Consumption, Savings and Demography

by
Rob J.M. Alessie and Arie Kapteyn

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CONSUMPTION, SAVINGS AND DEMOGRAPHY

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ABSTRACT: This paper estimates and tests an expected (multiperiod) utility maximization model of the joint determination of savings and of expenditure on different goods using panel data. The emphasis is on appropriate modelling of demographic effects (as taste shifters) and on the estimation of within period preferences that are consistent with intertemporal two stage budgeting under uncertainty. The parameters of the intratemporal utility function depend on demographic factors in a flexible way.

Certain implications of the rational expectations-life cycle hypothesis are tested along the lines of HALL(1978). The empirical results indicate rejection of the hypothesis and suggest the existence of liquidity constraints. Therefore we have estimated a within period demand system, based on the Almost Ideal Demand System (A. I. D. S.) cost function. Both the allocation of consumption across the life cycle and the allocation of expenditures within a given period depend heavily on demographics.

I. Introduction

Only since the pioneer work of MODIGLIANI and BRUMBERG (1955), have many economists paid much attention to the Life Cycle Hypothesis (LCH). Today it is hardly conceivable that one would attempt an economic analysis of consumption and savings over a consumer's life cycle without using some version of the LCH as a starting point. In this paper, we model the influence of the demographic composition of a population on the size and composition of private consumption and savings within the LCH-framework.

There are two major channels through which the demographic composition of a population influences consumption and savings. In the first place, age and family composition can act as taste shifters. For example, older people may have different tastes than younger people and large families may have different preferences than small families. In the second place, age is an important planning variable. For example, the simpler version of the LCH imply that a consumer will start dissaving when the end of his life draws nearer.

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Although our emphasis is on the role of demographic characteristics, a fair amount of space is devoted to a discussion of assumptions and proper estimation strategies for LCH-models. Recently, various new approaches have been suggested to the estimation of LCH-models, like the constant $\lambda$ variety of HECKMAN (1978), HECKMAN and MacURDY (1980), MacURDY (1981) and BROWNING, DEATON and IRISH (1985). As discussed in Section 2, these approaches are based on rather restrictive assumptions of consumer preferences. Another area of the literature conditions on within-period total expenditures (or "full expenditures" if labor supply is modelled jointly with consumption). See, e. g., BLUNDELL and WALKER (1986) and ALTONJI (1986). In the latter case, preference assumptions are less stringent, but since in the applications by BLUNDELL and WALKER and ALTONJI only cross-section data are used, no real test of the LCH can be performed. It is not possible, for instance, to check whether consumers are liquidity constrained.

In Section 2 we present the LCH-model in rather general terms and we discuss some of the estimation strategies proposed in the literature. Also, we outline our own estimation method which is closely related to the approach by MacURDY (1983). Section 3 gives details on functional specifications. For the explanation of consumption expenditures on various goods within periods, a flexible specification (AIDS) is chosen with cubic splines of ages of family members to represent demographic effects. These demographic effects are allowed to influence both the intercept and the slope of the ENGEL curves within periods.

For the modelling of the distribution of total expenditures (and hence of savings) across periods, a more restrictive, yet convenient functional form is chosen. Once again, the influence of age is modelled by means of cubic splines. Next, Sections 4, 5, and 6 discuss the data and present estimation results. One of the most striking empirical outcomes is that age is a strong taste shifter for total expenditures, in the sense that older people tend to consume substantially less, saving more than young people. This taste effect dominates the planning effect (i.e. that at the end of the life cycle one could deplete physical wealth), and as a result, older people save more than younger people. Further, in an aging population, one may expect private savings to go up rather than down, as simpler versions of the LCH would suggest. However, tests of the first stage part of the model (the explanation of the allocation of consumption across the life cycle) indicate rejection, so that this implication has to be viewed with some reservation. The rejection of the first stage part does not invalidate the second stage of the model (the allocation of expenditures within each period). The second stage model appears to be consistent with the data Section 7 concludes.
II. The Life Cycle Hypothesis and Two-Stage Budgeting

Consider a single consumer (or household), who has to plan consumption from the present period \( t \) up to a terminal period \( T \) in an uncertain environment. We assume that the consumer maximizes the following inter-temporally additive utility function:

\[
U(t) = E_t \left( \sum_{\tau=t}^{T} \frac{1}{1+p}^{T-\tau} u(z(\tau), q(\tau)) \right),
\]

with

\( E_t \): mathematical expectation conditional on all information available at the beginning of period \( t \) (expectations are rational)

\( q(\tau) \): vector of consumption goods in period \( \tau, \tau = t, \ldots, T \)

\( z(\tau) \): vector of taste shifters at age \( \tau \)

\( u(z(\tau), q(\tau)) \): subutility function for period \( \tau \), strictly concave

\( p \): rate of subjective time preference.

This utility function is maximized subject to the following constraints:

\[
A(\tau) = (1+r) A(\tau-1) + y(\tau) - p(\tau)' q(\tau), \quad \tau = t, \ldots, T, \tag{2.2a}
\]

\( A(t-1) \) given, \tag{2.2b}

\( A(T) = 0 \) ("no bequest motive"), \tag{2.2c}

where

\( A(\tau) \): value of assets at the end of period \( \tau \)

\( r \): interest rate

\( p(\tau) \): vector of prices in period \( \tau \)

\( y(\tau) \): labor income in period \( \tau \), plus income transfers received in period \( t \), next of taxes.

In this specification, credit markets are assumed to be perfect (no liquidity constraints and equal borrowing and lending rates). We have also assumed a constant interest rate over time. Relaxation of this assumption has little impact on the empirical model. In our model \( p(\tau), z(\tau) \) and \( y(\tau) \) are exogenous variables.

The vectors \( v(\tau) = (p(\tau), z(\tau), y(\tau))' \), \( \tau > t \), contain all the
variables that are uncertain prior to period t. The random vector \( v(\tau) \) is realized at the beginning of period \( \tau \). With respect to the probability distribution of the \( v(\tau) \), we only assume the existence of certain moments. The distribution of \( v(\tau) \) represents the consumer's subjective judgements about future variables.

