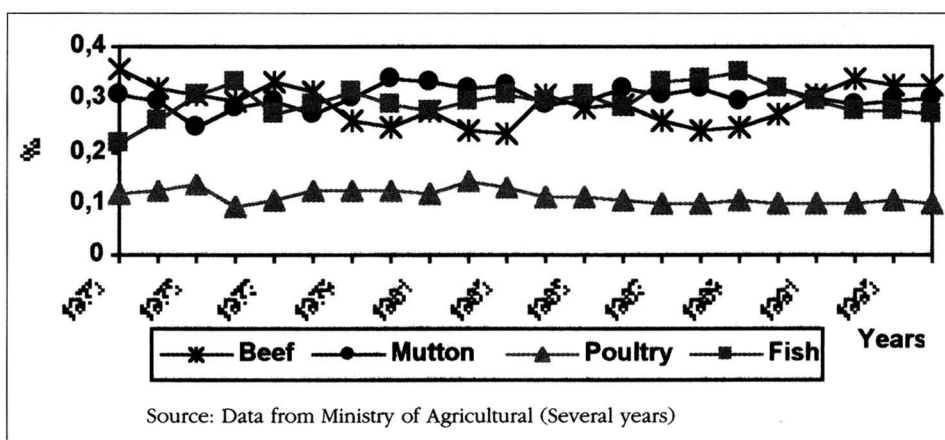


Figure 2 - Budget Shares of red meat, poultry and fish consumed in Tunisia.

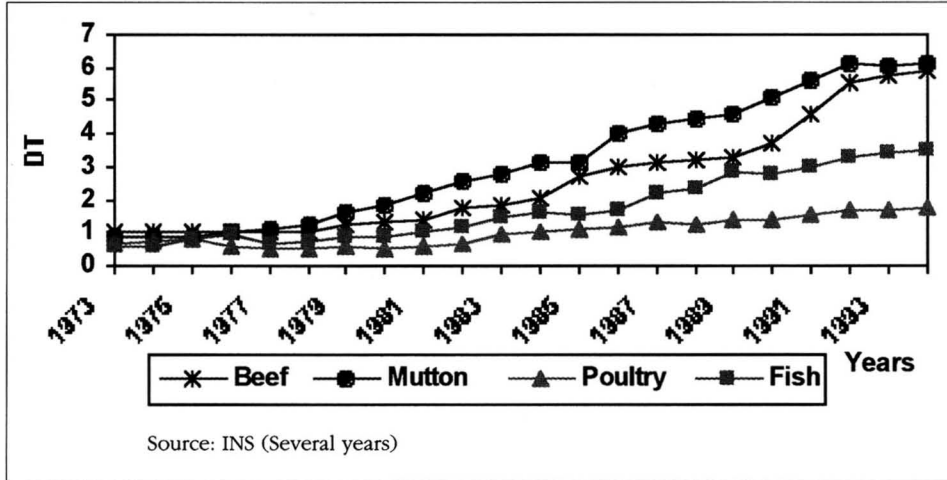


Figure 3 - Prices of red meat, poultry and fish consumed in Tunisia.

METHODOLOGY

1. Generalized Addilog Demand System

The Generalized Addilog Demand System (GADS), developed by Theil (1969), is used in this paper to analyze the demand for red meat, poultry and fish in Tunisia. The system used here guarantees the non-negativity property and satisfies the aggregation restriction. The GADS model has been used in the last few years to describe the food expenditure structure in several western countries. Among others, it can be pointed out Bewley and Young (1987), to study the demand for meat in Great Britain; Gaiha and Young (1989), analyzing the demand for cereals and starchy products in developing countries; and Angulo *et al.* (1997) to study food convergence patterns within the European Union. The GADS model assumes that budget shares have the following structure:

$$w_{it} = \frac{e^{\delta_{it}}}{\sum_k e^{\delta_{kt}}} \quad (1)$$

where $\delta_i = \alpha_i + \beta_i \ln y_t + \sum_{j=1}^n \gamma_{ij} \ln p_{jt}$, and w_{it} is the budget share of the i -th good in period t ($t = 1, 2, \dots, T$), y_t is total meat and fish expenditure in period t ($t = 1, 2, \dots, T$); and p_{jt} is the price of the j -th good in period t ($t = 1, 2, \dots, T$).

