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Estimating Nonseparable Preference Specifications for Asset Market Participants

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Estimating Nonseparable Preference Specifications for Asset Market Participants[*]

Kris Jacobs[†]

Résumé / Abstract

À l'aide de données de panel et d'équations d'Euler, nous estimons les spécifications de préférence inséparables pour la consommation et les loisirs. L'analyse économétrique fait appel aux données de panel, et diffère en cela des études économétriques existantes qui reposent sur un cadre agent représentatif. De plus, notre analyse porte particulièrement sur les implications non-linéaires de la théorie et par conséquent, elle est différente des études à données de panel existantes qui portent sur les linéarisations. Les équations d'Euler sont estimées pour des échantillons qui incluent uniquement des participants au marché des actions, et aussi pour des échantillons qui incluent des consommateurs qui ne participent pas à ce marché. Il ressort que nous obtenons des estimations intuitivement plausibles seulement lorsqu'on exclue les non-participants de l'échantillon, ce qui montre l'extrême importance de la prise en compte, à la fois de la participation au marché des actions et de l'incomplétude du marché. Pour les participants, les valeurs de paramètre estimées sont totalement différentes de celles des études existantes. Nos résultats ont par conséquent leur place dans une littérature extensive de la macroéconomie et de la finance.

This paper uses panel data and Euler equations to estimate preference specifications that are nonseparable in consumption and leisure. The econometric analysis uses panel data, and therefore it differs from existing econometric studies that use a representative agent framework. Moreover, the analysis focuses on nonlinear implications of the theory and therefore, it is different from existing panel data studies that investigate linearizations. Euler equations are estimated for samples that only include asset market participants, and for samples that also include consumers who do not participate in asset markets. The evidence shows that we obtain intuitively plausible estimates only when excluding non-participants from the sample, indicating that it is critically important to take asset market participation and market incompleteness into consideration. For market participants, estimated parameter values are radically different from existing studies. The findings are therefore of interest for an extensive literature in macroeconomics and finance.

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Keywords: Market incompleteness, asset market participation, equity premium puzzle, dynamic macroeconomics, nonseparabilities, consumption, leisure, Euler equation estimation

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1 Introduction

This paper estimates and tests nonlinear Euler equations using preferences that are nonseparable in consumption and leisure. Parameter estimates and test statistics are obtained using a minimum of ancillary assumptions. Besides the assumption that the households are at an interior solution for consumption, we require that the households participate in asset markets. Because this is obviously not the case for every household, we split up the sample into households that report holding assets and households that do not. The evidence shows that we obtain intuitively plausible estimates only when using the samples that only include asset market participants.

The resulting estimates and test statistics are of interest to several (related) areas of the literature in dynamic economics and finance. There is widespread agreement that the intertemporal aspects of human behavior are of substantial interest. However, there is still no agreement on the values of the parameters characterizing these intertemporal trade-offs, and therefore the impact of intertemporal theory on many policy issues is unclear. For example, consider government design of social security programs. It is clear that the relative effectiveness of different social security programs will be determined by the ease with which economic agents trade off consumption or leisure over time, and the literature contains a wide range of estimates for the parameters characterizing these intertemporal trade-offs. Therefore, additional work that explains these differences and that helps to narrow this range is required.

Because the estimation of preference parameters addresses one of the "primitives" used in dynamic modeling, it reflects on every implication of dynamic economics. Whereas it is important to get an overview of the differences with existing studies and to discuss the implications of these differences, it is impossible to comment on all related studies, and therefore a compromise approach is adopted. The relevance of the empirical results is addressed by comparing estimation and test results with three related areas of the literature.[1] First, I provide a detailed discussion of the relevance of the results for the asset pricing literature, which stresses the importance of heterogeneity, asset market participation and market incompleteness. Besides being of substantial interest in its own right, the asset pricing literature reflects on dynamic economics in general because it investigates the most elementary implications of dynamic economies (see the discussion in Cochrane and Hansen (1992)). Second, a comparison with the available micro data literature focuses on the importance of separability and the impact of linearizations. Third, a comparison with an important part of the dynamic macroeconomics literature addresses the importance of parameter choice in simulation exercises.

One of the main motivations for studying nonseparable preferences is the asset pric-

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[1] The reader will notice that these areas are so intimately related that the division is in some sense artificial. The main differences between the research areas are methodological, and not based on economic intuition.

ing literature. Hansen and Singleton (1982) pioneered the estimation of nonlinear Euler equations in a representative agent context, using a time-separable constant relative risk aversion (TS-CRRA) utility function. The approach was later used to analyze other preference specifications, and Mankiw, Rotemberg and Summers (1985) (henceforth MRS) and Eichenbaum, Hansen and Singleton (1988) (henceforth EHS) provide an analysis of nonseparabilities between consumption and leisure in a representative agent context. Following those papers, it was concluded that the inclusion of leisure in the utility function is not likely to improve the performance of asset-pricing models. This paper argues that the perceived failure of nonseparable utility specifications to solve asset pricing puzzles may be due to the complete markets assumption that underlies these studies. If this assumption does not hold, it is the properties of the individual agent's consumption and leisure instead of aggregate consumption and leisure that determine asset prices. Mankiw and Zeldes (1991) and Jacobs (1999) show that aggregation issues are critically important when evaluating the TS-CRRA specification. Here I investigate if similar arguments apply for the evaluation of preferences that are nonseparable in consumption and leisure.

The literature that studies consumption and savings decisions has widely used micro level data to analyze implications of dynamic models . While this literature is extensive, many studies analyze separable preferences. Those that do analyze nonseparable preferences almost always investigate linearizations of the nonlinear Euler equations, because of the presence of measurement error in panel data. This paper takes an alternative approach, and investigates if parameter estimates are intuitively plausible when analyzing nonlinear Euler equations for nonseparable preferences. To illustrate the implications of this approach, a detailed comparison with existing results from the literature on consumption and savings decisions is provided.

A third area of research that this study impacts on is the literature on dynamic macroeconomics. Following the work by Kydland and Prescott (1982), a number of studies in dynamic macroeconomics evaluate theoretical models by comparing actual data with data simulated from the model under study. These simulations require estimates of a wide variety of parameters, including preference parameters. For this literature, reliable estimates of parameters that describe intertemporal behavior are therefore very valuable.

Asset market participation proves to be critically important for interpreting the results. For each empirical specification, estimation and test results are reported for three different samples. The first sample includes all households. The second and third samples include households who participate in asset markets. I find that whereas parameter estimates are always intuitively plausible for the second and third samples, this is almost never the case for the first sample. For those samples that yield intuitively plausible estimates, the results indicate that leisure enters the utility function in a statistically significant way, casting doubt on studies that use separable preference specifications. The parameter values are significantly different from those obtained by other panel data studies, and from the ones obtained in MRS (1985) and EHS (1988). Also, point estimates are different from the estimates typically used in simulation studies in dynamic macroeconomics. The special case of logarithmic preferences, which is also often used in this literature, is rejected by the data. The rejection of separability is also of interest for the asset pricing literature, which almost without exception uses separable preferences. Statistical tests of overidentifying restrictions indicate less dramatic evidence against the model compared to similar tests obtained using a TS-CRRA specification. It is therefore tempting to conclude that the asset pricing literature should adopt nonseparable preferences. However, additional analysis is needed to determine whether nonseparable preferences can solve a number of well-known asset-pricing puzzles, like the equity premium puzzle.

The paper proceeds as follows. Section 2 provides a detailed motivation for this study and provides an extensive discussion of the three research areas mentioned above. Section 3 discusses the data and Section 4 discusses the estimation and testing methodology. Section 5 presents the empirical results. Section 6 provides a robustness analysis. Section 7 relates the paper's findings to the related literature and Section 8 concludes.

2 Motivation

Estimation and testing are carried out with a minimum of auxiliary assumptions. We assume the existence of a large number of individuals with an identical per period Cobb-Douglas utility function, specified as

$$u(c_{i,t}, l_{it}) = \frac{1}{\psi} c_{i,t}^{\psi} l_{i,t}^{\kappa}. \tag{1}$$

where $c_{i,t}$ is the consumption of individual i in period t, $l_{i,t}$ is the leisure of individual i in period t and ψ and κ are parameters. We present estimates of the parameters using the first-order condition with respect to consumption (assuming an interior solution)

$$u_c(c_{i,t}, l_{it}) - \lambda_{i,t} = 0. \tag{2}$$

where $\lambda_{i,t}$ is the Lagrange multiplier associated with individual i's time t budget constraint. One way to generate testable restrictions from the model is to exploit intertemporal optimality conditions, by specifying assets that the individual can invest in. Many existing panel data studies assume that the individual only has a riskless asset (a T-bill or a money market account) to invest in. Here we assume that the individual can invest in risky assets (stocks) as well as in T-bills. This yields the following two Euler equations

$$1 = \beta E_{t-1} (\frac{1}{q_{t-1}}) (\frac{c_{i,t}}{c_{i,t-1}})^{\psi-1} (\frac{l_{i,t}}{l_{i,t-1}})^{\kappa}. \tag{3}$$

$$1 = \beta E_{t-1}(\frac{p_t + d_t}{p_{t-1}})(\frac{c_{i,t}}{c_{i,t-1}})^{\psi-1}(\frac{l_{i,t}}{l_{i,t-1}})^{\kappa}. \tag{4}$$

where p_t is the price of the risky asset in period t; d_t is the dividend on the risky asset in period t; q_t is the (normalized) price of the riskless asset in period t; β is the discount factor, and E_t is the mathematical expectation conditional on information available at time t.

Two important advantages of focusing on the estimation of (3) and (4) have to be emphasized at this point. First, it is clear that the derivation of (3) and (4) assumes that the household is at an interior solution w.r.t. the holdings of the riskless and the risky asset and w.r.t. consumption. However, no assumption has been made about the existence of corner solutions or rigidities in the labor market. This is important for an empirical study, because many individuals are clearly at a corner solution for leisure choice, and it is difficult to tell from available data whether an individual is at a corner solution or not. It would of course be preferable to include extra information about leisure choice in the econometric analysis, because this extra information would generate more precise parameter estimates and more powerful test statistics. However, given that the extra power comes at a higher risk of classification error and inconsistent estimation, the focus in this paper is on the estimation of (3) and (4) only. Second, to derive (3) and (4) no assumptions about the structure of financial markets have to be made beyond the existence of a riskless and a risky asset. In particular, we do not have to make the complete markets assumption which underlies all of the representative agent studies of consumption and leisure choice (e.g. see EHS (1988) and MRS (1985)). In view of the overwhelming evidence against complete markets in the literature (see Cochrane (1991), Mace (1991), Hayashi, Altonji and Kotlikoff (1996) and Attanasio and Davis (1996)), the absence of this assumption is reassuring. In addition, we do not model the entire economy, but simply investigate the consumption and leisure allocations resulting from the presence of some unspecified idiosyncratic risk.

The importance of estimating preference parameters using elementary implications of dynamic equilibrium models can hardly be overstated. The last two decades have witnessed the emergence of dynamic aspects of human behavior as one of the cornerstones of economics. Estimates of parameters characterizing intertemporal behavior are therefore of interest to almost every theory-based economic study, because often such parameters are of fundamental importance to assess the theory's policy implications or its empirical performance. To further motivate the paper, it is instructive to provide a more detailed motivation by discussing its impact on different research areas. The problem is that because we study one of the "primitives" of dynamic modeling, it impacts on all its implications, and these cannot all be discussed. On the other hand, a more detailed discussion is necessary: the estimation of behavioral parameters such as the ones in (3) and (4) has been tackled using different auxiliary assumptions in different areas of the economics and finance literature, each motivated by different questions and concerns. These different approaches give rise to different parameters estimates and widely varying assessments of their relevance and policy implications.

