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Demand analysis for dairy products in Tunisia: An econometric approach

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SUMMARY – The present paper analyses the demand for dairy products in Tunisia using the CBS model for the 1973-2002 period. Expenditure elasticities indicate that butter and cheese can be considered luxury goods. In the other hand, milk is considered as a normal good. However, expenditure elasticity of yogurt suggest it a necessity in the Tunisian diet. Result from Marshallian elasticities indicates that the resulting demand for dairy products is inelastic. Cross-price elasticities show strongest competitive relationship between cheese and milk, in one hand, and between butter and yogurt, from another. Finally, a quality change index (QCI) of dairy products consumption is constructed and decomposed into real expenditure effect, substitution effect, trend effect and residual effect. Results show that there is a moderate increase in quality in consumption of dairy products by 0.068% per year during the total period. However, the quality changes of dairy products consumption in Tunisia decrease since 1988.

Keywords: Dairy products consumption, CBS model, price and expenditure elasticities, Quality Change Index (QCI), Tunisia.

RESUME *– "Analyse de la demande de produits laitiers en Tunisie : Une approche économétrique". Le présent travail a pour objectif l'analyse de la demande des produits laitiers en Tunisie en se basant sur le système de demande CBS pour la période 1973-2002. Les valeurs des élasticités dépenses du beurre et du fromage dépassent l'unité et sont considérées donc comme des biens de luxe. Le lait est révélé comme un bien normal. Cependant, le yaourt est considéré comme un bien de première nécessité dans la diète tunisienne. Les résultats de recherche obtenus à partir des élasticités marshalliennes ont montré que la demande de produits laitiers est inélastique. Les élasticités croisées ont suggéré une forte relation de substitution entre le fromage et le lait frais, d'une part, et entre le beurre et le yaourt, d'autre part. Finalement, un Indice de Changement de la Qualité (QCI) des produits laitiers a été construit. Dans un deuxième temps, cet indice a été décomposé en un effet réel des dépenses, un effet de substitution, un effet tendance et un effet résiduel. Les résultats de cette décomposition ont montré une légère augmentation dans la qualité de consommation des produits laitiers durant l'ensemble de la période, avec une moyenne annuelle de l'ordre de 0,068%. Toutefois, cet indice décroît depuis 1988.*

Mots-clés : *Consommation des produits laitiers, modèle d'analyse CBS, élasticités prix et dépenses, Indice de Changement de la Qualité (ICQ), Tunisie.*

Introduction

Since 1986, the Tunisian economy fell into recession. In response, the government designed and implemented a structural adjustment program which affected the subsidies system. One of the sectors, Tunisian dairy sector, was strongly supported by government intervention in the form of price policies and subsidies. However, several government policies were instituted which influenced the dairy sector. Prices controls were put in at every level of milk production and marketing (production, processing and consumption). Moreover, a national strategy of development of the sector was implemented in 1994 in order to reduce imports and reach self-sufficiency in dairy products at 2000. This policy was based on integrated policies of production, collection and transformation. This led to a high expansion in milk production (167 millions litters in 1970, to 934 million litters, in 2001).

Accordingly, milk and dairy consumption sector was affected by these phenomena. Thus, the evolution of the dairy consumption structure in recent years shows that the pattern of dairy consumption has been constantly changing (Khaldi and Naili, 2001; Laajimi *et al.*, 2003; Dhehibi and Gil, 2003). Making available information on expected dairy products demand will facilitate policy makers to estimates social welfare and market adjustments under alternative policies (prices policy, subsidies policy, etc.) in order to identify the improvements that be made to achieve self sufficiency and avoid the disequilibrium between demand and supply.

Given the above, the objective of this paper was to estimate and determine the factors influencing the demand for dairy products in Tunisia using a quantitative approach. In order to reach these objective the paper is organized as follows. In the next section, we discuss the structure and evolution of dairy food consumption in Tunisia. The methodological framework is specified in the third section. First a description of the demand model employed is developed. Second, data and estimation procedure are explained. Finally, a quality change index (QCI) is constructed from the CBS model estimation and decomposed. Section 4 describes the empirical results and discussions. The final section summarizes major findings and conclusions.

