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.

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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 (2007) 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 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, we 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 (2007), 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. (2005), Blundell et al. (2007), Donni (2004), Chiappori (1988; 1982), 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 Euler Equations of Singles and Couples

In this section, we test the hypothesis that the constant rejection of household Euler equations is generated by the fact that most of the households included in their estimation are composed of two or more decision makers who make joint decisions based on their individual decision power. The section will be divided into three parts. In the first subsection, we provide theoretical arguments that explain why the inclusion of married and cohabiting couples in the estimation of Euler equations will generally result in their rejection. We then introduce a test that enables us to evaluate whether our hypothesis can explain the rejections of the household Euler equations. In the second subsection, we describe the data that will be used in the implementation of the test. In the last subsection, we discuss how the tests is implemented, some econometric issues, and our empirical results.

2.1 Rejections of Euler equations and Household Composition

In the past three decades, Euler equations have been extensively used to test intertemporal models and to estimated preference parameters. The most frequently used test that relies on Euler equations is the excess sensitivity test proposed by Hall (1978) and Sargent (1978), which is based on the following idea. Household should choose current and future consumption according to the Euler equations using all the information available at the time of the decision. As a consequence, the difference between the current marginal utility of consumption and next period expected marginal utility of consumption should be independent of variables that are known to the household at the time of the decision. Many papers have tested this implication of the standard intertemporal model and regularly rejected it.

The model generally used to derive Euler equations, the unitary model, is well-suited to characterize the intertemporal decisions of households composed of a single individual. It is therefore also a good model to estimate the intertemporal dimension of the preferences of single individuals, such as their risk aversion or intertemporal elasticity of substitution. That model is not, however, well-suited to represent the behavior of married or cohabiting couples for reasons that will be discussed in the next paragraph. In spite of this, papers that estimate Euler equations rely either on a sample composed exclusively of couples, which is the case for instance in Attanasio and Browning (1995) and Meghir and Weber (1996), or alternatively on a sample that includes both couples and single individuals, as it is the case for example in Attanasio and Weber (1995) and Zeldes (1989). A potential explanation for the constant rejections of the Euler equations is therefore that the model used to derive them is not the proper model for most of the households included in the estimation.

To understand why the model employed to derive Euler equations is problematic when used to characterize couples, we will introduce a generalization to an intertemporal setting of the collective model of the household, which is by now a standard framework to study household decisions. The main feature of the collective model is that it explicitly recognize that the majority of households are composed of several individuals with potentially heterogeneous preferences who make joint decisions. This is done by assigning a utility function to each household member and by aggregating the individual preferences using the assumption that decisions are Pareto efficient. We will denote with u^i the utility function of member i and with μ the Pareto weight. Since in the U.S. most households with several decision makers are couples, we will consider the case in which households are composed of two members. To be consistent with the literature on the estimation of Euler equations we will assume that individuals have preferences over non-durable consumption c. Specifically, we assume that preferences are strongly separable between consumption and leisure and that there is no distinction between consumption goods that are private and public within the household. Following some of the papers that have estimated Euler equations, we will control for potential non-separabilities between consumption and leisure in the estimation. Moreover, since public consumption is an important aspect of household decisions, we will distinguish between private and public goods starting from the next section. In the model, household members live for T periods and can transfer resources over time using a risk-free asset with gross return R. The only source of uncertainty is household income, Y, which is the sum of members' income, $Y = \sum y^i$.

To generalize the collective model to an intertemporal setting, one has to take a stand on the ability of household members to commit to future allocations of resources. We will assume that household members can commit to future plans. The conclusions of this section do not change if a model without commitment is employed.[1] Under full commitment and the assumptions on preferences, the intertemporal collective model can be written in the following form:

$$\max_{\left\{c^1_{t,\omega},c^2_{t,\omega},s_t\right\}_{t,\omega}} \quad \mu\left(Z\right)E_0\left[\sum_{t=0}^{T}\beta^t u^1\left(c^1_{t,\omega}\right)\right]+\left(1-\mu\left(Z\right)\right)E_0\left[\sum_{t=0}^{T}\beta^t u^2\left(c^2_{t,\omega}\right)\right] \tag{1}$$

$$s.t. \quad \sum_{i=1}^{2}c^i_{t,\omega}+b_t\leq\sum_{i=1}^{2}y^i_{t,\omega}+R_t b_{t-1} \quad \forall t,\omega$$

$$b_T\geq 0 \;\; \forall\omega.$$

The Pareto weights μ and $1-\mu$ can be interpreted as the individual decision power of the two household members. They generally depend variables that have an effect on the intra-household

[1] The differences between collective models of the household with and without commitment are discussed in Mazzocco (2001), Mazzocco (2007), and Chiappori and Mazzocco (2014).

decision power such as prices, wages, and income. We will denote with Z the vector that includes those variables.

An important feature of the intertemporal collective model just introduced is that its solution is identical to the solution of the following two stage formulation of the household problem. In the first stage, the household allocates optimally lifetime resources across periods and states of nature. In the second stage, conditional on the amount of resources allocated to a given period and state of nature, the household chooses their optimal allocation between the two spouse. To formally describe the two stages, it is convenient to start from the second stage. Denote with $C_{t,\omega}$ an arbitrary amount allocated to period t and state ω. Conditional on $C_{t,\omega}$, in the second stage the household chooses the consumption of the two spouses as the solution of the following static problem:

$$U\left(C_{t,\omega}, \mu\left(Z\right)\right) = \max_{\left\{c^1_{t,\omega}, c^2_{t,\omega}\right\}} \quad \mu\left(Z\right) u^1\left(c^1_{t,\omega}\right) + \left(1 - \mu\left(Z\right)\right) u^2\left(c^2_{t,\omega}\right) \tag{2}$$

$$s.t. \quad \sum_{i=1}^{2} c^i_{t,\omega} = C_{t,\omega},$$

where $U\left(C_{t,\omega}, \mu\left(Z\right)\right)$ is the household's indirect utility function. In the first stage, the household chooses the allocation of lifetime resources over time and across states of nature using the indirect utility function derived in the second stage by solving the following standard intertemporal problem:

$$\max_{C_{t,\omega}} \quad E_0\left[\sum_{t=0}^{T} \beta^t U\left(C_{t,\omega}, \mu\left(Z\right)\right)\right] \tag{3}$$

$$s.t. \quad C_{t,\omega} + b_t = Y_{t,\omega} + R_{t+1} b_{t+1} \quad \forall t, \omega. \tag{4}$$

The two-stage formulation of the household decision problem is useful because the household Euler equation can easily be derived using the first stage of the household decision process and standard steps. It takes the following form:

$$U_C\left(C_t, \mu\left(Z\right)\right) = \beta R_{t+1} E_0\left[U_C\left(C_{t+1}, \mu\left(Z\right)\right)\right]. \tag{5}$$

Equation (5) can be used to clarify why the model commonly used to derive household Euler equations is problematic if applied to couples. Consider two households in which the two husbands have identical risk aversion, the two wives have identical risk aversion, and the wives' risk aversion is greater than the husbands' risk aversion. The two households are identical in any dimension except that the wife in the first household has a college degree at the time of marriage, whereas the other wife only has a high school diploma. The two households have therefore different vector Z and different intra-household decision power $\mu\left(Z\right)$. Suppose that, given the higher education of the wife in the first household, she has more decision power than the wife in the second household. The first household will then be more risk averse than the second one, it will assign more value to consumption smoothing, and it will have a flatter consumption path. The difference in consumption paths will be detected in the estimation of the Euler equations and will be explained using the only variable that can rationalize it, education, and variables that are correlated with it, such as wages and labor force participation. The reduced-form result will therefore be that education, wages, and labor force participation have an effect on the household Euler equations even if they are known at the time decisions are made. The intertemporal model will therefore be rejected because of excess sensitivity.

Notice that the previous argument does not apply to singles, since for them the indirect utility function $U(C_{t,\omega}, \mu(Z))$ simplifies to the standard utility function $U(C_{t,\omega})$. The excess sensitivity test is therefore well-defined for households with only one decision maker. This result provides us with a way of testing our hypothesis that the constant rejection of the household Euler equations is generated by the fact that most households are composed of individuals with different preferences who make joint decisions which depend on their decision power. If this hypothesis is correct, an excess sensitivity test should reject the household Euler equations for the sample of couples, but it should not reject them for the sample of singles. This is the subject of the next two subsections.

2.2 The Consumer Expenditure Survey (Maria will write the latest version)

Since 1980, the CEX survey has been collecting data on household consumption, income, and different types of demographics. The survey is a rotating panel organized by the Bureau of Labor Statistics (BLS). Each quarter about 4500 households representative of the US population are interviewed. 80% are reinterviewed the following quarter, while the remaining 20% are replaced by a new randomly selected group. Each household is interviewed at most for four quarters and detailed information is elicited with regard to expenditures for each of the three months preceding the interview and with regard to income and demographics for the quarter preceding the interview. Information on income is collected only in the first and fourth quarters and it measures income of the year preceding the interview. We assume that the rate at which income is earned is constant for the year. Under this assumption one can construct income for the first and fourth quarters by dividing income by four.[2] The data used in the estimation cover the period 1982-1995. The first two years are excluded because the data were collected with a slightly different methodology.

Following Attanasio and Weber (1995) total consumption is computed as the sum of food at home, food out, tobacco, alcohol, public and private transportation, personal care, maintenance, heating fuel, utilities, housekeeping services, repairs and clothing. As in Attanasi and Weber (1995), the price index is constructed in two steps. First, the components of the Consumer Price Index published by the Bureau of Labor Statistic for each category of consumption are gathered. The price index is then computed as the weighted average of these components where the weights corresponds to the expenditure share spent by a give household on that particular component of consumption.

[2]See Gervais and Klein (2008) for a detailed discussion of how income is measured in the CEX.

Total consumption is deflated using this household specific price indexes. Household income is computed as total household income plus transfers for the year preceding the interview. The wife's income is the sum of the components that can be imputed to her, i.e. income received from non-farm business, income received from farm business, wage and salary income, social security checks, and supplemental security income checks for the year preceding the interview. As in Attanasio and Weber (1995), the real interest rate is the quarterly average of the 20-year Municipal bond rate deflated using the household specific price index.

Rather than employing the short panel available in the CEX, we follow Attanasio and Weber (1995) and use synthetic panels. These are constructed using two variables: the year of birth of the head of the household and a dummy equal to 1 if the head is married and 0 otherwise.[3] All households are assigned to one of these cells which are constructed using a 7-year interval for the head's year of birth. The variables of interest are then averaged over all the households belonging to a given cohort observed in a given quarter. To avoid the complicated error structure that the timing of the interviews implies, we follow Attanasio and Weber (1995) and for each household in each quarter we use only the consumption data for the month preceding the interview and drop the data for the previous two months.

To construct the synthetic cohorts we exclude from the sample rural households, households with incomplete income responses, and households experiencing a change in marital status. Only cohorts for which the head's age is between 21 and 60 are included in the estimation. With regard to the minimum cohort size allowed in the estimation, two specifications are employed. In one case, the same size cutoff of 150 observations is used for married and single households. The use of the same cutoff has the disadvantage of generating samples of different size for singles and married. To determine whether the differences in results for married and single households is a consequence of the heterogeneity in sample size, a second specification is used that generates samples with the same number of observations. In this case, for married households, cohorts with size smaller than 150 are dropped. For single households, a cohort is dropped if it has size smaller than 100. An cohort-observation is then kept in a particular period if it is available for both the cohort of singles and the cohort of married individuals. Table **??** contains a description of the cohorts. Table **??** reports the summary statistics for the CEX sample.

2.3 Excess Sensitivity Test for Singles and Couples

In this subsection, we test the formulated hypothesis that the rejections of the Euler equations are generated by the aggregation of individual preferences in households with more than one adult. We do this in two steps. We first follow previous papers and estimate the Euler equations on the sample that includes both singles and couples. We then divide the sample in a subsample composed exclusively of singles and a subsample composed only of couples and estimate the Euler equations

[3]The husband is assumed to be the head of the household in a married or cohabiting couple.

separately on the two subsamples. If our hypothesis is correct, we should reject the household Euler equations only for couples. If the rejections are explained by other hypothesis, such as the existence of preference shocks and non-separabilities between consumption and leisure, the Euler equations should be rejected for both couples and singles.

To be consistent with the empirical approach used in the literature on the estimation of Euler equations, we employ the functional form used in most of those papers. Specifically, we estimate Euler equations of the following form:

$$\Delta \log \left(C_{i,t+1}\right) = \alpha + \zeta \log R_{t+1} + \epsilon_{i,t+1}, \tag{6}$$

where ζ represents the intertemporal elasticity of substitution, $\epsilon_{i,t+1}$ is a residual which captures the expectational error at time t, and the constant is a function of the discount factor and of the second and higher moments corresponding to the distribution of ϵ_{t+1}. Using standard arguments, this equation can be derived by log-linearizing the Euler equation (5) derived earlier in the paper.[4] Here is where our assumption that individuals only have preferences over non-durable consumption, without distinguishing between private and public goods, is important. Absent this assumption, we would not be able to estimate the same Euler equations employed in the literature.

