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ESTIMATION AND HYPOTHESIS TESTING IN DYNAMIC SINGULAR EQUATION SYSTEMS: AN APPLICATION TO CONSUMERS EXPENDITURE IN GREECE

By

Agelike Nikolaou
University of Macedonia

Abstract

Restrictions on systems of demand equations have been traditionally tested using static models. The usual results of these tests are a rejection of the restrictions imposed by the economic theory. A possible explanation of these findings is inadequate dynamic specification of the demand functions. This paper estimates a vector time series model of expenditure shares in the context of a singular dynamic demand system. The model allows for non-symmetric and non-homogeneous short run behaviour. The homogeneity and symmetry restrictions are only examined in the long run structure. Results based on Greek time series data are presented and reject the static modelling while restrictions suggested by economic theory are not rejected when imposed on the long run structure. (JEL D12)

1. Introduction

The AIDS model of Deaton and Muellbauer (1980 a, b) is considered the most popular demand system in applied demand analysis for a number of reasons. First, it is derived from a specific cost function and thus corresponds to a well defined preference structure, which is convenient for welfare analysis. Second, the functional form of the preferences is flexible in that it can be thought of as a local second-order approximation to an unknown preference structure. Third, homogeneity and symmetry restrictions depend only on estimated parameters and so are easily imposed and tested. Finally Deaton and Muellbauer (1980b) suggested a linear approximation of the nonlinear AIDS model, which works well if prices are collinear, and is frequently what is estimated in practise.

However when AIDS demand system was applied to annual British data although Deaton and Muellbauer (1980a) found plausible structural parameter estimates and reasonable price and income elasticity estimates homogeneity and symmetry restrictions were rejected. Based on these and other results they concluded that influences other than current prices and current total expenditure must be explicity incorporated into the model to explain consumer behavior in a theoretically coherent and empirically robust way. They suggest generalizing their static model by adding dynamic elements and including other factors to improve their original framework.

Anderson and Blundell (1982, 1983), developed a dynamic specification of AIDS. In their approach, which was adopted by this paper, equilibrium theory is used to generate a representation of long run behaviour. A convenient reparameterisation, similar to that of Hendry and Von Ungern Sternberg (1981), is used to partition the dynamic model into its long and short run components. They also applied the above model on Canadian time series data and rejected current practise of static modeling while restrictions suggested by economic theory were not rejected when imposed on long-run structure.

In this paper, we attempt to investigate, the pattern of Greek demand by estimating Andersons and Blundels (1982) dynamic specification of AIDS as well as all nested models including the static one. In Sections 2 and 3 we discuss the general dynamic model as well as the nested models while in Section 4 we estimate and test the above models by using annual time series data for five categories of non-durable Greek expenditure. As it turns out the static system is rejected by the data which means that further tests and estimated elasticities based on such a model are no longer valid. Finally, in section 5, some conclusions are drawn concerning the use of static systems as description of consumers' behaviour over time.

2. The Structure of Dynamic Singular Equation Systems

Singular systems have often been estimated as a set of equilibrium equations of the form:

$$w(t) = f(x(t); \theta) \tag{1}$$

where w(t) is an nxl vector of shares in the total expenditure on η commodity classifications, the nxl elements of the vector function f( ) depend upon a kxl vector of nonstochastic variables x(t) which very over time, and a jxl vector of parameters θ assumed constant over time. Since the elements of w(t) always sum to unity the system of equations (1) is singular, and so the parameters θ will satisfy some restrictions with certainty.

The essential feature of the problem are retained if (1) is assumed to be linear in variables x(t), the first element of which is an intercept term. When the equations are augmented by a vector of stochastic errors u(t), (1) may be written as:

$$w(t) = \Pi\ (\theta)\ x(t) + u(t) \tag{2}$$

where $\Pi(\theta)$ is an nxk matrix of functions of the coefficients θ. The adding up restrictions now imply that for an appropriately dimensioned unit vector i:

$$i'\ \Pi(\theta) = (1\ \ 0\ \ 0\ \ ...),$$
$$i'\ \Pi(\theta) = 0, \text{ for all t.}$$

