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INTERTEMPORAL NON-SEPARABILITY OR BORROWING RESTRICTIONS? A DISAGGREGATE ANALYSIS USING THE US CEX PANEL

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Intertemporal Non-Separability or Borrowing Restrictions? A Disaggregate Analysis Using the US CEX panel

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Abstract

We propose a method to test for liquidity constraints which relies on using the within period Marginal Rate of Substitution condition as a benchmark to evaluate the intertemporal Euler equation. If spot markets for non durable goods exist, but financial markets either do not exist, or are imperfect, we show how the comparison of first order conditions involving the relevant spot and intertemporal prices can be used to detect the imperfection.

We apply our methodology to a large sample of US households, drawn from eight years of the Consumer Expenditure Survey (1980-87). Our empirical results allow for a general non-separable preference structure which is empirically important. Our estimates of first order conditions obtained from the consumer dynamic optimization problem do not indicate the presence of liquidity constraints.

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Introduction

In the existing literature on life cycle consumption, tests for the absence of liquidity constraints often rely on very stringent preference structures. Thus the typical framework for testing has been a model which imposes separability across time as well as separability and homotheticity within the period (see Zeldes, 1989, and Runkle, 1991, among others). Given that many tests have been carried out using either macro data or data where the individual consumption of commodities has not been available, this is not surprising. However, it is easy to see that misspecification of preferences, either across time (intertemporal separability) or within the period can lead to rejections of the hypothesis of no liquidity constraints, simply because the omitted terms typically correlate with income. Then again it can be argued validly that preferences may seem nonseparable or even non-homothetic *because* of liquidity constraints: Quantities of other goods or labour market status can often be construed as proxying for nothing but anticipated income growth. Thus without a benchmark which allows us to separate out the effects of liquidity constraints from preferences it is arguable that there is an identification problem.

The basic premise of this paper is that the relevant aspects of preferences can be identified independently from the presence of liquidity constraints under quite general conditions so long as we have data on more than one non-durable commodity in each period. We argue that with such data we can investigate both the within period preference structure and some aspects of intertemporal preferences by considering the within period marginal rate of substitution between commodities. The intertemporal Euler condition can then be used to investigate the presence or otherwise of liquidity constraints. Thus for example if we find no evidence of dynamics in preferences using the MRS while such dynamics become evident in the Euler equation (or *vice versa*) this would be evidence of borrowing restrictions. Moreover, if dynamics in the utility function are genuinely important and preferences are stable over time, the MRS representation identifies all we need to know about preferences, including the intertemporal elasticities. In this case we expect the Euler equation to lead us to the same conclusions. In any case our methodology hinges on the idea that dynamics in preferences can be identified quite independently from the ability to smooth the marginal utility of consumption over time.

In the paper we model explicitly three non-durable goods over time and within period: Food at home, Transport and Services. The choice is governed by the fact that these goods can not generally be used as collateral for borrowing purposes.Moreover these goods are generally consumed by all households and hence we minimise the incidence of zeros. This would not be the case for commodities such as tobacco which is never considered by a large group of consumers. Moreover, commodities such as food out of the home are often at a corner. On the other hand 'problematic' goods such as clothing, food out of the home, labour market status etc. may well be non-separable from the goods we model. Thus we allow the three goods we model to depend on the observed consumption of clothing, fuel, food out of the home and on the labour market status of the household members. Hence our implicit demand functions are conditional on these other goods as suggested amongst others by Browning and Meghir (1991). Ignoring such non-separabilities could generate the impression of liquidity constraints or spurious dynamics.

Other studies that have considered non-separability of preferences across goods in an intertemporal context are Browning, Deaton and Irish (1985) and Blundell, Browning and Meghir (1993) Non separability across time has further been introduced by Hayashi (1985), Dunn and Singleton (1986), Hotz, Kydland and Sedlacec (1988) and in the context of habit formation by Spinnewyn (1981), Muellbauer and Pashardes (1988), and Costantinides (1991). In general, though, there is a lack of work using microeconomic data and often these issues have been investigated using aggregate time series data (e.g. Hall (1988), Hansen and Singleton (1982), Campbell and Mankiw (1989), Bean (1986) etc.)

The data we use in this paper is the US Consumer Expenditure Survey (CEX) from 1980-1988. This is a 'rolling' panel where each household is observed four times over a year. New samples enter every month. This survey combines the advantages of covering a long time period with relatively low attrition rates (relative to what they would have been if the individuals were followed for long time periods). We select only married couples with or without children. We use prices provided by the Bureau of Labor Statistics, which present regional as well as time variation. However, regional variation is limited, as only broad areas are recorded for confidentiality reasons. Finally we use the municipal bond interest rate which is tax exempt.

The paper is organised as follows: section 1 provides a non-technical summary of the literature on testing for liquidity constraints, and of the intuition behind our approach. In section 2 the model is formally laid out together with a detailed justification of our methodology. Section 3 discusses the empirical specification, the role of conditioning goods and the stochastic structure we assume. Next, in Section 4 we deal with the important identification issues that arise when preferences are allowed to be non-separable across time as well as within the period. Moreover we discuss identification in conditional systems such as ours here. In Section 5 we discuss our estimation method. In Section 6 we present a descriptive analysis of the relevant aspects of our data. The empirical results are discussed in section 7 while a brief set of concluding remarks are offered in section 8.

1. Testing for liquidity constraints - background

In testing the life-cycle model, the specification that is most often used is that of additive preferences over time. Thus the consumers maximise

$$V(A_t) = \max_{A_{t+1}, c_t} \{ U(c_t) + E_t \beta V_{t+1}(A_{t+1}) \}$$

subject to

$$A_{t+1} = (1 + r_t)(A_t - c_t + y_t),$$

where $\beta = 1/(1+\delta)$ is the rate of time preference, A_t are assets at the start of time period t, c_t is consumption, r_t is the real interest rate and y_t is some (exogenous and) stochastic income stream.

Usually the borrowing constraints are expressed as a floor on asset holdings, i.e. A_{t+1}, end of period assets, must be non-negative. This specification gives rise to the first-order conditions

$$\frac{\partial U}{\partial c_t} = \lambda_t$$

$$\lambda_t = E_t \frac{1 + r_t}{1 + \delta} (\lambda_{t+1} + \mu_t)$$

where $\lambda_t = \frac{\partial V_t}{\partial A_t}$ is the marginal utility of wealth and μ_t is the Kuhn-Tucker multiplier on the constraint $A_{t+1} \geq 0$. When the liquidity constraints are not binding, $\mu_t = 0$ and the marginal utility of wealth λ_t is a martingale as in Hall (1978) and Hansen and Singleton (1982). When they are binding, $\mu_t > 0$ and the standard Euler equation is no longer valid. This basic model has been tested using both macro data and micro data and following several different approaches.

The first approach - the excess sensitivity test - is based on the idea that if $\mu_t = 0$, predictable changes in income should not explain λ_{t+1} given λ_t. If they do, the marginal utility of consumption is 'too sensitive' to current income. In effect, since μ_t is a function of current income, among other variables, the growth rate of income is correlated with μ_t. Some of the excess sensitivity literature is discussed in Deaton, 1992. Of course excess sensitivity in household level data may be due to measurement error problems as argued by Altonji and Siow (1987).

Although these tests are highly intuitive and often compelling, they suffer from several problems.

First, suppose an individual anticipates a labour market transition. This will lead to an anticipated change in income. Consumption may shift as a result, either because it is not separable from labour supply or because of excess sensitivity. Since most of the predictable changes in income are probably due to labour market transitions, it is hard to disentangle the two effects directly.

The second problem is similar and is also addressed here. If preferences are not separable over time, then the growth rate in income will proxy the omitted lags and leads in consumption. In fact, most of the excess sensitivity papers qualify their results based on this criticism.

Finally, there is an implementation problem. Often the consumption Euler equation is estimated as a log approximation which introduces the conditional variance of consumption as an unobservable. Although demographics may be used to partially control for this effect, they may not capture well the conditional variance of consumption. In fact, income growth may be a better explanatory factor for this term. As Carroll (1991) suggests, consumption may track income because of precautionary savings. Thus, in general, the excess sensitivity tests on micro data are very specific to a particular framework.

An alternative approach by Zeldes (1989) and Runkle (1991) uses the idea that high-wealth households should have $\mu_t = 0$ and hence the high-wealth households act as a control group where the null is valid. In fact, Zeldes's empirical results show that income growth is less significant for those households than for the low-income ones. A key issue here is whether we can correct credibly for selection bias in implementing such a test although Zeldes does provide quite a convincing procedure which is valid under the null of no liquidity constraints.

The approach we present here is meant to complement the ones described briefly above and to add evidence by looking at the problem from a different angle. Our methodology is based on the observation that LCs affect all non-durable goods that do not have value as collateral in the same way. Thus, while differencing across time (Euler equation) may not eliminate the effects of LCs, differencing across goods will do so. In other words, the marginal rates of substitution across these commodities are unaffected by LCs. The basic premise of our approach is that the structure of dynamics in preferences should be analysed within the context of the MRS function and not over time where dynamics can arise spuriously because of liquidity constraints. Armed with the estimates from the MRS function, we can then consider the Euler equations. Under the null, both models should lead us to the same conclusion about preferences. Under the alternative differences should arise, particularly for low wealth households. In the next section we set up our model.

2. The Model

We assume that the period t utility function depends on the consumption vector of period t-1 (in a non-additive way), i.e. $U_t = U_t(X_t, X_{t-1})$, where $X_t = (x_{1t}, \ldots, x_{nt})$ is a vector of goods. Given beginning of period assets A_t, the consumer is assumed to maximise the intertemporal value function

$$[1] \quad V_t(X_{t-1}, A_t) = \max_{X_t, A_{t+1}} \left\{ U_t(X_t, X_{t-1}) + \frac{1}{1+\delta} E_t \left[V_{t+1} (X_t, A_{t+1}) \right] \right\}$$

where δ is the personal rate of time preference. Assets evolve, as before, according to the standard difference equation

$$[2] \quad A_{t+1} = (1+r_t)(A_t - p_t' X_t + y_t)$$

In the above p_t is a vector of prices, r_t is the nominal net of tax interest rate and y_t is disposable household income (earnings and transfer income).[1] The expectations operator E_t is taken with respect to future prices, interest rates and income flows which are assumed uncertain. In implementing our estimation approach we will be assuming rational expectations. Finally we define a function describing liquidity constraints as

[2a] $$A_{t+1} \geq g(z_t)$$

where z_t is a vector of individual-specific characteristics. This could include wages, labour supply behaviour or durable goods but we assume that $g(\cdot)$ does not depend on food at home, on transport or services; i.e. on the goods we model. The rationale for such an assumption is that such goods in themselves cannot be used as collateral or even as a signal of credit worthiness to lending authorities. We are assuming that no special good-specific credit facilities are offered for the purchase of any of these three categories of goods.[2]

Defining the marginal utility of wealth $\partial V_t/\partial A_t$ to be λ_t, the first order conditions for the maximisation of [1] subject to [2] and [2a] are

[3] $$\lambda_t = E_t\{(1+r_t)/(1+\delta)](\lambda_{t+1} + \mu_t)\}$$

[4] $$\frac{\partial U_t}{\partial x_{tj}} + \frac{1}{1+\delta} E_t\left[\frac{\partial U_{t+1}}{\partial x_{tj}}\right] - \frac{p_{tj}}{1+\delta} E_t\left[(1+r_t)(\lambda_{t+1} + \mu_t)\right] = 0$$

In the above μ_t is the Kuhn-Tucker multiplier on the liquidity constraint. Clearly if the liquidity constraint is not binding μ_t=0 as before.

