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Home production and the allocation of time and consumption over the life cycle

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Abstract

This paper estimates a model of female time allocation and non-durable consumption in an intertemporal utility maximization framework. We are using rather extensive but relatively unexploited series of repeated cross sections from the Dutch B.O. consumer expenditure survey from Statistics Netherlands (1978-2000). As male labor supply is known to respond rather inelastically to wage changes –perhaps due to restrictions on the labor market– we condition on male labor supply in the analysis. We specify assumptions on domestic production technology that allows us to estimate labor supply elasticities that are consistent with non-separable preferences over consumption, leisure and a non-marketable domestically produced good, without the explicit use of time-use data. We find that when intertemporal re-allocation of resources is taken into account female labor supply elasticities increase about 50% in size relative to what we find in a static framework (1.1 to about 1.7). Furthermore, we identify parameters of intertemporal allocation on a log linearized Euler equation using a synthetic panel with a large T dimension. The intertemporal allocation parameter is of reasonable size, but is imprecisely estimated. Moreover, we find that current income is a significant predictor for consumption growth (conditional on demographics). This could be interpreted as evidence against the validity of our version of the life cycle model. We do however offer a number of different explanations for this finding.

Keywords: Life Cycle models, female labor supply, synthetic panel data, Euler equation

JEL classification: D91, J22, C23, C24

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1 Introduction

Recent studies on time allocation emphasize the importance of domestic production (e.g., child care) within the context of female labor supply.[1] These studies depart from the traditional dichotomous tradeoff between consumption and leisure and consider a tradeoff between three goods: consumption, leisure and a good that is produced within the home. In the Netherlands working women reduce working hours from about 30 to about 16 on average after having children indicating the importance of this change of focus [see table (3). source: Statistics Netherlands expenditure survey]. Right at the outset we wish to attend the reader to the fact that we are mainly interested in female labor supply behavior. Male labor supply (in the Netherlands) is known to respond relatively inelastically to wage changes, perhaps due to important restrictions on the labor market (Theeuwes and Woittiez, 1992; Evers, de Mooij, and van Vuuren, 2008). We choose not to worry too much about the complex institutional context of the decision process on male labor supply and use it as a conditioning variable in our analysis (Browning and Meghir, 1991).

Empirical studies dealing with consumption, leisure and home production in a simultaneous framework are rare. Data requirements for estimating these models are rather demanding as information on time use must be combined with detailed information on wages, income and ideally consumption expenditures. Donni (2008) contributes to this problem by deriving properties of the domestic production function[2] that subsequently allows for estimating and interpreting standard models of labor supply (i.e., where domestic production is mistakenly ignored).[3] Donni (2008)'s analysis hinges on the assumption that the home produced good is a *marketable* good (i.e., a close substitute can be obtained from the market). In this paper we derive sufficient conditions on domestic technology that allows for estimating and interpreting standard models of labor supply when the home produced good is non-marketable.

We are furthermore considering the life cycle aspects of labor supply behavior. In this paper we are endogenizing the intertemporal allocation of full expenditures within the context of an expected utility model. (The intertemporal allocation of full expenditures is related to savings, but is not the same. Out of habit however we refer to this concept when we talk about savings in this paper.) Modeling the decision to save and the allocation of time simultaneously seems important. We motivate this with a short example: *Young couples planning to have children within a few years foresee significant increases in consumption related expenditures. When children are born, 'time' for leisure activities is scarce as children need to be looked after. To cover the expected increase in expenditures efficiently (i.e., by maximizing expected utility over the life cycle) households choose to increase current hours of market labor by sacrificing current leisure and increase savings. These households accumulate wealth that is used for consumption when children are born.* Static models typically do not capture this type of decision making.

In our example households not only decide on consumption, leisure and savings, but also consider home production, as in child care. The importance of home production in household

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[1] We use domestic production and home production interchangeably.

[2] We use the terms home production and domestic production interchangeably.

[3] Donni (2008) concludes: "a simple model of market labor supplies, which does not allow for domestic production, may conveniently fit the data if and only if (i) the profit function is additive or (ii) Engel curves are linear and the profit function has a particular, not necessarily additive form." "Quite importantly, however, the results ... crucially depend on the assumption that domestic goods are marketable (Donni, 2008)".

behavior has been taken seriously [See for example Becker (1965), Chiappori (1997), Apps and Rees (1997) and Apps and Rees (2003)]. Standard empirical studies of labor supply however often neglect the impact of home production on the allocation of time and consumption simply because standard data sets lack explicit time use data. Implicitly or explicitly, weakly separable preferences over the home produced good versus leisure and consumption are assumed. Separability assumptions of this kind are typically hard to justify. It is likely that a mother's choice to work or to leisure is affected by the time she spends in child care which rejects weak separability.[4]

Allowing for home production in one form or the other therefore seems important, but it is, as we already indicated, rather often frustrated by tough data requirements (i.e., we need full information on time use and wages). On top of that, modeling the endogenous decision to save is even more demanding in terms of data as in order to construct meaningful measures of full expenditures we need detailed information on consumption expenditures as well. Static models of labor supply typically assume that period t earnings are consumed within that same period and neglect for example savings in anticipation of demographic expansions. Furthermore, it has been argued that for estimating intertemporal preferences a large time T dimension of the data set is vital [our understanding of the literature on estimating Euler equations is that we typically need time variation as opposed to cross-section variation in the interest rate variable (Carroll, 2001; Attanasio and Low, 2002)].

In this paper we take a slightly different route than Donni (2008) in solving data related problems. We derive sufficient conditions on home production technology under which standard models of labor supply are well interpretable when *non-marketable* home production is mistakenly ignored (i.e., preferences over home production are non separable from leisure and consumption).[5] Obviously without data on time-use it is difficult to make statements about how people substitute between leisure and domestic labor such that –in that sense– the model is not fully identified. Yet, the required parameters for predicting hours of market labor supply and for predicting labor supply elasticities may be estimated without explicit time-use data. Under our assumptions on domestic technology standard preference parameters over consumption and leisure should be reinterpreted as perhaps complicated functions of preferences for consumption, leisure, home production and domestic technology parameters. This outcome offers a theoretical motivation for the importance of interacting parameters of standard labor supply models with demographic characteristics.

This paper presents two empirical novelties on Dutch micro data. We estimate a within period model on the allocation of female time and non-durable consumption that is consistent with intertemporal utility maximizing under uncertainty. Second, we estimate an Euler equation of non-durable consumption on a large T synthetic panel data set. Our estimation strategy is largely based on earlier work by Blundell and Walker (1986) as well as Blundell, Browning, and Meghir (1994). Blundell and Walker (1986) estimate a model of household labor supply and consumption that is consistent with intertemporal two-stage budgeting under uncertainty. Blundell, Browning, and Meghir (1994) study the life cycle allocation of household expenditures and the demand on different goods conditional on within period expenditure. Both papers

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[4] Weak separability is rejected when the marginal rate of substitution between leisure and consumption depends on the level of home production.

[5] Providing necessary conditions –like Donni (2008) does for marketable home production– is beyond the scope of the paper, but offers interesting and promising possibilities for further research.

originate from the two-stage budgeting principle that we also adopt here.

Euler equations are well suited for estimating intertemporal preference preferences which are needed to obtain a 'complete' picture of preferences. Blundell and Walker (1986) for example estimate a within period model that is consistent with life cycle theory, but do not estimate intertemporal preference parameters. Instead, they impose ad hoc assumption on intertemporal preferences for calculating life cycle consistent (or Frisch-) elasticities. We would like to emphasize that estimating intertemporal preference parameters is empirically significant in its own right. This study is the first that we know of that estimates consumption Euler equations on a Dutch large T micro data set. Note that in this paper we often refer to intertemporal preference parameters (or parameters of intertemporal allocation) as opposed to more specific concepts such as the elasticity of intertemporal substitution EIS (a concept that is often directly estimated from Euler equations under the assumption of CRRA preferences). As a result of the relative complexity of our model model specification intertemporal preference parameters do not exhibit such straightforward interpretations.

The intertemporal preference parameters are estimated using a log linearized Euler equation of non-durable consumption. Feasibility of estimating Euler equations has been on debate quite substantially. Excess sensitivity of consumption growth to lagged income and consumption variables has been found and has fueled criticism on the empirical credibility of the life cycle model. Another –more micro oriented– strand of the literature shows however that after correcting for demographics, excess sensitivity disappears (Blundell, Browning, and Meghir, 1994). We also control for demographics in estimating Euler equation, but still find excess sensitivity. Further resistance against the use of Euler equations to identify intertemporal parameters originates from a Monte Carlo study by Carroll (2001). Carroll (2001) argues that the log-linear Euler equation should be abandoned as a tool for estimating intertemporal parameters. The validity of his argumentation depends however on whether cross sectional variation rather than time variation in the interest rate is used in estimation, and when households are buffer stock savers (i.e., impatient households that are confronted with (not binding) borrowing constraints). The interest rate on average, only affects the size of the buffer stock, not the expected change in consumption. Attanasio and Low (2002) in another Monte Carlo analysis show that Carroll's claim does not apply when the T dimension of the data set is sufficiently large. Our micro data set spanning 23 years seems to satisfy the large T requirement.

Our main findings are summarized as follows: under specific, but reasonable assumptions on home production technology we are able to estimate a intertemporal model of female labor supply and consumption, without time-use data and without forcing undesirable separability assumptions on preferences. We have been estimating a within period model of female labor supply and consumption, conditional on male labor supply and demographic variables. We find no evidence for non-separable preferences over non-durable consumption and female non-market time.[6] Furthermore, after conditioning on demographics and male labor supply variables we still find excess sensitivity of consumption to lagged income. We offer a number of different explanations for this finding. The intertemporal allocation parameter we find on a log-linearized version of the Euler equation of non-durable consumption is imprecisely estimated. Within the

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[6] Female non-market time is defined as female time other than market labor supply. Non-market time is the sum of hours of leisure and hours of domestic labor supply.

context of the Euler equation we do not detect specification errors for the within period model as the overidentifying restriction on the intertemporal allocation parameter could not be rejected.

The paper is organized as follows: section (2) sets up a theoretical framework from which structural relationships are derived. Section (3) elaborates on the data set we use in estimation. Section (4) deals with the econometric techniques that are needed to estimate the parameters of interest and presents the regression results as well as the estimated elasticities. We report average within group elasticities. Groups were selected on the basis of age and on the presence of children within the household (Blundell and Walker, 1986).

2 Theory

In the introduction we emphasize the need for a multi-period model to describe preferences. The standard vehicle for that purpose is a life cycle model. Households are assumed to maximize expected utility over the life cycle subject to a set of constraints. We follow Blundell, Browning, and Meghir (1994) by defining instantaneous utility.

$$U_t = F_t\left(u_t\left(c_t^{ND}, l_{m,t}, l_{f,t}, x_t, \tilde{z}_{1t}\right), z_{2t}\right) + H\left(z_{3t}\right) \tag{1}$$

Instantaneous utility is a function of non-durable consumption c_t^{ND}, male leisure $l_{m,t}$, female leisure $l_{f,t}$, a non-marketable domestically produced good x_t and three vectors of (possibly endogenous) conditioning variables $\tilde{z}_{1t}$, z_{2t} and z_{3t}. These variables may contain male labor supply, demographic composition etc., and may contain overlapping elements. The $\tilde{z}_{1t}$ variables are non-separable from the goods of interest and directly affect within period demand. The z_{2t} variables are weakly separable from goods of interest, such that they do not affect within period demand, but affect the intertemporal allocation of full expenditure. Variables in z_{3t} are additively separable from the goods of interest and its level does not affect any (important) decision making directly. $H\left(z_{3t}\right)$ is therefore excluded from the analysis.

