Journal of Econometrics 59 (1993) 137–160. North-Holland

Labour supply and intertemporal substitution*

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This paper concerns the estimation of an intertemporal model for labour supply and consumption that recognises the presence of nonworkers and which is cast in a structural optimising framework that allows for uncertainty. Through the utilisation of a micro-data source that measures consumption and labour supply we are able to estimate a flexible preference model which incorporates corner solutions and uncertainty.

1. Introduction

It is of considerable interest to know precisely how labour supply responds to anticipated changes in economic and demographic factors, in particular whether or not changes in participation and working hours over the business cycle can be explained by anticipated real wage fluctuations. Although there exists extensive evidence on the size of the intertemporal substitution elasticity for consumption,[1] there is less evidence for labour supply. This is especially the case for female labour supply.[2] An important question is whether women do in fact respond to anticipated changes in wages by large changes in hours of work and

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* We should like to thank James Banks, Angus Deaton, John Ham, Guglielmo Weber, two anonymous referees, and participants at the Venice Panel Data conference for their comments. Finance for this research, provided by the ESRC, under project W100281002, is gratefully acknowledged. The data for this research were provided by the Department of Employment. All errors remain ours alone.

[1] See Attanasio and Weber (1989) for a recent discussion of results.

[2] See Altonji (1986), Ham (1986a, b), and MaCurdy (1981) for micro-level evidence on male labour supply.

ultimately by entering and exiting the labour force. In addition we wish to know how the responses change as women go through a typical life cycle – from the early days of marriage through the childbearing period and onto retirement. To answer these questions we require a methodology that accounts for the large number of nonworking women and allows for uncertainty.

A further issue relates to the lack of micro-data sources that provide information on both labour supply and consumption.[3] Without such data strong additivity assumptions are required on preferences which imply independence between the marginal utility of labour supply and the level of consumption over the complete life cycle. In this paper we use a data source for the UK that records detailed consumption and hours of work. We show that this information is sufficient to allow full identification of all intertemporal parameters even in the presence of corner solutions and uncertainty.

Our approach to estimation and identification is sequential: estimates of the parameters of the within-period hours of work/consumption trade-off are first obtained, and this is then followed by the estimation of an Euler equation for the marginal utility of consumption. Together these identify all the parameters of interest. We show that the Euler condition for consumption holds even in the presence of nonparticipation and nonseparability between goods and leisure, provided the wage is replaced by its shadow value.

Our approach follows the methodology for intertemporal consumption modelling developed in Blundell, Browning, and Meghir (1992). In that study the two-stage sequential approach described above was applied to the time series of repeated cross-sections which are available for the UK Family Expenditure Survey over the 1970s and 1980s. An advantage of the FES, apart from its length, is the large and accurate collection of expenditure data. In addition, detailed information on household characteristics, income, and working hours is collected which makes it an ideal data source for the proposed study of labour supply and intertemporal substitution.

A drawback, however, of using repeated cross-section data rather than pure panel data for intertemporal substitution analysis is the inability to follow the same individuals through time. However, we follow the approach of Browning, Deaton, and Irish (1985)[4] and construct an *exactly* aggregated pseudo panel of year of birth cohorts. Using this aggregation procedure, Blundell, Browning, and Meghir (1992) found strong effects of characteristics and labour market states on intertemporal consumption allocations in the UK FES. However, their analysis was conditional on labour market behaviour and, although being

[3] Even the Panel Study for Income Dynamics in the US, for which consumption data are available, only records detailed information on food expenditure. It is likely that the Consumers Expenditure Survey for the US, which does record expenditures and labour supply in some detail, will now become a major resource for such research.

[4] See also Attanasio and Weber (1989), Deaton (1985), and Moffitt (1989).

robust to the determinants of labour market entry or exit, it could not identify intertemporal preferences over labour supply. Our aim in this paper is to identify a complete set of intertemporal labour supply responses, and we will argue that this can be achieved through a combination of a within-period (life cycle consistent) labour supply model with an Euler equation for consumption that conditions on the estimated shadow wage.

Our data span the period of the 1970s through to the middle of the 1980s. From these data we are able to provide a picture of life cycle participation, hours of work, and savings decisions, by superimposing the patterns of behaviour for each cohort over the part of the life cycle in which it is observed. Our focus is on the labour supply of married women whose participation and hours of work behaviour, presented in figs. 1 and 2, display considerable variation over the life cycle for each cohort and over the time period under consideration. We include male labour supply as a conditioning factor, but do not attempt to model its behaviour directly.

In the analysis of intertemporal substitution it is important to decompose labour supply movements into those that can be considered as responses to anticipated changes in real wages, interest rates, and demographic variables, and those that are largely reactions to unanticipated events. The unconditional patterns displayed in raw data do not make such a distinction. Moreover, they do not separate the influences of anticipated real wage changes from those

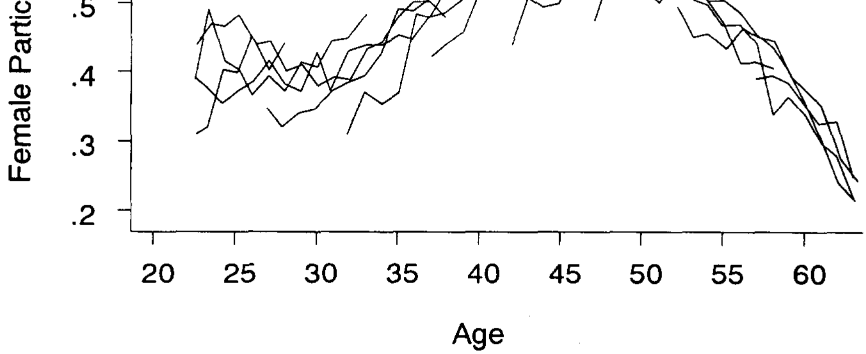

Fig. 1. Female participation over the life cycle; married women only.