To account for changes in household composition and preference shocks, we follow Attanasio and Weber (1995) and Zeldes (1989) and assume that the demographic variables and preference shocks z enter the instantaneous utility function multiplicatively through an exponential function, which implies that

$$U_{i,t} = U\left(C_{i,t}\right) exp\left(\phi' z_{i,t}\right)$$

In the estimation, the vector z will be composed of family size, number of children, and a set of seasonal dummies.

The Euler equation (6) is derived under the assumption that household consumption is strongly separable from leisure. To measure the effect of possible non-separabilities between consumption and leisure, we follow Browning and Meghir (1991), Attanasio and Weber (1995), and Meghir and Weber (1996) and model the leisure variables as conditioning variables, namely variables that may affect preferences over the goods of interest, but are not of primary interest. Specifically, following Attanasio and Weber (1995) and Meghir and Weber (1996), the Euler equations will also

[4] There is mixed evidence on the effect of the log-linearization on the parameter estimates. Carroll (2001) and Ludvigson and Paxson (2001) find that the approximation may introduce a substantial bias in the estimation of the preference parameters. On the other hand, Attanasio and Low (2004) show that using long panels it is possible to estimate consistently log-linearized Euler equations. It is important to remark that under the standard assumption in the intertemporal literature that couples behave as single agents, the linearization of the Euler equations has the same effect on singles and married. To see this notice that couples behave as single agents only if exact aggregation is satisfied. This is equivalent to the existence on a unique utility function for the couple that does not depend on prices, income, and other exogenous variables. Under the assumption that a unique utility function exists for couples, Euler equations and hence their linearized version are independent of family structure.

be estimated by including different combinations of the following variables: the head's leisure, a dummy equal to 1 if the head works, and, for couples, similar variables for the spouse.

To summarize, the following Euler equation is estimated:

$$\Delta \log (C_{i,t+1}) = \alpha + \gamma \log R_{t+1} + \phi' \Delta \bar{z}_{i,t+1} + \epsilon_{i,t+1}, \quad (7)$$

where $\bar{z}_{i,t+1}$ includes demographic and labor supply variables.

Before reporting the results, we discuss some econometeric issues. The error term of equation (7), $\epsilon_{i,t+1}$, contains the expectation error implicit in the Euler equation. Since part of the expectation error is generated by aggregate shocks, $\epsilon_{i,t+1}$ should be correlated across households. This implies that Euler equations can be consistently estimated only if households are observed over a long period of time as suggested by Chamberlain (1984). In the CEX, one of the main advantages of using synthetic panels is that cohorts are followed for the whole sample period. This should reduce the effect of aggregate errors on the estimation results.

The Euler equations are estimated using the Generalized Method of Moments (GMM). Under the assumption of rational expectations, any variable known at time t should be a valid instrument for GMM. However, measurement errors may introduce dependence between variables known at time t and concurrent and future variables even under rational expectations. To address this issue we only use variables known at $t-1$. The GMM estimates are obtained using the efficient weighting matrix, which is generated using a consistent GMM estimator in a first step. Given the longitudinal nature of the dataset employed in the estimation, it is important to allow each household to have a different and unrestricted covariance structure. To that end, the covariance matrix is computed using the efficient weighting matrix in the GMM procedure. As shown in Wooldridge (2002), this covariance matrix is general enough to allow for heteroskedasticity and arbitrary dependence in the residuals.

We can now discuss our empirical findings. The results obtained by estimating the household Euler equations on the sample that includes both singles and couples are reported in Table 2. The first three columns describe the results when a two-step GMM estimator is used, whereas in columns 4 through 6 we discuss the results obtained employing a 2-stage least squares estimator to evaluate the effect of the efficient weighting matrix. Since the results are similar, we will only discuss the first set of estimates. In the first column, we report the outcome of the test when we only include demographic variables in the estimation. The results are consistent with the findings of previous papers: the intertemporal elasticity of substitution is positive and around 0.15, but statistically insignificant; changes in family size and number of children have a positive effect on consumption growth; the coefficient on time-t log income is large, positive, and statistically significant, indicating that the excess sensitivity test rejects the intertermporal model. In column 2, we add to the estimation a dummy equal to 1 if the head works and a similar dummy for the spouse as variables capable of capturing potential non-separabilities between consumption and leisure. The coefficient on the head's dummy is negative large and statistically significant, which suggests that households in which the head works are better able to smooth consumption. This variable is therefore capable of explaining part of the variation in consumption growth, but the coefficient on income is even larger than in the first column and statistically significant. In the third column, in addition to the two labor dummies, we add the log of the head's and of spouse's quarterly leisure. The estimated coefficients are consistent with the ones described in column 2. Households in which the head works longer hours are better able to smooth consumption shocks. Remarkably, once we control for the head's leisure, the spouse's work dummy becomes positive and statistically significant. This result can be explained using an added-worker effect argument: with a significant probability, a spouse chooses to participate in the labor market when the households is hit by an adverse shock that increases consumption volatility. In spite of the introduction of the two leisure variables, the coefficient on time t income is still positive, large, and statistically significant, indicating that the household Euler equations are rejected.

We will now describe the results obtained by estimating the household Euler equations separately on the samples of singles and couples, which are reported in Table 3. We only present the results obtained using the two-step GMM estimator because the ones obtained using 2-stage least squares are similar. The first column reports the estimates for the sample of singles. The results are similar to the ones obtained for the entire sample except that now the coefficient on income is about two thirds the size of the coefficient estimated for the entire sample and statistically indistinguishable from zero. In this first specification, there is therefore no evidence of excess sensitivity for singles. In the second column, we present the results obtained by estimating the same specialization for couples. The intertemporal elasticity of substitution, the coefficient on family size, and the coefficient on number of children are all estimated to be positive. More importantly, the coefficient on income is positive, more than twice the size the coefficient for singles, and statistically significant. For couples, we can therefore reject this specification of the Euler equations. In columns 3 and 4, we add to the estimation for singles and couples the work dummy for the head of the household and, if present, for the spouse. In both samples, the coefficient on the dummy is positive, large, and statistically significant. This finding can be explained by non-separabilities between consumption and leisure: households with a head that changes employment status from not working to working increase their expenditure on goods related to their job such as gasoline and clothing. The main result, however, does not change. The coefficient on period-t income is still small and insignificant for singles and large and statistically significant for couples. In the last two columns, we report the estimates when we include in the specification the log of the head's quarterly leisure and, for couples, the same variable for the spouse. The leisure variable is positive for the head of a single household, but not statistically significant. For couples, the coefficient on the wife's leisure is positive and large, but statistically insignificant. Similarly to the previous specification, the coefficient on income is negligible and insignificant for singles, but large, positive, and statistically significant for couples.

We can therefore conclude that, even with the addition of demographic variables and variables that account for possible non-separabilities between consumption and leisure, Euler equations are rejected for couples because of excess sensitivity. We cannot, however, reject them for singles. These findings indicate that the excess sensitivity displayed by the Euler equations when estimated on the entire sample is generated by couples. As such, they provide strong evidence in favor of our hypothesis that the rejection of the Euler equations is produced by the aggregation of individual preferences in households with several decision makers.

Recently, a growing number of papers in micro and macro economics have developed intertermporal models of the households in which household members are characterized using individual utility functions.[5] To answer relevant questions, these papers require reliable estimates of the intertemporal preferences for women and men. The results of this section imply that the parameters characterizing the intertemporal preferences, such as the intertemporal elasticity of substitution, cannot be estimated using household Euler equations and samples composed of all households or samples composed of only couples. One possible way of addressing this issue is to rely only on singles for which households Euler equations are not rejected. One limitation of this approach is that it only works if there is no selection into marriage based on intertemporal preferences. For instance, if the more risk averse women and the less risk averse men are less likely to find a partner, the intertemporal preferences estimated on the sample of singles are not well suited to characterize the intertemporal preferences of married individuals. In the rest of the paper, we develop an alternative method to identify and estimate the intertemporal preferences of married women and men which is not affected by the selection issue mentioned above. Our method will also enable us to understand whether selection into marriage is a real concern when estimating intertemporal preferences. If it is not, the sample of singles can safely be used to recover the intertemporal aspects of individual preferences.

3 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 $y^i(t,\omega)$, supplies labor in quantity $h^i(t,\omega)$, and chooses expenditure on a private composite good $c^i(t,\omega)$ and on children $Q(t,\omega)$. Since children are for the most part a public good for their parents, $Q(t,\omega)$ will be modeled as public consumption. Let $C(t,\omega)$ be household total private consumption and let $l^i(t,\omega) = 1 - h^i(t,\omega)$ be leisure of member i, where the time endowment is normalized to 1. The price of private and public consumption will be denoted by $p(t,\omega)$ and $P(t,\omega)$, and agent i's wage

[5] Some examples are Casanova (2010), Gemici and Laufer (2012), **?**), Greenwood, Guner, and Knowles (2003), Jones, Manuelli, and McGrattan (2003), and Doepke and Tertilt (2010).

by $w_i(t,\omega)$. Household members can save jointly 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.[6] 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. 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.

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

where δ_i is the altruism parameter. It is assumed that the two spouses have the same discount factor β.[7]

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

3.1 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 $U\left(C,l^1,l^2,Q\right)$ and a household discount factor β. Intertemporal decisions can then be determined by solving the following problem:[8]

$$\max_{\left\{C_t,l_t^1,l_t^2,Q_t,s_t\right\}} E_0\left[\sum_{t=0}^{\mathcal{T}}\beta^t U\left(C_t,l_t^1,l_t^2,Q_t\right)\right] \tag{8}$$

$$s.t.\ p_tC_t+P_tQ_t+s_t\leq\sum_{i=1}^{2}\left(y_t^i+w_t^ih_t^i\right)+R_ts_{t-1}\quad\forall t,\omega$$

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

The first order conditions of the unitary model (8) can be used to derive the following standard household Euler equations for private consumption:

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

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

[7]This assumption is made for expositional purposes. If the individual discount factors are different, it can be shown that the identification method proposed here still works with small modifications.

[8]The dependence on the states of nature is suppressed to simplify the notation.

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 (2007) 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.[9] Mazzocco (2008) 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 (2007; 2008) 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.

3.2 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; 2007), 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:

$$\max_{\left\{c_t^1, c_t^2, l_t^1, l_t^2, Q_t, s_t\right\}} \mu E_0 \left[\sum_{t=0}^{\mathcal{T}} \beta^t u^1(c_t^1, l_t^1, Q_t)\right] + (1-\mu)\, E_0 \left[\sum_{t=0}^{\mathcal{T}} \beta^t u^2(c_t^2, l_t^2, Q_t)\right] \tag{9}$$

$$s.t. \sum_{i=1}^{2} \left(p_t c_t^i + w_{it} l_t^i\right) + P_t Q_t + s_t = \sum_{i=1}^{2} \left(y_t^i + w_{it}\right) + R_t s_{t-1} \quad \forall t, \omega$$

$$0 \leq l_t^i \leq 1 \quad \forall i, t, \omega, \qquad s_T \geq 0 \quad \forall \omega,$$

[9] See Browning and Lusardi (1995) for a survey.

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:

$$u_c^i\left(c_t^i, l_t^i, Q_t\right) = \beta_i E_t\left[u_c^i\left(c_{t+1}^i, l_{t+1}^i, Q_{t+1}\right) R_{t+1}\frac{p_t}{p_{t+1}}\right] \quad \forall\ i = 1, 2. \tag{10}$$

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.