Optimization of (2.1) subject to the budget constraints (2.2) implies the following first order conditions for period \( t \)\(^1\) (see Macurdy (1983)):

\[
\frac{\partial u(z(t),q(t))}{\partial q(t)} = \lambda(t) p(t) \tag{2.3}
\]

\[
\lambda(t) = E_t \frac{(1+\tau)}{(1+\rho)} \lambda(t+1), \tag{2.4}
\]

where \( \lambda(\tau) \), \( \tau = t, t+1 \), is the Lagrange multiplier associated with the budget constraint of period \( \tau \). The quantity \( \lambda(\tau) \) is the marginal utility of after tax wealth in period \( \tau \). From equations (2.3) and (2.4) it follows that intertemporal additivity allows for two-stage budgeting. In the first stage, the household derives total consumption \( x(t) \) at time \( t \) by equalizing the marginal utility of suitably discounted after tax wealth in all periods of the life cycle (see the Euler equation (2.4)). As a result, also the optimal savings-decision is determined in this stage. In the second stage the amount of total expenditures \( x(t) \) in period \( t \) is allocated to consumption goods according to condition (2.3).

There is another important implication of the life cycle-rational expectations hypothesis. One can rewrite the Euler equation (2.4), for example, in the following two ways

\[
\lambda(t+1) = \frac{(1+\rho)}{(1+\tau)} \lambda(t) + \varepsilon(t+1), E_t \varepsilon(t+1) = 0 \tag{2.4a}
\]

and

\[
\lambda(t+1) = \frac{(1+\rho)}{(1+\tau)} \lambda(t) (1+\varepsilon(t+1)), E_t \varepsilon(t+1) = 0 \tag{2.4b}
\]

The condition \( E_t \varepsilon(t+1) = 0 \), in both formulations, implies that \( \varepsilon(t+1) \) will be uncorrelated with all lagged variables in the consumer's information set. This econometric implication of rational expectations has been exploited in a number of estimation methods, which have been proposed in the literature and which will be discussed below. In this dis-

\(^1\) For the moment, only interior solutions are assumed.
discussion, the cardinal period specific utility function associated with period \( t \) is parameterized as

\[
u(z(t), q(t)) = F(u^*(z(t), q(t)), z(t)), \tag{2.5}\]

where \( F(.) \) is a monotonically increasing function in \( u^*(.) \), and \( u^*(.) \) possesses all the conventional properties of a utility function\(^2\). The choice of the monotonic transformation is irrelevant in static analysis. However, this is not the case in a multiperiod setting.

BROWNING, DEATON and IRISH (1985) use the first order conditions (2.3) and (2.4) to construct the so-called \( \lambda \)-constant (or FRISCH) functions, which take the following form

\[
q(t) = f(p(t), z(t), \lambda(t)) \tag{2.6}
\]

The general properties of the demand equations (2.6) are described in detail in BROWNING, DEATON and IRISH (henceforth referred to as B. D. I.) and the use of these functions provides a useful interpretation of life-cycle behavior. Since the marginal utility of wealth \( \lambda(t) \) changes only when new information becomes available and all information about future variables is summarized in this sufficient statistic, one can compute equation anticipated (intertemporal) price elasticities from this.

B. D. I. want to estimate (2.6) by using panel data and treating \( \ln \lambda(t) \) as a fixed effect. Fixed effects can most easily be dealt with by differencing, provided that they appear additively in the demand equations, i.e. it is required the FRISCH demand of good \( i \) is of the form

\[
\tau_i(q_i(t)) = \eta_i \ln \lambda(t) + \eta_i(p(t), z(t)), \tag{2.7}
\]

where \( \eta_i(.) \) and \( \tau_i(.) \) are suitable functions. In an environment of un-

\(^2\) Of course, if \( u^*(.) \) represents the intratemporal preferences with respect to \( q(t) \), then so does \( F(u^*(.), z(t)) \). It is a matter of notational convenience to pick an arbitrary representation \( u^*(.) \) and then to highlight the cardinal nature of the intertemporal utility function by showing the uniqueness of the transformation \( F \), given \( u^*(.) \).
certainty, one can apply the estimation procedure of B. D. I. if the random variable \( \ln \lambda(t+1) - \ln \lambda(t) \) is a sum of an observable variable and a random variable \( \omega(t+1) \), which satisfies \( E_t \omega(t+1) = 0 \). This property does not follow directly from the EULER equations (2.4a) or (2.4b). One needs some extra distributional assumptions about the forecast error appearing in (2.4a) or (2.4b) in order to justify the estimation procedure of B. D. I..

The major disadvantage associated with the use of the B. D. I. approach is, as they point out, the requirement that \( \ln \lambda(t) \) enters additively in (2.7), thereby imposing severe restrictions on within period preferences. (see B. D. I. and BLUNDELL, FRY and MEGHIR (1985)).

An alternative estimation method proposed in the literature (see e.g. BLUNDELL and WALKER (1986)) is to condition on within period total (or "full") expenditures rather than marginal utility of wealth. In other words, this approach only requires the estimation of a complete static demand system. By using this approach one does not have to impose a priori restrictions on within period preferences and one can deal easily with corner solutions (see BLUNDELL and WALKER (1986) and Macurdy (1983)). Obviously, with this procedure one can only estimate the parameters of the ordinal utility function \( u^*(\cdot) \) in (2.5) and not the parameters of the monotonic transformation \( F(\cdot) \). BLUNDELL and WALKER (1986) have retrieved intertemporal (constant-\( \lambda \)) price elasticities through the addition of some arbitrarily chosen identifying assumptions on the monotonic transformation \( F(\cdot) \).

To obtain a feeling for the advantages and disadvantages of the approach we explore first the properties of the solution for \( q(t) \) derived from the optimization of (2.1) subject to (2.2) and a liquidity constraint of the form

\[
A(t) \geq M(t) \quad , \quad t = t, \ldots, T
\]  

(2.9)

where \( M(t) \) may be a function of current income.

\[
M(t) = \varpi_0 + \varpi_1 y(t) \quad \varpi_1 < 0
\]  

(2.10)

This formulation of the liquidity constraints is the same as that of, inter alia, MUELLBAUER (1983), ZELDES (1985), IOANNIDES (1986) and MARIGER (1987).