Structure of dairy consumption in Tunisia

In Tunisia, daily per capita calorie intake has substantially increased in the last 30 years at an annual growth rate of 1.6% (2278 kcal, in 1970, and 3238 kcal, in 2002). On the other hand, the proportion of calories coming from animal products still is very low and hardly reaches 10.7% of total calorie intake due to the high consumption of poultry and less consumption of other meats with relatively higher prices in comparison to other food products.

According to the statistics of INS (National Statistic Institute), the consumption of animal products has substantially increased along the period 1975-2000. In 1975, both food groups represented around 10.4% of total food expenditure while in 2000 this percentage reached 12.2%. It is noteworthy that the importance of this percentage is due to increased milk and milk products budget share into animal food group. The relative importance of dairy and dairy products increased from 2.8% to 4.2% in total food products indicating the importance of dairy products into Tunisian diet.

Milk and dairy products consumption in Tunisia has experienced several changes, not only in terms of expenditure as indicated above but also in terms of quantities. The quantity of consumed milk was increased by 9.63% over the last three decades, despite of slow tendency to decreasing since 1985. This aspect, jointly to a decrease in the real expenditure, indicates a decrease in relative prices. Among the products that showed a straight increase in the quantity consumed, there are cheese (600%) and butter (57.14%). After a decrease in 1995, yogurt recovered an increasing trend (5%, over the 1995-2000 periods). However, it can be observed that dairy consumption is irregular and non-uniform, especially for yogurt and cheese. The observed fluctuations between 1980 and 2000 are still linked to the agricultural production level, particularly during the final of 90's, characterized by difficult farm harvests. Moreover, we can notice, in general, that consumption of dairy products has increased due to change of habit consumption for Tunisian households.

Methodological framework

Empirical model

The CBS system developed by Keller and Van Driel (1985) is one of the flexible demand systems that is expressed as a system of linear equation behavioural parameters. It is a so-called demand differential system based on the differential equation for the budget shares of the consumer goods. The derivates or functions of derivates of this equation are assumed to be constant, in order to obtain estimable expressions.

Depending on which constancy assumptions are made, we may obtain different versions of this differential equation, so it is a whole family of differential consumer demand systems which includes the Rotterdam Model (Theil, 1980) and the differential version of the Almost Ideal Demand System

(Deaton and Muellbauer, 1980). This specification implies that dairy products items are separable from the other food items in the consumer budget. Therefore, weak separability of preferences has been assumed and the multi-budgeting process is then justified. First the consumer determines the amount of expenditure devoted to food purchases. Then, he/she distributes this amount among the food products.

The negativity of own-price substitution terms and the relationships between net substitutes and complements can be immediately obtained from parameter estimates. Income and price elasticities in this system are also linear in parameters. Hence, it is possible to test the statistical significance of all elasticities.

The CBS model application for food products demand has been accomplished by a number of studies (Fousekis and Pantzios, 2000; Van Driel *et al*., 1997; Lee *et al*., 1994; Gao and Spreen, 1994, Barten, 1993, and Laajimi *et al*., 2003). It describes the differential change in the quantity share as a function of changes in the total expenditure and price.

The CBS demand specification for the i^{th} type of dairy product is:

$$w_i \, d\log q_i = (w_i + \beta_i)\, d\log Q + \sum_{j=1}^{n} \pi_{ij}\, d\log p_j \quad i = 1, 2, \ldots, k \quad (1)$$

Where:

$d\log Q = \sum_{j=1}^{n} w_j \, d\log q_j = d\log y - \sum_{j=1}^{n} w_j \, d\log p_j$ is total real dairy products expenditure implicitly

q_i : quantity of the i^{th} type of dairy food
p_i : price of the i^{th} type of dairy food
y : value of total expenditure in dairy products
w_i : is the budget share of good i, $w_i = p_i q_i / y$
k : is the number of dairy goods

The parameters β_i and π_{ij} (the price Slutsky coefficients) are assumed to be constant.

