Individual Rather Than Household Euler Equations: Identification and Estimation of Individual Preferences Using Household Data

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Abstract

In this paper it is shown that the intratemporal and intertemporal preferences of each decision maker in the household can be identified even if individual consumption is not observed. This identification result is used jointly with the Consumer Expenditure Survey (CEX) to estimate the intratemporal and intertemporal features of individual preferences. This paper is one of the first attempts to provide estimates of the wife's and husband's intertemporal preferences by taking into account that household behavior is the outcome of joint decisions. The empirical findings indicate that there is heterogeneity in intertemporal preferences between wife and husband. The identification and estimation results are important for at least two reasons. First, they suggest that to answer policy questions the household decision process should be characterized using one set of preferences for each decision maker. Second, the estimates of individual preferences provided in this paper can be used to evaluate policies aimed at affecting household intertemporal behavior.

1 Introduction

The evaluation of many public policies requires knowledge of the preferences that determine the behavior of multiperson households. Changes in tax rates on pension assets, asset-based means-tested welfare programs, and marriage penalty relief programs are only a few examples. The traditional approach for estimating preferences assumes that households behave as single agents. Under this assumption, each household can be characterized using a unique utility function independently of the household structure. Since the unique utility function depends on household total consumption, which is observed, the intratemporal and intertemporal features of household preferences can be identified and estimated using standard methods.

Numerous papers have rejected the hypothesis that households behave as single agents. For instance, the results of Schultz (1990), Thomas (1990), Browning et al. (1994), Browning and Chiappori (1998), and Mazzocco (2005) indicate that micro-level data are not consistent with this hypothesis. The main implication of this finding is that public policies cannot be evaluated using a unique household utility function, since as shown in Mazzocco (2004) important aspects of intra-household risk sharing and specialization are ignored. Estimates of the preferences of each decision maker in the household are required. The main obstacle in the identification and estimation of individual preferences is that they depend on individual consumption, which is generally not observed. The goal of this paper is to identify and estimate such preferences using the limited amount of information which is available in household surveys. This is one of the first attempts to identify and estimate the intertemporal features of individual preferences by taking into account that household-level data are the outcome of joint decisions by household members.

This paper makes two main contributions. First, it is shown that the preferences of each decision maker in the household can be identified even if individual consumption is not observed, provided that household consumption, individual labor supply, and individual wages are observed. To illustrate the idea behind this result, consider a married couple. If individual consumption were observed, individual preferences could be identified by standard methods using individual Euler equations, i.e. one set of intertemporal optimality conditions for each agent, and intraperiod optimality conditions. Individual consumption is generally not observed, but household consumption, individual labor supply, and wages provide information on this variable. In particular, if at least one agent works in each period, the marginal rate of substitution between individual consumption and leisure should equal the real wage. As a consequence, this agent's consumption can be written as a function of labor supply and wages. Since consumption of the second agent is equal to the difference between total household consumption and consumption of the first agent, the spouse's consumption can also be written as a function of observed variables. These functions can be used to substitute out individual consumption from the marginal utilities that define the individual Euler equations and intraperiod optimality conditions. It can then be shown that these reduced-form

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optimality conditions and variations in household consumption, individual labor supply, and wages provide sufficient information to recover the original utility functions.

As a second contribution, individual preferences are estimated using the described identification result, a specific functional form for the individual utility functions, and data from the CEX. To evaluate the performance of the identification result, individual preferences are first estimated for single females and males with no children. For this group of households, individual consumption is observed since it is equivalent to household consumption. Individual preferences can therefore be estimated using the identification method proposed in this paper as well as standard methods. The results indicate that the identification method performs well in the sense that the parameter estimates obtained using the identification result are comparable to the estimates obtained using standard methods. The empirical findings also suggest that there is heterogeneity in intertemporal preferences between single females and single males: the intertemporal elasticity of substitution of single males is more than twice the corresponding elasticity for single females.

The identification result is then applied to a sample of couples. Similarly to single individuals, I find strong evidence of heterogeneity in intertemporal preferences between wives and husbands. In particular, the intertemporal elasticity of substitution of wives is about half the elasticity for husbands or, equivalently in this paper, wives are about twice as risk averse as husbands. A comparison of the parameter estimates for single and married agents indicates that single males are less risk averse than married males and that single females are more risk averse than married females.

These findings have one main implication. In Mazzocco (forthcoming), it is shown that households behave as single agents only if individual preferences belong to the Harmonic Absolute Risk Aversion (HARA) class with identical curvature parameter. The preference heterogeneity found in this paper indicates that this condition is not satisfied. Therefore economists and policy makers should not rely on preference estimates obtained using the standard unitary model to evaluate alternative policy recommendations. Instead, policy analysis should be performed using individual preferences and the corresponding parameter estimates.

This paper is related to the literature on the collective representation of household behavior. Manser and Brown (1980) and McElroy and Horney (1981) are the first papers to characterize the household as a group of agents making joint decisions. In those papers the household decision process is modeled as a Nash bargaining problem. Chiappori (1988; 1992) extends their analysis to allow for any type of efficient decision process. The theoretical model used in the present paper is an intertemporal generalization of Chiappori's collective model.

The intraperiod features of individual preferences have been identified and estimated in other papers. For instance, Blundell et al. (2001), Chiappori (1988; 1982), Chiappori et al. (2004), Donni (2004), Fong and Zhang (2001) show that different aspects of intraperiod preferences can be identified. Donni (2004) also estimates them. The present paper is, however, one of the first attempts

to identify and estimate the intertemporal features of individual preferences using household data.

The paper is organized as follows. In section 2, the individual Euler equations are derived. Section 3 outlines the identification procedure. Section 4 describes the empirical implementation. Section 5 discusses econometric issues. Section 6 describes the data and section 7 presents the estimation results. Section 8 concludes.

2   Household and Individual Euler Equations

Consider a two-person household living for $\mathcal{T}$ periods in an uncertain environment. In each period $t \in \{0, ..., \mathcal{T}\}$ and state of nature $\omega \in \Omega$, member i receives non-labor income $y^i(t, \omega)$, consumes a private composite good in quantity $c^i(t, \omega)$ and supplies labor in quantity $h^i(t, \omega)$. Let $C(t, \omega)$ be household total private consumption and let $l^i(t, \omega) = T - h^i(t, \omega)$ be leisure of member i, where T is the time available to each spouse in each period. The price of private consumption will be denoted by $p(t, \omega)$ and agent i's wage by $w^i(t, \omega)$. Household members can save jointly by using a risk-free asset. Denote by $s(t, \omega)$ and $R(t)$, respectively, the amount of wealth invested in the risk-free asset and its gross return.[1] Each household member is characterized by individual preferences, which are assumed to be separable over time and across states of nature. The corresponding utility function U_i is assumed to be increasing, concave, and twice continuously differentiable. Agent i's utility function can depend on agent j's private consumption and leisure but only additively, i.e.

$$U^i\left(c^1, c^2, l^1, l^2\right) = u^i\left(c^i, l^i\right) + \delta_i u^j\left(c^j, l^j\right),$$

where δ_i is the altruism parameter. Let β_i be the discount factor of member i.

The next two subsections describe two different approaches to identifying and estimating the intertemporal and intratemporal features of the preferences that characterize household decisions.

2.1   Household Euler Equations

The theoretical and empirical literature on intertemporal decisions has traditionally assumed that households behave as single agents independently of the number of decision makers. This is equivalent to assuming that the utility functions of the individual members can be collapsed into a unique utility function which fully describes the preferences of the entire household. Following this approach, suppose that household preferences can be represented using a unique von Neumann-Morgenstern utility function $U\left(C, l^1, l^2\right)$ and a household discount factor β. Intertemporal decisions

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[1]The results of the paper are still valid if risky assets are introduced in the model.

can then be determined by solving the following problem:[2]

$$\max_{\{C_t, l_t^1, l_t^2, s_t\}} E_0 \left[\sum_{t=0}^{\mathcal{T}} \beta^t U \left(C_t, l_t^1, l_t^2 \right) \right] \tag{1}$$

$$s.t. \ p_t C_t + s_t \leq \sum_{i=1}^{2} \left(y_t^i + w_t^i h_t^i \right) + R_t s_{t-1} \quad \forall t, \omega$$

$$s_T \geq 0 \quad \forall \omega.$$

The first order conditions of the unitary model (1) can be used to derive the following standard household Euler equations for consumption:

$$U_C \left(C_t, l_t^1, l_t^2 \right) = \beta E_t \left[U_C \left(C_{t+1}, l_{t+1}^1, l_{t+1}^2 \right) R_{t+1} \frac{p_t}{p_{t+1}} \right].$$

Since the variables defining these intertemporal optimality conditions are observed in various datasets, in the past two decades the standard household Euler equations have been used to test the intertemporal decisions of the household and to estimate the parameters that characterize its behavior.

