NUTRIENT EFFECTS ON CONSUMER DEMAND: A PANEL DATA APPROACH

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ABSTRACT

The objective of this paper is to analyse the Spanish demand for food taking into account the consumer's concern about the relationship between food diet and health. This concern is forcing food demand analysts to assume that consumer utility is a function of nutrients instead of simply the food products themselves. A CBS demand model has been considered to model the new demand function obtained, which is estimated with a complete panel data set. Ten broad categories, nine nutrients and the most relevant socio-economic variables have been considered. Finally, after an apropriate model selection strategy, expenditure, price and nutrient elasticities, as well as main sociodemographic effects, have been calculated.

Keywords: Nutrients, Demand for Food, CBS, Panel Data, Spain.

INTRODUCTION

A large body of scientific research has shown that diet plays an important role in determining the risk of chronic diseases such as coronary heart disease, cancer, stroke, diabetes, hypertension and osteoporosis. As a consequence, food consumption patterns are increasingly being driven by a much more complex set of factors than those economists have traditionally incorporated in demand studies.

Several studies based on time series data have already incorporated certain types of health information indexes to capture the effect of the increasing consumers' concerns about the potential health effects of food diet (Brown and Schrader, 1990; Capps and Schmits, 1991; Kinnucan et al., 1997; Kim and Chern, 1999; and, Ben Kaabia et al., 2001). When using cross section data, food demand analyses have tended to take into account nutrient intakes. In this context, two main approaches have been used. The first one, directly measures the effect of income and sociodemographic variables on the demand for nutrients (Adrian and Daniel, 1976; Devaney and Fraker, 1989; Nayga, 1994; Ramezani, 1995; Subramanian and Deaton, 1996; or Chesher, 1998, among others). The second develops an indirect approach based on a two-step process. First, a food demand system is estimated in order to calculate the effects of relevant variables. Second, nutrient intake effects are obtained by applying nutrient conversion factors to the resulting food effects (Xiao and Taylor, 1995; Ramezani et al., 1995; and Huang, 1999).

However, both approaches, in our view, merely analyse the demand for nutrients instead of the demand for food. Since nutrients are not directly available in the market, the applicability of such results is limited. Hence, in this paper, we consider that it would be more useful to incorporate this new nutrient intake awareness into a demand model to enable us to make conclusions about food demand (in terms of changes in quantities consumed of different products) rather than about nutrients demand.

Based on this hypothesis, this paper tries to provide a new perspective to analyse food demand by incorporating nutritional factors. The study is applied to Spain but it can be generalise to other countries. From the methodological point of view it is assumed that the consumer utility function is a function of nutrients and not a function of the goods themselves. It is not unrealistic to assume that consumers are starting to think more in terms of food nutrients than in terms of food products, while also taking into account prices and disposable income. The result is a demand function in which food quantities are considered as dependent variables, while income, prices and nutrients are the exogenous variables. Second, a functional form based on the CBS demand system proposed by Keller and van Driel (1985) is used. Finally, the specified model is estimated over a panel data set using the information provided in the Spanish Continuous Household Expenditure Survey (Encuesta Continua de Presupuestos Familiares, ECPF).

This paper is structured as follows. First, the theoretical foundation as well as the functional form of the model is presented. Section 3 is devoted to the description of the panel data set used in the paper. The econometric and main results are presented in Section 4. The paper ends drawing main conclusions together with some indications for further research on this topic.

MODEL SPECIFICATION

Theoretical model

The basic assumption of our model, as mentioned in the introduction, is that Spanish consumers' utility function depends on nutrients instead of goods[1]. In this context, the consumer choice problem can be represented by the following optimization problem:

$$\begin{aligned} & Max.\ \ U\ \phi_1 ...,\phi_k\ ) \\ s.a \quad & i)\ \ \sum_{j=1}^{n} p_j q_j \ \leq\ X; \\ & ii)\ \ \phi_k = \sum_{j=1}^{n} a_{jk} q_j \\ & \quad q_j\ \geq\ 0 \qquad\qquad k = 1,...,K;\ \ j = 1,...,n \end{aligned} \tag{1}$$

where, U is the utility function that depends on k nutrients $(\phi_1 ...,\phi_k)$. Such utility function is subject to the traditional budget restriction (i), and also to a second restriction referred to the "technology" of nutrient production (ii), which transforms food quantities into nutrient intakes using the factors a_{jk} (where a_{jk} denotes the level of nutrient k by unit of product j) . As usual, vectors $p = (p_1, p_2, ..., p_n)$ and $q = (q_1, q_2, ..., q_n)$ denotes, respectively, prices and quantities of goods.