To organize the discussion, I therefore discuss the importance of preference specification in three different (but related) areas: first, the literature on dynamic macroeconomics that uses computational experiments; second, the literature that unites macroeconomics and asset pricing; and third, the literature on consumption and savings, which includes a large component that studies data at the micro level. This somewhat arbitrary division into research areas is motivated by the fact that within each group, the econometric and methodological tools used in the analysis are fairly similar. First, in dynamic macroeconomics an extensive literature has developed that investigates the implications of general equilibrium models using simulation. In principle, this literature does not depend on estimates of behavioral parameters, but the empirical implementation used in many studies requires estimates of behavioral parameters as model inputs. Therefore, specific values for behavioral parameters are mostly assumed as part of the primitives of the model. For instance, Kydland and Prescott (1982) use the Cobb-Douglas preference specification

$$u(c_{i,t}, l_{it}) = \frac{1}{\gamma\theta}(c_{i,t}^{\gamma} l_{i,t}^{1-\gamma})^{\theta}. \tag{5}$$

Kydland and Prescott (1982) argue that it is straightforward to parameterize (5) by interpreting γ as the percentage of the agent's time allocated to consumption activities. Also, by interpreting $c_{i,t}^{\gamma} l_{i,t}^{1-\gamma}$as a generalized version of a unit of consumption, they interpret $1-\theta$ as the rate of constant relative risk aversion. They therefore set γ equal to 1/3, based on the fact that households' allocation of time to nonmarket activities is about twice as large as the allocation to market activities, and they use three different values of the parameter θ in their simulations: -1, -0.5 and -0.1.

It is clear that (5) is simply (1) with $\theta = \psi + \kappa$ and $\gamma = \psi/\theta$. For our purposes, it is convenient to report on the parameters in equation (1), because inspection of the standard error on κ allows us to determine whether leisure enters the utility function in a significant manner and whether the underlying optimization problem is concave. However, for reasons of comparison with the literature on dynamic macroeconomics, all tables also list the point estimates of γ and θ that are implied by our estimates of ψ and κ. In this context, the parameter $1-\theta$ will be referred to as the rate of relative risk aversion in accordance with the terminology proposed by Kydland and Prescott (1982).

Several studies in dynamic macroeconomics employ the utility specification (5) used in Kydland and Prescott (1982) (e.g. see Backus, Kehoe and Kydland (1992)).[2] A central question is therefore whether the range of estimates for θ proposed by Kydland and Prescott

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[2] The merits and criticisms of computational experiments are not the focus of this paper. We simply note that the analysis of dynamic models has become the state of the art in macroeconomics, and some of this literature uses computational experiments. We therefore focus on the implications of this study for this methodology, which uses a simulation setup where parameter values from other studies are used as inputs into the analysis. For a discussion of this methodology see the papers by Kydland and Prescott (1996), Hansen and Heckman (1996) and Sims (1996).

(1982) includes the parameter estimate from the data. Moreover, many existing studies use a logarithmic specification that is a special case of (5) for $\theta = 0$ (see Christiano and Eichenbaum (1992)). It is therefore of interest to verify if this restriction is supported by the data.

The second area of interest that has studied the importance of leisure is the asset pricing literature. Following the work of Lucas (1978) and Breeden (1979), the asset pricing literature has focused on estimating and testing general equilibrium models of asset pricing. Parameter estimation is critically important in this context because the theory is usually evaluated conditional on parameter estimates obtained under the maintained hypothesis that the theory holds. After several studies demonstrated the inadequacy of the TS-CRRA specification to explain the volatility of asset returns (see Hansen and Singleton (1982,1983,1984) and Mehra and Prescott (1985)), several authors proposed the inclusion of leisure in the utility function to remedy the problem (see MRS (1985) and EHS (1988)). However, the representative agent literature has concluded that the presence of leisure in the utility function is not likely to solve notorious asset pricing puzzles. Using the intuition captured by the work of Hansen and Jagannathan (1991), the problem with consumption based asset pricing is that the consumption series is not volatile enough to generate sufficient volatility in asset returns, given the available parameterization of the utility function. For the TS-CRRA specification, one needs an "implausibly large" risk aversion parameter to generate sufficient variability in the intertemporal marginal rate of substitution (IMRS). Because the time series of monthly, quarterly or yearly aggregate leisure is also very smooth, it is not surprising that the parameters needed to generate sufficient variability in the IMRS are judged implausible as well (see also Campbell, Lo and MacKinlay (1997, p.326)).

More generally, the relationship between nonseparable preferences and asset prices has not attracted abundant interest in the finance literature.[3] Mayers (1972, 1973) emphasizes the importance of leisure and human capital accumulation at an early stage in the context of the Capital Asset Pricing Model. Cochrane and Hansen (1992) and Fama (1991, p. 1610) make a forceful point for establishing a theoretical and empirical connection between asset returns and intuitively plausible pricing factors emanating from general equilibrium models, such as leisure. In the theoretical literature, the importance of leisure choice has been analyzed among others by Bodie, Merton and Samuelson (1992) and Basak (1999).[4] The work of Jagannathan and Wang (1996) suggests that human capital accumulation could be

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[3] Besides the poor performance of leisure in an intertemporal pricing context, there are other explanations for this. First, arbitrage pricing techniques (Ross (1976)) do not necessitate an elaborate description of the economic environment. Second, pricing factors derived from theoretical multiperiod models such as consumption have not performed well in cross-sectional asset pricing (Breeden, Gibbons and Litzenberger (1989)).

[4] The stochastic properties of leisure are also of interest in the literature on nontraded assets, even though leisure is not included in the utility function in many studies in that literature (e.g. see Detemple (1999) and Svensson and Werner (1993)).

of interest in cross-sectional asset pricing.

This paper argues that the perceived failure of nonseparable utility specifications to solve asset pricing puzzles may be due to the complete markets assumption that underlies these studies. If this assumption does not hold, it is the properties of the individual agent's consumption and leisure instead of aggregate consumption and leisure that determine asset prices. Mankiw and Zeldes (1991) and Jacobs (1999) show that these aggregation issues are critically important when evaluating the TS-CRRA specification. These findings are confirmed in more recent papers by Attanasio, Banks and Tanner (1998), Brav, Constantinides and Geczy (1999), Cogley (1999), Vissing-Jorgensen (1999) and Balduzzi and Yao (2000). This paper investigates if similar arguments apply for the evaluation of preferences that are nonseparable in consumption and leisure.[5]

It must be noted at this point that in the asset pricing literature, a slightly different approach to testing is often used (e.g. see Mehra and Prescott (1985) and Hansen and Jagannathan (1991)). In this approach, the implications of the theory are evaluated for a wide range of values of the behavioral parameters. If parameter values can be found that can explain the theoretical implications, the researcher asks himself the question if those parameter values are intuitively plausible. Whereas the assessment of plausibility is presumably based on a wide range of available sources, including introspection, it is clear that existing parameter estimates are most useful as reference points for this literature.[6]

This study is also related to a third important area of research, the empirical literature on consumption choice and savings. This literature includes a large number of empirical studies that use micro level data.[7] For purposes of comparison with this study, a potential problem is that most existing studies analyze the linearized version of Euler equations (3) and (4).

$$\Delta \ln c_{i,t} = \omega_1 + \omega_2 \ln R_t + \omega_3 \Delta \ln l_{i,t} + u_{i,t} \tag{6}$$

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[5] An alternative approach to assess the importance of market incompleteness is provided by Telmer (1993) and Heaton and Lucas (1996). They use a general equilibrium approach and find that for most parameterizations of the economy, the incomplete markets assumption does not help to explain asset pricing puzzles. Constantinides and Duffie (1996) clearly show that this conclusion is at least partly due to assumptions made in the general equilibrium setup.

[6] Whereas the existence of nonseparabilities between consumption and leisure has not received a lot of attention recently, the specification of preferences has received considerable attention in the asset pricing literature. Most notably, the specification of preferences with time-nonseparabilities has become quite popular (e.g. see Abel (1990), Altug and Miller (1998), Campbell and Cochrane (1995), Constantinides (1990), Detemple and Zapatero (1991) and Sundaresan (1989)). Whereas this paper does not deny that this type of specification is intuitively plausible, it explores how much leverage can be obtained from a specification without time-nonseparabilities once the complete markets assumption is relaxed.

[7] For micro data studies, see Attanasio and Weber (1995), Keane and Runkle (1992), Runkle (1991), Zeldes (1989) and the references in the overview paper by Browning and Lusardi (1996). There is an equally extensive literature that relies on aggregate data (see Hall (1988) and the references in Deaton (1992)).

where the parameter ω_2 is the intertemporal rate of substitution for consumption, which using a lognormality assumption can be related to the preference specification (1) as $\omega_2 = 1/(1-\psi)$. The main motivation for using linearizations is that measurement error is an important problem with panel data (see Altonji (1986) and Altonji and Siow (1987)), and it is easier to deal with measurement error problems in a linear context. While this study does not deny the importance of measurement error, it takes the alternative view that it is worth investigating the original nonlinear Euler equations (3) and (4) directly. We know so little about estimates obtained from the nonlinear Euler equations (3) and (4) that the marginal benefit from such an analysis is high, even if we acknowledge that the presence of measurement error may lead to inconsistent estimates.[8] If measurement error is a serious problem *in this context and for this purpose*, it will likely lead to implausible parameter estimates and a lack of robustness. Moreover, we have to keep in mind that if the lognormality assumption leading to (6) is incorrect, the resulting parameter estimates will also be inconsistent.

Besides the linearization, there are other issues that complicate a comparison with the existing literature. Instead of testing the overidentifying conditions, Euler equations are often tested with extra variables included in the specification, to improve the power of the tests. Moreover, many studies estimate models that are additively separable between consumption and leisure.[9] As originally pointed out by Heckman (1974), this may be problematic. The life-cycle model is often questioned because several studies have documented a relationship between consumption patterns and variables such as age. However, if older people compensate for lower consumption by enjoying more leisure, this rejection of the life-cycle model would be called into question. Without knowledge of the relative weights placed on consumption and leisure it is hard to appreciate the importance of this argument.

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[8] There are a few papers in the panel data literature that provide an analysis of nonlinear Euler equations. Hotz, Kydland and Sedlacek (1988) analyze a translog utility function. Because this utility specification is quite different from the ones traditionally analyzed in the literature, it is not straightforward to compare their results with other studies. Altug and Miller (1990) analyze a utility function that contains several nonseparabilities between consumption and the leisure of different members of the household. However, their estimates are obtained under the hypothesis of market completeness. Moreover, the econometric framework they use results in some instances in imprecise estimates. The results in this paper therefore differ quite strongly from the ones in those two studies.

[9] It is not claimed that the modeling of nonseparabilities between consumption and leisure using micro data is novel to this paper. Altug and Miller (1990) and Browning and Meghir (1991), for example, provide evidence of such nonseparabilities. Table 5.1 in Browning and Lusardi (1996) presents an overview of other available micro data studies. Most of the studies that control for leisure follow the conditional approach of Browning and Meghir (1991). From the perspective of estimating elasticities and testing for separability in the Euler equation (6) that approach does not differ from the one used in this paper, but its advantage is that one does not have to model leisure choice explicitly. However, in this paper, the focus is explicitly on recovering the parameters of the utility function in (1).

3 Data

The empirical investigation uses data from the Panel Study of Income Dynamics (PSID) for the period 1974-1987. The data set is described in more detail in the Appendix. The most critical issues are the construction of leisure and consumption. The main purpose of the analysis is to retrieve estimates of behavioral parameters that can be used in theoretical analysis, most of which studies a representative person. Ideally we would therefore like to use consumption and leisure data for such a represenatative person. However, we face two problems. First, the data are often available at the level of the household, not the individual. Second, a representative person does not exist. This is evidenced by the widely different decisions men and women make with respect to their choice of hours of work outside the house. There are two possible responses to this problem. The first is to attempt to model the household decision process as adequately as possible. The second, which is followed in this paper, is to simplify the problem in the hope of finding a fairly robust answer to a more narrowly formulated question.

More specifically, the biggest problem is that the consumption variable available in the PSID is household consumption. Ideally one would therefore like to construct a matching measure of household leisure, or to model the leisure decisions of the entire household. However, in this paper I limit myself to modeling the leisure of the household head. Obviously, the resulting matchup of houshold consumption with the household head's leisure necessitates a number of troublesome separability assumptions, in light of the existing literature on labor supply. The paper therefore attempts to provide an answer to the more narrowly formulated question whether nonseparability is of interest when estimating the nonlinear Euler equations. The broader question of how to specify the nature of these nonseparabilities in the household is left for future work.