This approach has one major limitation: the parameter estimates of the intertemporal unitary model can be used to understand household behavior and to answer policy questions only if households behave as single agents. Mazzocco (forthcoming) shows that this assumption is satisfied if and only if the following strong restrictions on individual preferences are satisfied: (i) household members have identical discount factors; (ii) the individual preferences belong to the HARA class and have identical curvature parameters. The evidence based on household Euler equations indicates that this assumption is violated. In particular, in the past twenty years economists have rejected household Euler equations using either the sample of couples or the sample of couples jointly with singles.[3] Mazzocco (2005) estimates the standard household Euler equations for couples and separately for singles using the CEX and the Panel Study of Income Dynamics (PSID). He finds that the standard household Euler equations are rejected for couples, but not for singles. Two additional tests based on household Euler equations are performed in Mazzocco (2005; forthcoming) and the outcome suggests that the behavior of a group of agents differs from the behavior of single agents. Additional evidence against the unitary model has been collected in a static framework for instance by Thomas (1990), Browning, Bourguignon, Chiappori and Lechene (1994), Browning and Chiappori (1998).

These empirical findings indicate that it may be important to estimate an alternative model that better characterizes the intertemporal behavior of the household.

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[2]The dependence on the states of nature is suppressed to simplify the notation.
[3]See Browning and Lusardi (1995) for a survey.

2.2 Individual Euler Equations

This section relaxes the assumption that the individual utility functions can be collapsed into a unique utility function. Without this restriction, it must be established how individual preferences are aggregated to determine household decisions. Following Chiappori (1988; 1992) and Mazzocco (2004; forthcoming), it is assumed that every decision is on the ex-ante Pareto frontier, which implies that household intertemporal behavior can be characterized as the solution of the following Pareto problem:

$$\max_{\{c_t^1, c_t^2, l_t^1, l_t^2, s_t\}} E_0 \left[\sum_{t=0}^{\mathcal{T}} \beta_1^t u^1(c_t^1, l_t^1) \right] + \mu E_0 \left[\sum_{t=0}^{\mathcal{T}} \beta_2^t u^2(c_t^2, l_t^2) \right] \tag{2}$$

$$s.t. \sum_{i=1}^{2} p_t c_t^i + s_t \leq \sum_{i=1}^{2} \left(y_t^i + w_t^i h_t^i \right) + R_t s_{t-1} \quad \forall t, \omega$$

$$s_T \geq 0 \quad \forall \omega,$$

where μ is a combination of Pareto weights and altruism parameters, and it can be interpreted as the relative decision power at the time of household formation.

Under standard assumptions, the following Euler equations for consumption can be derived:

$$u_c^i \left(c_t^i, l_t^i \right) = \beta_i E_t \left[u_c^i \left(c_{t+1}^i, l_{t+1}^i \right) R_{t+1} \frac{p_t}{p_{t+1}} \right] \quad \forall \, i = 1, 2. \tag{3}$$

Two remarks are in order. First, the individual Euler equations are not affected by the aggregation problem that affects the standard household Euler equations, since they are satisfied independently of the number of household members. Second, the leisure Euler equations could be added to the consumption Euler equations to characterize the intertemporal behavior of the household. However, they are satisfied only if the corresponding agent supplies a positive amount of labor in each period and state of nature. Since this assumption is excessively strong, only the consumption Euler equations will be employed.

Three main assumptions characterize the intertemporal collective model (2) and the corresponding Euler equations. First, the household Euler equations as well as the individual Euler equations characterize only the intertemporal behavior of households that are not borrowing constrained. There is mixed evidence on the importance of liquidity constraints. For instance, Zeldes (1989) and Gross and Souleles (2002) find that borrowing constraints characterize a significant fraction of the U.S. population. Runkle (1991), Meghir and Weber (1996), and Carneiro and Heckman (2002) find that at most a small fraction of households are liquidity constrained. The theoretical and empirical results of this paper hold for household that are not borrowing constrained in the period considered in the analysis.[4]

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[4]Future borrowing constraints affect household decisions in period t and $t + 1$. This effect is captured in the individual Euler equations by the information set at t. Consequently, as long as the individual Euler equations are satisfied during the survey period, the identification and estimation results hold.

Second, it is assumed that there is no household production or equivalently that household production is determined exogenously. Under this assumption, if individual labor supply is observed, individual leisure is also observed. The generalization of the identification and estimation results to a framework with household production is an important research topic, but it is left for future research.

Third, it is assumed that household decisions are always on the ex-ante Pareto frontier, which implies that the individual members must be able to commit to future allocations of resources at the time of household formation. To test whether the assumption of ex-ante efficiency represents a good approximation of household decisions the following standard efficiency condition will be analyzed jointly with the Euler equations:

$$\frac{u_c^1\left(c_t^1, l_t^1\right)}{u_c^2\left(c_t^2, l_t^2\right)} = \mu. \tag{4}$$

If individual private consumption and individual labor supply were observed, individual preferences could be estimated using the individual Euler equations and the efficiency condition. Unfortunately, consumption is only measured at the household level. The next section is devoted to showing that the parameters that characterize household intertemporal behavior can be identified using the consumption Euler equations and the intraperiod conditions even if consumption is not observed at the individual level.

3   Identification of Individual Preferences

Consider a household making efficient decisions and suppose that the following variables are observed: household private consumption, individual labor supply, individual wages and interest rate. It is assumed that each agent is characterized by a utility function which is twice continuously differentiable. But the functional form of the utility function is unknown. It will be shown that under these conditions individual preferences can be identified.

Suppose that in each period t at least one agent supplies a positive amount of labor. Without loss of generality, it will be assumed that agent 1 satisfies this restriction. Under this assumption, period t first order conditions of the intertemporal collective model imply that agent 1's marginal rate of substitution between private consumption and leisure must be equal to the real wage, i.e.,

$$\frac{u_l^1\left(c_t^1, T - h_t^1\right)}{u_c^1\left(c_t^1, T - h_t^1\right)} = q\left(c_t^1, h_t^1\right) = \bar{w}_t^1,$$

where $\bar{w}_t^1 = w_t^1/p_t$.

If the inverse function of q is well-defined, agent 1's consumption can be written as the following unknown function of individual labor supply and real wage:

$$c_t^1 = g\left(\bar{w}_t^1, h_t^1\right),$$

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where the parameter T is included in the function g.[5] Since household private consumption is observed, agent 2's private consumption can also be written as a function of observed variables as follows:

$$c_t^2 = C_t - g\left(\bar{w}_t^1, h_t^1\right).$$

Using the function g, individual private consumption can be substituted out of the marginal utilities that define the Euler equations for private consumption and the intraperiod optimality conditions. Denote with f_k^1 and f_k^2 these transformed marginal utilities with respect to good k for agent 1 and 2. Then f_k^1 and f_k^2 can be defined as follows:

$$f_k^1\left(\bar{w}_t^1, h_t^1\right) = u_k^1\left(g\left(\bar{w}_t^1, h_t^1\right), T - h_t^1\right) \quad k = c, l,$$

$$f_k^2\left(C_t, \bar{w}_t^1, h_t^1, h_t^2\right) = u_k^2\left(C_t - g\left(\bar{w}_t^1, h_t^1\right), T - h_t^2\right) \quad k = c, l. \tag{5}$$

The transformed marginal utilities can be used to rewrite the individual private consumption Euler equations as functions of variables that are observed. To that end, the assumption that agent 1 can freely choose and decides to supply a positive amount of labor must be fulfilled for two consecutive periods. Under this restriction, the individual private consumption Euler equations can be written as follows:

$$f_c^1\left(\bar{w}_t^1, h_t^1\right) = \beta_1 E_t\left[f_c^1\left(\bar{w}_{t+1}^1, h_{t+1}^1\right) R_{t+1}\frac{p_t}{p_{t+1}}\right], \tag{6}$$

$$f_c^2\left(C_t, \bar{w}_t^1, h_t^1, h_t^2\right) = \beta_2 E_t\left[f_c^2\left(C_{t+1}, \bar{w}_{t+1}^1, h_{t+1}^1, h_{t+1}^2\right) R_{t+1}\frac{p_t}{p_{t+1}}\right]. \tag{7}$$

Since household private consumption, individual labor supply, individual wages, and the interest rate are observed, the transformed marginal utilities f_c^1 and f_c^2, and the discount factors β_1 and β_2 can be identified using methods that have been developed for the identification of Euler equations.

The remaining transformed marginal utilities can be identified using the intraperiod optimality conditions. Specifically, agent 1's marginal rate of substitution between private consumption and leisure must be equal to the real wage even if individual consumption is substituted out using the function g. This implies that

$$\frac{u_l^1\left(g\left(\bar{w}_t^1, h_t^1\right), T - h_t^1\right)}{u_c^1\left(g\left(\bar{w}_t^1, h_t^1\right), T - h_t^1\right)} = \frac{f_l^1\left(\bar{w}_t^1, h_t^1\right)}{f_c^1\left(\bar{w}_t^1, h_t^1\right)} = \bar{w}_t^1.$$

Since the function f_c^1 is known for any combination of $\bar{w}_t^1$ and h_t^1 the transformed marginal utility f_l^1 is identified.

The private consumption efficiency condition can be written using the transformed marginal utilities in the following form:

$$\frac{f_c^1\left(\bar{w}_t^1, h_t^1\right)}{f_c^2\left(C_t, \bar{w}_t^1, h_t^1, h_t^2\right)} = \mu. \tag{8}$$

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[5]The consumption function g is well-defined if the marginal rate of substitution q is strictly increasing in consumption, which is a standard assumption in the labor literature. Lemma 1 in the appendix gives a formal statement of the condition under which g is well-defined. The function g corresponds to the m-consumption function introduced by Browning (1998).