To discuss the identification of individual preferences it is helpful to rewrite the household problem using a two-stage formulation. Under the assumption that individual preferences are separable over time and across states of nature, the solution of the household problem (9) is equivalent to the solution of the following two-stage problem. In the second stage, conditional on the amount of resources available in period t and state ω, the household chooses how much to spend on consumption and leisure. Formally, let $\bar{Y}\left(t, \omega\right)$ be the amount of resources available in period t and state ω. In the second stage, the household solves the following static problem for each t and ω:

$$V\left(\bar{Y}_t, w_{1t}, w_{2t}, p_t, P_t\right) = \max_{c_t^1, l_t^1, c_t^2, l_t^2, Q_t} \mu u^1\left(c_t^1, l_t^1, Q_t\right) + \left(1-\mu\right) u^2\left(c_t^2, l_t^2, Q_t\right)$$

$$s.t. \sum_{i=1}^{2}\left(p_t c_t^i + w_{it} l_t^i\right) + P_t Q_t = \bar{Y}_t$$

$$0 \leq l_t^i \leq 1 \quad \text{for } i = 1, 2.$$

The standard Marshallian demand functions for public consumption, household private consumption, and leisure can be derived as the solution of this second-stage problem. They depend on the prices of public and private consumption, the individual wages, and the resources available in period t and state ω, i.e. $Q_t = Q\left(p_t, P_t, w_{1t}, w_{2t}, \bar{Y}_t\right)$, $C_t = c_t^1 + c_t^2 = C\left(p_t, P_t, w_{1t}, w_{2t}, \bar{Y}\right)$, $l_t^1 = l^1\left(p_t, P_t, w_{1t}, w_{2t}, \bar{Y}_t\right)$, and $l_t^2 = l^2\left(p_t, P_t, w_{1t}, w_{2t}, \bar{Y}_t\right)$. In the first stage the household chooses the optimal allocation of resources to each period and state of nature by solving the following dynamic problem:

$$\max_{\{\bar{Y}_t, s_t\}} \sum_{t=0}^{\mathcal{T}} E_0 \left[\beta^t V\left(\bar{Y}_t, w_{1t}, w_{2t}, p_t, P_t\right)\right]$$

$$s.t.\ \bar{Y}_t = \sum_{i=1}^{2} \left(y_t^i + w_{it}\right) + R_t s_{t-1} - s_t \quad \forall t, \omega$$

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

The two-stage formulation will be used to describe the type of variation required in the identification of the individual preferences for expenditure on children.

Three main assumptions characterize the intertemporal collective model (9) 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.[10]

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:

$$\frac{u_c^1\left(c_t^1, l_t^1, Q_t\right)}{u_c^2\left(c_t^2, l_t^2, Q_t\right)} = \mu. \tag{11}$$

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

[10] 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.

using the consumption Euler equations and the intraperiod conditions even if consumption is not observed at the individual level.

4 A General Example

In this section we will consider an example which illustrates how the intertemporal conditions help in the identification of the parents' preferences for expenditure on children. In an attempt to provide a clear intuition of the identification results, in this session we will consider an environment with no uncertainty. we will only discuss the case in which only agent 1, the father, works since in this case the identification of the parameters of interest is more difficult to achieve.

In the example discussed in this section we will consider a specific functional form for the parents' preferences. It is assumed that each parent has a utility function that is non-separable in public consumption and has the following form:

$$U\left(l^{i}, c^{i}, Q\right) = \left(c^{i}\right)^{\sigma_i} \left(l^{i}\right)^{\theta_i} (Q)^{\gamma_i} + \delta_i \ln Q.$$

The utility function is a standard Cobb-Douglas utility function augmented to include a public good. The public good enters individual preferences in two different ways: through a separable function and through a function in which public consumption is non-separable from leisure and private consumption. This feature of the utility function will enable me to describe which variation is required for the identification of the non-separable part of the preferences for public consumption and which variation is needed to recover the separable part.

The problem of identifying the parameters of interest can be stated in the following way. The econometrician knows public consumption, household private consumption, the father's leisure, the father's wage, the prices of private and public consumption, and the amount of resources that the household decides to allocate to each period. Since the mother does not work, no variation in her wage and leisure is observed. A dataset in which all these variables are observed is the Consumer Expenditure Survey (CEX). Using these variables, the econometrician can recover non-parametrically the Marshallian demand functions $Q = Q\left(p, P, w_1, \bar{Y}\right)$, $C = C\left(p, P, w_1, \bar{Y}\right)$, and $l^1 = l^1\left(p, P, w_1, \bar{Y}\right)$, which are the solution of the second stage of the household problem. They will therefore be assumed to be known. Note that the Marshallian demand function for the mother's leisure cannot be recovered because by assumption there is no variation in her leisure. Since the Marshallian demand functions are known, the derivatives of public consumption, private consumption, and the father's leisure with respect to wages, resources, and prices are also known. Given this information, the econometrician is interested in recovering the preference parameters and the decision power parameter.

In the parametric examples considered in this section, identification can be easily analyzed using the first order conditions for private consumption, leisure, and public consumption. The following approach will be employed. The first order conditions will be used to derive a set of equations that depend on the parameters of interest and variables that are known. The equations can then be solved for the parameters of interest. If a unique solution exists, the model is identified. If more than one solution exist, the model is not identified.

We will start with the derivation of the first order conditions. Denote by λ_t the multiplier of the budget constraint of the household problem in period t and let $\mu_1 = \mu$ and $\mu_2 = 1 - \mu$. In the example considered here, the first order conditions for private consumption of parent i can be written in the form

$$\beta^t \mu_i \sigma_i \left(c_t^i\right)^{\sigma_i - 1} \left(l_t^i\right)^{\theta_i} \left(Q_t\right)^{\gamma_i} = p_t \lambda_t,$$

the leisure first order condition of the working parent takes the form

$$\beta^t \mu_1 \theta_1 \left(c_t^1\right)^{\sigma_1} \left(l_t^1\right)^{\theta_1 - 1} \left(Q_t\right)^{\gamma_1} = w_{1t} \lambda_t,$$

and the public consumption first order condition can be written as

$$\beta^t \sum_{i=1}^{2} \mu_i \left(\gamma_i \left(c_t^i\right)^{\sigma_i} \left(l_t^i\right)^{\theta_i} \left(Q_t\right)^{\gamma_i - 1} + \frac{\delta_i}{Q_t} \right) = P_t \lambda_t,$$

where $l_t^2 = 1$ for the mother. Finally, in an environment without uncertainty, the first order condition that captures the optimal allocation of resources over time has the following form:

$$\lambda_t = R_{t+1} \lambda_{t+1}.$$

Using these first order conditions one can derive the five optimality conditions that will be employed in the identification of the parameters of interest: (i) an equation stating that the marginal rate of substitution between consumption and leisure of the working parent must equal his real wage; (ii) the efficiency condition for private consumption; (iii) the efficiency condition for public consumption; (iv) the private consumption Euler equation for the mother; (v) the private consumption Euler equation for the father.[11] In the present example, the first optimality condition has the following form:

$$\frac{\theta_1}{\sigma_1} \frac{c_t^1}{l_t^1} = \frac{w_{1t}}{p_t}.$$

The private consumption efficiency condition can be written as

$$\frac{\sigma_1 \left(c_t^1\right)^{\sigma_1 - 1} \left(l_t^1\right)^{\theta_1} Q_t^{\gamma_1}}{\sigma_2 \left(c_t^2\right)^{\sigma_2 - 1} Q_t^{\gamma_2}} = \frac{1 - \mu}{\mu}. \tag{12}$$

[11] The model considered in this paper is over-identified in the sense that the number of optimality conditions that can be used to recover the parameters of interest is greater than the number of parameters. For instance, the public consumption Euler equation could be used in place of one of the five conditions employed in this section. The optimality conditions that are not used in the identification of the parameters can be used to test the model.

Using the first order conditions for public and private consumption, the public consumption efficiency condition can be written as follows:

$$\frac{\gamma_1}{\sigma_1}\frac{c_t^1}{Q_t}+\frac{\delta_1}{\sigma_1}\frac{1}{\left(c_t^1\right)^{\sigma_1-1}\left(l_t^1\right)^{\theta_1}Q_t^{\gamma_1+1}}+\frac{\gamma_2}{\sigma_2}\frac{c_t^2}{Q_t}+\frac{\delta_2}{\sigma_2}\frac{1}{\left(c_t^2\right)^{\sigma_2-1}Q_t^{\gamma_2+1}}=\frac{P_t}{p_t}.$$

Finally, the father's private consumption Euler equation takes the form

$$\beta R_{t+1}\frac{p_t}{p_{t+1}}\left(\frac{c_{t+1}^1}{c_t^1}\right)^{\sigma_1-1}\left(\frac{l_{t+1}^1}{l_t^1}\right)^{\theta_1}\left(\frac{Q_{t+1}}{Q_t}\right)^{\gamma_1}=1,$$

whereas the mother's can be written as follows:

$$\beta R_{t+1}\frac{p_t}{p_{t+1}}\left(\frac{c_{t+1}^2}{c_t^2}\right)^{\sigma_2-1}\left(\frac{Q_{t+1}}{Q_t}\right)^{\gamma_2}=1.$$

We will now discuss how the parameters of the non-separable part of the father's preferences σ_1, θ_1, and γ_1 can be recovered by using his private consumption Euler equation. The Euler equations depend on private consumption which is not observed. However, one can use the optimality condition that relates the marginal rate of substitution of the father to his real wage to derive the father's private consumption as a function of own leisure and own real wage, i.e.

$$c_t^1=\frac{\sigma_1}{\theta_1}\frac{w_{1t}}{p_t}l_t^1.$$

In each period the sum of individual private consumption must equal total household private consumption C_t, which is observed. As a consequence, the mother's private consumption can also be written as a function of variables that are observed, i.e.

$$c_t^2=C_t-\frac{\sigma_1}{\theta_1}\frac{w_{1t}}{p_t}l_t^1.$$

The private consumption Euler equation of the father can now be written in terms of variables that are observed by substituting out individual consumption. After the substitution, this intertemporal optimality condition becomes

$$\beta R_{t+1}\left(\frac{p_t}{p_{t+1}}\right)^{\sigma_1}\left(\frac{w_{1t+1}}{w_{1t}}\right)^{\sigma_1-1}\left(\frac{l_{t+1}^1}{l_t^1}\right)^{\sigma_1+\theta_1-1}\left(\frac{Q_{t+1}}{Q_t}\right)^{\gamma_1}=1.$$

By taking the logarithm of both sides, it can be rewritten in the following simpler form:

$$\Delta\ln Q_{t+1}+\rho_1^1\Delta\ln l_{t+1}^1=-\rho_2^1\Delta\ln w_{1t+1}-\rho_3^1\ln\left(\frac{p_t}{p_{t+1}}\right)-\rho_4^1\ln\left(R_{t+1}\right)-\rho_4^1\ln\beta. \tag{13}$$

where $\rho_1^1=\frac{\sigma_1+\theta_1-1}{\gamma_1}$, $\rho_2^1=\frac{\sigma_1-1}{\gamma_1}$, $\rho_3^1=\frac{\sigma_1}{\gamma_1}$, and $\rho_4^1=\frac{1}{\gamma_1}$. Two features of this optimality condition are worth a discussion. First, this equation depends on five unknown parameters ρ_1^1, ρ_2^1, ρ_3^1, ρ_4^1, and β, and observed variables. Second, in an environment with uncertainty one needs this equation plus four additional moment conditions to identify the five parameters. The standard approach in the estimation of parameters contained in Euler equations is to use lagged variables to construct the four additional moment conditions. With the goal of providing some insight on the variation required in the data to identify these parameters, instead of considering the standard case with uncertainty we will discuss the case of no uncertainty.

Consider a change in the amount of resources allocated to period t, $\bar{Y}_t$, generated for instance by a variation in the father's wage in period $t' \neq t, t+1$. The household will respond to this variation by changing how the father's leisure, the father's private consumption, and public consumption evolve between t and $t+1$. This intertemporal change depends on the father's taste for leisure and private consumption relative to his taste for public consumption, which is described by ρ_1^1. It can be determined by differentiating the father's private consumption Euler equation (13) with respect to $\bar{Y}_t$ and it can be described using the following equation:

$$\Delta \ln Q_{\bar{Y}_t,t+1} + \rho_1^1 \Delta \ln l^1_{\bar{Y}_t,t+1} = 0,$$

where $Q_{\bar{Y}_t,t+1}$ and $l^i_{\bar{Y}_t,t+1}$ are the partial derivatives of public consumption and leisure with respect to $\bar{Y}_t$. This implies that one can recover the father's taste for leisure and private consumption relative to his taste for public consumption by simply observing the intertemporal change in father's leisure and public consumption in response to a change in resources available in a given period, i.e.

$$\rho_1^1 = -\frac{\Delta \ln Q_{\bar{Y}_t,t+1}}{\Delta \ln l^1_{\bar{Y}_t,t+1}}.$$

Now that the relative taste parameter ρ_1^1 is known, it is straightforward to identify the parameter ρ_3^1 which provides information on the father's taste for private consumption relative to his taste for public consumption. Consider a change in the price of private consumption at t. The household varies the father's leisure and public consumption according to the following optimality condition:

$$\Delta \ln Q_{p_t,t+1} + \rho_1^1 \Delta \ln l^1_{p_t,t+1} = -\rho_3^1 \frac{1}{p_t}.$$

As a consequence, ρ_3^1 can be recovered if one observes a change in p_t and the corresponding change in leisure and public consumption. Specifically,

$$\rho_3^1 = -p_t \left(\Delta \ln Q_{p_t,t+1} + \rho_1^1 \Delta \ln l^1_{p_t,t+1} \right).$$

Finally one can recover the parameter ρ_2^1, which provides different information on the father's taste for private consumption relative to his taste for public consumption, if variation in the father's wage in period t is observed. The effect of this variation on the father's leisure and public consumption can be determined by differentiating the father's private consumption Euler equation with respect to his wage. The following equation describes the effect:

$$\Delta \ln Q_{w_{1t},t+1} + \rho_1^1 \Delta \ln l^1_{w_{1t},t+1} = \rho_2^1 \frac{1}{w_{1t}}.$$

The parameter ρ_2^1 is therefore equal to

$$\rho_2^1 = w_{1t}\left(\Delta \ln Q_{w_{1t},t+1} + \rho_1^1 \Delta \ln l^1_{w_{1t},t+1}\right).$$

Now that the reduced form parameters ρ_1^1, ρ_2^1, and ρ_3^1 are known, it is straightforward to recover the father's preference parameters for the non-separable part of his utility function. They are equal to the following functions of the reduced form parameters:

$$\sigma_1 = \frac{\rho_3^1}{\rho_3^1 - \rho_2^1}, \quad \theta_1 = \frac{\rho_1^1 - \rho_2^1}{\rho_3^1 - \rho_2^1}, \quad \gamma_1 = \frac{1}{\rho_3^1 - \rho_2^1}.$$

Since γ_1 has been recovered, the reduced-form parameter ρ_4^1 is also known. The discount factor can then be identified by solving the private consumption Euler equation for β.

