A Perhaps Adequate Demand System with Application to France, Italy, Spain, and the USA

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Long-term, multisectoral modeling requires calculation of consumer expenditures in some detail by product. Finding a functional form to represent the market demand functions of consumers for this work has proven a surprisingly thorny problem. Clearly, the form must deal with significant growth in real income, the effects of demographic and other trends, and changes in relative prices. Both complementarity and substitution should be possible among the different goods. Increasing income should certainly not necessarily, by the form of the function, force the demand for some good to go negative. Prices should affect the marginal propensity to consume with respect to income, and the extent of that influence should be an empirical question, not one decided by the form of the function.

This paper will present a form which meets these requirements and extends a form suggested twenty years ago by Almon [1979]. Applications of the new form to forty-product demand systems for France, Italy, Spain and the United States are reported and the results compared.

Before presenting this form, however, it may be well to see just how tricky it can be to find a form with these simple requirements by looking at another form, the "Almost Ideal Demand System" (AIDS) suggested by Deaton and Muellbauer [1980]. Its name, the eminence of its authors and its place of publication have led to wide usage. It has, however, a most peculiar property which is likely to sink any growth model in which it is used. Like many others, it is derived from utility maximization; its problems will therefore emphasize the important fact that such derivation does not automatically imply reasonable properties. One of the properties it does imply, however, is Slutsky symmetry in the market demand functions. This property was not mentioned above. Should it have been? What role should this symmetry play in market demand functions? This question also needs to be examined before presenting the new form, for it plays a key role in its formulation.

1. Problems and lessons of the AIDS form.

The AIDS form can be written as an equation for the budget share of good i:

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* Department of Economics, University of Maryland, College Park, MD 20742. I am indebted to the University of Florence, Faculty of Political Science for covering expenses during a research visit which made the completion of this work possible. Maurizio Grassini, Paul Salmon, Rossella Bardazzi, Marco Barnabani, Elena Alonso, and the Inforum staff at the University of Maryland provided the cooperation and encouragement which made working on the project a joy.

$$s_i = a_i + \sum_{j=1}^{n} d_{ij} \cdot \log(p_j) + b_i \cdot \log(y/P) \qquad (1)$$

where s_i is the budget share of product i, p_j is the price of product j, y is nominal income and P is an overall price index, the matrix of d's is symmetric and has zero row and column sums, the sum of all the a_i is 1, and the b_i sum to zero. Consequently, if any b_i is positive, then one or more others must be negative. Thus *increasing real income must ultimately drive the consumption of one or more goods negative*, unless, of course, it has no effect at all on budget shares. This property seems rather less than "ideal". Moreover, the partial derivative of the share with respect to real income is independent of the relative prices, whereas common sense suggests that it should depend on them. Because of these properties, the AIDS form, while possibly "almost ideal" from some point of view, is surely absolutely inadequate for use in any growth model. Since it is derived from utility maximization, it also serves, as already said, as a clear warning that the mere fact of such ancestry is no assurance whatsoever of the adequacy of a form. Perhaps there is also in the AIDS story a lesson for modesty in naming a form, a lesson which has been heeded in naming the "PADS" form proposed here.

A number of other forms derived from utility maximization were reviewed in the Almon cited and found wanting relative to the simple properties set out above. The only study which to my knowledge has estimated these forms, AIDS, and the Almon form all on the same data and compared the results is Gauyacq [1985]. Using French data for 1959-1979, he estimated "the linear expenditure system of Stone; the model with real prices and income of Fourgeaud and Nataf; the additive quadratic model of Houthakker and Taylor; the logarithmically additive model of Houthakker, ... the Rotterdam model of Theil and Barten, the Translog model based on a logarithmic transformation of the utility function; the AIDS model of Deaton and Muellbauer; .... [and] the model proposed by Clopper Almon." The conclusion was not surprising to anyone who had compared the properties of the forms to the simple requirements stated above: "De l'étude que nous avons effectué, il apparaît en définitive que seul le modèle de C. Almon constitue un système que satisfasse approximativement aux attendus théoriques et présente un réel intérêt pour l'étude économétrique de fonctions de demande détaillées." (p. 119). (From the study which we have done, it appears that definitely only the model of C. Almon offers a system which satisfies approximately theoretical expectations and is of real interest for the econometric study of detailed demand functions.) Elegant theoretical derivations, apparently, are of little help in finding adequate forms. Despite this relative success, there is a problem with the Almon suggestion, as we will see in section 3, where we will also see a way to fix it.

2. Slutsky Symmetry and Market Demand Functions

Just about the only non-obvious implication of the theory of the single consumer who maximizes utility subject to a budget constraint is the Slutsky symmetry shown in equation (2).

$$\frac{\partial x_i^k}{\partial p_j} + \frac{\partial x_i^k}{\partial y^k} \cdot x_j^k = \frac{\partial x_j^k}{\partial p_i} + \frac{\partial x_j^k}{\partial y^k} \cdot x_i^k \qquad (2)$$

Here x_i^k is the consumption of product i by individual k, y^k is the nominal income of individual k, and p_j is the price of product j. A comparable relation, however, need not hold for the market demand functions, the sum over all k of individuals' demand functions. Summing the above equation over the individuals gives equation (3),

$$\frac{\partial \sum_k x_i^k}{\partial p_j} + \sum_k \frac{\partial x_i^k}{\partial y^k} \cdot x_j^k = \frac{\partial \sum_k x_j^k}{\partial p_i} + \sum_k \frac{\partial x_j^k}{\partial y^k} \cdot x_i^k \qquad (3)$$

which is in general not the same as -- and does not imply -- equation (4),

$$\frac{\partial \sum_k x_i^k}{\partial p_j} + \frac{\partial \sum_k x_i^k}{\partial \sum_k y^k} \cdot \sum_k x_j^k = \frac{\partial \sum_k x_j^k}{\partial p_i} + \frac{\partial \sum_k \partial x_j^k}{\partial \sum_k y^k} \cdot \sum_k x_i^k \qquad (4)$$

which is what Slutsky symmetry of the market demand functions would imply. Thus, strict micro theory does not imply Slutsky symmetry of market demand functions. Consequently, there is in general no "representative consumer." To suppose that market demand functions derived by maximizing the utility of this non-existent entity have "micro foundations" not enjoyed by functions not so derived is hardly respectful of micro theory. Rather, any market demand functions so derived are on exactly the same theoretical footing as market demand functions made up without any reference to utility maximization. Both kinds of functions must meet the same "adequacy" criteria.

With that point clearly established, we may, however, ask Are there restrictive conditions under which equation (3) would imply equation (4)? One condition is, of course, that all individuals should have not only the same utility function but also the same income, and that the increase in aggregate income is accomplished by giving each the same increase. That condition is hardly interesting for empirical studies. A less restrictive condition is that the marginal propensity to consume a given product with respect to income should be the same for all individuals, or in effect, that the Engel curves for all products should be straight lines. If, for example,

$$\frac{\partial x_i^k}{\partial y^k} = a_i \qquad (5)$$

then the second term on each side of equation (3) can be factored to yield

$$\frac{\partial \sum_k x_i^k}{\partial p_j} + a_i \cdot \sum_k x_j^k = \frac{\partial \sum_k x_j^k}{\partial p_i} + a_j \cdot \sum_k x_i^k \qquad (6)$$

This is exactly what equation (4) states, for in this case it makes no difference to whom the "infinitesimal" increase in income is given and

$$\frac{\partial \sum_k x_i^k}{\partial \sum_k y^k} = a_i \ . \tag{7}$$

Now the assumption that all Engel curves are straight lines is generally contradicted by cross-section budget studies, even when one uses total expenditure in place of income in the Engel curves. (See, for example, Chao [1991] where Figure 2.2 shows Engel curves for 62 products). On the other hand, many products have virtually straight Engel curves over a considerable middle range of total expenditure where most households find themselves. Thus, one gets the impression that while Slutsky symmetry is certainly not a necessary property of market demand curves, *it probably does no great violence to reality to impose symmetry to reduce the number of parameters to be estimated.*

3. A Perhaps Adequate Form

The 1979 Almon article introduced a form with a multiplicative relation between the income terms and the price terms. Its general form is:

$$x_i(t) = (a_i(t) + b_i(y/P)) \prod_{k=1}^{n} p_k^{c_{ik}} \tag{8}$$

where the left side is the consumption *per capita* of product i in period t and $a_i(t)$ is a function of time. The b_i is a positive constant. The y is nominal income *per capita*; $_kp$ is the price index of product k; P is an overall price index defined by

$$P = \prod_{k=1}^{n} p_k^{s_k} \tag{9}$$

where s_k is the budget share of product k in the period in which the price indexes are all 1, and the c_{ik} are constants satisfying the constraint

$$\sum_{k=1}^{n} c_{ik} = 0. \tag{10}$$

Any function of this form is homogeneous of degree 0 in all prices and income and satisfies all of the properties set out in the first paragraph. It has three problems:

1 It is not certain that expenditures will add up to income.

2 There is no way to choose the parameters to guarantee Slutsky symmetry *at all prices* if we want to. We can, however, arrange to have symmetry in some particular base period. As long as the shares of various products in total expenditure do not change very much from those of that base period, we will continue to have approximate symmetry.

3 There are a lot of c's to be estimated.

Problem 1 can be easily fixed by adding on a "spreader," that is, by summing all expenditures, comparing them with *y*, and allocating the difference in proportion to the marginal propensities to consume with respect to *y* at the current prices. The amount to be spread is usually small and the form with a spreader has essentially the same properties as the form without, plus the adding up property. We need not complicate the mathematics here by adding the spreader, but in practice it should be added when the equations are used in modeling.

Problem 2, in view of section 2, is more a cautionary note than a real problem. Symmetry in a base year is probably quite adequate.

Problem 3 -- which occurs in all forms which provide for varying degrees of substitution and complementarity -- can be quite severe. If we have 80 categories of expenditures, we have 6,400 c's less the 80 determined by equation (10). If we have 20 years of annual data, we have 1,600 data points from which to determine these 5,600 parameters, or 3.5 parameters per data point! Clearly, we have to have employ some restrictions. Even if we had only one parameter per data point, we would probably want restrictions to insure reasonableness of the parameters. Indeed, the principal theoretical problem in consumption analysis is to find ways to specify what is "reasonable."