The functions f_c^1 and f_c^2 are known, which implies that the ratio of Pareto weights μ is identified.

Finally, under the additional assumption that agent 2 can choose freely and decides to supply a positive amount of labor, agent 2's transformed marginal utility of leisure can be identified by equating her marginal rate of substitution between private consumption and leisure to the real wage, i.e.,

$$\frac{f_l^2\left(C_t, \bar{w}_t^1, h_t^1, h_t^2\right)}{f_c^2\left(C_t, \bar{w}_t^1, h_t^1, h_t^2\right)} = \bar{w}_t^2.$$

All the transformed marginal utilities are therefore identified. However, the information on individual preferences is contained in the original marginal utilities. The following proposition shows that the original marginal utilities are identified if the transformed marginal utilities are known and variations in household private consumption, individual labor supply, and wages are observed.

Proposition 1 *If both agents supply a positive amount of labor and either u^1 or u^2 satisfies the invertibility condition (15), then u_c^1, u_c^2, u_l^1, u_l^2, μ, and g are identified up to the additive constant of g.*

If only agent 1 supplies a positive amount of labor and u^1 satisfies the invertibility condition (15), then u_c^1, u_c^2, u_l^1, μ, and g are identified up to the additive constant of g.

Proof. In the appendix. ∎

To provide the intuition underlying proposition 1, note that by equation (5) for every realization of the exogenous variables agent 2's transformed marginal utility of consumption must satisfy the following equality:

$$f_c^2\left(C, \bar{w}^1, h^1, h^2\right) = u_c^2\left(C - g\left(\bar{w}^1, h^1\right), T - h^2\right). \tag{9}$$

Consider variations in the exogenous variables that generate a group of households with identical $\bar{w}_1$, h_1, h_2, but different C. This group of households provides information on $u_{c,c}^2$, i.e. on how agent 2's marginal utility of consumption varies with agent 2's consumption holding everything else constant. To see this observe that f_c^2 is known, which implies that it is known how f_c^2 varies with C if $\bar{w}_1$, h_1, and h_2 are held constant. Since (9) is satisfied for every feasible C, how u_c^2 varies with C holding $\bar{w}_1$, h_1, and h_2 constant must be equivalent to how f_c^2 varies with C if $\bar{w}_1$, h_1, and h_2 are held constant. Finally, how u_c^2 varies with C holding $\bar{w}_1$, h_1, and h_2 constant is equal to $u_{c,c}^2$.

Consider changes in the exogenous variables that generate the group of households for which C, $\bar{w}_1$, and h_2 are constant, but h_1 varies. This group of households provides joint information on how agent 2's marginal utility of consumption varies with agent 2's consumption and on how $g\left(\bar{w}^1, h^1\right)$ varies with h_1 holding everything else constant. To explain this note that it is known how f_c^2 varies with h_1 if C, $\bar{w}_1$, and h_2 are held constant. By (9), how u_c^2 varies with h^1 holding C, $\bar{w}_1$, and h_2 constant must be equivalent to how f_c^2 varies with h_1 if C, $\bar{w}_1$, and h_2 are held constant. Finally, observe that by varying h^1 on the right hand side of (9) we obtain information on $u_{c,c}^2 g_{h_1}$.

Consider variations in the exogenous variables that generate the group of households for which C, h_1, and h_2 are constant, but $\bar{w}_1$ varies. Using the argument employed for the previous group of households, it can be argued that this set of observations provides information on $u_{c,c}^2 g_{\bar{w}_1}$.

It is therefore possible to identify how $g\left(\bar{w}^1, h^1\right)$ varies with h_1 using the first group of households jointly with the second. Using the first and third group of households, it can be identified how $g\left(\bar{w}^1, h^1\right)$ varies with $\bar{w}_1$. Finally, since it is known how $g\left(\bar{w}^1, h^1\right)$ varies with h_1 and with $\bar{w}_1$, the function g is also known up to an additive constant. It is then straightforward to recover the original marginal utilities using the transformed marginal utilities and g.

Proposition 1 implies that the individual preferences over private consumption and leisure that determine the intertemporal and intratemporal household decisions can be identified. This leads to the following corollary.

Corollary 1 *The individual preferences over private consumption and leisure are identified up to an additive constant.*

This section shows that individual preferences can be identified without assuming a particular utility function. In the following sections, specific utility functions will be used jointly with the identification result presented in this section to estimate the key parameters of the intertemporal collective model.

4 Empirical Implementation

The next two subsections will outline the preference and heterogeneity assumptions used in the estimation of individual preferences and the class of measurement errors that are allowed.

4.1 Preference Assumptions

The empirical analysis will focus on the estimation of individual preferences for private consumption and leisure. The implicit assumption is that private consumption and leisure are strongly separable from public consumption. Since this assumption is more realistic for the group of households with no children, the estimation will be performed using this restricted sample.

It is assumed that agent i's preferences can be represented using the following utility function:

$$u^i\left(c^i, T - h^i\right) = \frac{\left[\left(c^i\right)^{\sigma_i}\left(T - h^i\right)^{1-\sigma_i}\right]^{1-\rho_i}}{1 - \rho_i},$$

with $\rho_i > 0$, $0 < \sigma_i < 1$. This utility function has been used extensively in the past for its simplicity in research projects that attempt to model the relationship between consumption and leisure. Three notable examples are Kydland and Prescott, (1982) Prescott (1986), and Browning, Hansen,

and Heckman (1999). The parameter ρ_i captures the intertemporal aspects of individual preferences. In particular, $-1/\rho_i$ is agent i's intertemporal elasticity of substitution, which measures the willingness to substitute the composite good $\left(c^i\right)^{\sigma_i} \left(T - h^i\right)^{1-\sigma_i}$ between different dates. The parameter σ_i captures the intraperiod features of individual preferences and it measures in each period the fraction of expenditure assigned to agent i which is allocated to private consumption.

The consumption function $g\left(\bar{w}^1, h^1\right)$ corresponding to these preferences can be written in the following form:

$$g\left(\bar{w}^1, h^1\right) = \frac{\sigma_1}{1 - \sigma_1} \bar{w}_t^1 \left(T - h_t^1\right).$$

4.2 Household Heterogeneity and Measurement Errors

So far the only source of household heterogeneity is the realization of the state of nature. In the estimation of individual preferences, I will allow for two additional sources of heterogeneity. A subscript h will be used to denote an observation for household h.

The main idea underlying the identification of individual preferences is that individual consumption can be written as a function of individual labor supply and own wage. In particular, given the functional form assumed for the utility functions, individual consumption and the individual value of leisure, $\bar{w}_t^1 \left(T - h_t^1\right)$, should be linearly related and therefore perfectly correlated. This implication of the model can be tested using the sample of singles, since their individual consumption is observed. In the CEX, the correlation is 0.30 for single females and 0.26 for single males. This indicates that there is a positive relationship between individual consumption and value of leisure as predicted by the model. But it also suggests that there is additional heterogeneity characterizing the function g. A potential interpretation of this finding is that, for a given $T - h^i$, the perceived value of leisure varies with age, education and seasonal dummies, because the available alternatives vary with these variables. This source of heterogeneity will be captured by assuming that agent i's utility function depends on effective leisure, $\hat{l}^i$, where effective leisure is defined as

$$\hat{l}_{t,h}^i = \left(T - h_{t,h}^1\right) \exp\left(\alpha_i' z_{t,h}\right),$$

and $z_{t,h}$ is a vector containing the wife's and husband's age, an education dummy for the wife and for the husband, and a seasonal dummy. This implies that[6]

$$c_{t,h}^1 = g\left(\bar{w}_{t,h}^1, h_{t,h}^1, z_{t,h}\right) = \frac{\sigma_1}{1 - \sigma_1} \bar{w}_{t,h}^1 \left(T - h_{t,h}^1\right) \exp\left(\alpha_i' z_{t,h}\right).$$

As an additional source of heterogeneity, it will be assumed that the logarithm of the ratio of Pareto weights varies across households according to an unknown distribution with mean $\overline{l\mu}$. This implies that $\log\left(\mu_h\right)$ can be written in the form

$$\log\left(\mu_h\right) = \overline{l\mu} + \eta_h,$$

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[6]An alternative interpretation of the low correlation between consumption and value of leisure is that the assumption on preferences is restrictive.

where η is a mean-zero random variable. It is important to remark that under ex-ante efficiency the household ratio of Pareto weights cannot change over time.