Solving the first order conditions from the Lagrangian associatied to problem (1), the following demand equations are obtained:

$$\mathrm{q_i} = \mathrm{q_i}\ (\mathrm{p_1}, \mathrm{p_2}, ..., \mathrm{p_n}, a_{11}\ , \ldots, a_{1K}\ , ..., a_{n1}\ , ..., a_{nK}\ , x) \tag{2}$$

A basic property of demand systems with factors such as nutrients is that if the demand for any product increases as a result of a change in a particular nutrient intake, the demand for other products has to decrease in the same amount, as total consumer expenditures are constant. In this case, and following Barten (1977), the effect of nutrient changes on consumption can be related to the substitution effects of price changes as follows:

$$\frac{\partial q_i}{\partial a_{jk}} = -\left(\frac{1}{\lambda}\right) \sum_{h=1}^{n} \left(\frac{\partial q_i}{\partial p_h} + \frac{\partial q_i}{\partial x}\ q_h \right) \left(\frac{\partial \left(\dfrac{\partial U}{\partial q_h} \right)}{\partial a_{jk}} \right) \tag{3}$$

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[1] This assumption is plausible, in general, in developed countries.

i.e,
$$\frac{\partial q_i}{\partial a_{jk}} = -\left(\frac{1}{\lambda}\right)\sum_{h=1}^{n} s_{ih} v_{hjk} \tag{4}$$

where, $\lambda = \dfrac{\partial U}{\partial x}$ is the marginal utility of income; $s_{ih} = \dfrac{\partial q_i}{\partial p_h} + \left(\dfrac{\partial q_i}{\partial x}\right) q_h$ is the Slutsky substitution effect or the demand price slope with utility keeping constant; and, $v_{hjk} = \dfrac{\partial\left(\dfrac{\partial U}{\partial q_h}\right)}{\partial a_{jk}}$ is the effect of nutrient changes on marginal utility.

If both sides of equation (3) are multiplied by $\left(\dfrac{p_i q_i}{x}\right)\left(\dfrac{a_{jk}}{q_i}\right)$, the following expression is obtained:

$$\left(\frac{p_i q_i}{x}\right)\left(\frac{\partial q_i}{\partial a_{jk}}\right)\left(\frac{a_{jk}}{q_i}\right) = -\sum_{h=1}^{n}\left(\frac{p_i p_h}{x}\right) s_{ih}\left[\frac{\partial\left(\dfrac{\partial U}{\partial q_h}\right)}{\partial a_{jk}}\right]\left(\frac{a_{jk}}{\lambda p_h}\right) \tag{5}$$

or, in terms of budget shares $w_i = \dfrac{p_i q_i}{x}$:

$$w_i\left(\frac{\partial \ln q_i}{\partial \ln a_{jk}}\right) = -\sum_{h=1}^{n}\pi_{ih}\gamma_{hjk} \tag{6}$$

where $\pi_{ih} = \left(\dfrac{p_i p_h}{x}\right) s_{ih}$ is the Slutsky coefficient

and $\gamma_{hjk} = \dfrac{\partial\left[\ln\left(\dfrac{\partial U}{\partial q_h}\right)\right]}{\partial \ln a_{jk}}$ is the elasticity of the marginal utility for good *h* with respect to nutrient *k* in food item *j*.

Functional form

Once the theoretical foundations of the model as well as some of its implications have been derived, the following step consists of choosing a functional form for the model. Let us start by obtaining the logarithmic differential of Equation 2:

$$d\ln q_i = \eta_i d\ln x + \sum_{j=1}^{n}\mu_{ij} d\ln p_j + \sum_{j=1}^{n}\sum_{k=1}^{k}\left(\frac{\partial \ln q_i}{\partial \ln a_{jk}}\right) d\ln a_{jk} \tag{7}$$

where η_i is the income elasticity of demand for good i; μ_{ij} is the uncompensated price elasticities; and $\dfrac{\partial \ln q_i}{\partial \ln a_{jk}}$ is the elasticity of demand for good *i* with respect to nutrient *k* in food item *j*.

Taking into account that the Slutsky equation is also valid for the present approach, substituting in (7) the term μ_{ij} by $\mu_{ij} = e_{ij} - \eta_i w_j$, we get:

$$d\ln q_i = \eta_i\left(d\ln x - \sum_{j=1}^{n} w_j d\ln p_j\right) + \sum_{j=1}^{n} e_{ij} d\ln p_j + \sum_{j=1}^{n}\sum_{k=1}^{k}\left(\frac{\partial \ln q_i}{\partial \ln a_{jk}}\right) d\ln a_{jk} \tag{8}$$

where e_{ij} represent the compensated price elasticities.

Next, multiplying both sides of (8) by w_i, and using the result obtained in (6), the logarithmic differential version of the model is obtained:

$$w_i\, d\ln q_i = \alpha_i + \theta_i\, d\ln Q + \sum_{j=1}^{n} \pi_{ij}\, d\ln p_j + \sum_{j=1}^{n}\sum_{k=1}^{k} \beta_{ijk}\, d\ln a_{jk} \tag{9}$$

where $\theta_i = \mathrm{w_i}\, \eta_\mathrm{i} = \mathrm{p_i} \frac{\partial \mathrm{q_i}}{\partial \mathrm{x}}$ is the marginal budget share

$\pi_\mathrm{ij} = w_i e_{ij}$ is the Slutsky coefficient

$$d\ln Q = d\ln x - \sum_{j=1}^{n} w_j\, d\ln p_j = \sum_{j=1}^{n} w_j\, d\ln q_j \text{ is the Divisia volume index}$$

$$\beta_{ijk} = -\sum_{j=1}^{n} \pi_{ij}\, \gamma_{jjk}$$

and an intercept α_i in order to capture changes in consumers' tastes.