The theoretical restrictions of adding-up, homogeneity and symmetry, implied by demand theory, are satisfied by the following parametric restrictions:

Adding-up : $\sum_{i=1}^{k} \beta_i = 0, \quad \sum_{i=1}^{k} \pi_{ij} = 0$ (2)

Homogeneity: $\sum_{j=1}^{k} \pi_{ij} = 0$ (3)

Symmetry : $\pi_{ij} = \pi_{ji}$ (4)

The negativity condition is $\sum_{i=1}^{k} \sum_{j=1}^{k} \tau_i \; \pi_{ij} \tau_j \leq 0 \;, \forall \tau$ (5)

Indicating that the matrix Π, must be negative semi-definite of rank k-1. The negativity condition implies that the eigenvalues of Π matrix must all be no positive. Since the rank of Π is (k-1) therefore, the negative semi-definite condition requires the eigenvalues to be one zero and (k-1) negatives.

Elasticities can be calculated from the estimated parameters as follows:

- Total expenditure: $\eta_i = \frac{\beta_i}{w_i} + 1$ (6)

- Marshallian price elasticities: $E_{ij} = \frac{\pi_{ij}}{w_i} - \eta_i \, w_j$ (7)

- Heksian price elasticities: $$\varepsilon_{ij} = \frac{\pi_{ij}}{w_i} \qquad (8)$$

Data and estimation procedure

Data description

The annual consumption data for fresh milk, butter and cheese are collected from the Food Balance Sheet elaborated by the Food and Agricultural Organization (FAO). In order to get *per capita* data, population figures were collected from the same source. Consumption *per capita* of yogurt is approximated by the supply of this food elaborated by the Ministry of Industry for Tunisia divided by the population. Annual consumer price series for each commodity are found in the monthly statistical bulletin of Tunisia published by the INS (National Statistics Institute). Four dairy products are used in the analysis: fresh milk, yogurt, butter and cheese. The sample period covers yearly data from 1973 to 2002.

Estimation procedure

The CBS model (1) reads in differentials. In order to arrive at estimable equations it has to be converted to finite changes (Van Deriel *et al*., 1997). However, for estimation we need to work with finites change and follow the usual practice of approximating w_{it}, $dlogp_{it}$ and $dlogq_{it}$ for $\frac{(w_{it} + w_{it-1})}{2}$, $\log \frac{p_{it}}{p_{i,t-1}}$ and $\log \frac{q_{it}}{q_{i,t-1}}$, respectively, where subscript t indicates time.

The empirical model specified for this study (1) was estimated using the Full Information Maximum Likelihood (FIML) procedure. The "cheese" equation was deleted to avoid singularity of the variance and covariance matrix of residuals due to the adding-up restriction. Restrictions imposed by economic theory (homogeneity and symmetry) were tested. Results indicates that both of these restrictions are not rejected at the standard statistical criteria (5% level of significance), it means that the model is consistent with economic theory.

Quality change and its decomposition in Tunisian dairy products consumption

Taking into account that quality concept measures the desirability of the consumption basket from the consumer's point of view as revealed by his behaviour. Moreover, the term quality change in consumption does not involve any judgment *ex-ante* what is good and what is not for the consumer.

In conclusion, commodities for which the marginal share exceeds the corresponding budget share are more attractive in preferences to the consumer. Based on this analysis, Theil (1980) has been used to calculate a quality change index (QCI) and to decompose it into real expenditure, substitution, and other effects.

The following quality change index (QCI) in consumption in differential form is given as:

$$QCI = \mathrm{dlog}\,\mathrm{Q}^{\mathrm{F}} - d\log Q \qquad (9)$$

Where $dlogQ^F$ is the Frisch quantity index, which weighs quantity changes of individual commodities by the respective marginal shares.

For the CBS model, the QCI can be developed as:

$$QCI = \sum_{i=1}^{n} \beta_i \, d\log q_i \qquad (10)$$

To quantify QCI, equation (1) is substituted into equation (10). Result from this substitution is given as:

$$QCI = \sum_{i=1}^{4} \beta_i (c_i / w_i) + \sum_{i=1}^{4} \beta_i (\beta_i / w_i + 1)_{\,i}\, \mathrm{dlogQ} + \sum_{i=1}^{4}\sum_{j=1}^{4} \beta_i (\pi_{ij} / w_i) + \sum_{i=1}^{4} \beta_i (u_i / w_i) \quad (11)$$

Where:

QCI	: Quality Change Index
i, j =1, ., 4	: Attach to fresh milk, yogurt, butter and cheese
C_i	: Coefficient associated with trends

The equation (11) decomposes the QCI into a:

- Trend Effect: $$TE = \sum_{i=1}^{4} \beta_i (c_i / w_i) \quad (12)$$

- Real Expenditure Effect:

$$REE = \sum_{i=1}^{4} \beta_i (\beta_i / w_i + 1)_{\,i}\, \mathrm{dlogQ} \quad (13)$$

- Substitution Effect:

$$SE = \sum_{i=1}^{4}\sum_{j=1}^{4} \beta_i (\pi_{ij} / w_i) \quad (14)$$

- Residual Effect:

$$RE = \sum_{i=1}^{4} \beta_i (u_i / w_i) \quad (15)$$

Results and discussion

With respect to the specification test, none of the equations of the model show autocorrelation problems, because all values of this test are clearly lower than the critical value at the 5% level of significance, $\chi^2(1)=3.84$. Hence our specification is acceptable from an econometric point of view. Parameter estimates of the CBS model are used to calculate the price and expenditure elasticities. Table 1 shows the expenditure, own and cross-price elasticities, evaluated at the mean point of the explanatory variables. These values are reasonable in signs and magnitude and, for the most part, are individually significant. All expenditure elasticities are positive and significant at the 10% level. Expenditure elasticities of butter and cheese are greater than one, indicating that they are luxury goods. Whereas, expenditure elasticity of milk is very close to unity, so it can be considered as a normal good. However, expenditure elasticity of yogurt is less than the unity and suggest it a necessity in the Tunisian diet.

Milk product is considered as a normal good, since the corresponding expenditure elasticity close to one (1.024) and statistically different from zero. This result is plausible taking into account the importance of this product in the diet. Expenditure elasticity of yogurt is less than the unity, although significant, indicates that this product may be considered as an inferior good. It is important to notice the decrease consumption responsiveness of yogurt to income increases. The descriptive analysis confirms this result, since the relative proportion of the budget allocated to yogurt is loosing importance as part of total expenditure allocated to dairy products. Butter exhibits higher expenditure elasticity. Such result seems to be implausible, but not if it is borne in mind that retail price of this product is higher and increase rapidly in the last years of study.

The expenditure elasticity obtained for cheese is plausible in magnitude, since an increase in dairy products expenditure would induce more than proportional increase in the demanded quantity. This indicates the new trend and changes that occurred in the food structure (consumption away from home), since consumption on this product is increasing, particularly in urban areas, as a response to income increases.

Table 1. Expenditure, own and cross price elasticities for demand of dairy products in Tunisia

	Milk	Yogurt	Butter	Cheese
Expenditure elasticities	1.024 (21.50)	0.235 (2.59)	1.39 (1.86)	1.29 (4.37)
Marshallian elasticities				
Milk	-0.84 (-30.65)	-0.079 (-14.52)	-0.053 (-2.69)	-0.044 (-1.62)
Yogurt	-0.24 (-4.00)	-0.19 (-2.48)	0.15 (2.78)	0.047 (0.73)
Butter	-1.41 (-3.42)	0.206 (1.97)	0.62 (1.003)	-0.80 (-2.93)
Cheese	-0.73 (-4.50)	-0.028 (-0.35)	-0.44 (-1.87)	-0.045 (-0.163)
Hecksian easticities				
Milk	-0.094 (-0.34)	-0.0048 (-0.87)	-0.013 (-0.66)	0.027 (1.93)
Yogurt	-0.05 (-0.87)	-0.17 (-2.26)	0.164 (2.94)	0.064 (0.83)
Butter	-0.27 (-0.66)	0.309 (2.94)	0.67 (0.85)	-0.71 (-1.66)
Cheese	0.31 (1.93)	0.066 (0.83)	-0.39 (-1.66)	0.0091 (0.033)

Note: t-ratios are in parenthesis.

Results from own-price elasticities indicate that the resulting demand for dairy products is inelastic. That is, changes in own prices have inverse impacts on quantities demanded. Among the three products there composed this food group, own price elasticity of milk is the largest in absolute terms, followed by yogurt and cheese. Cheese product is more prices inelastic, implying that consumption of this dairy product is not sensitive to price change. Hence, if prices and income (total expenditure) changes at the same time, consumption would be more affected by income than prices.