Finally, to determine which class of measurement errors can be allowed in the model, I will add measurement errors in private household consumption and individual wages. It will be assumed that the measurement errors satisfy the following three conditions. First, they are additive in the logarithm of private household consumption and individual wages. Second, let $C^*_{t,h}$ and $w^{i*}_{t,h}$ be true private household consumption and wages for household h in period t and denote with $C_{t,h}$ and $w^i_{t,h}$ the observed variables. It is assumed that the true variables can be written in the following form:

$$\log C^*_{t,h} = \log C_{t,h} + \delta_C + \delta_h + \epsilon_{t,h}, \quad \log w^{i*}_{ht} = \log w^i_{t,h} + \delta_{w^i} + \delta_h + \epsilon_{t,h},$$

where δ_C and δ^i_w are two constants, δ_h is a household fixed effect, and $\epsilon_{t,h}$ is a mean-zero random variable which is common to private consumption and wages.[7] Third, in each period t, the common component $\epsilon_{t,h}$ and the household fixed effect δ_h are independent of the information known to the household.[8]

Let $\gamma_i = \sigma_i (1 - \rho_i)$ and $\theta_i = (1 - \sigma_i)(1 - \rho_i)$. The assumptions on preferences and household heterogeneity imply that the individual Euler equations (6) can be written as follows:

$$\beta_1 E_t \left[\left(\frac{\bar{w}^1_{t+1,h}}{\bar{w}^1_{t,h}} \right)^{\gamma_1 - 1} \left(\frac{T - h^1_{t+1,h}}{T - h^1_{t,h}} \right)^{-\rho_1} e^{\alpha_1(\gamma_1 - \rho_1 - 1)(z_{t+1,h} - z_{t,h})} R_{t+1,h} \frac{p_t}{p_{t+1}} \right] = \frac{e^{(\gamma_1 - 1)(\delta_{w^i} + \delta_h + \epsilon_{t,h})}}{E_t \left[e^{(\gamma_1 - 1)(\delta_{w^i} + \delta_h + \epsilon_{t+1,h})} \right]},$$

the individual Euler equations (7) can be written in the form

$$\beta_2 E_t \left[\left(\frac{C_{t+1,h} - \hat{\phi}\bar{w}^1_{t+1,h} \left(T - h^1_{t+1,h} \right) e^{\alpha_1 z_{t+1,h}}}{C_t - \hat{\phi}\bar{w}^1_{t,h} \left(T - h^1_{t,h} \right) e^{\alpha_1 z_{t,h}}} \right)^{\gamma_2 - 1} \left(\frac{T - h^2_{t+1,h}}{T - h^2_{t,h}} \right)^{\theta_2} \right.$$

$$\left. e^{\alpha_2 \theta_2 (z_{t+1,h} - z_{t,h})} R_{t+1,h} \frac{p_t}{p_{t+1}} \right] = \frac{e^{(\gamma_2 - 1)(\delta_C + \delta_{w^i} + \delta_h + \epsilon_{t,h})}}{E_t \left[e^{(\gamma_2 - 1)(\delta_C + \delta_{w^i} + \delta_h + \epsilon_{t+1,h})} \right]},$$

and the efficiency condition (8) as

$$(\gamma_1 - 1) \log \bar{w}^1_{t,h} - \rho_1 \log \left(T - h^1_{t,h} \right) - (\gamma_2 - 1) \log \left(C_{t,h} - \hat{\phi}\bar{w}^1_{t,h} \left(T - h^1_{t,h} \right) e^{\alpha_1 z_{t,h}} \right) -$$

$$\theta_2 \log \left(T - h^2_{t,h} \right) - (\alpha_1 \rho_1 + \alpha_2 \theta_2) z_{t,h} = \overline{l\mu} + \eta_h + (\gamma_1 - 1) \log \hat{\phi} + (\gamma_2 - \gamma_1)(\delta_C + \delta_{w^i} + \delta_h + \epsilon_{t,h}),$$

where $\hat{\phi} = \dfrac{\sigma_1}{(1 - \sigma_1) \exp (\delta_C)}$.

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[7] Under the standard assumption that measurement errors have zero mean, the constants δ_C and δ_{w^i} must be equal to zero and the consumption and wage measurement errors must be identical.

[8] Preferences will also be estimated for single agents. In married households two respondents provide information on consumption and wages, whereas in single households only one respondent is present at the interview. To take this into account, in the estimation of preferences for singles I will also allow for measurement errors $\varepsilon^s_{C,t,h}$ and $\varepsilon^s_{w,t,h}$ that are specific to singles.

Taking the unconditional expectation of both sides, agent 1's Euler equations become

$$\beta_1 E\left[\left(\frac{\bar{w}_{t+1,h}^1}{\bar{w}_{t,h}^1}\right)^{\gamma_1-1}\left(\frac{T-h_{t+1,h}^1}{T-h_{t,h}^1}\right)^{-\rho_1}e^{\alpha_1(\gamma_1-\rho_1-1)(z_{t+1,h}-z_{t,h})}R_{t+1,h}\frac{p_t}{p_{t+1}}\right]=1, \qquad (10)$$

agent 2's Euler equations can be written as

$$\beta_2 E\left[\left(\frac{C_{t+1,h}-\hat{\phi}\bar{w}_{t+1,h}^1\left(T-h_{t+1,h}^1\right)e^{\alpha_1 z_{t+1,h}}}{C_{t,h}-\hat{\phi}\bar{w}_{t,h}^1\left(T-h_{t,h}^1\right)e^{\alpha_1 z_{t,h}}}\right)^{\gamma_2-1}\left(\frac{T-h_{t+1,h}^2}{T-h_{t,h}^2}\right)^{\theta_2}\right.$$
$$\left. e^{\alpha_2\theta_2\left(z_{t+1,h}-z_{t,h}\right)}R_{t+1,h}\frac{p_t}{p_{t+1}}\right]=1, \qquad (11)$$

and the efficiency condition becomes

$$E\left[(\gamma_1-1)\log\bar{w}_{t,h}^1-\rho_1\log\left(T-h_{t,h}^1\right)-(\gamma_2-1)\log\left(C_{t,h}-\hat{\phi}\bar{w}_{t,h}^1\left(T-h_{t,h}^1\right)e^{\alpha_1 z_{t,h}}\right)-\right.$$
$$\left.\theta_2\log\left(T-h_{t,h}^2\right)-(\alpha_1\rho_1+\alpha_2\theta_2)z_{t,h}\right]=\overline{l\mu}+(\gamma_1-1)\log\hat{\phi}+(\gamma_2-\gamma_1)\left(\delta_C+\delta_{w^i}\right). \qquad (12)$$

Using CEX data, the coefficients ρ_1, γ_i, θ_i, $\hat{\phi}$, and $\overline{l\mu}+(\gamma_2-\gamma_1)\left(\delta_C+\delta_{w^i}\right)$ will be estimated by applying the Generalized Method of Moments (GMM) to these three equations. The parameters of the individual utility functions can then be recovered using the following equations:

$$\gamma_i=\sigma_i\left(1-\rho_i\right), \qquad \theta_i=\left(1-\sigma_i\right)\left(1-\rho_i\right), \qquad \phi=\frac{\sigma_1}{1-\sigma_1}.$$

5 Econometric Issues

The transformed Euler equations of agent 2 cannot be log-linearized. Consequently, individual preferences will be estimated using the non-linear transformed Euler equations jointly with the efficiency condition. The non-linearities in the Euler equations imply that I can only allow for the class of measurement errors introduced in the previous section, which is a special case of the measurement errors that can be allowed in linear models. To evaluate the effect of the non-linearities on the coefficient estimates, the sample of single households will be used. In particular, the estimation of individual preferences for single households requires only the transformed Euler equation of agent 1, which can be log-linearized. The individual preferences can therefore be estimated using a linear and a non-linear version of the model. The estimates can then be compared to examine the effect of a larger class of measurement errors.

The identification result of Proposition 1 holds only if the consumption function g is well defined. This requires that at least one household member decides to supply a positive amount of labor in two consecutive periods. In the sample of couples used in the estimation the fraction of households in which the husband supplies a positive amount of labor for the entire survey period is around 80%, whereas the fraction in which the wife works during the survey is around 70%. In spite of

this, in the estimation the wive's labor supply and wage will be used to derive the consumption function g for the following two reasons. First, there is more variation in the labor supply of married women relative to married men. Second, the correlation between individual consumption and value of leisure is higher for single females relative to single males, which suggests that the correlation should be higher for married women relative to married men. All this implies that the sample used in the estimation can be composed only of households in which the wife works during the survey period. As a consequence, if the residuals of the transformed Euler equations are correlated with the labor force participation decisions of the wife, the estimation results will be affected by a selection bias.

To quantify the selection bias I will use the sample of single households. Denote with D_t^1 a dummy equal to 1 if agent 1 works in period t and let ζ_{t+1}^i be the error term corresponding to the transformed Euler equations of agent i. Since individual preferences are estimated using the sample of households in which agent 1 works at t and $t+1$, the parameter estimates of both couples and singles are unbiased only if

$$E\left[\zeta_{t+1}^i \,\middle|\, D_t^1 = 1, D_{t+1}^1 = 1\right] = 0,$$

i.e. only if ζ_{t+1}^i is independent of the participation decisions in period t and $t+1$. Suppose this independence assumption is not satisfied. For both couples and singles, the labor force participation decision of agent 1 can be formulated using the model proposed in this paper. In particular, in each period t agent 1's marginal rate of substitution between leisure and consumption is equal to the real wage if $D_t^1 = 1$, but it is greater than the real wage if $D_t^1 = 0$. Under the functional form assumptions for the individual utilities, this implies that

$$c_t^1 \leq \phi \bar{w}_t^1 T \quad \text{if } D_t^1 = 1,$$
$$c_t^1 > \phi \bar{w}_t^1 T \quad \text{if } D_t^1 = 0.$$

It is assumed that the wage equation is determined outside the model and that it can be written as

$$\log w_t^1 = X_t \beta + e_t,$$

where X_t includes labor market experience, its square, and a price index that is household and region specific. The selection equations in period t can then be written in the form

$$\log c_t^1 - \log \phi - \log T - X_t \beta \leq e_t \quad \text{if } D_t^1 = 1,$$
$$\log c_t^1 - \log \phi - \log T - X_t \beta > e_t \quad \text{if } D_t^1 = 0.$$