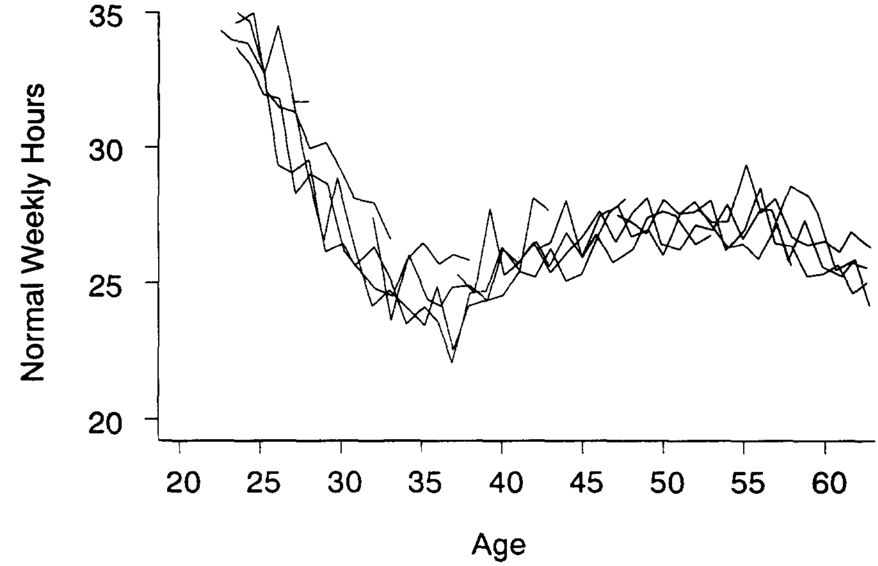

Fig. 2. Hours of work over the life cycle; working married women only.

resulting from planned demographic changes and the labour market responses of other household members. The aim of this paper is to place these data within a dynamic economic optimisation structure.

In the next section a formal model is developed that allows for nonparticipation. In section 3 specific issues relating to the empirical specification are considered and a description of the econometric methodology for estimation with cohort data is presented. In section 4 our empirical results are discussed. They show well-determined and reasonably-sized intertemporal labour supply elasticities. Finally, in section 5, some conclusions are drawn.

2. The model

2.1. Intertemporal choices

Consider a utility function of consumption c_t and hours of work h_t, conditional on a set of characteristics z_t,

$$F[U(c_t,h_t \mid z_t) \mid z_t] \,, \tag{1}$$

where $F[x_t \mid z_t]$ is a strictly monotonic increasing function of x_t given z_t. One of the choice variables, h_t, will be allowed to be zero, and the issue is to model the intertemporal choice of c_t and h_t given z_t. Modelling this intertemporal choice involves estimating the parameters characterising $F[\cdot]$ and $U[\cdot]$. We assume that the individual solves the problem

$$G(A_t) = \max_{h_t, c_t, A_{t+1}} \{F[U(c_t, h_t \mid z_t) | z_t] + (1 + \delta_t)^{-1} \mathrm{E}_t G(A_{t+1})\} , \tag{2}$$

subject to the asset accumulation constraint

$$A_{t+1} = (1 + r_t)(A_t - c_t + w_t h_t + y_t) . \tag{3}$$

In the above A_t are assets at the start of period t, δ_t is the rate of time preference, r_t is the real interest rate, w_t the real wage rate, and y_t is income from other sources (in real terms). The expectations operator E_t is taken over future uncertain wages, other income, interest rates, and exogenous lay-offs and is conditional on information at time period t.

This framework has often been used to measure the intertemporal elasticity of substitution both for consumption (with respect to the interest rate) and for hours of work (with respect to the wage rate). But invariably for labour supply corner solutions have either been ruled out [e.g., Browning, Deaton, and Irish (1985)] or perfect foresight has been assumed [e.g., Heckman and MaCurdy (1980)]. In particular, under perfect foresight and additive separability between consumption and hours of work, the life cycle labour supply takes the form

$$h_t = h_t(w_t, \lambda \mid z_t) , \tag{4}$$

where λ is the marginal utility of wealth. Optimisation under perfect certainty implies that λ will be constant over time but, of course, individual-specific. With appropriate restrictions on preferences, (4) will be linear in λ which can then be treated as a fixed effect.[5] Hence, as in Heckman and MaCurdy (1980), a fixed effects limited dependent variable model can be specified accounting for corner solutions. The object is to improve on this methodology by allowing for uncertainty and by not imposing additive separability.

Our approach, following MaCurdy (1983), is to recognise that the complete set of preferences may be estimated using both the Euler equation and the within-period marginal rate of substitution. First consider the latter. Consumption and hours of work will be chosen to satisfy

$$\frac{\partial U_t / \partial h_t}{\partial U_t / \partial c_t} = -w_t . \tag{5}$$

[5] For a detailed discussion of preference restrictions in such models see Blundell, Fry, and Meghir (1990), Browning (1986), and Nickell (1988).

Note that in (5) the monotonic transformation $F[\cdot]$ does not appear since it cancels out of the ratio of the marginal utilities. This reflects the fact that intertemporal elasticities cannot in general be identified from the within-period allocation of goods. Hence (5) can only be used to identify some aspects of preferences. To obtain an empirical model we define the within-period budget identity

$$c_t \equiv w_t h_t + \mu_t \,, \tag{6}$$

where μ_t is an other income measure reflecting net dissaving [see Blundell and Walker (1986)]. Combining (6) with (5) we can, in general, obtain a labour supply equation of the form

$$h_t = h_t(w_t, \mu_t \,|\, z_t, \theta) \,, \tag{7}$$

where θ are the unknown parameters to be estimated.