The father's private consumption can also be recovered since it only depends on the parameters σ_1 and θ_1. As a consequence, the mother's private consumption is also identified. It should be remarked that individual consumption can be identified only because of the particular functional form chosen for the utility functions. In general, individual consumption can be identified only up to an additive constant. In the example considered here, the constant is assumed to be zero.

We will now describe how the mother's preference parameters for private consumption and the non-separable part of her preferences for public consumption can be recovered using her private consumption Euler equation. Her taste for leisure, however, cannot be identified since no variation in her labor supply is observed. Since the mother's private consumption is now known, there is no need to substitute out private consumption from her Euler equation, which can be written in the form

$$\Delta \ln Q_{t+1} + \rho_1^2 \Delta \ln c^2_{t+1} = -\rho_2^2 \ln\left(R_{t+1}\frac{p_t}{p_{t+1}}\right) - \rho_2^2 \ln \beta,$$

where $\rho_1^2 = \frac{\sigma_2 - 1}{\gamma_2}$ and $\rho_2^2 = \frac{1}{\gamma_2}$. The identification of the mother's preference parameters can be achieved using the logic used for the father. Consider a change in the resources available in period t generated by a variation in one of the exogenous variables in period $t' \neq t,\ t+1$. This change modifies how the household allocates resources between t and $t+1$. The corresponding intertemporal change for the mother can be described by differentiating her private consumption Euler equation with respect to $\bar{Y}_t$, i.e.

$$\Delta \ln Q_{\bar{Y}_t,t+1} + \rho_1^2 \Delta \ln c^2_{\bar{Y}_t,t+1} = 0.$$

This type of variation enables one to recover the mother's taste for private consumption relative to her taste for public consumption ρ_1^2, i.e.

$$\rho_1^2 = -\frac{\Delta \ln Q_{\bar{Y}_t,t+1}}{\Delta \ln c^2_{\bar{Y}_t,t+1}},$$

The inverse of the taste for public consumption ρ_2^2 can now be recovered if variation in the price of private consumption at t and the corresponding changes in intertemporal decisions are observed.

These changes are described by the following equation:

$$\Delta \ln Q_{p_t,t+1} + \rho_1^2 \Delta \ln c^2_{p_t,t+1} = -\rho_2^2 \frac{1}{p_t}.$$

which implies that

$$\rho_2^2 = -p_t \left(\Delta \ln Q_{p_t,t+1} + \rho_1^2 \Delta \ln c^2_{p_t,t+1} \right).$$

Finally, the mother's preference parameters for private and public consumption can be recovered using the information on the reduced-form parameters ρ_1^2 and ρ_2^2. Specifically,

$$\sigma_2 = \frac{\rho_1^2 + \rho_2^2}{\rho_2^2}, \quad \gamma_2 = \frac{1}{\rho_2^2}.$$

Only three of the parameters of interest remain to be identified: the decision power parameter μ and the parameters that describe the separable part of the individual preferences for public consumption δ_1 and δ_2. Intuitively, one should expect that these parameters cannot be identified by simply using the private consumption Euler equations, since they provide no information on the individual decision power and on the separable part of the preferences for the public good. Some additional restrictions imposed by the model on individual behavior must be employed to identify the remaining parameters.

The decision power parameter can be recovered using the private consumption efficiency condition (12). In this equation all the parameters and variables are known except μ. One can therefore identify the individual decision power by solving this equation for μ. The parameters δ_1 and δ_2 can be recovered using the public consumption efficiency condition in two different periods. The public consumption efficiency condition at t and $t+1$ can be written in the following form:

$$A_t^1 + \delta_1 B_t^1 + A_t^2 + \delta_2 B_t^2 = \frac{P_t}{p_t},$$

and

$$A_{t+1}^1 + \delta_1 B_{t+1}^1 + A_{t+1}^2 + \delta_2 B_{t+1}^2 = \frac{P_{t+1}}{p_{t+1}}.$$

where A_t^i, B_t^i, A_{t+1}^i and B_{t+1}^i are functions of known parameters and observed variables. The parameters that characterize the separable part of the individual preferences for public consumption can therefore be recovered by solving these two equations for δ_1 and δ_2. They can be written in the form

$$\delta_1 = \frac{B_t^2 A_{t+1}^1 + B_t^2 A_{t+1}^2 - A_t^1 B_{t+1}^2 - A_t^2 B_{t+1}^2 - B_t^2 P_{t+1} + P_t B_{t+1}^2}{B_t^1 B_{t+1}^2 - B_{t+1}^1 B_t^2},$$

and

$$\delta_2 = \frac{B_t^1 A_{t+1}^1 + B_t^1 A_{t+1}^2 - B_{t+1}^1 A_t^1 - B_{t+1}^1 A_t^2 + B_{t+1}^1 P_t - B_t^1 P_{t+1}}{B_{t+1}^1 B_t^2 - B_t^1 B_{t+1}^2}.$$

The results presented in this section suggest that the parents' preferences for expenditure on children can be identified even if only one parent works and the individual preferences are non-separable in public consumption. The information on preferences for expenditure on children can be used to predict how much parents in different income quartiles will invest in their children. Policies that attempt to improve the cognitive and non-cognitive abilities of children living in deprived environments can then be designed to reflect potential differences in early investments across income quartiles.

5 A General Identification Result

The identification result presented in the previous section will be extended to the general set of utility functions described in section ??. Identification is achieved in four steps. In the first step, individual consumption is derived as a function of observed variables using the optimality condition that relates the individual marginal rate of substitution between consumption and leisure to own real wage. In the second step, individual consumption is substituted out of the individual marginal utilities using the consumption function obtained in the first step. In the third step, intra-period and intertemporal optimality conditions are derived using the reduced-form marginal utilities obtained in the second step. It is then shown that the reduced-form marginal utilities and individual decision power can be identified using this set of conditions. In the last step, the individual utilities are recovered exploiting the information on the reduced-form marginal utility functions.

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

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

where $\bar{w}_{1t} = \dfrac{w_{1t}}{p_t}$. 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, public consumption, and real wage:[12]

$$c_t^1 = g\left(\bar{w}_{1t}, h_t^1, Q_t\right).$$

Since household private consumption is observed and in each period $C_t = c_t^1 + c_t^2$, agent 2's private consumption can also be written as a function of observed variables as follows:

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

[12] 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. More formally, lemma 1 in the appendix shows that g is well-defined if

$$u_{lc}^1\left(c_t^1, 1-h_t^1, Q_t\right) u_c^1\left(c_t^1, 1-h_t^1, Q_t\right) - u_{cc}^1\left(c_t^1, 1-h_t^1, Q_t\right) u_l^1\left(c_t^1, 1-h_t^1, Q_t\right) \neq 0. \tag{14}$$

The function g corresponds to the m-consumption function introduced by Browning (1998).

Using the function g, the unobserved individual private consumption can be substituted out of the marginal utilities that define the intratemporal and intertemporal optimality conditions. Denote with f_k^1 and f_k^2 the reduced-form marginal utilities with respect to good k for agent 1 and 2 obtained with this substitution. Then f_k^1 and f_k^2 can be defined as follows:

$$f_k^1\left(\bar{w}_{1t}, h_t^1, Q_t\right) = u_k^1\left(g\left(\bar{w}_{1t}, h_t^1, Q_t\right), 1 - h_t^1, Q_t\right) \quad k = c, l, Q, \tag{15}$$

$$f_k^2\left(C_t, \bar{w}_{1t}, h_t^1, h_t^2, Q_t\right) = u_k^2\left(C_t - g\left(\bar{w}_{1t}, h_t^1, Q_t\right), 1 - h_t^2, Q_t\right) \quad k = c, l, Q. \tag{16}$$

An example for f_k^1 and f_k^2 can be easily derived using the parametric specification assumed in the previous section. For instance, in that case the father's reduced-form marginal utility for private consumption is characterized by the reduced form parameters $\alpha_1 = \sigma_1 - 1$, $\alpha_2 = \sigma_1 + \theta_1 - 1$, $\alpha_3 = \sigma_1\left(\frac{\sigma_1}{\theta_1}\right)^{\alpha_1}$, and by the preference parameter γ_1.

The reduced-form marginal utilities can be used to rewrite the individual private consumption Euler equations in terms of observed variables. To that end, the assumption that agent 1 supplies a positive amount of labor must be fulfilled for two consecutive periods. Under this restriction, the intertemporal optimality conditions can be written as follows:

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

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

Since household private consumption, public consumption, individual labor supply, individual wages, and the interest rate are observed, the reduced-form marginal utilities f_c^1 and f_c^2, and the discount factor β can be identified using the private consumption Euler equations and methods that have been developed for the identification of Euler equations.[13]

The remaining reduced-form marginal utilities can be identified using the intra-period optimality conditions and the public consumption Euler equation. Observe that 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 consumption function g. This implies that

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

Now consider a realization of the exogenous variables p_t, P_t, w_{1t}, w_{2t}, and of the amount of resources $\bar{Y}_t$, which are all observed.[14] Conditional on this realization, the household members choose the

[13] As mentioned in the introduction, in principle the Euler equations can be identified non-parametrically. However, until a paper on non-parametric identification of Euler equations is written the identification result of this paper relies on parametric methods of identification of Euler equations.

[14] Note that $\bar{Y}_t$ is not exogenous but it depends on all exogenous variables in each period. It can therefore be varied by changing one of the exogenous variables at $t' \neq t$. In the remainder of the section, it will therefore be treated as an exogenous variable.

optimal amount of C_t, Q_t, h_t^1, and h_t^2, which are also observed. For the observed $\bar{w}_{1t}$, h_t^1, Q_t, the function $f_c^1\left(\bar{w}_{1t}, h_t^1, Q_t\right)$ is known from the private consumption Euler equations. Consequently, one can recover $f_l^1\left(\bar{w}_{1t}, h_t^1, Q_t\right)$ for the observed $\bar{w}_{1t}$, h_t^1, and Q_t by setting it equal to $\bar{w}_{1t} f_c^1\left(\bar{w}_{1t}, h_t^1, Q_t\right)$. By using the same argument for every realization of p_t, P_t, w_{1t}, w_{2t}, and $\bar{Y}_t$, the entire function f_l^1 can be identified.

The individual decision power can be identified using a similar idea. The private consumption efficiency condition can be written using the reduced-form marginal utilities in the following form:

$$\frac{f_c^1\left(\bar{w}_{1t}, h_t^1, Q_t\right)}{f_c^2\left(C_t, \bar{w}_{1t}, h_t^1, h_t^2, Q_t\right)} = \frac{1-\mu}{\mu}.$$

For every realization of p_t, P_t, w_{1t}, w_{2t}, and $\bar{Y}_t$, the functions f_c^1 and f_c^2 are known from the Euler equations. The relative decision power μ is therefore also identified.