Equation [3] is the standard Euler equation adjusted for the presence of liquidity constraints. These in effect raise current marginal utility of consumption relative to tomorrow's implying that desired consumption growth is

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[1] Equation [2] can be generalized to include several assets, as shown by Hansen and Singleton (1982). Our formal analysis would be unaffected.

[2] See Alessie, Malenberg and Weber (1989) for a treatment of the case where the borrowing limit depends on a choice variable.

higher than observed. The empirical problem with testing for liquidity constraints is that under the alternative, μ_t is an unobservable which depends on all state variables such as current Assets and on goods that can serve as collateral and hence whose purchase can alleviate the liquidity constraint. Short of using a full solution approach to the dynamic programme to compute μ_t, the latter is not explicitly identifiable. If we do not control for its presence μ_t is likely to bias the dynamic structure of preferences and/or lead to the rejection of the assumptions that underlie the economic structure of the problem. Finally note that when $\mu_t = 0$ the marginal utility of wealth still has the standard martingale property despite the presence of dynamics in the utility function.

Combining [3] and [4], we obtain an expression of the marginal utility for good j as:

$$[5] \qquad \frac{\partial U_t}{\partial x_{tj}} + \frac{1}{1+\delta} E_t\left[\frac{\partial U_{t+1}}{\partial x_{tj}}\right] = p_{tj}\,\lambda_t.$$

Equation [5] is the Frisch demand function for good j when preferences are non-separable over time. The usefulness of [5] lies in the fact that both liquidity constraints and the unobservable marginal utility of wealth affect all goods *in the same way* through λ_t. Hence the marginal rate of substitution between any two goods in the same time period does not change as a result of capital market imperfections of the sort implied by [2a]. This is in spite of the presence of dynamics and it implies that dynamics in preferences can be analysed using marginal rate of substitution functions even in the presence of liquidity constraints. A simple interpretation of the above is that the common effect μ_t is differenced away across goods.

Thus an estimable model which is robust to the presence of liquidity constraints can be obtained by eliminating λ_t from [5] using the first-order conditions for another good. Hence

$$\text{[5a]} \quad \frac{\partial U_t}{\partial x_{tj}} + \frac{1}{1+\delta} E_t \frac{\partial U_{t+1}}{\partial x_{tj}} = \frac{P_{tj}}{P_{to}} \left[\frac{\partial U_t}{\partial x_{to}} + \frac{1}{1+\delta} E_t \frac{\partial U_{t+1}}{\partial x_{to}} \right]$$

The marginal rate of substitution between any two goods (j,0) will depend in general on the quantities of *all* goods but only on the prices of these two goods (j,0). It is this restriction which identifies one MRS from another in the absence of separability. Moreover the MRS does not depend on the interest rate. The identification issues are discussed in a separate section.

In the absence of liquidity constraints, we can use the martingale property of λ_t implied by [3] (when $\mu_t = 0$) to derive the Euler equation for each good. This takes the form

$$\text{[6]} \quad \frac{\partial U_t}{\partial x_{tj}} + \frac{1}{1+\delta} E_t\left[\frac{\partial U_{t+1}}{\partial x_{tj}}\right] - E_t\left\{\left[\frac{\partial U_{t+1}}{\partial x_{t+1j}} + \frac{1}{1+\delta}\left[\frac{\partial U_{t+2}}{\partial x_{t+1j}}\right]\right] \frac{(1+r_t)p_{jt}}{(1+\delta)p_{jt+1}}\right\} = 0$$

The dynamic structure of the Euler equation is richer but it only involves the interest rate and the good specific rate of price appreciation. The particular price that enters this equation identifies (non-parametrically) one Euler equation from another.

The issue now is what can we learn about preferences by the empirical analysis based on [5a] rather than on [6].

First, [5a] is robust to the absence of perfect credit markets; [6] is not. This implies that the parameters estimated using observations on the within period allocations are not affected by the absence of a complete set of markets. Their robustness makes them an ideal benchmark by which to evaluate the empirical implications of the Euler equations.

Second, the analysis of within period allocations can be informative about the structure of dynamics in preferences. Consider first the case where preferences are not weakly separable over time: By definition this implies that the marginal rate of substitution between any two goods will depend on consumption levels from other periods. Not only; in this case transforming the current period utility index $U_t(X_t, X_{t-1})$ by some monotonic transformation changes the within period marginal rates of substitution between any two goods. Hence, in this case the within period analysis can identify all relevant aspects of preferences including those parameters determining intertemporal allocations.

The case of weakly separable preferences is different. For within-period allocations not to depend on other periods' consumption (when preferences are non-additive) the current utility index must be of the form: $U_t(X_t, X_{t-1}) = U_t(X_t)U_{t-1}(X_{t-1})$. Crucially, today's consumption must affect today's utility exactly in the same way as tomorrow's utility - an interpretation is that today's utility scales next period's rate of time preference. If preferences have this particular structure then the intertemporal utility function viewed from period t can be written as

$$U^L = U_t(X_t)[U_{t-1}(X_{t-1}) + \beta E_t U_{t+1}(X_{t+1})] + E_t \Sigma_{s=t+2}^{T} \beta^{s-t} U_s(X_s)U_{s-1}(X_{s-1})$$

which implies the following within-period condition:

$$\frac{\partial U_t(X_t)}{\partial X_{1t}}[U_{t-1}(X_{t-1}) + \beta E_t U_{t+1}(X_{t+1})]/p_{1t} =$$

$$\frac{\partial U_t(X_t)}{\partial X_{0t}}[U_{t-1}(X_{t-1}) + \beta E_t U_{t+1}(X_{t+1})]/p_{0t}$$

and the common factor $[U_{t-1}(X_{t-1})+\beta E_t U_{t+1}(X_{t+1})]$ cancels out, leaving the MRS a function of current period variables alone.[3] The intertemporal Euler equation, though, will reflect this special type of dynamics. In this case,

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[3] We owe this point to John Broome who made it during a joint Bristol-Exeter seminar. Note that it is not any index of last period's consumption that will give rise to weak separability; it has to be the same index as the one that entered utility in the previous period. For example the functional form $U_1(X_{t-1})U_2(X_t)$ with $U_1(X) \neq U_2(X)$ does not imply intertemporally weakly separable preferences will not lead to this result.

the within period allocations are in fact invariant to monotonic transformations of $U_t(X_t)$ (but not, in general, of $U_t(X_t)U_{t-1}(X_{t-1})$)).

To summarise: In general the within period MRS will reflect the structure of dynamics which can be estimated without contamination from the presence of liquidity constraints. The exception is the form of weak intertemporal separability described above.

Given these arguments, we can obtain quite a sharp test for the empirical importance of imperfect capital markets, by comparing results from estimating preferences using within period allocations to those obtained using observed intertemporal allocations: If we identify dynamics when we use the within period allocations then we expect the structure of preferences estimated from the intertemporal Euler condition to be the same. Divergence of the results will imply that unobservables are distorting the intertemporal allocations. If on the other hand we find no evidence of dynamics when we estimate preferences using the within period allocations but dynamics are identified when estimating the Euler equation this will imply one of two possibilities: Either the absence of perfect capital markets have important implications of individual consumption behaviour leading to misspecification in the dynamics, or preferences have the very special weakly separable structure described above. Although the latter is an unlikely possibility the structure of the problem does offer ways of resolving this ambiguity: It is either possible to use the parameter estimates from the first stage to test whether the very special dynamic structure can explain the discrepancy of the results between the within period MRS and the intertemporal Euler condition or alternatively we can estimate the model on high wealth individuals as originally suggested by Hayashi (1985) and Zeldes(1989).

3. Empirical Specification

In the context of time separable preferences it is often preferable to specify an expenditure function or indirect utility function as the basis of the empirical model. In the non-time separable context with rational expectations no such dual approach has been developed and hence we specify the direct utility function.[4]

We assume that preferences for M goods can be described by a modified version of the direct translog utility function

$$U_t = \sum_{j=1}^{M}\left[c_j x_{jt} + a_j \ln x_{jt}\right] + \frac{1}{2}\sum_{j=1}^{M}\sum_{k=1}^{M} b_{jk} \ln x_{jt} \ln x_{kt} + \sum_{j=1}^{M}\gamma_j \ln x_{jt} \ln x_{jt-1} \quad [7]$$

In the above specification we have imposed the simplifying assumption that dynamics across goods are not important. Hence x_{it} only interacts with the lagged value of itself (x_{it-1}) and not with lagged values of other goods. This simplification is testable on our data. Additive separability for any two goods (j,k) is imposed if $b_{jk}=0$. Homothetic separability (Cobb-Douglas preferences) can be imposed in addition, by setting $b_{ii}=0$ for all goods. Finally intertemporal separability implies $\gamma_i=0 \ \forall \ i$. Allowing for such general preferences is quite novel in the literature on intertemporal allocation of consumption and adds important flexibility to the empirical analysis; most preference specifications used in the literature on intertemporal allocations impose homotheticity and within period separability.[5]

Given our chosen functional form, the marginal rate of substitution between any two goods i and j consumed in period t implies the relationship

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[4] Browning (1991) developed a dual approach to non-additive preferences over time, based on the profit function. Under uncertainty his approach requires point expectations for prices which we are not willing to entertain here.