Optimization of (2.1) subject to (2.2) and (2.9) gives the following first order conditions.

\[
\frac{\partial u(q(t), z(t))}{\partial q(t)} = \lambda(t) p(t)
\]  

(2.11)
(2.12) \[ \lambda(t) - u(t) = E_t \frac{(1+r)}{(1+p)} \lambda(t+1) \]

(2.13) \[ u(t) [A(t) - M(t)] = 0 \]

If \( u(t) \) is equal to zero, the liquidity constraint is not binding. As before, the optimal plan then follows from the first order conditions (2.3) and (2.4). However, if \( u(t) \) is greater than zero, then it follows from (2.13) that total expenditures \( x(t) \) are completely determined by the liquidity constraint (2.9). Thus, consumption is not entirely determined by the FRISCH demand functions. The optimal allocation of total expenditures over the different goods follows from (2.11) and can be described by a complete demand system. From the first order conditions (2.3) and (2.11), it is clear, that the functional form of the demand systems, which are derived from the two optimization problems mentioned above, are the same.

Since the two optimization problems yield the same demand system for \( q(t) \), the strategy of BLUNDELL and WALKER yields estimates of the parameters appearing in \( u^*(.) \) that are more robust with respect to the possible presence of liquidity constraints than the constant \( \lambda \) approach, used by B. D. I. and MACURDY. However, in this way one cannot identify the parameters appearing in the function \( F(.) \) introduced in (2.5), because the within-period demands are invariant with respect to choices of \( F \). This implies, that BLUNDELL and WALKER have to assume that the life cycle hypothesis is true, before they can derive inter-temporal elasticities.

The discussion so far motivates the choice of estimation method adopted in this paper. In order to explain our procedure we rewrite the EULER equation (2.4). Combining this equation with (2.3) and (2.5), one obtains the equation

\[
F'(t) \frac{\partial v^*(x(t), p(t), z(t))}{\partial x(t)} = E_t \frac{(1+r)}{(1+p)} F'(t+1) \frac{\partial v^*(x(t+1), p(t+1), z(t+1))}{\partial x(t+1)}
\]

(2.14)

where \( F'(t) \) is the derivative of \( F(.) \) with respect to \( u^*(t) \), \( x(t) \) denotes total expenditures, and \( v^*(.) \) is the indirect utility function corresponding to \( u^*(t) \). This equation implies the relation

\[
\frac{(1+p)}{(1+r)} F'(t) \frac{\partial v^*(x(t), p(t), z(t))}{\partial x(t)} [1+\kappa(t+1)]
\]

(2.15)
where $c(t+1)$ is a forecast error with $E_t c(t+1) = 0$ and consequently uncorrelated with variables observed by period $t$. Taking natural logs of (2.15) yields

$$\ln \left[ F'(t+1) \frac{\partial \psi^*(x(t+1), p(t+1), z(t+1))}{\partial x(t+1)} \right] = \gamma(t+1) +$$

$$\ln[F'(t) \frac{\partial \psi^*(x(t), p(t), z(t))}{\partial x(t)}] + \xi(t+1), \quad (2.16)$$

where $\gamma(t+1) = \ln \left( \frac{1+\mu}{1+\tau} \right) + E_t \ln(1+\epsilon(t+1))$

$$\xi(t+1) = \ln(1+\epsilon(t+1)) - E_t \ln(1+\epsilon(t+1)).$$

In our approach we obtain the parameters of the function $F(.)$ and $\psi^(.)$ by simultaneously estimating a demand system with total expenditures as the conditional variable and equation (2.16). Since the innovation $\xi(t+1)$ will, in general, be correlated with variables dated $t+1$, an instrumental variable estimator is required to estimate (2.16).

Although we allow $E_t \ln(1+\epsilon(t+1))$ to correlate with other variables on the right hand side of (2.16) dated $t$, we will assume that $E_t \ln(1+\epsilon(t+1))$ is constant across households.\(^3\) This means among other things that we do not allow for heteroskedasticity of the forecast error. We will also assume that $p$ and $r$ are constant across households so that $\gamma(t+1)$ may be treated as a constant.

Our estimation method is very similar to the estimation procedure which MacCurdy (1983) has used in his empirical analysis. However, he rewrites the Euler equation (2.4) in a different manner. He uses the following equation

$$\lambda(t) = \left[ \partial u(q_i(t), z(t))/\partial q_i(t) \right]/P_i(t) \quad (2.17)$$

and imposes restrictions on the within period preferences $u^*(.)$, such as additivity. Furthermore, he estimates the parameters of the within

\(^3\) The approach that seems preferable to imposing this expectational assumption, is to estimate the Euler equation (2.15) directly by using the method of generalized instrumental variables estimation of nonlinear rational expectation models proposed by Hansen and Singleton (1982). This procedure does not require specific assumptions about the forecast errors. However, given our specification of $F(.)$ and $u^*(.)$, which will be presented in section 3, our estimation method is much simpler to carry out than the alternative method. In various other papers (for instance B.D.I. (1985), MacCurdy (1983), the estimation problem has been reduced considerably in the same manner as we do namely by transforming the Euler equation (2.4a) and (2.15) and consequently by making some distributional assumptions about the forecast error.
period utility function $u^*(.)$ by estimating marginal utilities instead of using a demand system.

Notice, finally, that by our procedure (as well as by Macurdy's) one can estimate both the parameters of $u^*(.)$ and $F(.)$. Moreover, we can choose a flexible functional form for the within-period preferences and we are able to test some theoretical implications of the life cycle hypothesis along the lines set out by Hall (1978). A consequence of the life cycle hypothesis is that, apart from consumption prices and taste shifters, none of the lagged variables should have explanatory power with respect to current consumption (see equation (2.15)). We test this implication in the empirical part of the paper by adding lagged income to equation (2.16). It is clear from the equations (2.10), (2.11), (2.12) and (2.13), that lagged income, $y(t)$, has a significant effect on consumption in period $t+1$ if the household is liquidity constrained in period $t$.