However, there is no strong a priori reason to assume that θ_i's and π_{ij}'s must be constant. To flexibilize this point, it is possible to use the Working's Engel model to derive that the i^{th} marginal budget share differs from the corresponding budget share by β_i; that is, that $\theta_i = w_i + \beta_i$. Then substituting this expression in (9), we get the CBS model (Keller and van Driel, 1985) for the purpose of this paper:

$$w_i\, d\ln q_i = \alpha_i + (\beta_i + w_i)\, d\ln Q + \sum_{j=1}^{n} \pi_{ij}\, d\ln p_j + \sum_{j=1}^{n}\sum_{k=1}^{k} \beta_{ijk}\, d\ln a_{jk} \tag{10}$$

Following Theil (1980) and Duffy (1987, 1989, 1990), we assume that $\beta_{ijk} = -\pi_{ij}\gamma_{jjk}$ and we let $\gamma_{jjk} = \gamma_{jk}$. The resulting demand system is given by:

$$\begin{aligned} w_i\, d\ln q_i &= (\beta_i + w_i)\, d\ln Q + \sum_{j=1}^{n} \pi_{ij} \left(d\ln p_j - \sum_{k=1}^{n} \gamma_{jk}\, d\ln a_{jk} \right) \\ &= (\beta_i + w_i)\, d\ln Q + \sum_{j=1}^{n} \pi_{ij}\, d\ln p_j^{*} \end{aligned} \tag{11}$$

where γ_jk represents the elasticity of marginal utility with respect to nutrient k in food j.

The CBS is a flexible demand system in which economic theory restrictions can be easily imposed on its parameters. In particular, adding-up: $\sum_{i=1}^{n} \alpha_i = 0$, $\sum_{i=1}^{n} \beta_i = 1$ and $\sum_{i=1}^{n} \pi_{ij} = 0$; homogeneity: $\sum_{j=1}^{n} \pi_{ij} = 0$; and symmetry: $\pi_{ij} = \pi_{ji}$. Finally, the negativity condition needs $\varpi' \pi \varpi \le 0 \ \forall \ \varpi \neq 0$, indicating that the matrix π must be negative semi-definite of rank n-1. The negativity condition implies that the eigenvalues of the π matrix must all be non-positive. Since the rank of π is (n-1) therefore, the negative semi-definite condition requires the eigenvalues to be one zero and (n-1) negatives. In this context, the negativity condition cannot be tested statistically; however, the eigenvalues of the parameter matrix can be used to indicate whether, on average values, this condition holds.

DATA AND PRELIMINARY TRANSFORMATIONS

Data is collected from the Spanish Continuous Household Expenditure Survey (*Encuesta Continua de Presupuestos Familiares*, ECPF), which is conducted by the Spanish National Statistic Office (*Instituto Nacional de Estadística,* INE).

The ECPF is conducted every quarter on around 3,200 households. One eighth of the sample is renewed quarterly and hence an individual can be followed for a maximum of eight quarters (two consecutive years). Nevertheless, there are an important percentage of households not completing all the interviews (Browing and Collado, 1999).

In this study a complete panel data set has been constructed by “following” those households that remain in the sample from the first quarter of 1998 to the fourth quarter of 1999. Additionally, those households that report zero expenditure in all food groups or in all groups minus one were dropped from the sample. As a result, we were able to collect information on expenditure and quantities consumed of different food products[2] from a total of 217 households during 8 periods, which gives a total of 1,736 observations.

Food products have been aggregated into ten broad groups: 1) cereals and potatoes; 2) red meat (beef and pork); 3) white meat (poultry) and eggs; 4) fish; 5) dairy products; 6) oils; 7) fruits; 8) vegetables; 9) sugar and soft drinks; and 10) other food (alcoholic beverages). Additionally, the following nutrients have been considered: calories (kilocalories), carbohydrates (grams), lipids (grams), proteins (grams), fibre (grams), calcium (milligrams), others minerals (milligrams), cholesterol (grams) and vitamins (milligrams). Agregation was based on similarities of nutrients composition. Furthermore, there exists for some food groups, a higher correlation with specific nutrients. The cereals and potatoes group provides a high percentage of total carbohydrates and fibre; the same for meat (red and white) and eggs, with respect to protein, lipids and cholesterol intake; dairy products, in relation to calcium and minerals; fruits and vegetables groups, with respect to fibre, vitamins and minerals intake; oils, with respect to lipids; and finally, sugar and other food provides an important percentage of total calories. Finally, note that the nutrient content, a_{jk}, is defined as the average nutritional content per unit of food consumed. That is, they are calculated by dividing the total amount of nutrient by the quantity of food consumed. For such calculations, Andújar et al. (1983)’s nutrient conversion tables have been used.