Suppose that ζ_{t+1}^i, e_t, and e_{t+1} are normally distributed with mean vector 0 and covariance matrix

$$\begin{bmatrix} \sigma_{\zeta^i}^2 & \rho_{\zeta^i,t} & \rho_{\zeta^i,t+1} \\ & 1 & \rho \\ & & 1 \end{bmatrix}.$$

Then, by Tunali (1986),

$$E\left[\zeta_{t+1}^i \,\middle|\, D_t^1 = 1, D_{t+1}^1 = 1\right] = \sigma_{\zeta^i}\rho_{\zeta^i,t}\xi_t^i + \sigma_{\zeta^i}\rho_{\zeta^i,t+1}\xi_{t+1}^i,$$

where

$$\xi_t = \frac{\phi\left(X_t\beta\right)\Phi\left(\dfrac{X_{t+1}\beta - \rho X_t\beta}{(1-\rho^2)^{1/2}}\right)}{G\left(X_t\beta, X_{t+1}\beta, \rho\right)}, \quad \xi_{t+1} = \frac{\phi\left(X_{t+1}\beta\right)\Phi\left(\dfrac{X_t\beta - \rho X_{t+1}\beta}{(1-\rho^2)^{1/2}}\right)}{G\left(X_t\beta, X_{t+1}\beta, \rho\right)},$$

and where ϕ, Φ and G are, respectively, the standard univariate normal density function, the standard univariate normal distribution function, and the standard bivariate normal distribution function. Individual consumption is observed for singles without children. Consequently, for this group of households the individual Euler equations can be estimated jointly with the labor force participation equations to quantify the selection bias. Following Newey and McFadden (1994), the Euler equations adjusted for selection are estimated using GMM in one step by adding as moment conditions the first order conditions of the bivariate probit, which determines the probability of being in one of the four possible labor supply states defined by D_t^1 and D_{t+1}^1. A similar approach could be used for couples, but stronger assumptions are required.[9]

The residuals of the individual Euler equations contain the expectation error implicit in these intertemporal optimality conditions. Since part of the expectation error is generated by aggregate shocks, it could be correlated across households. As suggested by Chamberlain (1984), this implies that the Euler equations can be consistently estimated only if the sample period covered by the data is long enough to contain all the stages of the business cycle. For this reason, data from 1982 to 1998 are used in the estimation.

The Euler equations and the efficiency conditions will be estimated using the continuous updating GMM. The choice of this GMM estimator is based on work by Hansen, Heaton, and Yaron (1996) and Donald and Newey (2000) indicating that the continuous updating GMM estimator has smaller bias than the more common two-step efficient GMM estimator, with and without autocorrelation. Under the assumption of rational expectations, any variable known at time t should be a valid instrument for GMM. The existence of measurement errors, however, may introduce dependence between variables known at time t and concurrent and future variables, even under rational expectations. To address this problem, only variables known at $t-1$ are used. This requires three consecutive observations for the same household: two to compute the growth rate for consumption,

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[9]To estimate agent 1's participation equations for couples, individual consumption must be substituted out using the first order conditions for consumption, which depend on the budget constraint multiplier in the corresponding period. Using the Euler equations and an approach similar to Heckman and MaCurdy (1980) and Browning et al. (1986), the multiplier in each period can be written as a function of the multiplier at 0 and the sequence of interest rates. If a long panel is available, the participation equations can therefore be estimated jointly with the individual Euler equations and efficiency conditions by using a fixed effect estimator. Unfortunately, the panel used in this paper covers only two consecutive period, which implies that the participation equations can be estimated only if it is assumed that the initial multiplier is constant across households or by using as a proxy for the multiplier initial wealth.

leisure, and wages, and at least one additional observation to construct the instrument set. In the CEX, labor supply and labor income data are only measured in the first and last interview, which implies that only two consecutive observations are available for each household. To address this problem, the set of instruments is constructed employing lagged cohort variables, where the cohort variables are computed using 7-years intervals for the head's year of birth.

6 CEX Data

The CEX survey is a rotating panel organized by the Bureau of Labor Statistics (BLS). Each quarter about 4,500 households, representative of the U.S. population, are interviewed: 80 percent are reinterviewed the following quarter, while the remaining 20 percent are replaced by a new randomly selected group. Each household is interviewed at most for four quarters and detailed information is collected on expenditures, income, and demographics. Following Meghir and Weber (1996) household level data for the available quarters are used in the estimation. The sample employed in this paper covers the period 1982-1998. The first two years are excluded because the data were collected with a slightly different methodology.

The CEX collects consumption data in each quarter of the survey. Labor supply and labor income data, however, are gathered only during the first and last interviews unless a member of the household reports changing his or her employment. In the second and third interviews the labor variables are set equal to the data reported in the first interview. Consequently, in the estimation I use quarterly variables computed using the first and last interviews.

Quarterly household consumption of singles is computed as the sum of food at home, food away from home, tobacco, alcohol, public and private transportation, personal care, clothing, house maintenance, heating fuel, utilities, housekeeping services, and transportation repairs, which is the definition used in Attanasio and Weber (1995). Household consumption of couples is obtained by subtracting the expenditure on goods that are clearly public consumption from the definition used for singles, namely house maintenance, heating fuel, and housekeeping services. Quarterly individual labor supply is calculated as the number of hours usually worked per week multiplied by 13 weeks. The total amount of time that an agent can divide between labor supply and leisure, T, is set equal to 1183, which is equal to 13 hours per day times 7 days a week times 13 weeks a quarter.[10] Quarterly leisure can then be computed as T minus quarterly labor supply. The individual hourly wage rate is determined using three variables: the amount of the last gross pay, the time period the last gross pay covered, and the number of hours usually worked per week in the corresponding period. The after-tax wage rate is computed using federal effective tax rates

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[10]The 13 hours per day are computed by allocating 8 hours to sleep, 1 hour to the time required to reach the workplace, and 2 hours to exogenous household production. I also experimented with 12 and 14 hours per day. This change has a small effect on the estimation of σ, which can be explained by noting that, for any level of labor supply, T determines the amount of leisure. However, the main findings of the paper do not change. An alternative approach would be to use a time survey to compute T for married females and males, and for single females and males.

generated by the NBER's TAXSIM model. The gross interest rate is obtained compounding the 20-year municipal bond rate for the three quarters that separate the first interview from the last. Household consumption, individual after-tax wages, and the gross interest rate are deflated using a household specific price index. The index is calculated as a weighted average of the consumer price indices published by the Bureau of Labor Statistics, with weights equal to the expenditure share for the particular consumption good.

The identification result requires that at least one household member supplies a positive amount of labor in two consecutive periods. Consequently, I drop from the sample couples in which the wife does not work during at least one of the two quarters used in the estimation. For singles, I drop a household if the head does not work in one of the two quarters. Households with children and households in which the head is older than 65 and younger than 22 are also excluded. Households with missing values in one of the variables defining the individual Euler equations and efficiency condition are dropped. For couples, a household is not used in the estimation if the husband's or the wife's labor supply is lower than 20 hours, or the wife's real after-tax hourly wage is larger than 50 dollars. For singles, I drop a household if the head's labor supply is less than 20 hours or the real after-tax hourly wage is larger than 50 dollars.[11] Summary statistics in 1984 dollars for the main variables are reported in table 1.

Table 1: Summary Statistics

Independent Variable	Mean for Singles	Mean for Couples
Real Consumption per Quarter	1563.8	2545.1
Head's Labor Supply per Week	42.7	44.4
Spouse's Labor Supply per Week	-	32.1
Conditional Spouse's Labor Supply per Week	-	38.8
Head's After Tax Wage per Hour	7.7	9.2
Wife's Before Tax Wage per Hour	-	6.6
Number of Observations	9464	5064
Number of Families	2366	1266

7 Results

To evaluate the performance of the identification result, individual preferences are initially estimated for single agents using several specifications. First, preferences are estimated using standard

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[11]The fraction of couples in which the wife's wage is larger than 50 dollars is around 0.5 percent. The fraction of single males and females is around 0.2 percent. The fraction of couples in which the wife works less than 20 hours is 5 percent of the sample. The fraction of singles in which the head works less than 20 hours is around 1 percent for males and around 2 percent for females.

household consumption Euler equations and the intraperiod condition. Under the assumptions on preferences and heterogeneity of section 4, the two equations can be written as follows:

$$E\left[\left(\frac{C_{t+1,h}}{C_{t,h}}\right)^{\gamma-1}\left(\frac{T-h_{t+1,h}}{T-h_{t,h}}\right)^{\theta}e^{\alpha\theta\left(z_{t+1,h}-z_{t,h}\right)}\beta R_{t+1,h}\frac{p_{t,h}}{p_{t+1,h}}\right]=1,\tag{13}$$

$$E\left[\log C_{t,h}-\log\hat{\phi}-\log\left(\bar{w}^1_{t,h}\left(T-h^1_{t,h}\right)\right)-\alpha'z_{t,h}\right]=0.\tag{14}$$

This specification corresponds to the approach traditionally used by the intertemporal literature, except that the intraperiod condition is included in the estimation to pin down the intraperiod parameter σ.[12] Second, preferences of singles are estimated using agent 1's transformed consumption Euler equations (10) and the identification result. Note that the transformed Euler equations (10) contain the same information as equations (13) and (14), since they are obtained by substituting the intraperiod condition in the standard Euler equations.

