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This paper is circulated for discussion purposes only and its contents should be considered preliminary.

A MICROECONOMETRIC MODEL OF INTERTEMPORAL SUBSTITUTION AND CONSUMER DEMAND

by

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ABSTRACT

In this paper we investigate the relationship between within-period preferences and the degree of intertemporal substitution. We first present a theoretical discussion which argues that the form of within-period preferences and the way these differ across consumers may have important consequences for the formulation and specification of intertemporal models. We then apply this methodology to a detailed study of disaggregate household expenditure patterns using a pooled cross-section of some 70,000 households across 15 years. Our objective is to assess the degree of intertemporal substitution across different household types avoiding aggregation bias and accounting for nonadditive within-period preferences and nonlinearity in Engel curves.

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1. INTRODUCTION

A glance through the literature on empirical demand analysis points to two clear properties of consumer demand systems: preferences are neither homothetic nor additive across goods. In more accessible terms, Marshallian demand equations do not display unitary budget elasticities and the marginal utility of each good tends to depend on the consumption of other goods. The relevance of these two properties for analysing intertemporal consumer behaviour is simple. Non-unitary budget elasticities mean that the marginal utility of income in any period cannot be assumed proportional to total real consumption in that period. While, a lack of additivity implies that it is not possible to separately analyse the intertemporal behaviour of a single good independently of the consumption level of other goods. Instead, marginal utility of income depends on the degree of nonlinearity in each Engel curve and the degree of substitution between different goods. Moreover, at the micro level it will also be evident that demographic variables and other household characteristics affect this marginal utility and therefore influence the optimal path of consumption over the life-cycle.

A number of recent papers have appeared in the literature which identify strong and implausible restrictions underlying many models professing to estimate the determinants of intertemporal substitution. Given that the estimated elasticity of intertemporal substitution is often used as a basis for evaluating the effects of after tax real interest rates on savings, reliability of these estimates is far from merely academic. For example, Blundell, Fry and Meghir (1985), Browning (1986) and Nickell (1988) have pointed to the severe restrictions placed on both within and across period preferences in standard formulations of the life-cycle consumption model under uncertainty.

In modern discussions of intertemporal substitution (see, Hall (1978) and Browning, Deaton and Irish (1985)), the intertemporal substitution elasticity is recovered from the condition, derived from life-cycle utility maximisation under uncertainty, that the expected marginal utility of wealth (suitably discounted) will remain constant over the life-cycle. Consumption patterns over the life-cycle will be adjusted such that the discounted marginal value of an extra unit of expenditure in any period is equalised. The intertemporal elasticity then measures the movement of consumption from one period to another in response to a change in prices or interest rates. Clearly, if the marginal utility is being measured incorrectly then so may be the intertemporal elasticity. Despite this, most analyses of intertemporal substitution have chosen forms for marginal utility that impose restrictions on consumer preferences that are at odds with one or other or both of the two properties of consumers' behaviour mentioned above.

Marshallian demand analysis is clearly not suited to the identification of parameters reflecting intertemporal substitution. Such demand analysis simply represents the lower stage of a life-cycle two-stage budgeting process in which the intertemporal allocation of total expenditure is made at the top stage. It can therefore only recover the parameters of utility in any period up to some monotonic transformation. Unless this transformation is fixed arbitrarily, further information is needed in order to pin down the parameters of intertemporal substitution. It should be pointed out that this transformation can depend on any characteristics other than price and income. Marshallian demand analysis does, however, provide us with the appropriate value of the marginal utility apart from this monotonic transformation. Moreover, it is the natural framework for discovering the degree of Engel curve nonlinearity and preference non additivity. Once these within period properties are estimated the marginal utility of wealth condition can be used to estimate the remaining intertemporal parameters.

In this paper we utilise a pooled cross section of some 70,000 households across 15 years to investigate the properties of within period preferences and the degree of intertemporal substitution. Micro level data avoids the problem of aggregation bias and allows us not only to assess the degree of nonlinearity in the Engel curve for particular goods but also to analyse the importance of other cross-section determinants of demand. We present a detailed study of dissaggregate household expenditure patterns from which we recover the appropriate marginal utility terms for each individual household. This is then used to assess the degree of intertemporal substitution across different household types.

One drawback of our data for the measurement of intertemporal substitution is that it does not follow the same individuals through time. We follow Browning, Deaton and Irish (1985) by constructing cohort means and following these through time. This approach also has the advantage of both minimising attrition problems and providing a relatively long time-series of observations in comparison to true panel data. Since we possess the actual micro data we can minimise any aggregation bias by exactly aggregating the appropriate marginal utility terms across households in any cohort. This will also allow us to assess the importance of household characteristics in intertemporal behaviour. In particular we shall be wishing to evaluate the importance of labour market status and housing tenure. It is likely that these variables reflect an ability to intertemporally substitute rather than a preference alone. We will not be able to distinguish between these two effects in our estimated intertemporal elasticity - a low elasticity may reflect a low preference to borrow or a difficulty of borrowing.

2. A THEORETICAL FRAMEWORK

2.1 Two-Stage Budgeting

Two-stage budgeting schemes provide a powerful structure for thinking about intertemporal allocations. At the second or lower stage, purchase decisions within a particular period are made using only within period prices and within period total expenditure. As Gorman (1959) shows, preferences must be intertemporally weakly separable for this to be optimal. At the first or top stage, allocation of lifetime wealth is made using only indices of each period's prices. If we restrict ourselves to just one index per period and assume intertemporal weak separability, then within period preferences must be homothetic or intertemporal preferences must be explicitly additive and within period preferences must take a Generalised Gorman Polar Form (see Deaton and Muellbauer (1980), chapter 5).

Our estimation procedure exploits a two-stage budgeting scheme but relaxes the restrictions imposed on within preferences and on intertemporal substitution preferences allowing the latter to be a general function of observables. Specifically, although we shall assume that preferences are intertemporally additive we shall begin by assuming that the within period indirect utility function takes the form

$$U(p,x) = F\{G[x/a(p)]/b(p)\} = F(V(p,x)) \qquad (2.1)$$

where $a(p)$ is a linear homogenous price index, $b(p)$ is a zero homogenous price index, x is within period total expenditure and $F(\cdot)$ and $G(\cdot)$ are strictly increasing functions whose structure is such that $U(p,x)$ is strictly concave in x. In this framework $V(p,x)$ completely determines within period demands while the additional parameters in F are required to describe the allocation of consumption expenditure across periods. For example, if F is the log transformation all parameters necessary to determine intertemporal decisions are identified from within period preferences (see Muellbauer (1988), for example)). Indeed, in this case $U(p,x)=\ell nG(x/a(p))-\ell nb(p)$ and a single price index $a(p)$ is sufficient to determine intertemporal consumption decisions. The form of preferences in (2.1) is fairly general. In particular, if we take $G(\cdot)=\ell n(\cdot)$ then this gives a PIGLOG specification (see Muellbauer(1976)in which indirect utility is $V(p,x) = (\ell nx-\ell na(p))/b(p)$. Indeed, (2.1) covers the complete class of rank two demand systems described in Gorman (1981). We note here that although the preferences are sufficient for a 'top' stage optimal allocation using just two price indices it is by no means necessary.

As well as providing this useful structure for analysing intertemporal allocations, two-stage budgeting provides a natural scheme for specification and estimation. To anticipate: we first estimate a demand system on a time series of Family Expenditure Surveys to derive the parameters of within period allocation; that is, the parameters of $a(\cdot)$ $b(\cdot)$ and $G(\cdot)$ which determine indirect utility $V(\cdot)$ in (2.1). We then use these parameters to construct the price indices and other terms that are used in the estimation of the parameters of $F(\cdot)$. This second step takes the form of a Hall type consumption function on consistently aggregated cohort data.

Up to now we have implicitly assumed that we shall be modelling the allocation over all goods. This is clearly not possible and as a result we partition goods into two groups. The first is the group of interest; let this have quantity and price vectors (q,p). The second group contains those goods that we do not model explicitly. Denote the vector of such goods z and let sub-vectors be given by z^1, z^2,... where z^i and z^j may have common elements. We generalise within period preferences to be represented by the conditional indirect utility function

$$U(p,z,x) = F(V(p,z^1,x),z^2) + H(z^3) \tag{2.1'}$$

This function gives the maximum utility in the period for an agent who has total expenditure x on the first group of goods with prices p conditional on other goods and household characteristics z.

This treatment of conditioning factors has a natural interpretation for our discussion of intertemporal allocations. All those factors in z^3 but not in z^1 nor z^2 enter neither the demand system nor the consumption function. They are explicitly additive from all other commodities. Factors in z^2 but not in z^1 enter the consumption function but not the demand system. These are weakly separable from q. Those in z^1 influence the marginal rate of substitution between elements in q and are therefore not separable. Factors in z^1 but <u>not</u> in z^2 condition demand directly but do not affect intertemporal allocation except through their effect on the parameters of demand used in the consumption function. Finally, we note that we can have elements in z^1 and z^3 that are not in z^2.