in a time series context (2) is a static model assuming an intertemporal intependence in the systematic structure given by (1). It is assumed that changes in w(t) are responses to anticipated and unanticipated changes in x(t) in an attempt to maintain a long-run relationship of the form (1) in the sense that should x(t) stabilize to some constant value over time then so would the expected value of w(t). Such a model may be written, using the lag operator L, as:

$$B^*\ (L)\ w(t) = \Gamma^*\ (L)\ x(t) + \varepsilon(t) \tag{3}$$

where

$$B^*\ (L) = I + B_1^* L + B_2^* L^2 + \ldots + B_p^* L^p,$$

$$\Gamma^*\ (L) = \Gamma_0^* + \Gamma_1^* L + \Gamma_2^* L^2 + \ldots + \Gamma_q^* L^q,$$

and ε(t) is an independent identically distributed random disturbance vector. The systematic part of the dynamic model is assumed to be stable. Equation (3) may reparametrised to give an observationally equivalent set of equations of the form:

$$\Delta w(t) = -B\ (L)\ \Delta w(t) + \Gamma(L)\ \Delta\tilde{x}(t) - B^*\ (1)\ (w\ (t\text{-}p)$$
$$-B^*\ (1)^{-1}\ \Gamma^*\ (1)\ x\ (t\text{-}q)) + \varepsilon(t)$$

which may be rewritten as:

$$\Delta(w) = -B(L)\,\Delta w(t) + \Gamma(L)\,\Delta\tilde{x}(t) - A\,(w\,(t\text{-}p)$$

$$-\Pi(\theta)\;x\,(t\text{-}q) + \varepsilon(t) \qquad (4)$$

where $B(L) = \sum_{i=1}^{p-1} \left(\sum_{j=0}^{i} B_j^* \right) L^i, \qquad p > 1$, null otherwise;

$$\Gamma(L) = \sum_{i=0}^{q-1} \left(\sum_{j=0}^{i} \tilde{\Gamma}_j^* \right) L^i, \qquad q \geq 1,$$

$$A = \sum_{j=0}^{p} B_j^* = I + B_1^* + B_2^* + \ldots + B_p^*,$$

$\tilde{\Gamma}_j^*$ is Γ_j^* with the first column deleted; and $\tilde{x}(t)$ with the first element deleted.

The restrictions suggested by economic theory are imposed only on the long-run structure. In the short run we are not assuming that agents are in equilibrium and therefore there seems no reason why short-run behaviour should satisfy any such restrictions. Note that the adding up restrictions associated with (3) imply for (4) that:

$i'B_j = m_j i', \qquad j = 1, \ldots, p\text{-}1,$

$i'\Gamma_l = 0 \qquad l = i, \ldots, q\text{-}1$

$i'A = ki',$

$i'\,\Pi(\theta) = (1\ 0\ 0\ \ldots\ 0),$

where B_j is the jth coefficient matric in B(L) and Γ_l is the lth coefficient matrix in Γ(L).

As it stands, (4) is not estimable since the explanatory variables appearing in each equation are perfectly collinear. Redundancy arises because anyone of the elements of w(t) and consequently Δw(t) is an exact combination of the other elements in the vector and the intervept term. Letting the subscript on a matrix denote the deletion of the nth row, and superscript denote an nxn-1 dimensional matrix (4) may be written as:

$$\Delta w(t) = -B^n(L)\,\Delta w_n(t) + \Gamma(L)\,\Delta\tilde{x}(t) - A^n(w_n\,(t\text{-}p)$$

$$-\Pi_n(\theta)\;x\,(t\text{-}q) + \varepsilon(t) \qquad (5)$$

which represents an estimable set of equations.

3. The Empirical Model

The demand system which we use to describe long-run behaviour is the Almost Ideal Demand system of Deaton and Muellbauer (1980b). In its static version this takes the form:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i \ln (m/P) \tag{6}$$

p_j being the price of good j, m the per capita expenditure on all n goods and P a price index given by:

$$\ln P = \alpha_0 + \sum_{k=1}^{n} \alpha_k \ln p_k + 1/2 \sum_{k=1}^{n} \sum_{j=1}^{n} \gamma_{kj} \ln p_k \ln p_j \tag{7}$$

for this model $\sum_{i=1}^{n} \alpha_i = 1$, $\sum_{i=1}^{n} \gamma_{ij} = \sum_{i=1}^{n} \beta_i = 0$ are the adding-up restrictions, $\sum_j \gamma_{ij} = 0$ are the homogeneity restrictions and $\gamma_{ij} = \gamma_{ji}$ are the symmetry restrictions.