The value function $V_t\left(A_t\right)$ represents the value of all future expected discounted utilities as a function of wealth [like Zeldes (1989)].

$$\begin{aligned} V_t\left(A_t\right) = \max_{c_t^{ND}, d_{m,t}, d_{f,t}, h_{f,t}} \Big[& F_t\left(u_t\left(c_t^{ND}, l_{m,t}, l_{f,t}, x_t, \tilde{z}_{1t}\right), z_{2t}\right) + E_t \frac{1}{1+\delta} V_{t+1}\left(A_{t+1}\right) \\ & -\mu_{1ft}\left(-h_{ft}\right) - \mu_{2mt}\left(-d_{mt}\right) - \mu_{2ft}\left(-d_{ft}\right) \Big] \end{aligned} \tag{2a}$$

where

$$\begin{aligned} A_{t+1} &= \left(1+r_{t+1}\right)\left(A_t + \tilde{I}_t^{other} + \left(T_f - l_{f,t} - d_{f,t}\right) w_{f,t} + \left(T_m - l_{m,t} - d_{m,t}\right) w_{m,t} \right. \\ & \quad \left. -p_t^{ND} c_t^{ND} - E_t^D\right) && \text{(2b)} \\ x_t &= x\left(d_{m,t}, d_{f,t}\right) && \text{(2c)} \\ A_L &= 0 && \text{(2d)} \\ l_{m,t} &= T_m - \bar{h}_{m,t} - d_{m,t} && \text{(2e)} \\ l_{f,t} &= T_f - h_{f,t} - d_{f,t} && \text{(2f)} \end{aligned}$$

We model the period t decision making process of non-durable consumption c_t^{ND}, female hours of leisure $l_{f,t}$ and male domestic labor supply $d_{m,t}$ and female domestic labor supply $d_{f,t}$. We condition on male hours of market labor supply $\overline{h}_{m,t}$ and $\tilde{z}_{1t}$. Male and female domestic labor supplies – $d_{m,t}$ and $d_{f,t}$– are the only production factors in producing x_t. $d_{m,t}$ and $d_{f,t}$ are fully determined conditional on domestic technology, wages and the amount x_t that the household decides upon. $d_{f,t}$, $d_{m,t}$ and $h_{f,t}$ are nonnegative. μ_{1ft}, μ_{2mt} and μ_{2ft} are the respective Kuhn-Tucker multipliers associated with the nonnegativity constraints. Expected future value of wealth $V_{t+1}(A_{t+1})$ is discounted at rate δ.

The right hand side of equation (2b) are end of period t savings[7] earning an interest r_{t+1} at the beginning of period $t+1$. End of period t savings is the sum of period t assets A_t, other income $\tilde{I}_t^{other}$, male market labor income $(T_m - l_{m,t} - d_{m,t})\, w_{m,t}$, female market labor income $\left(T_f - l_{f,t} - d_{f,t}\right) w_{f,t}$, minus non-durable expenditures $p_t^{ND} c_t^{ND}$ (where p_t^{ND} is the price of non-durable goods), minus durable expenditures E_t^D. We assume that there is no bequest motive (equation (2d)). Hours of market labor as well as hours of domestic labor cannot be smaller than zero. The non-negativity constraint on hours of male market labor supply is automatically satisfied as male labor supply $\overline{h}_{m,t}$ is a conditioning variable in the analysis. The model differs from a standard life cycle model of labor and consumption by the incorporation of home production. Hours of leisure depend directly on the level of home production.

It is convenient to rewrite the above defined consumer problem by constructing a cost function for the home domestically produced good x_t and subsequently impute this in the original problem. The cost function represents the minimum cost of attaining x_t and is a function of market wages, domestic technology parameters and x_t itself. Under certain assumptions on home production technology this procedure identifies an 'implied price' of the home produced good as the cost function maybe written as $p_t^{HP}\left(w_{m,t}, w_{f,t}, \Theta\right) x_t$. Where $p_t^{HP}\left(w_{m,t}, w_{f,t}, \Theta\right)$ is the implied price of the home produced good and is a function of male and female wages and technology parameters Θ. This representation of the cost function allows us to deal –at least in theory– with non-marketable home production x_t in the same as way we deal with any other good. The problem with this relatively general representation of the cost function is that we somehow need to measure home production and time-use data to estimate the parameters of the home production technology function. The following section elaborates on some of the principles of home production. Under some –to our judgement reasonable– assumptions on home production technology, standard models of female labor supply remain well interpretable without using time-use data.

2.1 Home production

The analysis of home production often starts with defining home production technology. In line with standard models of the firm, Apps and Rees (2003) for example introduce a home production function that is strictly quasi concave. Quasi concavity implies complementarities of both production factors. In standard production theory, when capital and labor are the two important factors of production it is often intuitive that the marginal product of labor increases in the level of capital stock. For home production –when male and female time are often the only

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[7] Until now we have used 'savings' as short for the intertemporal allocation of full expenditures. Here we use the term 'savings' in the usual interpretation.

factors of production– the story is quite different. It is not obvious why the wife's efficiency in taking the children to school increases while the husband mows the lawn. In this particular case perfect substitutability of the production factors in production may be more appropriate. Note that perfect substitutability does not imply that both household members are equally efficient in producing, but only that the elasticity of substitution between factors is constant.

We note however that perfect substitutability is not satisfactory in all cases. A child may benefit from being raised by both of its parents such that complementarities between male and female time should be introduced. There is, however, no a priori rationale to prefer one over the other technology beforehand. Interesting progress could be attained by testing one against the other econometrically with time-use data. In this paper we assume that the factors of production are perfect substitutes and in addition we assume that the production function exhibits constant returns to scale. The constant returns to scale assumption is another important requirement for our subsequent results. For many types of domestic jobs the constant returns to scale assumption seems reasonable however. Driving the children to school n times requires n time inputs, no matter the size of n. Under the assumptions mentioned above, the production function has the following form:

$$x_t = x\left(d_{m,t}, d_{f,t}\right) = k \times \left(\pi d_{m,t} + d_{f,t}\right) \tag{3}$$

k is a measure of productivity of the household and π is measure of male productivity relative to female productivity. When $\pi = 1$ males and females are equally productive in producing x_t. The cost function is derived by minimizing the cost of production for a given level of output and non-negative domestic labor supplies:

$$\text{cost}\left(w_{m,t}, w_{f,t}, x_t\right) = \min_{d_{m,t}, d_{f,t}} \left[w_{m,t}d_{m,t} + w_{f,t}d_{f,t} \middle| x_t = k \times \left(\pi d_{m,t} + d_{f,t}\right), -d_{mt} \leq 0, -d_{ft} \leq 0\right] \tag{4}$$

The cost of one hour of domestic labor are hourly market wages (i.e., the forgone revenue of one hour of market labor supply). The cost function conditional on our production technology (3) becomes:

$$\text{cost}\left(w_{m,t}, w_{f,t}, x_t\right) = p_t^{HP} x_t = \begin{cases} \frac{w_{f,t}}{k} x_t & \text{if } w_{f,t} < \frac{w_{m,t}}{\pi} \\ \frac{w_{m,t}}{k\pi} x_t & \text{if } w_{f,t} > \frac{w_{m,t}}{\pi} \end{cases} \tag{5}$$

The cost function consists of two parts. First, when female wages relative to female productivity is smaller than the male counterpart it is optimal for women to take care of all home production x_t that the household decides upon. Similarly, when male wages relative to male productivity is smaller then the female counterpart it is optimal for men to take care of all home production. The first representation of the cost function is probably the most appropriate for the Dutch situation, as on average women earn less then men and take care of the larger share of the household's child care. Note that x_t could in principle be a vector that contains different kinds of home produced goods, each produced with technology similar to equation (3). The analysis could be extended for x_t being a vector of multiple domestically produced goods where domestic jobs are allocated between husband and wife in terms of their relative efficiency in producing. If all goods are produced with equation (3) based technology the subsequent analysis does not change fundamentally.

In the next sections we study the most obvious case where women are cost efficient in producing the home produced good, but the exact same reasoning will apply to the case when men are cost efficient (i.e., we assume that $w_{f,t} < \frac{w_{m,t}}{\pi}$). Conventional models of labor supply are consistently estimated in both cases, but the interpretation of the preference parameters differs between the two. Under the assumption that women are cost effective in home production the cost function of the home produced goods boils down to the following simple representation:

$$\text{cost}\left(w_{m,t}, w_{f,t}, x_t\right) = p_t^{HP} x_t = \frac{w_{f,t}}{k} x_t \tag{6}$$

Male time in producing the home produced good equals zero, such that the production function (equation (3)) simplifies as follows:

$$x_t = kd_{f,t} \tag{7}$$

The key result of our assumptions on home production technology is that the implied price of the home produced good is a linear function of either male or female wages. Perfect substitutability of production factors (male and female time) and constant returns to scale of home production technology is sufficient to satisfy this property. Under these properties of home production technology the price of the home produced good is a linear function of male or female wages on the whole positive wage domain. When prices of $l_{f,t}$ and x_t move in lockstep, Hicks' composite commodity theorem applies. It is subsequently straightforward to show that estimating a model of female labor supply without explicit time-use data is feasible, even if preferences for the home produced good are non-separable from leisure and consumption.

Deaton and Muellbauer (1980) elaborate on the working of Hicks' composite commodity theorem:'... this is the composite commodity theorem, which asserts that if a group of prices move in parallel, then the corresponding group of commodities can be treated as a single good.' Define a within period cost function $c\left(w, p^{HP}, p, u\right)$ governing preferences over leisure l, the home produced good x and a consumption vector q with respective prices w, p^{HP} and p. As a result from our assumptions on home technology the implied price of the home produced good is proportional to (male or female) wages: $p^{HP} = \frac{w}{k}$. The cost function therefore becomes $c\left(w, \frac{w}{k}, p, u\right)$ which –since k is a fixed parameter– can be written as a function of w, p and u alone: $c^*(w, p, u)$. Differentiating this cost function with respect to w yield the compensated demand for the composite good $\frac{\partial c^*(w,p,u)}{\partial w} = l + \frac{x}{k}$.[8] So, $l + \frac{x}{k}$ is the quantity of the composite commodity that corresponds to price w. 'Since the cost function provides a complete picture of preferences, this demonstration shows that ... new preferences can be defined over q and $l + \frac{x}{k}$ and that these preferences lead to the same choices as the original ones (Deaton and Muellbauer, 1980).'

The composite good corresponding to female wages is the sum of female leisure and home production scaled by a productivity factor $l_{f,t} + \frac{x_t}{k}$. Using equation (7) it is straightforward to show that the composite good equals female time that is spent outside the labor market, hence the sum of hours of leisure and hours of domestic labor supply. We define this variable as female 'non-market time' or n_t:

$$n_{f,t} = l_{f,t} + \frac{x_t}{k} = l_{f,t} + d_{f,t} \tag{9}$$

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[8]

$$\frac{\partial c^*(w,p,u)}{\partial w} = \frac{\partial c\left(w, \frac{w}{k}, p, u\right)}{\partial w} = c_1\left(w, \frac{w}{k}, p, u\right) + c_2\left(w, \frac{w}{k}, p, u\right) \times \frac{1}{k} = l + \frac{x}{k} \tag{8}$$

c_1 and c_2 are partial derivatives with respect to the first and the second element respectively.

Female market labor supply is the complement of female non-market time: $h_{f,t} = T_f - n_{f,t}$. The above derivations show that under our technology assumptions, standard (static as well as dynamic) models of labor supply can be consistently estimated and interpreted even if time-use data is not available. The traditional dichotomous tradeoff between leisure and consumption should be reinterpreted as a tradeoff between non-market time and consumption. It is obvious therefore that the interpretation of the preference parameters as well as the estimated elasticities should also be reinterpreted. Preferences for consumption and non-market time composites of preferences for consumption, leisure, home produced goods, and domestic productivity parameters. The change of focus also seems to indicate that discriminating households with and without children deserves additional attention. Clearly, when couples become parents preferences for non-market time will change drastically. Preferences for the home produced good, female leisure and the productivity parameters cannot be identified separately without the appropriate data (i.e., time-use data, definitions of home produced goods).