2.2 A Model for Within Period Preferences

The form of within period preferences is independent of the normalisation $F(\cdot)$ in (2.1). More precisely, the shape of Engel curves and the specific form of within period substitution is independent of the parameters determining intertemporal substitution. Thus to derive our demand system we only need to parameterise $V(\cdot)$, that is $G(\cdot)$, $a(\cdot)$ and $b(\cdot)$. For $G(\cdot)$ we take the Box-Cox transform

$$G(y) = \begin{cases} y^{\{\theta\}} = (y^{\theta}-1)/\theta & \theta \neq 0 \\ \ell n y, & \text{otherwise.} \end{cases} \tag{2.2}$$

Given (2.1) and (2.2) the indirect utility representation of within period preferences is given by

$$V(p,x) = \left(\frac{x}{a(p)}\right)^{\{-\theta\}} \frac{1}{b(p)} \qquad \theta \neq 0 \tag{2.3a}$$

and

$$V(p,x) = \frac{\ell nx - \ell na(p)}{b(p)} \qquad \text{otherwise} \tag{2.3b}$$

in which we have suppressed the conditioning variables z described above for brevity. These two are members of the PIGL and PIGLOG classes respectively. Applying Roy's Identity and rearranging, we have the demand system

$$w_i = \frac{a_i}{a(p)} + \frac{b_i}{b(p)} \left(\frac{x}{a(p)} \right)^{\{\theta\}} \qquad \text{for } i=1,\ldots,n \tag{2.4}$$

where w_i is the budget share for good i and a_i and b_i are the price derivatives of a(p) and b(p) respectively.

To estimate (2.4) we adopt the parameterisations:

$$\ell na(p) = \alpha_o + \Sigma\alpha_k \ell np_k + \frac{1}{2}\Sigma_k\Sigma_j\, \gamma_{kj}\ell np_k \ell np_j \qquad \text{and}$$

$$\ell nb(p) = \Sigma_k\beta_k\ \ell n\ p_k$$

where we shall allow the α and β parameters to vary across households and across time as a function of demographic characteristics as well as the conditioning factors described above. To satisfy adding-up we require $\Sigma\alpha_k=1$, $\Sigma\beta_k=0$ and $\Sigma_k\gamma_{kj}=0$, while homogeneity implies $\Sigma_j\gamma_{kj}=0$. Substituting these parameterisations into (2.4) we have the demand system

$$w_i = \alpha_i + \Sigma_j\, \gamma_{ij}\ \ell n\ \bar{p}_j + \beta_i(x/a(p))^{\{\theta\}} \tag{2.4'}$$

for i=1,...,n. The value of θ determines the shape of the Engel curve. If θ=0 we have the Almost Ideal Demand System of Deaton and Muellbauer (1980). Alternatively, if θ=-1 we have quasi-homothetic preferences whilst θ=+1 gives a form of quadratic Engel curves in which expenditure shares can be written linear in x. If all of the β_i's are zero we have homothetic preferences; in this case all Engel curves are linear through the origin and θ is not identified in the demand system.

2.3 The Consumption Function

The last sub-section derived a fairly standard but flexible demand system. In this sub-section we derive a consumption function from the same preference representation. Our approach is based on the Bewley (1976) - Hall (1978) Euler equation formulation and follows closely the methodology of MaCurdy (1983). This uses the idea that rational agents will allocate expenditure across time so as to try and maintain a constant marginal utility of (discounted) expenditure over time. Notice that since we have assumed that preferences are additive over time, the normalisation $F(\cdot)$ in (2.1) is fixed (up to an increasing, affine transformation); consequently the marginal utility of expenditure in any period is well determined. We take the following functional form for $F(\cdot)$ in (2.1)

$$F(V_t) = \delta_t V_t^{\{1+\rho_t\}} \tag{2.5}$$

where, as before, the superscript in { } denotes the Box-Cox transform. The parameters δ and ρ will again be allowed to vary across households and across time according to movements in demographic and other characteristics.

Given this normalisation we may write the log of the marginal utility of expenditure (in current terms) for any household in period t as:

$$\ln \lambda_t = \rho_t \ln V_t + \ln V'_t + \ln \delta_t \tag{2.6}$$

where V'_t is the derivative of V_t with respect to x_t. To estimate ρ_t we shall exploit the Euler equation which governs the evolution of λ_t over time. Under perfect capital markets with a nominal rate of interest r_t between periods t and (t+1) this is given by

$$E_t\{(1+r_t)\lambda_{t+1}\} = \lambda_t \ . \tag{2.7}$$

In this equation $E_t(\cdot)$ represents the expectation conditional on information available at time t. To proceed, re-write (2.7) as

$$(1+r_t)\,\lambda_{t+1} = \lambda_t u_{t+1} \quad , \quad E_t(u_{t+1}) = 1 \tag{2.8}$$

For purposes of estimation on our cohort data described below, we shall assume that u_{t+1} is distributed in such a way that

$$E_t(\ell n u_{t+1}) = - d_{t+1} + \varepsilon_{t+1}, \qquad E_t(\varepsilon_{t+1}) = 0$$

where d_{t+1} represents the conditional variance (or higher moments) of u_{t+1}. In estimation, time effects will allow these conditional moments to vary systematically across time and cohorts. Taking logs through (2.8) we can then approximate (2.7) by

$$\Delta \ell n\lambda_{t+1} + r_t + d_{t+1} = \varepsilon_{t+1}, \tag{2.9}$$

where Δ refers to the first difference operator.

Substituting (2.6) in (2.9) we can rewrite (2.9) as

$$\Delta\, \rho_{t+1} \ell n V_{t+1} + \Delta \ell n V'_{t+1} + r_t + d_{t+1} + \Delta \ell n \delta_{t+1} = \varepsilon_{t+1} \tag{2.10}$$

in which all parameters identifiable from within period preferences are summarised in the V and V′ expressions. Note that $\Delta \ell n \delta_{t+1} = -\delta$ if utility is discounted at a constant rate δ. Moreover, when u_t is lognormally distributed the $(d_{t+1}-\delta)$ term becomes $(\frac{1}{2}\sigma^2_{t+1}-\delta)$, since in this case d_{t+1} equals the conditional variance $\frac{1}{2}\sigma^2_{t+1}$, and can be interpreted as capturing the trade-off between impatience and caution. For example, if the future was certain then the variance term is zero and a positive value of δ effectively lowers the interest rate; this raises future discounted prices and causes agents to consume more in the present. If, on the other hand, there is a good deal of uncertainty then agents postpone consumption; this is to be interpreted as precautionary saving.

Using our definition of V from (2.3), the 'Euler' equation (2.10) becomes

$$\Delta\rho_{t+1}\ell nC_{t+1}^{\{-\theta\}} - (1+\theta)\Delta\ell n\, C_{t+1} - \Delta(1+\rho_{t+1})\ell n\, b(p_{t+1}) \qquad (2.11)$$
$$+(r_t - \Delta\ell na(p_{t+1})) + (d_{t+1} - \delta) = \varepsilon_{t+1}$$

where we have used C_t to represent total real consumer's expenditure $x_t/a(p_t)$. Equation (2.11) relates changes in consumption to changes in relative prices, to the real interest rate $(r_t - \Delta\ell n\ a(p_{t+1}))$, to the discount/precautionary term discussed above and to the surprise term ε_{t+1}.

The relationships given by (2.4) and (2.11) constitute our description of the consumer's allocation scheme. This parameterisation has a recursive nature : there are some parameters that enter both the intra-temporal and inter-temporal allocation decisions i.e. θ and the parameters of $a(p_t)$ and $b(p_t)$. There is also one set of parameters that enter only at the top stage, namely ρ_t. In particular, θ, $a(p_t)$ and $b(p_t)$ determine the shape of the underlying Engel curves while for any given value of these ρ_t determines intertemporal substitution. If we change the former then we shall usually change the latter.

We concentrate attention on the intertemporal substitution elasticity; that is, the percentage change in consumption for an anticipated one percent rise in discounted prices. This is given by

$$\Phi_t = \frac{U'_t}{x_t U''_t} = \frac{C_t^{\{\theta\}}}{\rho_t - (1+\theta)C_t^{\{\theta\}}} \qquad (2.12)$$

where we shall scale $a(p)$ so that the minimum value of $C_t(=x_t/a(p_t))$ is unity. Given this, we see that Φ is zero at the minimum level of expenditure (so long as $\rho_t \neq 0$). This is sensible; agents on the edge of subsistence have no substitution possibilities. Given our assumptions the intertemporal elasticity should be negative for all values of C_t. This will be the case if ρ_t is negative. If, however, ρ_t is positive then for low values of C_t the intertemporal elasticity will be positive. If ρ_t is negative then the intertemporal elasticity is bounded below by $-(1+\theta)^{-1}$ which is potentially quite limiting.

3. ESTIMATION AND EMPIRICAL EVIDENCE

3.1 A Methodology for Estimation

For estimation purposes it is worth collecting together the expressions containing the parameters of interest from the previous section. Within period preference parameters are completely contained in the demand system given by share equations (2.4') to which we append a random disturbance v_{it} and rewrite as

$$w_{it} = \alpha_{it} + \sum_j \gamma_{ij} \ell n p_{jt} + \beta_i (x_t / a(p_t))^{\{\theta\}} + v_{it} \tag{3.1}$$

for i=1,...,n. Apart from adding-up which ensures $\sum_{i=1}^{n} v_{it} = 0$ for all t, the distributional properties of v_{it} are left unrestricted.