III. Specification of the Model

In order to analyse the life cycle model empirically, we adopt explicit functional forms for the within period indirect utility function $F(u^*(t), z(t)) = F(\psi^*(x(t), p(t), z(t)), z(t))$. Suppose $\psi^*(.)$ can be described by the Almost Ideal Demand System (AIDS) utility function of Deaton and Muehlbaier (1980)

$$\psi^*(x(t), p(t), z(t)) = \frac{(\ln x(t) - \ln a(z(t), p(t)))}{b(z(t), p(t))}$$  \tag{3.1}

where

$$\ln a(z(t), p(t)) := a_0(z(t)) + \sum_{i=1}^{I} a_i(z(t)) \ln p_i(t) +$$

$$\sum_{i=1}^{I} \sum_{j=1}^{I} \gamma_{ij} \ln p_i(t) \ln p_j(t),$$  \tag{3.2}

$$b(z(t), p(t)) := \prod_{i=1}^{I} (p_i(t))^{\beta_i(z(t))},$$

with $I$ the number of goods, $z(t)$ the vector of taste shifters and

$$\sum_{i=1}^{I} a_i(z(t)) = 1; \sum_{i=1}^{I} \beta_i(z(t)) = \sum_{i=1}^{I} \gamma_{ij} = 1,$$

$$\sum_{j=1}^{I} \gamma_{ij} = 0; \gamma_{ij} = \gamma_{ji}. $$  \tag{3.3}
The functional form of the monotonic transformation $F(u^*(t))$ is given by

$$F(u^*(t), z(t)) = \beta_0(z(t)) \ u^*(t)$$  \hfill (3.4)

This leaves the following function to be maximized subject to (2.2)

$$E_t \sum_{t=1}^{T} \left( \frac{1}{1+r} \right)^{T-t} F(u^*(\tau), z(t))$$  \hfill (3.5)

The estimation model becomes

$$b(z(t), p(t))x(t) = E_t b(z(t+1), p(t+1))x(t+1) \frac{(1+r)}{(1+p)}$$  \hfill (3.6)

$$w_i(t) = a_i(z(t)) + \sum_{j=1}^{I} \gamma_{ij} \ln p_j(t) +$$

$$\beta_i(z(t)) [\ln x(t) - \ln a(z(t), p(t))], \quad i = 1, \ldots, I$$  \hfill (3.7)

where $w_i(t)$ is the budget share of good $i$ in period $t$.

The linear form chosen for $F(.)$ greatly simplifies estimation. However, it is also restrictive. It turns out, for example, that the intertemporal (constant-$\lambda$) price elasticity

$$\frac{\partial \ln q_i(t)}{\partial \ln p_j(t)} = -\delta_{ij} - \beta_j + \frac{\gamma_{ij} - \beta_j - \beta_i \gamma_{jk} \ln p_k(t))}{w_i(t)}$$

can be recovered from knowledge of $u^*(.)$ alone and is therefore completely determined by the estimated cross-section demand system. These remarks also apply to the elasticities $\partial \ln q(t) / \partial \ln \lambda(t)$, and $\partial \ln x(t) / \partial \ln p_i(t)$. The elasticity $\partial \ln x(t) / \partial \ln \lambda(t)$ is equal to -1. Only the constant $\lambda$ elasticities $\partial \ln q_i(t) / \partial \ln \lambda(t)$ depend on parameters of the function $F(.)$. For these reasons, in future work richer specifications for $F(.)$ will be considered.

To incorporate demographic effects into the second stage model (3.7) we parameterize $a_0(z(t)), a_i(z(t))$ and $\beta_i(z(t))$, as follows:

$$a_0(z(t)) = a_0 + \rho \ln fs(t)$$  \hfill (3.8)

$$a_i(z(t)) = a_i + \sum_{j=1}^{I} \delta_j f^i(a_j(t)) + \beta_i^1 Q_1(t) + \beta_i^2 Q_2(t)$$  \hfill (3.9)
\[ \beta_i(z(t)) = \beta_i + \eta_i \ln f_s(t), \quad (3.10) \]

where

- \( f_s(t) \) = family size (i.e. number of household members) in period \( t \)
- \( a_1(t) \) = age of head of household in period \( t \)
- \( a_2(t) \) = age of partner of head of household in period \( t \) (if present)
- \( a_3(t), \ldots, a_{f_s}(t) \) = ages of the remaining household members, arranged in order of declining age (if present)
- \( f^i(.) \) = a cubic spline function with knots at the ages 0, 6, 18, 65 and 79.
- \( \delta_j := 1 \text{ if } j = 1 \)
- \( := \ln (j/(j-1)) \text{ if } j > 2 \)
- \( Q_1(t) := 1 \text{ if head of household has a paid job} \)
- := 0 otherwise
- \( Q_2(t) := 1 \text{ if both the head of the household and his or her partner have a paid job} \)
- := 0 otherwise

Thus \( a_i(z(t)) \) depends on family composition and the labor force participation of both the head of the household and his or her partner, whereas \( a_0(z(t)) \) and \( \beta_i(z(t)) \) only depend on family size. The definition of \( \delta_j \) implies a weighting of household members which increases logarithmically with their rank number. The cubic spline \( f^i(.) \) is defined on the interval \([0,79]\) and if the age of the \( j \)-th member of the household exceeds 79 it is set equal to 79. For this study we restrict the form of the cubic spline \( f^i(a_j(t)) \) at the end points 0 and 79. In particular we restrict the second order derivatives at 0 and 79 in the following way: \( f^{i''}(0) = \frac{1}{2} f^{i''}(6) \) and \( f^{i''}(79) = \frac{1}{2} f^{i''}(65) \).

Without these restrictions the data matrix would be extremely ill-conditioned (see BLUNDELL (1980)). Moreover these restrictions permit us to write the cubic spline as follows (see POIRIER (1976))

\[ f^i(a) = \sum_{j=1}^{5} \text{SPL}_j(a)e_{ij} \quad i = 1, \ldots, I \]

\[ a = 0, \ldots, 79 \]
In this equation, the 80 x 5 values of $SPL_j(a)$ are known and the $\xi_{ij}$ are ordinates of the spline function corresponding to the abscissa values 0, 6, 18, 65, 79. Details can be found in POIRIER (1976, ch. 3). Given estimates of $\xi_{ij}$ we can derive estimates of $f_i(a)$. The functional form of \[ \sum_{j=1}^{5} \delta_j f^i(a_j(t)) \] is given by

\[
fs(t) = \sum_{j=1}^{5} \delta_j f^i(a_j(t)) = \sum_{j=1}^{5} \left( \sum_{k=1}^{5} \delta_j \sum_{j=1}^{j-1} \sum_{k=1}^{k-1} \xi_{ik} \right) \]

Note that

\[
\sum_{k=1}^{5} WSPL_k(t) = 1 + \ln fs(t)
\]

By choosing these functional forms for $a_0(z(t))$, $a_1(z(t))$ and $\beta_i(z(t))$, we have adopted an approach similar to RAY's (1983), who has introduced the use of a price and/or utility dependent 'Engel scale'. The Engel scale $m(u^*(t), p(t), fs(t), a_1(t), ..., a_{fs}(t))$ corresponding to our functional specification is given by

\[
\ln m(u^*(t), p(t), fs(t), a_1(t), ..., a_{fs}(t)) = \rho \ln fs(t)
\]