2.2 A model of female time allocation

We simplify the original consumer problem described by equation (2) by incorporating the results on home production derived in the previous section. The new model deals with the life cycle allocation of non-market time and consumption.

$$V_t\left(A_t\right) = \max_{c_t^{ND}, n_{f,t}} \left[F_t\left(u_t\left(c_t^{ND}, n_{f,t}, z_{1t}\right), z_{2t}\right) + E_t \frac{1}{1+\delta} V_{t+1}\left(A_{t+1}\right) - \mu_{1ft}\left(-\left(T_f - n_{f,t}\right)\right)\right] \tag{10a}$$

subject to:

$$A_{t+1} = \left(1 + r_{t+1}\right)\left(A_t + I_t^{other} + \left(T_f - n_{f,t}\right) w_{f,t} - p_t^{ND} c_t^{ND} - E_t^D\right) \tag{10b}$$

$$A_L = 0 \tag{10c}$$

where I_t^{other} includes male income, hence $I_t^{other} = \tilde{I}_t^{other} + \overline{h}_{m,t} w_{m,t}$. z_{1t} includes male leisure. The non-negativity constraints on female domestic labor supply are satisfied by equation (4).

λ_t is defined as the marginal utility of wealth $V_t'\left(A_t\right)$. The conditions for a maximum of the above decision problem are:

$$1 : \frac{\partial F_t}{\partial u_t} \frac{\partial u_t}{\partial c_t^{ND}} - \lambda_t p_t^{ND} = 0 \tag{11a}$$

$$2 : \frac{\partial F_t}{\partial u_t} \frac{\partial u_t}{\partial n_{f,t}} - \lambda_t w_{f,t} - \mu_{1ft} = 0 \tag{11b}$$

$$3 : -\left(T_f - n_{ft}\right) \leq 0 \quad \text{with equality if } \mu_{1ft} > 0 \tag{11c}$$

$$4 : \lambda_t = E_t \frac{1 + r_{t+1}}{1+\delta} \lambda_{t+1} \tag{11d}$$

μ_{1ft} is the Kuhn-Tucker multiplier associated with the inequality constraints on hours of female market labor supply. For the moment we assume that the Kuhn-Tucker multiplier is zero such that the nonnegativity constraint on hours of market labor supply is not binding. We account for this data selection in the empirical analysis by adjusting the likelihood function [see Blundell and

Walker (1986)]. Equation (11d) presents the well known result of dynamic utility optimization models. In expectation, discounted marginal utility of wealth should be constant over time. This type of relationships are known as Euler equations and are utilized in section (4) to identify intertemporal allocation parameters.

2.2.1 Two-stage budgeting and the specification of preferences

To estimate a life cycle model that allows for labor supply one basically needs data on consumption alongside data on hours and wages to construct reliable measures of *full* expenditures (i.e., the total 'expenditures' on non-market time of and consumption). The availability of detailed information on consumption, income variables and hours of paid labor within our data set allows us to take the life cycle approach. Note however that panel data (or synthetic panel data) is not a prerequisite in order to estimate a model that is consistent with intertemporal maximization under uncertainty. Simply by combining condition (11a) and condition (11b) with the within period budget constraint one is able to construct a model of labor supply that is consistent with expected utility maximization under uncertainty [e.g., Blundell and Walker (1986)]. We use this property in this paper which allows us to estimate all the interesting parameters of the model in two consecutive steps.

This particular identification strategy is better known as the two-stage budgeting approach (e.g., Blundell and Walker (1986)). Households allocate life time resources over consecutive periods in the first stage, fixing full expenditure in every period. In the second stage households allocate full period t expenditures over within period goods. Note that we are analyzing a *conditional* consumer allocation problem where households make decisions conditional on z_{1t} (that includes male labor supply). Full expenditures therefore means the total expenditures on the goods of interest, female non-market time and non-durable consumption. An attractiveness of two-stage budgeting is that the parameters of the instantaneous utility function $u(\cdot)$ can be identified conditional on within period prices and within period full expenditures. A disadvantage of the strategy is that preferences must be (weakly) separable over time. In the empirical section (4) we find that consumption growth is excessively sensitive to lagged income measures. Excess sensitivity may have many causes of which intertemporal non-separability is one.

The second stage model may be constructed by combining the first order conditions (11a) and (11b) with full expenditures on the goods of interest y_t. y_t therefore operates as a suitable conditioning variable capturing 'future anticipation and past decisions (Blundell and Walker, 1986).' These conditions show that within period behavior is completely characterized conditional on full period t expenditures and within period prices, and offers the opportunity to estimate a good deal of the model parameters by estimating standard (conditional) uncompensated demand functions. Note that the parameters of F are not identified in the second stage as the terms that include F cancel out by combining (11a) and (11b).

In this paper we derive the second stage demand system from an indirect utility function. The *conditional indirect utility function* is defined as follows:

$$F\left(\Psi_t\left(p_t^{ND}, w_{f,t}, z_{1t}, y_t\right), z_{2t}\right) = \max_{c_t^{ND}, n_{f,t}} \left[F\left(u\left(c_t^{ND}, n_{f,t}, z_{1t}\right), z_{2t}\right) \middle| y_t = p_t^{ND} c_t^{ND} + w_{f,t} n_{f,t}\right] \qquad (12)$$

As opposed to defining direct utility functions it is rather common that indirect utility functions (or cost functions) are specified to derive demand functions. Indirect utility functions exhibit the important advantage that they may be specified sufficiently flexible to accommodate important features of demand while at the same algebraic solutions for the structural relationships (e.g., demand systems) still exist. The usual candidates for a direct utility function does not exhibit both properties simultaneously. Other scholars however employ direct within period utility functions to facilitate the estimation of the intertemporal allocation parameters using Euler equations of non-durable consumption (Bean, 1986; Ziliak and Kniesner, 2005) sacrificing the opportunity of constructing demand systems (in case of Ziliak and Kniesner (2005)). This is a sensible option as estimating the Euler equations of non-durable consumption seems the most profitable strategy of estimating intertemporal allocation parameters. In the empirical section of this paper we were unable to reject the linear expenditure system in favor of the more general specification that we propose in this section. For the linear expenditure system there exists a direct utility function. In section (4.2) we therefore switch back to this direct utility function to derive the Euler equation of non-durable consumption that is subsequently used for estimating the parameters of F.

A widely used functional form to organize intertemporal preferences $F(\cdot)$ is the CRRA (Constant Relative Risk Aversion) utility function. This specification is popular, because it is capable of capturing some important aspects of behavior such as for example the precautionary motive (Browning and Lusardi, 1996). We are specifying the following functional form to operationalize equation (12):

$$F\left(\Psi_t\left(p_t^{ND}, w_{f,t}, z_{,1t}, y_t\right), z_{2t}\right) = \frac{1}{1-\rho}\left(\frac{y_t - a\left(p_t^{ND}, w_{f,t}, z_{1t}\right)}{b\left(p_t^{ND}, w_{f,t}, z_{1t}\right)}\right)^{1-\rho} \times \exp\left[\alpha' z_{2t}\right] \tag{13}$$

The parameter ρ determines the curvature of the utility function and is a measure of risk aversion. When ρ is large, households display high aversion to future utility losses and indifference to future utility gains. $a(\cdot)$ and $b(\cdot)$ are homogenous of degree 1 in within period prices and α is a vector of parameters:

$$\begin{aligned} a\left(p_t^{ND}, w_{f,t}, z_{1t}\right) &= \gamma_c\left(z_{1t}\right) p_t^{ND} + \gamma_n\left(z_{1t}\right) w_{f,t} + 2\gamma_{nc}\sqrt{p_t^{ND} w_{f,t}} && (14) \\ \ln b\left(p_t^{ND}, w_{f,t}, z_{1t}\right) &= \beta_c\left(z_{1t}\right) \ln p_t^{ND} + \beta_n\left(z_{1t}\right) \ln w_{f,t} && (15) \end{aligned}$$

The model nests the linear expenditure system if $\gamma_{fc} = 0$. The variables z_{1t} are (potentially) non-separable from within period goods and (potentially) affect within period decision making directly. We allow for this dependence in roughly the same way as in Blundell and Walker (1986). The cost of living parameters (γ_n and γ_c) are allowed to vary with family size (i.e., the number of household members fs). During demographic transitions preferences for the home produced good will change such that interacting the preference parameters with demographic variables is important.

$$
\begin{aligned}
\gamma_n &= \gamma_n^0 + \gamma_n^{fs} \cdot fs && (16) \\
\gamma_c &= \gamma_c^0 + \gamma_c^{fs} \cdot fs && (17) \\
\gamma_{nc} &= \gamma_{nc} && (18)
\end{aligned}
$$

γ_{nc} is not parameterized. The β parameters are interacted with age (age), male hours of market labor supply ($\overline{h}_m$) and three dummy variables $D1$, $D2$ and $D3$. The three dummy variables are unity when the youngest child is below 6, between 6 and 12 and between 12 and 18 years old respectively. The presence of young children is expected to affect preferences strongly as the household's relative valuation of time at home increases. We obtain:

$$
\begin{aligned}
\beta_n &= \beta_n^0 + \beta_n^{D1} \cdot D1 + \beta_n^{D2} \cdot D2 + \beta_n^{D3} \cdot D3 + \beta_n^{age} \cdot (age - 40) + \beta_n^{h_m} \cdot \overline{h}_m && (19) \\
\beta_c &= 1 - \beta_n && (20)
\end{aligned}
$$

The adding up constraint imposes $\beta_c = 1 - \beta_n$.

Due to the adding up constraint on demand, one of the two demand functions is dropped from the analysis without loss of generality. The choice for either one of the two demand functions is arbitrary. In this paper we focus on demand for female non-market time or on its complement: female market labor supply. The specification of a conditional indirect utility function allows us to derive conditional demand functions. The conditional uncompensated demand function for female non-market time is derived by applying Roy's identity to the indirect utility function. The female market labor supply function is subsequently constructed by subtracting demand for non-market time from total time endowment T_f:

$$
\begin{aligned}
h_{f,t}^{\text{uncomp.}} = T_f - n_{f,t} &= -a^*_{w_{f,t}} - \frac{b_{w_{f,t}}}{b}\left[y_t^* - a^*\right] && (21) \\
&= -\gamma_n^* - \gamma_{nc}\sqrt{\frac{p_t^{ND}}{w_{f,t}}} - \frac{\beta_n}{w_{f,t}}\left[y_t^* - \gamma_c p_t^{ND} - \gamma_n^* w_{f,t} - 2\gamma_{nc}\sqrt{p_t^{ND} w_{f,t}}\right] && (22)
\end{aligned}
$$

where

$$
\begin{aligned}
a^*\left(p_t^{ND}, w_{f,t}, z_{1t}\right) &= \gamma_c\left(z_{1t}\right) p_t^{ND} + \gamma_n^*\left(z_{1t}\right) w_{f,t} + 2\gamma_{nc}\sqrt{p_t^{ND} w_{f,t}} && (23) \\
\gamma_n^* &= \gamma_n - T_f && (24) \\
y_t^* &= y_t - T_f w_{f,t} = p_t^{ND} c_t^{ND} - h_{f,t} w_{f,t} && (25)
\end{aligned}
$$

Specifying total time endowment T_f is not necessary as due to our assumptions on preferences, T_f is subsumed in one of the parameters. $a^*_{w_{f,t}}$ and $b_{w_{f,t}}$ are partial derivatives with respect to female wages of a^* and b respectively. y_t^* is our 'new' measure of full expenditures. The parameters of Ψ are estimated using the relationship defined by (22) in the second stage regression of section (4.1).

Compensated demands are obtained by inverting the conditional indirect utility function and writing y_t^* as a function of prices and within period utility (i.e., the conditional cost function) and substituting this into equation (21):

$$h_{f,t}^{\text{comp.}} = -a^*_{w_{f,t}} - b_{w_{f,t}} \overline{U} \tag{26}$$

where $\overline{U}$ and is a measure of within period utility. Note that the parameters of F do not enter the compensated nor the uncompensated demand functions.[9]

The demand functions (21) and (26) are consistent with life cycle theory. However, elasticities that are calculated on the basis of these models are conditional on full expenditures and within period utility respectively and therefore do not account for the intertemporal reallocation of resources. We have argued in our introduction that the intertemporal context of decision making matters, such that in the optimum full expenditures y_t^* will respond to within period price changes. More specifically, our model assumes that y_t^* responds to within period price changes in such a way that marginal utility of wealth (λ_t) stays constant over time (in expected discounted terms). Demand functions that exhibit this property are called Frisch (or λ-constant) demand functions. It is intuitive that Frisch demand elasticities can be estimated only after having acquired information on the structure of intertemporal preferences F.