Information on a limited number of socio-economic characteristics is also provided by the survey. We have selected, those variables that exert a significant effect on food demand: size of the town where the household lives, level of education and age of the household head and, finally, the percentage of members over thirteen years old in the household. Finally, as prices are not recorded, unit values for each group are calculated by dividing expenditure by quantities. These values may reflect not only spatial variations caused by supply shocks (i.e., transportation costs, cost of information, seasonal variations, etc.) but also differences in quality which can be attributed to brand loyalty or marketing services among other factors (Cramer, 1973; Cox and Wohlgenant, 1986). For this reason, unit values must be adjusted before using them in demand analysis (Cowling and Raynor, 1970; Deaton, 1989). Following Gao et al. (1997), the quality-adjusted price can be defined as the difference between the unit price and the expected price, given its specific quality characteristics[3]. The expected price is calculated by a hedonic price function such that:

$$P_k = \vartheta_k + \sum_s \iota_s \, K_{ks} + \varepsilon_k \tag{12}$$

where P_k is the unit value and K_{ks} are variables affecting the consumer choice of qualities, such as income and household characteristics, which are used as proxies for household preferences for unobservable quality characteristics. Regional and seasonal dummy variables have not been included, because, although they reflect systematic supply variations, their average effects are reflected by the intercept ϑ_k. Finally, the quality-adjusted price is then defined by:

$$P_k^{'} = P_k - \sum_s \hat{\iota}_s \, K_{ks} = \hat{\vartheta}_k + \hat{\varepsilon}_k \tag{13}$$

ECONOMETRIC SPECIFICATION AND ESTIMATION RESULTS

Once the theoretical framework as well as the available panel data set have been discussed, the appropriate econometric specification of the model must be determined.

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[2] Data on expenditure were available for all items within each food group or category. However, data on quantities were not available for all items. Approximately, within each group we were able to collect information for the majority of food products representing, on average, 75% of total expenditure on each food category.

[3] In those cases where unit values do not exist as households do not buy the specific product, they have been estimated from a regresion of the observed unit values of households which actually buy the product on dummy variables reflecting household characteristics such as region, season and income. Estimated parameters are then used to predict unit values for a specific household.

In the context of a panel data set, the CBS demand system specified in (11) can be written as:

$$w_{imt}\ d\log q_{imt} = \alpha_i + (\beta_i + w_{imt})\ d\log Q_{mt} + \sum_{j=1}^{n} \pi_{ij}\ d\log p^{*}_{jt} + \mu_{im} + \upsilon_{imt} \qquad (14)$$

where w_{imt} and q_{imt} are the budget share and the quantity of good i (i=1, ..., n) at time t (t=1, ..., T) for a household m (m=1, ..., M), respectively; p^{*}_{jt} is the perceived price of good j at time t; μ_{im} represents the household specific effects, which can be modelled either as fixed (obtaining the fixed effect model) or random (deriving in the random effect model). Finally, the term υ_{imt} represents the conventional error term. In this paper, we have assumed a Random Effect Model as the starting point if specification tests do not provide evidence in favour of the Fixed Effect Model.

Our methodological approach starts with the estimation of system (14) assuming random unobserved household specific effects (Baltagi, 1999). Theoretical restrictions (homogeneity and symmetry) have been imposed, while the adding-up restriction has required dropping one equation from the system to avoid the covariance matrix singularity problem. In our case, the “other food” equation has been taken out. Parameters for such deleted equation have been obtanied later on from the adding-up conditions. Finally, the negativity condition has been checked after estimation through the signs of the π_{ij} matrix eigenvalues. Since all the obtained values were non-positive (-0,00684; -0,0109; -0,02034; -0,0240; -0,027776; -0,043496; -0,0517; -0,05671; -0,08188 and, obviously, 0), such condition is satisfied and, hence, it is not necessary to be imposed.

Additionally, some misspecification tests have been carried out on the estimated model. First, null hypotheses of, respectively, homoscedasticity and non-autocorrelation of error terms were tested. The first one has been tested through the White test for all the equations. From the obtained results, it can be concluded that there exist serious problems of heteroscedasticity for red meat, white meat and eggs, and other food equations. However, taking into account that, on one hand, all equations in the system must be equally specified and, on the other, only a few equations present heteroscedasticity, we consider that, in general terms, the specification of the system is good enough. In any case, to avoid inference problems when testing hypotheses, the robust t-ratios proposed by White (1980) have been calculated for those equations presenting heteroscedasticity.

In relation to autocorrelation, tests proposed by Bera et al. (2001) have been used. In fact, two types of statistics have been used. The first one (RS_{μ}) tests the existence of serial correlation under a random effects model, while the second ($RS_{\mu\rho}$) jointly tests the joint specification of a random effects model and no autocorrelation. Both statistics are distributed as a χ^2 with 1 and 2 degrees of freedom, respectively. The obtained results for both tests indicate that the null of no autocorrelation is never rejected[4].