The parameters of (3.1) completely describe the indirect utility function V_t in (2.5) but not the marginal utility of income λ_t, for which the parameter ρ_t is also required as can be seen from (2.6). To identify parameters of λ_t we need to estimate the 'consumption function' described by equation (2.11). This we can rewrite in terms of the indirect utility V_t using (2.9) as

$$\Delta \ell n\ V'_{t+1} + \Delta\rho_{t+1}\ \ell n\ V_{t+1} + \tau_{t+1} = \varepsilon_{t+1} \tag{3.2}$$

where the τ_{t+1} represent the interest rate, personal discount rate and conditional variance terms in (2.10). Clearly, both V'_t and V_t are individual as well as time specific and depend on all the parameters and variables entering the demand system (3.1). But, if we consider the case where ρ is constant, once V'_t and V_t are known, (3.2) simply contains one parameter ρ. In practice we shall wish to allow ρ to vary with individual specific characteristics which may be time varying.

The intertemporal allocation model (3.2) possesses three important features. First, estimation requires panel data. Secondly, V_{t+1} and V'_{t+1} will be constructed variables which depend on estimated parameters. Thirdly, these variables depend on x_{t+1} which is clearly correlated with ε_{t+1}. For this reason (3.2) must be estimated by instrumental variable techniques and in particular methods which exploit the moment restrictions between ε_{t+1} and past consumption and price variables which follow from the Euler equation. Nevertheless, consistent estimation can proceed following the two-stage framework of the model. First, estimating system (3.1) including the Engel curve parameter θ allowing $(x_t/a(p_t))$ to be endogenous. Secondly, estimating the parameters underlying ρ_{t+1} in (3.2), conditional on the estimates of the first stage parameters.

3.2 The Data

In our demand system describing within period preferences we have chosen a group of seven broad commodities for each household. These are: food, alcohol, fuel, clothing, transport, services and other goods. The results reported here refer to a sample of 64,271 GB households from 1970-1984 inclusive, whose head is more than 18 and less than 60 years of age and is not self-employed. These data are drawn from the annual UK Family Expenditure Survey and are more fully described in the data appendix at the end of the paper. Our choice of goods clearly excludes some other non-durables like tobacco as well as durables, leisure and various public goods. As described in Section 2.1 we allow for the effect of some of these on our allocation scheme by entering them as conditioning variables in the demand system and consumption model.

3.3 Estimating Within Period Preferences

Working at the household level allows a more detailed analysis of the influence of individual characteristics as well as an assessment of the shape of the Engel curves for each good reflected by the θ parameter of the share equation (3.1) above. This micro-level analysis will clearly have implications for the type of analysis we will have to pursue in constructing our cohort groups to be used in estimating the 'first stage' consumption function of our intertemporal model. Our results for the 'second stage' demand system utilise estimates from a seven equation Almost Ideal demand system. Here our interest is on recovering estimates for each household in each period of the indirect utility function $V(p,x;z)$ defined in sections 2.2 and 2.3 above. In particular we shall be interested in factors that cause households to differ in their marginal value placed on consumption in any period not only through price changes but also through the introduction of household characteristics and non-linear Engel curves.

Before describing the results of this first stage in our analysis it is worth briefly considering the way in which demographic and other variables are introduced into our estimated model. Turning to the share equations (3.1) we allow the α and β parameters to household 'h' specific in the following way:

$$\alpha_{ih} = \alpha_{io} + \Sigma_k z_{kh} \alpha_{ik} \tag{3.3}$$

and

$$\beta_{ih} = \beta_{io} + \Sigma_k z_{kh} \beta_{ik} \tag{3.4}$$

where the z_{kh} are conditioning variables including the z^1 variables of equation (2.1′) including characteristics such as age, number of children per age group etc.

Turning first to Table 1(a) we present the estimates of the Almost Ideal demand model, θ=0. This table contains the parameter estimates relating to the γ_{ij} and β_i parameters in demand system (3.1) respectively. For example PFOOD is the log of the food price and LnC is the log of total real expenditure (ℓnC_t^h). The parameter estimates relating to other demographic variables and conditioning variables which are entered in the intercept of the share equation are listed in Appendix B. To account for the likely endogeneity of total expenditure in each household's lower stage choices, we have instrumented all the terms in the logarithm of total real expenditure for each household. As already mentioned many individual demographic, locational and labour market characteristics were allowed to enter each share equation and each of these was used as an instrument for the total real expenditure terms. Additional instruments included normal disposable income, interest rates and local unemployment rates. The complete list ofinstruments used is given in Appendix A.

It should also be noted that homogeneity and symmetry restrictions have been imposed. The one degree of freedom t-test statistics for homogeneity for each share equation are presented at the foot of Table 1(a) and show broad agreement with the data. The symmetry test is less acceptable with a Chi-square statistic of 80.02 with 15 degrees of freedom. However, it should also be pointed out that we are estimating on a very large data set where one might expect use of a smaller size of test for

Table 1(a): Restricted Price and Income Parameters for The Almost Ideal Model (θ=0)

	FOOD	*ALCOHOL*	*FUEL*	*CLOTHING*	*TRANSPORT*	*SERVICES*	*OTHER*
PFOOD	0.09549	0.008900	-0.015619	0.002953	-0.040691	-0.013748	-0.031388
	(.00986)	(.00670)	(.00548)	(.00801)	(.01110)	(.00820)	......
PALC		-0.058948	0.059719	-0.005651	0.041823	-0.005645	-0.040198
		(.00875)	(.00589)	(.00617)	(.01052)	(.00790)	......
PFUEL			0.007386	-0.000340	-0.048787	-0.015903	0.013543
			(.00666)	(.00531)	(.00872)	(.00632)	......
PCLOTH				0.015460	-0.004968	-0.014239	0.012690
				(.00938)	(.01069)	(.00796)	......
PTRPT					0.049782	0.009941	-0.007100
					(.02384)	(.01319)	......
PSERV						0.014671	0.024922
						(.01334)	......
POTH							0.027531
DlnC	0.002042	-0.002260	0.000856	0.001940	-0.004648	0.001270	0.000800
	(.00032)	(.00026)	(.00018)	(.00035)	(.00045)	(.00037)	......
S1LnC	-0.006488	-0.005083	-0.005069	-0.004163	0.015229	0.010667	-0.005094
	(.00238)	(.00192)	(.00137)	(.00256)	(.00330)	(.00270)	......
S2LnC	-0.012108	-0.004799	0.004974	-0.006389	0.009867	0.013350	-0.004895
	(.00238)	(.00192)	(.00137)	(.00256)	(.00330)	(.00269)	......
S3LnC	-0.015181	-0.008093	0.012065	-0.006251	0.005501	0.014508	-0.002548
	(.00233)	(.00188)	(.00135)	(.00251)	(.00323)	(.00264)	......
LnC	-0.131479	0.052971	-0.059122	0.035100	0.032784	0.075471	-0.005725
	(.00209)	(.00169)	(.00122)	(.00225)	(.00290)	(.00237)	......
Homog(1)	0.5	0.4	0.4	0.9	0.2	0.1	0.6

Notes: Figures in parentheses are asymptotic standard errors. A detailed data description is given in the Data Appendix. Quarterly seasonal dummies, regional dummies and a linear time trend were included throughout. Coefficient estimates for included demographic and other variables are given in Appendix B.

It is comforting to note that, in line with the results of Blundell, Pashardes and Weber (1988), many of the coefficients on the log price variables (PFOOD,...,POTH) are significant despite the large number of other characteristics allowed to influence expenditure shares. The significant coefficients on many of the *ln*C terms also indicate a strong rejection of homotheticity identified earlier in this paper as one of the crucial assumptions underlying many intertemporal models. Corresponding elasticities are provided in Table 1(b). Since one area of interest for this paper, was the shape of the Engel curve it is also important to assess the acceptability of the $\theta = 0$ (see (3.1)) assumption in this Almost Ideal model against more reasonable alternatives than the homothetic case. Before investigating this assumption it is worth briefly examining the other factors which influence demand patterns listed in Appendix B. The