Part of the solution of problem 3 can be found, if we wish, in the point noted in problem 2, namely that we can impose Slutsky symmetry at some prices. The Slutsky condition may be derived either from equation (2) or, more simply, by assuming that the compensating change in income is that which keeps *y/P* constant. Either approach gives as the symmetry condition equation (11):

$$c_{ij} \cdot x_i / p_j = c_{ji} \cdot x_j / p_i \tag{11}$$

Multiplying both sides by $p_i p_j / y$ gives equation (12).

$$c_{ij} / s_j = c_{ji} / s_i \tag{12}$$

If we then define

$$\lambda_{ij} = c_{ij} / s_j \tag{13}$$

then the form can be written as

$$x_i(t) = (a_i(t) + b_i(y/P)) \prod_{k=1}^{n} p_k^{\lambda_{ik} s_k} \tag{14}$$

where

$$\lambda_{ij} = \lambda_{ji}. \tag{15}$$

This restriction cuts the number of parameters by a half. That reduction is a big help but is clearly insufficient.

Further help with this problem can be found through the idea of groups and subgroups of commodities. The side box shows an example with fifteen basic commodity categories. These are subdivided into three groups and several categories which are not in any group. The first group is divided into two subgroups; the second, into one subgroup and a category not in the subgroup; the third group has no subgroup.

The idea of the Almon [1979] article was to assume that $\lambda_{ij} = \lambda_o$ if i and j are not members of the same group or subgroup, while if they are in the same group, G, $\lambda_{ij} = \lambda_o + \mu'_G$, and if they are in the same subgroup, g, of the group G, $\lambda_{ij} = \lambda_o + \mu'_G + \nu'_g$. Thus, there were as many parameters to estimate as there were groups + subgroups + 1. Estimation was fairly simple because, given a value of λ_o, estimation of the other parameters had to involve only products within the same group or subgroup. Several values of λ_o were chosen, all equations estimated, and the value of λ_o chosen which gave the best over-all fit.

The problem with this form was that products which had no natural partners with which to form a group all ended up either in very strange groups or, if they were given no group at all, all with nearly the same own price elasticity, namely $-\lambda_o$. It is often difficult to find groups for such goods as Telephone service, Medical service, Education, or Religious services. A specification which forces them all to have, for that reason, nearly the same own price elasticity is certainly inadequately flexible.

Illustration of Groups and Subgroups

Group	Product Subgroup	
	1.	Meat
I		A
	2.	Fish
I		A
	3.	Dairy products
I		A
	4.	Cereal products
I		B
	5.	Fruits and vegetables
I		B
	6.	Other food products
I		B
	7.	Automobiles
II		C
	8.	Gasoline and oil
II		C
	9.	Tires, batteries, repair
II		C
	10.	Public transportation
II		
	11.	Clothing
III		
	12.	Shoes
III		
	13.	Other durables
	14.	Other non-durables

An adequate form, it now seems, should allow every product to have its own own-price elasticity. We will then have as many price-exponent parameters as there are products plus groups plus subgroups. A simple way to achieve this generalization is to introduce n parameters, λ_1, ..., λ_n, and use them to define the λ_{ij} as follows. If i and j are not members of the same group or subgroup, then

$$\lambda_{ij} = \lambda_i + \lambda_j \tag{16}$$

while if they are in the same group, G, $\lambda_{ij} = \lambda_i + \lambda_j + \mu'_G$, and if they are in the same subgroup, g, of the group G, $\lambda_{ij} = \lambda_i + \lambda_j + \mu'_G + \nu'_g$. The definitions apply only for i not equal to j. The λ_{ii} are each determined by equation (10), the homogeneity requirement.

Using these definitions, for product i, a member of group G and subgroup g, the equation becomes

$$x_i(t) = (a_i(t) + b_i(y/P)) \prod_{k \neq i}^{n} p_k^{(\lambda_i + \lambda_k) s_k} \prod_{k \in G,\, k \neq i} p_k^{s_k \mu'} \prod_{k \in g,\, k \neq i} p_k^{s_k \nu'} \cdot p_i^{c_{ii}} \tag{17}$$

Equation (10) requires

$$\sum_{k \neq i} \lambda_k s_k + \lambda_i \sum_{k \neq i} s_k + \mu'_G \sum_{k \in G,\, k \neq i} s_k + \nu'_g \sum_{k \in g,\, k \neq i} s_k + c_{ii} = \tag{18}$$

If we solve this equation for c_{ii} and substitute in equation (17), we obtain, after a bit of simplification,

$$x_i(t) = (a_i(t) + b_i(y/P))(p_i/P)^{-\lambda_i} \prod_{k=1}^{n} (p_k/p_i)^{\lambda_k s_k} \left(\prod_{k \in G} (p_k/p_i)^{s_k} \right)^{\mu'_G} \left(\prod_{k \in g} (p_k/p_i)^{s_k} \right)^{\nu'_g} \tag{19}$$

where we have inserted the terms involving p_i/p_i into all of the products, because this term is always 1.0 no matter to what power it is raised. We can make the form even simpler by introducing price indexes for the group G and subgroup g defined by

$$P_G = \left(\prod_{k \in G} p_k^{s_k} \right)^{1/\sum_{k \in G} s_k} \quad \text{and} \quad P_g = \left(\prod_{k \in g} p_k^{s_k} \right)^{1/\sum_{k \in g} s_k} \tag{20}$$

We then obtain simply equation (21)

$$x_i(t) = \left(a_i(t) + b_i(y/P)\right) \cdot \left(\frac{p_i}{P} \right)^{-\lambda_i} \prod_{k=1}^{n} \left(\frac{p_i}{p_k} \right)^{-\lambda_k s_k} \cdot \left(\frac{p_i}{P_G} \right)^{-\mu_G} \left(\frac{p_i}{P_g} \right)^{-\nu_g} \tag{21}$$

where

$$\mu = \mu' \sum_{k \in G} s_k \quad \text{and} \quad \nu = \nu' \sum_{k \in g} s_k \tag{22}$$

This is the form for estimation. Note that it has one parameter, a λ, for each good, plus one parameter, a μ, for each group, plus one parameter, a ν, for each subgroup. Thus, it appears to have an adequate number of parameters. The Slutsky symmetry of (21) at the initial prices and income may be verified directly by taking partial derivatives of (21).

A special case of historical interest arises when all the λ_i are the same and equal to $\lambda_o/2$, for in that case equation (21) simplifies to

$$x_i(t) = \left(a_i(t) + b_i(y/P)\right) \cdot \left(\frac{p_i}{P}\right)^{-\lambda_o} \left(\frac{p_i}{P_G}\right)^{-\mu_G} \left(\frac{p_i}{P_g}\right)^{-\nu_g} \tag{23}$$

which is exactly the form suggested in the Almon [1979] article. Thus, the present suggestion is a simple generalization of the earlier one.

In practice, there are apt to be a few commodities, such as Tobacco, Sugar, or Medical care which show so little price sensitivity that they cannot be fit well by this system. For them, we will assume that all the λ_{ij} in their rows and columns are 0. Note that this assumption is perfectly consistent with the symmetry of the lambda's. When there are such "insensitive" commodities in the system, equation (21) is modified in two ways. For these items, there are no price terms at all, while for other items the product term which in (21) is shown with k running from 1 to n is modified so that k runs only over the "sensitive" and not the "insensitive" commodities.

It is useful in judging the reasonableness of regression results to be able to calculate the compensated own and the cross price elasticities. ("Compensated" here means that y has been increased so as to keep y/P constant.) Their derivation is straight-forward but complicated enough to make the results worth recording. In addition to the notation already introduced, we need

u_{ij} = the share in the base year of product j in the group which contains product i, or 0 if i is not in a group with j.

w_{ij} = the share in the base year of product j in the subgroup which contains product i or 0 if i is not in a subgroup with j.

μ_i = the μ for the group which contains product i, or 0 if i is not in a group. (Note that μ_i is the same for all i in the same group.)

ν_i = the ν for the subgroup which contains product i, or 0 if i is not in a subgroup. (Similarly, note that η_i is the same for all i in the same subgroup.)

L = The share-weighted average of the λ_i:

$$L = \sum_{k=1}^{n} \lambda_k s_k \tag{24}$$

The compensated own price elasticity of product i is then

$$\eta_{ii} = -\lambda_i(1-s_i) - L + \lambda_i s_i - \mu_i(1-u_{ii}) - \nu_i(1-w_{ii}) \tag{25}$$

while the cross price elasticity, the elasticity of the demand for good i with respect to the price of good j, is

$$\eta_{ij} = \lambda_i s_j + \lambda_j s_j + u_{ij}\mu_i + w_{ij}\nu_i \tag{26}$$

Two tables are produced by the estimation program. One shows, for each product, its share in total expenditure in the base year, the group and subgroup of which it is a member and its share in them,

its λ and the μ and ν of its subgroups, its own price elasticity, and various information on the income parameters. Thus, it contains all the data necessary for calculating any of the cross elasticities. It is small enough to be reasonably reproduced. The other table shows the complete matrix of own and cross elasticities. It is generally too large to be printed except in extract.

It should be noted that the complexity in estimating equation (21) comes from the term indicated by the product sign. Without this term, the equation could be estimated separately for each product or group of products. On the other hand, it is this term which gives Slutsky symmetry at the base point. If one did not care about this symmetry, then this term could omitted from the equation, with a great reduction in complexity in estimation. Once the programming has been done to estimate with this term, however, it is little trouble to use the program.

So far, we have said little about the "income" term, the term within the first parenthesis of equation (21). In the equations reported below we have used just a constant, real income per capita, the first difference of real income per capita, and a linear time trend. Furthermore, we have used the same population measure, total population, for computing consumption per capita for all items. The estimation program, however, allows much greater diversity. By use of adult-equivalency weights, different weighted populations can be used for computing the per capita consumption of different items. Further, if the size distribution of income is known, it can be used to compute income-based indicators of consumption more appropriate to each item than just average income. Thus, the program allows a different income variable to be used for each consumer category. Finally, instead of just a linear time trend, one can use a "trend" variable appropriate to a particular category. For example, the percentage of the population which smokes could be used in explaining spending on tobacco. The estimation program allows for all these possibilities. On the other hand, in view of this diversity, it seemed pointless to try to place constraints on the parameters of the income terms to make the income terms add up to total income. Instead, in applying the estimated functions, one should calculate the difference between the assumed total expenditure and that implied by the equations and allocate it to the various items.