Since we only consider expenditures within one period, we set all prices equal to one, without loss of generality. Inserting (3.8)-(3.11) into (3.7) yields

\[
w_i(t) = (a_i - \beta_i a_0) + \sum_{k=1}^{5} WSPL_k(t) \xi_{ki} + \beta_1 Q_1(t) + \beta_2 Q_2(t) + \\
+ \beta_i \ln x(t) + \eta_i \ln x(t) \ln fs(t) - (\beta_i p + \eta_i a_0) \ln fs(t) - \\
- \eta_i \ln^2 fs(t)
\]
Since \[ \sum_{k=1}^{5} WSPL_{k}(t) = 1 + \ln fs(t) \], model (3.13) can be rewritten as

\[ w_{i}(t) = (\alpha_{i}^{*} + \beta_{i} \alpha_{0}) + \sum_{k=1}^{5} WSPL_{k}(\xi_{ki}^{*} - \beta_{i} \alpha_{0}) + \]

\[ \eta_{1} Q_{1}(t) + \eta_{2} Q_{2}(t) + \beta_{i} \ln x(t) + \eta_{i} \ln x(t) \ln fs(t) - \]

\[ \eta_{i} \ln^{2} fs(t), \]

(3.13')

with \( \alpha_{i}^{*} = \alpha_{i} - \beta_{i} \alpha_{0} + \eta_{i} \alpha_{0} \)

\( \xi_{ki}^{*} = \xi_{ki} - \eta_{i} \alpha_{0} \)

Comparison of these functions to the Working-Leser Engel functions that follow from the standard AIDS-model without demographic effects,

\[ w_{i}(t) = (\alpha_{i} - \beta_{i} \alpha_{0}) + \beta_{i} \ln x(t), \]

(3.14)

reveals that family composition is allowed to influence both the slope and the intercept of the Engel functions. In addition, total expenditures are scaled by \( fs^{0} \). Finally, we have allowed, in a somewhat ad hoc manner, for effects of non-separability of consumption and leisure by the incorporation of 2 dummies in (3.12), that indicate whether a family has zero, one, or two or more earners.

The Euler equation (3.6), which describes the first stage model, can be replaced by

\[ \frac{(1+r)}{(1+p)} \frac{B_{0}(z(t+1))}{b(z(t+1), p(t+1)) x(t+1)} = \frac{B_{0}(z(t))}{b(z(t), p(t)) x(t)} (1+e(t+1)), \]

(3.15)

where \( e(t+1) \) is a forecast error uncorrelated with variables observed by period \( t (E_{t+1}^{e} = 0) \). We have specified the parameter of the monotonic transformation \( B_{0}(z(t)) \) as follows

\[ \ln B_{0}(z(t)) = \zeta_{0} + \zeta_{1} Q_{1}(t) + \zeta_{2} Q_{2}(t) + \]

\[ \ln fs(t) \sum_{j=1}^{\delta} h(a_{j}(t)) \]

(3.16)

where

\[ h(.) = \text{cubic spline function with knots at ages 0, 6, 18, 65 and 79 years.} \]
The variables $a_j(t)$ and $\delta_j$ were defined before. Given this specification of $\theta_0(z(t))$ and given $p_i(t) = 1$ for all $i = 1, \ldots, I$, we may rewrite (3.15) in the following manner

$$
\ln x(t+1) = \gamma_0(t+1) + \ln x(t) + \zeta_1 \Delta Q_1(t+1) + \zeta_2 \Delta Q_2(t+1) +
$$

$$
\Delta \sum_{j=1}^{I} \delta_j h(a_j(t+1)) - \sum_{i=1}^{I} \eta_i \ln p_i(t+1) \ln fs(t+1) + \xi(t+1)
$$

(3.17)

where

$$
\gamma_0(t+1) := \ln \left( \frac{1+r}{1+r} \right) + E_t \ln(1+\varepsilon(t+1)) - \sum_{i=1}^{I} \beta_i \ln p_i(t+1)
$$

$$
\xi(t+1) := \ln (1+\varepsilon(t+1)) - E_t \ln(1+\varepsilon(t+1)),
$$

and $\Delta$ is a first difference operator. Since we assume that all consumers face the same prices, we may treat the terms $\sum_{i=1}^{I} \beta_i \ln p_i(t+1)$ and $\sum_{i=1}^{I} \eta_i \ln p_i(t+1)$ as constants in a cross-section. Along the same lines as in (3.11) the function $\Delta \sum_{j=1}^{I} \delta_j h(a_j(t+1))$ can be replaced by

$$
\Delta \sum_{j=1}^{I} \delta_j h(a_j(t+1)) = \sum_{k=1}^{5} \Delta WSPL_k(t+1) \xi_{k+2}
$$

(3.18)

As a result equation (3.17) becomes

$$
\ln x(t+1) = \gamma_0(t+1) + \ln x(t) + \zeta_1 \Delta Q_1(t+1) + \zeta_2 \Delta Q_2(t+1) +
$$

$$
+ \sum_{k=1}^{5} \Delta WSPL_k(t+1) \xi_{k+2} - \gamma_1(t+1) \ln fs(t+1) + \xi(t+1),
$$

(3.19)

where $\gamma_1(t+1) = \sum_{i=1}^{I} \eta_i \ln p_i(t+1)$

Thus the relative change in total expenditures in period $t+1$, $\Delta \ln x(t+1)$, can be expressed as a function of changes in the labor force participation of both the head of the household and his or her partner, and family composition. Once again, the incorporation of the labor force participation dummies can be seen as a rather crude way to allow for a possible non-separation between consumption and leisure.
IV. Data, Identification and Estimation

The data used to estimate the model developed above comes from the 1980-1981 Consumer Expenditure Survey of the Netherlands Central Bureau of Statistics. We have used 1579 observations of households whose expenditures, income, family composition, occupational status, etc., are known for both 1980 and 1981. Expenditures are classified according to the following seven categories:

1. Food (including outdoor meals)
2. Housing (including rent, maintenance, appliances, tools, heating, electricity)
3. Clothing and footwear
4. Personal care and medical expenditures (including payments for domestic services)
5. Education and recreation (including holidays, smoking, stationary and subscriptions)
6. Transportation (including public transportation, bicycles, mopeds, motor cycles, cars)
7. Other expenditures.