Table 1(b) : Price and Income Elasticities : $\theta=0$

	Food	Alcl	Fuel	Commodity Group Cloth	Trpt.	Other	Serv.
Income Elasticity	0.612	1.828	0.245	1.361	1.231	1.626	0.955
Uncompensated Price Elasticities:							
Food	-0.5722	0.0688	-0.0493	0.0344	-0.0329	0.0195	-0.07849
Alcl	-0.0649	-2.0722	0.7107	0.0010	0.2935	-0.0674	-0.62933
Fuel	-0.0750	0.6640	-0.6536	0.0598	-0.3874	-0.1449	0.29250
Clot	-0.1437	0.0318	-0.0449	-0.8294	-0.2352	-0.3196	0.17995
Trpt	-0.2805	0.1496	-0.2680	-0.1210	-0.7703	0.1225	0.06311
Other	-0.2955	-0.0250	-0.2227	-0.3060	0.1169	-0.9105	0.01693
Serv.	-0.3793	-0.3463	0.1810	0.2201	-0.0569	0.0991	-0.65730
Compensated Price Elasticities:							
Food	-0.3596	0.1095	0.0025	0.0965	0.0759	0.0906	-0.0154
Alcl.	0.5721	-1.9503	0.8659	0.1871	0.6196	0.1458	-0.4402
Fuel	0.0102	0.6803	-0.6328	0.0847	-0.3438	-0.1164	0.3178
Cloth	0.3304	0.1226	0.0706	-0.6909	0.0075	-0.1609	0.3207
Trpt.	0.1482	0.2317	-0.1636	0.0043	-0.5508	0.2660	0.0642
Other	0.2708	0.0834	-0.0847	-0.1405	0.4068	-0.7209	0.1851
Serv.	-0.0466	-0.2826	0.2620	0.3173	0.1134	0.2104	-0.5585
NT σ^2	484.56	322.79	159.68	571.00	940.22	620.80	---

NOTES: $NT\sigma^2$ refers to the sample size weighted estimate of the equation variance.

interpretation of the demographic variables in each share equation in Appendix B is quite simple. For example, the variable CH02 indicates that an additional child of less than 3 years old will add 0.019 to the share of expenditure on food. On the other hand, with the head of household being a white collar worker, even allowing for income differences the share will fall by -0.005 (see the White Collar variable WHC). A similar effect is found for the number of earners variable (EARNNR).

To assess whether the $\theta=0$ assumption is a reasonable approximation we provide two alternative models to which we shall return in analysing the sensitivity of the intertemporal model with regard to changes in within period parameters. These are the quasihomothetic and quadratic systems for

Tables 2(a) : The Quasi Homothetic Model (θ=-1)

	Food	Alcl	Fuel	Cloth	Trpt.	Other	Serv.
	Commodity Group						
Income Elasticities	0.647	1.769	0.318	1.316	1.206	1.577	0.953
Uncompensated Price Elasticities:							
Food	-0.5653	0.0604	-0.0358	0.0218	-0.0386	0.0019	-0.09085
Alcl.	-0.0753	-2.0258	0.6382	0.0118	0.2854	-0.2854	-0.59284
Fuel	-0.0323	0.5982	-0.5188	-0.0209	-0.3998	-0.2267	0.24083
Cloth	-0.1586	0.03790	-0.0673	-0.8086	-0.2323	-0.2948	0.20816
Trpt.	-0.2702	0.1442	-0.2656	-0.1214	-0.7762	0.1307	-0.04742
Other	-0.3186	0.0068	-0.2719	-0.2840	0.1336	-0.8795	0.03581
Serv.	-0.4079	-0.3265	0.1450	0.2429	-0.0338	0.1152	-0.67290
Compensated Price Elasticities:							
Food	-0.3401	0.1035	0.0191	0.0876	0.767	0.0773	-0.0240
Alcl.	0.5409	-1.9079	0.7883	0.1991	0.6009	0.1958	-0.4099
Fuel	0.0784	0.6194	-0.4918	0.0532	-0.3431	-0.1897	0.2737
Cloth	0.2996	0.1256	0.0443	-0.6747	0.0023	-0.1414	0.3442
Trpt.	0.1499	0.2246	-0.1633	0.0013	-0.5611	0.2713	0.0773
Other	0.2310	0.1120	-0.1380	-0.1234	0.4150	-0.6956	0.1990
Serv.	-0.0759	-0.2630	0.2259	0.3399	0.1362	0.2263	-0.5743
NT σ^2	595.62	326.16	172.12	582.05	952.49	660.68	----

Table 2(b) : The Quadratic Model (θ=+1)

	Food	Alcl	Fuel	Cloth	Trpt.	Other	Serv.
	Commodity Group						
Income Elasticities	0.580	1.879	0.181	1.398	1.253	1.667	0.954
Uncompensated Price Elasticities:							
Food	-0.5617	0.0779	-0.0497	0.0303	-0.0374	0.0351	-0.07461
Alcl	-0.0459	-2.1554	0.7885	-0.0178	0.2716	-0.1258	-0.59478
Fuel	-0.0652	0.7328	-0.7336	0.0656	-0.3854	-0.0755	0.27975
Cloth	-0.1811	0.0205	-0.0485	-0.8156	-0.2180	-0.3327	0.17746
Trpt	-0.3074	0.1433	-0.2743	-0.1096	-0.7652	0.1190	-0.05878
Other	-0.2737	-0.0577	-0.1810	-0.3179	0.1082	-0.9481	0.00326
Serv.	-0.3763	-0.3210	0.1652	0.2215	-0.0452	0.0886	-0.67170
Compensated Price Elasticities:							
Food	-0.3596	0.1166	-0.0005	0.0893	0.0661	0.1027	-0.0146
Alcl	0.6088	-2.0301	0.9480	0.1753	0.6068	0.0933	-0.4004
Fuel	-0.0020	0.7449	-0.7182	0.0841	-0.3530	-0.0543	0.2985
Cloth	0.3059	0.1137	0.0701	-0.6733	0.0313	-0.1697	0.3220
Trpt.	0.1291	0.2268	-0.1680	0.0179	-0.5418	0.2651	0.0708
Other	0.3070	0.0534	-0.0395	-0.1482	0.4055	-0.7538	0.1757
Serv.	-0.0440	-0.2574	0.2462	0.3186	0.1249	0.1998	-0.5730
NT σ^2	555.67	349.10	185.53	576.43	955.40	619.28	---

which $\theta=-1$ and $\theta=+1$, respectively. The quasihomothetic model is a popular Engel curve specification, a restricted version of which underlies the Linear Expenditure System. The elasticities corresponding to those in 1(b) are presented in tables 2(a) and 2(b). The corresponding NT σ^2 criteria for each system is given in each case. Here NT represents the sample size and σ^2 an estimate of the structural variance for each equation. Although showing similar elasticities to the Almost Ideal ($\theta=0$) case they are uniformly dominated on an equation by equation comparison.

3.4 Cohort Aggregation and the Estimation of Intertemporal Substitution

Turning now to the estimation of the consumption function described in section 2.3, we note again that our data rather than being a panel, following the same individuals across time, is a time series of cross sections. As a result we construct a pseudo panel using cohort averages in order to estimate the model. To relate these cohort averages to our discussion in Section 2.3 we consider equation (3.2), which defines marginal utility 'λ' for each individual, and take expectations conditional on the person belonging to cohort c. With sufficiently large cohort groups we may replace the expectation terms by their corresponding cohort averages. Taking cohort expectations, (2.6) becomes

$$E_c \ln\lambda_t = E_c \rho(z_t)\ln V_t + E_c \ln(V'_t) \tag{3.5}$$

where we have allowed the parameter ρ_t to depend on a vector of characteristics z_t. Providing entry into the cohort (through immigration) and exit (through death and emigration) are uncorrelated with the marginal utility of wealth, from (2.9) we obtain

$$\Delta E_c \ln\lambda_t + r_{t-1} + d_t = E_c \varepsilon_t \tag{3.6}$$

where again Δ is the first difference operator. Using (3.5) and (3.6) we can now construct a counterpart for (3.2) which is estimable on average cohort data provided the averages are constructed in a way that is consistent with (3.6). To do this firstly note that given the parameters of the demand system $\ell n(V'_t)$ and ℓnV_t are estimated from the demand analysis described above for each individual in the survey. Specifying $\rho(z_t)$ to be

$$\rho(z_t) = \rho_0 + \Sigma_k \rho_k z_{tk} \tag{3.7}$$

we see that (3.5) involves the cohort means of $\ell n(V')_t$, of ℓnV_t and the cross moments of ℓnV_t with the characteristics z_t. We thus use the sample equivalents of these expectations. In other words the exact way in which the cohort averages in our pseudo panel is constructed are governed by the specification of the consumption function and the estimated 'second stage' demand system.

Given this consistent aggregation procedure, the ρ parameters in (3.7) can be estimated using a generalised method of moments estimator on

$$\Delta\ell n(V'_t)_c + \rho_0\Delta\ell n(V_t)_c + \Sigma_k\rho_k\Delta(z_{tk}\ \ell nV_t)_c + r_{t-1} + (d-\delta)_t = (\varepsilon_t)_c \tag{3.8}$$

where the subscript c on the differenced terms points to the fact that we are differencing cohort averages rather than individual observations (see Appendix A(ii)). The instruments used in the methods of moments estimator are cohort averages or differences in cohort averages both lagged and that do not involve any estimated parameters. The stochastic process underlying the Euler condition does require careful attention in applications to micro-data as has been recognised by Chamberlain (1984) and Hayashi (1987). For example, it is quite possible that innovations which are uncorrelated across time for any individual may be correlated across individuals in any time period. For this reason "N" asymptotics may not be sufficient to guarantee the consistency of Method of Momments parameter estimates using lagged instruments but few time series observations. Our solution to this potentially important problem is to exploit our comparatively long time series of cohort observations and to carefully assess the validity of chosen instrumental variables at each step in estimation.