The reduced-form marginal utilities of public consumption can be recovered using the public consumption Euler equation and the public consumption efficiency condition. To understand how these functions can be recovered, note that the public consumption Euler equation can be written in the form

$$\begin{gathered} f_Q^1\left(\bar{w}_{1t}, h_t^1, Q_t\right) + \frac{1-\mu}{\mu} f_Q^2\left(C_t, \bar{w}_{1t}, h_t^1, h_t^2, Q_t\right) = \\ \beta E_t\left[\left(f_Q^1\left(\bar{w}_{1t+1}, h_{t+1}^1, Q_{t+1}\right) + \frac{1-\mu}{\mu} f_Q^2\left(C_{t+1}, \bar{w}_{1t+1}, h_{t+1}^1, h_{t+1}^2, Q_{t+1}\right)\right) R_{t+1} \frac{P_t}{P_{t+1}}\right], \end{gathered}$$

where μ and β are known from the private consumption efficiency condition and Euler equations. The public consumption Euler equation enables one to recover the following function:

$$G\left(C_t, \bar{w}_{1t}, h_t^1, h_t^2, Q_t\right) = f_Q^1\left(\bar{w}_{1t}, h_t^1, Q_t\right) + \frac{1-\mu}{\mu} f_Q^2\left(C_t, \bar{w}_{1t}, h_t^1, h_t^2, Q_t\right). \tag{17}$$

Household decisions must also satisfied the following public consumption efficiency condition:

$$\frac{f_Q^1\left(\bar{w}_{1t}, h_t^1, Q_t\right)}{f_c^1\left(\bar{w}_{1t}, h_t^1, Q_t\right)} + \frac{f_Q^2\left(C_t, \bar{w}_{1t}, h_t^1, h_t^2, Q_t\right)}{f_c^2\left(C_t, \bar{w}_{1t}, h_t^1, h_t^2, Q_t\right)} = \frac{P_t}{p_t}. \tag{18}$$

Note that for every realization of p_t, P_t, w_{1t}, w_{2t}, and $\bar{Y}_t$ the functions f_c^1 and f_c^2, and the decision power parameter μ are known. The reduced-form marginal utilities for public consumption can therefore be identified by solving equations (17) and (18) for f_Q^1 and f_Q^2 for every realization of p_t, P_t, w_{1t}, w_{2t}, and $\bar{Y}_t$.

Under the additional assumption that agent 2 chooses to supply a positive amount of labor, agent 2's reduced-form marginal utility of leisure can also be identified by equating her marginal rate of substitution between private consumption and leisure to the real wage, i.e.,

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

The function f_c^2 is known from the Euler equations for every realization of the exogenous variables p_t, P_t, w_{1t}, w_{2t}, and $\bar{Y}_t$. Thus, f_l^2 can be identified by setting it equal to $\bar{w}_{2t} f_c^2$.

All the reduced-form 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 reduced-form marginal utilities are known and variation in all the exogenous variables is observed.

Proposition 1 *If both agents supply a positive amount of labor and either u^1 or u^2 satisfies the invertibility condition (14), the marginal utilities u_c^1, u_c^2, u_l^1, u_l^2, u_Q^1, u_Q^2, the decision power μ, and the consumption function 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 (14), all the marginal utilities are identified except the marginal utility of leisure for the spouse that does not work. Moreover, 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 if the function $g\left(\bar{w}_1, h^1, Q\right)$ is known the original marginal utilities can be easily identified by means of equations (15) and (16). We will now discuss how $g\left(\bar{w}_1, h^1, Q\right)$ can be recovered using variation in variables that are observed in the data. Since some insight for the case of a household with only one worker was provided in the previous section, here we will consider the case of a household in which both parents work. Equation (16) implies that for every realization of the exogenous variables agent 2's reduced-form marginal utilities of private and public consumption must satisfy the following identities:

$$f_c^2\left(C, \bar{w}_1, h^1, h^2, Q\right) = u_c^2\left(C - g\left(\bar{w}_1, h^1, Q\right), 1 - h^2, Q\right). \tag{19}$$

and

$$f_Q^2\left(C, \bar{w}_1, h^1, h^2, Q\right) = u_Q^2\left(C - g\left(\bar{w}_1, h^1, Q\right), 1 - h^2, Q\right). \tag{20}$$

Consider variations in the exogenous variables that generate a group of households with identical $\bar{w}_1$, h_1, h_2, and Q but different C. This group of households enables one to recover $u_{c,c}^2$, i.e. how agent 2's marginal utility of private consumption varies with agent 2's private 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, h_2, and Q are held constant. Since (19) is satisfied for every feasible C, how u_c^2 varies with C holding $\bar{w}_1$, h_1, h_2, and Q constant must be equivalent to how f_c^2 varies with C if $\bar{w}_1$, h_1, h_2, and Q are held constant. Finally, how u_c^2 varies with C holding $\bar{w}_1$, h_1, h_2, and Q constant corresponds to u_{cc}^2. Consequently, $u_{cc}^2 = f_{cc}^2$. The same argument applied to equation (20) implies that $u_{Qc}^2 = f_{Qc}^2$.

Consider now changes in the exogenous variables that generate the group of households for which C, $\bar{w}_1$, h_2, and Q are constant, but h_1 varies. This group of households provides joint information on u^2_{cc} and g_{h_1}. To explain this note that it is known how f^2_c varies with h_1 if C, $\bar{w}_1$, h_2, and Q are held constant. By (19), how u^2_c varies with h^1 holding C, $\bar{w}_1$, h_2, and Q constant must be equivalent to how f^2_c varies with h_1 if C, $\bar{w}_1$, h_2, and Q are held constant. Finally, observe that by varying h^1 on the right hand side of (19), one obtains information on $u^2_{cc}g_{h_1}$. This implies that $u^2_{cc}g_{h_1} = -f^2_{ch_1}$.

Consider the variation in the exogenous variables that generates the group of households for which C, h_1, h_2, and Q are constant, but $\bar{w}_1$ varies. Using the argument employed for the previous group of households, it can be shown that $u^2_{cc}g_{\bar{w}_1} = -f^2_{c\bar{w}_1}$. Consider the variation in p_t, P_t, w_{1t}, w_{2t}, and $\bar{Y}_t$ that generates the group of households for which C, h_1, h_2, and $\bar{w}_1$ are constant, but Q varies. The logic employed for the previous two groups of households indicates that $-u^2_{cc}g_Q + u^2_{cQ} = f^2_{c\bar{w}_1}$.

All the information required to identify how $g\left(\bar{w}^1, h^1, Q\right)$ varies with $\bar{w}_1$, h_1, and Q is now known. Using the first and second group of households one obtains that $g_{h_1} = -f^2_{ch_1}/f^2_{cc}$. The first and third group of households imply that $g_{\bar{w}_1} = -f^2_{c\bar{w}_1}/f^2_{cc}$. Using the first and fourth group of households it can be shown that $g_Q = \left(f^2_{Qc} - f^2_{c\bar{w}_1}\right)/f^2_{cc}$. Finally, since it is known how $g\left(\bar{w}^1, h^1, Q\right)$ varies with $\bar{w}_1$, h_1, and Q, the function g is known up to an additive constant. It is then straightforward to recover the original marginal utilities using the reduced-form marginal utilities and g.

An implication of Proposition 1 is that the individual preferences over private consumption, public consumption, and leisure can be identified. This leads to the following corollary.

Corollary 1 *If both parents work, the individual preferences over public consumption, private consumption, and leisure are identified up to an additive constant.*

If only one parent works, the individual preferences over public and private consumption for both parents and the preferences over leisure for the working parent are identified up to an additive constant.

This Corollary indicates that the preferences for expenditure on children of the mother and father can be identified even if only one of them supplies a positive amount of labor hours. This result should help researchers in predicting which of different policies designed to improve the cognitive and non-cognitive abilities of children will be the most effective.

The implementation of the identification method proposed in this paper requires a longitudinal dataset that contains information on leisure, public consumption, private consumption, and wages. A dataset with these features is the CEX, which is a longitudinal dataset with information on all the required variables. Individual labor supply and wages are observed. Detailed data on expenditure on different consumption items are collected. Moreover, the expenditure data include information on the main components of children expenditure, namely expenditure on children clothing, children shoes, school books, and other educational expenses. All these variables are observed for four consecutive quarters. A drawback of the CEX is that food consumption is only measured at the household level. It is therefore not possible to determine which fraction is consumed by children, which represents public consumption. As a partial solution, the econometrician can either assume that food consumption is separable from other consumption goods and leisure or she can impute the fraction of food items consumed by children using information on the type of goods purchased by the household and the family structure.

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.

6 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.

6.1 Preferences

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.

The possible choice to characterize individual preferences is the Cobb-Douglous utility function $\frac{\left[\left(c^i\right)^{\sigma_i}\left(T-h^i\right)^{1-\sigma_i}\right]^{1-\rho_i}}{1-\rho_i}$. With this utility function, the implementation of the identification method developed in this paper is straightforward. Unfortunately, the Cobb-Douglas utility function imposes strong restrictions on the relationship between consumption and leisure, as the share of resources allocated to each good must be constant. The data do not support this restriction, as the share of resources allocated to consumption increases with income. In the PSID, a regression of the share of consumption on income generates a coefficeint of 0.23 with a standard error of 0.10. To allow for a more general pattern between the share of consumption and resources, we adopt the following more flexible utility:

$$u^i\left(c^i, h^i\right) = \left[\frac{\left(c^i\right)^{1+\eta_i}}{1+\eta_i} - \theta_i \frac{\left(h^i\right)^{1+\gamma_i}}{1+\gamma_i}\right]^{1+\rho_i},$$

with $\rho_i < 0$, $\eta_i < 0$, $\gamma_i > 0$, and $\theta_i > 0$. Since the pioneering work by ?), ?), and ?), the utility function inside the square brackets has been used extensively in labor economics to allow for a flexible relationship between consumption and leisure or, analogously, between consumption and labor supply. By applying the power $1 + \rho_i$, the utility function is generalized to allow for non-separabilities between consumption and leisure and a richer intertemporal response to change in prices (?), Ziliak and Kniesner (2005) and Keane (2011)). As pointed out by ?) and the rest of the section will clarify, there is a clear distinction between the parameters η_i, γ_i, and θ_i and the parameter ρ_i. The first set can be identified using only the equation that relates the marginal rate of substitution between consumption and hours of work, whereas the identification of ρ_i requires panel data and Euler equations.

In the estimation, we allow for unobservable heterogeneity through the labor taste parameter θ_i. Specifically, we assume that $\theta_i = \exp\{\delta_i + \epsilon_i\}$.

6.2 Estimation for Singles

For singles, we can estimate the model's parameters using both standard methods and our identification result. We can therefore evaluate its performance using this subsample. The estimation is executed in two steps following ?). In the first step, we estimate the parameters $\eta_i < 0$, $\gamma_i > 0$, and $\theta_i > 0$ using the relationship between the marginal rate of substitution between consumption and leisure and the ratio of their prices. In the second step, we estimate the intertemporal parameter ρ_i using the standard Euler equation. We then implement the second step using our identification result. We first use the parameters estimated in the first step to derive the consumption function $c^1 = g\left(\bar{w}^1, h^1\right)$ which, under the assumption of this section, takes the following form

$$g\left(\bar{w}^1, h^1\right) = \left(\frac{\theta_1}{\bar{w}_t^1}\right)^{\frac{1}{\eta}} \left(h_t^1\right)^{\frac{\gamma}{\eta}}.$$

We then estimate ρ_i using the reduced-form Euler equation obtained using $g\left(\bar{w}^1, h^1\right)$. We then compare the estimates of ρ_i obtained using the two alternative approches.

First step. The first order conditions of a single individual imply the following relationship between the marginal rate of substitution between consumption and hours of work and the individual's wage:

$$\left(c^i\right)^{\eta_i} = \frac{\theta_i \left(h^i\right)^{\gamma_i}}{\bar{w}^1}.$$

By taking logs and replacing $\theta_i = \exp\{\delta_i + \epsilon_i\}$, we have,

$$\ln h^i = -\frac{1}{\gamma_i} \ln \delta_i + \frac{1}{\gamma_i} \ln \bar{w}^{1*} + \frac{\eta_i}{\gamma_i} \ln c^i + \epsilon_i.$$

In the previous equation, the effect of the intertemporal aspects of the individual decisions on labor supply are accounted for by consumption. This variable incorporates all the past and future variables that influence the decision process. Because of this, $\ln c^i$ is endogenous. We do not have human capital accumulation in the model. But in the empirical part, we allow for the possibility that wages are affected by it, by treating $\ln \bar{w}^{1*}$ as endogenous. We account for the endogeneity of these two variables by employing the strategy proposed by ?) and use the following two sets of instruments instruments. The first set is composed of two measures of individual earning potential. For those that are employed hourly, the first alternative measure is represented by the reported hourly wages, whereas for those that are not employed hourly, the first alternative wage measure is constructed as total labor earnings divided by 40 hours a week times 52 weeks. The second alternative wage measure is an individual-specific permanent component of the wage obtained by regressing the observed wage on individual and year fixed effects. The second set of instruments includes the following demographic variables: age, age squared, year fixed effects, gender and race dummies, number of children, and a disability dummy.