From equation (5) a first order dynamic version of AI demand system takes the form of an error correction model:

$$\Delta w(t) = \Gamma \Delta \tilde{x}(t) - A^n (w_n (t-1) - \Pi_n (\theta) x (t-1)) + \varepsilon(t) \tag{8}$$

where x is some 1x1 vector of transformed income and price variables. The advantage of estimating (8) is that attention is readily focused upon the long-run structure in the term $(w(t-p) - \Pi(\theta) x(t-q))$. In addition the formulation is easily related to models previously considered in the literature since they are nested within it. A set of restrictions can give the static equilibrium model with vector autoregressive error process:

$$w(t) = \Pi(\theta) x(t) + u(t) \tag{9}$$

$$u(t) = R^n u(t-1) + \varepsilon(t)$$

It is interesting to note that this autoregressive model is the most general dynamic specification nested in (6) that requires equality between each long run and short run effect. This common root restriction is a strong constraint on consumer behaviour and one that it is important to test in any empirical study.

An equally simple set of restrictions yields the classical partial adjustment model:

$$\Delta w(t) = M\ (\Pi(\theta)\ x(t) - w(t-1)\ ) + \varepsilon\ (t) \tag{10}$$

Nested within both the autoregressive and partial adjustment models is the static model most commonly used in the litterature. The restrictions that these models imply in terms of the structure of (8) are outlined in Table 1.

4. An Application to Consumers' Expenditure Decision in Greece

The data used in this application are an annual time series on five categories of non-durable consumers' expenditure in Greece for the period 1958-92 inclusive. The above data set is provided by the National Accounts of Greece. The five groups are food, alcohol and tobacco, clothing and footwear, recreation and finally medical care and health expenses. The recreation category contains recreation, entertainment, education and cultural services; Full information maximum likelihood methods were used to estimate all models derived in section 3 making use of nonlinear routines in main frame TSP. For computational convenience, throughout this paper, per capita total expenditure was deflated using the share weighted index, $\ln P = \sum^{n} w_j \ln p_j$ rather than index (7). As indicated in Deaton and Muellbauer (1980a, b) as well as in Anderson and Blundell (1983), use of this index has little effect on the value of the loglikelihood.

As will be shown, there is sufficient variation in this five commodity Greek sample to identify all the parameters of the unrestricted model (5) developed in the previous section. The methodology of the previous section of this paper has been to generate a flexible model both in terms of aggregate consumers' preferences and dynamic adjustment. In small samples the required flexibility naturally reduces the available degrees of freedom. Experimental evidence with static demand systems (see Bera et all (1981)), Laitenen (1978) and Meisuer (1979) suggests that these procedures lead to over-rejection in finite samples. This propensity to over-reject may be severe but tends to be less so in small systems of the size considered here and diminishes with the use of the likelihood ratio rather than Wald type statistics. Various small sample corrections are available and have been used in empirical demand studies, for example Pudney (1981) and Simmons (1980). However, these adjustments are only approximate and their properties are unkown in dynamic systems where even for linear within equation restrictions, no exact criteria exist. The impact on test conclusions of these adjustments can be large and will therefore be discussed thoughout the empirical investigation presented here.

The results of the tests on dynamic structure are given in Table 2 which may be seen as the empirical counterpart of Table 1. The critical values (C V) and x^2 values refer to the asymptotic likelihood ratio criteria discussed above while x^{2*} is the corrected test statistic as suggested by Pudney (1981). To keep the overall significance level reasonable and to protect, to some extent, against the over-rejection discussed above, all tests were contacted at the 1% level. The important conclusion to be drown from Table 2 is that, even at this low significance level, one of the two submodels, the autoregressive one, is rejected using the asymptotic criteria. Despite the rejection of this model, it is of interest to consider the results of testing the static model against either of these simpler dynamic represantations. In both cases, Table 2 indicates a decisive rejection of the static model.