Another limitation is that the PSID does not contain a satisfactory measure of total consumption. Therefore, I follow existing studies that use the PSID by using household food consumption as the consumption measure. Again, it is clear that the use of the food consumption variable necessitates awkward separability assumptions. However, we simply have to live with the imperfections of existing datasets. The alternative is to use the Consumer Expenditure Survey (CEX) to investigate the preference specifications in (1) and (5). Unlike the PSID, the CEX contains data on total household consumption, and the frequency of the data is quarterly, therefore yielding more time series observations than the PSID. However, in the CEX data on leisure are only available on a yearly basis. Moreover, the CEX is not a genuine panel dataset because households are only followed for five consecutive time periods. One therefore has to resort to the construction of synthetic cohorts, and to investigate the impact of aggregation problems this approach is not necessarily appealing. In contrast, the PSID is a genuine panel dataset, even though observations on a given household are not available in any given year. Summarizing, there is no perfect dataset available to analyze these issues. The problems associated with the PSID are no worse than the problems associated with the alternatives.

The PSID allows the construction of samples of households who are at interior solutions with respect to asset choice. This allows an assessment of the quantitative importance of asset market participation. To identify households at interior solutions, I use a 1984 question from the PSID which asks households for their holdings of liquid assets and stocks. This question is the same as that used by Mankiw and Zeldes (1991) and Jacobs (1999). It is discussed in more detail in the Appendix. The question can be used to construct five successively smaller samples: a sample including all households that satisfy the selection criteria; a sample including only households who fulfill the selection criteria and who have nonzero holdings of both the riskless *and* the risky asset; and samples including only households who fulfill the selection criteria and who have holdings of *both* assets larger than \$1,000, \$10,000, and \$100,000 respectively.[10] Unfortunately the samples based on \$10,000 and \$100,000 holdings are too small to yield reliable econometric results. Parameter estimates are imprecise and not very robust. Results are therefore only reported using the first three samples.

Returns on stocks and T-bills are constructed as follows: yearly returns are computed as the average of twelve returns on one-year investments which expire at the end of every month of the year. This construction is motivated by the interpretation of consumption as yearly totals (flows) and not stocks at one point in time. The risk-free returns are returns on rolling over three-month treasury bills and are obtained from Moody's. The stock returns are returns on the Standard and Poor's 500 composite.

4 Estimation and Testing

As with most other available panel datasets, the household and not the individual is the unit of observation in the PSID. This complicates empirical testing because preferences are defined at the level of the individual. To resolve this issue, I include an exponential function of household size in periods t-1 and t in the Euler equation.[11] Another issue of interest is that many available micro data studies estimate preferences conditional on demographic variables such as age and marital status and some of the agent's decision variables such as education. For purposes of comparison with these earlier studies, I therefore estimate the Euler equations with and without an exponential function of such variables included as

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[10] So in each sample households have to hold the treshold for the risky asset as well as the riskless asset. Alternatively one could use samples based on holdings of one of the assets, the riskless or the risky one. We do not follow this approach because we want to compare results for the two Euler equations based on the same sample.

[11] As mentioned previously, this issue is complicated here by the fact that the consumption measure is household consumption, and the leisure measure is leisure of the household head. An alternative approach would be to correct more carefully for family size using equivalence scales. Preliminary robustness exercises suggest that this does not change the results.

preference shifters. The most general specification of the Euler equations is therefore given by

$$1 = \beta E_{t-1} R_t (\frac{c_{i,t}}{c_{i,t-1}})^{\psi-1} (\frac{l_{i,t}}{l_{i,t-1}})^{\kappa} \exp[\pi_1 \ fam_{i,t} + \pi_2 \ fam_{i,t-1}] \exp[\sigma \ demo_{i,t}]. \tag{7}$$

where $\mathrm{fam}_{i,t}$ stands for family size in period t, $\mathrm{demo}_{i,t}$ stands for a vector of preference shifters at time t, $\pi_1$and π_2 are scalar parameters and σ is a vector of parameters.[12] As mentioned before, many studies use panel data to investigate linearizations of (7). The most general linearization investigated in this paper is

$$\Delta \ln c_{i,t} = \omega_1 + \omega_2 \ln R_t + \omega_3 \Delta \ln l_{i,t} + \pi_1 \ fam_{i,t} + \pi_2 \ fam_{i,t-1} + \sigma \ demo_{i,t} + u_{i,t}. \tag{8}$$

By estimating the parameters in (8), we can retrieve the parameters ψ and κ that characterize the utility function (1).[13]

Parameter estimates and test statistics are obtained using a generalized method of moments (GMM) framework (see Hansen (1982)). Regardless of whether one is estimating the nonlinear Euler equation (7) or the linearized equation (8), parameter estimates and test statistics can be obtained by exploiting the orthogonality between the Euler equation errors and variables in the agent's information set. Consider the error associated with the nonlinear Euler equation (7) or with the linearized Euler equation (8) and for simplicity label it e_{it} , where t is the time index and i is the household index. Theory specifies $E_{t-1}e_{it} = 0$. Consider a maximum of T observations on H households, and consider M instruments per household $z^1_{i,t-1}, ..., z^n_{i,t-1}, ..., z^M_{i,t-1}$. Then consider $v^n_{i,t} = e_{it} \ z^n_{i,t-1}$. Using the law of iterated expectations we know that $Ev^n_{i,t} = 0$, for all n and i. Rather than using all MxH orthogonality conditions in estimation, we sum over the orthogonality conditions to obtain a more powerful test statistic. Denote the number of households in the sample at time t as H_t and consider the M orthogonality conditions $E\overline{v^n_t}, n = 1, ..., M$ where $\overline{v^n_t} = \frac{1}{H_t} \sum_{i=1}^{H_t} v^n_{i,t}$. The GMM estimator exploits the fact that if the theory is correct $\sum_1^T \overline{v^n_t}$ should be close to zero. Define the $Mx1$ vector $\overline{v_t} = (\overline{v^1_t}, ..., \overline{v^M_t})'$ and consider minimizing

$$[\frac{1}{T} \sum_{t=1}^{T} \overline{v_t}(\phi)'] \ W \ [\frac{1}{T} \sum_{t=1}^{T} \overline{v_t}(\phi)]. \tag{9}$$

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[12] When deriving (7) explicitly from an underlying utility function that depends on preference shifters, one obtains π_1 and π_2 coefficients that are equal in absolute value. This constraint is not imposed in estimation. Also, more in general, one would obtain similar results for the other preference shifters in $\mathrm{demo}_{i,t}$.

[13] Hansen and Singleton (1983) use time series data and a lognormality argument to estimate a linearized version of the Euler equation in structural as opposed to reduced form. This allows them to identify additional preference parameters such as the discount factor β. In this paper we follow the papers in the panel data literature and estimate the reduced form.

for an arbitrary MxM weighting matrix W. From Hansen (1982) we know that the test statistic

$$J_T = T\ [\frac{1}{T}\sum_{t=1}^{T}\overline{\widehat{v}'_t}(\phi)']\ \widehat{Q}^{-}\ [\frac{1}{T}\sum_{t=1}^{T}\overline{\widehat{v}_t}(\phi)]. \tag{10}$$

is distributed χ^2_{M-K}, where $\widehat{Q} = \widehat{P}\widehat{\Omega}\widehat{P'}, \widehat{P} = I - \widehat{H}(\widehat{H'}W\widehat{H})^{-1}\widehat{H'}W$, $H = E[\overline{\partial v_t}/\partial\phi']$ and $\widehat{Q}^{-}$ is the generalized inverse of Q. All matrices in (10) are evaluated at $\widehat{\phi}$, the value of the parameters that minimizes (9). The covariance matrix $\widehat{\Omega}$ is computed as

$$\widehat{\Omega} = \frac{1}{T}\sum_{t=1}^{T}[\overline{\widehat{v}_t} - (\frac{1}{T}\sum_{t=1}^{T}\overline{\widehat{v}_t})]\ [\overline{\widehat{v}_t} - (\frac{1}{T}\sum_{t=1}^{T}\overline{\widehat{v}_t})]'. \tag{11}$$

In accordance with the rational expectations assumption, this covariance matrix does not allow for the Euler errors of a household to be correlated over time. However, it allows for Euler errors of different households at the same time to be correlated. It must be noted that nonzero autocorrelation can be induced in the Euler equation errors for a household as a result of measurement error. Allowing for first and second-order autocorrelation of this kind does not significantly change the results. The covariance matrix of $T^{1/2}(\phi - \widehat{\phi})$ can be computed as

$$(\widehat{H'}W\widehat{H})^{-1}(\widehat{H'}W\widehat{\Omega}W\widehat{H})(\widehat{H'}W\widehat{H})'^{\,-1}. \tag{12}$$

The small-sample reliability of parameter estimates and test statistics depends on the weighting matrix W. Define for a given $1xM$ vector of instruments $Z_t = (\frac{1}{H_t})\ (z^1_{i,t-1}, ..., z^M_{i,t-1})$. The inverse of $\sum_{t=1}^{T} Z'_t Z_t$ is used as the weighting matrix W. This choice of W effectively reduces the minimization in (9) to NL2SLS.[14]

5 Empirical Results

Tables 1 through 6 present different estimation and test results. This section discusses table 1, which contains the results of the estimation of (3) and (4) using a benchmark instrument set. This instrument sets contains the following 9 instruments: family size in periods t and $t-1$, a constant, the riskless and risky rates of return lagged once, the occupational unemployment rate lagged once, the occupational unemployment rate lagged once interacted with age and education of the household head, the industry unemployment rate lagged once

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[14] Optimization is carried out using analytical derivatives and the DFP algorithm as implemented in the GQOPT package. Identification in the linear case is relatively straightforward, but this is not necessarily the case for the nonlinear Euler equation. An extensive robustness analysis was performed to check for local optima. Whereas several choices of instrument sets yield local optima, reported global optima are remarkably robust to the choice of starting values.

and the industry unemployment rate lagged once interacted with age and education of the household head.

Each table contains two parts, with the first part presenting estimation and test results for the riskless asset and the second part presenting estimation and test results for the risky asset. Also, each table presents results for three different samples: the first column presents results for a first sample, which contains all households who fulfill the selection criteria specified in the Appendix. This yields a sample with $H = 3555$ households. The panel is unbalanced, and we have $N = 18813$ observations in this sample. The second column in every table presents results for smaller samples: they include those households present in the first sample who have nonzero holdings of the riskless asset *and* nonzero holdings of the risky asset. This sample contains $H = 740$ households and $N = 5029$ observations. The third column contains only those households who have holdings of the riskless *and* the risky asset larger than \$1000, $H = 413$ households and $N = 2990$ observations respectively. For each sample we present parameter estimates and standard errors for the parameters based on the utility specification (1), as well as the implied point estimates of the parameters in utility specification (5) that can be derived by using $\theta = \psi + \kappa$ and $\gamma = \psi/\theta$.

A first important observation in table 1A is that the results in columns 2 and 3 are remarkably similar. The point estimates of the discount rate β are 0.828 and 0.869. For the optimization problem under study to be well defined, the estimate of $\psi - 1$ has to be negative. This is the case in both samples and the estimates are not very different. Note that we do not investigate the consumer's decision with respect to leisure, and therefore we do not need the estimate of κ to imply concavity in order for these estimates to make sense. However, the estimates of κ of -1.267 and -1.436 would guarantee that we were dealing with a concave problem, if we were to analyze leisure choice. Also, the estimates of π_1 and π_2, indicating the importance of family size, have the expected sign. The significance level for the J statistics indicates that the statistical evidence against the theory is not very strong. Finally, each column lists the implication of the estimates of ψ and κ for the parameters γ and θ in utility specification (5). We obtain estimates of γ of 0.360 and 0.309 in columns 2 and 3 respectively and estimates of θ of -1.980 and -2.081 respectively. These estimates for γ are very close to the calibrated 1/3 first proposed by Kydland and Prescott and commonly used in the dynamic macroeconomics literature. However, the value for θ, which determines the rate of relative risk aversion, is different from the parameter values used in many simulation studies.