From compensated prices elasticities, it can be observed that cheese has the strongest competitive relationship with milk. Cross-price elasticity of cheese with respect to milk is greater than that of milk with respect to cheese. This implies that the price of cheese does not have an influence on the consumption of milk while the price of milk affects the consumption of cheese. This is because consumer's in Tunisia consumed more milk than cheese. Another competitive relationship can be appointed between butter and yogurt. This result indicates that the price of better does not have an influence on the consumption of yogurt while the price of yogurt affects the consumption of better. It appears also a complementary relationship between butter and cheese implying that the consumption of butter is influenced by the price of cheese. This is true when regarding the evolution of prices of these dairy products along the period of study.

Parameter estimate of the CBS model were used to calculate and decompose Quality Change Index (QCI) into real expenditure effect, substitution effect, trend effect and residual effect. Results from this decomposition for the analysis period and for the different sub-periods (1973-87, 1988-94, and 1995-02) are showed in Table 2. Empirical results suggest that over the period of analysis, there is a moderate increase in quality of consumption for dairy products by 0.068% per year. The real-expenditure effect decreases with the dispersion of expenditure elasticities among the four dairy products. This is due to the fact that *the Divisia quantity index* decreases over the sample period.

As well as regarding the substitution effect, it appears that values of this term become positives. In definition, the substitution effect becomes positive when the price of goods for which the marginal share exceeds the respective budget share tends to decrease relative to the rest of goods. This is

true, in our case, since the prices of butter and cheese, for which the expenditure elasticities are greater than unity, 1.39 and 1.29, respectively, have decreased faster than the prices of the rest of others dairy products, namely fresh milk and yogurt.

Table 2. Quality change index (QCI) and its decomposition for demand of dairy products in Tunisia

Periods	QCI	Real expenditure	Components of quality change		
			Substitution	Trend	Residual
1973-1987	0.105	0.002	0.007	0.09	0.0043
1988-1994	0.048	9.8E-04	0.004	0.05	-0.008
1995-2002	0.021	2.9E-04	0.008	0.009	7.7E-04
1973-2002	0.068	0.0013	0.0069	0.06	1.39E-04

Source: Own elaboration.

The trend effect is positive since β and c coefficients have the same sign in each equation of the system. Given that, the trend effect and QCI are very similar not only for the sample period but also for the different sub-periods. Thus, the change in QCI must be attributed to change in the trend effect. Finally, the residual effect is not significant.

Concluding remarks

Elasticity estimates are critical parameters in developing countries for policy analysis. Elasticities used in past applied models in Tunisia have been calculated at aggregated level (total food) and to the authors' knowledge, this investigation constitutes the first attempt to empirically estimate dairy products in Tunisia using demand systems.

Results from quantitative analysis showed that expenditure elasticities of butter and cheese are greater than one, indicating that they are luxury goods. Expenditure elasticity of milk is very close to unity, so it can be considered as a normal good. However, expenditure elasticity of yogurt is less than the unity and suggest it a necessity in the Tunisian diet. The findings from Marshallian elasticities indicate that demand for dairy products is inelastic. Cheese product is more prices inelastic, implying that consumption of this dairy product is not sensitive to price change. Hence, if prices and income (dairy expenditure) changes at the same time, consumption would be more affected by income than prices. Moreover, cross-price elasticities show strongest competitive relationship between cheese and milk, in one hand, and between butter and yogurt, from another. This result indicates that the price of better does not have an influence on the consumption of yogurt while the price of yogurt affects the consumption of better. In addition, a complementary relationship between butter and cheese is outlined, implying that the consumption of butter is influenced by the price of cheese.

The findings from quality change index (QCI) decomposition of dairy products consumption in Tunisia show that there is a moderate increase in quality in consumption of dairy products by 0.068% per year. It appears also that the quality change of dairy products consumption in Tunisia decrease over the period of analysis.

Finally, results obtained in this paper are strictly conditioned to the chosen bundle of dairy products categories, the sample period and the used model. However, it would be more interesting from policy maker point of view to analyse the influence of socio-demographic characteristics (level of education of household head, size of town, socio-professional categories, income classes, etc.) of consumers. Such analysis can be also improved by incorporating other determinants of food consumption such as nutrition quality, the nutrient content of food and the increasing concern about health.

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