The precise specification of (7) is left to the next section and reflects the form of $U(\cdot)$. Here we stress that (7) can be used to identify those components of $U(\cdot)$ that determine within-period allocation. To complete identification we can write the conditional Euler equation which characterises the intertemporal allocation of consumption, i.e.,

$$\mathrm{E}_t\{(\partial F/\partial U)_t(\partial U/\partial c_t) - (1+\delta_t)^{-1}(1+r_t)(\partial F/\partial U)_{t+1}(\partial U/\partial c_{t+1})\} = 0 \,. \tag{8}$$

To the extent that $(\partial F/\partial U)_t$ is not constant across time (constancy would only be the case under explicit additive separability of goods from hours of work), (8) can be used to identify those aspects of preferences not identified by (7). Anything not identified from (7) and (8) is not needed for the purposes of estimating the within-period and intertemporal elasticities.[6]

2.2. Corner solutions and identification

The above modelling framework makes the modelling of corner solutions more straightforward. First, a selectivity type model [as in Blundell, Ham, and Meghir (1991)] can be used to estimate (7) over workers. In fact, we take the estimates directly from Blundell, Ham, and Meghir (1991). This procedure

[6] As Altug and Miller (1990) point out in the presence of macro-shocks, the zero conditional expectation condition (8) is only valid in short panels under complete markets. Indeed, complete markets are shown to be sufficient to make the log approximation to (8) exact. Our pooled cross-section cohort aggregation approach allows us to estimate over a comparatively long time period for each cohort, thus to an extent avoiding this short panel criticism.

generalises the standard Tobit model and avoids the necessity to infer a market wage for nonworkers. The stochastic specification in such a model comes from random preference variation in one of the parameters in the vector θ. The endogenous variables are other income μ_t, the wage rate w_t, and the selectivity indicator I_t. This estimation requires at least three identifying assumptions. Clearly the structure of the economic model suggests that asset income $r_t A_t$ is excluded from (7) given μ_t. Moreover $r_t A_t$ is predetermined and hence we assume it is weakly exogenous for (7). We also assume that education affects labour supply via the wage rate only. In addition, we assume that macroeconomic conditions affect the observed participation rates and the wage rate but not labour supply directly. We represent these macroeconomic conditions by regional unemployment and unemployment by age. As explained in Blundell, Ham, and Meghir (1991), these exclusion and exogeneity assumptions are sufficient to identify the model. Similar identifying assumptions have been used by Arellano and Meghir (1992). Thus with this structure and exploiting within-period allocations we can identify θ provided we have data on both hours of work and consumption.

The remaining parameters that will allow us to characterise intertemporal allocation can be estimated using (8). Note that the presence of corner solutions in hours of work does not cause any problem for estimation of (8) since it will depend on the actual hours worked and not on the censored desired hours.[7] To identify the parameters in (8) we can use as instruments lagged realisations of consumption and hours of work since these will be uncorrelated with the expectational error induced by replacing the expectation terms by observed realisations. Under a rational expectations assumption and with the additional assumption that random preference errors are serially uncorrelated, variables from period $t-1$ will be exogenous for (8). Note moreover that in the absence of random preference errors, information dated t will in fact be exogenous for (8). We discuss the role of random preference errors in the estimation section.

2.3. Estimation of a specification based on the indirect utility function

It is often convenient to specify the structure of the economic model starting from the indirect utility function. This is particularly true when an explicit form for the labour supply model is required and at the same time restrictions on preferences need to be avoided. The principal idea of the methodology outlined above does not change but we need to note some aspects of the implementation.

Suppose we specify an indirect utility function,

$$U_t = F[V(w_t, \mu_t \mid z_t) \mid z_t] \,, \tag{9}$$

[7] This argument is similar to the conditional demand system approach as in Browning and Meghir (1991).

where μ is defined by the budget identity (6). Then (9) is just another representation of the within-period utility function. Labour supply is given by applying Roy's identity, i.e.,

$$h^* = \frac{\partial V/\partial w}{\partial V/\partial \mu}, \tag{10}$$

where h^* represents desired hours. The marginal utility of wealth is given by

$$\begin{aligned} \lambda_t &= \partial V(w_t, \mu_t \mid z_t)/\partial \mu_t \quad \text{for} \quad h_t^* > 0, \\ &= \partial V(\tilde{w}_t, \mu_t \mid z_t)/\partial \mu_t \quad \text{for} \quad h_t^* \leq 0, \end{aligned} \tag{11}$$

where $\tilde{w}_t$ is the reservation wage defined by

$$h_t(\tilde{w}_t, \mu_t \mid z_t, \theta) = 0. \tag{12}$$

In substituting the wage for the reservation wage we are in effect integrating back to the direct utility function evaluated at observed hours (zero). Hence, given the reservation wage, the Euler equation (8) can be used to identify $F[\cdot]$ by replacing $\partial U/\partial c$ in (8) with λ_t as defined in (11).

This formulation enables the use of the more flexible indirect utility approach despite the presence of corners. This approach is similar to the one suggested by Lee and Pitt (1986), and it should be noted that for the economic model to make sense the estimated labour supply model should satisfy the integrability conditions (positive compensated wage derivative). These guarantee the uniqueness of the reservation wage. Finally note that the whole approach can still be carried out when c_t is a vector of goods so long as none of these goods is at a corner. Indeed, Blundell, Browning, and Meghir (1992) estimate the intertemporal elasticity of substitution for consumption starting from many goods and condition on labour supply.

2.4. *Derivation of λ-constant elasticities*

Frisch or λ-constant elasticities relate changes in consumption (or hours of leisure) to expected changes in prices (or wages) over the life cycle keeping the marginal utility of wealth, λ, constant. These Frisch elasticities may be obtained from the Marshallian elasticities if one extra parameter, the consumption elasticity of intertemporal substitution, denoted by e_{cp}^{λ}, is known for each period t. That is, $1 + e_{cp}^{\lambda}$ measures the percentage variation in period t consumption, following a one percent change in all period t prices, assuming that the household is compensated such as to keep λ constant. Browning (1985) shows that this elasticity may be obtained through the expression

$$e^{\lambda}_{cp} = \frac{\lambda}{x \cdot \lambda_x}, \tag{13}$$

where λ_x is the first derivative of λ with respect to consumption expenditure x.

Since we analyse consumption and leisure decisions jointly, we shall denote by ϕ the full income or full expenditure elasticity of intertemporal substitution. Thus, $1 + \phi$ measures the percentage variation of full income in period t, following an anticipated one percent change in all prices and wages in period t. This elasticity is not the parameter of interest for policy and welfare analysis, and it has to be decomposed into the hours and consumption λ-constant elasticities (e^{λ}_{hw} and e^{λ}_{cp}, respectively).