If asset market participation and corner solutions are important, one would expect the estimates in column 1 to differ from those in columns 2 and 3. Whereas the estimate of ψ is already quite different, the sign of κ is different from that of the estimates in columns 2 and 3, even though the parameter is fairly precisely estimated. It must be emphasized that this is not necessarily a problem, because we are not analyzing leisure choice, but if we obtain a similar estimate from the first order condition for leisure it would indicate that the optimization problem is not well defined. It is perhaps more intuitively appealing to investigate the implications of these parameter estimates for the values of the parameters γ

and θ in the utility specification (5). We see that the weight placed on consumption γ is 0.117, much smaller than in columns 2 and 3. Moreover, the parameter θ, which determines the rate of relative risk aversion, has the wrong sign. In summary, the parameter estimates for the large sample seem much less plausible than those for the smaller samples. This conclusion is reinforced by the observation that the parameters π_1 and π_2 also have the wrong sign. A final important observation is that the test statistic indicates little evidence against the theoretical specification. This is problematic, because we do not expect the theory to hold for households who are at corners and the parameter estimates indicate the importance of these corner solutions.

Table 1B presents estimation and test results for the Euler equation associated with the risky asset. The most important observation is that estimation and test results largely confirm the results reported in table 1A. Parameter estimates in columns 2 and 3 are dramatically different from those in column 1. Once again, the parameter estimate for κ in column 1 would place us in the nonconcave region of the parameter space if we were to analyze the optimal leisure decision. Whereas parameter estimates for π_1 and π_2 have the expected sign in columns 2 and 3, they do not in column 1. In terms of the implied point estimates for parameters γ and θ in utility specification (5), the estimates in column 1 imply a negative weight on consumption ($\gamma = -0.040$) and again the parameter θ has the wrong sign. When comparing the estimates of γ and θ in columns 2 and 3 with those in table 1A, we find that the weight γ on consumption is higher in table 1B, and that risk aversion is higher too. Finally, the test statistic in column 1 of table 1B is again surprisingly low.[15]

It is instructive at this point to relate these parameter estimates and test statistics to the results for the time separable constant relative risk aversion (TS-CRRA) specification studied in Jacobs (1999). There are some interesting parallels and differences. First, the differences between the parameter estimates obtained from the Euler equation for the riskless and the risky asset are in a certain sense similar to the ones in Jacobs (1999). For example, the estimates of the discount rate β obtained from the Euler equation for the risky asset in Jacobs (1999) are also smaller than those obtained from the Euler equation for the riskless asset. Second, if one interprets $1 - \theta$ as the rate of relative risk aversion for the composite good as in Kydland and Prescott (1982), then the finding that the rate of risk aversion is larger when estimating the Euler equation for the risky asset also obtains in Jacobs (1999). However, there are some interesting differences. First, the discount rate β estimated in this study is almost always lower than the one estimated in Jacobs (1999).[16] Second, the test statistics

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[15] The low value of the test statistic in column 1 of table 1B is actually even more surprising than the corresponding low value in table 1A. Even if agents declare zero asset holdings, they may be at an interior solution with respect to the riskless asset provided they have debts. This argument cannot plausibly be used for the Euler equation involving the risky asset.

[16] Most estimated values of β are much lower than those obtained from studies that use time series data. Vissing-Jorgensen (1999), in the context of a TS-CRRA model, argues that under certain types of measurement error, the bias in β will be larger than the bias in the risk aversion parameter. Her result extends to

in this study are lower. It must of course be remembered that we know very little about the performance of these test statistics in small samples in a panel data context. However, systematic overrejections or underrejections are equally likely to influence the results in a similar fashion. The results therefore suggest that leisure is an important determinant in the utility function, a conclusion which is of course reinforced by the finding that the parameter κ is significantly estimated in columns 2 and 3 of the tables. Third, estimation and test results in Jacobs (1999) do not vary significantly across different columns, seemingly implying that asset market participation is not very important. When taking the presence of leisure in the utility function into account, the results in tables 1 through 3 clearly show that asset market participation is critically important and causes significant biases in estimated parameters. Inference on the importance of corner solutions and asset market participation therefore seems critically dependent on the utility function under study.

6 Robustness

The most important robustness exercise concerns the choice of instrument set. The instrument set discussed in Section 5 was chosen because of high correlation of the instruments with the consumption growth and asset return variables. When using similar instrument sets with good quality instruments parameters estimates are very similar. However, test statistics vary widely. These results are not reported in order to keep the number of tables manageable. Another important robustness issue that is not reported is the specification of leisure time. There is a certain arbitrariness involved in the definition of leisure time, because it is constructed using available data on hours worked. The results in table 1 are obtained by specifying total time available to the consumer in the year as 5840 hours (16 hours per day multiplied by 365). Leisure time is then computed as 5840 hours minus hours of work reported for that year. This construction follows the work of EHS (1988) and MRS (1985). However, one can also justify including sleeping time in the available leisure time, or specifying that an individual has less than 16 hours available every day. To investigate the implications of this assumption, we also estimated the Euler equations using total time endowment of 8760 hours (24 hours x 365 days). The main impact of this change is that the estimated absolute value of the parameter κ is larger in columns 2 and 3. As a consequence the implied point estimates of γ and θ in (5) are different: γ is smaller by about 30% on average and the rate of risk aversion θ is larger (in absolute value) by about 25% on average.

Table 2 investigates how estimation and test results are affected by estimating linearizations of the original nonlinear Euler equations.[17] An analysis of these linearized equations

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the nonseparable specification in this paper.

[17] Strictly speaking this is not an investigation of the robustness of the results, because we do not relax any of the assumptions used to obtain those results; on the contrary, to analyze the linearizations one has to make additional assumptions.

is of interest for several reasons. First, many available studies that use micro data analyze linearized Euler equations.[18] Also, to the best of my knowledge, analysis of linearized Euler equations has only been performed for the Euler equation associated with the riskless asset. Because estimation and test results in table 1A differ from those in table 1B, it is worth investigating if this is also the case when analyzing linearized equations. Finally, it is well known that measurement error problems can be solved in a linear context by an appropriate choice of instruments. When estimating nonlinear Euler equations, dealing with measurement error problems is much more problematic. To some extent, analysis of the linearized Euler equations can therefore be interpreted as an analysis of robustness of the nonlinear analysis to measurement error problems.[19]

Table 2A presents estimation and test results for the linearization of the Euler equation (8) associated with the riskless asset, using the same instrument set used for table 1. Comparing the results to those in table 1A, it is clear that they are different. First, the test statistics indicate dramatically stronger evidence against the model. Second, when using the estimates of ω_2 and ω_3 to derive implied parameters ψ and κ, the absolute values of ψ and κ are much larger in columns 2 and 3 of table 2A compared to table 1A. Translating these parameters to the more intuitively appealing parameters γ and θ of utility specification (5), it is seen that the share of consumption in the utility function γ is roughly comparable to the one estimated in table 1A. However, the parameter θ, which indicates the rate of relative risk aversion, is much higher. A third interesting observation is that the implied estimates of the parameters γ and θ in column 1 are more similar to those in columns 2 and 3 than is the case in table 1A. Also, the estimates for π_1 and π_2 in column 1 have the expected sign, just as in columns 2 and 3. Table 2B provides a similar analysis for the risky asset. The same observations as in table 2A apply. Interestingly, it is the case that the estimates for the parameter of relative risk aversion are higher than those obtained in table 2A, just as the estimates obtained in table 1B are higher than those obtained in table 1A.

A final important robustness analysis is performed with respect to the inclusion of demographics in the Euler equation. Most of the literature that uses micro data estimates (linearizations of) Euler equations or demand systems by conditioning on a number of de-

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[18] It is well known that estimation and test results for these analyses can differ dramatically depending on the sample under investigation, and therefore it is difficult to compare our results with existing parameter estimates.

[19] It is clear though that this interpretation is potentially troublesome: if one can investigate the robustness to measurement error by investigating linearizations, there would be no motivation for investigating the nonlinear Euler equations in the first place. While there are costs to analyzing the nonlinear equations (higher probability of measurement error problems), there are costs to analyzing the linearized equations (is the linearization valid?). Moreover, there is no evidence indicating that linearization solves all potential measurement error problems in this context, nor that measurement error strongly biases parameter estimates for this particular estimation problem. The only thing we know for sure is that measurement error problems are potentially serious in these datasets (see Altonji (1986) and Altonji and Siow (1987)) and that the effects of these errors are much more likely to cause problems in a nonlinear environment.

mographic variables (preference shifters) such as age, education, marital status, race and others (see table 5.1. in Browning and Lusardi (1996)). Motivation for such analyses seems obvious, for instance by plotting consumption over the life cycle as a function of age. However, once one considers nonseparable preferences it is clear that such techniques may be misleading because other components of the utility function may change too. For instance, as people get older they may consume less but still confirm to intertemporal optimization theory because they enjoy more leisure. Exactly how much more leisure they have to enjoy to make the theory work is an open question, because it depends on the parameterization of the utility function. It could therefore be the case that age enters significantly in the utility function because it proxies for leisure, with which it is highly correlated. Therefore, this paper takes a different approach from much of the literature by first investigating the theory without preference shifters included, and then investigating the robustness of the results to the inclusion of demographics. Our results show that this is a worthwhile approach.

Table 3 presents results for the Euler equations augmented with two regressors: the age of the household head and the age of the household head squared. Table 4 augments the Euler equations with the education of the household head and the education of the household head squared. In both cases the instrument set used is the one used for tables 1 and 2 augmented with both regressors. Comparing the results of table 3A to those of table 1A, it is clear that the point estimates of ψ and κ are very different. Translating this into the parameters γ and θ, it is seen that the share of leisure is very small in column 2 and negative in column 3. The estimates in column 1 are not very different from the ones in table 1A, but they were not intuitively plausible to start with. Why do these differences occur? A serious problem with the estimates in column 2 and 3 is that the parameter κ is very imprecisely estimated. Further inspection shows that σ_1 and σ_2 are also very imprecisely estimated.[20] Also, the parameters π_1 and π_2 are less precisely estimated than in table 1A. It can therefore be argued that the point estimates for ψ and κ and the resulting point estimates for γ and θ have to be interpreted with caution. It is tempting to conclude that a likely reason for these imprecise estimates is that age and leisure are highly correlated. Another potential problem is that age is highly correlated with family size. However, comparison of tables 3B and 1B shows that the problem is more complex: when analyzing the Euler equation for the risky asset, including age and age squared in the Euler equation does not significantly bias the estimates of ψ and κ. This is interesting because just as in table 3A, the parameters σ_1, σ_2, π_1 and π_2 are not very precisely estimated.

Inspection of table 4 nevertheless shows that the properties of the age variable are part of the problem. When including education and education squared in the Euler equation, point estimates of ψ and κ, and the resulting point estimates of γ and θ, are not significantly affected. This finding can partially be explained by the fact that the parameter κ is

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[20] These findings are not due to the inclusion of too many regressors. Identical results obtain when only age and not age squared is included in the regression.

estimated with similar standard errors as in table 1. Nevertheless, it is again the case that the parameters σ_1 and σ_2 are very imprecisely estimated and that the J statistics in table 4 are in many cases higher than the corresponding ones in table 1. Summarizing, except for one set of preference shifters, the estimation of behavioral parameters is quite robust. The same cannot be said for test statistics. Further investigation of specifications that include various permutations of these demographic parameters yielded similar results.

The final question addressed is whether the problems with estimating utility parameters in the presence of preference shifters are specific to the analysis of nonlinear Euler equations. Almost all available studies estimate preference parameters in the presence of preference shifters from linearized equations. Because these studies sometimes report estimates in the presence of different sets of preference shifters, but not while excluding preference shifters, it is not always straightforward to verify whether they incur similar difficulties. Tables 5 and 6 investigate this issue by including age and age squared and education and education squared respectively in the linearized Euler equations. Table 5A shows that just as in the nonlinear case, problems occur when including the age variables in the Euler equation associated with the riskless asset. The parameter ω_3 is very imprecisely estimated and the resulting point estimates for γ and θ are not intuitively plausible. Table 5B shows that problems also obtain when analyzing the Euler equation for the risky asset, but they are less serious, just as in the nonlinear case. Finally, table 6 shows that the problems are again much less serious when including the education variables in the Euler equation as preference shifters.