4. The Mathematics of Estimation

The function in equation (21) is nonlinear in all its parameters. In a system with 80 consumption categories there will be over 400 parameters involved in the simultaneous non-linear estimation. This size makes it worthwhile to note in this section some simplifying structure in the problem. All non-linear estimation procedures take some guess of the parameters, evaluate the functions with these values to obtain vectors of predicted values, $\hat{x}_i$, and subtract these from the vectors of observed values, x_i, to obtain vectors of residuals, r_i, thus:

$$r_i = x_i - \hat{x}_i$$

They then, in some way, pick changes in the parameters, and re-evaluate the function with the new values. The only difference in the various methods lies in how the changes in the parameters are picked. The Marquardt algorithm, which we use, is very nearly the same as regressing the residuals on the partial derivatives of the predicted values with respect to the parameters. It requires, in

particular, these derivatives. For equation (21), they are reasonably easy to calculate if one remembers the formula from the table of derivatives:

$$\frac{d\,a^{x}}{dx} = a^{x} \ln a \tag{28}$$

where ln denotes the natural logarithm. Then for the derivative of the demand for the i[th] good with respect to its own lambda is

$$\frac{\partial \hat{x}_i}{\partial \lambda_i} = \hat{x}_i \left(\ln \left(\frac{\prod p_i^{s_k}}{p_i} \right) \right) = \hat{x}_i \left(\sum s_k \ln p_k - \ln p_i \right) \tag{29}$$

and for j not equal to i

$$\frac{\partial \hat{x}_i}{\partial \lambda_j} = \hat{x}_i \ln \left(\frac{p_j}{p_i} \right) s_j = \hat{x}_i \left(\ln p_j - \ln p_i \right) s_j \tag{30}$$

and if i is a member of the group G

$$\frac{\partial \hat{x}_i}{\partial \mu_G} = \hat{x}_i \ln \left(\frac{P_G}{p_i} \right) = \hat{x}_i \left(\ln P_G - \ln p_i \right) \tag{31}$$

and if further i is a member of the subgroup g

$$\frac{\partial \hat{x}_i}{\partial \nu_g} = \hat{x}_i \ln \left(\frac{P_g}{p_i} \right) = \hat{x}_i \left(\ln P_g - \ln p_i \right) \tag{32}$$

To explain the estimation process, we shall denote the vector of parameters of the "income-and-time term," the term preceding the first dot in equation (21), for product i by $\mathbf{a_i}$ and the vector of parameters of the "price term", the rest of the formula, by **h**. Thus, **h** consists of all values of λ, μ, and ν. Note that **h** is the same for all products, though a particular μ or ν may not enter the equation a given commodity. If we let $\mathbf{A_i}$ be the matrix of partial derivatives of the predicted values for product i with respect to the $\mathbf{a_i}$ and similarly let $\mathbf{B_i}$ be the matrix of partial derivatives of the predicted values of product i with respect to **h**, and finally let $\mathbf{r_i}$ be the residuals, all evaluated at the current value of the parameters, then the regression data matrix, (X,y) in the usual notation, for three commodities is:

$$(X, y) = \begin{pmatrix} A_1 & 0 & 0 & B_1 & r_1 \\ 0 & A_2 & 0 & B_2 & r_2 \\ 0 & 0 & A_3 & B_3 & r_3 \end{pmatrix} \tag{33}$$

If we now form the normal equations, X'Xb = X'y in the usual notation, we find

$$\begin{pmatrix} A_1'A_1 & 0 & 0 & A_1'B_1 \\ 0 & A_2'A_2 & 0 & A_2'B_2 \\ 0 & 0 & A_3'A_3 & A_3'B_3 \\ B_1'A_1 & B_2'A_2 & B_3'A_3 & \sum_{i=1}^{3} B_i'B_i \end{pmatrix} \begin{pmatrix} da_1 \\ da_2 \\ da_3 \\ dh \end{pmatrix} = \begin{pmatrix} A_1'r_1 \\ A_2'r_2 \\ A_3'r_3 \\ \sum_{i=1}^{3} B_i'r_i \end{pmatrix} \tag{34}$$

After initial values of the parameters have been chosen and the functions evaluated with these values and the sum of squared residuals (SSR) calculated, the Marquardt procedure consists of picking a scalar, which we may call M, and following these steps:

1. Compute the matrices of equation 34, multiply the diagonal elements in the matrix on the left by 1 + M and solve for the changes in the $\mathbf{a}_i$ and **h** vectors. Make these changes and evaluate the functions at the new values.

2. If the SSR has decreased, divide M by 10 and repeat step 1.

3. If the SSR has increased, multiply M by 10, go back to the values of the parameters before the last change, evaluate the functions again at these values, and repeat step 1.

The process is stopped when very little reduction in the SSR is being achieved and the changes in the parameters are small. (As M rises, the method turns into the steepest descent method, which can usually find a small improvement if one exists, while as M diminishes, the method turns into Newton's method, which gives rapid convergence when close enough to a solution that the quadratic approximation is good.)

To economize on space in the computer and to speed the calculations, we can take advantage of the structure of the matrix on the left side of equation (34). To do so, let $\mathbf{Z}_i$ be the inverse of $\mathbf{A}_i'\mathbf{A}_i$. Then by Gaussian reduction (34) can be transformed into

$$\begin{pmatrix} I & 0 & 0 & Z_1A_1'B_1 \\ 0 & I & 0 & Z_2A_2'B_2 \\ 0 & 0 & I & Z_3A_3'B_3 \\ 0 & 0 & 0 & \sum_{i=1}^{3} B_i'B_i - B_i'A_iZ_iA_i'B_i \end{pmatrix} \begin{pmatrix} da_1 \\ da_2 \\ da_3 \\ dh \end{pmatrix} = \begin{pmatrix} Z_1A_1'r_1 \\ Z_2A_2'r_2 \\ Z_3A_3'r_3 \\ \sum_{i=1}^{3} B_i'r_i - B_i'A_iZ_iA_i'r_i \end{pmatrix} \tag{35}$$

The columns of the matrix on the left which are just columns of the identiy matrix do not need to be stored in the computer. Instead, the program computes the terms in the last column of this matrix and in the vector on the right, stores only them, and at the same time builds up the sums in the lower

right corner of the matrix and in the bottom row of the vector on the right. Once the matrix and vector of equation (35) are ready, the program solves the equations in the last row for **dh** and then substitutes back into the other equations to solve them for the $\mathbf{da}_i$.

The estimation program initializes the income parameters by regressing the dependent variables on the just the constant, income, and trend terms. Then all lambda's are started at .25 and all mu and nu at 0. The program was written in Borland C++ 4.5 with DOS extender and with a double-precision version of the BUMP library of matrix and vector objects and operators. The time required to do the estimation seems to be roughly proportional to the fourth power of the number of sectors. The work of evaluating the B matrices and taking B'B grows roughly with the cube of the number of sectors, so the time required for a single iteration grows with the cube of the number of sectors. The number of iterations, however, seems to grow at least linearly with the number of sectors, so the total time required should grow with the fourth power of the number of sectors. Thus, a 90-sector study can be expected to take about 16 times as long to estimate as a 45-sector study. This is roughly what we have experienced, with a 93-sector USA system requiring about 100 minutes while a 42-sector Spanish study took only five or six minutes on a 133 MHz pentium. The USA study required about 120 iterations. The big drops in the objective function started to appear after about 80 iterations.

5. Comparative estimation for France, Italy, Spain, and the USA

To test how adequate this system is for representing the consumer behavior in a variety of countries, it has been estimated for France, Italy, Spain, and the USA. At the same time, so that the results would tell us something about the similarities and differences among these countries, the categories have been a been made as similar as possible. The categories, the groups, and the sub-groups are shown in the table below.

I. Food group
A. Protein source subgroup
2 Meat
3 Fish & seafood
4 1 Dairy products
1 Cereal and bakery products
5 Fats & oils
6 Fresh fruit
7 Fresh vegetables
8 Sugar & sweets
9 Processed fruit and vegetables
10 Other prepared food, Pet food
11 Nonalcoholic beverages
12 Alcoholic beverages

II. Dress group
14 Clothing and its cleaning and repair
15 Footwear and repair

III. House furnishing and operation group
18 Furniture
19 Floor coverings and textile products
20 Kitchen & hh appliances
21 China & glaswr, tablwr & utensils
22 Other non-durables and services
23 Domestic services
32 TV, radio, audio, musical instruments, computers

IV. Medical group
24 Drug preparations and sundries
25 Ophthalmic & orthopedic eqpt
26 Physicians, dentists, other
27 Hospitals, nursing homes

V. Transportation group
A. Private transportation
28 Vehicles
29 Operation of motor vehicles
30 Public transportation

Ungrouped products
13 Tobacco
16 Tenant occupied nonfrm spac, Water
17 Electricity, oil, gas, coal
31 Communication
33 Books & maps, Magazines and newspapers
34 Education
35 Recreational services
36 Personal care
37 Hotels & motels, restaurants
38 Other goods
39 Financial services and insurance
40 Other services

Extra American sectors not in European accounts
41 Food furnished employees and food on farms
42 Owner-occupied housing
43 Foreign travel
44 Imputed financial services

In using the word "test," I should make clear that I do not mean any sort of test of statistical "significance," which I regard as essentially meaningless here. The test is rather to see whether the system is flexible enough to fit the historical data *with plausible values of the parameters*. Moreover, it is not a test to see whether the program can find those reasonable values from the data alone. Whether or not that is possible depends upon what range of experience history has given us. It is often necessary to tell the program what values are plausible by soft constraints. The details of how that has been done are described in Appendix A on using the program.

The Italian and Spanish data were for forty categories of consumer expenditures, most of them being exactly comparable. The French data were more detailed but were clearly based on the same

statistical concepts and could be aggregated to match the Spanish and Italian. The three European datasets showed that the statisticians who had prepared them had been talking to one another and had achieved some degree of comparability. No such fundamental comparability infected the U.S. data. It was, however, available in much more detail than was the European, and in most cases, it was possible to match the European concept -- as I understand it from the words in the definition -- fairly closely. There were a few exceptions among foods. The Europeans had the following sectors:

6 Fruits and vegetables, except potatoes
7 Potatoes
9 Coffee, tea, and cocoa

I could not match these with U.S. data but made up three sectors which at least kept the numbering the same for the other sectors. They were

6 Fresh fruit
7 Fresh vegetables
9 Processed fruits and vegetables

In the U.S. sectors, coffee, tea, and cocoa are in sector 10, Other prepared food.