[5] Exceptions are Browning, Deaton and Irish (1985) and Blundell, Browning and Meghir (1993).

$$\frac{1}{\bar{p}_{tj}}\left\{c_{jt}+\frac{a_{jt}}{x_{jt}}+\sum_k b^{*}_{jk}\frac{\ln x_{kt}}{x_{jt}}+\gamma_j\frac{\ln x_{jt-1}}{x_{jt}}+\frac{\gamma_j}{1+\delta}E_t\left[\frac{\ln x_{jt+1}}{x_{jt}}\right]\right\}-$$

$$\frac{1}{\bar{p}_{tl}}\left\{c_{lt}+\frac{a_{lt}}{x_{lt}}+\sum_k b^{*}_{lk}\frac{\ln x_{kt}}{x_{lt}}+\gamma_l\frac{\ln x_{lt-1}}{x_{lt}}+\frac{\gamma_l}{1+\delta}E_t\left[\frac{\ln x_{lt+1}}{x_{lt}}\right]\right\}=0 \quad [8]$$

Similarly, the Euler equation which reflects the first order condition for the allocation of expenditure of good for good j over two periods (t,t+1) implies the relationship

$$\left\{c_{jt}+\frac{a_{jt}}{x_{jt}}+\sum_k b^{*}_{jk}\frac{\ln x_{kt}}{x_{jt}}+\gamma_j\frac{\ln x_{jt-1}}{x_{jt}}+\frac{\gamma_j}{1+\delta}E_t\left[\frac{\ln x_{jt+1}}{x_{jt}}\right]\right\}-$$

$$E_t\left\{\frac{p_{tj}}{p_{t+1j}}\frac{(1+r_t)}{1+\delta}\left[c_{jt+1}+\frac{a_{jt+1}}{x_{jt+1}}+\sum_k b^{*}_{jk}\frac{\ln x_{kt+1}}{x_{jt+1}}+\right.\right.$$

$$\left.\left.+\gamma_j\frac{\ln x_{jt}}{x_{jt+1}}+\frac{\gamma_j}{1+\delta}\frac{\ln x_{jt+2}}{x_{jt+1}}\right]\right\}=0 \quad [9]$$

and involves expenditure data from four consecutive periods.

An appealing feature of equation [9] is that it is linear in known transformations of the variables, making estimation relatively easy. More importantly, this linearity has been achieved without imposing a constant conditional variance - something which is usually imposed when using the popular isoelastic utility function, but may lead to incorrect inferences on the presence of liquidity constraints, as argued by Carroll (1991). The superiority of our approach is of course conditional on the utility function we use being a reasonable representation of household preferences.

3.1 Conditioning goods and characteristics

The three goods we model explicitly (food in the home, transport and services[6]) were chosen because of their non-durable nature and because they are unlikely to be usable as collateral or generally as a means of alleviating liquidity constraints. Nevertheless they may be non-separable from other goods that do not share these properties. This implies that the MRS functions will depend on the available quantities of such goods. These may be market commodities more or less durable or non-market such as the number and ages of children. In the former category we include home ownership, labour force participation dummies, food out of the home, clothing and fuel. This conditioning allows for the possibility that the goods we model are not separable from those in the above list. It is important to account for such non-separabilities since omitting these goods could lead to spurious dynamics.

Of particular interest in the list we presented are the labour force participation dummies. Other authors, such as Bean (1986), Blundell, Browning and Meghir (1993), and Attanasio and Weber (1993), have found that labour market variables are significant in Euler equations over time. Clearly this may well be due to non-separabilities of the type described here. On the other hand, since anticipated labour market transitions are likely to account for a large part of anticipated changes in household income, it is hard to distinguish genuine non-separability of preferences from excess sensitivity when one looks at the Euler equation. The MRS does not suffer from this problem - if labour force variables are found to be important in the MRS, then we can conclude (subject to standard misspecification comments) that this is due to preference non-separability and not due to excess sensitivity.

To fix ideas note that our analysis will concern married couples only. We specify

$$a_{jt} = a_{j0} + \Sigma_k a_{jk} z_{jt}$$

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[6] The precise composition of these goods is given later but we note that none of these goods include any durable component.

where z_{jt} include household composition variables, the labour market status of both spouses, quantities of food consumed out of the home (foodout henceforth), fuel, and clothing (from which the goods we model may be non-separable) as well as race, housing tenure variables, region and urbanisation and seasonal dummies. We also allow the b_{11} parameters to depend on the employment status of the wife.

At this point it is worth noting that if preferences are not separable over time [5] is *not* invariant to monotonic transformations of the 'within period' utility index $U_t(X_t, X_{t-1})$ and the MRS functions identify all we need to know about preferences both over time and within the period. In other words we do not need the Euler equation to identify the intertemporal elasticities of substitution. This is of course no longer true when preferences are additive (or even weakly separable) over time.

The other side of the same argument is that in the absence of dynamics the parameter estimates obtained using the Euler equation can not be compared to those obtained using the marginal rate of substitution function unless the monotonic transformation determining intertemporal allocations is explicitly specified; otherwise the Euler equation parameters will adjust to provide estimates of intertemporal elasticities in which case within period effects will not be recoverable. Nevertheless, whatever conditioning characteristics are important determinants for within period allocations should also enter the determination of intertemporal decisions.

3.2 Stochastic Specification

In the empirical implementation of [7] and [8] there are two sources of stochastic specification. First, the innovations generated by substituting the expectations of choices dated t+1 and t+2 by their realisations. These errors (u_{jt+1}) are, by the assumption of rational expectations, orthogonal to variables known in period t. Second we allow for preferences shocks by assuming that the c_{jt} vary across individuals and time. Given the nature of our data we assume that these distributed independently across time and across individuals. The MRS representation allows us to test this assumption. Finally we assume that all relevant macroeconomic shocks are reflected in prices and interest rates - the error terms are uncorrelated across individuals.[7]

Thus the error term in the MRS equation takes the form form $(c_{it}+\gamma_i u_{it+1})/p_{it} - (c_{jt} + \gamma_j u_{jt+1})/p_{jt}$ and is orthogonal to variables dated t-1 or earlier. This error term is serially uncorrelated if the c_{jt} are serially uncorrelated. The Euler equation error term has the MA(1) structure $c_{jt+1}(1+r_t)p_{jt}/[(1+\delta)p_{jt+1}] - c_{jt} + u^{*}_{jt+1}$. This error term is again orthogonal to variables dated t-1. Thus the empirical model allows both for expectational errors and for some simple form of unobserved heterogeneity in tastes.

The important property of our stochastic specification is that it makes both the Euler equation and the MRS empirically tractable and compatible: This requirement imposes quite a lot of prior structure to the stochastic specification we can choose.

In the absence of dynamics in preferences the only source of stochastic variation in the marginal rate of substitution functions are random preferences. This reflects the well known fact that demand systems which condition on current total consumption or some other current and observable decision are compatible with intertemporal optimisation even under uncertainty.

4. Identification

The identification of preferences in the context described earlier is particularly important. Most studies assume some form of separability across

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7 Given the model is fundamentally identified by price and interest rate variability this assumption is essentially an identifying assumption. To allow for macroeconomic trends we include a trend term in each equation.

goods and across time when analysing intertemporal allocations which provides very strong over identifying restrictions. In the absence of separability what distinguishes, in a fundamental sense, one marginal rate of substitution from another are exclusion restrictions on the price vector. Thus in the MRS for food and transport only the relative price of food to transport is relevant. Similarly, in the food Euler equation for instance, only the relative price of food in two adjacent periods as well as the nominal interest rate enter. This implies that relative price variation is of fundamental importance to identification (as in all analyses that involve many goods). In practice though the functional form restrictions, implied by the specification of our utility function also provides identification.

In a general, non-separable context, identification of Euler equations is a non-trivial matter. Consider our specification which already contains some restrictions in terms of the structure of the utility function which limits the history dependence to one period. The implied Euler equation for the jth good takes the good specific form

$$E_t\left(f_j(X_{t-1}, X_t, X_{t+1}, X_{t+2}, r^*_{tj}) \right) = 0 \qquad [10]$$

where X is an nx1 vector of goods and r^*_{tj} is the real interest rate on any asset held by the consumer at period t (deflated by j-th good price appreciation). Variables dated t belong to the information set but because of random preferences shocks all choices made in period t (such as X_t) are *not* valid instruments. Given our assumption that preference shocks are independent over time this leaves the following valid instruments: prices dated t and t-1, the nominal interest rate, quantities dated t-1 and assets dated t-1. If only one asset exists, the equation is still underidentified. In practice we use restrictions on the dynamic structure which allows the lags in the utility function to interact only with the own good. This is sufficient to (over)identify the model. However, it is interesting to note that, if the dimension of the asset return space, K, is larger than the number of commodities, n, overidentification is achieved via exclusion of either k-1 asset returns or the relevant asset shares in household portfolios. In n-good world it is perhaps to be expected that the k-fund separation theorem should hold for k>n (if the n-goods have genuine time variation in prices, they must be produced by firms which are affected by different shocks).

Thus in principle the model is identifiable without restrictions on the dynamics, just by using portfolio allocations.

Identification of the within period marginal rate of substitution function between any two goods can be achieved more simply with the same instrument set, since this equation contains one lag less than the Euler equation. The MRS between goods i and j can be written as

$$E_t\left(g_{ij}(X_{t-1}, X_t, X_{t+1}, p_{ti}/p_{tj}) \right) = 0 \qquad [11]$$

Clearly, with the same stochastic specification, all instruments discussed above are valid, and overidentify the model. This, extra flexibility allows serial correlation tests to be carried out using our data.

Finally note that among the conditioning characteristics we include labour market status variables dated t which may be endogenous. Although the obvious instrument for labour market status would be the wage rate this is not useful for two reasons. Its person specific nature may make it endogenous. Moreover it is only observed for workers. Hence we have decided to use lagged labour market status as an instrument. The complete list of instruments is provided in the empirical section.

5. Estimation

The two models we estimate consist respectively of two equations (MRS) and three equations (Euler). Estimation of the model is performed using standard method of moments estimation, (see for example Hansen(1982)). In our case this consists of minimising a criterion function of the form $C = \Sigma_j \varepsilon_j' P_Q \varepsilon_j$ where $P_Q = Q(Q'Q)^{-1}Q$, Q being the matrix of instruments. The summation over j represents summation over the equations of each model model respectively. We assume that the instruments chosen are not correlated with ε_{jit}, i.e. $E(\varepsilon_{jit}|q_{it})=0$, where i stands for individual, t for time period and q is one of the instruments in Q. This orthogonality condition defines the estimator. Denote the number of individuals in the sample by N and the number of observations over time by T. We assume that $\text{plim}_{N\to\infty, T\to\infty} Q'Q/(NT) = M_{QQ}$ is positive definite and that $\text{plim}_{N\to\infty, T\to\infty}(Q'\partial\varepsilon_j/\partial\theta)/(NT) = M_{Qx}$ where M_{Qx} has rank equal to the dimension of the vector of parameters to be estimated θ. Apart from the standard stationarity assumptions implicit in the above we have also assumed that the model is identifiable without the cross equation restrictions. Consistency of the parameter estimates follows on directly from these assumptions.