Life cycle consistent (or Frisch-) demand functions are obtained by writing marginal utility of wealth λ_t as a function of full expenditures and by substituting this relationship into the uncompensated demands:[10]

$$h_{f,t}^{\text{Frisch.}} = -a^*_{w_{f,t}} - b_{w_{f,t}} \left[\left(\frac{b\lambda_t}{\exp\left[\alpha' z_{2t}\right]} \right)^{-\frac{1}{\rho}} \right] \tag{27}$$

Price elasticities derived from equation (27) incorporate the effects of intertemporal reallocation of full expenditures on the goods of interest and lead to interesting deviations from standard uncompensated elasticities.

In order to compute Frisch demand responses the parameters of F are estimated in addition to the parameters of Ψ and requires appropriate data with a long T dimension. Blundell and Walker (1986) however fix the parameters of F at a 'reasonable' value (i.e., $\rho = 1$ such that $\frac{1}{1-\rho}(\cdot)^{1-\rho} = \log(\cdot)$). We obtain an estimate of ρ by estimating an Euler equation of non-durable consumption. We return to this issue in section (4). Note that even if households make decisions such that borrowing constraints (not explicitly modeled) are currently binding Frisch demand functions may be constructed. In that case however, estimated elasticities based on Frisch demands are hard to interpret as the elasticities no longer reflect efficient intertemporal re-optimization of resources.

3 Data

We estimate the parameters of our model using a time series of cross-sections drawn from the public-use files of the Statics Netherlands B.O. consumer expenditure survey. The survey has

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[9] Within period utility U is defined as $F\left(\frac{y_t^* - a_*}{b}, z_{2t}\right)$. $\overline{U}$ is defined as $F^{-1}(U, z_{2t})$.

[10] We can show that in the optimum $\lambda_t = \frac{\partial}{\partial y_t^*} \frac{1}{1-\rho} \left(\frac{y_t^* - a^*\left(p_t^{ND}, w_{f,t}, z_{1t}\right)}{b\left(p_t^{ND}, w_{f,t}, z_{1t}\right)} \right)^{1-\rho} \times \exp\left[\alpha' z_{2t}\right] = \left(\frac{y_t^* - a^*\left(p_t^{ND}, w_{f,t}, z_{1t}\right)}{b\left(p_t^{ND}, w_{f,t}, z_{1t}\right)} \right)^{-\rho} \frac{1}{b\left(p_t^{ND}, w_{f,t}, z_{1t}\right)} \times \exp\left[\alpha' z_{2t}\right]$

collected yearly data of around 2000 households from 1978 to 2000.[11] The study relates information on household's state, such as income, number of children, etc., to expenditure on a detailed set of consumption goods, services and taxes. Moreover, we have information on both male and female hours of paid labor for the 1988 to 1991 waves. All waves, from 1978 to 2000, contain information on whether both male and female work full-time, part-time or not at all.

The within period model (the consumption - non-market time tradeoff conditional on within period full expenditures) is estimated on the 4 waves that contain complete information on hours of labor and consumption (i.e., the 1988 to 1991 waves). Consumer expenditure is broken down into two broad categories: durable- and non-durable consumption goods. Non-durable consumption goods fully depreciate within one period. Durable consumption goods depreciate at a slower rate. Non-durable consumption goods concern food, clothing, rent (as well as imputed rents for house owners). Durable consumption expenditures are investments in education, cars, furniture, refrigerators, etc. Durable consumption is excluded from the analysis such that we effectively assume that preferences for durable consumption are sufficiently separable from the process under study.

For estimating the parameters of F we estimate a dynamic model on a synthetic panel that is constructed out of the full data set. It has been shown that dynamic models can be estimated using series of repeated cross-sections (Moffitt, 1993; Verbeek and Vella, 2004). This technique predicts unobserved lagged (dependent) variables with cohort dummies as instruments and is equivalent to estimating dynamic models with cohort averages as variables. One of the disadvantages of using synthetic panels is that it introduces sampling error as cohort averages are just estimates of cohort means. To minimize the sampling error cohort averages should be constructed out of a sufficiently large group of individual households. Sampling weights are used to improve the representativeness of the cohort averages. Individual households in our sample are separated into cohorts that span five years. Using this procedure we end up with 15 cohorts measured over 23 year (=345 observations). On average the number of household specific observations per cohort/time average is 185, with about 5% of the cohort/time averages that are constructed out of less than 50 individual households.

Three issues with missing data occurred. Most of our waves (all of them except the 1988 to 1991 waves) lack information on hours of market labor supply of both adult members of the household. Fortunately, all waves contain information about the full-time or part-time labor status of both adult household members. These binary variables appear to be very good predictors for hours of labor. With the information on full-time or part-time labor status we have imputed hours where they were missing. To obtain estimates on hours we use the 'hotdeck' imputation procedure.[12] Note that the imputed hours are merely used as a conditioning variable in estimating the Euler equation and not to estimate the within period labor supply model.

Second, the 1989 wave lacks information on tax expenditures other than income tax. Missing data is imputed by means of a regression analysis using data of the adjacent years, 1988 and 1990. i.i.d. error terms are added to the predicted values to preserve the variability of the data. Third, our data set does not contain explicit information on hourly wages. Evidently, wages are

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[11] From 1978 to 1987 the data set contained of around 2500 observations per year. From 1988 to 2000 of around 1700 observations per year, where 1991 is an negative outlier with 900 observations per year

[12] The hotdeck method starts from the principle of taking random draws from appropriate sub samples of the data set.

an important argument in a female labor supply model. Net wages are therefore constructed by dividing female net labor income by the number of hours of labor. Because hours of labor are likely to be measured with error, constructed wages are infected with the same measurement error. This is problematic not only because the measurement error leads to imprecisely estimated wages, but it also produces a spurious negative correlation between hourly wages and hours of labor. We solve the measurement error problem by instrumenting the constructed wages[13] and using the predicted wages in the labor supply regression.

3.1 Stylized facts at the macro and at the micro level

Before we are estimating the parameters of the model we show some of the important stylized facts of the data. This improves intuition about the process that drives economic outcomes and checks for possible irregularities in the data. First we check whether the consumption series of the expenditure survey (our data set) corresponds to aggregate consumption series of the national accounts. Moreover, we check whether the predicted hours of labor exhibit the well known upward trend that has been driving average female hours over the sample period. On a micro scale we are interested in the relevancy of a life cycle model. After correcting for family size and number of children, we show that 'consumption smoothing' concept seems justified, at least visually.

The relevance of our econometric estimates depend obviously on the reliability of the data set we use. We have compared our data from the expenditure survey with other measures of consumption. To do so, we have constructed aggregate consumption series from the expenditure survey and plotted it together with macro economic figures on consumption from the national accounts in figure (1A.). For making both series comparable, data from the expenditure survey is corrected for population growth and change in family size.[14] The (corrected) measure of total consumption from the expenditure survey matches the aggregate measure of consumption from the national accounts very well such that there is no reason to reject one measure over the other in terms of reliability. When we impute hours of labor we assume that the expected hours of labor for the average full-time and part-time worker is constant over time. Hereby we attribute any visible change in hours of female labor activity over time to an increase in the number of females working full-time or part-time. The time series of figure (1B.) suggest that an increasing number of women engage in paid labor over time. A result that is consistent with the general trend in the Netherlands.

We also take a closer look at the micro properties of our data. Here we follow the reasoning of e.g., Attanasio and Browning (1995) to justify the attempts to model female time allocation and consumption within a life cycle framework. It is obvious that we would not want to assume a concept of consumption smoothing when households actually do something else. The life cycle specification in its most elementary form –without uncertainty and restrictions of any sort and with the interest rate equal to the rate of time preference– predicts a constant level of consumption

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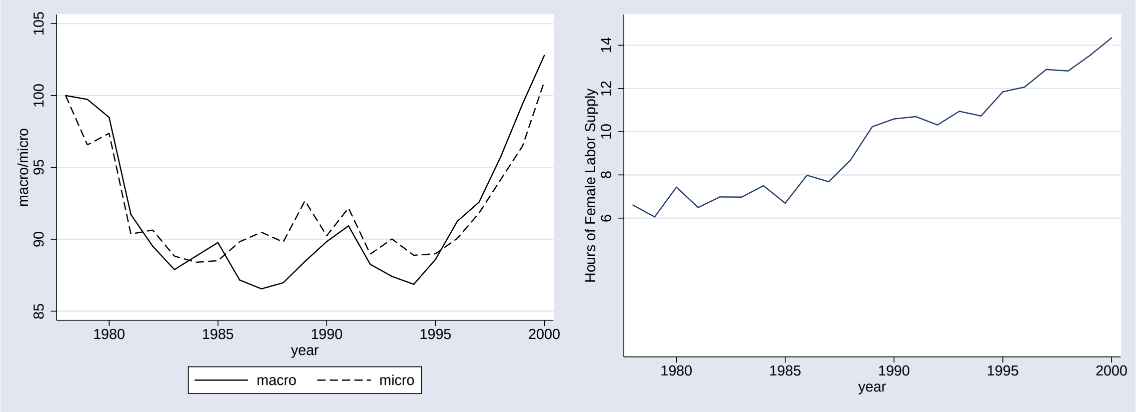
[13] One should not worry about endogeneity problems in this wage equation, because the interest is not in identifying causal relationships regarding wages. An OLS regression of wages on some (possible endogenous) explanatory variables leads to the best linear prediction of the conditional expectation function and gets rid of the measurement error.

[14] Family size decreases over the period under investigation. A constant level of consumption per household implies a rising level of consumption per capita.

Figure 1: **A.** Consumption National Accounts (macro) vs. Consumption Expenditure Survey (micro). **B.** Average Weekly Hours of Female Paid Labor, per household.



until death. Extensions of the specification that allow for uncertainty however predict different consumption profiles. A typical feature budget data at the household level is that average household income and average household consumption are 'hump-shaped' functions of age. Carroll and Summers (1989) interpret this empirical regularity as evidence against simple forms of the life cycle model. Attanasio and Browning (1995) blow new life into the life cycle concept by showing that controlling for family size and number of children yields average (adjusted) consumption patterns that are reasonably flat. We find the same pattern.

Figure (2) shows life cycle patterns of log real non-durable consumption, log real income, development of the number of children within the household, adjusted log real non-durable consumption, female hours of labor and male hours of labor. All as functions of age of the head of the household.[15] Each connecting segment represent averages of a birth cohort over the 23 years that are sampled. Birth cohorts are defined within a five year birth year interval with the full sample spanning 23 years. Each cohort overlaps adjacent cohorts therefore at 18 years. Within the sampled 23 years cohorts clearly do not span their entire life cycle. The numbers connected to the line segments represent the average year of birth of the household head of the respective birth cohort. Vertical differences between lines represent cohort/time effects where age/time effects are visible along the lines. Unlike the non-durable consumption profile, the household log real income profile reflects obvious cohort/time effects (younger cohorts earn more). Younger cohorts are therefore richer conditional on age, but do not spent the excess wealth on non-durable goods. However, if we control for changes in family size we find slight cohort/time effects.