Thus to estimate our first-stage consumption function we construct cohorts using the same data as the one used in the demand system estimation. We have ten cohorts each covering a five year band. This choice leads to cohorts with approximately 300-400 members each (per year) a number hopefully sufficient to make the error in measurement problem discussed by Deaton (1985) of second order significance. Moreover, in removing any household whose head over 60 years of age we hope to minimise the effects of non random attrition due to death. After allowing for the different periods over which each cohort is observed (see Appendix A(ii)) and the loss of observations due to differencing and lagging the instrument set, the resulting data set comprises 100 observations. For the interest rate we use the simple bank lending rate available at the end of period t-1. Since most households hold bank deposits this seems an appropriate choice.

In Table 3 we present the estimated coefficients for alternative estimators of the cohort 'consumption function' derived from equation (3.8) under $\theta=0$, our preferred assumption for the shape of Engel curves. All standard errors in Table 3 are heteroscedasticity adjusted and the GMM estimator exploits this adjustment to improve upon the efficiency of the simple IV estimator. Moreover, the variation in the estimated parameters underlying the indirect utility parameter of V is allowed for. All instruments were dated t-2. This timing of instruments reflects the indication of first order autocorrelation in the errors detected by the r_1 statistic. Such MA(1) errors may well be generated by time aggregation as has been suggested by Hall (1988). The r_1 diagnostic in Table 3 is a one degree of freedom test of this hypothesis and is distributed asymptotically as N(0,1) under the null. It is quite clear from Table 3 that the use of OLS on such an Euler equation generates considerable bias. Our discussion of results therefore centers on the GMM estimates which display a similar pattern to those of the IV estimator but are more precisely determined. The Sargan criteria suggest that the assumed properties on the instruments are acceptable.

The first coefficient ρ_o is self explanatory and feeds in directly to the intertemporal substitution elasticity which from (2.12) may be written as:

$$\Phi_h = \frac{\ln C_t^h}{\rho_o + \Sigma_k \rho_k z_{tk}^h - \ln C_t^h} \tag{3.9}$$

Table 3 : The Cohort Model Estimates (θ=0)

	OLS	GMM			
ρ_o	2.2963	-1.9915	0.2041	-0.6561	0.0
	(0.4868)	(1.3328)	(1.2248)	(1.2211)	(restricted)
HUNEMP	-0.1203	-1.3816	-0.6868	-0.8339	-0.7271
	(0.1469)	(0.4413)	(0.4053)	(0.4272)	(0.3377)
OWNER	0.1987	0.5702	-0.7342	-0.8888	-0.7880
	(0.1579)	0.4988)	(0.3744)	(0.3465)	(0.4304)
LA	0.3997	0.4165	-0.1078	-0.0526	-0.1654
	(0.1491)	0.3854)	(0.3040)	(0.3574)	(0.3580)
SGLADLT	0.0449	1.7230	0.7335	0.9456	0.8532
	(0.1744)	0.6563)	(0.5852)	10.6277	(0.5253)
MULTADLT	0.2669	0.8776	0.6069	0.6281	0.7298
	(0.1286)	(0.3801)	(0.2971)	(0.2932)	(0.3126)
CH02	-0.0008	0.7898	0.9392	1.0994	0.0743
	(0.2073)	(0.6563)	(0.5213)	(0.6147)	(0.4753)
CH34	-0.1145	0.1845	0.1853	0.4786	0.3605
	(0.1918)	(0.3971)	(0.2875)	(0.3108)	(0.3240)
CH510	0.1162	0.1077	0.2753	0.2099	0.2566
	(0.1057)	(0.2131)	(0.1702)	(0.1778)	(0.1932)
CH1118	0.1162	0.2049	0.1631	0.2823	0.1912
	(0.1051)	(0.2162)	(0.1880)	(0.1831)	(0.1979)
WWORK	0.1450	1.0047	0.8408	0.9595	0.9100
	(0.0999)	(0.3078)	(0.2526)	(0.2651)	(0.1815)
Cohort Effects	✓	✓	✓	-	-
UN	-	-	✓	✓	✓
Sargan	-	22.6180	28.9570	22.2399	25.8078
Φ	-2.9700	-0.7842	-1.1895	-0.9747	-1.1390
	(0.9590)	(0.1949)	(0.3875)	(0.2412)	(0.1000)
r_1		-2.3124	-1.6663	-1.8920	-2.2014
r_2		1.0975	-0.6809	-0.8088	-0.4208

Notes: Standard errors in parentheses. Instruments listed in Appendix A. r_1 and r_2 are first and second order serial correlation test statistics respectively (N(0,1) under the null). The Sargan test is a 24 degree of freedom test of instrument validity.

for household type h. The remaining coefficients refer to the ρ_k parameters in (3.8) and (3.9) and only switch on when the household type possesses one of these characteristics. The base level household represents a childless couple living in rented accommodation with the head of household in employment. For this type of household the value of ℓnC_t^h, the log of real expenditure, is approximately -2.5 indicating a very large and negative intertemporal elasticity using the OLS estimates but a value insignificantly different from -1 for estimates from the GMM estimators.

The estimates in column 1 and 2 of Table 3 include cohort special effects which act as fixed effects in equation (3.8) reflecting differences in d-δ across cohorts. Since the d parameter measures a conditional variance and may include higher order moments it was felt worth experimenting with variables that might capture any movements in this variable over time. Moreover, it is clearly worth assessing whether the cohort dummies themselves are required. The third and fourth columns of Table 3 present some evidence on these issues. The third column adds the implied cohort regional unemployment rate UN, appropriately lagged, to the intercept in (3.8). This not only has the impact of reducing the first order serial correlation test statistic r_1 but also reduces the direct impact of unemployment on the ρ parameter although it remains significant. The next column removes the cohort effects completely from the model (they remain in the list of instruments) and surprisingly produce few changes to the parameter estimates. The final column of Table 3 sets the parameter ρ_o, rather imprecisely determined in all the models, to zero. This implies using an identity transformation for F in equation (2.5) in the base case, suggesting a base line intertemporal elasticity of -1.

Table 3 suggests that it is the labour market status variables that dominate the determination of the intertemporal substitution elasticity Φ once ℓnC_t^h is allowed for. The presence of a head unemployed in the household significantly reduces ρ and therefore Φ (ceteris paribus). Conversely, households with a working wife (WWORK) have a significant increase in ρ as do households with multiple adults (MULTADLT). In each column of Table 3 we present the mean value of the intertemporal elasticity of substitution Φ implied by these estimates.

3.5 Preference misspecification and the intertemporal elasticity.

In our empirical results reported earlier we suggested that the curvature of the Engel curves when $\theta=0$ provided a better description of within period preferences than the quasihomothetic model ($\theta=-1$) or the quadratic model ($\theta=+1$). The latter performed worse of all. Yet it is interesting to establish whether such misspecification would lead to severe misspecification in the intertemporal elasticity of substitution. Note that the overall concavity of the utility function with respect to total expenditure, which determines intertemporal substitution, depends on the values of θ and ρ. Just by examining (2.11) we can see that ρ and θ are separately identified only to the extent that $\Delta \ell nb(p_{t+1})$ is not zero everywhere, i.e. if preferences are not homothetic and there is sufficient relative price variation over the years of the sample. To the extent that this is true, ρ will not be able to adapt fully to keep Φ the same as we vary θ. We have seen from the empirical results on the demand system that homotheticity is strongly rejected. Moreover, the significance of the price terms in the demand system includes relative prices which do seem to vary the above for the intertemporal elasticity of substitution.

In Table 4 we present the parameter estimates corresponding to the three values of θ. In each case the price indices involved in the Euler quite a lot within the sample. Here we look at the empirical relevance of equation have been obtained by estimating the demand system fixing θ to the relevant value. The scaling of the parameters across models is different and only their signs are directly comparable. On the basis of the parameter estimates in Table 4 we note that the sign pattern is the same for the quasihomothetic model ($\theta=-1$) and for the AI model ($\theta=0$). On the other hand the results obtained using the quadratic specification are quite different. In fact the estimated intertemporal elasticity of substitution, presented at the bottom of the table together with its standard error, is significantly smaller for the quadratic model in comparison to the other two.

Table 4 Within Period Preferences and Intertemporal Substitution

	θ=0	θ=-1	θ=+1
ρ_o	0.2041	-1.0490	84.301
	(1.2248)	(0.3209)	30.479
HUNEMP	-0.6868	-0.2498	99.087
	(0.4033)	(0.1236)	38.699
OWNER	-0.7342	-0.2447	61.098
	(0.3744)	(0.1168)	41.967
LA	-0.1078	-0.0390	-17.507
	(0.3040)	(0.1001)	(25.6424)
SGLADLT	0.7335	0.2508	-130.7230
	(0.5852)	(0.1840)	(45.001)
MULTADLT	0.6069	0.1808	-78.9626
	(0.2971)	(0.0920)	(59.609)
CH02	0.9392	0.3115	-62.920
	(0.5213)	(0.1638)	(49.808)
CH34	0.1853	0.0530	-7.949
	(0.2875)	(0.0913)	(40.605)
CH510	0.2753	0.0769	-52.295
	(0.1702)	(0.0537)	(24.196)
CH1118	0.1631	0.0455	-30.2079
	(0.1880)	(0.0588)	(27.277)
WWORK	0.8408	0.2792	-65.503
	(0.2526)	(0.0815)	(30.160)
Φ	-1.1895	-1.073	-0.59860
	(0.3875)	(0.332)	(0.1406)
Sargan	28.957	27.843	13.7010
r_1	-1.6663	-1.7987	-2.0712
r_2	-0.6809	-0.4517	-0.1586

Notes: As Table 3. GMM used throughout. Cohort effects and UN included throughout.