Table 1 gives some sample information on the budget shares of these categories and some general household characteristics.

The complete model consists of (3.13') and (3.19), with error terms added to (3.13'). We estimate model (3.13') for period t+1. The complete model can be summarized as follows:
Table 1: Sample means and standard deviations of some variables

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Food, $w_1$</td>
<td>0.218</td>
<td>0.072</td>
<td>0.215</td>
<td>0.070</td>
</tr>
<tr>
<td>2. Housing, $w_2$</td>
<td>0.313</td>
<td>0.106</td>
<td>0.331</td>
<td>0.107</td>
</tr>
<tr>
<td>3. Clothing/Footwear, $w_3$</td>
<td>0.083</td>
<td>0.044</td>
<td>0.079</td>
<td>0.043</td>
</tr>
<tr>
<td>4. Personal care and medical expenditure, $w_4$</td>
<td>0.130</td>
<td>0.044</td>
<td>0.132</td>
<td>0.044</td>
</tr>
<tr>
<td>5. Education and recreation, $w_5$</td>
<td>0.140</td>
<td>0.075</td>
<td>0.130</td>
<td>0.074</td>
</tr>
<tr>
<td>6. Transportation, $w_6$</td>
<td>0.105</td>
<td>0.089</td>
<td>0.102</td>
<td>0.086</td>
</tr>
<tr>
<td>7. Other expenditures, $w_7$</td>
<td>0.012</td>
<td>0.018</td>
<td>0.011</td>
<td>0.017</td>
</tr>
</tbody>
</table>

General Characteristics of the households

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total expenditures, $x$ (Dfl x 1,000)</td>
<td>33,019</td>
<td>13,970</td>
<td>33,248</td>
<td>14,070</td>
</tr>
<tr>
<td>2. After tax income, $y$ (Dfl x 1,000)</td>
<td>35,590</td>
<td>15,004</td>
<td>37,035</td>
<td>15,955</td>
</tr>
<tr>
<td>3. Family size, $f$</td>
<td>2.985</td>
<td>1.394</td>
<td>3.003</td>
<td>1.394</td>
</tr>
</tbody>
</table>
\[ \ln x(t+1) = \gamma_0(t+1) + \ln x(t) + \sum_{k=1}^{5} \Delta \text{WSPL}_k(t+1) \xi_k + 2 \]

\[ \xi_1 \Delta Q_1(t+1) + \xi_2 \Delta Q_2(t+1) + \gamma_1(t+1) \ln f_s(t+1) + \xi(t+1) \tag{4.1} \]

\[ w_i(t+1) = (a_i + \beta_i \rho) + \sum_{k=1}^{5} \Delta \text{WSPL}_k(t)(\xi^*_k - \beta_i \rho) + \theta_1^1 Q_1(t+1) + \theta_2^2 Q_2(t+1) \]

\[ + \beta_i \ln x(t+1) + \eta_i \ln f_s(t+1) - \eta_i \rho \ln^2 f_s(t+1) + \omega_i(t+1) \tag{4.2} \]

\[ i \in \{1, \ldots, I\} \text{ (I = number of goods)} \]

\[ \gamma_0(t+1) = \ln \left(\frac{1+r}{1+\rho}\right) - E_t \ln (1+\epsilon(t+1)) - \sum_{i=1}^{I} \beta_i \ln p_i(t+1) \]

\[ \gamma_1(t+1) = - \sum_{i=1}^{I} n_i \ln p_i(t+1) \]

\[ a^*_i = a_i - \beta_i a_0 + n_i a_0 \]

\[ \xi^*_k = \xi_k - n_i a_0 \]

\[ \sum_{i=1}^{I} a_i = 1; \sum_{i=1}^{I} \xi_k = 0; \sum_{i=1}^{I} n_i = 0; \sum_{i=1}^{I} \beta_i = 0 \]

\[ \sum_{i=1}^{I} \theta_1^1 = 0; \sum_{i=1}^{I} \theta_2^2 = 0. \]

Since the budget shares add to unity, any one equation in (4.2) can be dropped from the estimation. We have chosen to drop the last one.

With respect to the stochastic specification of the model we make some simplifying assumptions. First we assume that the distribution of \( \xi(t+1) \) in (4.1) is the same across consumers. Consequently, \( \gamma_0(t+1) \) is a period specific parameter, which has the same value for all consumers. Furthermore, we assume \( \omega(t+1) = (\xi(t+1), \omega_1(t+1), \ldots, \omega_6(t+1))' \equiv (\xi(t+1), \omega^*(t+1))' \) to be (normally) independently and identically distributed across observations with mean zero and variance covariance matrix \( V \), given by
with $V$ symmetric positive definite but otherwise unrestricted. We have estimated (4.1) and (4.2) separately by using (non-linear) two stage least squares methods for both equations and by ignoring the restriction $\gamma_1(t+1) = -\sum_1^I \eta_i \ln p_i(t+1)$. We need an instrumental variable estimator in (4.1), because the taste shifters dated $t+1$ may be correlated with $\gamma(t+1)$. We use a number of household characteristics like $Q_1(t)$, $Q_2(t)$, region, family size etc.. Since our panel consists of 2 waves we have only levels and not first differences of these instruments, such as $\Delta Q_1(t)$, at our disposal. Therefore, the correlation between the instruments and the endogenous variables on the right hand side tends to be small. Some instruments deserve further comment: given the size and age composition of the family in 1980, we have computed the following variables

$$f_s(t)$$

$$WSPLI_k(t) = \sum_1^I \delta_j SPL_k(a_j(t)+1)$$

Good instruments for $\Delta WSPLI_k(t+1)$ may be

$$\Delta WSPLI_k(t) = WSPLI_k(t) - WSPLI_k(t) \quad k = 1, \ldots 5$$

Since $\sum_1^5 WSPLI_k(t) = 1 + \log f_s(t)$, we have added only four of the five variables in (4.4) to the set of instruments.

We have to estimate model (4.2) by means of nonlinear two stage least squares, because $\ln x(t+1)$ and $\ln x(t+1) \ln f_s(t+1)$ are endogenous variables, due to assumption (4.3). We have used the following instruments $\ln x(t)$ and $\ln x(t) \ln f_s(t+1)$. (We assume that we may treat taste shifters in period $t+1$, such as $\ln f_s(t+1)$, as exogenous variables in the second stage model.)