Although from autocorrelation tests we have found some empirical evidence in favour of the random effects model, the Hausman (1978)’s test has been used to corroborate such result. If the null hypothesis of no correlation between the explicative variables and the specific effects included in the error terms is rejected, the random effect estimator is not consistent and, then, the fixed effect estimator should be used. In our case, the mentioned statistic took a value of 252.35, which was under the critical value of $\chi^2_{0.05}$ (237)=273.91. Hence, the null hypothesis could not be rejected and the random effect estimator is preferred to the fixed one.

Finally, a measure of goodness of fit measure has been calculated following the system R^2 proposed by Bewley and Young, 1987), based on log-likelihood values from the estimated model and from a model with only intercepts (restricted model). The system R^2 was 0.48, which is relatively high taking into account that the dependent variable is defined in first differences.

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[4] The obtained values for the satistic RS_{μ} for the 10 equations were: cereals and potatoes (0.72); red meat (1.04); white meat and eggs (1.61); fish (2.09); dairy (1.47); oils (0.70); fruits (0.95); vegetables (2.23); sugar (1.77); and other food (0.18), all of them less than the critical value at 5% of significance of 3.84. The obtained values for the satistic $RS_{\mu\rho}$ for the 10 equations were: cereals and potatoes (2.23); red meat (3.71); white meat and eggs (2.45); fish (3.12); dairy (2.92); oils (3.89); fruits (4.47); vegetables (3.27); sugar (2.68); and other food (3.17), all of them less than the critical value at 5% of significance, which equals 5.99.

Furthermore, to measure the explicative power of nutrients, the analogous measure was calculated for a model without nutrients. In this case, the R^2 took the value of 0.39, indicating that incorporating nutrient intake variables in the system significally increased the explicative power of the model.

From the estimated parameters[5], all elasticities (expenditure, price and nutrient) are calculated. For comparison purposes, elasticities for the model without nutrients have been calculated. Nevertheless, before analysing them, remind that, since weak separability has been imposed, they have been calculated with respect to total food expenditure.

Expenditure and uncompensated own-price elasticities, calculated at mean values, are shown in Table 1. All expenditure elasticities are positive and significant at the 5% level of significance. Red meat, oils, fruits, vegetables and the other food group (alcoholic drinks) are luxury goods (when total food expenditure increases, the allocation to such products increases more than proportional). Elasticities for white meat and eggs, and fish are close to unity (0.90 and 0.93, respectively). The obtained results are quite consistent with expectations. Perhaps, in the case of red meat, fish and dairy it would be expected higher values because those products use to be high-priced. However, as mentioned in footnote 2, it is necessary to bear in mind that within each group, some of the most expensive products have not been considered due to unavailability of quantity data. In fact, in the case of red meat, lamb meat is not included and, in the case of dairy, only fresh milk and sterilized milk are considered, excluding high added value products such as cheese and other dairies. Regarding fish, only hake and whiting (fresh and frozen) have been included, which are products of a relatively low price. Finally, just remark that incorporanting nutrient intake information slightly increases expenditure elasticities for the different food groups with the only exception of cereals and potatoes, white meat and eggs, fish and dairy. Nevertheless, the relative magnitude of elasticities among the different food groups does not change.

Table 1. Expenditure and own-price Elasticities at mean values.

Food Products	Expenditure Elasticities		Own Price Elasticities	
	With Nutrients	Without Nutrients	With Nutrients	Without Nutrients
Cereals and Potatoes	0.84**	0.87**	-0.47**	-1.00**
Red Meat	1.12**	1.02**	-0.46**	-0.47**
White meat and Eggs	0.90**	1.09**	-0.32**	-1.01**
Fish	0.93**	0.94**	-0.28**	-0.16**
Dairy	0.87**	0.95**	-0.49**	-0.72**
Oils	1.01**	0.95**	-0.23**	-0,19**
Fruits	1.20**	1.16**	-0.64**	-0.83**
Vegetables	1.09**	1.06**	-0.42**	-0.39**
Sugar (a)	0.66**	0.63**	-0.17**	-0.56**
Other Food (b)	1.32**	1.23**	-0.31**	-0.30**

(a) Sugar and soft drinks.
(b) Alcoholic beverages.
** Indicates significance at 5% level.
* Indicates significance at 10% level.

All uncompensated own-price elasticities are negative and significant. In general terms, demand for the different products are quite inelastic, being the most elastic fruits, cereals and potatoes, dairy and red meat. Comparison between these elasticities and those obtained from a model without nutrient shows that, in general, the incorporation of nutrients into the specification of the demand system significatively reduces price elasticities.

Finally, food demand elasticities with respect to a nutrient composition change, nutrient elasticities, have been calculated. Since nutrient effects are through prices, own and cross nutrient elasticities (similarly to price elasticities) can be calculated. In fact, taking into account the properties of theoretical model, an increase in, for instance, the cholesterol level contained in white meat and eggs will have a double

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[5] Not included, but available from authours.

consequence: i) on quantities demanded for such products (own-effect) and, ii) on quantities demanded for the other products (cross-effect). Nevertheless, main attention will be paid to own effects[6]. Results are gathered in Table 2.