7 Comparison With Existing Literature

This section discusses the relevance of the parameter estimates obtained in sections 5 and 6 for the existing literature. First, the implications for dynamic macroeconomics are discussed, with particular attention to those studies that employ the computational experiment methodology, which uses parameter estimates as inputs into the model. Estimates of the parameter θ in columns 2 and 3 of table 1 are between -1.980 and -3.564. As mentioned before, these estimates are representative of the results obtained with a large number of instrument sets. Therefore the evidence indicates marked differences with the range of parameter values used by Kydland and Prescott (-1, -0.5 and -0.1). It may be argued that the differences are economically insignificant. Indeed, when interpreting $1-\theta$ as the rate of relative risk aversion, it is clear that the differences between the parameter estimates in this paper and some of the parameters estimated or proposed in the representative agent literature are small. However, because of the nonlinear nature of these models and the methodology used, it is often not clear how even modest changes in parameter values influence the results.

Many of the studies in dynamic macroeconomics that use computational experiments use the preference specification (5) of Kydland and Prescott (1982) and several studies use similar parameter estimates. For instance, Backus, Kehoe and Kydland (1992) use $\theta = -1$. Another potential problem for many studies in this literature is that several authors use a logarithmic preference specification, which maintains additive separability between consumption and leisure (e.g. see Christiano and Eichenbaum (1992)). The logarithmic utility function used in those studies can be formulated as a special case of (5) with $\theta = 0$. This hypothesis can be tested by using the delta method to compute standard errors for γ and θ that are implied by the point estimates and covariance matrix for (1). Whereas γ is sometimes imprecisely estimated, estimates for θ are always highly significant (not reported). Our findings therefore indicate that the logarithmic specification used in several studies is not supported by the data.

The parameter estimates and test statistics reported in this paper also have important implications for the asset pricing literature. Because the parameter κ is estimated significantly different from zero, test results in asset pricing studies that (implicitly) assume additive separability between consumption and leisure may be biased. This conclusion is reinforced by the finding that the test statistics in this paper are lower than the corresponding ones in Jacobs (1999). To investigate this issue more in detail, a comparison of the estimates obtained in this paper with estimates of preference parameters in the representative agent literature is also instructive. MRS (1985) and EHS (1988) provide a representative agent analysis of nonlinear Euler equations.[21] However, their setup differs from the one in this paper in several respects. First, both studies use information from the first order condition for leisure as well as the first order condition for consumption. Second, whereas MRS (1985) study time-separable preferences, EHS (1988) exclusively study preferences with time-nonseparabilities modeled as in Kydland and Prescott (1982). Conditional on these interpretational difficulties, the differences between estimates in those studies and ours are striking. When MRS (1985) exclusively use the intertemporal optimality condition and the first order condition wrt consumption, they do not obtain statistically significant parameter estimates. Perhaps not surprisingly, estimation results are also not robust. This contrasts with the estimates obtained by EHS. They report two estimates of θ, 0.85 and 0.8 and a third estimate -0.16 after adjusting for taxes. While these estimates are in the concave region of the parameter space, the implied value of the rate of relative risk aversion is much lower than the one obtained in this paper. Also, EHS's estimate of the share parameter γ is around 0.15, much lower than ours. Besides the fact that this estimate may be strongly affected by the time-nonseparabilities in leisure allowed for in their paper, it must also again be noted that this estimate is partially determined by the definition of total available time. Using alternative definitions of leisure time, one obtains estimates that are closer to those of EHS

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[21] Note again that for this discussion studies are grouped together mainly according to methodology. The studies by MRS (1985) and EHS (1988) are intimately related to and motivated by the "real business cycle" methodology pioneered by Kydland and Prescott (1982). However, because they provide tests of Euler equations they are intimately related to the asset pricing tests of Hansen and Singleton (1982) and for that reason they are discussed here. This goes to prove once again that the results in this paper are of interest in several research fields, but these fields are intimately connected.

(1988). EHS also note (1988, p.67) that changes in their definition of leisure time could bring their estimates more in line with our estimate (and Kydland and Prescott's (1982) calibrated value).

Despite the apparent promise of nonseparability to resolve outstanding issues in asset pricing, a more detailed analysis is necessary. Whereas the asset pricing literature attaches great importance to the test statistics studied in this paper (see Hansen and Singleton (1982) and Epstein and Zin (1991)), a lot of attention is focused on one particular dimension of the data, the so-called "unconditional restrictions" of the model.[22] This dimension of the model is related to the most conventional representation of the equity premium puzzle and the riskfree rate puzzle, and it is not necessarily obvious that the nonseparable preferences will perform equally well in this dimension.[23] Moreover, an investigation of nonseparable specifications along the lines of Hansen and Jagannathan (1991,1997) is desirable. A detailed investigation of these issues is left for future work.

Estimates of the parameters ψ and κ are also of interest to the consumption literature because of several reasons. First, in the consumption literature many tests are constructed using additive separability. The statistically significant estimates of κ show that this assumption is not supported by the data. Second, the estimate of $\omega_2 = -1/(\psi - 1)$ in (6) is of interest because it is the rate of intertemporal substitution in consumption. Because our estimates of $\psi - 1$ in columns 2 and 3 of table 1 are between -1.645 and -2.749, our results imply a rate of intertemporal substitution of consumption between 0.363 and 0.607. It is not straightforward to compare these point estimates to the existing literature, because it contains a wide range of parameter estimates. Another caveat is that most available estimates of the rate of intertemporal substitution in consumption are obtained using an additively separable specification which is TS-CRRA in consumption. In this context the intertemporal rate of substitution in consumption is simply one divided by the rate of risk aversion. In the representative agent literature, most studies point towards a very large rate

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[22] Because to a certain extent this terminology is a misnomer, it is instructive to indicate exactly what is meant with unconditional information. In a GMM setup, "unconditional information" can be thought of as exploiting the orthogonality between the Euler equation error and a constant. In contrast, the estimation and testing in this paper exploits orthogonality between the Euler equation and a constant as well as other variables in the agent's information set. To appreciate that this difference can be important, with a TS-CRRA specification unconditional information yields large estimates of the rate of risk aversion, whereas conditional information such as the one used in this paper yields much smaller estimates (see Hansen and Singleton (1982, 1983) and Grossman, Melino and Shiller (1987)).

[23] For nonseparable preferences this issue is less straightforward than in the separable case. In the TS-CRRA case, one can simply use the orthogonality condition associated with the riskless asset and a constant and the orthogonality condition associated with the risky asset and a constant to determine the two parameters of interest, the discount rate and the rate of relative risk aversion. In the nonseparable case we need to determine three parameters, so we need to add an orthogonality condition involving a third asset. If one adds a third asset that has different time series properties from the riskless and risky asset, the danger is that test results will be impacted by the choice of this asset. The best solution is probably to work with the riskless asset and two risky assets with properties similar to the market return.

of risk aversion and therefore a small intertemporal elasticity (e.g. see Hall (1988), Mehra and Prescott (1985) and Hansen and Jagannathan (1991)). The exception is the evidence in Hansen and Singleton (1982, 1983): when using conditional information, their estimates of the intertemporal substitution elasticity are in line with ours. In the panel data literature, under additive separability different studies have reported a wide range of point estimates. Zeldes (1989) reports estimates in line with the small elasticities in the representative agent literature. The elasticities in Runkle (1991) and Keane and Runkle (1992) are larger, but still smaller than the estimates in this paper. Attanasio and Weber (1995), using synthetic cohorts from the CEX find small elasticities. In the representative agent literature that investigates nonseparable preferences, the study by EHS (1988) is a natural reference point, because the results in MRS (1985) are not very robust. Their estimates of the intertemporal rate of elasticity are actually larger than ours.

It is not the objective of this paper to attempt to reconcile these different estimates. They are determined, among other things, by differences in data selection and econometric methodology. However, comparison of the nonlinear results in table 1A and the estimation results for the linearized equation in table 2A suggests one potential explanatory factor. Many elasticities estimated in the panel data literature are estimated using linearized Euler equations, and they are far more in line with the results in table 2A than with those in table 1A. Whereas the existing literature does not investigate the Euler equation associated with the risky asset, inspection of the results in table 2B indicates intertemporal substitution elasticities even smaller than the ones reported in existing literature obtained using the riskless asset.

8 Concluding Remarks

This paper estimates and tests nonlinear Euler equations using a Cobb-Douglas preference specification that is nonseparable in consumption and leisure. It finds that for samples that exclusively contain asset market participants, parameter estimates are intuitively plausible. Parameter estimates indicate that the optimization problems under study are concave, which is reassuring. Furthermore, the implied point estimates for the share of consumption in the utility function and the rate of relative risk aversion are intuitively appealing. For a sample that also includes households that do not participate in asset markets, parameter estimates are hard to interpret. This finding indicates that participation in asset markets is critically important when estimating preference parameters. As a result studies of representative agent models are likely to be flawed. Whereas estimation results depend on whether one analyzes the Euler equation associated with the riskless or the risky asset, these differences are relatively minor.

A critical difference between the methodology used in this paper and the approach of most of the existing panel data literature is that almost all available papers investigate linearizations of the original nonlinear Euler equations. It is shown that when investigating linearizations, parameter estimates are dramatically different. Most importantly, the implied rate of relative risk aversion is much higher than the one obtained using nonlinear analysis. Even though it may be tempting to conclude from this that linearization biases parameter estimates, this is not necessarily the case. It is clear that measurement error is a serious problem in panel data, and that this problem is more serious in a nonlinear context. Therefore, parameter estimates obtained from the nonlinear analysis may be biased because of measurement error problems. This paper must be seen as a first step that explores the implications of the nonlinear Euler equations, while abstracting from measurement error. Many estimated parameter values are not entirely implausible, and it is therefore possible that measurement is not a serious problem in certain dimensions. However, estimates of the rate of time preference β are surprisingly low in some cases. Another difference between this paper and many others is that except for family size, no other preference shifters are included in the Euler equations. When including preference shifters, it is shown that the presence of age variables in the Euler equations leads to imprecise estimates and a lack of robustness when analyzing the Euler equation for the riskless asset.

The implications of these results for existing research are extensive. Because preference specification lies at the basis of most economic analysis, these findings are of substantial interest for almost every empirical study that is based on economic theory. Given that a complete discussion of all these implications is not possible, I take a more narrowly focused approach. I discuss in detail the importance of the findings in this paper for three different but interconnected research areas: 1) intertemporal asset pricing; 2) the literature on consumption and savings; and 3) the dynamic macroeconomics literature that uses computational experiments.

These findings suggest a number of questions and extensions. First, it is clear that the use of the PSID, which forces us to use food consumption, may be a problem. The CEX offers data on total consumption, but is not a panel. Perhaps investigation of datasets from countries other than the United States will be helpful here, but such analysis may not be instructive to explain phenomena that are typical to the United States, such as the low savings rate. Second, some of the comparisons made with other studies in the literature are imperfect, because many existing studies use time-nonseparabilities. This observation suggests an analysis of those more general utility functions. Also, the patterns of the test statistics are sometimes difficult to understand. A detailed study of the performance of the test statistics used here in a panel data context is desirable. Finally, the measurement error issue has to be addressed. However, the problem is that one needs instruments such as the ones in this paper to obtain estimates that are sufficiently precise. To investigate measurement error in this context by means of a Monte Carlo experiment, one therefore needs to simulate general equilibrium models with heterogeneity that generate large cross-sections of these variables, such as unemployment rates. Such a Monte Carlo experiment may prove to be prohibitively expensive in terms of computer time.

9 Appendix: Data Selection

This appendix describes the data selection procedure for the Panel Study of Income Dynamics (PSID) data used in the empirical analysis. I use data from the PSID for the years 1974 to 1987. The data is taken from the 1987 respondent and non-respondent files of the PSID and includes all data on families headed by a male, including single males. Observations on individuals in the poverty subsample are included in the sample if they fulfil the selection criteria.

Two central issues are the construction of the leisure and consumption variables. The consumption variable used is household consumption, and the leisure variable is the leisure of the houshold head. This variable is computed using a question that asks for the number of hours worked. Leisure time in a given year is then computed by specifying a total time endowment of 5840 hours minus the hours of work reported for that year. The impact of this assumption is investigated by using alternative assumptions for the time endowment. Regarding the consumption variable, the PSID allows only the construction of a measure of food consumption. I therefore follow the existing literature by using food consumption as the consumption measure. To alleviate the problems caused by the mismatch between household consumption and household head leisure on the one hand, and the mismatch between theory (for individual agents) and data (at least some data cannot be reduced below household level) on the other hand, I include a function of family size in the Euler equation. All consumption measures in the PSID are in nominal terms. They are converted to real terms by deflating by the food consumption price index, which is obtained from the Economic Report of the President.