As a result our estimation procedure will yield consistent, but not fully efficient estimates of the parameters in (4.1) and (4.2).

Finally, we pay some attention to the identification of the structural parameters in model (4.2). Under the statistical assumptions made, all reduced parameters can be estimated consistently. However, the re-
duced form parameters do not contain enough information to identify all structural form parameters. This can be seen as follows: $\beta_i$, $\eta_i$, $\delta_i^1$, $\delta_i^2$ are reduced form parameters and hence identified. Next use the reduced form parameter corresponding to $\ln^2 f_s(t)$ to determine $\rho$. Then, it is easy to see that the parameters $\xi_{ki}$ and $\alpha^*_i$ are also identified. However, knowing $\xi_{ki}$ and $\alpha^*_i$ still leaves us one piece of information short to be able to solve for the structural parameters $\alpha_i$, $a_0$ and $\xi_{ki}$.
FIG. 5.1: Estimated age function (cubic spline), $H(\text{age})$, plus the corresponding confidence interval.
V. Results for the First Stage

The parameter estimates for equation (4.1) are given in Table 2. The \( R^2 \)-value is quite acceptable, though not surprising for a model with a lagged dependent variable. For the rest, the empirical results are a bit disappointing, because most coefficients do not differ significantly from zero. Undoubtedly, this is partly due to the available instruments, which do not correlate highly with the explanatory variables.

The age function drawn in Fig. 5.1 also has wide confidence intervals (defined as 1.96 times the standard error of the estimate of the function value), and a test of the hypothesis of a constant age function does not lead to rejection (\( F(4,1570) = 1.83 \)), although it is close (the probability of an \( F(4,1570) \)-statistic exceeding 1.83 equals 0.12.). From (2.5), (3.4) and (3.16) it is clear that the age function serves to weight utility in different periods. The shape of the age function suggests, that beyond the age of twenty one, there is a tendency to give lower weights to consumption at older ages (over and above the effect of the subjective discount rate). Since the taste shift is foreseen (i.e. "rational"), the ceteris paribus effect of age on consumption is a monotonic decrease after the age of twenty.

Table 2: Estimation results for the first stage (asymptotic t-values in parentheses)

<table>
<thead>
<tr>
<th>Equation 4.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma_0(1981) = 0.030 \ (1.786) )</td>
</tr>
<tr>
<td>( \gamma_1(1981) = 0.002 \ (0.112) )</td>
</tr>
<tr>
<td>Labor participation dummies</td>
</tr>
<tr>
<td>( \xi_1 = -0.025 \ (-0.309) )</td>
</tr>
<tr>
<td>( \xi_2 = 0.010 \ (0.116) )</td>
</tr>
<tr>
<td>total expenditures</td>
</tr>
<tr>
<td>( \gamma_2 = 1 )</td>
</tr>
<tr>
<td>( \text{var}(\eta(1981)) = 0.059 )</td>
</tr>
<tr>
<td>( R^2 = 0.710 )</td>
</tr>
</tbody>
</table>

We have also estimated an equation of the following form by means of 2SLS.
\[
\ln x(t+1) = a_0(t+1) + a_1 \ln x(t) + a_2 Q_1(t+1) + a_3 Q_2(t+1) \\
+ a_4 Q_1(t) + a_5 Q_2(t) + \sum_{j=1}^{5} a_{j+5} \text{WSPL}_{j}(t+1) \\
+ \sum_{j=1}^{5} a_{j+10} \text{WSPL}_{j}(t) + \xi(t+1)
\] (5.1)

Note that equation (4.1) is nested in (5.1). We can thus use an asymptotic F-test to investigate whether the restrictions implied by (4.1) are valid. The test rejects the restriction decisively \( F(7, 1563) = 27.82 \). A possible explanation is, that the functional form of the monotonic transformation \( F \) is not correct.

Finally, we have added lagged income to equation (5.1). The corresponding coefficient differs significantly from zero (\( t(1562) = 5.107 \)). One can interpret this result as a contradiction of the life cycle-rational expectations hypothesis, which says that of the lagged variables, only lagged consumption and taste shifters (in our case demographic factors and labor participation dummies) should have a nonzero coefficient in such a regression (see HALL (1978)). A possible cause for the departure of the life cycle-rational expectation hypothesis is the presence of liquidity constraints and the possibility of consumer expectations not being rational.

The significance of the lagged income coefficient may also be due to a violation of some other assumptions we made. We assumed, for example:

1. The within period preferences are weakly separable between consumption and leisure.
2. The consumer is not subject to rational habit formation.
3. The coefficient \( \gamma_0(t+1) \) is the same across individuals. This means that we neither allow for a varying rate of time preference \( \rho \) nor for heteroskedasticity of the forecast error. One can somewhat relax this assumption by treating \( \gamma_0(t+1) \) as a random effect, provided that it does not correlate with variables dated \( t \).

4) \( fs(\tau) \)

Note that \( \sum_{j=1}^{\text{WSPL}_{j}(\tau)} = 1 + \log fs(\tau), \tau = t, t+1. \)
If assumptions 1 or 2 are violated, the within period demand system will be misspecified. The violation of the third assumption, or non-rational expectations, or liquidity constraints, need not induce misspecification of the second stage model. Maintaining assumptions 1 and 2 we present estimation results for the within period demand system in the next section.

VI. Results for the Second Stage

Parameter estimates for model (4.2) are given in Table 4. Once more, the results for the spline functions are given in graphs, see Figures 6.1 through 6.6. The $R^2$-s are rather low, which suggests that it might be useful to add more explanatory variables to the model. Lagged budget shares (as an indication of (myopic) habit formation) may be especially important determinants of current budget shares. One should note, however, that although the explanation of variation in budget shares across households leaves something to be desired, the explanation of expenditures is much better. Rewriting (4.2) in terms of expenditures reveals that more than 50 % of the variance of expenditures across households is explained by the model.