Model (1) is difficult to estimate and, then, some transformations have to be made for estimation purposes. After those transformations (Bewley and Young, 1987), the following linear version of the GADS model can be derived which allows us to estimate it and to impose the homogeneity and symmetry restrictions:

$$\begin{aligned} \overline{w_{it}} &= \log (q_{it}/w_t^+) = a_i + \theta_i \log \\ (y_t/p_t^+) &+ \sum_{j=1}^n \pi_{ij} \log p_{jt} \end{aligned} \quad (2)$$

where $\overline{w_{it}}$ is the average budget share of the i -th good in period t ($t = 1, 2, \dots, T$); q_{it} is the quantity of the i -th good in period t ($t = 1, 2, \dots, T$); and

$$\log w_t^+ \text{ is } \sum_{j=1}^n \overline{w_j} \log p_{jt}$$

$$\log p_t^+ = \sum_{j=1}^n \overline{w_j} \log p_j$$

$$a_i = \overline{w_i} (\alpha_i - \sum_{j=1}^n \overline{w_j} \alpha_j) \quad \theta_i = \overline{w_i} \eta_i$$

$$\pi_{ij} = \overline{w_i} E_{ij} + \overline{w_i} \overline{w_j} \eta_j$$

being θ_i and π_{ij} the marginal budget shares and the Slutsky parameters, respectively, calculated at the mean budget shares.

The adding-up restriction implies that $\sum_{i=1}^n a_i = 0$, $\sum_{i=1}^n \theta_i = 1$, $\sum_{i=1}^n \pi_{ij} = 0$, and homogeneity and symmetry that

$$\sum_{j=1}^n \pi_{ij} = 0 \text{ and } \pi_{ij} = \pi_{ji}, \text{ respectively. Furthermore, the}$$

estimated average budget shares are positive and sum to unity.

Elasticities can be calculated from the estimated parameters as follows:

– Total expenditure: $\eta_i = \theta_i / w_i$

– Uncompensated price elasticities: $E_{ij} = (\pi_{ij} - w_i w_j \eta_i) / w_i$

Finally, compensated price elasticities are obtained from the Slutsky equations.

2. Dynamics and the long-run structure

Consumers do not adjust instantaneously to changes in prices and income. In fact, consumers, very often, react with some delay to price and income changes and as a consequence, adjustments towards new equilibrium are spread over several time periods. Brown (1952), Houthakker and Taylor (1970), and Philips (1983) tried to explain the source of these lags. First, consumers adjust slowly to changes in income and prices because there is some inertia in their reaction to these changes. The inertia is due to consumer's memories of the previous levels of income and prices. Secondly, a lagged effect on consumer reaction is generated due to some habit persistence which is inherent to food consumption as a result of past behaviour. Thus, habits and inertia exerts a stabilising effect on current consumption. However, in food consumption it is difficult to say which reason is more important as both seem to be present. The dynamic behaviour has been incorporated in

demand analysis in different ways: (1) modifying the constant term α_i in the demand system equations (Alessie and Kapteyn, 1991; Assarson, 1991); (2) estimating the model in first or four differences (Eales and Unnevehr (1988) and Moschini and Meilke (1989), in USA; Reynolds and Goodard (1991), in Canada); and (3) using a more general dynamic framework following Anderson and Blundell (1983b). This approach has been used in Burton and Young (1992), for Great Britain, and in Kesavan *et al.* (1993) for USA and it is the approach that has been used in the present study.

This general dynamic specification is able to incorporate different dynamic structures and allows for direct estimation of long-run coefficients. It is assumed that changes in endogenous variables are responses to anticipate and unanticipated changes in exogenous variables needed to maintain a long-run relationship between them. This general dynamic demand framework will be applied to the GADS model defined in (1). Following Anderson and Blundell (1983a), the general dynamic GADS model can be defined as follows:

$$B(L)\bar{w}_i \ln\left(\frac{q_{it}}{w_{it}^+}\right) = \Gamma(L) \left[a_i + \theta_i \ln\left(\frac{y_t}{P_t^+}\right) + \sum_{j=1}^n \pi_{ij} \ln p_{jt} \right] + \epsilon_t \quad (3)$$

where; $B(L) = I - B_1L - B_2L^2 - B_3L^3 - \dots - B_pL^p$; $\Gamma(L) = \Gamma_0 - \Gamma_1L - \Gamma_2L^2 - \Gamma_3L^3 - \dots - \Gamma_qL^q$, being L the lag operator.