The life cycle profile of average number of children also shows clear cohort effects. When age is between 30 and 55, younger cohorts on average have less children than older cohorts. This fact may be related to changes in the supply of female labor, as younger cohorts tend to work more. Another clear feature of the data is that young cohorts drastically reduce their hours of labor when they enter their thirties. This pattern indicates that women tend to cut hours when they are having children and indicates the relevance of extending the labor supply analysis with home production. We find no such pattern for male hours of labor, such that –when push comes

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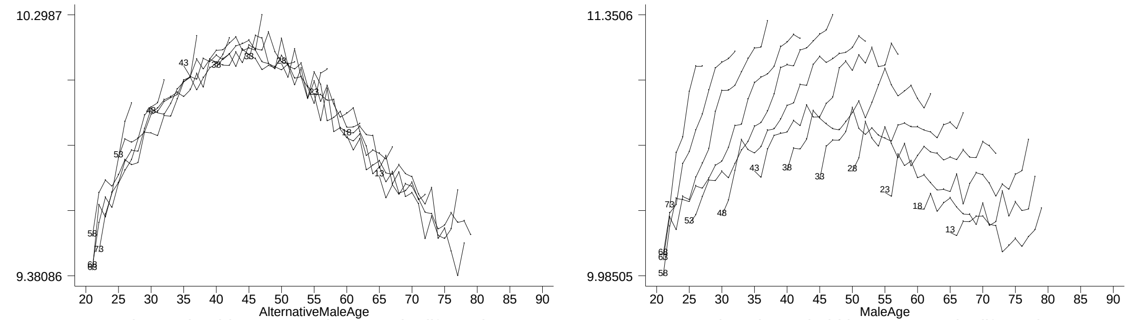
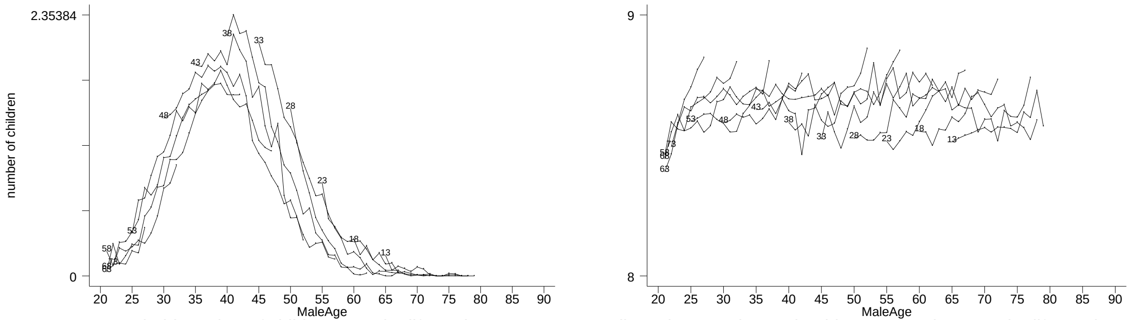
[15] Regressing log non-durable consumption on family size and number of children ($\ln c^{ND} = \alpha + \beta_1 fs + \beta_2 nch$). Adjusted consumption is constructed as ($\ln c^{ND}_{adj} = \ln c^{ND} - \hat{\beta}_1 fs - \hat{\beta}_2 nch$).



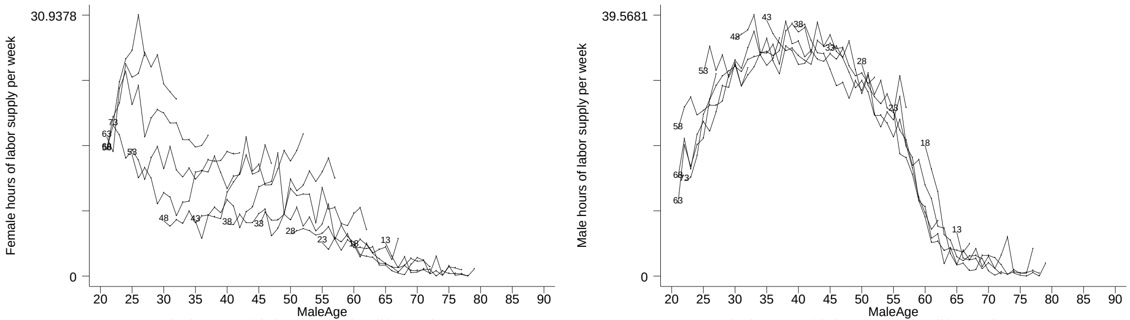
Log real non−durable consumption over the life cycle

Log real net household income over the life cycle



Household number of children over the life cycle

adjusted Log real non−durable consumption over the life−cycle



Female hours of labor over the life cycle

Male hours of labor over the life cycle

Figure 2: Life Cycle Profiles

to shove– women rather than men seem to take responsibility for child care. Whether these differences result from lower relative wages or from higher relative productivity or both remains unanswered.

The fourth figure –adjusted consumption– does not show any hump shape. After correcting for family composition average consumption stays fairly constant over time and does not show any obvious relationship with the average income. We take this as informal evidence in favor of life cycle consumption smoothing. The exact relationships between all variables cannot be directly inferred from figure (2) however. Blundell, Browning, and Meghir (1994) argue that all variables are jointly determined within the household and focussing on any pair in isolation could be misleading. Interaction between variables should be explored by an econometric analysis.

4 The empirical analysis

Section (4) estimates all parameters of the life cycle model presented in section (2.2). In section (4.1) we are estimating the parameters of Ψ using the within period model of female labor supply. In section (4.2) we subsequently derive and estimate an Euler equation of non-durable consumption. Section (4.3) presents elasticities that are calculated on the basis of the regression results. We present compensated, uncompensated and Frisch elasticities of female labor supply and non-durable consumption, conditional on demographics and hours of male labor supply. Different elasticities for groups with different demographic characteristics have been discriminated.

4.1 The second stage: the labor supply model

We estimate the labor supply model using the 1988 to 1991 waves as these waves report complete information on hours of market labor supply for both males and females (=7663 obs.). Information on time use (other than market labor supply) is not available such that identifying the production parameter k or disentangling preference parameters for non-market time into preferences for leisure and home production is not possible. Yet, as we show in section (2.1) we are able to identify labor supply and consumption elasticities. The following regression model has been estimated:

$$h_{f,it} \quad = \quad -\gamma^{*}_{n,it} - \gamma_{nc}\sqrt{\frac{p^{ND}_{it}}{w_{f,it}}} - \frac{\beta_{n,it}}{w_{f,it}}\left[y^{*}_{it} - \gamma^{*}_{n,it}w_{f,it} - \gamma_{c,it}p^{ND}_{it} - 2\gamma_{nc}\sqrt{p^{ND}_{it}w_{f,it}}\right] + \eta_{it} \tag{28}$$

We have attached the *it* subscript to the model parameters to indicate their dependence on household specific characteristics according to (16), (17) and (19). η_{it} is a normally distributed error term that is independent across observations. For deriving this model we have assumed that the Kuhn-Tucker multipliers associated with the non-negativity constraint on market labor supply μ_{1ft} are zero. As a consequence this model applies only to working females. We follow Blundell and Walker (1986) by selecting data on working females and by using a truncated regression method that scales the individual likelihood contributions by the probability of being selected. We exclude non-working females, pensioners and the self-employed from the analysis yielding 1906 observations with positive female market labor supply. The likelihood contribution of household i becomes:

$$\phi\left(\eta_{it}\right)/P\left(h_{f,it} > 0\right) \tag{29}$$

$\phi\left(\eta_{it}\right)$ denotes the density function of the disturbance η_{it} in equation (28). $P\left(h_{f,it} > 0\right)$ is the probability that a household is selected in the sample.

Real wages are constructed by dividing real after tax income by the reported hours (separate incomes for males and females are recorded). We use Stone price indices[16] to discount nominal income and non-durable consumption expenditures. Stone price indices are household specific

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[16] Stone price indices are calculated as follows

$$\ln p^{Stone}_{it} = \sum_{j=1}^{K} w_{ji} \ln p_{jt} \tag{30}$$

where the price index of individual i depends on its income share spent on product category j, w_{ji} and the price index of that product category, p_{jt}.

Table 1: ESTIMATES OF THE WITHIN PERIOD MODEL

PARAMETERS	ESTIMATES	t-stat.	ESTIMATES	t-stat.
β_n^0	0.4513***	[20.9]	0.4525***	[21.0]
β_n^{D1}	0.0764***	[4.1]	0.0854***	[9.0]
β_n^{D2}	0.0435***	[3.6]	0.0483***	[5.6]
β_n^{D3}	0.0211***	[2.4]	0.0234***	[2.9]
β_n^{age}	0.0033***	[3.9]	0.0037***	[11.6]
$\beta_n^{h_{m,t}}$	−0.0009***	[−5.2]	−0.0010***	[−5.4]
γ_c^0	116.3694	[0.9]	102.4813	[0.9]
γ_c^{fs}	−126.7761***	[−2.8]	−119.3981***	[−2.8]
γ_n^0	−46.0052***	[−5.2]	−48.1035***	[−6.1]
γ_n^{fs}	−9.0210***	[−2.8]	−8.6037***	[−2.8]
γ_{nc}	−21.4486	[−0.4]	–	–
$\beta_{\varepsilon_{\overline{h}_{m,t}}}$	0.0584	[1.3]	0.0571	[1.3]
$\beta_{\varepsilon_{y_t^*}}$	0.0365	[1.5]	0.0385*	[1.7]
σ^2	78.2137***	[27.7]	78.2975***	[27.8]
log-likelihood	-6734.47		-6734.6	
Observations	1906		1906	

NOTE. Excluded instruments for y_t: male and female age and age squared, education variables, male year of birth and male wages. Excluded instruments for $h_{m,t}$: male wage, male education variables. Excluded instruments for female wages: female age, female education variables, male job type. ***, **, * indicate significance at the 1, 5 and 10% level.

price indices that correct for different rates of inflation for different bundles of goods [see for example Attanasio and Weber (1995)] [source: Statistics Netherlands. `http://statline.cbs.nl/`].

Male labor supply $\overline{h}_{m,t}$ and full expenditure y_t^* are simultaneously determined within the household and therefore endogenously related to female hours of labor supply. We carry out two Hausman type tests to test for weak exogeneity. The procedure simultaneously gets rid of the bias in the regression estimates (Smith and Blundell, 1986). For this test we have performed two linear regressions where y_t^* and $\overline{h}_{m,t}$ are both regressed on the variables of the model and two separate vectors of excluded instruments. Male and female age and age squared, male year of birth dummies, male education dummies and male wage rates are used to instrument y_t^*. Male wage rates and male education dummies are used as excluded instruments in the male labor supply equation. The residuals of both auxiliary regressions (the 'estimated errors') are included additively in the labor supply model. The null of exogeneity of both male market labor supply and full expenditure is tested with a t-test on significance of the two estimated error variables. The parameters associated with the estimated error variables are $\beta_{\varepsilon_{\overline{h}_{m,t}}}$ and $\beta_{y_t^*}$.

Table (1) reports estimates of two versions of equation (28) where one is nesting the other. The first model allows for a flexible γ_{nc}. The second model restricts γ_{nc} to zero such that the model collapses to the linear expenditure system. The estimate of γ_{nc} from the first specification is not significantly different from zero. Also, a likelihood ratio test does not reject one model in favor of the other ($LR = 0.26$, far below 3.84, the critical value at a 5% significance level). We are therefore unable to reject separable preferences over non-durable goods and female non-market time. Note however that performing a t-test on significance of γ_{nc} is effectively performing a joint test on parameter significance and model specification. The inability to reject separability could be due of our specific parametric assumptions. Yet, the test clearly favors the second version of the model over the first one as it needs less parameters to fit the data.

The parameters of interest –the β's and the γ's– are not particularly straightforward to interpret. We do conclude however that preferences for female non-market time change when households have children in the sense that time at home becomes more important. When children grow older the child effect on preferences for time becomes smaller. These results show that our extension of the traditional dichotomous tradeoff between leisure and consumption into a model that incorporates home production is significant. Parameterization of β_n is also economically important as within our data set it runs from .25 (low preference for non-market time) to .65 (high preference for non-market time) using the table (1) column 2 estimates. Note that given our model specifications, preferences for consumption and non-market time are in fact composites of preferences for consumption, leisure, domestic technology parameters and preferences for home produced goods (of which child care is an important one). From parameterizing preferences for non-market time with dummies of having children in certain age groups we obtain therefore a tentative estimate for preferences for child care. This under the assumption that households without children have no particular interest in child care. A final conclusion is that preference for non-market time increases with age and decreases in male hours of labor (significant impact of male hours on the female non-market hours - nondurable consumption tradeoff indicates non separabilities between these variables). The estimates associated with the estimated error variables are only significantly different from from zero at 10% for the full expenditure measure in the second column offering weak evidence for the econometric endogeneity of full expenditures. We do not find evidence for the econometric endogeneity of male labor supply.