The standard estimation and the estimation based on the identification result will be implemented using log-linearized as well as non-linear Euler equations. All specifications are estimated with and without selection correction terms.

The results for the log-linearized version of the model are reported in table 2 for females and table 3 for males. The estimates obtained using the identification result are similar to the ones obtained using the standard method. The estimates for the coefficient ρ are about 1.7 for single males and 5 for single females. The parameter σ is precisely estimated only if the intraperiod condition is added to the estimation as an additional moment condition. In this case the wife's σ is around 0.15, whereas the husband's is around 0.50. Note that in the estimation of couples' preferences an intraperiod condition will be used in the form of the efficiency equation. This will enable me to precisely estimate σ.

The results obtained using the non-linear version of the model are reported in table 4 for single females and table 5 for single males and are similar to the estimates obtained using the log-linearized Euler equations. This suggests that the estimation results do not vary if measurement errors and unobserved heterogeneity are generalized to the class that can be allowed in linear models. The addition of the selection terms to the model does not produce significant differences in the results, which are reported in tables 6, 7, 8, and 9. In all specifications the selection terms are never statistically significant. This finding can be interpreted in two different ways. Either I am not able to precisely estimate the labor force participation decision, or the unobservable heterogeneity in the participation decision is independent of the Euler equation error term. In most specifications both experience and its square have a statistically significant effect on the participation decision. This suggests that the second interpretation is plausible and that selection biases should not have significant effects on the estimation of individual preferences for couples.

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[12]Theoretically, σ can be estimated using only the standard household consumption Euler equations. But empirically σ can be precisely estimated only if the intraperiod condition is added to the estimation.

The main empirical results are the estimates for couples, which are obtained using the transformed Euler equation (10) for the wife, the transformed Euler equation (11) for the husband, and the efficiency condition (12). The results are reported in tables 10. The wife's ρ is estimated to be around 4.4, whereas the husband's ρ is estimated to be around 2.5. Moreover, the difference between the wife's estimated ρ and the husband's is statistically significant. The wife's and husband's σ are estimated to be around 0.28. Table 10 also reports the estimate of the mean relative decision power under the assumption that the constants δ_C and δ_{w^i} in the measurement errors are equal to zero. Note that the estimation of the model produces an estimate of the logarithm of the expected value of μ. The reported estimate is obtained by taking a first order Taylor expansion of it. The mean relative decision power is measured to be around 0.82, but the standard errors are five times as large. The last column of table 10 reports the results of the estimation of the standard unitary model with separability between consumption and leisure. The estimate of ρ is 3.7, which is between the estimated ρ for married females and married males and within the range of estimates obtained in the past.

Finally, to test the assumption of ex-ante efficiency, the individual Euler equations (10) and (11) are also estimated without including the efficiency condition (12). Using a distance statistic test with one degree of freedom, ex-ante efficiency cannot be rejected at any standard significance level.

To understand which features of the data generate the differences in intertemporal elasticities of substitution between females and males, consider a single agent. The parameter σ measures the consumption budget share of this individual. In the CEX, the average consumption budget share is around 0.25 for both single females and males. These numbers are consistent with the estimates obtained in this paper which are between 0.12 and 0.55.

To determine how ρ is identified, for a given σ define the composite good $\bar{C} = c^{\sigma} l^{1-\sigma}$. Note that if a single agent decides to save one unit of $\bar{C}$ in period t, she will be able to increase consumption at $t+1$ by $R_{t+1} (p_t/p_{t+1})^{\sigma} (w_t/w_{t+1})^{1-\sigma}$. We can therefore interpret $R_{t+1} (p_t/p_{t+1})^{\sigma} (w_t/w_{t+1})^{1-\sigma}$ as the gross return on $\bar{C}$, where R_{t+1} captures the return for investing one unit of $\bar{C}$ in the risk-free asset, and $(p_t/p_{t+1})^{\sigma}$ and $(w_t/w_{t+1})^{1-\sigma}$ measure the change in prices between t and $t+1$ of the two goods that form $\bar{C}$, weighted using the corresponding budget shares. Using the log-linearized model, it is straightforward to show that $1/\rho$ measures the percentage change in $\bar{C}_{t+1}/\bar{C}_t$ generated by a one percent increase in $R_{t+1} (p_t/p_{t+1})^{\sigma} (w_t/w_{t+1})^{1-\sigma}$. This elasticity can be determined in the CEX by implementing an IV regression of the logarithm of $\bar{C}_{t+1}/\bar{C}_t$ on the logarithm of $R_{t+1} (p_t/p_{t+1})^{\sigma} (w_t/w_{t+1})^{1-\sigma}$. If σ is set equal to the average consumption budget share, the estimated coefficient is 0.16 for single females and 0.56 for single males, which explains the estimated heterogeneity in intertemporal preferences.[13]

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[13]I use an IV regression instead of an OLS regression to replicate the GMM estimation and to take into consideration that labor supply is used to construct the dependent variable $\bar{C}$ as well as the regressor $R_{t+1} (p_{t+1}/p_t)^{\sigma} (w_{t+1}/w_t)^{1-\sigma}$.

It is now straightforward to understand how the data generates a different ρ for males and females. Consider two identical single households except that the first one has a female head whereas the second one has a male head. Since males and females have identical σ, these two households face the same return on $\bar{C}$ and given this return they choose $\bar{C}_{t+1}/\bar{C}_t$ optimally. Consider an increase in the rate of return. In the data both single females and males increase the ratio $\bar{C}_{t+1}/\bar{C}_t$. However, the increase in period $t+1$ consumption relative to period t is larger for males, which suggests that females have a higher willingness to pay for a smooth consumption path.

Two remarks are in order. First, there is weak evidence of selection in the marriage market based on individual preferences. In particular, agents that are at the extremes of the risk aversion distribution are less likely to be married. Second, according to the results, the elasticity of intertemporal substitution for males is around twice the elasticity for females. Since in the proposed model the parameter ρ is the coefficient of relative risk aversion for the composite good $\left(c^i\right)^{\sigma_i}\left(T-h^i\right)^{1-\sigma_i}$, the results also imply that females are more risk averse than males. In Mazzocco (forthcoming) it is shown that the standard unitary model represents a good approximation of household intertemporal behavior if and only if the individual preferences satisfy a generalization of Gorman aggregation to an intertemporal framework. The heterogeneity in the estimated ρ implies that Gorman aggregation is not satisfied. Consequently, simulations of competing policies based on the standard unitary model are generally misleading, because they do not consider the full extent of intrahousehold risk sharing and specialization that can be obtained if individual preferences are heterogeneous.

One example is the evaluation of the adequacy of household saving at the time of retirement. As shown in Mazzocco (2004), the effect of risk sharing on household saving can be divided into two parts. First, individual members pool their earnings and consequently eliminate part of the uncertainty faced by the household. Under convex marginal utilities, income pooling always has the intuitive effect of reducing saving. Second, household members insure each other by allocating pooled income according to individual risk preferences and decision power. This insurance component of risk sharing can have the counterintuitive effect of raising household saving. The heterogeneity in risk aversion reported in this paper indicates that the insurance component explains a significant fraction of the accumulation and reduction of household wealth. However, as shown in Mazzocco (2004), the unitary model, and therefore any simulation based on it, completely ignores this component of risk sharing. The traditional justification for using the unitary model in simulations in spite of this drawback is that there are no estimates that can be used to fix the parameters that characterize the individual intertemporal preferences. The estimates provided in this paper fill this void.

8   Conclusions

In this paper it is shown that the preferences of each decision maker in the household can be identified and estimated even if individual consumption is not observed. The main finding is that there is a significant difference in individual preferences, with the wife exhibiting a greater desire for smooth consumption.

The main implication of this result is that intertemporal decisions cannot be analyzed using a unique utility function for the entire household, because this approach ignores important aspects of intra-household risk sharing and specialization. This implies that any policy analysis related to household intertemporal decisions should be implemented by characterizing each household member by means of individual preferences.

The analysis can be extended in at least one directions. In this paper it is assumed that the time devoted to household production is exogenously given. Under this assumption, it can be incorporated in the available time T. An important project which is left for future research is to generalize the identification result to an environment that allows for endogenous choices of domestic labor. In the meanwhile, empirical works should model T as a function of exogenous variables that determine domestic labor. In this way, differences across households in domestic labor are captured by the heterogeneity in T.

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A   Proofs

A.1   Lemma 1

The following Lemma determines the condition under which the marginal rate of substitution function q can be inverted and therefore the consumption function g is well-defined.

Lemma 1 *The function* $g\left(\bar{w}_t^1, h_t^1\right)$ *is well-defined if*

$$u_{lc}^1\left(c_t^1, T - h_t^1\right) u_c^1\left(c_t^1, T - h_t^1\right) - u_{cc}^1\left(c_t^1, T - h_t^1\right) u_l^1\left(c_t^1, T - h_t^1\right) \neq 0, \qquad (15)$$

for any realization of the exogenous variables.