The covariance matrix of the estimator can be estimated by $V=(\Delta^2C)^{-1}X'\Omega X(\Delta^2C)^{-1}$, where (Δ^2C) is the second derivative matrix of the criterion function, X is the matrix of first derivatives for all observations both evaluated at the estimated parameter point and Ω is a block diagonal matrix with $(\hat{\varepsilon}_{it}\hat{\varepsilon}_{it}')$, $\hat{\varepsilon}_{it}$ being the mx1 vector of residuals for the m equations of the model evaluated at the estimated parameter point. This covariance matrix allows for the dependence of the residuals across equations as well as for general heteroscedasticity, (see White,1980).

As we describe in the data section each individual is observed for four consecutive quarters although the overall data set spans a number of years. This implies that the MRS is estimated over two consecutive cross sections for each individual and the error term is assumed to be serially uncorrelated as detailed in the section on the stochastic specification. The Euler equation does have an error with an MA(1) structure but each individual appears only once in the Euler equation sample. Hence, despite the MA(1) error all observations used are again independent which explains why our covariance matrix does not allow for serial correlation.

For the Marginal Rate of Substitution representation the residual ε_{jit} is defined as (dropping the i subscript denoting individuals)

$$\varepsilon_{jt} = 1/e_{0t} - a_{j1}/e_{jt} - \sum_k a_{jk}(z_{kt}/e_{jt}) - \sum_h \{b_{jh1}(\ln x_{ht})/e_{jt} + b_{jh2}WW_t(\ln x_{ht})/e_{jt}\}$$

$$+ \sum_k a_{0k}(z_{kt}/e_{0t}) + \sum_h \{b_{0h1}(\ln x_{ht})/e_{0t} + b_{0h2}WW_t(\ln x_{ht})/e_{0t}\}$$

$$- \gamma_j(\ln x_{jt-1})/e_{jt} - \gamma_j(\ln x_{jt+1})/e_{jt} + \gamma_{01}(\ln x_{0t-1})/e_{0t} + \gamma_{02}(\ln x_{0t+1})/e_{0t} \quad [12]$$

for j=food and transport. The parameters of good "0" (services) appear in both equations and we have imposed the normalisation restriction that $a_{01}=1$. In [12] e_{jt} is the nominal expenditure on good j, x_{jt} the quantity index for good j and WW_t is a dummy indicating whether the wife is working. The variables represented by z_{kt} are the quantities of Food consumed out of the home (which can be zero), and the logs of the quantities of clothing and fuel purchased, the number of children in the age groups 0-1, 2-15 and 16+, the labour market status of the wife and the husband, monthly seasonal dummies, housing tenure dummies, a race dummy, a dummy indicating an urban area, dummies for the population size of the city and regional dummies.

To estimate this system we first apply the method of moments estimator to obtain parameter estimates with no cross equation restrictions. We then apply minimum distance to the unrestricted parameters to impose the cross equation restrictions. This recovers the parameters of the services equation and imposes symmetry which allows us to compute all standard Marshallian price elasticities as well as total expenditure elasticities. Both estimation steps are linear. For details of the minimum distance procedure used see Browning and Meghir (1991) and the references therein.[8]

Similarly the for the Euler equation we have

$$\varepsilon_{jt} = (1/e_{jt} - R_t/e_{jt+1}) + \sum_k a_{jk}(z_{jt}/e_{jt} - R_t z_{jt+1}/e_{jt+1}) +$$

$$\sum_k \{ b_{jk0}[(\ln x_{kt})/e_{jt} - R_t(\ln x_{kt+1})/e_{jt+1}] +$$

$$b_{jk0}[WW_t(\ln x_{kt})/e_{jt} - WW_{t+1}R_t(\ln x_{kt+1})/e_{jt+1}] \} +$$

$$\gamma_0[(\ln x_{jt-1})/e_{jt} - R_t(\ln x_{jt})/e_{jt+1}] +$$

$$\gamma_1[(\ln x_{jt+1})/e_{jt} - R_t(\ln x_{jt+2})/e_{jt+1}]$$

where, j=food, transport and services $R_t = (1+r_t)/(1+\delta)$, r_t being the nominal interest rate between periods t and t+1 and δ is the rate of time preference. Here the estimates are all obtained in one go - no cross equation restrictions are imposed.[9] Conditional on the discount rate the estimation problem is linear. We do not explicitly estimate the discount rate δ but we tried several different values. The results we present here use a discount factor of 1.25% per quarter. The equation contains the same conditioning characteristics as the MRS.

The instruments we use in estimation of the MRS and the Euler equation corresponding to period t are as follows: a) Dated t: The prices of all goods (6 of them) and the nominal interest rate, dummies for education, region, urbanisation, city size, housing tenure, race, the number and ages of children and the age of the husband. Dated t-1: prices and interest rates, the employment status of husband and wife, pre-tax family income reported in the

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[8] Arellano and Meghir (1992) show that the minimum distance procedure we use is at least as efficient as imposing all the restrictions in one step. This is of course subject to identification of the unconstrained first step.

[9] To impose cross equation restrictions we should change the normalisation so that all equations using the same scaling factor as in the case of the MRS. This is not necessary for our case.

first interview, the quantities of food, transport, services, foodout of the home, clothing and fuel. Most[10] of the above are also included after being divided with nominal expenditure on food, transport and services (all dated t-1) to mimic as closely as possible the functions in the equations we estimate. Finally we include monthly dummies and a quadratic trend. Thus the model is identified in practice by excluding some lags in quantities and expenditures and lagged employment status as well as by the exclusion of the relevant price variables and income as explained in the identification section above.

6. The data

In our application we use eight years (1980-87) of the US Consumer Expenditure Survey (CEX). The CEX is a rotating panel based on a comprehensive survey run by the Bureau of Labor Statistics, which involves interviewing about 4,500 households every quarter: 80% of these are then reinterviewed the following quarter, while the remaining 20% are replaced by a new randomly drawn group. In principle each household should be interviewed five consecutive quarters. However, the first interview is only used to make contact and any information on it is withheld by the Bureau. In the remaining four interviews a number of questions are asked concerning household characteristics (demographics, work status, education, race, etc.) and detailed expenditures over the three months previous to the interview. This data set, which is further described in Attanasio, Koujianou and Weber, (1989) has recently been used by a number of researchers, but to our knowledge no one has yet exploited its rotating panel features.

In order to estimate the model described in section 1, we need household level information from all four available quarters, and thus select out those

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[10] We only include lag prices in the levels not in the interactions as well.

households who are not observed for all four interviews. We also want to capture the effects of male and female labour market status on goods consumption, and therefore concentrate on married couples (with either no children or own children only). We further select out all those households who live in student housing, whose head is either very young (less than 25) or nearing retirement (55 or over), and whose reported expenditure on the broad commodities we model is zero or negative over any one interview quarter.[11] After all these selections have been carried out, we are left with 4118 households, spread over 75 months of the sample period (because of the sampling design no household could be at their fifth interview in the early part of 1980 or in the second and third quarter of 1986). The within period MRS condition is estimated using two observations on each household. The Euler equation uses only one observation per household.

The commodity groupings we consider are: food consumed at home, transport (defined as the sum of motor fuel and public transport) and services, which we explicitly model, food away from home, clothing and heating fuel, which we treat as given.[12] We capture male and female non-market time through participation dummies, and acknowledge the effect of demographic and socio-economic characteristics by introducing indicator variables for the presence of children by sex and age, the presence of other adults in the households, age, race and education of the head. We also have regional and seasonal indicators (eleven monthly dummies, corresponding to the time of the interviews, and a trend), and use published regional prices which mostly exhibit monthly variability.

For the estimation of the Euler equation, we use the municipal bond

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[11] Given the nature of these commodities (food at home, transport and services) it is hard to imagine that zeros imply corner solutions over a whole quarter. Our belief is that these zeros just represent coding errors.

[12] This implies nothing about the way these commodities are chosen by the household; in a sense ours is just part of a larger simultaneous equations model.

interest rate, which is tax exempt, as suggested by Attanasio and Weber (1992). This combines the benefit of providing an after tax return (for the marginal investor) and being riskless (in nominal terms).

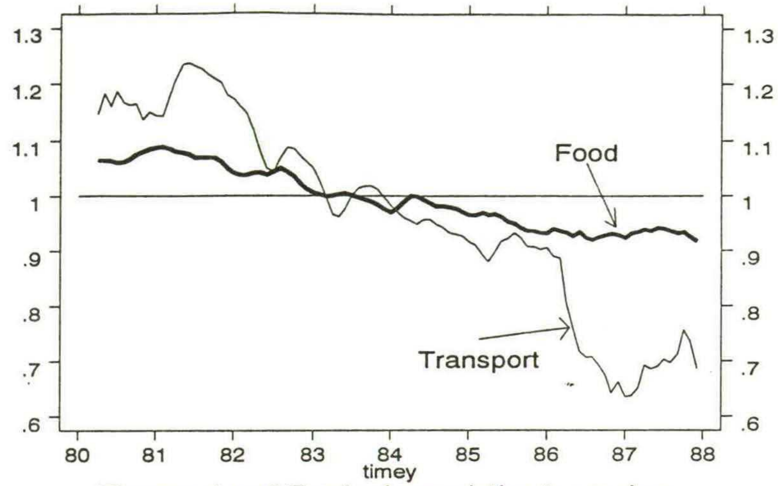
6.1 A Descriptive analysis of the data

To give a feel for the data we present below some simple nonparametric regressions and other descriptive material relevant to our empirical study.

Figure 1a shows the evolution of food and transport prices relative to services. The intertemporal variability of relative prices is very important since identification relies on such relative price variation. As can be seen the two relative prices move differently and both vary over time. The variability in transport prices is much larger reflecting the large variations in international crude oil prices in this period. In addition to intertemporal variability there is also some regional one. In figure 1b we also plot the regional standard deviation in these prices over time. This extra dimension may aid identification. Overall the correlation between the two relative prices is 0.91 which is quite high but the series are still distinguishable.