The relation between the λ-constant derivative, the u-constant, and μ-constant derivatives is discussed, for instance, in MaCurdy (1981). He concludes that if ϕ is negative (that is if the utility function $F[\cdot]$ is concave) and if leisure is a normal good, we have

$$e^{\lambda}_{hw} \geq e^{u}_{hw} \geq e^{\mu}_{hw} . \tag{14}$$

An evolutionary (anticipated) wage change which keeps λ constant induces a larger labour supply response than comparable u-constant or μ-constant wage changes. This is so because in the λ-constant case a change in wages is only due to a movement along the given life cycle profile, known at the beginning of the lifetime; therefore, there is no wealth effect associated with a λ-constant wage change. The same is not true for μ- or u-constant wage changes, which contain a wealth effect.

3. The empirical specification and choice of estimator

3.1. Labour supply and indirect utility

A useful survey of popular labour supply models and their properties is provided in Stern (1986). In general, labour supply functions should have a positive wage effect at zero or low hours, and this may become backward-bending for higher hours. That is, provided the income effect is sufficiently negative, labour supply curves which exhibit backward-bending behaviour for high hours can be theory-consistent at all conceivable points. This depends on the functional form chosen.

As noted above, we draw our estimates of (7) from Blundell, Ham, and Meghir (1991) in which for any individual i the specification of desired hours has the following form:

$$h_i^* = \alpha_0(z_i) - \beta(z_i,w_i)(\mu_i + a(w_i,z_i))/w_i + u_i \,, \tag{15}$$

where w_i is the real marginal after-tax wage rate and μ_i is other income constructed from the budget identity (μ = real household consumption − wh) as described in section 2.[8] Further, $\alpha_0(z_i)$, $\beta(z_i,w_i)$, and $a(w_i,z_i)$ are general functions of household-specific demographic and taste shift variables z_i.[9] The precise form of these functions is left as an empirical choice, although the general form for indirect utility V_t is given by

$$V(w_i,\mu_i;z_i) = \frac{\mu_i + a(w_i,z_i)}{b(w_i,z_i)} \,, \tag{16}$$

where $b(w_i,z_i) = w_i^{\beta}(w_i,z_i)$.

Four age groups are defined for children (0–2, 3–4, 5–10, and 11 +), and corresponding to these are the numbers *K1*, *K2*, *K3*, and *K4* of dependent children in the household in each category. Dummies are also defined by $DK1 = 1$ (if $K1 > 0$), $DK2 = 1$ (if $K2 > 0$, $K1 = 0$), $DK3 = 1$ if ($K3 > 0$, $K1 = K2 = 0$), and $DK4 = 1$ (if $K4 > 0$, $K1 = K2 = K3 = 0$) to capture the effect of the age of the youngest child. (Note that the base case is a childless couple.) The forms of $\alpha_0(z_i)$, $a(w_i,z_i)$, and $\beta(w_i,z_i)$ are provided in appendix A.

By excluding male labour supply from the z_i we are implicitly assuming weak separability between the within-period labour supply decisions. In principle, this is a testable assumption. However, it raises a number of identification issues and we do not provide for such a generalisation in this paper. None the less, we do relax explicit additive separability between household labour supplies by conditioning on male labour supply in our estimation of the intertemporal substitution model for female labour supply and consumption. That is, we allow $F(U \mid \cdot)$ in (1) above to depend on male labour force participation.

The inclusion of a wage term in $\beta(\ \ )$ breaks additive separability between hours and consumption. Model (15) is therefore a reasonably flexible labour supply specification. It should be noted, for example, that a negative coefficient on the wage in $\beta(\ \ )$ can generate a backward-bending labour supply curve.

Estimation of the labour supply parameters in (15) takes place in the generalised selectivity framework described above and, as noted there, means that we

[8] Using the marginal after-tax wage to define μ is equivalent to linearising the net-of-tax budget constraint.

[9] Note that (15) nests the popular, although restrictive, Stone–Geary or LES specification. Note also that the disturbance term u_i can be interpreted as an additive random preference effect attached to the income coefficient $\beta(z_i,w_i)$ so that its variance is proportional to $((\mu_i + a(w_i,z_i))/w_i)^2$.

do not have to infer a wage for nonworkers. As also mentioned above, to identify the labour supply parameters from our repeated cross-section data we will exclude human capital variables for husband and wife as well as demand-side variables.

3.2. *Intertemporal preferences*

In order to estimate the parameters that define, up to an affine transformation, the function F in (9) above, we use the Box–Cox transform [see MaCurdy (1983) and Blundell, Browning, and Meghir (1992)]:

$$F_t = V_t^{\{1+\rho_t\}}\,, \tag{17}$$

defined as

$$\begin{aligned} F_t &= (V_t^{1+\rho_t} - 1)/(1+\rho_t) \quad \text{if} \quad \rho_t \neq -1, \\ &= \log V_t \qquad\qquad\qquad\quad \text{otherwise,} \end{aligned}$$

in which V_t represents the within-period indirect utility (16). Note that if ρ_t is equal to zero, F_t corresponds to the identity transformation. The parameter ρ_t influences the elasticity of intertemporal substitution. It will be allowed to vary with a set of characteristics z_t,[10] likely to affect that elasticity as follows:

$$\rho_t = \rho(z_t) = \rho_0 + \sum_k \rho_k \cdot z_{tk}\,. \tag{18}$$

Expression (17) implies that λ is given by

$$\lambda_t = \partial F_t/\partial \mu_t = V_{t_t}^{\rho} \cdot V_t' \quad \text{for} \quad \rho_t \neq -1\,, \tag{19}$$

where V_t' is the derivative of V_t with respect to μ_t – the marginal utility of income – which will be positive.