4.2 The first stage: the Euler equation of non-durable consumption

So far we have estimated parameters of the within period model. The parameters of the monotonic transformation $F(\cdot)$ have not yet been estimated. The parameters of $F(\cdot)$ capture the household's willingness to reallocate expenditures across time in response to financial or demographic incentives. Expenditures in this example may be on consumer goods but also the expenditures on non-market time. The standard vehicle for estimating parameters of $F(\cdot)$ are Euler equations of the equation (11d) type. Equation (11d) is one of the first order conditions of the consumer problem and relates marginal utility of wealth now and in the future. Within our context –a life cycle model of consumption and female time– there are broadly three options for operationalizing equation (11d) for estimation purposes:

$$\lambda_t = F_\Psi \Psi_{y_t^*} \tag{31}$$

$$\lambda_t = \frac{1}{w_{f,t}} \left(F_u u_{n_{ft}} - \mu_{1ft} \right) \tag{32}$$

$$\lambda_t = \frac{1}{p_t^{ND}} \left(F_u u_{c_t^{ND}} \right) \tag{33}$$

Combining equation (31) and equation (11d) yields an Euler equation of full expenditures. A combination of equation (32) and equation (11d) yields an Euler equation of female non-market time. A combination of equation (33) and equation (11d) yields an Euler equation of non-durable consumption.[17] Perhaps the most obvious parameterization of λ_t to use in estimation is equation (31) simply because we specify Ψ in section (2.2.1). A functional form for the direct utility u has not been specified so far.

In a world without corner solutions optimal household behavior requires marginal utilities to be equal (in expected discounted terms) across goods within and between periods. Key issue here is that when a household's optimal allocation do involves corner solutions marginal utilities typically do not equalize. We have seen in the previous section that corner solutions are particularly important regarding labor supply behavior (i.e., there are a lot of women who do not work). The formulas for the proposed Euler equations of non-market time and that of full expenditures –as a result– would contain the unknown Kuhn-Tucker multipliers μ_{1ft} that are associated with the non-negativity constraints on female market labor supply. The indirect utility function (13) would no longer be a valid representation of preferences. When restrictions on the labor market are binding one should specify (indirect) utility functions of the restricted type (Neary and Roberts, 1980).

Selection on working females only would be necessary to estimate Euler equations of full expenditure or female non-market time. Selection on working females in this section –as opposed to the same selection in the previous section– would be inappropriate for at least three reasons. First, we would like to make statements about all households in the sample, not just about workers. Second, because we intend to estimate Euler equation on the basis of constructed cohort averages we will introduce significant sampling error as the number of observations within each cohort would be small. Third, even if selection on females with *current* positive labor supply is accepted we introduce a new selection problem that we should worry about. Euler equations predict that the error terms of the specified models are genuine forecast errors (mean independent of period t information). As a result, the errors will average out to zero when T gets large. Selection on workers has the important adverse side effect that the errors no longer average out to zero. Households with negative forecast errors will have a greater probability to be eliminated from the data set. The eliminated households should have been included in the sample to counterbalance the positive shocks.

Non-durable consumption is always positive (at least practically) and is therefore not in a corner solution. A strategy to identify the parameters of $F(\cdot)$ that gets round the trouble of non-zero Kuhn-Tucker multipliers or selection issues is to combine equation (33) with equation (11d) and construct an Euler equation of non-durable consumption. However, it is not evident to derive the Euler equation of non-durable consumption from an indirect utility function. To derive Euler equations of non-durable consumption we use one of our empirical results from section (4.1). Because γ_{nc} appears insignificant in our within period regression we were not able to reject the linear expenditure system (LES) [see table (1) first column]. For the LES there exists a direct (within period) utility function that corresponds to the indirect utility function that we define in section (2.2.1). It is straightforward to derive Euler equations of non-durable consumption from direct utility functions.

The direct utility function corresponding to the LES is known as the Stone-Geary utility function. The γ's and β's from the direct utility function correspond to the γ's and β's from the indirect utility function. Equation (12) relates the Stone-Geary utility function to the indirect

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[17] Other, but perhaps less intuitive, combinations would be possible as well.

utility function specified in section (2.2.1) under the restriction $\gamma_{nc} = 0$.

$$u\left(c_t^{ND}, n_{f,t}, z_{1t}\right) = \theta\left(n_{f,t} - \gamma_n\right)^{\beta_n}\left(c_t^{ND} - \gamma_c\right)^{(1-\beta_n)} \tag{34}$$

where $\theta = \beta_n^{-\beta_n}(1-\beta_n)^{-(1-\beta_n)}$. We combine the above definition with condition (33) and (11d) of the household's optimization problem. We subsequently impose $\gamma_n^* = \gamma_n - T_f$ and $n_{f,t} = T_f - h_{f,t}$ to derive the (exact) Euler equation of non-durable consumption.

$$\frac{1+r_{t+1}}{1+\delta}\,\frac{\left(\frac{-h_{ft+1}-\gamma_n^*}{c_{t+1}-\gamma_c}\right)^{\beta_n(1-\rho)}\left(c_{t+1}-\gamma_c\right)^{-\rho}\theta\left(1-\beta_n\right)\times\exp\left[\alpha' z_{2t+1}\right]}{\left(\frac{-h_{ft}-\gamma_n^*}{c_t-\gamma_c}\right)^{\beta_n(1-\rho)}\left(c_t-\gamma_c\right)^{-\rho}\theta\left(1-\beta_n\right)\times\exp\left[\alpha' z_{2t}\right]} = 1+\varepsilon_{t+1} \tag{35}$$

where ε_{t+1} is a forecast error such that its expected value is conditionally independent on information known at t:

$$E_t\varepsilon_{t+1} = 0 \tag{36}$$

The term $\theta(1-\beta_n)$ does not cancel out as β_n and hence θ are household and time dependent by depending on z_{1t}. The *it* subscripts are excluded for clarity.

We take *log*'s on both side of the Euler equation and construct a Taylor approximation of $[\ln 1 + \varepsilon_{t+1}]$ around $\varepsilon_{it} = 0$.

$$\begin{aligned}\Delta\ln\left(c_{t+1}-\gamma_c\right) &= \alpha_0 + \frac{1}{\rho}\ln\left(1+r_{t+1}\right) + \frac{1-\rho}{\rho}\Delta\beta_n\ln\left(\frac{-h_{ft+1}-\gamma_n^*}{c_{t+1}-\gamma_c}\right) + \\ &\quad \frac{1}{\rho}\Delta\ln\left[\theta\left(1-\beta_n\right)\right] + \frac{1}{\rho}\alpha'\Delta z_{2t+1} - \frac{1}{\rho}\left(\varepsilon_{t+1} + O_{t+1}(2)\right)\end{aligned} \tag{37}$$

$\alpha_0 = -\frac{1}{\rho}\ln(1+\delta)$ is constant and a function of the rate of time preference δ and the CRRA parameter ρ. The error term is written as the sum of the original forecast error ε_{t+1} and $O(2)$, which is a linear function of second and higher order moments of the forecast error.[18]

In estimation we assume that the r.h.s. variable $\frac{1}{\rho}\Delta\ln\left[\theta\left(1-\beta_n\right)\right]$ is sufficiently captured by a constant and the vector of taste shifters Δz_{2t+1}. Δz_{2t+1} contains changes is log family size, the number of children and a dummy for being single. The regression model becomes:

$$\begin{aligned}\Delta\ln\left(c_{t+1}-\gamma_c\right) &= \tilde{\alpha}_0 + \frac{1}{\rho}\ln\left(1+r_{t+1}\right) + \frac{1-\rho}{\rho}\Delta\beta_n\ln\left(\frac{-h_{ft+1}-\gamma_n^*}{c_{t+1}-\gamma_c}\right) + \\ &\quad +\tilde{\alpha}_1\Delta\ln \mathrm{fs}_{t+1} + \tilde{\alpha}_2\Delta\mathrm{nch}_{t+1} + \tilde{\alpha}_3\Delta\mathrm{single}_{t+1} + \nu_{t+1}\end{aligned} \tag{38}$$

γ_n^*, γ_c and β_n follow from the within period regression presented in table (1) column 2 and are treated as constants for constructing the equation (38) variables. We subsequently construct cohort means of the equation (38) variables using sampling weights to improve on representativeness of the cohort averages. Our data set then covers 13 cohorts spanning 23 years (1978-2000) yielding 255 observations (some observations were missing at the beginning of the sample for the young

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[18] Using a Taylor expansion we can write: $\frac{1}{\rho}\ln\left(1+\varepsilon_{t+1}\right) = \frac{1}{\rho}\left(\varepsilon_{t+1} + O(2)\right)$. $O(2)$ is linear in the of higher order moments of the forecast error ε_{t+1}.

cohorts and some were missing at the end for the older cohorts). We use the real interest rate (using yearly returns on government bonds as the nominal interest rate and the CPI for the price level. source: `http://statline.cbs.nl/`).

The CRRA parameter ρ appears twice in equation (38) and is therefore over-identified. We have tested this overidentifying restriction as a specification test rather than imposing the restriction at the outset. Note that hours of labor supply are predicted outside the 1988 to 1991 waves and the consumption variables are typically measured with error. The composite variable $\Delta\beta_n \ln\left(\frac{-h_{ft+1}-\gamma_n^*}{c_{t+1}-\gamma_c}\right)$ therefore seems to be seriously affected by measurement error. The first stage regression for the composite parameter ($F = 4.3$) are less convincing that the first stage regressions for the interest rate ($F = 25.6$). We tend to favor the estimates on ρ associated with the $\ln(1 + r_{t+1})$ variable in terms of reliability. We use this estimate of ρ therefore for constructing elasticities in the subsequent section.

Life cycle theory predicts that the forecast error ε_{t+1} is mean independent of current and past information (i.e., equation (36)) and hence offers a tool for estimating parameters using methods of moments type estimators. Life cycle theory is however not conclusive about whether the error term of the log-linearized Euler equation ν_{t+1} is mean independent of current and past information. For identification we therefore impose that the higher order moments of the forecast error ε_{t+1} are mean independent of period t variables as (i.e., $E_t O_{t+1}(2) = 0$). Forcing this assumption on the data rules out potentially important phenomenon such as buffer stock savings behavior (Deaton, 1991). Buffer stock savers typically would like to consume more than their current stock of wealth (i.e., they are impatient), but choose, in the presence of borrowing constraints, to build up a buffer stock of wealth as a precautionary measure to insure future negative (income) shocks. As a result of this type of behavior the conditional variance of the forecast error is a function of period t income which invalidates $E_t O_{t+1}(2) = 0$. In this case we could expect that consumption growth is 'excessively sensitive' to current income, which simply means that current income is a significant predictor of future consumption changes. However, excess sensitivity of period $t + 1$ consumption growth to period t income variables does not imply buffer stock saving behavior as binding borrowing constraints or specification errors such as intertemporal non-separabilities or wrong conditioning variables might yield similar findings. All of these phenomenon are typically hard to disentangle empirically. We test the statistical importance either one (or a combination) of these mechanisms by including *log* period t real household income as an additional regressor in the Euler equation.

Innovations to the interest rate and the composite variable are directly associated with the forecast error and are therefore instrumented. Future interest rates are unknown when households make decisions such that future interest rates are correlated with the forecast error. The composite variable is instrumented, because it is simultaneously determined with the dependent variable. Lagged interest rates (lagged one and two periods) are used to instrument the interest rate. One and two period lagged female labor supply variables and a two period lagged composite variable[19] and family composition dummies are used to instrument the composite variable. Households are assumed to perfectly anticipate changes in household composition one year in advance.

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[19] Due to possible measurement error in consumption, the composite error term in the log linearized Euler equation includes a MA(1) term such that one period lagged variables are bad instruments. In the presence of measurement error in the consumption variable, one period lagged variables are correlated with the error term. The interest rate is a macro variable and one period lags are therefore be assumed uncorrelated with the MA(1) term.