The measure of consumption is constructed by aggregating i) money spent on food in restaurants; ii) money spent on food in the home which is not purchased with food stamps; and iii) the monetary value of food obtained through food stamps. The expenditure information on food in and outside the house in interview year t+1 is interpreted as referring to year t. Other authors have assumed that expenditure on food consumed in the home and restaurants in year t is a weighted average of the responses from interview year t+1 and interview year t, usually with the respective weights being .75 and .25. It must be noted that this construction of the consumption measure interprets the relevant PSID questions as referring to a flow variable, as opposed to a stock at a point in time. The reason that different studies have not treated this information in a consistent way is that the questions asked are not without ambiguity (See Altug and Miller (1990), Hall and Mishkin (1982), Mankiw and Zeldes (1991), Runkle (1991) and Zeldes (1989) on this issue). Stock and T-bill returns are constructed to match the construction of the consumption series.

For each Euler equation, results are reported for three different samples. A first sample is the same regardless of the Euler equation under investigation and includes all observations for which the following data selection criteria are satisfied:

- the household head has to be between 25 and 60 years of age.
- yearly hours worked by the household head have to be between 100 and 4160.
- total real food consumption in 1987 dollars has to be less than $12,000 per person and more than $720 per person and total real family food consumption has to be less than $30,000.
- there can be no missing data on the demographic information used in the estimation exercises. The different demographic variables used as regressors are: age of the head, age of the head squared, family size in period t, family size in period t-1, dummies indicating whether the head is married or not in periods t and t-1, and the race of the head. Also, the educational achievement of the household head is used as a selection criterion because it is used in the construction of the instrument set. It must be noted that some estimation exercises using these demographics are not reported in the paper.

This first sample has 18813 observations. For all Euler equations under investigation, estimation and test results are reported for two other samples, which are meant to include only households with strictly positive holdings of the riskless and risky assets. The samples are created by including only households who state that they have nonzero holdings of both assets, or holdings larger than $1,000. To select these households, a series of 1984 questions from the PSID are used. These questions essentially ask households whether they have positive holdings of a relatively riskless and/or a risky asset at that time. Specifically, for the riskless asset the questions (questions # V10917 through # V10921) ask:

- "Do you (or anyone else in your family living there) have any money in checking or savings accounts, money market funds, certificates of deposit, government savings bonds, or Treasury bills, including IRA's?"
- if affirmative answer to i)
- "If you added up all such accounts for all of your family living there, about how much would they amount to right now?"
- iii) if no answer to ii)
- "Would it amount to $10,000 or more?" and dependent on this answer
- "$1,000 or more?" or "$100,000 or more?"

  For the risky asset, questions # V10912 through # V10916 are:
- "Do you (or anyone in your family living there) have any shares of stock in publicly held corporations, mutual funds, or investment trusts, including stocks in IRAs?"

- if affirmative answer to i)
- "If you sold all that and paid off everything you owed on it, how much would you have?"
- if no answer to ii)
- "Would it amount to $10,000 or more?" and dependent on this answer
- "$1,000 or more?" or "$100,000 or more?"

The main purpose of using these questions is a comparison of estimation and test results between the sample that exclusively includes asset market participants and the sample that also includes households at corner solutions. The analysis of the sample that only include households with holdings of both assets larger than $1,000 is interesting from two perspectives. First, this sample is less likely to contain classification errors (households at corner solutions), and therefore it is interesting to compare it to the sample that also includes households at corner solutions. Also, a comparison of estimation and test results between the different samples with positive asset holdings can indicate whether they have different characteristics. It must be noted that the questions listed above also allow construction of a sample of households with holdings of both assets larger than $10,000 and $100,000. However, these samples are not used in the analysis because they do not yield robust estimation results.

It must also be noted that the selection criterion used in this paper is potentially problematic. The most important problem is that for every year that a household is included in the sample, it is classified as an assetholder or a non-assetholder on the basis of this 1984 question. This may obviously give rise to misclassifications. Also, a potential problem with the interpretation of the results is that the difference between the second and the first sample for the analysis of a given Euler equation is not necessarily totally made up by households who are non-assetholders in 1984. A household may simply not be present in the sample in 1984, yet be an assetholder in every other year. For a more detailed discussion of the 1984 PSID question see Mankiw and Zeldes (1991).

References

[1] Abel, Andrew B., 1990, Asset prices under habit formation and catching up with the Joneses, *American Economic Review Papers and Proceedings* 80, 38-42.

[2] Altonji, Joseph G., 1986, Intertemporal substitution in labor supply: evidence from micro data, *Journal of Political Economy* 94, S176-S215.

[3] Altonji, Joseph G. and Aloysius Siow, 1987, Testing the response of consumption to income changes with (noisy) panel data, *Quarterly Journal of Economics 102*, 293-328.

[4] Altug, Sumru and Robert A. Miller, 1990, Household choices in equilibrium, *Econometrica* 58, 543-570.

[5] Altug, Sumru and Robert A. Miller, 1998, The effect of work experience on female wages and labour supply, *Review of Economic Studies* 65, 45-85.

[6] Attanasio, Orazio P. and Guglielmo Weber, 1995, Is consumption growth consistent with intertemporal optimization? Evidence from the consumer expenditure survey, *Journal of Political Economy* 103, 1121-1157.

[7] Attanasio, O. and S. Davis (1997). "Relative Wage Movements and the Distribution of Consumption," *Journal of Political Economy* 104, 1227-1262.

[8] Attanasio, Orazio P., James Banks and Sarah Tanner, 1998, Asset Holding and Consumption Volatility, NBER working paper 6567.

[9] Backus, David K., Patrick J. Kehoe and Finn E. Kydland, International real business cycles, *Journal of Political Economy* 100, 745-775.

[10] Balduzzi, Pierluigi and Tong Yao, 2000, Does heterogeneity matter for asset pricing?, working paper, Boston College.

[11] Basak, Suleyman, 1999, On the fluctuations in consumption and market returns in the presence of labor and human capital: an equilibrium analysis, *Journal of Economic Dynamics and Control* 23, 1029-1064.

[12] Bodie, Zvi, Robert C. Merton and William F. Samuelson, 1992, Labor supply flexibility and portfolio choice in a life cycle model, *Journal of Economic Dynamics and Control* 16, 427-449.

[13] Brav, Alon, George M. Constantinides and Christopher C. Geczy, 1999, Asset Pricing with Heterogeneous Consumers and Limited Participation: Empirical Evidence, working paper, University of Chicago.

[14] Breeden, Douglas T., 1979, An intertemporal asset pricing model with stochastic consumption and investing opportunities, *Journal of Financial Economics* 7, 265-296.

[15] Breeden, Douglas T., Michael Gibbons and Robert Litzenberger, 1989, Empirical tests of the consumption-based CAPM, *Journal of Finance* 44, 231-262.

[16] Browning, Martin and Annamaria Lusardi, 1996, Household saving: micro theories and micro facts, *Journal of Economic Literature* 34, 1797-1855.

[17] Browning, Martin and Costas Meghir, 1991, The effects of male and female labor supply on commodity demands, *Econometrica* 59, 925-951.

[18] Campbell, John Y. and John Cochrane, 1995, By force of habit: A consumption-based explanation of aggregate stock market behaviour, NBER working paper no. 4995, National Bureau of Economic Research, Cambridge, MA.

[19] Campbell, John Y., Andrew W. Lo, and A. Craig MacKinlay (1997), "The Econometrics of Financial Markets," Princeton University Press.

[20] Christiano, Lawrence J. and Martin Eichenbaum, 1992, Current real business cycle theories and aggregate labor-market fluctuations, *American Economic Review* 82, 430-450.

[21] Cochrane, John, 1991, A simple test of consumption insurance, *Journal of Political Economy* 99, 957-976.

[22] Cochrane, John and Lars Peter Hansen, 1992, Asset pricing lessons for macroeconomics, in O. Blanchard and S. Fischer, eds.: 1992 NBER Macroeconomics Annual (National Bureau of Economic Research, Cambridge, MA).

[23] Cogley, Timothy, 1999, Idiosyncratic Risk and the Equity Premium: Evidence from the Consumer Expenditure Survey, working paper, Arizona State University.

[24] Constantinides, George M., 1990, Habit formation: A resolution of the equity premium puzzle, *Journal of Political Economy* 98, 519-543.

[25] Constantinides, George M., and Darrell Duffie, 1996, Asset pricing with heterogeneous consumers, *Journal of Political Economy* 104, 219-240.

[26] Deaton, Angus S., 1992, Understanding consumption (Oxford University Press, New York, NY).

[27] Detemple, Jerome, 1996, Intertemporal asset pricing with incomplete markets and non-traded assets, working paper, McGill University.

[28] Detemple, Jerome and Fernando Zapatero, 1991, Asset prices in an exchange economy with habit formation, *Econometrica* 59, 1633-1657.

[29] Eichenbaum, Martin, Lars Peter Hansen, and Kenneth Singleton, 1988, A time series analysis of representative agent models of consumption and leisure choice under uncertainty, *Quarterly Journal of Economics* 103, 51-78.

[30] Epstein, Larry G. and Stanley E. Zin, 1991, Substitution, risk aversion, and the temporal behavior of asset returns: an empirical analysis, *Journal of Political Economy* 99, 263-287.

[31] Fama, Eugene, 1991, Efficient capital markets: II, *Journal of Finance* 46, 1575-1618.

[32] Ferson, Wayne E. and George M. Constantinides, 1991, Habit persistence and durability in aggregate consumption: empirical tests, *Journal of Financial Economics* 29, 199-240.

[33] Grossman, Sanford J., Melino, Angelo and Robert J. Shiller, 1987, Estimating the continuous-time consumption-based asset pricing model, *Journal of Business and Economics Statistics* 5, 315-327.

[34] Hall, Robert E., 1988, Intertemporal substitution in consumption, *Journal of Political Economy* 96, 339-357.

[35] Hall, Robert E., and Frederic S. Mishkin, 1982, The sensitivity of consumption to transitory income: Estimates from panel data on households, *Econometrica* 50, 461-482.

[36] Hansen, Gary, 1985, Indivisible labor and the business cycle, *Journal of Monetary Economics* 16, 309-327.

[37] Hansen, Lars Peter, 1982, Large sample properties of generalized method of moments estimators, *Econometrica* 50, 1029-1054.

[38] Hansen, Lars Peter and Ravi Jagannathan, 1991, Implications of security market data for models of dynamic economies, *Journal of Political Economy* 99, 225-262.

[39] Hansen, Lars Peter and Ravi Jagannathan, 1997, Assessing specification errors in stochastic discount factor models, *Journal of Finance* 52, 557-590.

[40] Hansen, Lars Peter and Kenneth Singleton, 1982, Generalized instrumental variables estimation of nonlinear rational expectations models, *Econometrica* 50, 1269-1286.

[41] Hansen, Lars Peter and Kenneth Singleton, 1983, Stochastic consumption, risk aversion and the temporal behavior of asset returns, *Journal of Political Economy* 91, 249-265.

[42] Hansen, Lars Peter and Kenneth Singleton, 1984, Errata, *Econometrica* 52, 267-268.

[43] Hansen, Lars Peter and James J. Heckman, 1996, The Empirical Foundations of Calibration, *Journal of Economic Perspectives* 10, 87-104.

[44] Hayashi, Fumio, Joseph Altonji and Laurence Kotlikoff, 1994, Risk sharing across and within families, *Econometrica* 64, 261-294.

[45] Heaton, John, 1993, The interaction between time-nonseparable preferences and time aggregation, *Econometrica* 61, 353-385.

[46] Heaton, John, 1995, An empirical investigation of asset pricing with temporally dependent preference specifications, *Econometrica* 63, 681-717.

[47] Heaton, John and Deborah Lucas, 1996, Evaluating the effects of incomplete markets for risk sharing and asset pricing, *Journal of Political Economy* 104, 443-487.