Other known noncomprabilities included the Italians having no sector for Education but only one for text books, while the Spanish did not attempt to divide "all-included" vacation packages between Transportation and Hotels and restaurants though the others did. Finally, the U.S. has four categories which have no corresponding component in the European accounts. First, and largest, is the imputed space-rental value of owner-occupied housing, which is seemingly not in the Standard National Accounts (SNA) used by the Europeans. Second is Services rendered without payment by financial intermediaries (e.g. free checking accounts). The existence of these services is recognized by the SNA, but the European statistical offices (incorrectly) consider that all of these services are rendered to businesses, and thus appear in the intermediate part of the input-output table and do not enter GDP. Foreign travel shows up elsewhere in the European accounts and was not among the data series I had. Finally, Food furnished employees or eaten on farms seems not to be part of the European system or appears directly in the various food categories. These extra sectors account for about 15 percent of American consumption. Within the forty more or less comparable sectors, the share of the American sectors in total consumption will average about 15 percent below the European.

The regressions were run from 1971 to 1994 (1993 for France.) It quickly became apparent that nearly all of the histories could be fit well, but often one or more of the parameters would have nonsense values. The income elasticity might turn out negative while there was a strong positive time trend. The own price elasticities, which should be negative, frequently turned out positive, perhaps at the same time that the income elasticity was negative. In short, the data were insufficiently varied to identify well the parameters. Fortunately, the program used for the estimation (our creation) allowed for imposing "soft" constraints, which are essentially extra, artificial observations designed to tell the computer, before the estimation, what would be sensible regression coefficients. By using soft constraints, it is often possible to find equations with sensible coefficients which fit almost as well as the unconstrained equation. Except in Spain, where there was a drop in income in the mid 1980's before entry into the Common Market, time and income were

very collinear, and it was necessary to softly constrain the time variable to be close to zero, though not exactly zero. In Spain, there was also a very soft constraint suggesting that the time trend coefficient should be small, but it was softer than in the other countries and consequently stronger time trends appear in the Spanish equations than in the others. In cases of products which evidently had strong time trends in tastes, such as fats and oils or tobacco, the soft constraint on the time trend was removed. Of course, the fact that soft constraints were used which were not identical in the different countries may reduce the comparability of the results. But it also shows that the system can be adapted to the situation in different countries.

Before commenting on the individual products, let us look at the results for the group parameters, as shown below.

	:		μ			:	ν	
	: food	dress	house	med	trans	:	protein	car
USA	: 0.25	0.96	-0.23	-0.26	0.06	:	-0.05	-0.54
Italy	:-0.02	1.83	0.70	0.33	0.02	:	0.09	0.48
Spain	: 0.12	-0.34	0.21	0.00	0.07	:	0.20	-0.28
France	: 0.61	0.15	0.77	-1.36	0.07	:	0.57	-0.51

The components of the Food group did indeed turn out to be substitutes in the USA, Spain, and, especially, France. The protein sources were especially strong substitutes with one another in France and less so in Spain and Italy. In the USA, their special interaction was in the direction of complementarity. Buying cars and operating them were decidedly complements in the USA, Spain, and France, but were rather strongly substitutes in Italy. The Italians may not, however, be totally crazy; automobile repair and new cars may indeed be substitutes. Shoes and Clothing turn out to be strongly substitutes in the USA and Italy, weak substitutes in France, and complements in Spain. The household furnishing and operating sectors showed considerable interaction, but were complements in America and substitutes in Europe. The medical sectors were complements in America and France and weakly substitutes in Italy. There is little interaction between public and private transportation in any of the countries.

Examining the individual sectors shows many interesting differences as well as some basic similarities among the countries. For each product, we will show the results of estimation for all four countries. The order of lines in these mini tables is USA, Italy, Spain, France. The sector titles have been left in the original language both to indicate the country and to describe as exactly as possible the content. On each line in the mini-tables for each product, you will find:

nsec	the sector number
title	the title of the product group in the language of the country
G	the number of the group in which the product is included. A 0 indicates that it was not in a group.
S	the number of the product's subgroup. A 0 means that it was not in a subgroup.
I	inclusion code: 1 if the product was included in the estimation of the system, otherwise 0.
lamb	the value of lambda, λ, for this product.

share the share of this product in total consumption in the base year, the year when all the prices were equal to 1. Unfortunately for purposes of comparison of these shares, the base years were different: 1992 for the USA, 1988 for Italy, 1986 for Spain, and 1980 for France. These differences should have little effect on comparability except on these shares.

IncEl The income elasticity, the percentage by which purchases of this item increase when income increases one percent.

Dinc The ratio of the coefficient on the change in income to the coefficient on income.

time% the change in demand for the product due to the passage of one year (without change in income or price) expressed as a percentage of the average purchase.

PrEl the elasticity of demand for the product with respect to its own price.

Err% Standard error of estimate expressed as a percentage of the average value.

rho Autocorrelation of the residuals.

The commentary on each group also reflects looking at the graph of the fit in each country for each product. These graphs are, unfortunately, too space-intensive to print.

We start with the staff of life.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
1	Cereal and bakery produ	1	0	1	0.18	0.013	0.18	-0.60	0.01	-0.55	4.33	0.80
1	Pane e cereali	1	0	1	0.06	0.024	0.13	-1.59	0.00	-0.12	1.56	0.74
1	Pan y cereales	1	0	1	-0.12	0.026	0.18	-0.17	-0.26	-0.02	2.53	0.61
1	Pain et cereales	1	0	1	0.05	0.024	0.45	-0.03	0.00	-0.69	1.44	0.49

The Food group holds some striking similarities among the countries as well as big differences. *Bread and bakery products* (1) have seen virtually no growth in per capita consumption over the years covered here. Note, however, that the share is nearly twice as high in Europe as in America. The income elasticities, however, do not come out at zero but have been offset in the US and France by significant price elasticities. Italy shows both smaller income elasticities and small price elasticity, while in Spain the income elasticity comes out the same as that in the US but is offset by a negative trend of half a percent per year. The higher income elasticity in France may reflect the attractiveness of real croissants, brioche, and the like.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
2	Meat	1	1	1	-0.16	0.018	0.03	0.47	-0.20	-0.19	3.98	0.74
2	Carne	1	1	1	0.05	0.056	0.23	2.00	0.00	-0.15	2.78	0.81
2	Carne	1	1	1	0.01	0.066	0.49	-1.00	-0.13	-0.21	2.94	0.50
2	Viandes	1	1	1	-0.80	0.062	0.54	0.00	0.00	-0.04	1.89	0.81

Only Spain has seen any noticeable growth in *Meat* (2) demand since 1980. It showed an income elasticity of .5 as did France, but Spain has had greater income growth. Both the US and Italy have very low income elasticities, though Italy has a positive "taste" term, while the US and Spain both show negative "taste" trends.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
3	Fish & seafood	1	1	1	1.78	0.002	1.17	-0.07	-0.20	-2.12	8.90	0.52
3	Pesce	1	1	1	0.01	0.013	0.89	0.20	0.00	-0.15	4.17	0.83
3	Pescado	1	1	1	-0.02	0.024	0.35	-0.13	-0.34	-0.27	4.45	0.80
3	Poissons	1	1	1	0.00	0.008	1.58	0.11	0.00	-1.22	5.19	0.65

In striking contrast to Bread and Meat, *Fish and seafood* (3) shows strong income elasticities, above 1.0 in the USA, Italy, and especially France. Fish is definitely the food of the affluent in these

countries, while it definitely is not in Spain, where consumption has declined steadily as income rose. Note, however, that the share of fish in the budget of Pedro was twice that of Pietro, three times that of Pierre, and twelve times that of Peter.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
4	Dairy products	1	1	1	-0.01	0.008	0.11	-0.13	-2.35	-0.34	6.53	0.70
4	Latte, formaggi	1	1	1	0.07	0.029	0.48	0.64	0.00	-0.20	1.97	0.69
4	Leche, queso y huevos	1	1	1	-0.10	0.033	0.07	-0.33	0.86	-0.18	3.68	0.79
4	Lait fromages et oeufs	1	1	1	0.04	0.025	0.83	0.04	0.00	-1.11	3.86	0.82

When it comes to *Milk and dairy products* (4), the US is the outlier. The European countries, where consumption runs from 2.5 to 3.3 percent of the total budget, have been increasing consumption steadily, while the USA is cutting back sharply from its already low share of .8 percent. The equation for France attributes the growth to income, the Spanish and Italian equations, more to taste trends. One may say that the American concern about cholesterol has not penetrated the European mind, or one may say that the American cheese industry has never approached the European in placing temptation in front of the consumer.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
5	Fats & oils	1	0	1	-0.08	0.002	0.06	-0.14	-0.37	-0.32	6.84	0.66
5	Oli e grassi	1	0	1	-0.04	0.008	0.07	2.43	-0.04	-0.03	2.85	0.73
5	Aceites y grasas	1	0	1	-0.08	0.011	0.06	-1.05	-0.54	-0.06	2.77	0.72
5	Huiles et graisses	1	0	1	-0.17	0.009	0.10	-0.62	-1.36	-0.53	2.42	0.34

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
6	Fresh fruit	1	0	1	0.15	0.003	0.86	-0.21	-2.48	-0.55	6.35	0.67
6	Frutta	1	0	1	0.05	0.043	0.26	-0.73	0.00	-0.11	1.64	0.04
6	Frutas y verduras	1	0	1	0.01	0.033	0.44	0.23	-1.04	-0.14	3.38	0.62
6	Fruits et legumes sauf	1	0	1	-0.45	0.025	0.20	0.52	0.00	-0.22	2.70	0.74

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
7	Fresh vegetables	1	0	1	0.12	0.004	0.93	-0.20	-1.82	-0.52	8.96	0.77
7	Patate	1	0	1	-0.05	0.002	0.18	0.62	-0.01	-0.01	3.45	0.23
7	Patatas y tubérculos	1	0	1	-0.05	0.005	0.03	-1.07	-2.35	-0.10	6.60	0.70
7	Pommes de terre et autr	1	0	1	-0.63	0.002	-0.04	-6.46	-1.48	-0.09	7.63	0.67

Fats and oils (5) have uniformly low income elasticities and negative taste trends. *Fruit* has been declining in the US, while *Fruit and vegetables* (6), including canned and frozen, have been rising in Italy and stable in Spain and France. Recall that the sectoral definitions are not comparable here. The rest of the story for the US is found in Fresh vegetables (7), also in gentle decline, and in Processed fruits and vegetables (9), which also fails to show any growth. The total share for the US is 1.3 percent of the budget, only a half or a third of that of the European countries. That low share does not necessarily mean that we consume less than they do of these products. There are at least two other factors: larger total consumption and lower prices on agricultural products. The graphs for *Potatoes* show that the French are rapidly losing their appetite for French fries, as are the Spanish, while the Italians are not.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
8	Sugar & sweets	1	0	1	0.02	0.006	-0.01	2.83	-0.52	-0.41	5.92	0.47
8	Zucchero	0	0	0	0.00	0.003	0.10	7.14	-0.01	0.00	3.32	0.48
8	Azúcar	0	0	0	0.00	0.002	0.09	-0.65	-0.50	0.00	4.32	0.87
8	Sucre	1	0	1	-0.30	0.002	0.09	0.97	-2.83	-0.42	5.11	0.34

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
9	Processed fruit and veg	1	0	1	-0.09	0.006	0.02	-0.27	-0.07	-0.30	6.16	0.86
9	Caffe, te, cacao	1	0	1	-0.03	0.005	0.43	-0.31	0.00	-0.03	2.73	0.67
9	Café, té y cacao	1	0	1	-0.01	0.006	0.03	-1.12	-0.44	-0.14	3.65	0.77
9	Cafe, thé	1	0	1	-0.44	0.006	0.24	-0.43	0.00	-0.27	6.84	0.90

Sugar (8) proved to be a problem in both Italy and Spain and was removed from the system in these two countries. The problem arose from substantial fluctuations in the price which had little effect.