It is now possible to specify the Euler equation (8) that describes the evolution of λ_t over time which may be rewritten as

$$\mathrm{E}_{t-1}\,\beta_t(1+r_t)\lambda_t = \lambda_{t-1}\,. \tag{20}$$

As was shown in the previous section, (20) holds whether or not some elements of the choice vector (including commodity demands and leisure) are on corner

[10] As noted above these will include male participation and need not coincide with the characteristics determining within-period allocations.

solutions provided the appropriate reservation wage replaces w_t in the expressions involving V_t. Expression (20) can be written as

$$\beta_{t-1}(1 + r_{t-1})\lambda_t = \lambda_{t-1}\varepsilon_t, \tag{21}$$

where

$$\mathrm{E}_{t-1}(\varepsilon_t) = 1 \,. \tag{22}$$

Note that we can also write

$$\mathrm{E}_{t-1}(\log \varepsilon_t) = -d_t + \log(\mathrm{E}_{t-1}(\varepsilon_t)) \,, \tag{23}$$

where d_t is an individual- and time-specific function of the moments of ε_t including its conditional variance. Taking logarithms of (21), defining a random variable e_t with zero mean, and denoting the first difference operator by Δ, such that $\Delta x_t = x_t - x_{t-1}$, we obtain

$$\Delta \log \lambda_t + \log \beta_t(1 + r_t) + d_t = e_t \,. \tag{24}$$

First differences of the logarithm of (19) give

$$\Delta \log \lambda_t = \Delta \rho_t \log V_t + \Delta \log V_t' \,, \tag{25}$$

and our estimating equation may finally be written as

$$\Delta \log V_t' + \rho_0 \cdot \Delta \log F_t + \sum_k \rho_k \cdot \Delta(z_{tk} \cdot \log F_t)$$

$$+ \log \beta_t(1 + r_t) + d_t = e_t \,, \tag{26}$$

where ρ_t is allowed to vary with observable characteristics z_{tk}.

To make (26) operational we need to specify d_t explicitly. In the empirical work here we allow d_t to depend on individual-specific characteristics which vary over time. The issue we cannot resolve here is whether the variability we allow for is sufficient to capture the conditional variance of the marginal utility of consumption.[11]

The cohort panel approach requires that for each time period and for each cohort we compute the sample averages of log F_t', log F_t, and $z_{tk} \cdot \log F_t$. In the

[11] This is an important identification issue which requires further investigation.

estimation of eq. (26), using pseudo panel data, we follow closely the methodology of Blundell, Browning, and Meghir (1992). We begin by writing the cohort aggregated model (26) as

$$Y(\xi) = X(\xi)\pi + u\,, \tag{27}$$

where Y and X are functions of data and ξ is a vector of estimated labour supply parameters defining indirect utility V. The set of parameters π, that is the ρ parameters and the intercept term in (26), is obtained applying the Generalised Method of Moments, GMM, estimator [e.g., Hansen (1982)] to (26),

$$\hat{\pi}_{\mathrm{GMM}} = (X'W(W'\hat{\Sigma}W)^{-1}W'X)^{-1}X'W(W'\hat{\Sigma}W)^{-1}W'Y\,, \tag{28}$$

where W is a matrix of appropriate instruments, $\hat{\Sigma}$ is a diagonal matrix with the square of the estimated residuals from a first-stage IV regression on the diagonal [see also White (1982)]. To obtain this estimator, we evaluate $X(\xi)$ and $Y(\xi)$ at consistent estimates of the α and β parameters in (15) and (16) above. The GMM estimator is heteroskedasticity-adjusted, and so it is more efficient than the simple IV estimator. The list of instruments W includes lagged values of cohort averages and differences in cohort averages, of the interest rate, the characteristics z, the logarithm of the real budget and its interactions with z, where the price index used to deflate the nominal budget does not involve any estimated parameters.

The consistency of the estimator (28) depends on the lack of autocorrelation of the residuals in (27). The empirical section reports tests for serial correlation. These tests are distributed asymptotically as N(0, 1) under the null of no serial correlation.

A final issue is concerned with the computation of the asymptotic variance–covariance matrix of the estimator (28). This should be adjusted for the fact that it depends on estimated parameters ξ [see Pagan (1986)]. Blundell, Browning, and Meghir (1992) describe the derivation of this matrix, in a pseudo cohort panel model that is very similar to this one.[12] They found negligible differences between the standard errors that do not take into account the fact that we are using variables that depend on estimated parameters and the ones that take into account this fact. The empirical section of this paper will report standard errors that are not corrected for the fact that ξ are estimated parameters.[13]

[12] See their appendix A.2.

[13] Up to now we have ignored the effect that the presence of random preferences will have on the Euler equation. Since we have specified the problem such that the labour supply equation is linear in the random preference error term, the Euler equation (8) would be nonlinear in this error. Ignoring it represents a nonlinear error in measurement problem and simple instrumental variables cannot

Table 1
The definition of the cohorts.

Cohort	Year of birth	Age in 1970	Age in 1984	Years in sample
1	1911–15	55–59	—	5
2	1916–20	50–54	—	10
3	1921–25	45–49	59–60	15
4	1926–30	40–44	54–58	15
5	1931–35	35–39	49–53	15
6	1936–40	30–34	44–48	15
7	1941–45	25–29	39–43	15
8	1946–50	20–24	34–38	15
9	1951–55	—	29–33	10
10	1956–60	—	24–28	5

4. Empirical results

4.1. Data

The Family Expenditure Survey contains information on cross-sectional units independently drawn over time, with no overlap. This exercise uses a sample of 43,671 married couples of working age selected according to criteria laid out in appendix B. The within-period labour supply estimates, which identify the parameters of the indirect utility V_t, are taken from the Blundell, Ham, and Meghir study using the 1981–84 Family Expenditure Surveys. However, the intertemporal Euler equation estimates have to draw on the cohort panel. Table 1 explains how households were assigned to the cohorts. The average number of observations per cohort is 364, which would seem to be large enough to provide reasonably accurate sample means.

The estimation of the Euler condition (28) requires the computation of cohort means of $\log F_t'$, $\log F_t$, and $z_{tk} \cdot \log F_t$ for each time unit. This resulted in a total of 120 observations. The loss of observations due to differencing, and lagging the instrument set reduces the resulting data set to 90 observations.