Proof. For any realization of the exogenous variables define

$$d^1\left(c^1, h^1, \bar{w}^1\right) = q^1\left(c_t^1, h_t^1\right) - \bar{w}_t^1 = 0.$$

By the implicit function theorem, $g^1\left(\bar{w}^1, h^1\right)$ is well-defined if $\dfrac{\partial d^1}{\partial c^1} \neq 0$. Which implies condition (15). ∎

A.2   Proof of Propositions 1

Given the assumption that preferences are separable over time and across states of nature, the household decision process can be divided into two stages. In the first stage, resources are optimally allocated to each period and state of nature. Let $Y_{t,\omega}$ the optimal amount of resources allocated to period t and state ω. In the second stage, the household chooses optimal consumption and leisure in each period and state of nature given $w_{t,\omega}^1$, $w_{t,\omega}^2$, $p_{t,\omega}$, and $Y_{t,\omega}$ according to the following problem:

$$\max_{c_{t,\omega}^1, c_{t,\omega}^2, l_{t,\omega}^1, l_{t,\omega}^2} \mu_1 \beta_1^t u^1(c_{t,\omega}^1, l_{t,\omega}^1) + \mu_2 \beta_2^t u^2(c_{t,\omega}^2, l_{t,\omega}^2)$$

$$s.t. \sum_{i=1}^{2} p_{t,\omega} c_{t,\omega}^i \leq \sum_{i=1}^{2} w_{t,\omega}^i h_{t,\omega}^i + Y_{t,\omega}$$

The price of the private good, $p_{t,\omega}$, agent 1's wage, $w_{t,\omega}^1$, and agent 2's wage, $w_{t,\omega}^2$, represent four independent sources of exogenous variation. The fifth source of variation is $Y_{t,\omega}$. It is important to remark that $Y_{t,\omega}$ is endogenously determined and it is a function of the exogenous variables in any period and state of nature. This has two implications. First, a change in one of the exogenous variables at $t' \neq t$ and $\omega' \neq \omega$ varies $Y_{t,\omega}$. Second, a change in an exogenous variable at $t' \neq t$ and $\omega' \neq \omega$ can vary household decisions in period t and state ω only through $Y_{t,\omega}$. In the remainder of the proof a change in $Y_{t,\omega}$ should be interpreted as a change in an exogenous variable in period t' and state ω' that varies $Y_{t,\omega}$.

Consider first the case in which both agents work. Note that if the function $g\left(\bar{w}_t^1, h_t^1\right)$ can be identified, the original marginal utilities can also be identified by means of the transformed marginal utilities which are known. In the remainder of the proof it will be shown that $\dfrac{\partial g}{\partial \bar{w}^1}$ and $\dfrac{\partial g}{\partial h^1}$ can be identified, which implies that $g\left(\bar{w}^1, h^1\right)$ can be identified up to an additive constant.

Consider an arbitrary period t and state ω. Given w^1, w^2, p, and Y, optimal household private consumption, agent 1's labor supply, and agent 2's labor supply can be written in the following form:

$$C = C\left(w^1, w^2, p, Y\right), h^1 = h^1\left(w^1, w^2, p, Y\right), h^2 = h^2\left(w^1, w^2, p, Y\right).$$

Agent 2's transformed marginal utility of private consumption is defined as follows:

$$f_c^2\left(C, \bar{w}^1, h^1, h^2\right) = u_c^2\left(C - g\left(\bar{w}^1, h^1\right), T - h^2\right). \tag{16}$$

By construction this equation is satisfied for any combination of w^1, w^2, p, and Y. Consider an arbitrary w^1, w^2, p, and Y. Let dw^1, dw^2, dp, and dY be a small change in the exogenous variables with the following properties: (i) $dw_1 = \dfrac{w_1}{p}dp$, which implies that $d\bar{w}_1 = 0$; (ii) dw_2, dp, and $d\bar{Y}$ are the solution of the following linear system:

$$\frac{\partial C}{\partial w_2}dw_2 + \left(\frac{\partial C}{\partial w_1}\frac{w_1}{p} + \frac{\partial C}{\partial p}\right)dp + \frac{\partial C}{\partial \bar{Y}}d\bar{Y} = dC \neq 0,$$

$$\frac{\partial h^1}{\partial w_2}dw_2 + \left(\frac{\partial h^1}{\partial w_1}\frac{w_1}{p} + \frac{\partial h^1}{\partial p}\right)dp + \frac{\partial h^1}{\partial \bar{Y}}d\bar{Y} = dh^1 = 0,$$

$$\frac{\partial h^2}{\partial w_2}dw_2 + \left(\frac{\partial h^2}{\partial w_1}\frac{w_1}{p} + \frac{\partial h^2}{\partial p}\right)dp + \frac{\partial h^2}{\partial \bar{Y}}d\bar{Y} = dh^2 = 0,$$

i.e., the change varies household private consumption, but agent 1's labor supply and agent 2's labor supply stay constant. The change in f_c^2 implied by dw_1, dw_2, dp, and $d\bar{Y}$ can be computed as follows:[14]

$$df_c^2 = \frac{\partial f_c^2}{\partial C}dC + \frac{\partial f_c^2}{\partial \bar{w}_1}d\bar{w}_1 + \frac{\partial f_c^2}{\partial h^1}dh^1 + \frac{\partial f_c^2}{\partial h^2}dh^2 = \frac{\partial f_c^2}{\partial C}dC.$$

Similarly, the change in u_c^2 implied by dw_1, dw_2, dp, and $d\bar{Y}$ can be written in the following form:

$$du_c^2 = -\frac{\partial u_c^2}{\partial c^2}dC.$$

Since equation (16) is satisfied for any w_1, w_2, p, and $\bar{Y}$, the change in f_c^2 must equal the change in u_c^2. Consequently,

$$\frac{\partial f_c^2}{\partial C} = -\frac{\partial u_c^2}{\partial c^2}. \tag{17}$$

Since $\dfrac{\partial f_c^2}{\partial C}$ is known, $\dfrac{\partial u_c^2}{\partial c^2}$ is also known.

Consider a change dw_1, dw_2, dp, and $d\bar{Y}$ with the following properties: (i) $dw_1 = \dfrac{w_1}{p}dp$, which implies that $d\bar{w}_1 = 0$; (ii) dw_2, dp, and $d\bar{Y}$ are the solution of the following linear system:

$$\frac{\partial C}{\partial w_2}dw_2 + \left(\frac{\partial C}{\partial w_1}\frac{w_1}{p} + \frac{\partial C}{\partial p}\right)dp + \frac{\partial C}{\partial \bar{Y}}d\bar{Y} = dC = 0,$$

$$\frac{\partial h^1}{\partial w_2}dw_2 + \left(\frac{\partial h^1}{\partial w_1}\frac{w_1}{p} + \frac{\partial h^1}{\partial p}\right)dp + \frac{\partial h^1}{\partial \bar{Y}}d\bar{Y} = dh^1 \neq 0,$$

$$\frac{\partial h^2}{\partial w_2}dw_2 + \left(\frac{\partial h^2}{\partial w_1}\frac{w_1}{p} + \frac{\partial h^2}{\partial p}\right)dp + \frac{\partial h^2}{\partial \bar{Y}}d\bar{Y} = dh^2 = 0,$$

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[14]Alternatively, one could totally differentiate f_c^2 with respect to the exogenous variables w_1, w_2, p, and $\bar{Y}$ and then impose the constraints implied by the system of linear equations.

i.e., the change varies agent 1's labor supply, but household private consumption and agent 2's labor supply stay constant. According to equation (16), the implied change in f_c^2 must equal the implied change in u_c^2. Consequently, the following equation must be satisfied:[15]

$$\frac{\partial f_c^2}{\partial h^1} = -\frac{\partial u_c^2}{\partial c^2}\frac{\partial g}{\partial h^1}.$$

Since $\dfrac{\partial f_l^2}{\partial h^1}$ and $\dfrac{\partial u_c^2}{\partial c^2}$ are known, $\dfrac{\partial g}{\partial h^1}$ is identified.

Consider a change dw_1, dw_2, dp, and $d\bar{Y}$ with the following properties: (i) $dw_1 \neq \dfrac{w_1}{p}dp$, which implies that $d\bar{w}_1 \neq 0$; (ii) dw_1, dw_2, dp, and $d\bar{Y}$ are the solution of the following linear system:

$$\frac{\partial C}{\partial w_1}dw_1 + \frac{\partial C}{\partial w_2}dw_2 + \frac{\partial C}{\partial p}dp + \frac{\partial C}{\partial \bar{Y}}d\bar{Y} = dC = 0,$$

$$\frac{\partial h^1}{\partial w_1}dw_1 + \frac{\partial h^1}{\partial w_2}dw_2 + \frac{\partial h^1}{\partial p}dp + \frac{\partial h^1}{\partial \bar{Y}}d\bar{Y} = dh^1 = 0,$$

$$\frac{\partial h^2}{\partial w_1}dw_1 + \frac{\partial h^2}{\partial w_2}dw_2 + \frac{\partial h^2}{\partial p}dp + \frac{\partial h^2}{\partial \bar{Y}}d\bar{Y} = dh^2 = 0,$$

i.e., the change does not vary household private consumption, agent 1's labor supply, and agent 2's labor supply. By equation (16), the implied change in f_c^2 must equal the implied change in u_c^2, which implies that the following equation must be satisfied:

$$\frac{\partial f_c^2}{\partial \bar{w}_1} = -\frac{\partial u_c^2}{\partial c^2}\frac{\partial g}{\partial \bar{w}_1}.$$

Since $\dfrac{\partial f_c^2}{\partial \bar{w}_1}$ and $\dfrac{\partial u_c^2}{\partial c^2}$ are known, $\dfrac{\partial g}{\partial \bar{w}_1}$ is identified.