In the US and France, the system had no problem handling the product, and virtually identical price elasticities, -.4, were found. In France, however, there has been a strong trend away from sugar not seen here.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
10	Other prepared food, Pe	1	0	1	-0.05	0.017	1.63	-0.72	0.00	-0.31	4.52	0.79
10	Altri generi alimentari	1	0	1	-0.03	0.006	0.64	-0.85	-0.01	-0.03	5.02	0.79
10	Otros alimentos	1	0	1	-0.02	0.007	0.34	-0.21	0.88	-0.13	2.08	0.71
10	Autres produits aliment	1	0	1	0.06	0.014	1.83	0.08	0.00	-0.74	3.25	0.49

The *Other prepared foods* (10), the sauces, mixes, and just-run-it-in-the-microwave products have shown strong growth. For the USA, Italy, and France the equations attribute this growth to income, because of the aversion to time trends expressed in the soft constraints. In Spain, however, there were greater fluctuations in income and it was easier for the regression to distinguish time from income. It found that the income elasticity was actually fairly low, .34, and used a strong time trend, .9 percent per year, to account for the growth.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
11	Nonalcoholic beverages	1	0	1	0.11	0.009	0.77	1.35	-0.01	-0.50	4.83	0.60
11	Bevande analcoliche	1	0	1	-0.01	0.004	1.58	-1.37	-0.04	-0.05	7.68	0.83
11	Bebidas no alcohólicas	1	0	1	-0.12	0.005	1.12	-0.60	-0.66	-0.03	3.50	0.57
11	Boissons non alcoolisee	1	0	1	0.12	0.004	1.82	0.18	0.01	-0.83	10.11	0.77

The *Soft drink* industry (11), stagnant in this country despite an income elasticity of .8 because of sharp price increases, has boomed in Italy and France, with income elasticity estimates of 1.6 and 1.8, respectively. The Spaniards have not been so easily seduced; they show an income elasticity of 1.1 and a negative time trend of .7 percent per year.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
12	Alcoholic beverages	1	0	1	0.38	0.018	0.03	-0.02	-0.05	-0.73	3.55	0.84
12	Bevande alcoliche	1	0	1	-0.04	0.012	0.01	23.43	-0.90	-0.02	2.80	0.52
12	Bebidas alcohólicas	1	0	1	-0.07	0.014	0.09	4.24	-1.17	-0.08	5.70	0.72
12	Boissons alcoolisees	1	0	1	-0.01	0.024	0.17	-0.07	0.00	-0.64	2.36	0.75

Alcoholic beverage (12) sales have been static in the USA country and France, but declining in Italy and Spain. All countries showed very low income elasticities.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
13	Tobacco	0	0	1	0.33	0.012	0.11	-0.02	-1.20	-0.48	3.16	0.21
13	Tabacco	0	0	0	0.00	0.016	0.03	37.79	1.03	0.00	7.10	0.86
13	Tabacos	0	0	1	0.06	0.016	0.34	-0.65	0.16	-0.09	3.00	0.53
13	Tabac	0	0	1	0.06	0.011	0.93	0.02	0.00	-0.17	2.82	0.76

The sharp decline in the use of *Tobacco* (13) in the USA has no parallel in Europe. In France, it was even rising up until 1992, showing an income elasticity of .93.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
14	Clothing and its cleani	2	0	1	0.00	0.044	1.36	-0.72	0.00	-0.30	1.31	0.46
14	Vestiario incl.riparazi	2	0	1	0.09	0.083	0.88	1.14	0.00	-0.53	2.57	0.64
14	Vestido	2	0	1	0.07	0.064	0.78	0.00	-0.74	0.00	2.97	0.46
14	Habillement sf chaus. y	2	0	1	0.22	0.059	0.15	-0.13	0.00	-0.33	2.16	0.66

One of the surprises for me was the sad story of France in the consumption of *Clothing*(14). I had thought of the French as fashion conscious. Not at all, according to these equations. Clothing accounts for a smaller share in France than in any of the other European countries. The French income elasticity is only .15, against .8 for Spain, 1.4 for the U.S., and .9 for Italy, which has also the highest share of the budget going to clothes. Clearly it is the Italians who are the sartorially conscious nation.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
15	Footwear and repair	2	0	1	0.04	0.008	1.23	-0.03	0.02	-1.00	4.48	0.62
15	Calzature incl riparazi	2	0	1	-0.13	0.022	1.20	1.71	0.00	-1.40	6.28	0.86
15	Calzado	2	0	1	0.14	0.024	1.23	-0.21	-2.96	0.09	2.94	0.35
15	Chaussures y.c.reparat.	2	0	1	0.05	0.014	0.17	-0.32	0.00	-0.28	2.40	0.70

The same story holds for *Footwear* (15). The U.S., Spain, and Italy all came out with an income elasticity of 1.2, while in France it was only .2.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
16	Tenant occupied nonfrm	0	0	1	0.05	0.046	0.98	-0.39	0.00	-0.21	2.20	0.71
16	Affitti per abitazioni	0	0	1	0.00	0.107	1.00	-0.42	0.00	-0.08	1.84	0.77
16	Alquileres y agua	0	0	1	0.03	0.111	0.53	-0.26	0.48	-0.05	6.98	0.96
16	Logement et l'eau	0	0	1	0.02	0.123	1.69	0.05	0.00	-0.12	2.55	0.69

Rent (16) on living quarters has risen steadily in all four countries; the income elasticities are 1.0 in the U.S. and Italy; 1.7 in France; but only .5 in Spain. Rental payments did not fall during the Spanish slump of the early 1980's, so the equation attributes most of the growth to the time trend rather than to income.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
17	Electricity, oil, gas,	0	0	1	-0.11	0.027	0.15	-0.08	0.00	-0.05	2.90	0.56
17	Combust.&energia elettr	0	0	1	-0.01	0.033	0.87	-0.07	0.00	-0.06	3.74	0.70
17	Calefacción y alumbrado	0	0	1	0.01	0.025	0.84	-0.28	2.08	-0.04	1.99	0.56
17	Electricité et combusti	0	0	1	0.00	0.052	0.53	-0.10	0.00	-0.11	3.95	0.45

Energy consumption (17) has been virtually constant in the U.S.; the equation found low income and price elasticities. All three European countries, but especially Spain, have seen significant growth. It is interesting that in Spain, where the equation was given less indication to avoid trend terms than in Italy and France, it used that extra freedom to get virtually the same income elasticity as was found in Italy, attributing the extra growth in Spain to the time trend.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
18	Furniture	3	0	1	-0.03	0.009	1.06	-0.03	-0.01	0.06	4.36	0.49
18	Mobili	3	0	1	0.04	0.028	1.57	0.26	0.00	-0.67	2.79	0.49
18	Muebles	3	0	1	0.08	0.021	1.38	-0.37	-1.95	-0.27	2.85	0.38
18	Meubles, tapis, y.c. re	3	0	1	0.57	0.031	0.43	-0.44	0.00	-1.23	4.67	0.66

The French are again the outlier in demand for *Furniture* (18). Spanish and Italian income elasticities are high and similar, 1.6 and 1.4 respectively; the US is a respectable 1.1; but France is only .4. Clearly the French have other priorities.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
19	Floor coverings and tex	3	0	1	0.06	0.004	1.64	-0.02	-0.17	-0.01	8.43	0.73
19	Biancheria e altri arti	3	0	1	-0.04	0.011	1.42	-0.30	0.00	-0.68	6.98	0.87
19	Artículos textiles	3	0	1	0.00	0.009	1.19	0.38	-1.08	-0.22	5.69	0.80
19	Art. de ménage en texti	3	0	1	0.00	0.007	0.00	-59.48	-0.03	-0.84	3.59	0.54

The story is the same for *Carpets, curtains, and household linens* (19). The French income elasticity is exactly 0, while it is 1.2 to 1.6 for the other three.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
20	Kitchen & hh appliances	3	0	1	0.10	0.005	0.53	-0.06	-0.04	-0.05	5.31	0.65
20	Elettrodomestici	3	0	1	-0.37	0.012	1.14	0.64	0.00	-0.35	2.55	0.44
20	Electrodomésticos	3	0	1	-0.10	0.010	1.64	0.71	-1.27	-0.12	5.30	0.69
20	Ap. de cuis., de chauf.	3	0	1	-0.02	0.016	0.44	-0.31	0.00	-0.76	4.10	0.59

Kitchen and household appliances (20) show a similar pattern, except that both the U.S. and France have income elasticities close to .5, while in Italy and Spain, they are 1.1 and 1.6 respectively.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
21	China & glaswr, tablwr	3	0	1	0.32	0.005	0.74	-0.03	0.08	-0.27	3.47	0.64
21	Cristallerie,vasellame	3	0	1	-0.66	0.006	1.02	0.21	-0.03	-0.10	3.28	0.61

21 Utensilios domésticos	3	0	1	0.04	0.005	0.17	-0.38	-1.65	-0.27	9.62	0.82
21 Verrerie, vaisselle et	3	0	1	-0.01	0.015	0.41	-0.17	0.00	-0.78	2.41	0.47

It is Italians and Americans who care about *China, glassware, and tableware* (21). The French have been particularly sensitive to the rising relative price of these products.