Second step. The intertemporal parameter ρ_i can now be estimated using Euler equations. Using the standard approach, the Euler equation can be written as follows:

$$E\left[\beta R_{i,t+1}\left(\frac{X_{i,t+1}}{X_{i,t}}\right)^{\rho_i}\left(\frac{c_{i,t+1}}{c_{i,t}}\right)^{\eta_i}\right]=1,$$

where $X_{i,\tau}=\frac{\left(c_\tau^i\right)^{1+\eta_i}}{1+\eta_i}-\theta_i\frac{\left(h_\tau^i\right)^{1+\gamma_i}}{1+\gamma_i}$. Its estimation requires knowledge of the variable $X_{i,\tau}$ for $\tau=t,t+1$, which is not observed in the data. We can, however construct it using the first step estimates and an idea developed in **?**). Note that

$$\theta_i=\exp\{\delta_i+\epsilon_i\}=\exp\{\gamma_i\ln h^i-\ln\bar{w}^{1*}-\eta_i\ln c^i\}.$$

We can therefore estimate θ_i using consumption, hours, wages, and the estimates for δ_i and γ_i obtained in the first step. With the estimated θ_i, we can then construct the variable $X_{i,\tau}$ and, since consumption is observed for singles, estimate the Euler equation using standard methods.

The intertemporal parameter ρ_i can also be implemented using the identification result and the consumption function $c^1=g\left(\bar{w}^1,h^1\right)=\left(\frac{\theta_1}{\bar{w}_1^1}\right)^{\frac{1}{\eta_1}}\left(h_1^1\right)^{\frac{\gamma_1}{\eta_1}}$. To that end, we first estimate θ_i using the approach described above. We can then construct the variable $X_{i,\tau}$ and the consumption function and estimate the following transformed Euler equation:

$$E\left[\beta R_{i,t+1}\left(\frac{X_{i,t+1}}{X_{i,t}}\right)^{\rho_i}\left(\frac{g\left(\bar{w}_{t+1}^1,h_{t+1}^1\right)}{g\left(\bar{w}_t^1,h_t^1\right)}\right)^{\eta_i}\right]=1,$$

where $X_{i,\tau}=\frac{g\left(\bar{w}_\tau^1,h_\tau^1\right)^{1+\eta_i}}{1+\eta_i}-\theta_i\frac{\left(h_\tau^i\right)^{1+\gamma_i}}{1+\gamma_i}$.

Results. The estimation results for men and women obtained using the standard method are presented in the first two columns of Table **??**. All standard errors are bootstrapped using ... at the household level. For single men, we find that the estimated power coefficient on consumption η is equal to -1.88, with a standard error of 0.4 and the estimated power coefficient on hours of work γ is equal to 0.62 with a standard error of 0.77. Their labor taste parameter θ is equal to 5.51×10^{-9} with a standard error of 0.45. The estimated power parameters on consumption and hours are equal, respectively, to -2.15 with a standard error of 0.36 and to 0.36 with a standard error of 0.51. Their labor taste parameter is equal to 3.58×10^{-9} with a standard error of 1.75×10^{-7} and their intertemporal parameter is estimated to be 1.02 with a standard error of 0.12.

The intertemporal parameter for single men and women can be estimated using both the standard and the identification method derived in this paper. With the standard method, we estimate the Euler equation using the observed individual consumption, whereas with the identification method we estimated the Euler equation after having replaced individual consumption with the consumption function $g\left(\bar{w}^i, h^i\right)$. For single men, the intertemporal parameter σ is estimated to be 1.26 with standard errors equal to 0.14 using the standard method and 1.31 with standard errors equal to 0.23 using the identification method. The estimated parameter is therefore similar in size and statistically indistinguishable using the two methods. The main consequence of using the identification method is an increase in standard errors, which should be expected. For single women, we also find that the two methods produce statistically indistinguishable estimates. Using the standard method their intertemporal parameter is estimated to be 1.02 with a standard error of 0.12, while the identification method produces an estimate that is equal to 1.05 with a standard error of 0.14.

6.3 Estimation for Couples

To estimate the parameters of interests for couple, we have to consider that only total household consumption is observed. We do this by estimating the parameters in three steps.

For this utility function, it is straightforward to show that the consumption function $g\left(\bar{w}^1, h^1\right)$ corresponding to these preferences can be written in the following form:

$$g\left(\bar{w}^1, h^1\right) = \left(\frac{\theta_1}{\bar{w}_t^1}\right)^{\frac{1}{\eta}} \left(h_t^1\right)^{\frac{\gamma}{\eta}}.$$

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

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

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[15]

$$c^1_{t,h} = g\left(\bar{w}^1_{t,h}, h^1_{t,h}, z_{t,h}\right) = \frac{\sigma_1}{\theta_1} \bar{w}^1_{t,h} \left(T - h^1_{t,h}\right) \exp\left(\alpha_i' z_{t,h}\right).$$

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

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

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, we 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:

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

where δ_C and δ^i_w are two constants and $\epsilon_{t,h}$ is a mean-zero random variable which is common to private consumption and wages.[16] Third, in each period t, the common component $\epsilon_{t,h}$ are independent of the information known to the household.[17]

Let $\gamma_i = \sigma_i(1-\rho_i)$, $\lambda_i = \theta_i(1-\rho_i)$, and $\xi_i = (1-\sigma_i-\theta_i)(1-\rho_i)$. The assumptions on preferences and household heterogeneity imply that the transformed marginal utilities for consumption have the following form:

$$f^1_c = \sigma_1 \left(\frac{\sigma_1}{\theta_1}\right)^{\gamma_1 - 1} \left(\bar{w}^1_{t,h}\right)^{\gamma_1 - 1} \left(T - h^1_{t,h}\right)^{\gamma_1 + \lambda_1 - 1} \left(Q_{t,h}\right)^{\xi_1} e^{\left((\gamma_1+\lambda_1-1)\alpha_1 z_{t,h}\right)} e^{(\gamma_1 - 1)\left(\delta_{w^1} + \epsilon_{t,h}\right)}$$

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

[16] 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.

[17] 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 we will also allow for measurement errors $\varepsilon^s_{C,t,h}$ and $\varepsilon^s_{w,t,h}$ that are specific to singles.

$$f_c^2 = \sigma_2 \left(C_{t,h} e^{\left(\delta_C + \epsilon_{t,h}\right)} - \frac{\sigma_1}{\theta_1} \bar{w}_{t,h}^1 e^{\left(\delta_{w^1} + \epsilon_{t,h}\right)} \left(T - h_{t,h}^1\right) e^{\alpha_1 z_{t,h}} \right)^{\gamma_2 - 1} \left(T - h_{t,h}^2\right)^{\lambda_2} \left(Q_{t,h}\right)^{\xi_2} e^{\alpha_2 \lambda_2 z_{t,h}}.$$

Hence, if one defines $\hat{\phi} = \dfrac{\sigma_1 \exp\left(\delta_{w^1}\right)}{\theta_1 \exp\left(\delta_C\right)}$, the individual Euler equations (5) can be written in the following form:

$$\beta_1 E_t \left[\left(\frac{\bar{w}_{t+1,h}^1}{\bar{w}_{t,h}^1} \right)^{\gamma_1 - 1} \left(\frac{T - h_{t+1,h}^1}{T - h_{t,h}^1} \right)^{\gamma_1 + \lambda_1 - 1} \left(\frac{Q_{t+1,h}}{Q_{t,h}} \right)^{\xi_1} e^{(\gamma_1 + \lambda_1 - 1)\alpha_1 \left(z_{t+1,h} - z_{t,h}\right)} R_{t+1,h} \frac{p_t}{p_{t+1}} \right] = \frac{e^{(\gamma_1 - 1)\left(\delta_{w^1} + \epsilon_{t,h}\right)}}{E_t \left[e^{(\gamma_1 - 1)\left(\delta_{w^1} + \epsilon_{t+1,h}\right)} \right]}.$$

The individual Euler equations (5) can be written in the following form:

$$\beta_2 E_t \left[\left(\frac{C_{t+1,h} - \hat{\phi} \bar{w}_{t+1,h}^1 \left(T - h_{t+1,h}^1\right) e^{\alpha_1 z_{t+1,h}}}{C_{t,h} - \hat{\phi} \bar{w}_{t,h}^1 \left(T - h_{t,h}^1\right) e^{\alpha_1 z_{t,h}}} \right)^{\gamma_2 - 1} \left(\frac{T - h_{t+1,h}^2}{T - h_{t,h}^2} \right)^{\lambda_2} \left(\frac{Q_{t+1,h}}{Q_{t,h}} \right)^{\xi_2} \times e^{\alpha_2 \lambda_2 \left(z_{t+1,h} - z_{t,h}\right)} R_{t+1,h} \frac{p_t}{p_{t+1}} \right] = \frac{e^{(\gamma_2 - 1)\left(\delta_C + \epsilon_{t,h}\right)}}{E_t \left[e^{(\gamma_2 - 1)\left(\delta_C + \epsilon_{t+1,h}\right)} \right]}.$$

Finally, if one takes the logarithm of the efficiency equation (5), this condition can be written as follows:

$$(\gamma_1 - 1) \log \bar{w}_{t,h}^1 + (\gamma_1 + \lambda_1 - 1) \log \left(T - h_{t,h}^1\right) + (\xi_1 - \xi_2) Q_{t,h} - (\gamma_2 - 1) \log \left(C_{t,h} - \hat{\phi} \bar{w}_{t,h}^1 \left(T - h_{t,h}^1\right) e^{\alpha_1 z_{t,h}} \right) - \lambda_2 \log \left(T - h_{t,h}^2\right) - (\alpha_1 (\gamma_1 + \lambda_1 - 1) + \alpha_2 \lambda_2) z_{t,h} = \overline{l\mu} + \eta_h + (\log \sigma_2 - \log \sigma_1) - (\gamma_1 - 1) \log \hat{\phi} + (\gamma_2 - \gamma_1)(\delta_C + \epsilon_{t,h}).$$

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

$$\beta_1 E \left[\left(\frac{\bar{w}_{t+1,h}^1}{\bar{w}_{t,h}^1} \right)^{\gamma_1 - 1} \left(\frac{T - h_{t+1,h}^1}{T - h_{t,h}^1} \right)^{\gamma_1 + \lambda_1 - 1} \left(\frac{Q_{t+1,h}}{Q_{t,h}} \right)^{\xi_1} e^{(\gamma_1 + \lambda_1 - 1)\alpha_1 \left(z_{t+1,h} - z_{t,h}\right)} R_{t+1,h} \frac{p_t}{p_{t+1}} \right] = 1, \tag{21}$$

agent 2's Euler equations can be written as

$$\beta_2 E \left[\left(\frac{C_{t+1,h} - \hat{\phi} \bar{w}_{t+1,h}^1 \left(T - h_{t+1,h}^1\right) e^{\alpha_1 z_{t+1,h}}}{C_{t,h} - \hat{\phi} \bar{w}_{t,h}^1 \left(T - h_{t,h}^1\right) e^{\alpha_1 z_{t,h}}} \right)^{\gamma_2 - 1} \left(\frac{T - h_{t+1,h}^2}{T - h_{t,h}^2} \right)^{\lambda_2} \left(\frac{Q_{t+1,h}}{Q_{t,h}} \right)^{\xi_2} \times e^{\alpha_2 \lambda_2 \left(z_{t+1,h} - z_{t,h}\right)} R_{t+1,h} \frac{p_t}{p_{t+1}} \right] = 1, \tag{22}$$

and the efficiency condition becomes

$$E \left[(\gamma_1 - 1) \log \bar{w}_{t,h}^1 + (\gamma_1 + \lambda_1 - 1) \log \left(T - h_{t,h}^1\right) + (\xi_1 - \xi_2) Q_{t,h} - \right. \tag{23}$$

$$(\gamma_2 - 1) \log \left(C_{t,h} - \hat{\phi} \bar{w}_{t,h}^1 \left(T - h_{t,h}^1\right) e^{\alpha_1 z_{t,h}} \right) - \lambda_2 \log \left(T - h_{t,h}^2\right) \tag{24}$$

$$\left. - (\alpha_1 (\gamma_1 + \lambda_1 - 1) + \alpha_2 \lambda_2) z_{t,h} \right] = \overline{l\mu} + (\log \sigma_2 - \log \sigma_1) - (\gamma_1 - 1) \log \hat{\phi} + (\gamma_2 - \gamma_1) \delta_C. \tag{25}$$

Using the CEX data, the coefficients γ_i, λ_i, $\hat{\phi}$, α_i, β_i, and $\overline{l\mu} + (\log \sigma_2 - \log \sigma_1) - (\gamma_1 - 1) \log \hat{\phi} + (\gamma_2 - \gamma_1) \delta_C$ will be estimated by applying the Generalized Method of Moments (GMM) to these three equations. The remaining parameters of the individual utility functions can then be recovered using the following equations:

$$\gamma_i = \sigma_i (1 - \rho_i), \qquad \lambda_i = \theta_i (1 - \rho_i), \qquad \xi_i = (1 - \sigma_i - \theta_i)(1 - \rho_i).$$

Finally, it is important to remark that the mean of the logarithm of the ratio of the Pareto weights $\overline{l\mu}$ can be identified only if it is assumed that the constant δ_C is equal to zero.