3.6 Comparison with a Hall type model.

In section 3.5 we established that severe misspecification of within period preferences can lead to misleading results on intertemporal substitution. We now compare our results to a standard Hall type model where $\log(1+r_{t-1})$ is regressed on $\Delta\log C_t$ using instrumental variables.[1] In constructing the data for this exercise we took the differences of the average of log individual household consumption for each cohort. In this sense the model is not directly comparable to those estimated on aggregated data by other authors. Conditions under which aggregate models provide a strong downward bias have been derived in the careful comparison of cohort and aggregate data by Attanasio and Weber(1989). In estimation we include cohort specific fixed effects. The intertemporal substitution obtained in this way was -1.96 with a standard error of (0.33). This is significantly larger than the one obtained using the more data coherent preference specifications in Table 3. Since the differences may be due to the fact that we ignore characteristics we generalise this model by including the

Table 5. A Hall type model(*)

ρ_o	HUNEMP	OWNER	LA	SGLADT	MULTAD	CH02	CH34	CH510	CH111	WWORK
-1.10	-0.17	-0.15	-0.02	0.16	0.13	0.19	0.06	0.05	0.04	0.18
(0.33	(0.09)	(0.08)	(0.06)	(0.13)	(0.06)	(0.10)	(0.06)	(0.03)	(0.04)	(0.05)

Sargan(24) 26.2, r_1 -1.88, r_2 -0.44, Φ -1.0 (0.33)

(*) Cohort dummies and UN included; standard errors in brackets. The Sargan test has 24 degrees of freedom, r_1 and r_2 are N(0,1) tests for first and second order serial correlation respectively.

consistently aggregated terms $\Delta(z_t \log C_t)$, for each cohort.

The results of this regression, which is analogous to column 2 of Table 3, are presented in Table 5. As can be seen the overall results are

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[1] We set up the regression in this way so as to maintain the analogy with the previous results.

similar to those obtained for the AI model and the Quasihomothetic model, both in terms of the sign pattern of the parameters and in terms of the implied intertemporal elasticity of substitution (Φ). However, it does appear to be the case that not estimating the demand system first may lead to bias even when the demographics are correctly allowed for and a cohort panel is used. Nevertheless, we may conclude that the main misspecification in the simple cohort level model originates from ignoring the effects of the different individual characteristics within any cohort in any period.

4. SUMMARY AND CONCLUSIONS

This paper has concerned the importance of preference restrictions in recovering parameters of intertemporal substitution. It has utilised a pooled cross-section on the nondurable and services expenditures of some 7000 households per year over some 15 years. The approach has been to exploit the two-stage budgeting properties of an intertemporally separable model under uncertainty. This enabled us to first identify the characteristics of within period behaviour from a detailed micro level demand analysis on pooled cross-section data. Then to estimate the remaining parameters that identify intertemporal behaviour using a panel of cohort data constructed from our repeated cross-section.

The advantage of the approach followed in this paper can be seen from the invariance of the resulting within period preference estimates to assumptions concerning the degree of intertemporal substitution. Many life-cycle models rest on the assumption of homothetic within period preferences which allow the use of a single price index for each period in deciding upon intertemporal allocations. However, no estimated models of consumer behaviour come close to accepting such an assumption on within period behaviour. Our micro-data source provides the ideal environment for checking this at the individual household level. We show that with two appropriately defined price indices, preferences can be chosen which accord quite satisfactorily with the micro-data source provided one allows for the many household characteristics which influence consumer behaviour.

Having arrived at a data coherent specification of within period preferences, using what is essentially standard Marshallian demand analysis, we are then in a position to construct the marginal utility of wealth up to some monotonic transformation for each household in our data.

The monotonic transformation, which is found to depend on individual characteristics, is all that is required to provide a complete identification of the intertemporal model. Associating each household with one of ten five year cohorts, our strategy, following that of Browning, Deaton and Irish (1985), is to average across cohort groups so as to produce a panel of over fifteen years of time series. This allows us to exactly aggregate, within any cohort, the stochastic Euler equation describing intertemporal behaviour in terms of the remaining unknown parameters. By so doing we are also in a position to assess the degree to which household characteristics affect intertemporal substitution. These factors, especially labour market status and housing tenure, do indeed turn out to be important.

Our estimates provide no single number for the intertemporal elasticity but rather one that differs systematically across individuals depending on their level of life-cycle income as well as many individual characteristics in particular labour market status. However, our mean estimated elasticity for nondurables and services seems to be robustly estimated at around -1, a plausible number but one that is smaller than is often used in policy based simulations. This estimate depends critically on consistent aggregation across households in each cohort and requires a careful treatment of the labour market and other characteristics of individual household members in each cohort.

STATISTICAL APPENDIX

A.1 The estimator.

The model we estimate can be represented by

$$y(\zeta) = X(\zeta)\beta + u \tag{A.1}$$

where $y(\zeta)$ and $X(\zeta)$ are functions of data and of the parameters ζ that are identifiable by estimating the demand system. Conditional on these parameters β, which characterises intertemporal substitution, is estimated in the following way. Let Z be a matrix of appropriate instruments. The the standard IV estimator for β is $\beta^{IV} = (X'PX)^{-1}X'Py$, where $P = Z(Z'Z)^{-1}Z'$. The second step GMM estimates then are $\beta^{GMM} = (X'Z(Z'\hat{\Sigma}Z)^{-1}Z'X)^{-1}X'Z(Z'\hat{\Sigma}Z)^{-1}Z'y$, where $\hat{\Sigma}$ is a diagonal matrix with $\hat{u}_i^2$ on the diagonal, $\hat{u}_i$ being the residual from the first stage IV regression (see, White (1980)). The estimators are made feasible by evaluating $X(\zeta)$ and $y(\zeta)$ at consistent parameter estimates obtained from the demand system. The latter is estimated by instrumental variables, where total expenditure is treated as endogenous. The instruments contained in Z matrix are all the variables in the regression lagged twice and in levels, as well as time dummies.

A.2 The Variance Covariance matrix of the estimator

We illustrate the computation of the standard errors for the AI model (θ=0). The same principles apply to all other models. In what follows we work with the restricted parameter vector of the demand system. We denote this by ζ. For this model,

$$y(\zeta)_t = -\Delta\left(\frac{1}{N_{ct}}\sum_{j\in c}[\log x_{tj} - (\log b(p|\zeta))_{tj}]\right) - \log(1+r_{t-1}) \tag{A.2}$$

where c denotes a cohort j an individual and t a time period. N_{ct} size of the cohort in time period t. We take into account of monthly variation of interest rates and prices. Thus r_{t-1} is the weighted average of the monthly interest rate during the year where the weights are determined by the number of members of cohort c interviewed in each month.

$$X(\zeta)_{it} = \Delta\left(\frac{1}{N_{ct}}\sum_{j\in c} z_{itj}\{\log[\log(x_{tj}/a(p|\zeta)_{tj})] - \log b(p|\zeta)_{tj}\}\right) \tag{A.3}$$

where z_{itj} is the ith characteristic included in the model, for the jth individual in the tth time period. To compute the standard errors we need the derivatives of $y(\zeta)$ and $X(\zeta)$ with respect to ζ. The non zero elements of these derivatives are the following. For $y(\zeta)$ all derivatives are zero except those corresponding to the expenditure coefficients $\beta(q)$ where q is the vector of goods conditioning the expenditure coefficients.

$$\partial y(\zeta)_t/\partial\beta_k = \Delta\left(\frac{1}{N_{ct}} \sum_{j \in c} q_{tj} \log p_{tk}\right) \tag{A.4}$$

where k is the goods index. The vector of derivatives is completed by placing zeros at the correct positions. All parameters of the demand system appear in $X(\zeta)_{it}$. We consider in turn the expenditure coefficients, $\beta(q)$, the intercept coefficients $a(q)$ and the price coefficients γ.

$$\partial X(\zeta)_{it}/\partial\beta_k = -\Delta\left(\frac{1}{N_{ct}} \sum_{j \in c} z_{itj}\, q_{tj} \log p_{tk}\right) \tag{A.5}$$

$$\partial X(\zeta)_{it}/\partial a_k = -\Delta\left(\frac{1}{N_{ct}} \sum_{j \in c} z_{itj} \frac{q_{tj} \log p_{tk}}{[\log(x_{tj}/a(p|\zeta)_{tj})]}\right) \tag{A.6}$$

$$\partial X(\zeta)_{it}/\partial\gamma_{ks} = -\Delta\left(\frac{1}{N_{ct}} \sum_{j \in c} z_{itj} \frac{\log p_{ts} \log p_{tk}}{[\log(x_{tj}/a(p|\zeta)_{tj})]}\right)\frac{1}{1+\delta_{ks}} \tag{A.7}$$

where δ_{ks} is the kronecker δ.