[48] Heckman, James J., 1974, Life-cycle consumption and labor supply: an explanation of the relationship between income and consumption over the life-cycle, *American Economic Review, 188-194.*

[49] Hotz, V. Joseph, Finn E. Kydland and Guilherme L. Sedlacek, 1988, Intertemporal preferences and labor supply, *Econometrica* 56, 335-360.

[50] Jacobs, Kris, 1999, Incomplete markets and security prices: do asset-pricing puzzles result from aggregation problems?, *Journal of Finance* 54, 123-164.

[51] Jagannathan, Ravi and Zhenyu Wang, 1996, The conditional CAPM and the cross-section of expected returns, *Journal of Finance* 51, 3-53

[52] Keane, Michael P. and David E. Runkle, 1992, On the estimation of panel data models with serial correlation when instruments are not strictly exogenous, *Journal of Business and Economic Statistics* 10, 1-9.

[53] Kydland, Finn and Edward Prescott, 1982, Time-to-build and aggregate fluctuations, *Econometrica* 50, 1345-1370.

[54] Kydland, Finn and Edward Prescott, 1996, The Computational Experiment: An Econometric Tool, *Journal of Economic Perspectives* 10, 69-85.

[55] Lucas, Robert, 1978, Asset prices in an exchange economy, *Econometrica* 46, 1429-1445.

[56] Mace, Barbara, 1991, Full insurance in the presence of aggregate uncertainty, *Journal of Political Economy* 99, 928-956.

[57] Mankiw, N. Gregory and Stephen P. Zeldes, 1991, The consumption of stockholders and nonstockholders, *Journal of Financial Economics* 29, 113-135.

[58] Mankiw, N. Gregory, Julio Rotemberg and Lawrence Summers, 1985, Intertemporal substitution in macroeconomics, *Quarterly Journal of Economics* 100, 225-252.

[59] Mayers, David, 1972, Non-marketable assets and capital market equilibrium under uncertainty, in: M. Jensen, ed.: Studies in the Theory of Capital Markets (Praeger, New York, NY), 223-248.

[60] Mayers, David, 1973, Nonmarketable assets and the determination of capital asset prices in the absence of a riskless asset, *Journal of Business* 46, 258-276.

[61] Mehra, Rajnish and Edward C. Prescott, 1985, The equity premium: A puzzle, *Journal of Monetary Economics* 15, 145-161.

[62] Ross, Steven, 1976, The arbitrage theory of capital asset pricing, *Journal of Economic Theory* 13, 341-360.

[63] Runkle, David E., 1991, Liquidity constraints and the permanent-income hypothesis: Evidence from panel data, *Journal of Monetary Economics* 27, 73-98.

[64] Sims, Christopher A., 1996, Macroeconomics and Methodology, *Journal of Economic Perspectives* 10, 105-120.

[65] Sundaresan, Suresh, 1989, Intertemporally dependent preferences and the volatility of consumption and wealth, *Review of Financial Studies* 2, 73-88

[66] Svensson, Lars and Ingrid Werner, 1993, Nontraded assets in incomplete markets, *European Economic Review* 37, 1149-1168.

[67] Telmer, Chris I., 1993, Asset pricing puzzles and incomplete markets, *Journal of Finance* 48, 1803-1832.

[68] Vissing-Jorgensen, Annette, 1999, Limited Stock Market Participation and the Equity Premium Puzzle, working paper, University of Chicago.

[69] Zeldes, Stephen P., 1989, Consumption and liquidity constraints, *Journal of Political Economy* 97, 305-346

Table 1A

Estimation and test results for the nonlinear Euler equation associated with the riskless asset.

Estimation and test results obtained by GMM estimation of the Euler equation

$$1=\beta\left(\frac{c_{i,t+1}}{c_{i,t}}\right)^{\psi-1}\left(\frac{l_{i,t+1}}{l_{i,t}}\right)^{\kappa}\left(\frac{1}{q_t}\right)\exp[\pi_1\, fam_{i,t+1}+\pi_2\, fam_{i,t}]+e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, q_t is the (normalized) price of the riskless asset in period t, $fam_{i,t}$ is the size of household i in period t and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
β	0.790	0.828	0.869
(Standard Error)	(0.098)	(0.084)	(0.057)
$\psi-1$	-0.437	-1.731	-1.645
(Standard Error)	(0.421)	(0.420)	(0.374)
κ	4.245	-1.267	-1.436
(Standard Error)	(1.045)	(0.670)	(0.735)
π_1	-0.011	0.050	0.038
(Standard Error)	(0.022)	(0.034)	(0.022)
π_2	0.013	-0.038	-0.035
(Standard Error)	(0.018)	(0.027)	(0.019)
Number of instruments	9	9	9
Degrees of Freedom	4	4	4
J statistic	3.091	13.235	6.768
(Significance Level)	(0.542)	(0.010)	(0.148)
Implied γ	0.117	0.360	0.309
Implied ϑ	4.808	-1.980	-2.081
H	3555	740	413
N	18813	5029	2990

Table 1B

Estimation and test results for the nonlinear Euler equation associated with the risky asset.

Estimation and test results obtained by GMM estimation of the Euler equation

$$1=\beta\left(\frac{c_{i,t+1}}{c_{i,t}}\right)^{\psi-1}\left(\frac{l_{i,t+1}}{l_{i,t}}\right)^{\kappa}\left(\frac{p_{t+1}+d_{t+1}}{p_t}\right)\exp[\pi_1 fam_{i,t+1}+\pi_2 fam_{i,t}]+e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, p_t is the price of the risky asset in period t, d_t is the dividend of the risky asset in period t , $fam_{i,t}$ is the size of household i in period t and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
β	0.404	0.555	0.720
(Standard Error)	(0.068)	(0.191)	(0.225)
$\psi-1$	-1.253	-2.749	-2.193
(Standard Error)	(0.707)	(0.767)	(1.103)
κ	6.445	-1.815	-2.085
(Standard Error)	(0.667)	(1.213)	(1.085)
π_1	0.013	0.010	0.054
(Standard Error)	(0.008)	(0.069)	(0.049)
π_2	0.019	-0.059	-0.045
(Standard Error)	(0.006)	(0.053)	(0.035)
Number of instruments	9	9	9
Degrees of Freedom	4	4	4
J statistic	2.456	9.664	13.228
(Significance Level)	(0.652)	(0.046)	(0.010)
Implied γ	-0.040	0.490	0.363
Implied ϑ	6.192	-3.564	-3.278
H	3555	740	413
N	18813	5029	2990

Table 2A

Estimation and test results for the linearized Euler equation associated with the riskless asset.

Estimation and test results obtained by GMM estimation of

$$\Delta \ln(c_{i,t+1}) = \omega_1 + \omega_2 \ln(\frac{1}{q_t}) + \omega_3 \Delta \ln(l_{i,t+1}) + \pi_1 fam_{i,t+1} + \pi_2 fam_{i,t} + e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, p_t is the price of the risky asset in period t, d_t is the dividend of the risky asset in period t , $fam_{i,t}$ is the size of household i in period t and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
ω_1	0.035	0.032	0.038
(Standard Error)	(0.012)	(0.010)	(0.018)
ω_2	0.148	0.224	0.178
(Standard Error)	(0.212)	(0.193)	(0.209)
ω_3	-0.877	-1.659	-1.722
(Standard Error)	(0.549)	(0.426)	(0.885)
π_1	0.018	0.010	0.011
(Standard Error)	(0.005)	(0.006)	(0.012)
π_2	-0.027	-0.017	-0.020
(Standard Error)	(0.005)	(0.007)	(0.011)
Number of instruments	9	9	9
Degrees of Freedom	4	4	4
J statistic	43.187	53.327	16.724
(Significance Level)	(0.000)	(0.000)	(0.002)
Implied ψ	-5.756	-3.464	-4.617
Implied κ	-5.925	-7.406	-9.674
Implied γ	0.492	0.318	0.323
Implied ϑ	-11.682	-10.870	-14.292
H	3555	740	413
N	18813	5029	2990

Table 2B

Estimation and test results for the linearized Euler equation associated with the risky asset.

Estimation and test results obtained by GMM estimation of

$$\Delta \ln(c_{i,t+1}) = \omega_1 + \omega_2 \ln(\frac{p_{t+1} + d_{t+1}}{p_t}) + \omega_3 \Delta \ln(l_{i,t+1}) + \pi_1 fam_{i,t+1} + \pi_2 fam_{i,t} + e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, p_t is the price of the risky asset in period t, d_t is the dividend of the risky asset in period t , $fam_{i,t}$ is the size of household i in period t and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
ω_1	0.032	0.033	0.039
(Standard Error)	(0.011)	(0.010)	(0.017)
ω_2	0.071	0.059	0.036
(Standard Error)	(0.061)	(0.059)	(0.076)
ω_3	-1.052	-1.797	-1.795
(Standard Error)	(0.446)	(0.470)	(0.847)
π_1	0.018	0.010	0.011
(Standard Error)	(0.005)	(0.006)	(0.012)
π_2	-0.028	-0.017	-0.020
(Standard Error)	(0.005)	(0.007)	(0.011)
Number of instruments	9	9	9
Degrees of Freedom	4	4	4
J statistic	481.434	41.537	16.375
(Significance Level)	(0.000)	(0.000)	(0.002)
Implied ψ	-13.084	-15.949	-26.777
Implied κ	-14.816	-30.457	-49.861
Implied γ	0.468	0.343	0.349
Implied ϑ	-27.901	-46.406	-76.638
H	3555	740	413
N	18813	5029	2990

Table 3A

Estimation and test results for the nonlinear Euler equation associated with the riskless asset.

Estimation and test results obtained by GMM estimation of the Euler equation

$$1 = \beta\left(\frac{c_{i,t+1}}{c_{i,t}}\right)^{\psi-1}\left(\frac{l_{i,t+1}}{l_{i,t}}\right)^{\kappa}\left(\frac{1}{q_t}\right)\exp[\pi_1 fam_{i,t+1} + \pi_2 fam_{i,t} + \sigma demo_{i,t+1}] + e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, q_t is the (normalized) price of the riskless asset in period t, $fam_{i,t}$ is the size of household i in period t, $demo_{i,t+1}$ consists of age and age squared of the household head, and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
β	0.895	0.953	1.014
(Standard Error)	(0.141)	(0.095)	(0.119)
$\psi - 1$	-0.376	-1.163	-0.942
(Standard Error)	(0.371)	(0.233)	(0.339)
κ	3.984	-0.202	-0.362
(Standard Error)	(1.085)	(1.201)	(1.533)
π_1	-0.010	0.021	0.009
(Standard Error)	(0.021)	(0.018)	(0.017)
π_2	0.013	-0.014	-0.008
(Standard Error)	(0.017)	(0.015)	(0.018)
σ_1	-0.005	0.0003	-0.001
(Standard Error)	(0.010)	(0.0040)	(0.005)
σ_2	0.0006	-0.00003	-0.067
(Standard Error)	(0.0013)	(0.00006)	(0.785)
Number of instruments	11	11	11
Degrees of Freedom	4	4	4
J statistic	5.521	10.049	27.387
(Significance Level)	(0.237)	(0.039)	(0.000)
Implied γ	0.135	0.039	-0.190
Implied ϑ	4.608	-4.179	-0.304
H	3555	740	413
N	18813	5029	2990

Table 3B

Estimation and test results for the nonlinear Euler equation associated with the risky asset.

Estimation and test results obtained by GMM estimation of the Euler equation

$$1 = \beta\left(\frac{c_{i,t+1}}{c_{i,t}}\right)^{\psi-1}\left(\frac{l_{i,t+1}}{l_{i,t}}\right)^{\kappa}\left(\frac{p_{t+1}+d_{t+1}}{p_t}\right)\exp[\pi_1 fam_{i,t+1} + \pi_2 fam_{i,t} + \sigma demo_{i,t+1}] + e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, p_t is the price of the risky asset in period t, d_t is the dividend of the risky asset in period t , $fam_{i,t}$ is the size of household i in period t, $demo_{i,t+1}$ consists of age and age squared of the household head, and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
β	1.472	0.442	0.758
(Standard Error)	(1.006)	(0.361)	(0.476)
$\psi - 1$	-1.191	-2.540	-1.925
(Standard Error)	(0.734)	(0.946)	(1.315)
κ	6.496	-1.030	-1.471
(Standard Error)	(0.668)	(2.558)	(1.418)
π_1	0.003	0.084	0.034
(Standard Error)	(0.077)	(0.075)	(0.047)
π_2	0.041	-0.051	-0.028
(Standard Error)	(0.054)	(0.055)	(0.039)
σ_1	-0.071	0.021	0.003
(Standard Error)	(0.046)	(0.029)	(0.021)
σ_2	0.090	-0.00029	-0.00007
(Standard Error)	(0.056)	(0.00038)	(0.00020)
Number of instruments	11	11	11
Degrees of Freedom	4	4	4
J statistic	6.133	11.754	16.639
(Significance Level)	(0.189)	(0.019)	(0.002)
Implied γ	-0.030	0.599	0.386
Implied ϑ	6.305	-2.570	-2.396
H	3555	740	413
N	18813	5029	2990

Table 4A

Estimation and test results for the nonlinear Euler equation associated with the riskless asset.