In our model the expenditure elasticity of good i is equal to

$$
\frac{\beta_i + \eta_i \ln fs(t)}{1 + \frac{\beta_i + \eta_i \ln fs(t)}{w_i}}
$$

The resulting expenditure elasticities for different family sizes are displayed in Table 3.
Table 3: Expenditure elasticities for different family sizes (evaluated at the 1981 sample means of \( w_1, \ldots, w_6, w_7 \))

<table>
<thead>
<tr>
<th>good</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. food</td>
<td>0.740</td>
<td>0.691</td>
<td>0.663</td>
<td>0.643</td>
</tr>
<tr>
<td>2. housing</td>
<td>0.964</td>
<td>0.960</td>
<td>0.957</td>
<td>0.955</td>
</tr>
<tr>
<td>3. clothing</td>
<td>1.063</td>
<td>1.125</td>
<td>1.161</td>
<td>1.186</td>
</tr>
<tr>
<td>4. personal care</td>
<td>1.061</td>
<td>0.856</td>
<td>0.736</td>
<td>0.651</td>
</tr>
<tr>
<td>5. education</td>
<td>1.092</td>
<td>1.215</td>
<td>1.287</td>
<td>1.338</td>
</tr>
<tr>
<td>6. transportation</td>
<td>1.490</td>
<td>1.633</td>
<td>1.716</td>
<td>1.776</td>
</tr>
<tr>
<td>7. other</td>
<td>0.364</td>
<td>0.679</td>
<td>0.863</td>
<td>0.994</td>
</tr>
</tbody>
</table>

We observe that food and housing are necessities irrespective of the size of the family. Personal care and medical expenditures are also necessities, if the family size is at least equal to two.

The other consumption categories are mostly luxuries. The estimate of \( \rho = 0.24 \) implies substantial economies of scale: An increase of family size by 10% increases the cost of maintaining a certain utility level by only 2.4% (cf. (3.12) with all prices equal to one). The estimates of the \( \delta \)'s show that one and two-earner families have a lower budget share for food and a higher budget share for personal care, medical expenditures and transportation than households with zero earners. For the remaining, the differences are slight.

Table 4: Second stage estimates (t-values in parentheses)

\[
\begin{align*}
\rho &= 0.236 \\
\alpha_1 &= 0.248 \ (4.78) \\
\alpha_2 &= 0.433 \ (5.07) \\
\alpha_3 &= 0.068 \ (1.91) \\
\alpha_4 &= -0.047 \ (-1.31) \\
\alpha_5 &= 0.220 \ (3.66) \\
\alpha_6 &= 0.040 \ (0.60) \\
\alpha_7 &= 0.038 \\
\beta_1 &= -0.056 \ (-5.65) \\
\beta_2 &= -0.012 \ (-0.75) \\
\beta_3 &= 0.005 \ (0.78) \\
\beta_4 &= 0.008 \ (1.18) \\
\beta_5 &= 0.012 \ (1.09) \\
\beta_6 &= 0.050 \ (3.96) \\
\beta_7 &= -0.007 \\
\eta_1 &= -0.015 \ (-1.59) \\
\eta_2 &= -0.002 \ (-0.15) \\
\eta_3 &= 0.007 \ (1.04) \\
\eta_4 &= -0.039 \ (-5.69) \\
\eta_5 &= 0.023 \ (2.13) \\
\eta_6 &= 0.021 \ (1.80) \\
\eta_7 &= -0.005 \\
\theta_1^1 &= -0.013 \ (-2.43) \\
\theta_1^2 &= -0.024 \ (-3.36) \\
\theta_2^1 &= 0.004 \ (0.42) \\
\theta_2^2 &= -0.000 \ (-0.01) \\
R_1^2 &= 0.2152 \\
R_2^2 &= 0.1044
\end{align*}
\]
Our attempt to make the specification of demographic effects as general as possible, makes it difficult to attach a direct interpretation to the parameter estimates. This is slightly different for the age functions incorporated in (3.13) since these represent an additive effect on the budget share of a good. The age functions are presented in Figures 6.1 through 6.6. The small seventh expenditure category has been omitted. Fig. 6.1 suggests that food consumption goes up until one reaches adulthood and afterwards remains constant. For housing, it would seem that in particular, the young and the elderly need a lot of space. It should be noted, of course, that people in the 30-50 range frequently will have children in the younger age-range. And it is only the sum of the age effects, logarithmically weighted, which appears in (3.13).

Fig. 6.3 suggests that the need for clothing only starts declining after the retirement age. The demand for personal and medical care (Fig. 6.4) shows a dip at the healthy ages between 3 and 25. Old people do not consume more medical care than younger people since in The Netherlands health insurance premiums are in principle constant across age groups. Not surprisingly, Fig. 6.5 shows that education and recreation are least consumed by the very young and the very old. Finally, Fig. 6.6 suggests that the budget share of transportation are more or less constant across the life cycle, with a slight dip around the age of ten.

VII. Concluding Remarks

The life-cycle hypothesis provides a convenient and powerful approach to the modelling of consumption and savings decisions. Even though the first stage model is rejected by the data, the additive separability of the intertemporal utility function allows for a flexible specification of the second stage expenditure allocation decision, which is not rejected by the data. For both the first and second stage model,
FIG. 6.1: Estimated age function (cubic spline), $F_1(age)$, of food plus the corresponding confidence interval.
FIG. 6.2: Estimated age function (cubic spline), $F_2(\text{age})$, of housing plus the corresponding confidence interval.
FIG. 6.3: Estimated age function (cubic spline), $F_3(\text{age})$, of clothes, footwear plus the corresponding confidence interval.
FIG. 6.4: Estimated age function (cubic spline), $F_4(\text{age})$, of personal and medical care plus the corresponding confidence interval.
FIG. 6.5: Estimated age function (cubic spline), $F_5(\text{age})$, of education and recreation plus the corresponding confidence interval.
FIG. 6.6: Estimated age function (cubic spline), $F_6(\text{age})$, of transportation plus the corresponding confidence interval.
demographic factors appear to be important determinants of behavior, through their role as taste shifters.

The rejection of the first stage model suggests the need to relax the stringent assumption of perfect capital markets. The low R² s for the second stage model indicate the need to pay more attention to the influence of taste shifters. In ALESSIE and KAPTEYN (1985) we have therefore incorporated habit formation and preference interdependence into the second stage model.
References


No. 5  Th. ten Raa and F. van der Ploeg, A statistical approach to the problem of negatives in input-output analysis, Economic Modelling, Vol. 6, No. 1, 1989, pp. 2 - 19.


No. 8  Th. van de Klundert and F. van der Ploeg, Wage rigidity and capital mobility in an optimizing model of a small open economy, De Economist 137, nr. 1, 1989, pp. 47 - 75.