The result of applying the small sample corrections suggested in Pudney (1981) and Simmons (1980) is to leave the rejection of the static model unaffected but to allow the autoregressive model to move out of the critical region as we see from Table 2. Given the limited degrees of freedom, this may not seem surprising. Nevertheless, as shown in section 3, the autoregressive model does impose strong restrictions on the relationship between long and short run behaviour in this framework. Clearly, the autoregressive specifications would be inclined to impose stronger constraints when aggregate behaviour is restricted to obey the homogeneity and symmetry restrictions. As we can see from Table 3, which reproduces Table 2 under these restrictions, with resulting parameter space reduced and with the larger values of the test statistic, both dynamic simplifications are rejected at reasonable levels of significance and this is also the case for the static model. It also should be noted that these results remain unaffected even with small sample corrections.

From the above it is apparent that model (5) is the chosen one as a suitable maintained hypothesis. However for comparison reasons we shall also discuss the estimation results from the static model.

First, we present the results for the unconstrained static version of the AI demand system in Table 5, and with homogeneity and symmetry imposed in Table 6. As we see from Table 4, where we present the tests on economic theory, the homogeneity as well as symmetry restrictions are rejected by the data a result unaffected by small sample adjustments of the type described above. The very considerable worsening of the Durbin-Watson Statistic under the null is also a notable feature of Table 5 in comparison with Table 6. This offers support for our hypothesis that there is a connection between the rejection of these restrictions and the dynamic properties of consumer demands.

In addition to adding-up symmetry and homogeneity, we also impose concavity (see Barten and Geyskens (1975), Conrad and Jorgenson (1979)). Concavity can be checked for any given estimates by calculating the eigenvalues of the slutsky matrix. The static model generates one non-negative eigenvalue even though, as we can see from Table 9, all the compensated own price effects are negative. Thus, there is some non-concavity present in this static version of the model.

Now we turn to the estimates of the dynamic model as defined by (8). Not wishing to impose restrictions on short run behaviour, the Γ coefficient matrix is left unrestricted throughout this test procedure. The conclusion to be derived from Table 4, is that neither the 4 homogeneity nor the 6 symmetry restrictions are rejected by the data even without a small sample correction. There is thus a striking difference between the static and dynamic models. Symmetry and homogeneity are strongly rejected for the static model and accepted, for the dynamic model. Moreover, while their imposition on the static model induces positive residual autocorrelation, for the dynamic model their imposition eliminates some symptoms of negative residual autocorrelation to give the satisfactory Durbin Watson statistic reported in Table 8. Since the model contains lagged dependent variables, the Durbin Watson statistics cannot be rigorously applied. However, a kind of Lagrange multiplier test can be constructed by re-estimating the demand system including for each equation the lagged residual as a sigle additional regressor. None of the coefficients on the lagged residuals were significant.

Table 9, reports the income elasticities and the compensated price elasticities for both dynamic and static models. In both symmetric models own_price elasticities appear to be negative while both models again classify food as necessity and the rest categories as luxuries. However the static model as would be expected biases the income elasticities towards unity. This may be interpreted as accommodating some lack of adjustment in the short-run.

The dynamic model also gives rise to one positive eigenvalue for the substitution matrix even though the compensated own price elasticities are all negative as we can see from Table 9. Another point that should be noted is the general price inelasticity of demand; only the category education/recreation appear to be price elastic for the dynamic model while for the static the categories clothing/footwear and medical care/health expences.

5. Conclusions

This paper has attempted a thorough empirical examination of the dynamic structure of an econometric model to ensure that it is not rejected by the data prior to examining the economic theory embodied therein. It has been shown that static, simple autoregressive and partial adjustnment models tend to be rejected by the data. The implications of these results are important for the modelling and prediction of consumers' behaviour. They suggest that it is not sufficient to simply adjust the error specification on the usual static systems or choose a dynamic model representing particular underlying theories of short run adjustment such as partial adjustment model. A more general dynamic specification is required. If this procedure is not followed, estimated income and relative price responses may be biased and resulting predictions of behaviour quite inaccurate. It has been shown that the general dynamic model performs better than all the other models, homogeneity and symmetry restrictions are not rejected by the data while there is not evidence of serial corellation between the residuals.