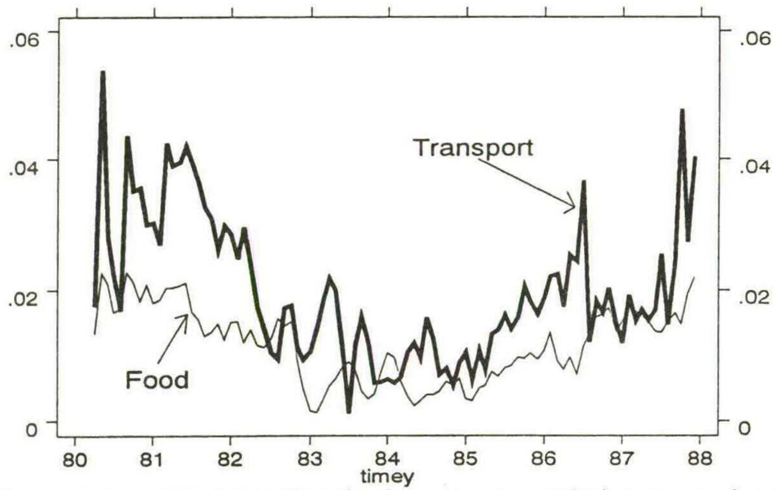
In figure 2 we plot the nominal interest rate as well as the interest rate minus the rate of change of the price for the three commodities we consider. Clearly the variability of the rate relative to the transport price dwarfs the other two. Nevertheless the three intertemporal prices show a lot of independent variation: The correlation coefficients are: Food and Services 0.41, Transport and Services 0.18, Transport and Food 0.06. Thus it seems that the price variability relevant for the identification of the Euler equation is greater than the one relevant for the MRS.

An important issue when using expenditure panels is whether the repeated nature of the observations has itself an impact on behaviour. We can not test this hypothesis directly but we have considered the following evidence: We estimated the total expenditure density function and the density function for



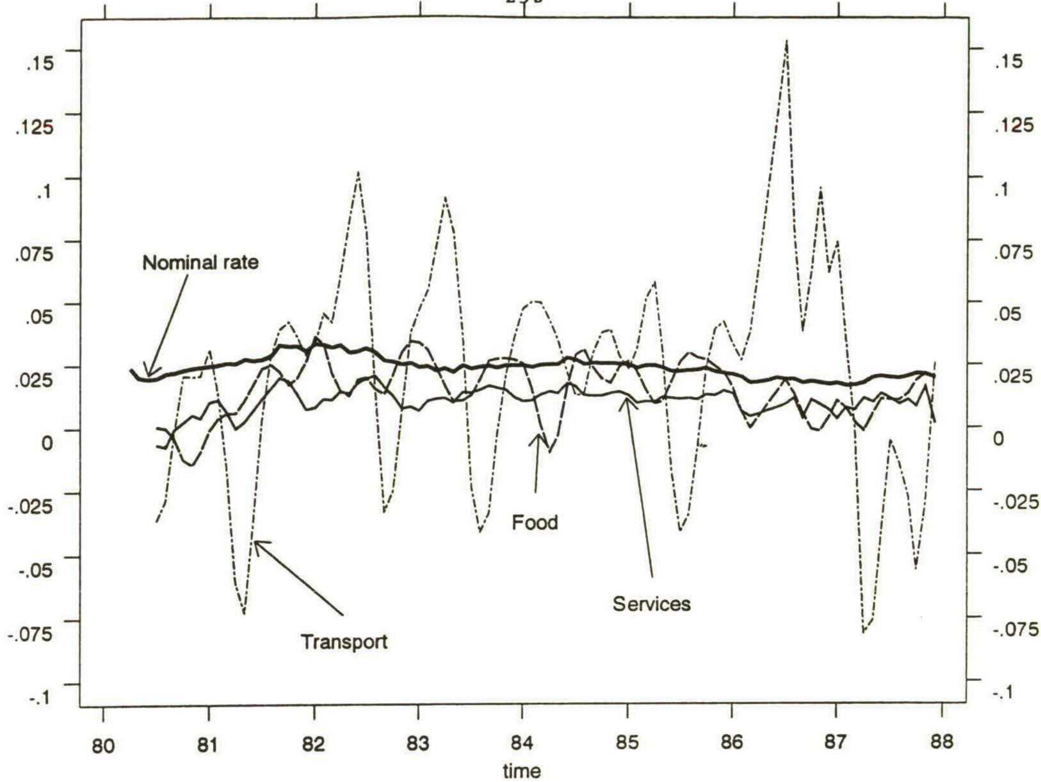
Transport and Food prices relative to services

FIGURE 1A



Transport and Food regional price S. Deviation relative to services

FIGURE 1b



Interest rates realtive to individual good price changes

FIGURE 2

the expenditure on each individual commodity separately for each interview,

Table 1

Vector Autoregressions

	Food	Transport	Services
Food t-1	0.3629 (0.0158)	0.0096 (0.0229)	0.0321 (0.0293)
Food t-2	0.2217 (0.0155)	0.0413 (0.0224)	0.0591 (0.0287)
Food t-3	0.1946 (0.0143)	0.0588 (0.0207)	-0.0090 (0.0266)
Transport t-1	0.0034 (0.0104)	0.2456 (0.0151)	0.0028 (0.0193)
Transport t-2	0.0049 (0.0105)	0.2257 (0.0153)	0.0076 (0.0195)
Transport t-3	0.0189 (0.0106)	0.2079 (0.0153)	-0.0109 (0.0196)
Services t-1	-0.0068 (0.0081)	-0.0087 (0.0117)	0.3734 (0.0150)
Services t-2	0.0065 (0.0084)	0.0362 (0.0121)	0.2232 (0.0155)
Services t-3	0.0178 (0.0079)	0.0021 (0.0114)	0.2093 (0.0146)

Monthly dummies included
All variables in logs

using non-parametric methods (implemented by Duncan and Jones, 1993).[13] Since all interviews are distributed uniformly throughout the year the distribution obtained from any one interview should not differ from that obtained using another. Figure 3a provides the four densities for log total expenditure by interview superimposed and figure 3b the same for log expenditure on our subset of goods, i.e. food, transport and services (as an example since all

[13] We used a Gaussian Kernel with a very small bandwidth: We set the bandwidth so that it is 10% of the standard deviation of the Gaussian Kernel. This leads to very low levels of smoothing.

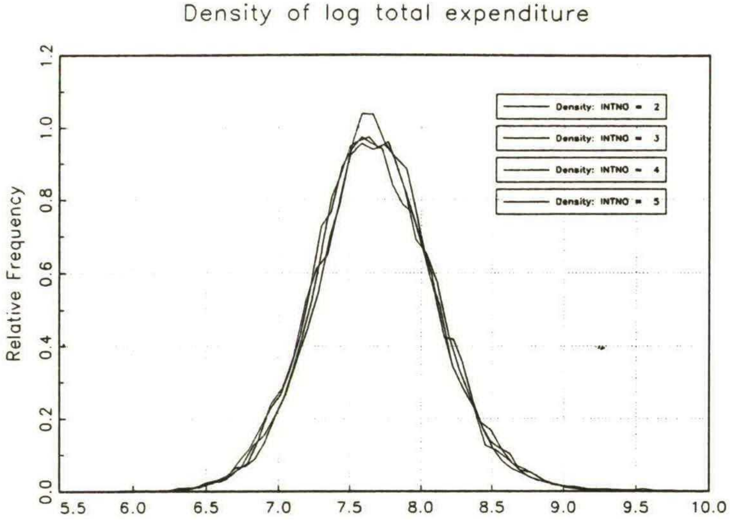


FIGURE 3A

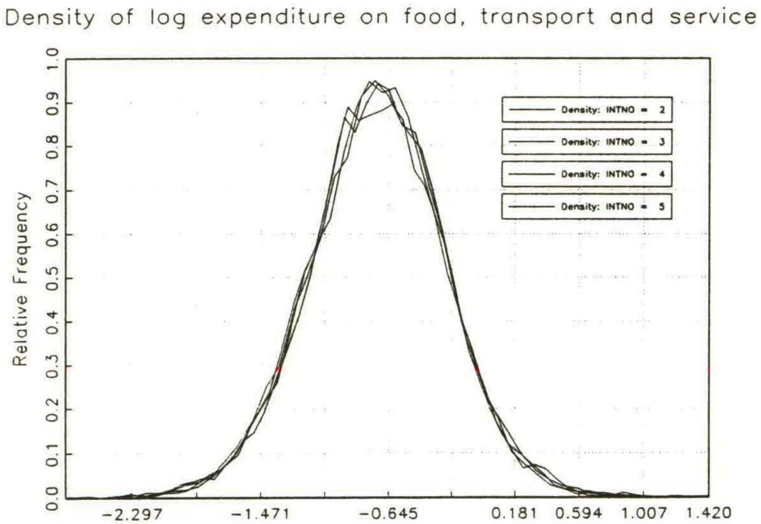


FIGURE 3b

goods were telling the same story). It is evident from these graphs that the distributions do not differ by interview. This indicates that there is no systematic shift in behaviour as individuals are re-contacted.

To provide some further evidence on the quality of the data, in Table 1 we also present a simple VAR of order 3 for the three goods we model estimated using OLS. This shows that indeed the correlations between levels of consumption in the four interviews is very strong. Some of the cross relationships are also quite significant.

We now turn to a simple descriptive analysis of the consumption and demand behaviour of our households. In figure 4 we present a set of graphs showing non-parametric regressions of the expenditure share of the three commodities we model on the log of the total real expenditure of these three goods.[14] To interpret the results note that the upper decile for the total expenditure variable is -0.16 and the lowest decile is -1.22. The respective quintiles are 0 and -1.44: 90% of the sample have a value below -0.16. Thus these Engel curves are essentially flat for the bulk of the sample, implying homotheticity. The food budget share does starts to fall with total expenditure for the upper decile of the expenditure distribution and this is matched by a rise in the services budget share in that region. Simple linear regressions reveal elasticities all very close to one. In this descriptive framework this subset of goods seems to be quite close to homotheticity. This could of course be due to us ignoring all other characteristics and the endogeneity of total expenditure which are controlled for in the structural analysis. Nevertheless this result will be confirmed by our regression results. What we do take into account here is annual price variability. The Engel curves are estimated year by year and we display the ones for 1981, 1984

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[14] We decided to show these Engel curves rather than the ones relating to total expenditure since this preserves the closest analogy to what is estimated in the structural model.