nsec title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
22 Other non-durables and	3	0	1	0.59	0.019	0.52	-0.01	0.00	-0.57	2.05	0.45
22 Art.non dur. e servizi	3	0	1	-0.24	0.011	1.32	-1.92	0.01	-0.49	7.99	0.72
22 Mantenimiento	3	0	1	-0.10	0.015	0.95	0.12	-1.07	-0.11	3.82	0.70
22 Art. de ménage non-dur	3	0	1	0.01	0.018	1.15	0.02	0.00	-0.78	2.08	0.72

nsec title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
23 Domestic services	3	0	1	1.14	0.003	0.84	-0.02	-5.13	-1.08	10.45	0.80
23 Servizi domestici	3	0	1	0.03	0.025	1.44	0.33	0.00	-0.68	6.83	0.89
23 Servicio doméstico	3	0	1	-0.06	0.007	1.10	-1.06	-2.24	-0.17	7.91	0.79
23 Services domestiques	3	0	1	0.01	0.010	0.56	-0.04	0.00	-0.82	5.56	0.75

Domestic service (23) fell steadily in the U.S. from 1950 up to 1981, whereupon it suddenly stabilized and began a slow rise. Strikingly similar patterns appear in Spain and France, with low points in 1986 or 1987. Italy, by contrast, has shown strong growth all along, with an income elasticity of 1.4. All equations except the Spanish showed strong price elasticities.

nsec title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
24 Drug preparations and s	4	0	1	0.08	0.018	1.42	-0.02	0.04	0.00	3.48	0.62
24 Medicinali e prod. farm	0	0	0	0.00	0.022	2.58	-1.01	-0.04	0.00	6.66	0.82
24 Medicamentos	4	0	0	0.00	0.016	3.03	-0.96	-1.42	0.00	15.31	0.84
24 Medicaments et autres p	0	0	1	1.06	0.021	1.50	0.21	0.00	-1.13	7.62	0.70

Medicines (24) have shown explosive growth in Europe. Note that all three European graphs ran off the standard scale. In Italy and France, this sector had to be thrown out of the system. The prices were rising and demand was soaring. Clearly, the problem was that the medicines were being paid for by third parties. The budget constraint had little relevance for the European buying medicine.

nsec title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
25 Opthalmic & orthopedic	4	0	1	0.07	0.003	2.35	-0.02	-0.34	0.02	9.62	0.73
25 Apparecchi e mater. ter	0	0	0	0.00	0.003	1.67	-0.70	-0.06	0.00	4.85	0.82
25 Aparatos terapéuticos	4	0	0	0.00	0.003	1.31	-1.28	0.20	0.00	9.59	0.82
25 Ap. et mat. therapeutiq	0	0	0	0.10	0.002	2.35	0.09	1.94	0.00	8.81	0.75

Similarly, *Ophthalmic and orthopedic devices* (25) could not be accommodated in the system in Italy and France. No price sensitivity but enormous income sensitivity is found in all countries.

nsec title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
26 Physicians, dentists, o	4	0	1	0.00	0.066	1.60	-0.02	0.00	-0.01	4.16	0.76
26 Serv. medici, infermier	4	0	1	0.26	0.024	1.29	-0.09	0.00	-0.44	4.85	0.79
26 Servicios médicos	4	0	0	0.00	0.010	1.80	-0.91	-0.70	0.00	8.58	0.81
26 Serv. des medecins infi	4	0	1	1.73	0.033	1.00	0.07	2.82	-1.25	5.02	0.66

Services of physicians, dentists, and other medical professionals (26) could be handled by the system in all countries. Only France, however, showed strong price sensitivity -- the U.S. showed none.

nsec title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
27 Hospitals, nursing home	4	0	1	0.07	0.063	1.40	-0.57	0.00	-0.07	3.54	0.86
27 Cure in ospedali&clinic	4	0	1	0.09	0.013	0.58	-2.59	0.00	-0.38	3.25	0.41
27 Atención hospitalaria y	4	0	0	0.00	0.006	0.89	-1.70	-0.83	0.00	5.07	0.63
27 Soins des hopitaux et a	4	0	1	0.91	0.018	0.32	-0.18	0.00	-0.11	2.93	0.53

The demand for *Hospitals* (27) has been decidedly more moderate than for the other members of the health care group. Only the U.S. shows an income elasticity greater than 1.0, and the French is down to .3.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
28	Vehicles	5	2	1	0.16	0.043	1.32	-0.35	-0.01	-0.03	8.65	0.64
28	Acquisto di mezzi trasp	5	2	1	0.90	0.044	1.27	2.55	0.00	-1.17	5.98	0.46
28	Compra de vehículos	5	2	1	0.16	0.036	1.85	1.04	0.99	-0.04	8.06	0.42
28	Automobiles, caravanes,	5	2	1	0.17	0.041	1.36	-0.04	0.00	0.03	8.87	0.56

Income elasticity for *Automobiles* (28) is strong in all countries: 1.3 in the U.S., Italy, and France, and 1.8 in Spain -- and the Spanish equation has a 1 percent per year time trend on top of that income elasticity. The Spanish are plainly making up for lost time in equipping themselves to congest their streets and highways. Price sensitivity was slight, except in Italy.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
29	Operation of motor vehi	5	2	1	0.27	0.060	0.67	-0.03	0.00	-0.20	2.20	0.42
29	Spese es. dei mezzi tra	5	2	1	-0.04	0.052	0.87	-1.26	0.00	-0.28	2.67	0.52
29	Gasto de uso de vehícul	5	2	1	0.10	0.075	1.10	-0.07	0.48	-0.06	2.15	0.54
29	Utilisation des véhicul	5	2	1	0.19	0.089	0.76	-0.13	0.00	-0.14	2.07	0.44

Motor vehicle operation (29), however, has an income elasticity of only .7 to .9 in three countries and 1.1 in Spain, where there is also a noticeable positive time trend.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
30	Public transportation	5	0	1	0.17	0.008	0.43	-0.04	-0.05	-0.38	5.04	0.74
30	Acquisto serv. di trasp	5	0	1	0.00	0.016	0.90	-0.89	0.00	-0.09	2.43	0.39
30	Servicios de transporte	5	0	1	0.04	0.018	0.45	0.42	0.97	-0.13	1.95	0.16
30	Services de transport	5	0	1	0.07	0.022	0.89	-0.06	0.00	-0.24	2.76	0.74

Public transportation (30) claims a share of the consumer budget in Europe that is twice as large as the American share. Moreover, the income elasticities in Italy and France are twice what they are in the U.S. . The U.S., however, is the most price sensitive, though the elasticity is only -.4.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
31	Communication	0	0	1	0.20	0.019	1.52	-0.92	0.00	-0.35	2.71	0.80
31	Comunicazioni	0	0	1	1.16	0.011	1.55	-1.10	0.08	-1.22	5.84	0.58
31	Comunicaciones	0	0	1	-0.01	0.008	1.28	-0.33	2.76	-0.02	3.85	0.41
31	Telecommunications et p	0	0	1	0.04	0.015	3.75	0.08	0.01	-0.15	6.73	0.63

Communications (31) ran off the standard scale in all the European graphs. In Spain, where the equation was freer to use a time trend, the income elasticity came in at 1.3 with a strong positive trend of 2.8 percent per year added on to the income effect. In France, the equation attributed all the growth to income with a elasticity of 3.7! Since in both countries, much of the growth is attributable to the modernization of a once stodgy telephone monopoly, I suspect the Spanish equation is more appropriate.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
32	TV, radio, audio, music	3	0	1	1.13	0.014	1.52	-0.01	0.00	-1.08	4.07	0.61
32	Apparecchi radio, tv, e	3	0	1	-0.46	0.040	1.87	-0.04	0.00	-0.14	2.17	0.44
32	Artículos de esparcimie	3	0	1	0.02	0.024	1.57	-0.04	0.00	-0.21	4.52	0.66
32	Radios, televiseurs, ar	3	0	1	0.02	0.036	1.52	-0.02	0.00	-0.69	4.13	0.57

The one and only runaway sector in the U.S. is *TV, radio, audio, musical instruments, and computers* (32). The enormous growth is, of course, in the computer component. We have not used the official "computer deflator" which would have made it grow even faster, but have left computers undeflated. It is not clear to me whether or not computers are in this category in Europe. They probably are, because the category's the share in total spending is considerably smaller here than

in Europe. Even so, the income elasticity in the U.S. 1.5, the same as in Spain and France, and below Italy's 1.9. The key to the super fast grow is the relatively strong price elasticity, -1.1, coupled with the rapid decline of the relative price of these products.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
33	Books & maps, Magazines	0	0	1	0.01	0.009	0.56	-0.05	0.01	-0.17	4.24	0.59
33	Libri, giornali e perio	0	0	1	0.01	0.017	0.73	0.61	0.00	-0.09	3.51	0.64
33	Libros, periódicos y re	0	0	1	0.06	0.017	0.60	-0.15	0.39	-0.08	2.56	0.64
33	Livres quotidiens et pe	0	0	1	0.04	0.015	0.54	0.13	0.00	-0.15	2.92	0.70

Despite the onslaught of electronic information and entertainment, *Books, magazines, and newspapers* (33) have hung on to their absolute level of sales, though they have been losing share in the consumer's dollar, as appears from the modest income elasticities of .6 or .7, the highest being in Italy, which, with Spain, has the highest share of the consumer's budget, almost twice that in the USA.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
34	Education	0	0	1	0.04	0.022	0.92	-0.02	0.00	-0.20	2.86	0.84
34	Libri per l'istruzione	0	0	1	-0.03	0.008	1.49	0.05	0.01	-0.05	6.22	0.85
34	Enseñanza	0	0	1	0.01	0.008	0.67	-1.68	-0.72	-0.04	4.82	0.66
34	Enseignement	0	0	1	-0.01	0.004	0.37	1.17	2.16	-0.10	16.51	0.77

Least that dismal comparison leaves you a bit embarrassed to be American, take heart from *Education* (34), for which the American budget share is nearly three times that of the European. Alas, however, the difference is much affected by accounting conventions. In the U.S., all of the endowment income of schools and colleges counts as consumption expenditures on education. The income elasticity in the USA is .9, .7 in Spain, and a paltry .4 in France, where the budget share is less than a fifth of that here. The French expect the state to cover all the costs of education.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
35	Recreational services	0	0	1	0.07	0.031	1.84	-0.64	0.00	-0.22	2.49	0.71
35	Spettacoli, serv. ricre	0	0	1	-0.02	0.023	1.05	-0.88	0.00	-0.06	3.13	0.73
35	Servicios de esparcimie	0	0	1	-0.03	0.019	0.67	-0.43	-1.01	0.00	2.36	0.66
35	Serv. de loisir, specta	0	0	1	0.08	0.019	1.08	0.03	0.00	-0.18	2.46	0.77