Appendix

TABLE 1

Alternative Dynamic Structures

Basic Equation: $\Delta w(t) = \Gamma\Delta\tilde{x}(t) - A^n(w_n\ (t\text{-}1) - \Pi_n(\theta)\ x\ (t\text{-}1)) + \varepsilon(t)$

Model	Restrictions
Autoregressive	$c_{ij} = \Pi_{ij+1}(\theta)$ for i=1, ..., n-1; j=1, ..., k-1 where c_{ij} and $\Pi_{ij}(\theta)$ are respectively the ij-th elements of Γ and $\Pi_n(\theta)$
Partial	$c_{ij} = \Sigma_k a_{ik}\Pi_{kj+1}(\theta)$ i = 1, ..., n - 1; j = 1, ..., k - 1 where c_{ij} and $\Pi_{ij}(\theta)$ are respectively the ij-th elements of Γ and $\Pi_n(\theta)$
Static	$a_{ij} = 1$ i = j i = 1, ... , n-1 = 0 i ≠ j j = 1, ... , n-1 $a_{nj} = 1$ j = 1, ... , n-1 where a_{ij} is the ij-th element of A

TABLE 2

Tests on the Dynamic Structure

Models		Test Statistics
General Dynamic Auroregressive	lnl = 630.069 lnl = 607.182	D.F. = 24 χ^2 = 45.8 χ^{2*} = 28.0 C.V. = 42.9
General Dynamic Partial Adjustment	lnl = 630.069 lnl = 610.262	D.F. = 24 χ^2 = 39.6 χ^{2*} = 21.9 C.V. = 42.9
Autoregressive Static	lnl = 607.182 lnl = 586.401	D.F. = 16 χ^2 = 41.5 χ^{2*} = 33.3 C.V. = 32.0
Partial Adjustment Static	lnl = 610.266 lnl = 586.401	D.F. = 16 χ^2 = 47.7 χ^{2*} = 38.8 C.V. = 32.0

Note: A * by the value of a χ^2 test statistic indicates the corrected χ^2.

TABLE 3

Tests on the Dynamic Structure with Homogeneity and Symmetry

Models		Test Statistics
General Dynamic Auroregressive	lnl = 616.722 lnl = 586.708	D.F. = 24 $\chi^2 = 60.0$ $\chi^{2*} = 43.2$ C.V. = 42.9
General Dynamic Partial Adjustment	lnl = 616.722 lnl = 586.389	D.F. = 24 $\chi^2 = 60.7$ $\chi^{2*} = 43.6$ C.V. = 42.9
Autoregressive Static	lnl = 586.708 lnl = 549.685	D.F. = 16 $\chi^2 = 74.1$ $\chi^{2*} = 65.5$ C.V. = 32.0
Partial Adjustment Static	lnl = 586.389 lnl = 549.685	D.F. = 16 $\chi^2 = 73.4$ $\chi^{2*} = 69.0$ C.V. = 32.0

Note: A * by the value of a χ^2 test statistic indicates the corrected χ^2.

TABLE 4

Tests on Economic Theory

General Dynamic Model	Static Model	Autoregressive Model	Partial Adjustment Model
Unrestricted lnL= 630.069	Unrestricted lnL = 586.401	Unrestricted lnL = 607.182	Unrestricted lnL = 610.266
D. F. = 4 $\chi^2 = 12.3$ C. V. = 13.3	D. F. = 4 $\chi^2 = 41$ C. V. = 13.3	D. F. = 4 $\chi^2 = 13.8$ C. V. = 13.3	D. F. = 4 $\chi^2 = 31.7$ C. V. = 13.3
Homogeneous lnl = 623.892	Homogeneous lnl = 565.903	Homogeneous lnl = 600.286	Homogeneous lnl = 594.428
D. F. = 6 $\chi^2 = 14.3$ C. V. = 16.8	D. F. = 6 $\chi^2 = 32.4$ C. V. = 16.8	D. F. = 6 $\chi^2 = 27.8$ C. V. = 16.8	D. F. = 6 $\chi^2 = 16.1$ C. V. = 16.8
Symmetric lnl = 616.722	Symmetric lnl = 549.685	Symmetric lnl = 586.401	Symmetric lnl = 586.389