4.2. The labour supply results

Using the consumption data available in the FES, we define a life cycle consistent other income variable μ for each household in our data set utilising

solve the problem. A structural solution to this problem is as follows: we can use the labour supply data to identify the conditional distribution of the random preference error given consumption, wages, and hours, and then integrate the unobservables out of the Euler condition. Here we simply set these error terms to zero.

the budget constraint definition (6). Estimation of the indirect utility parameters takes place on the individual labour supply of the married women in our sample. The estimator is a generalised selectivity type as described in section 3 in which we control for endogeneity of μ and w by adding the reduced form residuals $\hat{u}_\mu$ and $\hat{u}_w$, respectively [see Blundell, Ham, and Meghir (1991)].

Table 7 in appendix A contains the labour supply parameter estimates. These results indicate plausible labour supply behaviour in which growing older and having a child two years or younger has a significant effect on the α_0 term. Moreover, additional children of all ages (but the oldest) raise the marginal budget share of nonmarket time β as does growing older. The coefficients for the age of the youngest child dummy variables indicate that β increases in the presence of a youngest child less than 11 years. We also see that β is increasing in log w, causing labour supply to be less forward-sloping than it would be in the separable LES case where β does not depend on w. The coefficients and standard errors on the wage and virtual residuals indicate the importance of treating the wage and virtual income as endogenous.

As will be clear from the results presented below it should be noted that all the compensated labour supply elasticities are positive, implying that the estimated model satisfies the restrictions of economic theory everywhere in the sample of workers. When we compute the compensated nonmarket time elasticities for the nonworkers (evaluated at an imputed wage), they too have the correct (negative) sign. This is true for all workers and nonworkers, avoiding the exclusion of households for concavity reasons.

The results show a close adherence to the theoretical restrictions governing within-period labour supply. However, the small income coefficient and the negative estimates of the log wage coefficient for certain household types imply low wage elasticities and backward-sloping behaviour for certain household types. These estimates allow us to construct the components of indirect utility and shadow wage terms in the expression for marginal utility [see (19)] for each individual household.

4.3. The intertemporal substitution model

In estimating (26) the parameter ρ is allowed to be a function of the following z_{tk} variables: a dummy variable referring to the husband out of work (*HU*), number of children in each age category (*K1*, *K2*, *K3*, and *K4*), white collar occupation dummy for the husband (*WHC*), and a dummy variable for households with more than two adults (*MUL*). All variables are treated as endogenous in the GMM estimation procedure described in eq. (28) above. The interest rate r_t corresponds to the after-tax building societies lending rate available at the end of period $t - 1$. Since most of the households hold such saving deposits, this does not seem to be an inappropriate choice.

In table 2 we present the estimated ρ coefficients of the Euler equation (26). The columns are grouped in pairs according to the choice of sample, and within each pair they are distinguished according to the choice of instruments. In the first column of each pair instruments dated $t-1$ and $t-2$ are utilised. In the second column instruments dated $t-2$ only are used. Columns 1 and 1′ contain estimates for the complete data set including all cohorts. The remaining columns provide a comparison by sequentially deleting younger age groups and therefore younger cohorts in the second pair of columns and older cohorts in columns 3 and 3′. From these comparisons we choose to omit the young cohorts for whom liquidity constraints may well be more important and work with estimates in column 2 although all estimates display a similar pattern of behaviour.

Table 2
The Euler equation estimates.[a]

	All cohorts		Omitting young cohorts		Omitting young and old cohorts	
Variable	(1)	(1′)	(2)	(2′)	(3)	(3′)
Constant	− 1.6432	− 2.3045	− 2.3983	− 2.9550	− 2.4611	− 2.8601
	(0.3087)	(0.4898)	(0.3977)	(0.4758)	(0.4180)	(0.5028)
HU	− 0.0891	− 0.3083	− 0.1046	− 0.1924	− 0.0697	− 0.0840
	(0.0595)	(0.1077)	(0.0614)	(0.0909)	(0.0608)	(0.0910)
K1	0.1429	0.0447	0.1459	0.0010	0.1460	0.0944
	(0.0514)	(0.0707)	(0.0702)	(0.1065)	(0.0750)	(0.1141)
K2	− 0.0296	0.0386	− 0.1153	0.0075	− 0.1191	− 0.0583
	(0.0346)	(0.0441)	(0.0485)	(0.0737)	(0.0480)	(0.0740)
K3	0.0546	0.0301	0.0636	0.0350	0.0613	0.0540
	(0.0159)	(0.0207)	(0.0229)	(0.0294)	(0.0230)	(0.0296)
K4	0.0106	0.0089	− 0.0075	− 0.0072	− 0.0069	− 0.0038
	(0.0134)	(0.0191)	(0.0145)	(0.0201)	(0.0151)	(0.0205)
WHC	0.1161	0.1740	0.0974	0.1770	0.1212	0.1394
	(0.0464)	(0.0799)	(0.0558)	(0.0846)	(0.0571)	(0.0865)
MUL	0.0345	0.0164	0.0397	0.0177	0.0382	0.0212
	(0.0363)	(0.0447)	(0.0418)	(0.0482)	(0.0427)	(0.0488)
Sargan	41.0088	32.3204	30.3051	21.3478	31.9737	25.9516
p-value	0.0056	0.0007	0.0860	0.0299	0.0589	0.0066
	(21)	(11)	(21)	(11)	(21)	(11)
r_1	1.271	− 0.591	− 0.602	− 0.809	− 0.182	− 1.230
r_2	0.977	0.875	0.901	0.967	0.679	1.048

[a]Standard errors are given in parentheses below coefficients. Sargan refers to the χ^2 test of instrument validity, with the corresponding p-value and degrees of freedom reported below. r_1 and r_2 are first- and second-order serial correlation test statistics, respectively [N(0, 1) under the null].

From (13) and the definition of ρ in (17) it can be seen that the unemployment of the head of the household reduces the degree of intertemporal substitution in consumption. On the other hand, the white collar worker dummy *WHC* increases intertemporal substitution. Children have a mixed effect on the value of ρ.