The above transformation yields a general dynamic model difficult to estimate with a short time series data. Therefore, usually a first-order autoregressive distributed lag model is assumed ($p = 1$ and $q = 1$), assumption that has been also considered in this paper as sample period is short. Then, making the necessary transformations, model (3) can be expressed in an error correction form:

$$\Delta \left[\bar{w}_i \ln\left(\frac{q_{it}}{w_{it}^+}\right) \right] = \varphi_i \Delta \ln\left(\frac{y_t}{P_t^+}\right) + \sum_{j=1}^n \mu_{ij} \Delta \ln p_{jt} - \sum_{j=1}^{n-1} \lambda_{ij} \left[\bar{w}_j \ln\left(\frac{q_{i,t-1}}{w_{i,t-1}^+}\right) - a_j - \theta_j \ln\left(\frac{y_{t-1}}{P_{t-1}^+}\right) - \sum_{k=1}^n \pi_{jk} \ln p_{k,t-1} \right] + \epsilon_t \quad (4)$$

where θ_j and π_{jk} are the long-run income and prices affects; λ_{ij} are the adjustment coefficients; and φ_i and μ_{ij} are the short-run income and prices effects.

Again, due to the short sample period considered, the model defined in (4) is still too general for estimation purposes. To avoid having to calculate a large number of

parameters a diagonal adjustment process has been assumed, that is, $\lambda_{ij} = 0$ if $i \neq j$ and $\lambda_{ij} = \lambda$ if $i = j$. Hence, all equations in the system adjust in the same way to deviations to the long-run equilibrium. The adding-up restriction is guaranteed. Model (4) is transformed into:

$$\Delta \left[\bar{w}_i \ln\left(\frac{q_{it}}{w_{it}^+}\right) \right] = \varphi_i \Delta \ln\left(\frac{y_t}{P_t^+}\right) + \sum_{j=1}^n \mu_{ij} \Delta \ln p_{jt} - \lambda \left[\bar{w}_i \ln\left(\frac{q_{i,t-1}}{w_{i,t-1}^+}\right) - a_i - \theta_i \ln\left(\frac{y_{t-1}}{P_{t-1}^+}\right) - \sum_{j=1}^n \pi_{ij} \ln p_{j,t-1} \right] + \epsilon_t \quad (5)$$

Expression (5) nests other dynamic specifications such as, partial adjustment, first order autoregressive and the static model. By imposing some parameter restrictions it is possible to test the appropriate dynamic specification. If $\varphi_i = \lambda \theta_i$, and $\mu_{ij} = \lambda \pi_{ij}$ are imposed, the specification (5) yields the partial adjustment model:

$$\Delta \bar{w}_i \ln\left(\frac{q_{it}}{w_{it}^+}\right) = \left[a_i + \theta_i \ln\left(\frac{y_t}{P_t^+}\right) + \sum_{j=1}^n \pi_{ij} \ln p_{jt} - \bar{w}_i \ln\left(\frac{q_{i,t-1}}{w_{i,t-1}^+}\right) \right] \lambda + \epsilon_t \quad (6)$$

If $\varphi_i = \theta_i$, and $\mu_{ij} = \pi_{ij}$, the result is a first order autoregressive model:

$$\bar{w}_i \ln\left(\frac{q_{it}}{w_{it}^+}\right) = a_i \lambda + \theta_i \ln\left(\frac{y_t}{P_t^+}\right) + \sum_{j=1}^n \pi_{ij} \ln p_{jt} + (1 - \lambda) \left[\bar{w}_i \ln\left(\frac{q_{i,t-1}}{w_{i,t-1}^+}\right) - \theta_i \ln\left(\frac{y_{t-1}}{P_{t-1}^+}\right) - \sum_{j=1}^n \pi_{ij} \ln p_{j,t-1} \right] + \epsilon_t \quad (7)$$

Finally, if $\lambda = 1$ is imposed in (7), we get the static model (2).