The estimator of ζ has an asymptotic covariance matrix V_ζ. The error term of the model (A.1) when we condition on consistent parameter estimates $\hat{\zeta}$ can be approximated to the first order by

$$u^{*} = u - [\partial X/\partial\zeta](\hat{\zeta} - \zeta) + [\partial y/\partial\zeta](\hat{\zeta} - \zeta) = u + Q(\hat{\zeta} - \zeta) \tag{A.8}$$

Hence $E(u^{*} u^{*})' = \Sigma + QV_\zeta Q'$.

Finally the asymptotic covariance matrix of the GMM estimator of β described in A.1 above is

$$V_\beta = (X'P_\Sigma X)^{-1} + (X'P_\Sigma X)^{-1}X'P_\Sigma[QV_\zeta Q']P_\Sigma X(X'P_\Sigma X)^{-1} \tag{A.9}$$

where $P_{\Sigma} = Z(Z'\Sigma Z)^{-1}Z'$. This covariance matrix is commuted by replacing Σ by a diagonal matrix whose diagonal elements are the squared residuals from the second step GMM regression.

APPENDIX A

(i) The FES Data

A full description of the FES codes used to construct our variables is contained in Sell, Pashardes and Weber (1987).

The dependent variables of the seven second stage regression are commodity shares out of group expenditure, e.g. FOOD SHARE = (expenditure on food/total exp. on food, fuel, alcohol clothing, transport, other and services).

The following exogenous variables are used both as regressors and instruments: logarithm of goods prices, number of children aged 0-2, 3-5, 6-10, 11-16, 17-18

AGE = (age -40)
AGESQ = $(\text{age} -40)^2$
WHC = white collar dummy, taking value one if the head of household has occupation 1-5. (FES coding frame 3)
ADLTNR = number of adults
EARNNR = number of earners
RETNR = number of retired
HUNEMP = unemployment dummy, taking value 1 if the head of the household has economic position = 9, 10 and 11 (FES coding frame 23)
Regional Dummies (leaving out the South East)
Quarterly " (" " " fourth quarter)
Tenure dummies (leaving out home ownership outright)
Quarterly trend
ROOM = number of rooms,
FR = fridge dummy,
CH = central heating dummy,
WM = washing machine dummy,
DCAR = car dummy (1 if there is a car in the household)
DTOB = tobacco dummy (1 if there are smokers in the household)
MC = married couple dummy
WW = working wife dummy.
SGLPAR = single parent dummy,
Industry Dummies (see FES 1984 coding frame 4):
- AGRIC = agriculture, code takes value 1
- MFGSEC = intermediate products MFG industry (codes 2 and 4-11)
- TXTSEC = textile industry (codes 12-14)
- FUESEC = fuel products MFG industry (codes 3 and 15-23)
- SERSEC = services (codes 23-33)

CARS : number of cars
RAT : ratable value of the house

The following variables are used as additional instruments: logarithm of net normal income (NNY), prices of goods excluded from the analysis (tobacco,housing and durables), three-day week dummy, male unemployment rate lagged 1 and twelve months (URATE1 and URATE12), real ex-post interest rates on building society deposits and on mortgages (RL and RB), lagged 12 months, interaction between child dummy and age, age squared and net normal income (CAGE, CAGESQ, CNNY), interaction between zero-sum dummies and net normal income (S1NNY, S2NNY, S3NNY).

Table A1: Descriptive Statistics for the FES data

VARIABLE (N=64271)	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN
PFOOD	1.3607593	0.5526442	0.39944704	2.0707791	0.00217991
PALCL	1.1617263	0.5200744	0.43631757	1.9647319	0.00205144
PFUEL	1.5765258	0.6328847	0.61842363	2.4850733	0.00249642
PCLOTH	0.9235118	0.3810017	0.25075872	1.3558352	0.00150286
PTRPT	1.3792740	0.5583094	0.46310489	2.1313222	0.00220225
PSERV	1.5423438	0.5463339	0.65232519	2.3165866	0.00215502
POTH	1.4148727	0.5289365	0.55904420	2.1698534	0.00208639
P3	0.8032145	0.7327101	0.00000000	2.1873987	0.00289018
P4	1.6674758	0.5852575	0.74999999	2.5945828	0.00230855
P6	0.9088898	0.4195539	0.22154227	1.4322233	0.00165493
CH02	0.1838154	0.4408432	0.00000000	5.0000000	0.00173891
CH35	0.1897745	0.4497172	0.00000000	4.0000000	0.00177391
CH610	0.3305379	0.6445913	0.00000000	5.0000000	0.00254259
CH1116	0.3594156	0.6929764	0.00000000	6.0000000	0.00273345
CH1718	0.0243500	0.1589061	0.00000000	2.0000000	0.00062681
EARNNR	1.6770239	0.8624171	0.00000000	5.0000000	0.00340181
RETNR	0.0307915	0.1801605	0.00000000	2.0000000	0.00071064
MFGSEC	0.3432808	0.4748080	0.00000000	1.0000000	0.00187288
TXTSEC	0.0252524	0.1568921	0.00000000	1.0000000	0.00061886
FUESEC	0.2123508	0.4089750	0.00000000	1.0000000	0.00161320
UNC	0.0796782	0.2707965	0.00000000	1.0000000	0.00106816
CAGE	-1.2995752	6.7446271	-22.00000000	20.0000000	0.02660421
CAGESQ	47.1781830	81.2262739	0.00000000	484.0000000	0.32039741
CNNY	3.7267616	3.3475982	0.00000000	9.8098360	0.01320462
S1	0.2510152	0.4336006	0.00000000	1.0000000	0.00171034
S2	0.2427378	0.4287412	0.00000000	1.0000000	0.00169117
S3	0.2530690	0.4347736	0.00000000	1.0000000	0.00171497
TREND	30.5995239	17.2521589	1.00000000	60.0000000	0.06805122
AGE	0.6664125	11.3096685	-22.00000000	20.0000000	0.04461104
AGESQ	128.3507181	117.4463049	0.00000000	484.0000000	0.46326749
ADLTNR	1.1199764	0.7697593	0.00000000	4.0000000	0.00303632
FR	0.9053072	0.2927924	0.00000000	1.0000000	0.00115492
CH	0.5439778	0.4980661	0.00000000	1.0000000	0.00196462
WM	0.8062423	0.3952443	0.00000000	1.0000000	0.00155904
DCAR	0.6705513	0.4700167	0.00000000	1.0000000	0.00185398
ROOMS	3.0218606	1.5579281	1.00000000	6.0000000	0.00614525
NORENT	0.0261549	0.1595970	0.00000000	1.0000000	0.00062953
LA	0.3154922	0.4647152	0.00000000	1.0000000	0.00183307
RENT	0.1447465	0.3518478	0.00000000	1.0000000	0.00138787
OOM	0.4334770	0.4955588	0.00000000	1.0000000	0.00195473
NORTH	0.0658151	0.2479605	0.00000000	1.0000000	0.00097808
YORKHUMB	0.0944750	0.2924906	0.00000000	1.0000000	0.00115373
EASTMIDL	0.0697982	0.2548086	0.00000000	1.0000000	0.00100509
EANGLIA	0.0348057	0.1832889	0.00000000	1.0000000	0.00072298
GRLONDON	0.1197430	0.3246633	0.00000000	1.0000000	0.00128064
SOUTHWES	0.0684446	0.2525092	0.00000000	1.0000000	0.00099602
WALES	0.0513140	0.2206391	0.00000000	1.0000000	0.00087031
WESTMIDL	0.0992983	0.2990644	0.00000000	1.0000000	0.00117966
NORTHWES	0.1181093	0.3227400	0.00000000	1.0000000	0.00127305