Recreational services (35), which includes spectator sports, have been a growth industry everywhere except in Spain. The U.S. leads with an income elasticity of 1.8, and a budget share of 3.1 percent. Italy and France also have elasticities above 1 and budget shares of 2.3 and 1.9 percent respectively. In Spain, however, the income elasticity was only .7 and there was a negative time trend of a percent per year. My suspicion is that the great national spectator sport of bull fighting is to some extent losing its hold on the imagination of young, urban Spaniards.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
36	Personal care	0	0	1	0.28	0.015	0.72	-0.04	0.00	-0.43	3.93	0.82
36	Beni e servizi igiene p	0	0	1	0.04	0.030	1.21	-0.59	0.00	-0.11	6.07	0.91
36	Cuidados y efectos pers	0	0	1	0.00	0.014	0.76	-0.98	0.88	-0.03	2.80	0.37
36	Soins personnels, art.	0	0	1	-0.01	0.015	1.38	0.05	0.00	-0.10	4.30	0.83

Personal care articles and services (36), covering from tooth paste to hair salons, has been a growth industry in Europe, with income elasticities of 1.4 in France and 1.2 in Italy, in contrast to .7 in America. The Spanish equation used its greater freedom to use a trend term to find almost exactly the American income elasticity but add to it a time trend of .9 percent per year.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
37	Hotels & motels, restau	0	0	1	0.07	0.053	0.90	-0.03	0.00	-0.22	2.53	0.63
37	Spese alberghi e pubbl.	0	0	1	0.09	0.095	1.03	-0.25	0.00	-0.15	1.47	0.37
37	Restaurantes cafés y ho	0	0	1	0.08	0.013	0.88	-1.14	0.59	-0.11	3.32	0.43
37	Hotels, cafés, restaur.	0	0	1	0.10	0.065	0.82	0.00	0.00	-0.20	1.95	0.51

The *Hotel and restaurant* business (37) enjoys fairly good income elasticities (.8 to 1.0) in all four countries.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
38	Other goods	0	0	1	0.08	0.031	1.54	-0.02	0.00	-0.23	3.43	0.54
38	Altri beni	0	0	1	0.72	0.031	1.83	-0.25	0.00	-0.75	3.94	0.62
38	Otros artículos n.c.o.p	0	0	1	0.04	0.153	1.34	-0.30	0.19	-0.05	8.11	0.92
38	Autres articles	0	0	1	0.34	0.016	0.11	-2.44	0.00	-0.43	9.51	0.63

The *Other goods* category (38) seems to be totally non-comparable across countries. Just the fact that it accounts for 15 percent of the Spanish budget and 1.6 percent of the French budget indicates that the contents of the sector must be quite different.

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
39	Financial services and	0	0	1	0.05	0.039	1.60	-0.53	0.00	-0.20	2.57	0.67
39	Serv. finanz. e assicur	0	0	1	1.04	0.005	1.76	-0.69	0.18	-1.10	11.54	0.87
39	Servicios financieros n	0	0	1	0.12	0.002	1.72	-0.82	-4.83	-0.15	19.92	0.85
39	Services financiers n.d	0	0	1	0.10	0.007	3.67	0.06	0.09	-0.21	9.28	0.54

Financial services and insurance (39) has been a major growth industry in France and Italy, where it found income elasticities of 3.7 and 1.8, respectively. What looks like a change of definition has dominated the Spanish series. In America, this is a much more mature industry with roughly ten times the budget share it carries in Europe. (The services rendered without payment by financial intermediaries are *not* included here.)

nsec	title	G	S	I	lamb	share	IncEl	DInc	time%	PrEl	Err%	rho
40	Other services	0	0	1	0.07	0.064	1.27	-0.03	0.00	-0.22	2.87	0.61
40	Altri servizi	0	0	1	-0.07	0.008	1.16	-1.06	0.02	-0.01	7.90	0.88
40	Otros servicios n.c.o.p	0	0	1	0.10	0.033	0.55	-0.07	2.23	-0.12	3.61	0.76
40	Autres services n.d.a	0	0	1	0.07	0.022	0.88	-0.06	0.00	-0.18	2.86	0.75

Other services (40) are also much more important in the US than in Europe, but continue to have a higher elasticity here (1.3) than in France (.9) or Spain (.5). The Italian elasticity is high (1.2) but on a very small base, only 0.8 percent of the budget.

It would be safe and politic to conclude that this comparison has shown that the new functional form is capable of representing a variety of behavior, including significant substitution and complementarity. While that is, from a technical point of view, the most important conclusion, I cannot pass up the temptation to try to picture the national characters as they appear from these estimates. This venture is especially dangerous since citizens of all the four countries may be readers. Please take no personal offence.

The American has enough if not too much to eat, has become diet conscious and is cutting down on cholesterol but is, sad to say, bothering less and less to prepare fresh fruits and vegetables. He would like to eat more fish but is very sensitive to its price. He has no particular interest in more alcohol; soft drinks are sort of a necessity, not a special treat, and smoking is just a way to make yourself into a social outcast. Ms. America is very concerned about how she and her family are dressed. Housing and furnishing and equipment for the house are important, but using more energy for running the home is a matter of no interest. More domestic help for the working woman is becoming important again. The nation has gone bonkers over home computers. Every child of any age must have one. Books? Well, of course, a few books. But sports, concerts, plays, skiing, sailing, any kind of recreation, that's what America is all about. Relative to the Europeans, the American is not starved for medical care, and growth in this area has been less here than there. Automobiles are important but not much of a class symbol; operating them is just a necessity. Private education and tuition at

public universities is a serious matter. Use of communication has grown because of the declines in its price. Public transport is to be avoided.
The Italian is outstanding among Europeans for dressing well. He is proud of his country's *cucina*, and would gladly eat more cheese, fish, and, above all, soft drinks; but he is losing interest in *vino*. Of pasta, he has, thank you, enough. Eating out at a good trattoria, ah, that's worth the price. He continues to puff away on his cigarette just to show his defiance of statistics. In an energy-poor country, he wants more electricity and fuel. Signora is concerned not only with dressing the family well but is especially concerned to have a well-furnished house, refined furniture, attractive carpets and linens, and a bit of style and elegance in china and crystal. She wants appliances to help her with the house work. But most of all she wants domestic help. Dispensing with domestic servants was a modern idea that never crossed her sensible mind. The family has been upgrading its car, especially because prices have been coming down relative to other goods. The modest motor scooter is giving way to the even noisier motorcycle. But public transport is still a respectable way to get around. Especially if you have a portable telephone -- and who doesn't? Yes, computers and audio equipment have caught on fast, just not to the mania level of the Americans. Reading the newspaper is very important, and books still hold more allure than in any of the other three countries. One might suppose that just watching Italian politics would provide *spettacoli* enough, but no, recreation is high on the list of priorities. Socialized medicine led to explosive growth of spending on medicine but not on doctors, and certainly not on hospitals.

The Spanish are the newly rich of Europe. And the riches come after a period of declining income in the early 1980's. They have increased meat consumption in the last five years. Eating out is great, but please, no more fish! And less potatoes and wine. But an extra cigarette, *por favor*. Clothing is a good thing to economize on, as are shoes, though, of course, as income goes up you should look just a little better. Pretty much the same goes for furniture, rugs, and linens. China and glassware are an especially good place to economize when your income rises. One good place to put some of the savings on these goods is into more and better appliances along with the electricity to run then. Indeed, electricity is showing such a growth that one becomes suspicious that air conditioning might be catching on. But top priority for these savings is the car. No other of our countries is close to the Spanish income elasticity for cars. And if you have bought the car, then you have to drive it. But the new high-speed rail lines are making public transportation competitive again. Right behind the car in priority comes "recreational equipment" which seems to correspond to home electronics, including possibly the computer. Never mind, however, about those recreational services that everybody else is so crazy about. Just living in Spain is recreation enough. As in all three European countries, medical expenditures have skyrocketed: medicines, therapeutic devices, and services of doctors. Even hospital services have seen some rise.

Now the French seem utterly indifferent to improving, when income rises, how they are dressed or to how their house is furnished or to what sort of china or glassware they use, but not to what they eat and drink. Increase the French family's income by one percent, and it will spend .8 percent more on dining out, .5 percent more on meat, 1.6 percent more on fish and those delicious shellfish, .8 percent more on cheese, 1.8 percent more on candy and "other" prepared foods, 1.8 percent more on soft drinks, including, of course, mineral water, and even a bit more, .2 percent, on wine. If the French don't uphold their reputation as the fashion center of Europe, they are certainly *les*

gourmands of the continent. It must be added that they are cutting back sharply on sugar and potatoes. Alone among the four countries, they are increasing their use of tobacco. They attach less priority to buying household appliances than to increasing meat consumption. A pleasant effect of that indifference is that energy consumption has remained stable. They have relatively little interest in new cars, relative, that is, to their neighbors in Spain and Italy, and expenditures on operating the cars are correspondingly stable. Public transport is more income elastic than is operation of cars. Besides their interest in food, they spend added income on personal care, on home electronics and recreational equipment, on cultural and sporting events, on financial services, and on communications. As in the other European countries, the large shares of increased income have gone to -- or come in the form of -- medicines, therapeutic devices, and services of doctors.

Well, it seems we are not all the same. There do appear to be national differences that go beyond language. For the present purposes, however, the important point is that this new functional form seems to be able to work well in what turns out to be a surprising variety of situations. Perhaps it is adequate.

References

Almon, C. (1979) A system of consumption functions and its estimation for Belgium, *Southern Economic Journal*, vol. 46, No. 1, July, pp. 85-106.

Chao, Chang-yu I. (1991) *A Cross-sectional and Time-series Analysis of Household Consumption and a Forecast of Personal Consumption Expenditures.* Ph.D. Thesis, University of Maryland.

Deaton, A. and Muellbauer, J. (1980) An almost ideal demand system, *American Economic Review*, vol. 70, No. 3, June, pp. 312-326.

Gauyacq, Daniel 1985) Les systèmes interdépendants de fonctions de consommation, *Prévision et Analyse Economique, Cahiers du Gamma*, vol. 6, No. 2, June 1985 (entire issue).

Appendix A. Use of the estimation program

The estimation program has two control input matrices, groups.ttl and softcon.dat, and several data matrices, consum.dat, prices.dat, cstar.dat, popul.dat, and time.dat.