ESTIMATION AND RESULTS

Data come from different sources. Per capita consumption expenditures are obtained from a study conducted by the Ministry of Agriculture. Data on quantities have been estimated using the "Food Balance Sheet" approach, with requires the existence of statistical data on production, imports and exports, and changes in stocks in order to determine the quantity available for human consumption. Yearly data are used covering the 1973-1994 period. Finally, annual price series for each commodity have been found in the *Bulletin Mensuel de Statistique* (Monthly Statistical Bulletin) published by the *In-*

stitut National de la Statistique (National Statistics Institute, or INS) and have been deflated by the consumer price index taken from the same source. Since the GADS model adds up, the sum of residuals across the equations is equal to zero ($\sum U_i = 0$), and the variance and covariance matrix of residuals is singular. To overcome this problem, one equation must be arbitrarily deleted. In this paper, the fish equation was deleted. The system has been estimated using the Full Information Maximum Likelihood (FIML) procedure. Weak separability was also imposed, that is, it has been assumed that expenditure in meat and fish is separable from other expenditures. This approach has been extensively used in the literature on meat and fish demand. Under this assumption, elasticities has to be carefully interpreted. The first step in our analysis has been to estimate the GADS model in a diagonal error correction form and to test the theoretical restrictions (homogeneity and symmetry). Results from such tests are given in **table 1**. As it can be observed, it is not possible to reject both restrictions at the 1% level of significance. We have adopted the 1% level due to the short sample available and because such tests are asymptotic. As a second step, several tests have been performed in order to determine the appropriate dynamic specification with homogeneity and symmetry imposed. A Likelihood Ratio test has been used to discriminate among the alternative models (Partial Adjustment, First Order Autoregressive, and Static) (**table 2**). Results indicate that the hypothesis of error correction model is not rejected, at 1 percent level of significance. The Error Correction form means that actual consumption needs to be adjusted in the short-run towards a long-run equilibrium since there seems to exist strong deviations between the short-run and the long-run consumer behaviour. In order to assess the overall goodness of fit of the system, a system-wide measure has been used which has a similar interpretation than the single-equation measure. The system R^2 compares the current model with a benchmark, which in this case is a model with intercepts only (Bewley and Young, 1987). It has the following expression:

$$R^2 = 1 - \frac{1}{1 + 2 \times [LL_u - LL_b] \times \frac{1}{T \times (N - 1)}} \quad (8)$$

where LL_u is the log likelihood of the unrestricted model, LL_b is the log likelihood of the base model (only intercepts), T is the number of observations, and N is the number of equations in the system. The R^2 value for the GADS model was 0.63, indicating that the model performs relatively well in terms of explanatory power as dependent variable is in first differences. The estimated coefficients with homogeneity and symmetry imposed are presented in **table 3**. All income and own price pa-

Table 1 Testing theoretical restrictions.

	Log L	LR	D.F	Critical value	
				5%	1%
Unrestricted	201.48	—	—	—	—
Homogeneity	198.99	4.98	3	7.81	11.34
Homogeneity and symmetry	194.50	13.96	6	12.59	16.81

Note: Log L: Log of Likelihood Functions; LR: Likelihood Ratio; D.F: Degrees of Freedom.

Table 2 Testing for alternative dynamic specifications.

	Log L	LR	D.F	Critical value	
				5%	1%
ECM	194.50	—	—	—	—
Autoregressive	189.48	10.04	1	3.84	6.63
Partial Adjustment	187.02	14.96	1	3.84	6.63
Static	186.47	16.06	2	5.99	9.21

Note: Log L: Log of Likelihood Functions; LR: Likelihood Ratio; D.F: Degrees of Freedom.

rameters are statistically significant at the 5% level. The λ parameter, which measures the speed of adjustment to changes in the long-run equilibrium, is highly significant, indicating that it is an important determinant in food consumer demand. The most interesting economic parameters for policy analysis are elasticities. **Table 4** summarises the estimated long- and short-run meat and fish demand elasticities computed at sample means based on the estimated parameters. In general, the estimated price and expenditure elasticities for all groups are quite reasonable. The own price elasticities (Marshallian and Hicksian elasticities) have the expected negative signs and are lower than unity indicating that demand is inelastic in all cases. Beef meat and fish can be considered as luxury goods, in relation to total meat and fish expenditure, as they have expenditure elasticities greater than one. Then, an increase in total meat and fish expenditure induces more than proportional increases in beef and fish consumption. On the other hand, lamb and poultry are necessities (expenditure elasticity less than one). It is important to notice the low responsiveness of poultry to in-

Table 3 Maximum likelihood parameters of the error correction GADS model with homogeneity and symmetry restrictions imposed.