Let starts with a general comment. As shown in Table 2, own nutrient elasticities for several products are considerably high. These results are explained by the high value of estimated parameters (as the model is defined in first differences) and, also because for some products, households' variability is relatively small.

Table 2. Own-Nutrient Elasticities at mean values.

	Cereals and Potatoes	Red Meat	White meat and Eggs	Fish	Dairy	Oils	Fruits	Vegetables	Sugar [a]	Other Food [b]
Calories	4.508	-0.38**	-34.63**	-36.34**	-3.068	13.6**	0.24**	-3.498	-25.39**	-8.492
Carbohydrates	4.788	0.00	0.00	14.767**	-0.28	0.00	4.437	-0.413	23.541**	-4.285
Lipids	0.112	-7.963**	-16.61**	9.122**	-23.51**	-11.48**	-3.99**	-2.614	0.00	0.00
Proteins	-0.511	3.237**	77.976*	3.364**	-17.03**	0.00	-2.373	2.979	0.00	6.729
Fibre	5.102	0.00	0.00	0.00	0.00	0.00	5.396	-0.601	0.00	0.00
Calcium	-0.029	-0.212	-22.545	5.095**	3.08	0.00	-1.983	0.894**	-6.136**	3.016
Minerals	-3.389	-6.003	-57.38**	-3.033**	-10.61**	0.00	-6.44**	-0.003	-18.60**	-4.488
Cholesterol	0.00	-2.018**	-66.74**	5.414**	-1.64	0.00	0.00	0.00	0.00	0.00
Vitamins	-3.583**	4.189	88.60**	3.062	11.65**	0.00	10.3**	4.059*	0.00	-8.039**

(a) Sugar and soft drinks.
(b) Alcoholic drinks.
** Indicates significance at 5% level.
* Indicates significance at 10% level.

Demand for cereals and potatoes is quite inelastic to different nutrient changes. Only, vitamin content exerts a negative effect on demand. In the case of red meat and white meat and eggs, calories, lipids and the cholesterol content exert a significant and negative effect on quantities demanded of such products, while the protein content effect is positive. Fish demand is positively affected by changes in carbohydrates, lipids, cholesterol, calcium and protein content while it is negatively affected by calories and other minerals content. Dairy consumption is positively affected by the vitamins content while changes in the content of lipids, proteins and minerals exert a negative effect. Oils are negatively affected by the lipid content, while the effect of the calorie content is positive. Regarding fruits and vegetables, table 2 shows that a positive and significant influence is exerted by the vitamin content. Finally, sugar is positively affected by carbohydrates, while the effect of calories is negative.

As the final step, we will concentrate on the effects on food demand of main sociodemographic variables. Results are shown in Table 3.

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[6] Intuitively, it should be an upper limit to nutrient intake. If this were true, any increase in nutrient content of a product should decrease other product demand that incorporate such nutrient. However, as food products can be eaten mixed in different combination, it is difficult to set those upper limits. Hence, cross-elasticities can be positive or negative, but interpretation will depend on the reader's intuition.

Before considering the respective effects, it is necessary to take into account that the reference category are those households living in towns with less than 10,000 inhabitants, headed by an unschooled person, aged between 18 and 25 years old and, finally, with a percentage of members over thirteen years old less than 25%.

Table 3. Effect of main sociodemographic variables.

	Cereals and Potatoes	Red Meat	White meat and eggs	Fish	Dairy	Oils	Fruits	Vegetables	Sugar[(a)]	Other food [(b)]
Effect of size of the town										
10,001 – 50,000	-0.17	-0.109	-0.092	0.164	-0.067	0.231	0.094	0.051	0.196	-0.298
50,001 – 500,000	-0.018	-0.005	-0.055	0.012	-0.143	-0.032	0.136	-0.029	0.154	-0.021
> 500,000	0.022	-0.081	-0.034	-0.071	-0.052	0.088	-0.017	0.143	0.068	-0.066
Effect of level of education of the household head										
Primary school	-0.083	0.086	0.033	-0.029	0.139	0.230	-0.118	0.082	-0.130	-0.211
Secondary school	-0.35**	0.231	-0.016	0.011	-0.142	-0.032	-0.045	-0.060	-0.202	0.611
High school	-0.54**	0.058	-0.222	0.45**	-0.065	0.088	0.011	-0.109	-0.146	0.478
Effect of age of the household head										
From 26 to 45 years	0.224	-0.358	-0.401	-0.046	0.92**	0.116	0.196	-0.061	-0.96**	0.372
From 46 to 65	0.268	-0.421	-0.54**	0.204	0.82**	0.339	0.268	-0.191	-0.77**	0.025
More than 65	0.254	-0.57**	-0.53**	0.175	0.75**	0.101	0.413	0.176	-0.97**	0.198
Effect of percentage of members over thirteen years old										
25% - 50%	-0.083	0.086	0.033	-0.029	0.139	0.078	-0.118	0.082	-0.201	0.013
50% - 75%	-0.36**	0.232	-0.016	0.011	0.219	0.119	-0.045	-0.060	-0.130	0.026
More than 75%	-0.55**	0.058	-0.222	0.45**	0.38**	0.116	0.011	-0.109	-0.146	0.005

(a) Sugar and soft drinks.
(b) Alcoholic drinks.
** Indicates significance at 5% level.
* Indicates significance at 10% level.