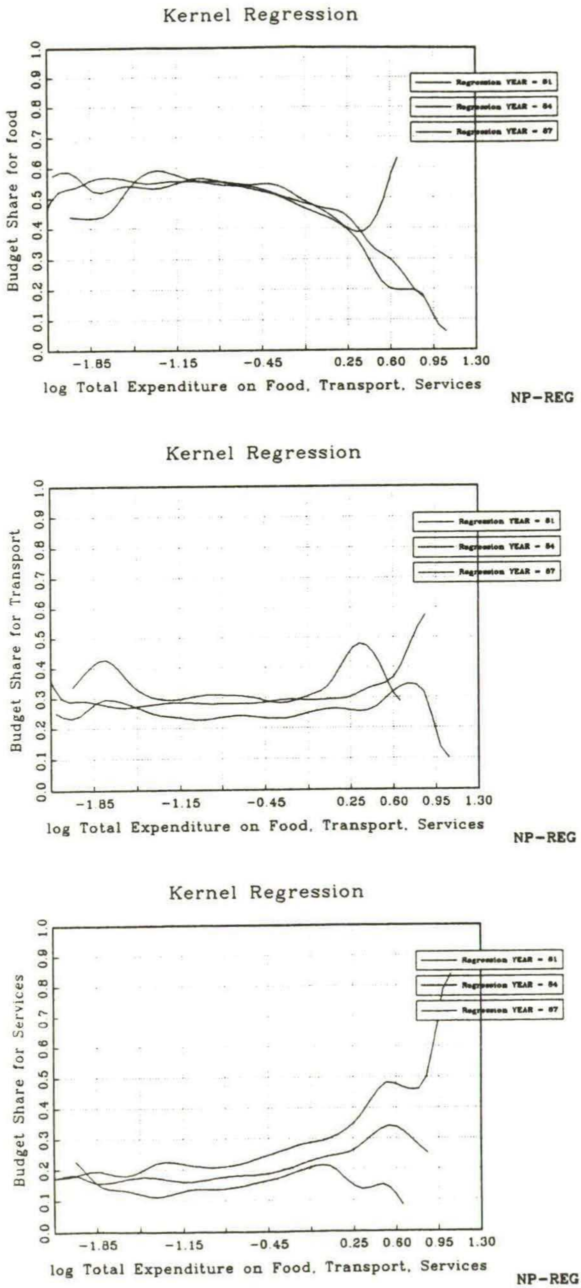
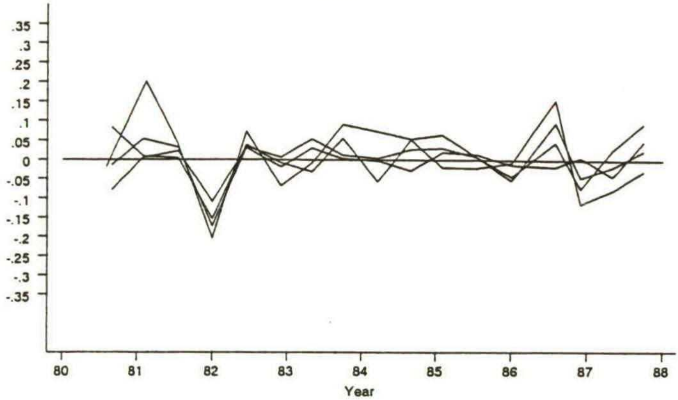

Kernel Regression
Budget Share for food
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Regression YEAR = 81
Regression YEAR = 84
Regression YEAR = 87
-1.85 -1.15 -0.45 0.25 0.60 0.95 1.30
log Total Expenditure on Food, Transport, Services
NP-REG
Kernel Regression
Budget Share for Transport
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Regression YEAR = 81
Regression YEAR = 84
Regression YEAR = 87
-1.85 -1.15 -0.45 0.25 0.60 0.95 1.30
log Total Expenditure on Food, Transport, Services
NP-REG
Kernel Regression
Budget Share for Services
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Regression YEAR = 81
Regression YEAR = 84
Regression YEAR = 87
-1.85 -1.15 -0.45 0.25 0.60 0.95 1.30
log Total Expenditure on Food, Transport, Services
NP-REG

FIGURE 4

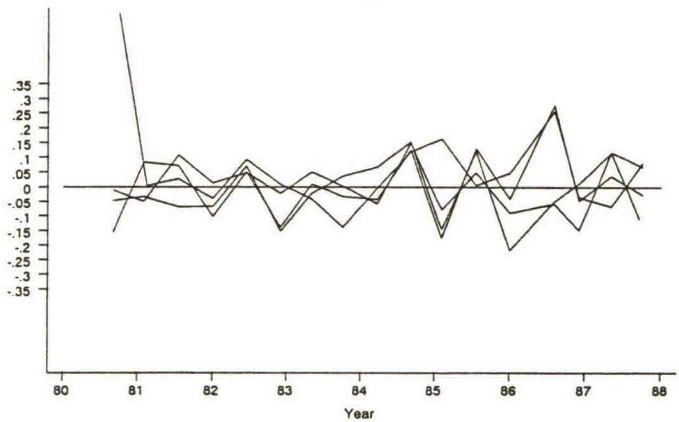
Food



Growth Rate for Food Consumption by Cohort

FIGURE 5a

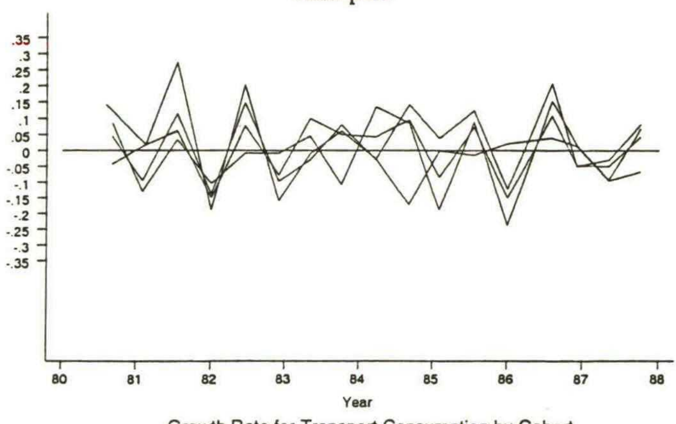
Services



Growth Rate for Services Consumption by Cohort

FIGURE 5b

Transport



Growth Rate for Transport Consumption by Cohort

FIGURE 5c

and 1987;[15] These curves do shift from year to year probably reflecting changes in relative prices.

Finally in figure 5a-5c we plot the quarterly growth rate for real expenditure for each of our commodities over time. We break down this information by date of birth cohort. Interestingly the growth rate for transport is much noisier which is in line with the high variability in the transport price over time (to the extent that this is predictable). There are striking cross cohort differences in behaviour obvious from these graphs but there seem to be strong seasonal effects.

7. Results.

We now turn to the results of structural estimation of the MRS and Euler equations. The estimated models are presented in Appendix A, Tables A1 and A2 together with the relevant tests for the overidentifying restrictions. These mostly reject at conventional significance levels, which is quite common when using large samples; we have carried out a number of experiments to assess the sensitivity of our results. First in the context of the MRS we took our instruments back one period. This had no significant impact on the parameter estimates. Second we reduced the number of instruments by removing the lagged labour market status and lagged earnings from the instrument set. This reduced precision, improved the tests of overidentifying restrictions but made no substantive difference to the results we will now discuss. We give a more focused discussion of our specification tests below.

7.1 The Structure of Dynamics and Liquidity Constraints.

We first focus on the estimated dynamic structure with the two alternative representations of the first order conditions. In Table 2 we

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[15] To recognise them on the graph note that the range of consumption increases with the years.

Table 2

The Dynamic Structure

		MRS	EULER
Food	$\ln(\text{Food})_{t-1}$	-0.0492 (0.0187)	0.0294 (0.0233)
	$\ln(\text{Food})_{t+1}$	0.0306 (0.0452)	-0.0223 (0.0660)
Transport	$\ln(\text{Transport})_{t-1}$	-0.0109 (0.0060)	0.0062 (0.0074)
	$\ln(\text{Transport})_{t+1}$	0.0202 (0.0108)	-0.0035 (0.0436)
Services	$\ln(\text{Services})_{t-1}$	-0.0000 (0.0018)	-0.0039 (0.0030)
	$\ln(\text{Services})_{t+1}$	-0.0059 (0.0038)	-0.0080 (0.0049)
Test of Joint Significance 6 degrees of freedom		14.41(2.54%)	7.15 (30.7 %)

present the relevant parameters for comparison. Under the null hypothesis that preferences are intertemporally separable the parameters of the MRS and the Euler equation are not comparable; the latter reflect also the monotonic transformation determining intertemporal allocations. Under the alternative, and in the absence of liquidity constraints, both sets of equations identify exactly the same parameters if we choose comparable normalisation restrictions. Thus we have rescaled the Euler equation parameters in Table 2 using the estimated intercepts from the MRS. Note that we expect the Euler equation parameters to be less precisely estimated since we loose one time series observation per individual. In our case this is half the sample.

Both sets of parameters are very close to zero and all but one of the food equation lags of the MRS are not significant individually. The joint test of significance of the dynamics in the MRS equation is 14.41 with six degrees of freedom while for the Euler equation the same test is 7.15. The respective p-values are 2.54% and 30.7%. The results imply that preferences, conditional on demographics and labour market variables, are intertemporally separable. The interesting result is that when we consider the Euler equation the conclusion is confirmed; despite the reduction in the sample size the loss of precision is in fact quite small in most cases and overall the absolute value of the parameters actually falls in most cases. What is certainly true is that again we accept the null hypothesis of intertemporal separability; in this fundamental respect the implications about preferences are the same, whether we look at the MRS results or the Euler equation results.

Nevertheless, given the marginally significant $\ln(\text{Food})_{t-1}$ term it is worth entertaining an alternative interpretation: Consumer preferences are non-separable but the behavioural implications of such non-separability are counteracted by imperfections in the financial markets. As a result the Euler equations do not imply dynamics despite some weak evidence of non-separabilities in the MRS. For this interpretation to carry through we should find some dynamics in the Euler equation when we select out the low wealth households and in any case the we should find significant differences in the parameters. We carried out such a selection based on information in interview one which is predetermined. The parameters for the "high wealth" subsample were not significantly different and neither did the results on the dynamics change with this experiment.