Table 2: Estimation Results of the Euler Equation of Non-durable Consumption

Variable	spec. 1	spec. 2	spec. 3
r_{t+1}	0.053	0.138	0.227
	(0.298)	(0.320)	(0.345)
$\Delta\left[\beta_n \ln\left(\frac{-h_f-\gamma_n^*}{c-\gamma_c}\right)\right]_{t+1}$	−0.700***	−0.287	−0.114
	(0.186)	(0.262)	(0.273)
$\Delta \ln \text{fs}_{t+1}$	0.794***	0.666***	0.614***
	(0.108)	(0.125)	(0.136)
$\Delta\ \text{nch}_{t+1}$	−0.154***	−0.107**	−0.103**
	(0.041)	(0.048)	(0.051)
$\Delta\ \text{single}_{t+1}$	0.025	−0.004	−0.055
	(0.094)	(0.106)	(0.122)
$\ln inc_t$	–	–	−0.040**
			(0.020)
Constant	−0.011	0.051***	0.465**
	(0.014)	(0.018)	(0.214)
birth cohort dummies included	no	yes (p−val: 0.01)	yes (p−val: 0.00)
overid test on ρ	p−val: 0.47	p−val: 0.14	p−val: 0.15
lagged income included in instrument list	no	no	yes
Sargan test on the instruments	p−val: 0.04	p−val: 0.42	p−val: 0.40
Observations	229	229	229

Note. Robust standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1% $\Delta \ln \text{fs}$ is the change in log family size. Δnch is the change in the number of children within the household. Δsingle is the change in the dummy for singles. The p-values associated with the birth cohort dummies test the hypothesis of excluding the dummies. The p-values associated with the overidentification test on ρ test the hypothesis whether the two estimates for ρ are the same [see equation (38)].

Excluded instruments: Real interest rate lagged one and two periods, female hours of labor lagged one and two periods, the composite variable $\beta_n \ln\left(\frac{-h_f-\gamma_n^*}{c-\gamma_c}\right)$ lagged two periods and current period family composition dummies. The Sargan test on the validity of the over-identifying restrictions cannot be rejected for spec. 2 and spec. 3. There is evidence of excess sensitivity to current income variables.

Table (2) spec. 1 reports the estimates the baseline regression of equation (38). Table (2) spec. 2 adds birth cohort dummies to the regression (the youngest cohort is the baseline). Table (2) spec. 3 includes current log real household income as an additional regressor to spec. 2. Birth cohort dummies are important in explaining the growth rates of non-durable consumption where older cohorts experience slower consumption growth (i.e., younger cohorts have steeper consumption paths). Moreover, the Sargan criterion indicates some model specification errors for spec. 1 which is resolved in spec. 2. The spec. 1 and spec. 2 results seem to indicate some important unobserved heterogeneity across cohorts. The parameter associated with the interest rate in spec. 2 is the estimate for $\frac{1}{\rho}$ that we use for calculating the elasticities in section (4.3). The estimate for ρ itself becomes $\hat{\rho} = 1/0.138 = 7.25$. Parameterization of $\frac{1}{\rho}$ by discriminating older and younger cohorts did not yield significant differences.

It is unfortunate that the estimation results for the $1/\rho$ are not very precise such that predictions based on this estimate are also imprecise. The difficulty of obtaining precise estimates of intertemporal allocation parameters is however not uncommon in the literature [see e.g., Attanasio and

Weber (1995); Vissing-Jörgensen (2002)]. Departures from the standard log-linear approach into more advanced econometric techniques seems fruitful. Alan and Browning (2003)'s Simulated Residual Estimation (SRE) for example seems promising in reducing the size of standard errors. For the moment we conclude that households hardly move expenditures back and forth through time in response to financial incentives like the interest rate. Demographic variables, as measured by family size and the number of children, are much more important.

As a specification test we add current real household income ($\ln inc_t$) as an additional regressor to the regression (table 2 SPEC. 3). The life cycle hypothesis predicts that the expected value of the forecast error conditional on current information is zero (i.e., equation (36)). We find that period t income is negatively and significantly related to consumption growth at $t+1$ pointing to a rejection of one of the underlying assumptions of the life cycle model presented in this paper (table (2) SPEC. 3). An outcome that is not affected by the inclusion of period t male labor supply in the regression. Low income cohorts seem to experience high consumption growth rates. Addressing the possible causes of excess sensitivity is an important issue for interpreting the elasticity estimates of following section. Important buffer stock behavior, borrowing constraints as well as intertemporal non-separabilities, or other specification errors could potentially lead to these outcomes. It is beyond the scope of the analysis to pinpoint the exact causes of this finding. We do wish to mention however that when intertemporal non-separabilities matter the standard two-stage budgeting procedure we employ in this paper might be invalidated as lagged expenditures would then (potentially) affect within period decisionmaking.

Under buffer stock behavior or under liquidity constraints the within period model is still consistently estimated. Note that the life cycle hypothesis predicts $E_t\varepsilon_{t+1} = 0$ and not $E_t\nu_{t+1} = 0$. A significant $\ln inc_t$ therefore does not imply a straight rejection of the life cycle hypothesis per se. Problems with interpretation are therefore much less severe under binding liquidity constraints or buffer stock behavior. The compensated as well as the uncompensated elasticities we estimate in the subsequent section may still be readily interpreted. Also under buffer stock behavior or under (occasionally binding) borrowing constraints –which is empirically similar– trying to get an idea of intertemporal preferences by estimating Euler equations is not necessarily hopeless. We may have some hope that the parameter estimate for $1/\rho$ is estimated with some precision such that the Frisch elasticities that we present in the following section may be interpreted with some degree of caution. For these households however, changes in financial incentives such as the interest rate are not that important as –because of their impatience– they are not willing to save anyway.

The estimates of ρ do not change much under after inclusion of the income variable. If the buffer stock savings mechanism is important, income may be correlated with the higher order moments of the forecast error ε_{t+1} without invalidating life cycle theory in its current form. Theory however provides no clear argument why the interest rate –as our most important regressor– and the higher order moments of the forecast error would be related. This offers an explanation of why the SPEC. 2 and SPEC. 3 outcomes are rather similar. Other explanations for our findings may be equally plausible. When intertemporal non-separabilities are important (e.g., habit formation) we should be cautious in interpreting our results. Under intertemporal non-separabilities past expenditures affect current period decision-making which we do not explicitly model. Excess sensitivity may also be explained by missing conditioning variables in z_{2t}. As a robustness check (not reported) we have included period t male market labor supply to see whether this had an effect on the significance of the income variable but it did not. We would like the reader to keep this in mind when interpreting the elasticities we provide in section (4.3).

4.3 Elasticities

With all relevant preference parameters now to our disposal we are able to calculate group specific elasticities. The formulas for the compensated, uncompensated, Frisch, and full expenditure elasticities are derived in appendix A. The elasticities are functions of the key variables we are studying. It makes sense therefore to construct potentially interesting subgroups and see how elasticities differ across groups. First of all, labor supply elasticities do not make much sense for non-workers. The elasticities presented in table (3) therefore are conditional on positive female hours. Moreover, the economic relevance of specific groups are hard to determine beforehand. It seems most natural to use the data set we have available for construct groups and simultaneously getting a feel of how representive these groups are for the Dutch population. For example: Within our sample there are 444 childless households where the female works and is below 30 years of age. The total number of households in our sample is 1906. The number of childless females under 30 therefore represents about 23% (= $\frac{444}{1906} \times 100\%$) of the female work force in the Netherlands.

We follow Blundell and Walker (1986) by evaluating elasticities on certain groups that are defined on the basis of some key variables within our data set. Section (2.1) argues that under specific assumptions on domestic technology, female non-market time may be regarded as a linear combination of hours of leisure and the home produced good (of which we consider child care as one of the most prominent types). Preferences for child care are strongly affected by the presence of children such that households substitute from market labor supply toward home production, both conditional on full expenditure y_t^* as conditional on the marginal utility of wealth λ_t. Various groups may be discriminated on the basis of the observables within our data set. We have selected groups of households on the basis of female age and we discriminate households with and without children. Other selections would also be possible but seem less interesting from our point of view. Table (3) reports labor supply, non-durable consumption and full expenditure elasticities. We use the parameter estimates of column 2 of table (1) and the estimated parameter for $\rho = 7.25$ from column 2 of table (2). We subsequently construct average elasticities within each subgroup. We also report average age within each subgroup, average predicted hours of female market labor supply $\hat{h}_f$, average hours of female labor supply h_f, male hours of market labor supply within each subgroup h_m (this is important as the predicted hours as well as the elasticities are conditional on male hours of labor supply), and the number of observations within each subgroup n.

Table 3: ELASTICITIES

							λ-constant elasticities				Full expenditure elast.			
Female age	kids	mean age	$\hat{h}_f$	h_f	h_m	n	E_{hh}	E_{hc}	E_{cc}	E_{ch}	η_h	η_h^*	η_c	η_c^*
<30	no	25.4	34.0	33.9	31.2	444	0.6	-0.5	-0.6	0.4	-1.1	-0.1	1.5	0.1
30-40	no	33.7	32.8	33.3	24.9	263	0.6	-0.5	-0.6	0.4	-1.2	-0.1	1.6	0.0
40-50	no	44.5	26.4	27.6	20.9	163	1.1	-0.8	-0.7	0.5	-1.9	-0.3	1.5	0.1
>50	no	54.4	23.8	22.3	15.7	175	1.2	-0.9	-0.7	0.5	-2.3	-0.3	1.5	0.1
<30	yes	27.2	17.1	16.3	33.7	101	2.7	-2.1	-0.9	0.7	-3.8	-1.0	1.5	0.3
30-40	yes	34.5	17.4	18.4	35.7	481	2.7	-2.1	-0.9	0.7	-3.7	-0.9	1.5	0.3
40-50	yes	42.7	17.7	19.4	35.4	268	2.6	-2.0	-0.9	0.7	-3.6	-0.9	1.4	0.3
>50	yes	51.1	12.2	13.7	14.6	11	7.8	-5.9	-0.9	0.7	-12.3	-3.9	1.4	0.3
total		35.8	24.7	25.2	29.8	1906	1.7	-1.3	-0.8	0.6	-2.5	-0.5	1.5	0.2

							Compensated elasticities				Uncompensated elasticities			
Female age	kids	mean age	$\hat{h}_f$	h_f	h_m	n	e_{hh}	e_{hc}	e_{cc}	e_{ch}	u_{hh}	u_{hc}	u_{cc}	u_{ch}
<30	no	25.4	34.0	33.9	31.2	444	0.6	-0.6	-0.5	0.5	0.2	-0.1	-1.1	1.0
30-40	no	33.7	32.8	33.3	24.9	263	0.6	-0.6	-0.5	0.5	0.2	-0.1	-1.1	1.1
40-50	no	44.5	26.4	27.6	20.9	163	0.9	-0.9	-0.6	0.6	0.5	-0.2	-1.1	1.0
>50	no	54.4	23.8	22.3	15.7	175	1.0	-1.0	-0.6	0.6	0.5	-0.2	-1.1	1.0
<30	yes	27.2	17.1	16.3	33.7	101	2.5	-2.5	-0.8	0.8	2.0	-1.0	-1.3	1.0
30-40	yes	34.5	17.4	18.4	35.7	481	2.4	-2.4	-0.8	0.8	1.9	-1.0	-1.4	1.1
40-50	yes	42.7	17.7	19.4	35.4	268	2.4	-2.4	-0.8	0.8	1.9	-0.9	-1.3	1.0
>50	yes	51.1	12.2	13.7	14.6	11	6.8	-6.8	-0.8	0.8	6.3	-2.4	-1.3	1.0
total		35.8	24.7	25.2	29.8	1906	1.5	-1.5	-0.6	0.6	1.1	-0.5	-1.2	1.0

NOTES: The subscripts $_{hh}$, $_{hc}$, $_{cc}$ and $_{ch}$ denote own price elasticity of labor, cross price elasticity of labor, own price elasticity of consumption and cross price elasticity of consumption respectively

Table (3) shows clear differences in predicted female hours of market labor supply $\hat{h}_f$ for households with and without children, after conditioning on age. When the average working woman between thirty and forty years old gets her first child the model predicts that she will reduce her hours of labor from 33 to 17 hours. This jump should not be explained by a sudden change in preferences for leisure, but merely by an increase in preferences for child care (i.e., home production). Splitting up the sample in households with and without children again shows the significance of considering the effects of child care on female labor supply behavior. The reduction in hours after having children is easily explained by our model.

The average female labor supply uncompensated wage elasticity is about 1.1 which is somewhat larger than the elasticities that have been found in previous empirical studies on Dutch data (Theeuwes and Woittiez, 1992; Evers, de Mooij, and van Vuuren, 2008). Discriminating (working) women with and without children reveals some interesting deviations from the global average. Working women without children work 30 hours per week on average, but seem hardly responsive to wage changes. The estimated uncompensated wage elasticity for this group is about 0.3. Working women with children work about 18 hours per week on average and are estimated to be much more responsive to wage changes, with an average elasticity of around 2. (Excluding the > 50 category with children does not affect the overall picture.) Note that we have been estimating a model of female labor supply conditional on male hours of labor. Male hours are significant predictors for female hours and therefore affect the elasticities that are reported in the table. Conditional on positive female hours, males work 35 hours on average when there are children. When there are no children, males work only 25 hours on average.