Starting by the effect of the size of the town where the household lives, it can be observed that households living in the smallest towns (reference category) show the highest expenditure shares for red and white meat, dairy and other products, and the lowest for sugar. The highest expenditure share for cereals and potatoes corresponds to households living in the two extreme sizes, the biggest and the smallest. Allocations to fish and fruits are more important for households living in the middle size towns (within 10,001 to 500,000). Finally, note that the lowest oils and vegetables shares are for households living in towns between 50,001 and 500,000 inhabitants.

The level of education also plays an important role explaining differences in food consumption among Spanish households. In general terms, Table 3 shows that as the level of education of the household head increases, cereals and potatoes expenditure share decreases. Furthermore, households headed by a higher-educated person (with at least secondary school), allocate higher expenditure shares for red meat, fish and other products, while lower to white meat, dairy and vegetables.

Regarding the age of the household head, it can be observed that the reference category, those households headed by a person between 18 and 26 years old, show the highest expenditure shares for red meat, white meat and eggs, and for sugar, but the lowest for cereals and potatoes, dairy, oils, fruits and other food. The highest fish shares are for households headed by a person older than 46. Furthermore, it is observed that for middle age household heads (between 26 and 65 years old), the lowest allocation to vegetables is taken place.

Finally, we will concentrate on the effect of household composition, measured by the percentage of members over thirteen years old. In general, the household composition seems to have a positive effect on red meat, fish, dairy and oils consumption, while the effect is negative for cereal and potatoes, white meat and eggs, fruits, vegetables and sugar.

CONCLUDING REMARKS

Traditionally, food demand analyses have considered effects of main economic variables (income and prices) and also, in the case of cross-sectional studies, effects of main sociodemographic variables. However, in most developed countries economic variables are becoming less important in favour of certain characteristics related to health issues. This is the result of three main trends. First, food markets are increasingly saturated in developed economies, and differentiation or segmentation based on consumers lifestyles is a need for future success. Second, food expenditure is losing participation with respect to total expenditure. And third, information on diet and the relationship between food and health is increasing. In these new circumstances, consumers have started to think more in terms of nutrients than in terms of food products themselves (but, obviously, without ignoring the economic factors). As a consequence, in this paper we have tried to take into account this new enviroment by adopting a new approach to specify demand equations based on the assumption that utility depends on nutrients instead of goods. The solution to this optimisation problem allows us to estimate demand functions in which nutrient contents of food are considered.

The econometric framework followed in this paper is based on the construction of a real panel data set "following" the behaviour of each individual household during eight quarters. So we are considering both the cross section and the time path of the data set.

The approach followed in this paper allows the researcher interested in food demand analysis to calculate the price and income elasticities as well as the nutrient content elasticities. As consumers react in terms of food quantities purchased in the market, this approach seems more realistic that simply calculating the nutrient reactions to changes in income and prices. We believe that both the econometric framework and the theoretical model used here could better describe new trends in food consumption and, thus, producers and marketing agents could benefit from the obtained results in order to anticipate market trends.

Results obtained in this paper are quite consistent with previous expectations taking into account the evolution of food expenditure in Spain. Moreover, the introduction of nutrient content in the utility function has shown to generate some differences in food demand elasticities with respect to a model in which only prices and income are considered. Such differences are more evident in price elasticities. In fact, the incorporation of nutrient composition significatively reduces such elasticites. In the case of expenditure elasticity, the opposite takes place, that is, they are higher when nutrients are incorporated although only slight differences are observed in this case. The only exceptions are cereals and potatotes, white meat and eggs, fish and dairy.

As mentioned above, this approach also allows us to calculate the nutrient elasticities. Results seem to us quite interesting although, in general, the highest and most significant values are with respect to those products that greatly contributed to the respective nutrient intake. Nevertheless, the observed signs depend on effects exerted by nutrients on the different food products.

In spite of this promising approach, further reseach is needed at least in three main directions. The first one is to analyse the sensitivity of results from the selection of the functional form of the demand system. Second, although we have generated a "pure" panel data set, in the future less restrictive panel data can be used. For instance, instead of "following" the same household during eight quarter they stay in the sample it would have been possible to substitute households with similar characteristics in order to have a panel data set over a longer period. And third, the demand system could be extended to include alternative or complementary variables to take into account the increasing consumers concerns about relationship between food and health.

REFERENCES

Adrian, J., Daniel, R., 1976. Impact of the Socio-economic Factors on Consumption of Selected Food Nutrients in the United States. American Journal of Agricultural Economics 58, 31-38.