Since $\dfrac{\partial g}{\partial h^1}$ and $\dfrac{\partial g}{\partial \bar{w}_1}$ are known, the function g is identified up to the constant of integration. It is then straightforward to use $g\left(\bar{w}_1, h^1\right)$ to recover u_c^i, u_l^i, and from f_c^i and f_l^i up to the additive constant of g.

It is important to remark that the proof requires that the following matrix of coefficients of the linear systems:

$$\begin{bmatrix} \dfrac{\partial C}{\partial w_2} & \dfrac{\partial C}{\partial p} & \dfrac{\partial C}{\partial \bar{Y}} \\ \dfrac{\partial h^1}{\partial w_2} & \dfrac{\partial h^1}{\partial p} & \dfrac{\partial h^1}{\partial \bar{Y}} \\ \dfrac{\partial h^2}{\partial w_2} & \dfrac{\partial h^2}{\partial p} & \dfrac{\partial h^2}{\partial \bar{Y}} \end{bmatrix}$$

is of full rank. There are two cases in which this condition is not satisfied: (i) at least one of the demand functions is independent of all the exogenous variables; (ii) the rows or columns are linearly dependent. Since the first case is not realistic, only the second one will be discussed. The rows of the matrix are linearly dependent if the variation in one of the demand functions generated by changes in the exogenous variables provides no additional information conditional on the variation in the other demand functions. The columns are linearly dependent if a change in one of the exogenous variables provide no additional information on how the demand functions C, h^1, and h^2 vary conditional on the variation generated by the other exogenous variables. This emphasizes

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[15]The steps used to derive this equation are equivalent to the steps used to derive (17).

that the identification of individual preferences requires that independent variations in C, h^1, and h^2 are observed and that the exogenous variables can generate it.

Consider the case in which only agent 1 supplies a positive amount of labor. In this case, h^2 is always equal to zero and all the reduced-form marginal utilities are known except f_l^2. In the first part of the proof, the equation defining f_l^2 and variation in h^2 were never used. Consequently, the previous argument can also be applied to households in which only one agent supplies a positive amount of labor by dropping h^2 from equation (16) and the corresponding linear equation from the three linear systems. $g\left(\bar{w}_1, h^1\right)$ is therefore identified up to the additive constant and all marginal utilities are identified except u_l^2.

B Tables

B.1 Log-linearized Euler Equations for Singles.

Table 2: Log-linearized Individual Euler Equations for Single Females: Identification Result vs Standard Methods.

Parameters	Identification	Standard
ρ	5.02	5.21
	[2.49]	[1.08]
σ	0.30	0.12
	[0.44]	[0.07]
J-Statistics	15.2	37.9
$P > \chi^2$	0.71	0.73
number of observations		1228

Asymptotic standard errors in brackets. All models are estimated with GMM using the following instruments: first to second lags of after tax real wage growth, marginal tax growth; first to fourth lags of real consumption growth, income growth, gross pay growth, labor supply growth, the household specific price index growth. All instruments are calculated at the cohort level.

Table 3: Log-linearized Individual Euler Equations for Single Males: Identification Result vs Standard Methods.

Parameters	Identification	Standard
ρ	1.72	1.65
	[0.96]	[0.43]
σ	0.08	0.55
	[0.73]	[0.26]
J-Statistics	9.5	33.8
$P > \chi^2$	0.96	0.87
number of observations		1138

Asymptotic standard errors in brackets. All models are estimated with GMM using the following instruments: first to second lags of after tax real wage growth, marginal tax growth; first to fourth lags of real consumption growth, income growth, gross pay growth, labor supply growth, the household specific price index growth. All instruments are calculated at the cohort level.

B.2 Non-linear Euler Equations for Singles.

Table 4: Individual Euler Equations for Single Females: Identification Result vs Standard Methods.

Parameters	Identification	Standard
ρ	5.26	5.44
	[0.57]	[0.72]
σ	0.08	0.31
	[0.12]	[0.06]
J-Statistics	14.6	34.7
$P > \chi^2$	0.33	0.34
number of observations		1228

Asymptotic standard errors in brackets. All models are estimated with GMM using the following instruments: first lag of after tax real wage growth; first to third lags of real consumption growth, marginal tax growth, real gross interest rate growth; first to fourth lags of income growth, the household specific price index growth; all instruments are calculated at the cohort level.

Table 5: Individual Euler Equations for Single Males: Identification Result vs Standard Methods.

Parameters	Identification	Standard
ρ	1.96	1.62
	[0.63]	[0.39]
σ	0.45	0.51
	[0.56]	[0.24]
J-Statistics	5.5	20.9
$P > \chi^2$	0.85	0.75
number of observations		1138

Asymptotic standard errors in brackets. All models are estimated with GMM using the following instruments: first and second lags of labor supply growth; first to third lags of leisure growth; first to fourth lags of income growth, log of real gross rate of return; third and fourth lags of real consumption growth; all instruments are calculated at the cohort level.

B.3 Log-linearized Euler Equations for Singles, Controlling for Selection.

Table 6: Log-linearized Individual Euler Equations for Single Females: Identification Result vs Standard Methods Controlling for Selection.

Parameters	Identification	Standard
ρ	5.40	5.03
	[2.27]	[1.23]
σ	0.16	0.10
	[0.15]	[0.05]
Inverse Mills' Ratio t	2.12	4.24
	[2.10]	[3.45]
Inverse Mills' Ratio $t+1$	-1.69	-4.47
	[5.22]	[3.93]
J-Statistics	14.22	33.5
$P > \chi^2$	0.58	0.79
number of observations		1228

See note table 2.

Table 7: Log-linearized Individual Euler Equations for Single Males: Identification Result vs Standard Methods Controlling for Selection.

Parameters	Identification	Standard
ρ	2.14	1.70
	[1.09]	[0.31]
σ	0.10	0.18
	[0.20]	[0.09]
Inverse Mills' Ratio t	0.19	-0.53
	[0.75]	[0.88]
Inverse Mills' Ratio $t+1$	-0.65	4.62
	[2.14]	[3.76]
J-Statistics	9.3	33.2
$P > \chi^2$	0.90	0.80
number of observations		1138

See note table 3.

B.4 Non-linear Euler Equations for Singles, Controlling for Selection.

Table 8: Non-linear Individual Euler Equations for Single Females: Identification Result vs Standard Methods Controlling for Selection.

Parameters	Identification	Standard
ρ	5.41	5.13
	[0.85]	[1.11]
σ	0.14	0.32
	[0.19]	[0.08]
Inverse Mills' Ratio t	−0.74	−0.50
	[4.09]	[2.34]
Inverse Mills' Ratio $t+1$	1.29	2.33
	[6.38]	[4.36]
J-Statistics	14.9	32.6
$P > \chi^2$	0.14	0.29
number of observations		1228

See note table 4.

Table 9: Non-linear Individual Euler Equations for Single Males: Identification Result vs Standard Methods Controlling for Selection.

Parameters	Identification	Standard
ρ	1.90	1.84
	[0.65]	[0.29]
σ	0.45	0.26
	[0.35]	[0.15]
Inverse Mills' Ratio t	−0.40	2.08
	[2.63]	[2.65]
Inverse Mills' Ratio $t+1$	0.47	−1.84
	[1.76]	[2.10]
J-Statistics	5.62	23.4
$P > \chi^2$	0.59	0.44
number of observations		1138

See note table 5.

B.5 Euler Equations for Couples.

Table 10: Individual Euler Equations for Couples with the Efficiency Condition.

Parameters	Wife	Husband	Parameter Difference	Unitary Model with Separability
ρ	4.42	2.51	1.91	3.69
	[0.43]	[0.78]	[0.88]	[0.40]
σ	0.29	0.27	0.02	-
	[0.12]	[0.13]	[0.19]	
μ	0.82	-	-	-
	[4.32]			
J-Statistics			56.9	24.4
$P > \chi^2$			0.33	0.55
number of observations				1266

Asymptotic standard errors in brackets. The estimate of μ is obtained by computing a first order Taylor expansion under the assumption that the constants in the measurements errors are equal to zero. All models are estimated with GMM using the following instruments: first to second lags of marginal tax growth; first to third lags of wife's and husband's gross pay growth; first to fourth lags of real household consumption growth, household income growth, wife's and husband's after tax real wage growth, wife's and husband's labor supply growth.

Table 11: Individual Euler Equations for Couples without the Efficiency Condition.

Parameters	Wife	Husband	Parameter Difference
ρ	4.23	2.62	1.61
	[0.43]	[0.66]	[0.78]
σ	0.24	0.17	0.07
	[0.13]	[0.13]	[0.18]
μ	-	-	-
J-Statistics			56.1
$P > \chi^2$			0.36
Efficiency Test			
Distance Statistics			0.8
$P > \chi^2$			0.37
number of observations			1266

See note table 10.