Estimation and test results obtained by GMM estimation of the Euler equation

$$1=\beta\left(\frac{c_{i,t+1}}{c_{i,t}}\right)^{\psi-1}\left(\frac{l_{i,t+1}}{l_{i,t}}\right)^{\kappa}\left(\frac{1}{q_t}\right)\exp[\pi_1 fam_{i,t+1}+\pi_2 fam_{i,t}+\sigma demo_{i,t+1}]+e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, q_t is the (normalized) price of the riskless asset in period t, $fam_{i,t}$ is the size of household i in period t, $demo_{i,t+1}$ consists of education and education squared of the household head, and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
β	0.892	0.430	0.615
(Standard Error)	(0.087)	(0.337)	(0.303)
$\psi-1$	-0.994	-2.342	-1.972
(Standard Error)	(0.560)	(0.813)	(0.548)
κ	0.146	-2.211	-2.225
(Standard Error)	(1.064)	(0.796)	(0.714)
π_1	0.027	0.079	0.053
(Standard Error)	(0.024)	(0.062)	(0.030)
π_2	-0.022	-0.047	-0.046
(Standard Error)	(0.016)	(0.042)	(0.025)
σ_1	0.0018	0.050	0.024
(Standard Error)	(0.0040)	(0.078)	(0.091)
σ_2	0.0007	-0.0012	-0.0004
(Standard Error)	(0.0019)	(0.0026)	(0.0033)
Number of instruments	11	11	11
Degrees of Freedom	4	4	4
J statistic	29.695	0.881	5.809
(Significance Level)	(0.000)	(0.927)	(0.213)
Implied γ	0.039	0.377	0.304
Implied ϑ	0.152	-3.553	-3.197
H	3555	740	413
N	18813	5029	2990

Table 4B

Estimation and test results for the nonlinear Euler equation associated with the risky asset.

Estimation and test results obtained by GMM estimation of the Euler equation

$$1=\beta\left(\frac{c_{i,t+1}}{c_{i,t}}\right)^{\psi-1}\left(\frac{l_{i,t+1}}{l_{i,t}}\right)^{\kappa}\left(\frac{p_{t+1}+d_{t+1}}{p_t}\right)\exp[\pi_1 fam_{i,t+1}+\pi_2 fam_{i,t}+\sigma demo_{i,t+1}]+e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, p_t is the price of the risky asset in period t, d_t is the dividend of the risky asset in period t , $fam_{i,t}$ is the size of household i in period t, , $demo_{i,t+1}$ consists of education and education squared of the household head, and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
β	0.458	1.006	0.567
(Standard Error)	(0.178)	(0.257)	(0.509)
$\psi-1$	-1.228	-3.556	-2.826
(Standard Error)	(0.631)	(0.900)	(1.394)
κ	6.649	-2.777	-2.630
(Standard Error)	(0.737)	(1.416)	(1.359)
π_1	0.012	0.155	0.083
(Standard Error)	(0.077)	(0.101)	(0.076)
π_2	0.020	-0.064	-0.061
(Standard Error)	(0.062)	(0.089)	(0.049)
σ_1	-0.020	0.153	-0.016
(Standard Error)	(0.049)	(0.299)	(0.192)
σ_2	0.005	-0.0043	0.0012
(Standard Error)	(0.023)	(0.0102)	(0.0072)
Number of instruments	11	11	11
Degrees of Freedom	4	4	4
J statistic	1.964	2.543	11.063
(Significance Level)	(0.742)	(0.636)	(0.025)
Implied γ	-0.035	0.479	0.409
Implied ϑ	6.421	-5.333	-4.456
H	3555	740	413
N	18813	5029	2990

Table 5A

Estimation and test results for the linearized Euler equation associated with the riskless asset.

Estimation and test results obtained by GMM estimation of

$$\Delta \ln(c_{i,t+1}) = \omega_1 + \omega_2 \ln(\frac{1}{q_t}) + \omega_3 \Delta \ln(l_{i,t+1}) + \pi_1 fam_{i,t+1} + \pi_2 fam_{i,t} + \sigma demo_{i,t+1} + e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, p_t is the price of the risky asset in period t, d_t is the dividend of the risky asset in period t , $fam_{i,t}$ is the size of household i in period t, $demo_{i,t+1}$ consists of age and age squared of the household head, and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
ω_1	0.091	0.079	0.101
(Standard Error)	(0.038)	(0.073)	(0.115)
ω_2	0.301	0.301	0.243
(Standard Error)	(0.295)	(0.211)	(0.243)
ω_3	0.167	-0.155	-1.020
(Standard Error)	(0.893)	(0.867)	(2.251)
π_1	0.012	0.004	0.003
(Standard Error)	(0.004)	(0.008)	(0.020)
π_2	-0.019	-0.008	-0.009
(Standard Error)	(0.004)	(0.008)	(0.021)
σ_1	-0.0014	-0.001	-0.0019
(Standard Error)	(0.0020)	(0.003)	(0.0054)
σ_2	-0.000008	-0.000012	0.000002
(Standard Error)	(0.000026)	(0.000043)	(0.000068)
Number of instruments	11	11	11
Degrees of Freedom	4	4	4
J statistic	27.339	2.989	3.951
(Significance Level)	(0.000)	(0.559)	(0.412)
Implied ψ	-2.322	-2.322	-3.115
Implied κ	0.544	-0.514	-4.197
Implied γ	1.313	0.818	0.425
Implied ϑ	-1.767	-2.837	-7.312
H	3555	740	413
N	18813	5029	2990

Table 5B

Estimation and test results for the linearized Euler equation associated with the risky asset.

Estimation and test results obtained by GMM estimation of

$$\Delta \ln(c_{i,t+1}) = \omega_1 + \omega_2 \ln(\frac{p_{t+1} + d_{t+1}}{p_t}) + \omega_3 \Delta \ln(l_{i,t+1}) + \pi_1 fam_{i,t+1} + \pi_2 fam_{i,t} + \sigma demo_{i,t+1} + e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, p_t is the price of the risky asset in period t, d_t is the dividend of the risky asset in period t , $fam_{i,t}$ is the size of household i in period t, $demo_{i,t+1}$ consists of age and age squared of the household head, and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
ω_1	0.070	0.063	0.094
(Standard Error)	(0.040)	(0.075)	(0.118)
ω_2	0.088	0.068	0.050
(Standard Error)	(0.068)	(0.061)	(0.072)
ω_3	-0.435	-0.611	-1.503
(Standard Error)	(0.525)	(0.780)	(1.974)
π_1	0.013	0.004	0.006
(Standard Error)	(0.004)	(0.007)	(0.020)
π_2	-0.021	-0.009	-0.013
(Standard Error)	(0.004)	(0.008)	(0.020)
σ_1	-0.0006	-0.00026	-0.0017
(Standard Error)	(0.0022)	(0.0037)	(0.0055)
σ_2	-0.000015	-0.000018	0.0000048
(Standard Error)	(0.000028)	(0.000043)	(0.000066)
Number of instruments	11	11	11
Degrees of Freedom	4	4	4
J statistic	20.212	16.620	30.239
(Significance Level)	(0.000)	(0.000)	(0.000)
Implied ψ	-10.363	-13.705	-19.000
Implied κ	-4.943	-8.905	-30.060
Implied γ	0.677	0.604	0.387
Implied ϑ	-15.306	-22.691	-49.060
H	3555	740	413
N	18813	5029	2990

Table 6A

Estimation and test results for the linearized Euler equation associated with the riskless asset.

Estimation and test results obtained by GMM estimation of

$$\Delta \ln(c_{i,t+1}) = \omega_1 + \omega_2 \ln(\frac{1}{q_t}) + \omega_3 \Delta \ln(l_{i,t+1}) + \pi_1 fam_{i,t+1} + \pi_2 fam_{i,t} + \sigma demo_{i,t+1} + e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, p_t is the price of the risky asset in period t, d_t is the dividend of the risky asset in period t , $fam_{i,t}$ is the size of household i in period t, , $demo_{i,t+1}$ consists of education and education squared of the household head, and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
ω_1	0.001	-0.186	-0.055
(Standard Error)	(0.029)	(0.138)	(0.325)
ω_2	0.045	0.191	0.166
(Standard Error)	(0.187)	(0.198)	(0.230)
ω_3	-1.672	-2.413	-2.484
(Standard Error)	(0.556)	(0.489)	(0.581)
π_1	0.019	0.009	0.014
(Standard Error)	(0.006)	(0.007)	(0.014)
π_2	-0.028	-0.016	-0.023
(Standard Error)	(0.006)	(0.008)	(0.013)
σ_1	0.002	0.029	0.011
(Standard Error)	(0.004)	(0.020)	(0.046)
σ_2	0.00002	-0.0009	-0.0003
(Standard Error)	(0.00016)	(0.0007)	(0.0016)
Number of instruments	11	11	11
Degrees of Freedom	4	4	4
J statistic	29.002	71.707	231.738
(Significance Level)	(0.000)	(0.000)	(0.000)
Implied ψ	-21.222	-4.235	-5.024
Implied κ	-37.155	-12.633	-14.963
Implied γ	0.363	0.251	0.251
Implied ϑ	-58.377	-16.869	-19.987
H	3555	740	413
N	18813	5029	2990

Table 6B

Estimation and test results for the linearized Euler equation associated with the risky asset.

Estimation and test results obtained by GMM estimation of

$$\Delta \ln(c_{i,t+1}) = \omega_1 + \omega_2 \ln(\frac{p_{t+1} + d_{t+1}}{p_t}) + \omega_3 \Delta \ln(l_{i,t+1}) + \pi_1 fam_{i,t+1} + \pi_2 fam_{i,t} + \sigma demo_{i,t+1} + e_{i,t+1}$$

where $c_{i,t}$ is consumption of household i at date t, $l_{i,t}$ is the leisure time of household head i at date t, p_t is the price of the risky asset in period t, d_t is the dividend of the risky asset in period t , $fam_{i,t}$ is the size of household i in period t, $demo_{i,t+1}$ consists of education and education squared of the household head, and $e_{i,t+1}$ is an econometric error term.

	All Households	Asset Holdings > 0	Asset Holdings > 1000
ω_1	-0.001	-0.192	-0.055
(Standard Error)	(0.030)	(0.145)	(0.329)
ω_2	0.062	0.059	0.039
(Standard Error)	(0.057)	(0.063)	(0.089)
ω_3	-1.658	-2.510	-2.530
(Standard Error)	(0.501)	(0.587)	(0.582)
π_1	0.019	0.009	0.014
(Standard Error)	(0.006)	(0.007)	(0.014)
π_2	-0.027	-0.016	-0.023
(Standard Error)	(0.006)	(0.008)	(0.013)
σ_1	0.002	0.030	0.011
(Standard Error)	(0.004)	(0.021)	(0.046)
σ_2	0.000025	-0.00096	-0.00034
(Standard Error)	(0.00016)	(0.00079)	(0.0016)
Number of instruments	11	11	11
Degrees of Freedom	4	4	4
J statistic	32.623	12.393	25.492
(Significance Level)	(0.000)	(0.014)	(0.000)
Implied ψ	-15.129	-15.949	-24.641
Implied κ	-26.741	-42.524	-64.871
Implied γ	0.361	0.272	0.275
Implied ϑ	-41.870	-58.491	-89.512
H	3555	740	413
N	18813	5029	2990

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