Andujar, M. M., Moreiras-Varela, O., Gil, F., 1983. Tablas de Composición de Alimentos. Trabajo Publicado por el Consejo Superior de Investigaciones Científicas, CSIC,

Baltagi, B.H., 1999. Econometric Analysis of Panel Data. John Wiley & Sons Press.

Barten, A. P., 1977. The System of Consumer Demand Functions Approach: A Review. Econometrica 45, 23-51.

Ben Kaabia, M., Angulo, A.M., Gil, J.M., 2001. Health Information and the demand for meat in Spain. European Review of Agricultural Economics 28 (4), 499-517.

Bera, A.K., Sosa-Escudero, W., Yoon, M., 2001. Tests for the Error Component Model in the Presence of Local Misspecification. Journal of Econometrics 101, 1-23.

Bewley, R., Young, T., 1987. Applying Multinomial Extension of the Linear Logit Model to Meat Expenditure Data. American Journal of Agricultural Economics 69, 151-157.

Browning, M., Collado, D. 1999. The response of expenditures to anticipated income changes: Panel data estimates. Working Papers, WP-AD 99-19. Instituto Valenciano de Investigaciones Económicas (IVIE).

Brown, D.J., Schrader, L.F., 1990. Cholesterol Information and Shell Egg Consumption. American Journal of Agricultural Economics 72, 548-555.

Capps, O., Jr., Schmitz, J.D., 1991. A Recognition of Health and Nutrition Factors in Food Demand Analysis. Western Journal of Agricultural Economics 16, 21-35.

Chesher, A., 1998. Individual Demands from Household Aggregates: time and age variation in the composition of diet. Journal of Applied Econometrics 13, 505-524.

Cowling, R.G.D., Raynor, A.J., 1970. Price, Quality and Market Shares. Journal of Political Economy 78, 1292-1309.

Cox, T.L., Wohlgenant, M.K., 1986. Prices and Quality Effects in Cross-sectional Demand Analysis. American Journal of Agricultural Economics 68, 908-919.

Cramer, J. S., 1973. Interaction of income and price in consumer demand. International Economic Review 14, 351-363.

Devaney, B., Fraker, T., 1989. The Dietary Impacts of the School Breakfast Program. American Journal of Agricultural Economics 71, 932-948.

Duffy, M., 1987. Advertising and the Inter-Product Distribution of Demand: A Rotterdam Model Approach. European Economic Review 31, 1051-70.

Duffy, M., 1989. Measuring the Contribution of Advertising to Growth in Demand: An Econometric Accounting Framework. International Journal of Advertising 8, 95-110.

Duffy, M., 1990. Advertising and Alcoholic Drink Demand in the U. K.: Some Further Rotterdam Model Estimates. International Journal of Advertising 9, 247-57.

Gao, X.M., Richards, T.J., Kagan, A., 1997. A latent variable model of consumer taste determination and taste change for complex carbohydrates. Applied Economics 29, 1643-1654.

Huang, K.S., 1999. Effects of food prices and Consumer Income on Nutrient Availability. Applied Economics 31 (3), 367-380.

INE(Several years). Encuesta Continua de Presupuestos Familiares. Madrid.

Keller, W.J., Van Driel, J., 1985. Differential Consumer Demand Systems. European Economic Review 27, 375-390.

Kim, S., Chern, W.S., 1999. Alternative Measures of Health Information and Demand for Fats and Oils in Japan. Journal of Consumer Affairs 33, 92-109.

Kinnucan, H.W., Xiao, H., Hsia, C.J., Jackson, J.D., 1997. Effect of Health Information and Generic Advertising on U.S. Meat Demand. American Journal of Agricultural Economics 79, 13-23.

Nayga, R.M., 1994. Effects of Socioeconomic and Demographic Factors on Consumption of Selected Food Nutrients. Agricultural and Resource Economics Review, October, 171-182.

Ramezani, C.A., 1995. Determinants of Nutrient Demand: A Nonparametric Analysis. Journal of Agricultural and Resource Economics 20(1), 165-177.

Ramezani, C.A., Rose, D., Murphy, S., 1995. Aggregation, Flexible Forms, and Estimation of Food Consumption Parameters. American Journal of Agricultural Economics 77(3), 525-532.

Subramanian, S., Deaton, A., 1996. The Demand for Food and Calories. Journal of Political Economy 104 (1), 133-162.

Theil H., 1980. System-Wide Explorations in International Economics, Input-Output Analysis, and Marketing Research. Amsterdam: North Holland.

White, H., 1980. A Heteroskedasticity Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. Econometrica 48, 817-838.

Xiao, Y., Taylor, J.E., 1995. The Impact of Income Growth on Farm Household Nutrient Intake: A Case Study of a Prosperous Rural Area in Northern China. Economic Development and Cultural Change 43(4), 805-819.

Zellner, A., 1962. An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Bias. Journal of the American Statistical Association 57, 348-368.