The groups.ttl file, as the name suggests, defines the groups. It also specifies which categories are sensitive and which insensitive to price, which weighted population, which income variable, and which trend variable is to be used by each category. This file for the Spanish study is shown in the box below. Its first column consist of simply the integers from 1 to n, the number of categories of consumption. The second column carries the number of the group in which the category falls, or a zero if it is not assigned to a group, and the third column carries the number of the subgroup to which the category belongs or a zero if it belongs to none. The fourth is the number of the weighted population to be used for the item, the fifth is the number of the "income" (or Cstar) series to be used, the sixth is the number of the "trend" series to be used, and the seventh is a 1 if the category is a regular, price-sensitive commodity or a 0 if it is not. Although conceptually we have thought of neatly defined groups and subgroups strictly within the groups, the computer program makes no effort to enforce this tidy structure. It is possible to form "subgroups" with categories drawn from more than one group.

The second major control file is softcon.dat, which gives soft constraints for the various equations. It is, in fact, hardly to be expected that all parameters would come out with reasonable values when so many of the variables have similar trends. Thus the use of soft constraints on the coefficients is an integral part of the estimation process. The estimation program allows the user to specify the desired value of any parameter except the constant term and to specify a "trade-off parameter" to express the user's trade-off between closeness of fit and conformity with desired values of the parameters. In these studies, I began with constraints saying that I wanted the time trends to be close to zero. I then worked on the income elasticities to get them all positive; for some products, that meant relaxing the soft constraint on the time trend. Then I added soft constraints to make the own price elasticities all negative. Finally, some of the coefficients on the change in income had to be constrained to keep them from being more negative that the income term is positive.

The softcon.dat file for Spain is shown in a box below. For each product, there can be specified desired values of the income elasticity, the change in income in elasticity units, the time trend as a percent of the base year (1988) value, lambda, and the mu and nu of the group and subgroup. The table shows for each of these a pair of numbers, the desired value and the trade-off parameter. If the trade-off parameter is 0, the desired value has no effect on the estimation. The higher the parameter, the stronger the constraint relative to the data. A value of 1.0 for the trade-off parameter gives about equal weight to the constraint and to the data. Constraints on mu and nu values can be specified on the line for any member of the group or subgroup, but I have always placed them on the line of the first item in the group or subgroup. This table is, in fact, precisely the way the constraints are entered into the program; the table shows the contents of the file softcon.dat, which is read by the estimation program.

The Groups.ttl File for Spain

```
# Groups.ttl.  Columns are
# 1 The consumption category number
#    2 The group number
#       3 The subgroup number
#          4  Which weighted population number to be used with this category
#             5 Which Income (Cstar) variable
#               6 Which Trend variable
#                 7 Use price terms ( 1 = yes, 0 = no)
#                   8 The title of the category
 1  1  0  1  1  1 1 Pan y cereales
 2  1  1  1  1  1 1 Carne
 3  1  1  1  1  1 1 Pescado
 4  1  1  1  1  1 1 Leche, queso y huevos
 5  1  0  1  1  1 1 Aceites y grasas
 6  1  0  1  1  1 1 Frutas y verduras
 7  1  0  1  1  1 1 Patatas y tubérculos
 8  0  0  1  1  1 0 Azúcar
 9  1  0  1  1  1 1 Café, té y cacao
10  1  0  1  1  1 1 Otros alimentos
11  1  0  1  1  1 1 Bebidas no alcohólicas
12  1  0  1  1  1 1 Bebidas alcohólicas
13  0  0  1  1  1 1 Tabacos
14  2  0  1  1  1 1 Vestido
15  2  0  1  1  1 1 Calzado
16  0  0  1  1  1 1 Alquileres y agua
17  0  0  1  1  1 1 Calefacción y alumbrado
18  3  0  1  1  1 1 Muebles
19  3  0  1  1  1 1 Artículos textiles
20  3  0  1  1  1 1 Electrodomésticos
21  3  0  1  1  1 1 Utensilios domésticos
22  3  0  1  1  1 1 Mantenimiento
23  3  0  1  1  1 1 Servicio doméstico
24  4  0  1  1  1 0 Medicamentos
25  4  0  1  1  1 0 Aparatos terapéuticos
26  4  0  1  1  1 0 Servicios médicos
27  4  0  1  1  1 0 Atención hospitalaria y seguro médico privado
28  5  2  1  1  1 1 Compra de vehículos
29  5  2  1  1  1 1 Gasto de uso de vehículos
30  5  0  1  1  1 1 Servicios de transporte
31  0  0  1  1  1 1 Comunicaciones
32  3  0  1  1  1 1 Artículos de esparcimiento
33  0  0  1  1  1 1 Libros, periódicos y revistas
34  0  0  1  1  1 1 Enseñanza
35  0  0  1  1  1 1 Servicios de esparcimiento
36  0  0  1  1  1 1 Cuidados y efectos personales
37  0  0  1  1  1 1 Restaurantes cafés y hoteles
38  0  0  1  1  1 1 Otros artículos n.c.o.p.
39  0  0  1  1  1 1 Servicios financieros n.c.o.p.
40  0  0  1  1  1 1 Otros servicios n.c.o.p
41  0  0  1  1  1 1 Viajes turísticos todo incluido
```

The Softcon.dat File for Spain

```
sec  Title                        Income      DIncome     Time
   lambda     mu       nu
1 Pan y cereales                0     0      0     1     0   .5
   .2   5.   .1  1.
2 Carne                         0     0      0     0     0   .5
   .2   5.   0  0       .2 1.
3 Pescado                       0     0      0     0     0   .5
   .2   5.
4 Leche, queso y huevos        .1    1.     0     1.    0  1.0
   .2   5.
5 Aceites y grasas             .1    1.   -.04    1.    0   .0
   .2  10.
6 Frutas y verduras             0     0      0     0     0   .5
   .2   5.
7 Patatas y otros tubérculos  .0     1.   -.02    1.    0   .5
   .2  10.
8 Azúcar                      .1     1.   -.06    1.    0   .5
9 Café, té y cacao            .05    1.   -.03    1     0   .5
   .2  10.
10 Otros alimentos              0     0      0     0     0   .5
   .2  10.
11 Bebidas no alcohólicas       0     0      0     0     0   .5
   .2   5.
12 Bebidas alcohólicas         .05   1.     0     0     0   .5
   .2  10.
13 Tabacos                      0     0     -.2    1.    0   .5
   .2  20.
14 Vestido                      0     0      0     0     0   .5
   .2   5.
15 Calzado                      0     0      0     0     0   .5
   .2   5.
16 Alquileres y gasto de agua   0     0     -.05   1.    0   1.
17 Calefacción y alumbrado      0     0      0     0     0   .5
   .2   5.
18 Muebles                      0     0      0     0     0   1.
   .2   5.   .1  1.
19 Art. textiles para el hogar 0     0      0     0     0   .5
   .2  10.
20 Electrodomésticos            0     0      0     0     0   .5
   .2  10.
21 Utensilios domésticos       .1     1.   -.06   1.    0   .5
   .2   5.
22 Mantenimiento                0     0      0     0     0   .5
   .2   5.
23 Servicio doméstico           0     0    -1.2    1     0   .1
```

The consum.dat file begins with some dimensions and dates and then contains the data on consumption in almost exactly the form in which it would be written by the G command matty. The layout is shown in the above box for the Spanish case; the ... show where material has been cut out of the file to make it fit on the page. Notice the four numbers with which it begins. Each should be on its own line. Then come the data, with 20 series at a time across the "page". Comments may be introduced in the data by beginning the line with a #.

The Consum.dat File for Spain

```
42 Sectors
24 years of data
1971 First year
1986 Base year
# Consumption, constant 1986 prices, total (not percapita)
#   Date        kcpi1      kcpi2      kcpi3      kcpi4 ...   kcpi20
#   70.000    499.340   1021.118    549.566    467.982 ...  164.161
    71.000    490.641   1022.712    571.055    466.638 ...  175.657
    72.000    506.050   1017.367    574.642    472.211 ...  201.513
    73.000    548.905   1182.404    582.436    498.514 ...  210.624
    74.000    554.821   1338.080    536.756    562.671 ...  202.528
     ...        ...        ...        ...        ...          ...
    94.000    599.644   1666.945    606.117    735.611 ...  289.384
#  Date        kcpi21     kcpi22     kcpi23     kcpi24 ...   kcpi40
#   70.000    109.692    286.789    184.407    272.749 ...   68.330
    71.000    117.373    299.460    188.615    313.366 ...   74.745
    72.000    134.650    342.775    189.809    337.034 ...   79.912
    73.000    140.738    351.768    187.654    340.828 ...   85.539
    74.000    135.328    350.958    180.607    370.052 ...   86.795
     ...        ...        ...        ...        ...          ...
    94.000    121.689    412.728    183.031    780.092 ...  165.796
# Date        kcpi41     kcpi42
    70.000     34.073    298.342
    71.000     38.251    334.738
    72.000     45.404    395.237
    73.000     48.923    425.776
    74.000     55.430    479.674
     ...        ...        ...
    94.000     48.288    934.576

The ... indicate where data have been removed to fit the into this box.
```

Exactly the same format is followed for the prices.dat file, which give the price indexes, except that the four numbers at the top are omitted. The Cstar.dat, which gives the income series, begins with the number of such series. It then has these series arranged in columns. It has one extra year of data at the beginning so that the first difference of income can be calculated. The Popul.dat file is very similar; it begins with an integer giving the number of populations, followed by data in the same format. It also has the extra year at the beginning. Finally the tempi.dat file gives various series which may be used as the time trend. Like the popul.dat file, it has the number of series at the beginning but does not have the extra year of data at the beginning.

Once the files groups.ttl, consum.dat, prices.dat, cstar.dat, tempi.dat, and softcon.dat are ready, the program is run by the command "symcon [n]" from the DOS prompt. The optional parameter, n, is the number of iterations to be run before turning over control to the user. Thus "symcon" will run only 1 iteration and then give the user the option of quiting (by tapping y) or continuing the Marquardt process another iteration. If the command given is "symcon 40", then 40 iterations are automatically run without pausing for user input. In this case, when the limit is reached, the program sounds three long notes: low, high, low. A symcon calculation started in this way can be put into the background of a multitasking operating system such as OS2. When it has reached the limit, the

notes will sound, and the user can turn his attention to it. To check that data has been read correctly, use "symcon d". (The d is for "debug".)