7 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 we 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 **??** 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, we 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

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

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

$$\begin{aligned} c_{t}^{1} &\leq \phi\bar{w}_{t}^{1}T \quad \text{if } D_{t}^{1}=1, \\ c_{t}^{1} &> \phi\bar{w}_{t}^{1}T \quad \text{if } D_{t}^{1}=0. \end{aligned}$$

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

$$\begin{aligned} \log c_{t}^{1}-\log\phi-\log T-X_{t}\beta &\leq e_{t} \quad \text{if } D_{t}^{1}=1, \\ \log c_{t}^{1}-\log\phi-\log T-X_{t}\beta &> e_{t} \quad \text{if } D_{t}^{1}=0. \end{aligned}$$

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

$$\left[\begin{array}{ccc} \sigma_{\zeta^{i}}^{2} & \rho_{\zeta^{i},t} & \rho_{\zeta^{i},t+1} \\ & 1 & \rho \\ & & 1 \end{array}\right].$$

Then, by Tunali (1986),

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

where

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

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.[18]

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, 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.

[18] 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.

8 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.[19] 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 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

[19]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. We 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.

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, we 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, we 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, we 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.[20] 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

9 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 household consumption Euler equations and the intraperiod condition. Under the assumptions on preferences and heterogeneity of section 6, the two equations can be written as follows:

$$E\left[\left(\frac{C_{t+1,h}}{C_{t,h}}\right)^{\gamma_1-1}\left(\frac{T-h_{t+1,h}}{T-h_{t,h}}\right)^{\lambda_1}\left(\frac{Q_{t+1,h}}{Q_{t,h}}\right)^{\xi_1} e^{\alpha\theta\left(z_{t+1,h}-z_{t,h}\right)}\beta R_{t+1,h}\frac{p_{t,h}}{p_{t+1,h}}\right]=1, \qquad (26)$$

[20]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.

$$E\left[\log C_{t,h} - \log\hat{\phi} - \log\left(\bar{w}^1_{t,h}\left(T - h^1_{t,h}\right)\right) - \alpha' z_{t,h}\right] = 0. \quad (27)$$

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.[21] Second, preferences of singles are estimated using agent 1's transformed consumption Euler equations (21) and the identification result. Note that the transformed Euler equations (21) contain the same information as equations (26) and (27), 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 we are 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.

The main empirical results are the estimates for couples, which are obtained using the transformed Euler equation (21) for the wife, the transformed Euler equation (22) for the husband, and the efficiency condition (25). 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 hus-

[21]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.

band'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 constant δ_C in the measurement errors is 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 (21) and (22) are also estimated without including the efficiency condition (25). 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 $R_{t+1} \left(p_t / p_{t+1}\right)^{\sigma} \left(w_t / w_{t+1}\right)^{1-\sigma}$. We can therefore interpret $R_{t+1} \left(p_t / p_{t+1}\right)^{\sigma} \left(w_t / w_{t+1}\right)^{1-\sigma}$ 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 $\left(p_t / p_{t+1}\right)^{\sigma}$ and $\left(w_t / w_{t+1}\right)^{1-\sigma}$ 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 $R_{t+1} \left(p_t / p_{t+1}\right)^{\sigma} \left(w_t / w_{t+1}\right)^{1-\sigma}$. 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 $R_{t+1} \left(p_t / p_{t+1}\right)^{\sigma} \left(w_t / w_{t+1}\right)^{1-\sigma}$. 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.[22]

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

[22] we 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 $R_{t+1} \left(p_{t+1} / p_t\right)^{\sigma} \left(w_{t+1} / w_t\right)^{1-\sigma}$.

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 (2007) 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.

10 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 $g\left(\bar{w}_{1t}, h_t^1, Q_t\right)$ is well-defined if*

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

for any realization of the exogenous variables.

Proof. For any realization of the exogenous variables define

$$d^1\left(c^1, h^1, Q, \bar{w}_1\right) = q^1\left(c_t^1, h_t^1, Q\right) - \bar{w}_{1t} = 0.$$

By the implicit function theorem, $g^1\left(\bar{w}_1, h^1, Q\right)$ is well-defined if $\frac{\partial d^1}{\partial c^1} \neq 0$. Which implies the result. ■

A.2 Proof of Proposition 1

In the second stage of the household problem, the household chooses optimal consumption and leisure in each period and state of nature given $w_{1,t,\omega}$, $w_{2,t,\omega}$, $p_{t,\omega}$, $P_{t,\omega}$, and $\bar{Y}_{t,\omega}$ according to the following problem:

$$\max_{c_{t,\omega}^1, c_{t,\omega}^2, l_{t,\omega}^1, l_{t,\omega}^2, Q_{t,\omega}} \mu u^1(c_{t,\omega}^1, l_{t,\omega}^1, Q_{t,\omega}) + (1-\mu) u^2(c_{t,\omega}^2, l_{t,\omega}^2, Q_{t,\omega})$$

$$s.t. \sum_{i=1}^{2}\left(p_{t,\omega} c_{t,\omega}^i + w_{i,t,\omega} l_{t,\omega}^i\right) + P_{t,\omega} Q_{t,\omega} \leq \bar{Y}_{t,\omega}$$

The price of the private good, $p_{t,\omega}$, the price of the public good, $P_{t,\omega}$, agent 1's wage, $w_{1,t,\omega}$, and agent 2's wage, $w_{2,t,\omega}$, represent four independent sources of exogenous variation. The fifth source of variation is $\bar{Y}_{t,\omega}$. It is important to remark that $\bar{Y}_{t,\omega}$ 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 $\bar{Y}_{t,\omega}$. 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 $\bar{Y}_{t,\omega}$. In the remainder of the proof a change in $\bar{Y}_{t,\omega}$ should be interpreted as a change in an exogenous variable in period t' and state ω' that varies $\bar{Y}_{t,\omega}$.

Consider first the case in which both agents work. Note that if the function $g\left(\bar{w}_{1t}, h_t^1, Q_t\right)$ can be identified, the original marginal utilities can also be identified by means of the reduced-form marginal utilities which are known. In the remainder of the proof it will be shown that $\frac{\partial g}{\partial \bar{w}_1}$, $\frac{\partial g}{\partial h^1}$, and $\frac{\partial g}{\partial Q}$ can be identified, which implies that $g\left(\bar{w}_1, h^1, Q\right)$ can be identified up to an additive constant.

Consider an arbitrary period t and state ω. Given w_1, w_2, p, P, and $\bar{Y}$, optimal household private consumption, public consumption, agent 1's labor supply, and agent 2's labor supply can be written in the following form:

$$C = C\left(w_1, w_2, p, P, \bar{Y}\right), Q = Q\left(w_1, w_2, p, P, \bar{Y}\right), h^1 = h^1\left(w_1, w_2, p, P, \bar{Y}\right), h^2 = h^2\left(w_1, w_2, p, P, \bar{Y}\right).$$

Agent 2's reduced-form marginal utilities of private consumption and public consumption are defined as follows:

$$f_c^2\left(C,\bar{w}_1,h^1,h^2,Q\right)=u_c^2\left(C-g\left(\bar{w}_1,h^1,Q\right),1-h^2,Q\right). \tag{28}$$

$$f_Q^2\left(C,\bar{w}_1,h^1,h^2,Q\right)=u_Q^2\left(C-g\left(\bar{w}_1,h^1,Q\right),1-h^2,Q\right). \tag{29}$$

By construction these equations are satisfied for any combination of w_1, w_2, p, P, and $\bar{Y}$. Consider an arbitrary w_1, w_2, p, P, and $\bar{Y}$. Let dw_1, dw_2, dp, dP, and $d\bar{Y}$ be a small change in the exogenous variables with the following properties: (i) $dw_1=\frac{w_1}{p}dp$, which implies that $d\bar{w}_1=0$; (ii) dw_2, dp, dP, and $d\bar{Y}$ are the solution of the following linear system:

$$\begin{aligned}
\frac{\partial C}{\partial w_2}dw_2+\left(\frac{\partial C}{\partial w_1}\frac{w_1}{p}+\frac{\partial C}{\partial p}\right)dp+\frac{\partial C}{\partial P}dP+\frac{\partial C}{\partial \bar{Y}}d\bar{Y}&=dC\neq 0,\\
\frac{\partial Q}{\partial w_2}dw_2+\left(\frac{\partial Q}{\partial w_1}\frac{w_1}{p}+\frac{\partial Q}{\partial p}\right)dp+\frac{\partial Q}{\partial P}dP+\frac{\partial Q}{\partial \bar{Y}}d\bar{Y}&=dQ=0,\\
\frac{\partial h^1}{\partial w_2}dw_2+\left(\frac{\partial h^1}{\partial w_1}\frac{w_1}{p}+\frac{\partial h^1}{\partial p}\right)dp+\frac{\partial h^1}{\partial P}dP+\frac{\partial h^1}{\partial \bar{Y}}d\bar{Y}&=dh^1=0,\\
\frac{\partial h^2}{\partial w_2}dw_2+\left(\frac{\partial h^2}{\partial w_1}\frac{w_1}{p}+\frac{\partial h^2}{\partial p}\right)dp+\frac{\partial h^2}{\partial P}dP+\frac{\partial h^2}{\partial \bar{Y}}d\bar{Y}&=dh^2=0,
\end{aligned}$$

i.e., the change varies household private consumption, but household public consumption, 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, dP, and $d\bar{Y}$ can be computed as follows:[23]

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

Similarly, the change in u_c^2 implied by dw_1, dw_2, dp, 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 (28) is satisfied for any w_1, w_2, p, P, and $\bar{Y}$, the change in f_c^2 must equal the change in u_c^2. Consequently,

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

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

Consider a change dw_1, dw_2, dp, dP, and $d\bar{Y}$ with the following properties: (i) $dw_1=\frac{w_1}{p}dp$,

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

which implies that $d\bar{w}_1 = 0$; (ii) dw_2, dp, dP, and $d\bar{Y}$ are the solution of the following linear system:

$$\frac{\partial C}{\partial w_2}dw_2 + \left(\frac{\partial C}{\partial w_1}\frac{w_1}{p} + \frac{\partial C}{\partial p}\right)dp + \frac{\partial C}{\partial P}dP + \frac{\partial C}{\partial \bar{Y}}d\bar{Y} = dC = 0,$$
$$\frac{\partial Q}{\partial w_2}dw_2 + \left(\frac{\partial Q}{\partial w_1}\frac{w_1}{p} + \frac{\partial Q}{\partial p}\right)dp + \frac{\partial Q}{\partial P}dP + \frac{\partial Q}{\partial \bar{Y}}d\bar{Y} = dQ = 0,$$
$$\frac{\partial h^1}{\partial w_2}dw_2 + \left(\frac{\partial h^1}{\partial w_1}\frac{w_1}{p} + \frac{\partial h^1}{\partial p}\right)dp + \frac{\partial h^1}{\partial P}dP + \frac{\partial h^1}{\partial \bar{Y}}d\bar{Y} = dh^1 \neq 0,$$
$$\frac{\partial h^2}{\partial w_2}dw_2 + \left(\frac{\partial h^2}{\partial w_1}\frac{w_1}{p} + \frac{\partial h^2}{\partial p}\right)dp + \frac{\partial h^2}{\partial P}dP + \frac{\partial h^2}{\partial \bar{Y}}d\bar{Y} = dh^2 = 0,$$

i.e., the change varies agent 1's labor supply, but household private consumption, public consumption, and agent 2's labor supply stay constant. According to equation (28), the implied change in f_c^2 must equal the implied change in u_c^2. Consequently, the following equation must be satisfied:[24]

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

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

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

$$\frac{\partial C}{\partial w_1}dw_1 + \frac{\partial C}{\partial w_2}dw_2 + \frac{\partial C}{\partial p}dp + \frac{\partial C}{\partial P}dP + \frac{\partial C}{\partial \bar{Y}}d\bar{Y} = dC = 0,$$
$$\frac{\partial Q}{\partial w_1}dw_1 + \frac{\partial Q}{\partial w_2}dw_2 + \frac{\partial Q}{\partial p}dp + \frac{\partial Q}{\partial P}dP + \frac{\partial Q}{\partial \bar{Y}}d\bar{Y} = dQ = 0,$$
$$\frac{\partial h^1}{\partial w_1}dw_1 + \frac{\partial h^1}{\partial w_2}dw_2 + \frac{\partial h^1}{\partial p}dp + \frac{\partial h^1}{\partial P}dP + \frac{\partial h^1}{\partial \bar{Y}}d\bar{Y} = dh^1 = 0,$$
$$\frac{\partial h^2}{\partial w_1}dw_1 + \frac{\partial h^2}{\partial w_2}dw_2 + \frac{\partial h^2}{\partial p}dp + \frac{\partial h^2}{\partial P}dP + \frac{\partial h^2}{\partial \bar{Y}}d\bar{Y} = dh^2 = 0,$$

i.e., the change does not vary household private consumption, public consumption, agent 1's labor supply, and agent 2's labor supply. By equation (28), 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 $\frac{\partial f_c^2}{\partial \bar{w}_1}$ and $\frac{\partial u_c^2}{\partial c^2}$ are known, $\frac{\partial g}{\partial \bar{w}_1}$ is identified.