The Frisch elasticities take intertemporal re-allocation of full expenditures into account and reveal some additional interesting patterns. We find that ρ is imprecisely estimated and seems relatively large compared to what has been found in other studies. Moreover, we find evidence against the life cycle hypothesis as period t current household income is a significant predictor of consumption growth at $t + 1$. On the whole we need to be careful with interpreting Frisch elasticities. The large ρ indicates that households are not quite willing to reallocate resources over time in response to financial incentives. In other words, households highly dislike consumption losses and are fairly indifferent to consumption gains. From the formulas of the Frisch elasticities [equation (60), (62), (64) and (66)] we can infer that for increasing ρ Frisch elasticities converge to the compensated elasticities [equation (50), (52), (54) and (56)]. The average Frisch female labor supply elasticities across household categories is about 1.7. The Frisch elasticities on average about double the size of the un-compensated elasticities for the households without kids. Frisch elasticities for households that have children are about 30 percent larger than the uncompensated elasticities. Intertemporal reallocation of expenditures seems to play a more important role in allocating time when there are no children in the household. Recalculation of the elasticities with a smaller value for ρ imputed [we have used $\rho = 3$] increases the Frisch elasticities in absolute value by about 20%.

We also wish to emphasize that Frisch elasticities estimate responses to a temporary price/wage change. E_{hh} for example, predicts that labor supply responses only to a *current* wage increases while (expected) future wages are unchanged. A larger set of questions could analyzed within a simulation study. Not only could we predict current marginal wage/price effects, but effects of changes in expected income patterns or even changes in uncertainty about these income patterns.

Finally, the η^* and η represent full expenditure elasticities on the basis of y_t^* and y_t respectively. For constructing η we fixed the total time endowment at $T_f = 90$.

5 Conclusion

This paper employs the expected utility model as the organizing framework to analyze the allocation of female time and non-durable consumption conditional on a number of household demographic characteristics and male labor supply. We summarize the principle conclusions of our paper:

We show that when the production technology for non-marketable home produced goods exhibits constant returns to scale and when the factors of production are perfect substitutes standard empirical models of (female) labor supply may be consistently interpreted without imposing undesirable separability assumptions on the home produced good. Preference parameters for consumption and non-market time are perhaps complicated functions of preferences associated with consumption, leisure, home production and production technology parameters. This fact calls for a structural reinterpretation of parameter estimates of standard labor supply models and the importance to allow for demographic characteristics in estimation. The sharp decrease in average predicted hours of labor when women are having children indicates the need for the slightly different focus.

Working women without children work 30 hours on average as opposed to the 18 hours of average market labor supply of working women with children. Working women with children are however much more responsive to wage changes (with an elasticity of about 2) than women without children (with an elasticity of about 0.3). We show that when optimal intertemporal allocation of resources is taken into account, wage elasticities of female labor supply increase by about 50% on average (from 1.1 to 1.7).

We have estimated an Euler equation of non-durable consumption using a large T micro data set (we have constructed a synthetic panel spanning 23 years). The Euler equation is employed for identifying intertemporal preference parameters (the parameters of F in this paper). The parameters of intertemporal allocation are rather small and imprecisely estimated indicating that Dutch households are not particularly responsive to changes in financial incentive such as the interest rate. Changes in demographics like family size are much more important.

We find evidence against the life cycle hypothesis by testing for excess sensitivity of expected consumption growth to real current household income. We find this result after conditioning on family size and number of children (and male labor supply in a robustness check). There are multiple explanations for this finding ranging from speciation errors (wrong conditioning variables, intertemporal non-separabilities such as habit formation) to other concepts like buffer stock savings behavior or binding liquidity constraints. Disentangling these concepts empirically is typically hard and is beyond the scope of this paper.

A Elasticities

For the sake of convenience we write the elasticities in terms of the *observable* y_t^*.

Uncompensated demands:

$$h_{f,t}^{\text{uncomp.}} = T - n_{f,t} \quad = \quad -a_{w_{f,t}}^* - \frac{b_{w_{f,t}}}{b}\left[y_t^* - a^*\right] \tag{39}$$

$$c_t^{\text{uncomp.}} \quad = \quad a_{p_t}^* + \frac{b_{p_t}}{b}\left[y_t^* - a^*\right] \tag{40}$$

uncompensated labor supply elasticities:

$$\frac{\partial h_{f,t}}{\partial w_{f,t}} \frac{w_{f,t}}{h_{f,t}} \quad = \quad \left[-a_{ww}^* - \frac{b_{ww} b - [b_w]^2}{b^2}\left[y^* - a^*\right] - \frac{b_w}{b}\left[-a_w^*\right]\right] \cdot \frac{w}{h} \tag{41}$$

$$\frac{\partial h_{f,t}}{\partial p_t} \frac{p_t}{h_{f,t}} \quad = \quad \left[-a_{wp}^* - \frac{b_{wp} b - b_w b_p}{b^2}\left[y^* - a^*\right] - \frac{b_w}{b}\left[-a_p^*\right]\right] \cdot \frac{p}{h} \tag{42}$$

$$\frac{\partial h_{f,t}}{\partial y_t^*} \frac{y_t^*}{h_{f,t}} \quad = \quad -\frac{b_w}{b} \cdot \frac{y^*}{h} \tag{43}$$

uncompensated consumption elasticities:

$$\frac{\partial c_t}{\partial w_{f,t}} \frac{w_{f,t}}{c_t} \quad = \quad \left[a_{pw}^* + \frac{b_{pw} b - b_p b_w}{b^2}\left[y^* - a^*\right] + \frac{b_p}{b}\left[-a_w^*\right]\right] \cdot \frac{w}{c} \tag{44}$$

$$\frac{\partial c_t}{\partial p_t} \frac{p_t}{c_t} \quad = \quad \left[a_{pp}^* + \frac{b_{pp} b - \left[b_p\right]^2}{b^2}\left[y^* - a^*\right] + \frac{b_p}{b}\left[-a_p^*\right]\right] \cdot \frac{p}{c} \tag{45}$$

$$\frac{\partial h_{f,t}}{\partial y_t^*} \frac{y_t^*}{h_{f,t}} \quad = \quad \frac{b_p}{b} \cdot \frac{y^*}{c} \tag{46}$$

$\overline{U}$ λ may be written in terms of y^*. $\overline{U} = \frac{y_t^* - a^*}{b}$ and $\lambda = \left(\frac{y_t^* - a^*}{b}\right)^{-\rho} \frac{1}{b} \times \exp\left[\alpha' z_{2t}\right]$.

Compensated demands:

$$h_{f,t}^{\text{uncomp.}} \quad = \quad -a_{w_{f,t}}^* - b_{w_{f,t}} \overline{U} \tag{47}$$

$$h_{f,t}^{\text{uncomp.}} \quad = \quad a_{p_t}^* + b_{p_t} \overline{U} \tag{48}$$

such that:

$$\frac{\partial h_{f,t}}{\partial w_{f,t}}\frac{w_{f,t}}{h_{f,t}} = \left[-a^*_{ww} - b_{ww}\overline{U}\right]\cdot\frac{w_{f,t}}{h_{f,t}} \tag{49}$$

$$= \left[-a^*_{ww} - \frac{b_{ww}}{b}\left[y^* - a^*\right]\right]\cdot\frac{w_{f,t}}{h_{f,t}} \tag{50}$$

$$\frac{\partial h_{f,t}}{\partial p_t}\frac{p_t}{h_{f,t}} = \left[-a^*_{wp} - b_{wp}\overline{U}\right]\cdot\frac{p_t}{h_{f,t}} \tag{51}$$

$$= \left[-a^*_{wp} - \frac{b_{wp}}{b}\left[y^* - a^*\right]\right]\cdot\frac{p_t}{h_{f,t}} \tag{52}$$

and:

$$\frac{\partial c_t}{\partial w_{f,t}}\frac{w_{f,t}}{c_t} = \left[a^*_{pw} + b_{pw}\overline{U}\right]\cdot\frac{w_{f,t}}{c_t} \tag{53}$$

$$= \left[a^*_{pw} + \frac{b_{pw}}{b}\left[y^* - a^*\right]\right]\cdot\frac{w_{f,t}}{c_t} \tag{54}$$

$$\frac{\partial c_t}{\partial p_t}\frac{p_t}{c_t} = \left[a^*_{pp} + b_{pp}\overline{U}\right]\cdot\frac{p_t}{c_t} \tag{55}$$

$$= \left[a^*_{pp} + \frac{b_{pp}}{b}\left[y^* - a^*\right]\right]\cdot\frac{p_t}{c_t} \tag{56}$$

Frisch demand functions are:

$$h^{\text{Frisch.}}_{f,t} = -a^*_{w_{f,t}} - \frac{b_{w_{f,t}}}{(b\lambda_t)^{\frac{1}{\rho}}} \times \exp\left[\frac{1}{\rho}\alpha' z_{2t}\right] \tag{57}$$

$$c^{\text{Frisch.}}_{t} = a^*_{p_t} + \frac{b_{p_t}}{(b\lambda_t)^{\frac{1}{\rho}}} \times \exp\left[\frac{1}{\rho}\alpha' z_{2t}\right] \tag{58}$$

such that:

$$\frac{\partial h_{f,t}}{\partial w_{f,t}}\frac{w_{f,t}}{h_{f,t}} = \left[-a^*_{ww} - \frac{b_{ww} - [b_w]^2(\rho b)^{-1}}{(b\lambda)^{\frac{1}{\rho}}}\exp\left[\frac{1}{\rho}\alpha' z\right]\right]\cdot\frac{w_{f,t}}{h_{f,t}} \tag{59}$$

$$= \left[-a^*_{ww} - \frac{b_{ww} - [b_w]^2(\rho b)^{-1}}{b}\left[y^* - a^*\right]\right]\cdot\frac{w_{f,t}}{h_{f,t}} \tag{60}$$

$$\frac{\partial h_{f,t}}{\partial p_t}\frac{p_t}{h_{f,t}} = \left[-a^*_{wp} - \frac{b_{wp} - b_w b_p(\rho b)^{-1}}{(b\lambda)^{\frac{1}{\rho}}}\exp\left[\frac{1}{\rho}\alpha' z\right]\right]\cdot\frac{p_t}{h_{f,t}} \tag{61}$$

$$= \left[-a^*_{wp} - \frac{b_{wp} - b_w b_p(\rho b)^{-1}}{b}\left[y^* - a^*\right]\right]\cdot\frac{p_t}{h_{f,t}} \tag{62}$$

and:

$$
\begin{aligned}
\frac{\partial c_t}{\partial w_{f,t}} \frac{w_{f,t}}{c_t} &= \left[a^*_{pw} + \frac{b_{pw} - b_p b_w (\rho b)^{-1}}{(b\lambda)^{\frac{1}{\rho}}} \exp\left[\frac{1}{\rho} \alpha' z \right] \right] \cdot \frac{w_{f,t}}{c_t} && (63) \\
&= \left[a^*_{pw} + \frac{b_{pw} - b_p b_w (\rho b)^{-1}}{b} \left[y^* - a^* \right] \right] \cdot \frac{w_{f,t}}{c_t} && (64) \\
\frac{\partial c_t}{\partial p_t} \frac{p_t}{c_t} &= \left[a^*_{pp} + \frac{b_{pp} - \left[b_p \right]^2 (\rho b)^{-1}}{(b\lambda)^{\frac{1}{\rho}}} \exp\left[\frac{1}{\rho} \alpha' z \right] \right] \cdot \frac{p_t}{c_t} && (65) \\
&= \left[a^*_{pp} + \frac{b_{pp} - \left[b_p \right]^2 (\rho b)^{-1}}{b} \left[y^* - a^* \right] \right] \cdot \frac{p_t}{c_t} && (66)
\end{aligned}
$$

We normalize all the price data in the process such that non-durable prices become 1 and nominal wages become real wages.

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