SCOTLAND	0.0973223	0.2963984	0.00000000	1.0000000	0.00116914
DTOB	0.6690576	0.4705560	0.00000000	1.0000000	0.00185611
D3DAY	0.0136142	0.1158839	0.00000000	1.0000000	0.00045710
S1S	7.2767656	15.2690364	0.00000000	57.0000000	0.06022878
S2S	7.3691400	15.4451449	0.00000000	58.0000000	0.06092345
S3S	7.8494967	16.0499576	0.00000000	59.0000000	0.06330913
URATE1	0.0790301	0.0423062	0.02917237	0.1651907	0.00016688
URATE12	0.0715581	0.0386647	0.02917237	0.1651907	0.00015251
RL	-0.0194035	0.0403570	-0.16566174	0.0478476	0.00015919
RB	-0.0019282	0.0345445	-0.13362239	0.0915094	0.00013626
S1NNY	-0.0055358	2.8834630	-2.64366757	7.3573770	0.01137383
S2NNY	-0.0515009	2.8606342	-2.64366757	7.2087477	0.01128378
S3NNY	0.0258984	2.9113819	-2.64366757	6.8599112	0.01148396
HUNEMP	0.1130525	0.3166595	0.00000000	1.0000000	0.00124906
SGLPAR	0.0526209	0.2232773	0.00000000	1.0000000	0.00088072
AGRIC	0.0144233	0.1192287	0.00000000	1.0000000	0.00047030
WHC	0.3615161	0.4804433	0.00000000	1.0000000	0.00189511
MC	0.7868401	0.4095429	0.00000000	1.0000000	0.00161544
WW	0.4931306	0.4999567	0.00000000	1.0000000	0.00197208
CARS	0.8290987	0.7098500	0.00000000	7.0000000	0.00280001
RAT	3.0311654	0.8120022	-0.87546874	5.8230459	0.00320295
NNY	6.6384883	0.7605399	0.00000000	10.5746703	0.00299995
ODD	0.0000000	0.0000000	0.00000000	0.0000000	0.00000000
DL	0.5025906	0.4999972	0.00000000	1.0000000	0.00197224
DB	0.1674005	0.3733360	0.00000000	1.0000000	0.00147263
W1	0.3479432	0.1258260	0.00000000	1.0000000	0.00049632
W2	0.0666598	0.0778842	0.00000000	0.8663793	0.00030721
W5	0.0851943	0.0620741	-0.15178229	0.8228284	0.00024485
W7	0.1015409	0.1029931	0.00000000	0.7619116	0.00040626
W9	0.1034680	0.0711136	0.00000000	0.8795115	0.00028051
W10	0.1174414	0.1049053	-0.08519793	0.9578025	0.00041380
CLRX	2.1564959	1.9500937	0.00000000	6.5911590	0.00769215
S1LRX	-0.0109227	1.6420370	-1.64924307	4.6905247	0.00647702
S2LRX	-0.0279361	1.6402072	-1.64778975	4.9477292	0.00646980
S3LRX	0.0120111	1.6648265	-1.64924307	4.9433693	0.00656692
LRX	3.7819352	0.5896758	0.25540180	6.5969723	0.00232598

(ii) : The Cohort Data

Period: 10 cohorts in 5 year bands.
1st: 70 - 74.
2nd: 70 - 79
3rd - 8th: 70 - 84.
9th: 75 - 84.
10th: 79 - 84.

APPENDIX B

Table B : Coefficient Estimates for Demographic and Other Characteristics

INTCEPT	0.804497	-0.104054	0.379733	-0.087425	-0.019757	-0.096403	0.123409
	(.01413)	(.01168)	(.00833)	(.01524)	(.01974)	(.01615)	......
CH02	.019246	-0.005096	0.008108	-0.001133	-0.011674	-0.009046	-0.000405
	(.00102)	(.00082)	(.00059)	(.00110)	(.00142)	(.00116)	......
CH35	0.023303	-0.006922	0.004648	-0.002636	-0.008716	-0.007398	-0.002279
	(.00091)	(.00073)	(.00052)	(.00098)	(.00126)	(.00103)	......
CH610	0.028410	-0.008137	0.002474	-0.000082	-0.009668	-0.009712	-0.003285
	(.00067)	(.00054)	(.00038)	(.00072)	(.00093)	(.00076)	......
CH1116	0.029838	-0.008622	0.001872	0.003216	-0.008200	-0.012961	-0.005143
	(.00072)	(.00058)	(.00041)	(.00077)	(.00100)	(.00081)	......
CH1718	0.021080	-0.003349	-0.001944	0.002591	0.006480	-0.026404	0.001546
	(.00244)	(.00197)	(.00141)	(.00263)	(.00339)	(.00277)	......
FEMNR	-0.007503	-0.044260	0.004564	0.035193	-0.013273	0.005766	0.019513
	(.00100)	(.00081)	(.00058)	(.00108)	(.00139)	(.00114)	......
WHC	-0.004910	-0.005690	0.001930	0.003758	-0.016696	0.015750	0.005858
	(.00089)	(.00072)	(.00051)	(.00096)	(.00124)	(.00101)	......
AGE	0.001013	-0.000667	0.000440	-0.000295	-0.001054	0.000686	-0.000123
	(.00004)	(.00003)	(.00002)	(.00004)	(.00005)	(.00004)	......
AGESQ	-0.000031	0.000006	-0.000011	0.000020	0.000033	-0.000010	-0.000007
	(.00000)	(.00000)	(.00000)	(.00000)	(.00000)	(.00000)	......
ADLTNR	0.089192	-0.001225	0.005497	-0.023454	-0.008409	-0.059251	-0.002350
	(.00256)	(.002074)	(.00148)	(.00276)	(.00355)	(.00290)	......
ADTSQ	-0.012326	0.002730	-0.000619	0.001267	0.000829	0.009191	-0.001073
	(.00050)	(.00040)	(.00029)	(.00054)	(.00069)	(.00056)	......
EARNNR	-0.007511	0.009964	-0.002983	0.008313	0.005800	-0.011241	-0.002342
	(.00153)	(.00124)	(.00088)	(.00165)	(.00212)	(.00173)	......
HUNEMP	-0.009557	-0.000381	0.010112	-0.012999	0.010392	0.006136	-0.003704
	(.00209)	(.00169)	(.00121)	(.00225)	(.00290)	(.00237)	......
RETNR	0.000667	0.009129	0.002319	-0.008234	-0.004921	0.005596	-0.004557
	(.00221)	(.00179)	(.00127)	(.00238)	(.00306)	(.00250)	......
SGLPAR	0.054467	-0.034025	0.015891	0.005531	-0.015054	-0.026869	0.000059
	(.00211)	(.00170)	(.00122)	(.00227)	(.00292)	(.00239)	......
ROOMS	-0.007295	0.001689	-0.019387	0.009805	0.014485	0.003143	-0.002440
	(.00220)	(.00178)	(.00127)	(.00237)	(.00305)	(.00249)	......
LA	-0.031459	0.020580	-0.076019	0.034545	0.066874	0.001618	-0.016140
	(.00889)	(.00720)	(.00514)	(.00959)	(.01233)	(.01009)	....
RENT	-0.024369	0.015209	-0.061034	0.025910	0.046003	0.007251	-0.008971
	(.00609)	(.00493)	(.00352)	(.00657)	(.00844)	(.00690)	......
NORENT	0.027755	-0.010661	0.071315	-0.038317	-0.049160	-0.018165	0.17234
	(.00845)	(.00684)	(.00489)	(.00911)	(.01172)	(.00958)	......
OOM	-0.010779	0.006884	-0.018071	0.009542	0.015330	0.000032	-0.002938
	(.00257)	(.00208)	(.00148)	(.00277)	(.00356)	(.00291)	......
FR	-0.004643	-0.008281	0.002034	0.004820	0.000580	0.000563	0.004926
	(.00135)	(.00109)	(.00078)	(.00146)	(.00187)	(.00153)	.....
CH	-0.003976	-0.001428	0.000488	0.001792	0.000062	0.003371	-0.000309
	(.00082)	(.00066)	(.00047)	(.00089)	(.00114)	(.00093)	......
WM	-0.000543	-0.002805	0.002350	-0.000163	-0.001848	-0.001028	0.004038
	(.00102)	(.00082)	(.00059)	(.00110)	(.00141)	(.00116)	......

DCAR	-0.033755	-0.020890	-0.010239	-0.014017	0.110704	-0.022206	-0.009599
	(.00136)	(.00110)	(.00079)	(.00147)	(.00189)	(.00155)	......
MC	0.027086	-0.010335	0.005845	-0.003675	-0.010794	-0.011764	0.003637
	(.00195)	(.00158)	(.00113)	(.00211)	(.00271)	(.00221)	....
WW	0.001684	-0.007987	0.000316	-0.001385	-0.006667	0.011932	0.002106
	(.00172)	(.00139)	(.00099)	(.00186)	(.00239)	(.00195)	......
AGRIC	0.000579	0.020960	0.004089	-0.004976	-0.010677	-0.007101	-0.002875
	(.00078)	(.00063)	(.00045)	(.00084)	(.00109)	(.00089)	......
INDSEC	-0.002866	-0.008264	0.009282	-0.002609	-0.005418	0.009537	0.000339
	(.00089)	(.00072)	(.00052)	(.00096)	(.00123)	(.00101)	......
UNC	-0.007528	-0.011242	0.004874	-0.008559	0.027163	-0.002810	-0.001898
	(.00096)	(.00077)	(.00055)	(.00103)	(.00133)	(.00109)	......
DTOB	0.003117	-0.004944	0.010769	0.004254	-0.011188	-0.008616	0.006607
	(.00321)	(.00260)	(.00186)	(.00347)	(.00446)	(.00365)	......
RAT	0.006713	0.006999	-0.002907	0.004609	-0.009997	-0.003983	-0.001434
	(.00083)	(.00067)	(.00048)	(.00089)	(.00115)	(.00094)	......
CARS	0.003108	0.005089	0.005857	0.015466	-0.022416	-0.010258	0.003154
	(.00291)	(.00235)	(.00168)	(.00314)	(.00404)	(.00330)	......

Notes: See Table 1.

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