Similarly since the implied change in f_c^2 and f_Q^2 must equal the implied change in, respectively, u_c^2 and u_Q^2, the following equations must be satisfied:

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

[24]The steps used to derive this equation are equivalent to the steps used to derive (A.2).

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

Note that $\frac{\partial f_c^2}{\partial \bar{w}_1}$, $\frac{\partial f_Q^2}{\partial \bar{w}_1}$, and $\frac{\partial g}{\partial \bar{w}_1}$ are known, which implies that $\frac{\partial u_Q^2}{\partial c^2}$ and $\frac{\partial u_c^2}{\partial c^2}$ are identified.

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

$$\begin{aligned}
\frac{\partial C}{\partial w_2}dw_2 + \left(\frac{\partial C}{\partial w_1}\frac{w_1}{p} + \frac{\partial C}{\partial p}\right)dp + \frac{\partial C}{\partial P}dP + \frac{\partial C}{\partial \bar{Y}}d\bar{Y} &= dC = 0,\\
\frac{\partial Q}{\partial w_2}dw_2 + \left(\frac{\partial Q}{\partial w_1}\frac{w_1}{p} + \frac{\partial Q}{\partial p}\right)dp + \frac{\partial Q}{\partial P}dP + \frac{\partial Q}{\partial \bar{Y}}d\bar{Y} &= dQ \neq 0,\\
\frac{\partial h^1}{\partial w_2}dw_2 + \left(\frac{\partial h^1}{\partial w_1}\frac{w_1}{p} + \frac{\partial h^1}{\partial p}\right)dp + \frac{\partial h^1}{\partial P}dP + \frac{\partial h^1}{\partial \bar{Y}}d\bar{Y} &= dh^1 = 0,\\
\frac{\partial h^2}{\partial w_2}dw_2 + \left(\frac{\partial h^2}{\partial w_1}\frac{w_1}{p} + \frac{\partial h^2}{\partial p}\right)dp + \frac{\partial h^2}{\partial P}dP + \frac{\partial h^2}{\partial \bar{Y}}d\bar{Y} &= dh^2 = 0,
\end{aligned}$$

i.e., the change varies public consumption, but it does not vary household private consumption, agent 1's labor supply, and agent 2's labor supply. According to (28), the implied change in f_c^2 must equal the implied change in u_c^2, which implies that

$$\frac{\partial f_c^2}{\partial Q} = -\frac{\partial u_c^2}{\partial c^2}\frac{\partial g}{\partial Q} + \frac{\partial u_c^2}{\partial Q}.$$

Observe that $\frac{\partial f_c^2}{\partial Q}$, $\frac{\partial u_Q^2}{\partial c^2}$, and $\frac{\partial u_c^2}{\partial c^2}$ are known. Consequently, $\frac{\partial g}{\partial Q}$ is identified.

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

$$\begin{bmatrix}
\frac{\partial C}{\partial w_2} & \frac{\partial C}{\partial p} & \frac{\partial C}{\partial P} & \frac{\partial C}{\partial \bar{Y}}\\
\frac{\partial Q}{\partial w_2} & \frac{\partial Q}{\partial p} & \frac{\partial Q}{\partial P} & \frac{\partial Q}{\partial \bar{Y}}\\
\frac{\partial h^1}{\partial w_2} & \frac{\partial h^1}{\partial p} & \frac{\partial h^1}{\partial P} & \frac{\partial h^1}{\partial \bar{Y}}\\
\frac{\partial h^2}{\partial w_2} & \frac{\partial h^2}{\partial p} & \frac{\partial h^2}{\partial P} & \frac{\partial h^2}{\partial \bar{Y}}
\end{bmatrix}.$$

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, I will only discuss the second one. 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, Q, h^1, and h^2 vary conditional on the variation generated by the other exogenous variables. This emphasizes that the identification of individual preferences requires that independent variations in C, Q, 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, no variation in w_2 is observed, and the reduced-form marginal utility f_l^2 is not known. 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 equations (28) and (29), the corresponding linear equation from the three linear systems, and by setting $dw_2 = 0$. $g\left(\bar{w}_1, h^1, Q\right)$ is therefore identified up to the additive constant and all marginal utilities are identified except u_l^2.

A.3 Derivation of Euler Equations when Consumption and Leisure are Strongly Separable

The utility function takes the following form:

$$U(c,l) = \frac{c^{1-\rho}}{1-\rho} + \theta\frac{l^{1-\gamma}}{1-\gamma}.$$

The marginal utilities are therefore,

$$U_c(c,l) = c^{-\rho} \qquad \text{and} \qquad U_l(c,l) = \theta l^{-\gamma}.$$

The function $g(w, T-h)$ that determines consumption can then be written as follows:

$$c = g(w, T-h) = \left(\frac{1}{\theta}\right)^{\rho} w^{\rho}(T-h)^{\frac{\gamma}{\rho}}. \tag{30}$$

The standard Euler equation has the following form:

$$\beta E\left[\left(\frac{c_t}{c_{t+1}}\right)^{\rho} R_t\right] = 1.$$

The marginal utility of consumption after replacing c with $g(w, T-h)$ can be written as follows

$$f_c^1 = \frac{\theta^{2\rho}}{w^{2\rho}(T-h)^{\gamma}}.$$

Hence, the transformed Euler equation takes the following form:

$$\beta E\left[\left(\frac{w_t}{w_{t+1}}\right)^{2\rho}\left(\frac{T-h_t}{T-h_{t+1}}\right)^{\gamma} R_t\right] = 1.$$

The intratemporal condition can be derived by taking logs of equation (30) to obtain,

$$\ln c = -\rho\ln\theta + \rho\ln w + \frac{\gamma}{\rho}(T-h)$$

We can estimate the standard order equation using the non-linear formulation just derived or the following log-linear approximation:

$$\ln c_{t+1} - \ln c_t = \frac{1}{\rho}\ln\beta + \frac{1}{\rho}\ln R_t + \delta X_t + \epsilon_t.$$

For our approach,

$$\ln(T-h_{t+1}) - \ln(T-h_t) = \frac{1}{\gamma}\ln\beta + \frac{1}{\gamma}\ln R_t - \frac{2\rho}{\gamma}\left(\ln(w_{t+1}) - \ln(w_t)\right) + \delta X_t + \epsilon_t.$$

B Tables

B.1 Log-linearized Euler Equations for Singles.

Table 2: Estimation of Euler Equations for all Households

Ind. Variable		2-stage GMM			2-stage Least Squares	
$\ln(R_{t+1})$	0.148	0.106	0.013	0.156	0.173	0.096
	[0.125]	[0.137]	[0.145]	[0.155]	[0.166]	[0.178]
$\Delta \ln(\text{famsize})$	0.362^{*}	0.367	0.367	0.449^{*}	0.440	0.520
	[0.202]	[0.237]	[0.320]	[0.238]	[0.272]	[0.369]
Δkids	0.043	0.063	0.061	0.006	0.045	0.038
	[0.108]	[0.123]	[0.133]	[0.119]	[0.131]	[0.146]
Δhw	-	-0.552^{**}	-0.239	-	-0.542^{**}	-0.274
		[0.244]	[0.289]		[0.274]	[0.314]
$\Delta \ln(hl)$	-	-	0.249^{*}	-	-	0.333^{**}
			[0.140]			[0.161]
Δww	-	0.278	0.450^{*}	-	0.251	0.384
		[0.231]	[0.265]		[0.233]	[0.277]
$\Delta \ln(wl)$	-	-	-0.037		-	-0.034
			[0.053]			[0.056]
$\ln(y_t)$	0.168^{**}	0.201^{**}	0.202^{**}	0.168^{**}	0.187^{**}	0.206^{**}
	[0.075]	[0.087]	[0.092]	[0.085]	[0.092]	[0.100]
J-Statistic	43.4	36.2	30.7	-	-	-
$P > \chi^2$	0.33	0.55	0.72	-	-	-
n. of observ.	337	337	337	337	337	337
n. of cohort	7	7	7	7	7	7

Asymptotic standard errors are in brackets. All specifications include a constant and three seasonal dummies. The instrument set is the same across columns and includes the first lag of family size growth and of the change in two education dummies, the first equal to one if the head only attended elementary school, the second equal to one if the head attended high school but did not graduate; the first, second, and third lags of nominal municipal bond interest rate, the change in number of children, the change in number of children younger than 2, labor supply growth of the spouse if present, real consumption growth, real municipal bond interest rate, and marginal tax growth; the first, second, third, and fourth lags of the change in dummy equal to one if the head works and in a dummy equal to one if the wife works and is present, nominal 3-month treasury bill rate growth; the second and third lags of salary growth; the second, third and fourth lags of income growth and head's leisure growth. hw and ww are dummies equal to 1 if the head works and if the spouse works. $\ln(hl)$ and $\ln(wl)$ are the logs of head's and spouse's quarterly leisure. y_{t-1}, $y_{h,t-1}$ and $y_{w,t-1}$ are household, head's and spouse's income at $t-1$. (**) and (*) indicate that the coefficient is significant, respectively, at the 5 and 10 percent level.

Table 3: Estimation of Euler Equations for For Singles and Couples

Ind. Variable	Singles	Couples	Singles	Couples	Singles	Couples
$\ln(R_{t+1})$	0.029	0.366	0.278	0.596	0.227	0.606
	[0.751]	[0.433]	[0.822]	[0.475]	[0.830]	[0.492]
$\Delta\ln(\text{famsize})$	0.222	0.083	0.152	-0.010	0.278	-0.230
	[0.253]	[0.366]	[0.292]	[0.356]	[0.311]	[0.383]
Δkids	-0.050	0.267^{**}	0.035	0.306^{**}	-0.060	0.368^{**}
	[0.168]	[0.136]	[0.179]	[0.136]	[0.196]	[0.146]
Δhw	-	-	0.976^{**}	0.559^{**}	1.200^{**}	0.354
			[0.378]	[0.291]	[0.421]	[0.332]
$\Delta\ln(hl)$	-	-	-	-	0.457	-0.231
					[0.489]	[0.281]
Δww	-	-	-	0.175	-	0.601^{*}
				[0.189]		[0.347]
$\Delta\ln(wl)$	-	-	-		-	0.708
						[0.514]
$\ln(y_t)$	0.118	0.266^{**}	-0.024	0.187^{**}	-0.025	0.186^{**}
	[0.121]	[0.083]	[0.142]	[0.091]	[0.145]	[0.093]
J-Statistic	32.7	43.5	24.8	38.4	23.9	38.2
$P > \chi^2$	0.53	0.32	0.85	0.45	0.85	0.37
n. of observ.	333	366	333	366	333	366
n. of cohort	7	7	7	7	7	7

Asymptotic standard errors are in brackets. All specifications include a constant and three seasonal dummies. The instrument set is the same across columns and includes the first lag of family size growth and of the change in two education dummies, the first equal to one if the head only attended elementary school, the second equal to one if the head attended high school but did not graduate; the first, second, and third lags of nominal municipal bond interest rate, the change in number of children, the change in number of children younger than 2, labor supply growth of the spouse if present, real consumption growth, real municipal bond interest rate, and marginal tax growth; the first, second, third, and fourth lags of the change in dummy equal to one if the head works and in a dummy equal to one if the wife works and is present, nominal 3-month treasury bill rate growth; the second and third lags of salary growth; the second, third and fourth lags of income growth and head's leisure growth. hw and ww are dummies equal to 1 if the head works and if the spouse works. $\ln(hl)$ and $\ln(wl)$ are the logs of head's and spouse's quarterly leisure. y_{t-1}, $y_{h,t-1}$ and $y_{w,t-1}$ are household, head's and spouse's income at $t-1$. (**) and (*) indicate that the coefficient is significant, respectively, at the 5 and 10 percent level.

Table 4: 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 5: 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 6: 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 7: 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 8: 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 9: 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 10: 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 11: 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 12: 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 13: 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.