Table 3 reports the intertemporal labour supply and consumption elasticities. These are evaluated at the mean for five different subsamples of working women according to demographic characteristics. Compensated and uncompensated labour supply elasticities are also reported there and were obtained using the estimates from table 7. It is comforting to see that the λ-constant labour supply elasticity is positive and larger than the compensated and uncompensated elasticities, as economic theory postulates. Moreover, our empirical estimates show that this elasticity reflects that responses to anticipated changes in the wage rate are generally less than unity and nearer to 0.5 for those women workers with no children whose hours are largest, averaging more than 30 hours per week. The intertemporal consumption elasticity is very close to -0.5.

The estimates of the Euler equation allow us to obtain household-specific intertemporal elasticities. Thus in table 4 the sample distribution of the λ-constant intertemporal labour supply elasticity is presented. In accordance with our findings, the intertemporal elasticity of labour supply is smaller than unity

Table 3
Labour supply and consumption elasticities.[a]

	NOCHILD	*DK1*	*DK2*	*DK3*	*DK4*
ε^{μ}_{hw}	0.0774	0.4305	0.4246	0.2920	0.2274
ε^{u}_{hw}	0.3952	0.7849	0.7496	0.5955	0.5476
$\varepsilon^{\lambda}_{hw}$	0.5781	1.2230	1.0970	0.8722	0.8005
$\varepsilon^{\lambda}_{cp}$	-0.5605	-0.6883	-0.6321	-0.5998	-0.5174
Sample size	11,450	1,641	2,313	4,688	5,098

[a]Elasticities evaluated at the mean for the sample of working women.

Table 4
Sample distribution of $\varepsilon^{\lambda}_{hw}$ (working women only).

	NOCHILD	*DK1*	*DK2*	*DK3*	*DK4*
10%	0.1915	0.3581	0.3120	0.2541	0.2800
25%	0.2978	0.7385	0.6671	0.4486	0.4162
Median	0.4818	1.3816	1.2315	0.9323	0.7789
75%	0.9722	2.8588	2.4177	1.6988	1.3806
90%	1.8317	5.7955	4.4466	3.2293	2.5447
Mean	0.9010	2.5279	2.1061	1.4634	1.2350

Table 5
$\varepsilon^{\lambda}_{hw}$ by household type.[a]

Head	No children	$K1 = 1$	$K2 = 2$	$K3 = 1$	$K4 = 1$
White collar; employed	0.5850	1.3927	1.2063	1.0676	1.1202
White collar; unemployed	0.5795	1.3767	1.1953	1.0570	1.1090
Nonwhite collar; employed	0.5756	1.3654	1.1875	1.0495	1.1012
Nonwhite collar; unemployed	0.5707	1.3510	1.1774	1.0400	1.0910

[a]Workers only.

Table 6
$\varepsilon^{\lambda}_{cp}$ by household type.[a]

Head	No children	$K1 = 1$	$K2 = 2$	$K3 = 1$	$K4 = 1$
White collar; employed	– 0.5731	– 0.6792	– 0.6297	– 0.6410	– 0.5803
White collar; unemployed	– 0.5617	– 0.6664	– 0.6191	– 0.6283	– 0.5700
Nonwhite collar; employed	– 0.5537	– 0.6658	– 0.6116	– 0.6195	– 0.5627
Nonwhite collar; unemployed	– 0.5434	– 0.6460	– 0.6019	– 0.6081	– 0.5533

[a]Workers only.

for the bulk of the sample. Thus, large hours responses to anticipated changes in the wage rate are only likely to be observed for a small minority of the observations (and then to be associated with a small amount of hours of work). The remaining elasticities are presented in appendix C.

Table 5 indicates that a fairly stable pattern is observed over household types. Table 6 shows that the intertemporal consumption elasticities are around – 0.6.

5. Conclusions

The aim of this paper has been to analyse the intertemporal labour supply of married women, following them from their early stages of marriage, through their childbearing period, up to middle age and retirement. Through the utilisation of consumption and labour supply data we have shown that important preference restrictions can be relaxed while corner solutions and uncertainty are accounted for. The basic methodology rests on the idea that although the optimisation conditions for the allocation of labour supply over time are complicated by the presence of nonworkers, consumption allocations can still be described by the Euler equation if this is conditioned on appropriate labour market variables. Unless labour supply and consumption are explicitly additively separable over the complete life cycle, labour supply will enter this Euler condition. In fact, nonparticipation or corner solutions simply lead to the replacement of the market wage in the marginal utility of consumption by the shadow wage. Under explicit additivity all labour supply elasticities could be recovered from the standard within-period labour supply analysis without recourse to intertemporal models.

Our empirical analysis uses the long time series of repeated cross-section data from the UK FES which collects information on consumption and hours of work. These data are not a panel, and so estimation of the intertemporal model takes place on an exactly aggregated cohort panel as suggested in the path-breaking work of Deaton (1985) and Browning, Deaton, and Irish (1985).

Our results confirm the reasonably elastic nature of consumption allocations. They also display not insignificant labour supply elasticities, but also point to the importance of other characteristics in determining the path of labour supply over time. On the other hand, the lower intertemporal substitution elasticities for women without children are consistent with the idea that working women have rather stable labour market attachments. Only when young children are present does the elasticity of substitution become comparatively large.

Appendix A: The labour supply model

As in Blundell, Ham, and Meghir (1991), the $\alpha_0(\ )$ function is given by

$$\alpha_0(z_i) = \alpha_{00} + \alpha_{01} DK1_i + \alpha_{02} DK2_i + \alpha_{03} DK3_i \\ + \alpha_{04} DK4_i + \alpha_{0a} Age_i \,. \tag{29}$$

This assumes that $\alpha_0(z_i)$ depends on the wife's age and the age of her youngest child.