The fact that we find the Euler equation results compatible with the ones from the MRS is *prima facie* evidence of no liquidity constraints. Yet it is quite possible that serial correlation in the preference shocks is biasing both sets of results in the same direction. Given the large Sargan tests of overidentifying restrictions this could be a serious worry. To check this out we computed a serial correlation test for the residuals of the MRS equation. This tests the null hypothesis that the residuals from two consecutive observations on one individual are not correlated. For the Food/Services MRS this N(0,1) test statistic was 0.72 while for the Transport/Services one the test statistic was 1.66. Neither are significant. Moreover the serial correlation coefficient of the estimated residuals was 0.0106 and 0.0160 respectively.

We carried out an additional experiment with the MRS for further corroboration. We re-estimate the MRS equation taking the instruments back one period. If serial correlation was canceling out the dynamics we should find the lead and lag terms to significant now. The test statistic for the absence of dynamics is 14.57 (6 degrees of freedom p-value 2.4%) again showing now strong evidence of non-separability.

To add to the above evidence using more traditional tests we used a Wald test for the significance of log income in the Euler equations. This overidentifying restrictions test can be interpreted with some caution as an excess sensitivity test: In the CEX income is sampled only during the first and last interview and not in the intervening period. Thus for income in period t we use the first interview income while for t+1 we use the value reported in the last interview. In the Food equation income had a t-value of 0.43, in transport 2.2 and services the t-value was 1.87. The joint three degree of freedom χ^2 test of significance of income in the system was 9.018 which has a p-value of 2.98%.

To summarise: The dynamic structure of preferences implied by the Euler equation is the same as the one implied by the MRS representation, the latter being robust to the absence of perfect capital markets. In addition the Euler equation does not exhibit significant excess sensitivity. From the above we conclude that preferences are separable over time and that there is no significant evidence of liquidity constraints on this data.

We now turn to the remaining implications of our model that allow us to further strengthen our conclusions.

7.2 The Effect of Labour market Variables.

It has always been an issue of whether the noted importance of labour market type variables in Euler equations just reflects labour market imperfections or really a dependence of preferences on work choices. It is reasonable to believe that anticipated changes in labour market status explain most of the anticipated changes in income and hence excess sensitivity tests will have low power in the presence of labour market variables. This issue is in general hard to resolve but our approach offers further insights: We know that if labour market status variables are significant in the MRS representation then this can be interpreted as preference effects, since the MRS can be consistently estimated even in the presence of liquidity constraints. We also know that whatever variable is significant in the MRS should also affect the intertemporal allocations (although the reverse is not true). In Table 3 we present significance tests for the coefficients of the MRS and Euler equations that relate to labour market status.[16]

Table 3

The Significance of Labour Market variables

	MRS	**EULER**
Male Labour Market Status	20.1 (3) 0.016%	13.5 (3) 0.37%
Female Labour Market Status	195.0 (9) 0%	126.42 (12) 0%

χ^2 test followed by Degrees of fredom in parentheses, followed by p-value

The test for female labour supply has more degrees of freedom since female

[16] Since dynamics are not important the actual levels of the coefficients are not comparable as they are implicitly scaled differently.

labour market status interacts with other terms in the equations. From these results it is evident that labour market variables are highly significant both in the MRS and in the Euler equation. There is no evidence that they play a weaker role in the MRS than in the intertemporal equations. Interestingly when we remove the labour market status variables we find that dynamics become very important. The six degree of freedom test for the joint significance of the lags and leads in the MRS function becomes 28.21 which has a p-value of 0.0086%. Thus assuming preferences to be separable from labour market variables can lead to the the impression that preferences are non-separable over time. This result is quite important in that it corroborates earlier results that consider the effects of omitting labour market status on the validity of the life-cycle model. The important difference here is that we use at the same time the robust MRS results as a benchmark.

Quantitatively the effects of labour market status can also be quite large. Although the functional form we choose is both very flexible and very convenient it does not lend itself to immediate interpretation of the results. In order to quantify the effects of labour market variables (and other conditioning characteristics) we use the implicit function theorem to compute the effect of a change in the labour market status on the individual expenditure - given total expenditure; this is a derivative of a Marshallian demand function with respect to a taste shifting characteristic. We found that households with a non-working husband consume approximately 9% less services. All the reduction is transferred to food with no significant effect on transport. The sign of the effect is the same across the whole sample.

The effect of a working wife is much more varied (due to the significant interactions). For food it varies between -9% and 5%, for transport between -3% and 10% and -8% to 5% for services.[17]

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[17] These limits are the bottom and top quintiles of the distribution.

7.3 Within period separability between goods.

In setting up the empirical model we argued that it may be important to control for separability across commodities; ignoring non-separable goods may have been an important factor in generating excess sensitivity in earlier studies based on the PSID. As in the case of the labour market variables we can again use the MRS functions as a control for preferences; if we find that goods are not separable in the MRS then we must control for their presence in the Euler equation. Within our context we can test whether additive separability is a valid assumption for the group of goods we model and whether this group is separable from the remaining commodities we condition on. In Table 4 we present the relevant Wald tests for these hypotheses. It is quite clear that all separability assumptions are heavily rejected both in the context of the Euler equation and in the context of the MRS. This, together with the role of the labour market variables may account for the rejections of the life-cycle model based on the analysis of only one commodity.

Table 4

Tests for Separability

Additive Separability of Food, Transport and Services	
MRS: 6 dfs 51.52 p-value 0%	**Euler**: 12 dfs 47.59 p-value 0%
Separability of Food, Transport and Services from Foodout, Clothing and Fuel (9 degrees of freedom)	
MRS: 76.8 p-value 0%	**Euler**: 34.6 p-value 0%

7.4 Within period and Intertemporal elasticities.

Using the results of the estimated models we have computed both conventional within period elasticities - conditional on total expenditure in the group (i.e. food, transport and services) as well as intertemporal substitution elasticities. All elasticities are also conditional on labour market behaviour and on the quantities consumed of the other goods which we do not model explicitly.

The within period price elasticities are defined as $[\partial \log x_i / \partial \log p_i]|_y$ where y is total expenditure. We also compute $[\partial \log x_i / \partial \log y]$. From the first order conditions it is easy see that the marginal utility of wealth can be expressed as $\lambda_t = (\Sigma_i x_{it} MU_{it})/y_t$ where MU_{it} is the marginal utility of good i and y_t is the total expenditure in period t. Using this expression for λ we can derive elasticities conditional on y_t by writing the first order conditions as $MU_{it} = p_{it}(\Sigma_j x_{jt} MU_{jt})/y_t$ and then applying the implicit function theorem. The resulting total expenditure elasticities and price elasticities, conditional on y_t are presented in Table 5.[18]

Table 5

	Total Expenditure Elasticities			**Marshallian Price Elasticities**		
	Food	**Transport**	**Services**	**Food**	**Transport**	**Services**
Q10	0.96	0.87	0.88	-1.14	-1.14	-1.16
Q50	1.02	0.99	0.96	-1.03	-1.03	-1.00
Q90	1.15	1.15	1.38	-0.99	-0.97	-1.00

Qi is the ith percentile

The results conform with the picture we presented in the data description where the Engel curves were completely flat for most of the sample. Perhaps they are not surprising since we are modeling only a very narrow part of expenditure. They do serve though to show that the parameter estimates are quite consistent with basic economic theory. In fact the estimated utility function is concave almost everywhere in the sample.

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[18] These are Marshallian elasticities conditional on the quantities consumed of Food out of the home, Clothing and Fuel, on labour market status as well as on the leads and lags. In fact ignoring the latter from the computations makes no difference to the results, given our estimates.

In Table 6 we present the intertemporal elasticities as implied by the Euler equations. These can be easily computed by deriving the standard Frisch demand functions implied by our results. These are implicitly defined by [5]. The intertemporal elasticities, defined as $[\partial \ln x_{it}/\partial \ln p_{it}]|_{\lambda_t}$ are then computed applying again the implicit function theorem. The resulting elasticities exhibit much more variation and in general are all above 1 (in absolute value). Interestingly, they vary quite a lot with labour market status. As one would expect, given the travel costs to work, the transport elasticity is very sensitive to female labour market status.

Table 6

Intertemporal Elasticities of Substitution by Labour market status.

Food	**(0,0)**	**(0,1)**	**(1,0)**	**(1,1)**
Q25	-1.72	-1.32	-2.22	-1.84
Q50	-1.51	-1.22	-1.99	-1.34
Q75	-1.40	-1.17	-1.55	-0.41
Transport				
Q25	-1.67	-1.00	-2.18	-1.11
Q50	-1.87	-0.92	-1.58	-0.95
Q75	0.50	-0.81	-1.29	-0.86
Services				
Q25	-1.68	-2.00	-1.72	-1.97
Q50	-1.51	-1.51	-1.49	-1.51
Q75	-1.32	-1.31	-1.36	-1.27
Cell size	22	125	898	3073

Qi: The ith Percentile.

(dm, df) = Employment status of husband and wife respectively)
dm = 1 Husband employed, df = 1 wife employed.

8. Summary and Conclusions

In this paper we argue that the within period Marginal Rate of Substitution function can be used as a control when evaluating results obtained using the intertemporal Euler equation. We base our argument on the fact that in most cases the dynamics in preferences will be reflected in the within period allocations. By choosing to model non-durable goods that can not serve as collateral or as a signal of credit worthiness we can identify the dynamic structure of preferences whether or not there are imperfect credit markets, by estimating the within-period Marginal Rate of Substitution condition.

We use the US Consumer Expenditure Survey (CEX) to model the intertemporal and within period allocation of expenditure on Food in the home, Transport and Services. We reach the following conclusions:

a) Preferences are intertemporally separable. The results obtained are the same whether we use the MRS representation or the intertemporal Euler condition. We interpret the compatibility of the results as evidence of no liquidity constraints. We add to this evidence using an excess sensitivity test whose result is consistent with the hypothesis of no liquidity constraints.

b) Goods are not separable from labour market status. This is true in the MRS function as well as in the Euler equation and hence can be given a preference interpretation. Omitting labour market variables leads to the false impression of intertemporally non-separable preferences.

c) The goods we model are not weakly separable either from each other or from Food out of the home, clothing and fuel. This has implications for the intertemporal consumption studies where separability is imposed because of data limitations, such as the recording of only food expenditure in the PSID.

Appendix A: The parameter Estimates.