TABLE 5

Static Unrestricted Model

	Food	Al/tob	Cloth	Ed/rec	Med. c
α_i	2.01	0.31	-1.06	-0.09	-0.16
	(0.26)	(0.91)	(0.23)	(0.12)	(0.10)
β_i	-0.12	-0.017	0.11	0.01	0.02
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
γ_{i1}	0.27	-0.06	-0.20	0.01	-0.02
	(0.03)	(0.11)	(0.03)	(0.01)	(0.01)
γ_{i2}	-0.04	0.06	-0.01	-0.03	0.02
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
γ_{i3}	-0.05	0.00	0.05	0.02	-0.02
	(0.03)	(0.01)	(0.03)	(0.01)	(0.01)
γ_{i4}	-0.12	0.04	0.11	-0.01	0.05
	(0.03)	(0.01)	(0.03)	(0.01)	(0.01)
γ_{i5}	-0.00	-0.02	0.03	0.01	-0.02
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
R	0.96	0.98	0.88	0.96	
SEx100	0.6	0.2	0.6	0.3	
DW	1.5	1.7	1.6	2.2	

TABLE 6

Static Model with Symmetry and Homogeneity

	Food	Al/tob	Cloth	Ed/rec	Med. c
α_i	2.31	-0.37	-0.35	-0.19	-0.32
	(0.10)	(0.05)	(0.77)	(0.37)	(0.04)
β_i	-0.14	0.04	0.05	0.02	0.03
	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)
γ_{i1}	0.16	-0.07	-0.06	-0.02	-0.01
	(0.02)	(0.01)	(0.13)	(0.01)	(0.01)
γ_{i1}		0.01	0.09	-0.05	0.01
		(0.06)	(0.06)	(0.04)	(0.00)
γ_{i3}			-0.07	0.04	-0.00
			(0.01)	(0.01)	(0.00)
γ_{i4}				0.01	0.02
				(0.01)	(0.01)
γ_{i5}					-0.02
					(0.01)
R^2	0.90	0.90	0.70	0.95	
SEx100	0.9	0.4	0.9	0.3	
DW	0.7	0.9	1.0	2.0	

Terms in brackets are t-ratios.

TABLE 7

Dynamic Unrestricted Model

	Food	Al/tob	Cloth	Ed/rec	Med. c
α_i	1.84	0.32	-1.06	-0.19	0.09
	(0.45)	(0.12)	(0.41)	(0.20)	
b_i	-0.10	-0.02	0.11	0.02	-0.01
	(0.04)	(0.11)	(0.04)	(0.02)	
γ_{i1}	0.28	-0.06	-0.25	0.03	-0.01
	(0.06)	(0.02)	(0.05)	(0.03)	
γ_{i2}	-0.18	0.07	0.09	-0.08	0.10
	(0.07)	(0.02)	(0.06)	(0.03)	
γ_{i3}	-0.02	-0.01	0.05	0.04	-0.06
	(0.05)	(0.02)	(0.05)	(0.03)	
γ_{i4}	-0.13	0.03	0.08	-0.02	0.04
	(0.06)	(0.02)	(0.05)	(0.02)	
γ_{i5}	0.03	-0.02	0.02	0.02	-0.07
	(0.04)	(0.01)	(0.03)	(0.02)	
a_{i1}	-0.57	0.08	1.34	-0.39	-0.46
	(0.39)	(0.19)	(0.34)	(0.25)	
a_{i2}	-1.90	1.01	2.22	-0.54	-0.79
	(0.49)	(0.24)	(0.43)	(0.32)	
a_{i3}	-1.40	0.06	2.09	-0.38	-0.37
	(0.45)	(0.22)	(0.40)	(0.30)	
a_{i4}	-1.71	0.16	1.31	0.60	-0.36
	(0.50)	(0.24)	(0.44)	(0.33)	
c_{i1}	-0.19	-0.04	0.15	0.03	0.05
	(0.05)	(0.02)	(0.04)	(0.03)	
c_{i2}	0.27	-0.09	-0.18	0.02	-0.02
	(0.04)	(0.02)	(0.03)	(0.02)	
c_{i3}	0.07	0.04	-0.08	-0.02	-0.01
	(0.03)	(0.02)	(0.03)	(0.02)	
c_{i4}	-0.16	0.03	0.16	-0.07	0.04
	(0.05)	(0.03)	(0.05)	(0.03)	
c_{i5}	-0.07	0.02	0.00	0.02	0.03
	(0.04)	(0.02)	(0.03)	(0.02)	
c_{i6}	-0.11	0.00	0.09	0.00	0.02
	(0.03)	(0.01)	(0.02)	(0.02)	
R^2	0.86	0.83	0.85	0.67	
SEx100	0.4	0.2	0.3	0.2	
DW	2.3	2.3	2.5	2.4	

c_{ij} are the elements of matrix Γ terms in brackets are t-ratios.