Parameters	Beef	Mutton and Goat	Poultry	Fish
α_i	-0.218 (-0.64)	0.19 (0.97)	0.30 (2.16)	-0.27 (-1.05)
β_i	0.35 (3.36)	0.23 (3.79)	-0.96E-02 (-0.211)	0.41 (4.88)
γ_{11}	-0.07 (-1.35)	—	—	—
γ_{12}	0.029 (1.10)	-0.08 (-3.91)	—	—
γ_{13}	0.032 (2.00)	0.028 (2.35)	-0.068 (-6.92)	—
γ_{14}	0.82E-02 (0.16)	0.026 (1.25)	0.74E-02 (0.64)	-0.042 (-1.06)
λ	0.68 (5.34)	0.68 (5.34)	0.68 (5.34)	0.68 (5.34)

Note: t-ratios are in parenthesis.

Table 4 Long and short run expenditure and compensated price elasticities at mean values.

Elasticities	Beef	Mutton and Goat	Poultry	Fish
Expenditure	1.24* (0.91*)	0.78* (0.60*)	-0.08 (0.43*)	1.39* (1.69*)
Beef	-0.60* (-0.35*)	0.14* (-0.003)	0.11* (0.08*)	0.028 (0.002)
Mutton and Goat	0.098* (-0.002)	-0.51* (-0.47*)	0.084* (0.15*)	0.087* (0.14*)
Poultry	0.28* (0.22*)	0.25* (0.40*)	-0.60* (-0.74*)	0.066 (0.06)
Fish	0.027 (0.002)	0.089* (0.15*)	0.025* (0.022)	-0.55* (-0.67*)

Note: Italic figures are Marshallian own price elasticities; Short-run elasticities are in parenthesis;
*denotes significance at the 5% level.

come changes. If we consider now the compensated cross-price elasticities it can be observed that in the long-run all products are close substitutes. The most interesting relationships that can be pointed out are, between beef and poultry and between mutton and goat and poultry. In general, meat and fish consumption seems to be more responsive to own prices rather than to cross-prices changes. Finally, it is possible to point out that in the short-run responses are less significant than in the long-run. Only the own-price elasticity for poultry and the fish income elasticity are higher in the short-run.

CONCLUSIONS

Elasticity estimates are critical parameters in developing countries for policy analysis. Elasticities used in past-applied models in Tunisia have frequently been based on subjective judgement and have not been supported by quantitative and empirical evidence. The objective of this paper was to estimate Tunisian demand elasticities for beef, mutton, poultry, and fish, using a quantitative approach. Several static and dynamic versions of the GADS model were specified and estimated. Results have indicated that a GADS model in error correction form fitted better the data.

This specification indicates that it is needed to differentiate between the long-run and the short-run consumer behaviour in Tunisia. Calculated demand elasticities have indicated that beef and fish are considered as luxury products, while mutton and goat are normal goods (as expenditure in meat and fish increases, Tunisian consumers tend to buy relatively more beef and fish and less mutton and goat and poultry). As regards to price elasticities, all meat and fish categories are price inelastic.

Cross-price effects are low, but with substitutability prevailing. Results obtained in this study only apply to the sample period and groups of products considered (meat and fish). Further research is needed both at a more aggregated level (total food) and at a more disaggregated level (more fish categories). Finally, it would be more interesting from a policy maker point of view

to analyse the influence of calorie and protein intake on food demand as well as to assess the influence of sociodemographic characteristics of consumers. However, data needed to carry out such cross section studies are not yet available. Future availability could be of extraordinary importance to carry out studies of food demand in Tunisia. ●

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