The form of the $a(w_i,z_i)$ is given by

$$a(w_i,z_i) = w_i \alpha_0(z_i) - \alpha_q(z_i) \,,$$

where

$$\alpha_q(z_i) = \alpha_{10} + \alpha_{11} K1_i + \alpha_{12} K2_i + \alpha_{13} K3_i + \alpha_{14} K4_i \,. \tag{30}$$

Table 7
The labour supply model; 1981–84 subsample.[a]

Variable	Coefficient	Standard error
	α_0 variables	
Constant	84.384	2.487
DK1	9.395	2.446
DK2	4.453	3.667
DK3	− 1.844	1.981
DK4	− 0.549	1.745
Age	7.453	0.768
	α_q variables	
Constant	− 40.073	5.138
K1	− 12.325	5.226
K2	− 12.924	3.897
K3	− 10.381	1.723
K4	5.010	1.072
	Budget share (β) variables	
Constant	0.2725	0.0076
Age	0.0428	0.0037
Age^2	0.0082	0.0011
DK1	0.1250	0.0144
DK2	0.0898	0.0183
DK3	0.0440	0.0105
DK4	0.0149	0.0082
Log *wage*	0.1219	0.0059
	Wage and other income residuals	
$\hat{u}_w$	0.0817	0.0058
$\hat{u}_\mu$	− 0.0007	0.0002
σ	0.0752	0.0030

[a] *Source*: Blundell, Ham, and Meghir (1991).

Note that this assumes that the $\alpha_q(z_i)$ depends on the number of children in each age group.

The income coefficient $\beta(z_i,w_i)$ is given by

$$\beta(z_i,w_i) = \beta_0 + \beta_1 DK1_i + \beta_2 DK2_i + \beta_3 DK3_i + \beta_4 DK4_i + \beta_w \ln w_i + \beta_a Age_i + \beta_{aa} Age_i^2. \quad (31)$$

Thus the income coefficient is assumed to depend on the wife's age, the age of her youngest child, and her log wage.

Appendix B: Data description

The data used in this research were drawn from the annual UK Family Expenditure Survey for the years 1970 to 1984. We selected the sample according to the following criteria:

(a) Only married couples are considered.
(b) The head of the household is a male.
(c) None of the spouses is self-employed.
(d) The male is aged 20–60 and the female 18–60.
(e) The household lives in Great Britain (Northern Ireland excluded).
(f) Obvious inconsistencies (such as negative expenditures, zero wages for workers, etc.) were also deleted.

After selection the total number of households was 43,671.

Variable definitions

DCHILD	= child dummy (= 1 for couples with children),
K1	= number of children with $0 < \text{age} \leq 2$,
K2	= number of children with $3 \leq \text{age} \leq 5$,
K3	= number of children with $6 \leq \text{age} \leq 10$,
K4	= number of children with $11 \leq \text{age} \leq 18$,
DC1	= 1 if $K1 > 0$, 0 otherwise,
DC2	= 1 if $K2 > 0$, 0 otherwise,
DC3	= 1 if $K3 > 0$, 0 otherwise,
DC4	= 1 if $K4 > 0$, 0 otherwise,
NOCHILD	$= 1 - DCHILD$,
DK2	$= DC2(1 - DC1)$,
DK3	$= DC3(1 - DC2)(1 - DC1)$,
DK4	$= DC4(1 - DC3)(1 - DC2)(1 - DC1)$,
AGE	= (age of the female − 40)/10,
WHC	= white collar occupation dummy (= 1 if the head is white collar),
HU	= unemployment dummy (= 1 if the head is unemployed),
MUL	= dummy variable = 1 for households with more than two adults,
Wage (w)	= net real marginal wage (pounds per hour),
Hours (h)	= female hours of work (per week),
Budget (c)	= household's (nominal) consumption expenditure (pounds per week),
Other income (μ)	= after-tax earnings minus consumption.

The data set is normalised to December 1986 prices.

Cohort data

Households were allocated to 10 different cohorts, according to the year of birth: 1911–15, 1916–20, ..., 1956–60 (see table 1).

Table 8

Variable	Mean	Standard deviation	Minimum value	Maximum value
HU	0.0652	0.2469	0.0000	1.0000
MUL	0.2472	0.4314	0.0000	1.0000
WHC	0.3593	0.4798	0.0000	1.0000
(*Age* – 40)/10	– 0.1598	1.0581	– 2.0000	2.0000
Hours	16.0985	15.9151	0.0000	97
Budget	75.5374	63.6988	5.3600	1026.5400

Appendix C

Table 9

$\varepsilon_{cp}^{\lambda}$.

	NOCHILD	*DK1*	*DK2*	*DK3*	*DK4*
10%	– 0.7231	– 0.8897	– 0.8193	– 0.7633	– 0.6189
25%	– 0.6437	– 0.7947	– 0.7271	– 0.6844	– 0.5708
Median	– 0.5742	– 0.6986	– 0.6425	– 0.6087	– 0.5240
75%	– 0.5145	– 0.6155	– 0.5679	– 0.5451	– 0.4783
90%	– 0.4703	– 0.5522	– 0.5118	– 0.4983	– 0.4432
Mean	– 0.5880	– 0.7124	– 0.6549	– 0.6233	– 0.5293

Table 10

ε_{hw}^{m}.

	NOCHILD	*DK1*	*DK2*	*DK3*	*DK4*
10%	– 0.1236	– 0.0466	– 0.0460	– 0.0703	– 0.0668
25%	– 0.0818	0.1394	0.1378	0.0351	– 0.0091
Median	– 0.0008	0.5272	0.4874	0.3095	0.4851
75%	0.2841	1.3295	1.2270	0.7662	0.5439
90%	0.7622	2.7960	2.3951	1.6805	1.2270
Mean	0.2494	1.0714	0.9933	0.6231	0.4629

Table 11

ε_{hw}^{u}.

	NOCHILD	*DK1*	*DK2*	*DK3*	*DK4*
10%	0.1297	0.2409	0.2141	0.1694	0.4911
25%	0.2048	0.4614	0.4463	0.3055	0.2839
Median	0.3187	0.8819	0.8232	0.6303	0.5099
75%	0.6295	1.7372	1.5673	1.0974	0.8951
90%	1.1457	3.1719	2.7783	2.0375	1.5991
Mean	0.5672	1.4258	1.3183	0.9266	0.7830

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