Table A.1

The Marginal Rate of Substitution Function

	FOOD	TRANSPORT	SERVICES
Food	0.5877 (0.0764)		
Transport	0.1825 (0.0330)	0.0526 (0.0103)	
Services	0.0831 (0.0154)	0.0557 (0.0152)	0.0498 (0.0072)
Food*WW	-0.4670 (0.0729)		
Transport*WW	-0.1924 (0.0385)	-0.0050 (0.0059)	
Services*WW	-0.0851 (0.0179)	-0.0592 (0.0163)	-0.0444 (0.0071)
Foodout	-0.2726 (0.1387)	0.0022 (0.0071)	0.0955 (0.0319)
Clothing	0.0859 (0.0270)	0.0101 (0.0119)	0.0069 (0.0043)
Fuel	0.1564 (0.0295)	0.0967 (0.0135)	0.0358 (0.0054)
ed1	-0.5129 (0.0980)	-0.2510 (0.0374)	-0.0653 (0.0111)
ed2	-0.6652 (0.0940)	-0.2961 (0.0353)	-0.0838 (0.0102)
ed3	-0.6652 (0.0930)	-0.2953 (0.0354)	-0.0821 (0.0100)
ed4	-0.6531 (0.0937)	-0.2959 (0.0354)	-0.0727 (0.0107)
ed5	-0.7673 (0.0948)	-0.3380 (0.0366)	-0.1022 (0.0116)
Age	0.0122 (0.0167)	0.0057 (0.0076)	0.0043 (0.0033)
Age2	-0.0159 (0.0161)	-0.0057 (0.0075)	-0.0046 (0.0031)
Children 16+	-0.2029 (0.0263)	-0.0864 (0.0109)	-0.0318 (0.0042)

Children 2-15	-0.1302	-0.0566	-0.0236
	(0.0144)	(0.0054)	(0.0025)
Children 0-1	-0.0679	-0.0284	-0.0026
	(0.0277)	(0.0111)	(0.0056)
Trend	-0.1462	-0.0881	-0.0221
	(0.0387)	(0.0207)	(0.0080)
January	-0.2761	-0.1287	-0.0488
	(0.0577)	(0.0276)	(0.0113)
February	-0.2403	-0.1276	-0.0474
	(0.0522)	(0.0237)	(0.0106)
March	-0.1443	-0.0762	-0.0242
	(0.0552)	(0.0248)	(0.0111)
April	-0.1048	-0.0694	-0.0257
	(0.0600)	(0.0278)	(0.0121)
May	-0.3029	-0.1514	-0.0620
	(0.0578)	(0.0263)	(0.0120)
June	-0.2063	-0.0921	-0.0339
	(0.0542)	(0.0244)	(0.0113)
July	-0.2271	-0.1184	-0.0578
	(0.0622)	(0.0286)	(0.0128)
August	-0.2701	-0.1321	-0.0584
	(0.0529)	(0.0258)	(0.0113)
September	-0.3723	-0.1766	-0.0817
	(0.0613)	(0.0268)	(0.0122)
October	-0.2661	-0.1215	-0.0555
	(0.0559)	(0.0255)	(0.0114)
November	-0.2125	-0.0883	-0.0408
	(0.0606)	(0.0298)	(0.0123)
North East	-0.0173	-0.0126	-0.0054
	(0.0353)	(0.0157)	(0.0068)
North Central	-0.0090	-0.0137	-0.0028
	(0.0299)	(0.0137)	(0.0060)
South	-0.1148	-0.0679	-0.0223
	(0.0315)	(0.0153)	(0.0061)
Urban	-0.6056	-0.2441	-0.1276
	(0.0651)	(0.0263)	(0.0138)
Pop 4m+	-0.6409	-0.2731	-0.1339
	(0.0648)	(0.0278)	(0.0147)

Pop 1.25-4m	-0.5089 (0.0597)	-0.2107 (0.0259)	-0.1121 (0.0140)
Pop 0.4-1.25	-0.4208 (0.0622)	-0.1759 (0.0273)	-0.0971 (0.0144)
Pop 0.07-0.4m	-0.4216 (0.0649)	-0.1673 (0.0296)	-0.0908 (0.0154)
White	-0.1714 (0.0344)	-0.0818 (0.0160)	-0.0298 (0.0072)
Homeowner M	-0.1430 (0.0271)	-0.0826 (0.0128)	-0.0276 (0.0059)
Homeowner NM	-0.1458 (0.0408)	-0.0887 (0.0174)	-0.0328 (0.0071)
Male Works	-0.2889 (0.0645)	-0.0889 (0.0240)	-0.0403 (0.0098)
Female Works	-1.7809 (0.1922)	-0.5856 (0.0611)	-0.3394 (0.0284)
$\ln x_{t-1}$	-0.0492 (0.0187)	-0.0109 (0.0060)	-0.0000 (0.0018)
$\ln x_{t+1}$	0.0306 (0.0452)	0.0202 (0.0108)	-0.0059 (0.0038)
Constant	8.9154 (0.5806)	2.9432 (0.1395)	1.0 (-)

Test of overidentifying restrictions
a) Food/Services MRS 268.1 (125)
b) Transport/Services MRS 208.8 (125)
c) Equality of Services coefficients across the two equations 116.71 (46)

Notes
Asymptotic standard errors in parentheses.

Tests for serial correlation (N(0,1))

good/services	0.7166	Correlation of residuals	0.0106
transport/services	1.6587	Correlation of residuals	0.0160

Table A.2

The Intertemporal Euler Equations

	FOOD	TRANSPORT	SERVICES
Food	0.0955 (0.0216)	0.0067 (0.0111)	0.0247 (0.0142)
Transport	0.0318 (0.0092)	0.0621 (0.0107)	0.0027 (0.0110)
Services	0.0203 (0.0070)	0.0309 (0.0087)	0.0885 (0.0112)
Food*WW	-0.0736 (0.0240)	0.0057 (0.0134)	-0.0171 (0.0177)
Transport*WW	-0.0274 (0.0097)	-0.0565 (0.0120)	-0.0071 (0.0123)
Services*WW	-0.0185 (0.0075)	-0.0352 (0.0094)	-0.0534 (0.0124)
Foodout	0.0058 (0.0289)	-0.1097 (0.0384)	-0.0218 (0.0558)
Clothing	0.0055 (0.0029)	-0.0014 (0.0042)	0.0048 (0.0044)
Fuel	0.0171 (0.0058)	0.0210 (0.0065)	0.0170 (0.0078)
ed1	0.0134 (0.0418)	-0.0233 (0.0306)	-0.0187 (0.0272)
ed2	-0.0135 (0.0370)	-0.0447 (0.0254)	-0.0387 (0.0232)
ed3	-0.0262 (0.0340)	-0.0423 (0.0284)	-0.0471 (0.0237)
ed4	0.0022 (0.0368)	-0.0354 (0.0318)	-0.0621 (0.0271)
ed5	-0.0273 (0.0350)	-0.0546 (0.0273)	-0.0745 (0.0310)
Age	-0.0001 (0.0082)	0.0035 (0.0102)	-0.0014 (0.0079)
Age2	-0.0066 (0.0077)	0.0009 (0.0097)	-0.0036 (0.0085)
Children 16+	-0.0284 (0.0096)	-0.0570 (0.0115)	-0.0155 (0.0090)

Children 2-15	-0.0218 (0.0073)	-0.0167 (0.0059)	-0.0222 (0.0056)
Children 0-1	-0.0067 (0.0109)	-0.0175 (0.0106)	-0.0184 (0.0150)
Trend	-0.0228 (0.0199)	-0.0838 (0.0218)	-0.0077 (0.0267)
January	-0.0102 (0.0128)	-0.0230 (0.0135)	-0.0039 (0.0150)
February	-0.0266 (0.0136)	-0.0189 (0.0144)	-0.0218 (0.0148)
March	-0.0018 (0.0035)	-0.0111 (0.0047)	0.0054 (0.0058)
April	-0.0063 (0.0128)	-0.0207 (0.0135)	-0.0008 (0.0151)
May	-0.0182 (0.0135)	-0.0141 (0.0151)	-0.0181 (0.0150)
June	0.0044 (0.0035)	0.0013 (0.0047)	0.0127 (0.0069)
July	-0.0039 (0.0127)	-0.0116 (0.0147)	-0.0047 (0.0160)
August	-0.0208 (0.0133)	-0.0063 (0.0150)	-0.0085 (0.0159)
September	0.0051 (0.0031)	0.0027 (0.0043)	0.0099 (0.0064)
October	-0.0042 (0.0125)	-0.0102 (0.0140)	-0.0011 (0.0155)
November	-0.0194 (0.0131)	-0.0117 (0.0141)	-0.0115 (0.0150)
North East	0.0342 (0.0202)	0.0196 (0.0165)	-0.0188 (0.0186)
North Central	-0.0041 (0.0157)	-0.0200 (0.0178)	-0.0163 (0.0149)
South	-0.0138 (0.0151)	0.0198 (0.0184)	0.0030 (0.0177)
Urban	-0.1720 (0.0322)	-0.1615 (0.0369)	-0.1421 (0.0396)
Pop 4m+	-0.1495 (0.0372)	-0.1335 (0.0298)	-0.1488 (0.0482)

Pop 1.25-4m	-0.0734 (0.0276)	-0.1025 (0.0323)	-0.0974 (0.0471)
Pop 0.4-1.25	-0.0718 (0.0305)	-0.1311 (0.0319)	-0.1039 (0.0468)
Pop 0.07-0.4m	-0.0633 (0.0302)	-0.0782 (0.0324)	-0.0683 (0.0473)
White	-0.0144 (0.0132)	-0.0663 (0.0149)	-0.0323 (0.0194)
Homeowner M	-0.0210 (0.0162)	-0.0450 (0.0153)	-0.0231 (0.0133)
Homeowner NM	-0.0144 (0.0183)	0.0046 (0.0264)	-0.0383 (0.0167)
Male Works	-0.0852 (0.0260)	0.0176 (0.0132)	-0.0067 (0.0233)
Female Works	-0.3761 (0.0692)	-0.3445 (0.0492)	-0.3842 (0.0663)
$\ln x_{t-1}$	0.0033 (0.0026)	0.0021 (0.0025)	-0.0039 (0.0030)
$\ln x_{t+1}$	-0.0025 (0.0074)	-0.0012 (0.0049)	-0.0080 (0.0049)

Rate of time preference fixed at 1.25% per quarter

Tests of Overidentifying Restrictions:
a) Food 205.7 (165)
b) Transport 195.4 (165)
c) Services 234.7 (165)

d) Wald test on the exclusion of income (3) 9.018 p-value 2.9%

Notes
Asymptotic standard errors in parentheses.

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