TABLE 8

Dynamic Model with Symmetry and Homogeneity

	Food	Al/tob	Cloth	Ed/rec	Med. c
α_i	2.73	-0.68	-0.44	-0.13	-0.48
	(0.17)	(0.22)	(0.31)	(0.90)	
β_i	-0.18	0.07	0.05	0.02	0.05
	(0.02)	(0.02)	(0.03)	(0.00)	
γ_{i1}	0.23	-0.12	-0.09	0.02	-0.04
	(0.11)	(0.03)	(0.04)	(0.02)	
γ_{i2}		0.08	0.03	-0.04	0.05
		(0.10)	(0.10)	(0.03)	
γ_{i3}			0.05	0.02	-0.02
			(0.08)	(0.02)	
γ_{i4}				-0.01	0.00
				(0.02)	
γ_{i5}					-0.00
a_{i1}	-0.97	0.36	1.49	-0.32	-0.56
	(0.36)	(0.18)	(0.32)	(0.24)	
a_{i2}	-2.07	0.76	2.66	-0.58	-0.77
	(0.52)	(0.28)	(0.46)	(0.33)	
a_{i3}	-1.60	0.47	1.95	-0.29	-0.52
	(0.43)	(0.20)	(0.39)	(0.27)	
a_{i4}	-1.87	0.62	1.12	0.63	-0.49
	(0.45)	(0.22)	(0.41)	(0.30)	
c_{i1}	-0.17	-0.03	0.12	0.04	0.04
	(0.05)	(0.03)	(0.05)	(0.03)	
c_{i2}	0.25	-0.09	-0.17	0.03	-0.01
	(0.04)	(0.02)	(0.03)	(0.02)	
c_{i3}	0.06	0.06	-0.11	0.00	-0.02
	(0.03)	(0.02)	(0.03)	(0.02)	
c_{i4}	-0.13	0.03	0.13	-0.05	0.00
	(0.05)	(0.02)	(0.05)	(0.03)	
c_{i5}	-0.02	-0.01	-0.02	0.02	0.03
	(0.04)	(0.02)	(0.03)	(0.02)	
c_{i6}	-0.13	0.03	0.10	-0.00	0.00
	(0.03)	(0.01)	(0.02)	(0.02)	
R^2	0.83	0.72	0.80	0.63	
SEx100	0.4	0.2	0.4	0.2	
DW	2.2	2.0	2.3	2.2	

c_{ij} are the elements of matrix Γ terms in brackets are t-ratios.

TABLE 9

Income and Price Elasticities

(a) Dynamic Model Estimates

Commod. i	Income Elast	Price Elasticities e_{i1}	e_{i2}	e_{i9}	e_{i4}	e_{i5}
Food	0.68	-0.02	-0.11	0.01	0.12	-0.01
Al/tob	1.63	-0.56	-0.15	0.46	-0.29	0.52
Cloth.	1.31	0.02	0.30	-0.51	0.23	-0.05
Ed/Rec	1.22	0.85	-0.37	0.46	-1.06	0.11
Med. C.	1.82	-0.11	1.01	-0.14	0.16	-0.93

(β) Static Model Estimates

Commod. i	Income Elast.	Price Elasticities e_{i1}	e_{i2}	e_{i9}	e_{i4}	e_{i5}
Food	0.76	-0.17	-0.01	0.06	0.05	0.04
Al/tob	1.37	-0.07	-0.80	1.00	-0.39	0.15
Cloth.	1.29	0.23	0.64	-1.25	0.32	0.05
Ed/Rec	1.22	0.35	-0.49	0.65	-0.80	0.29
Med. C.	1.60	0.40	0.28	0.14	0.44	-1.30

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