NONDURABLES AND SERVICES RESPONSIVENESS
IN A NONLINEAR MODEL:
MORE EVIDENCE OF BINDING BORROWING CONSTRAINTS

by

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ABSTRACT

Recent empirical analyses using the Euler Equation approach have repeatedly rejected the stochastic implications of the Rational Expectations-Life Cycle Hypothesis. Several authors have argued that empirical results using aggregated data are inconclusive because of aggregation bias. Statistical conclusions from panel studies using food expenditure proxies are suspect as well. This study reexamines the stochastic implications of the hypothesis using a broader expenditure definition constructed from the Consumer Expenditure Survey. The study constructs sample orthogonality conditions from the underlying nonlinear Euler equations, and thereby relaxes the linear assumptions applied in previous studies. If the error structure of the model is conditionally heteroscedastic, it is shown that linearizing can produce bias and inconsistent estimation. For this study, hypothesis tests and parameter estimates are attained using the numerical solution of the generalized method of moments minimization problem. The hypothesis-testing methodology is flexible in that it tests the "pure" Rational Expectations Hypothesis against a borrowing constraint hypothesis through a split sample technique. Various test results from this study consistently show that borrowing constraints do affect consumption growth of financially strapped households. These conclusions are not as sharp when using food expenditure data alone, however.

I. INTRODUCTION

In recent years economists have tested numerous propositions concerning intertemporal consumer behavior using cross-sectional and panel data sets. Many of these tests are based on direct estimation of the first-order conditions, or Euler equations, of the consumer's optimization problem. One common practice used to simplify this estimation has been linearization of the Euler equations. This procedure induces two econometric problems that have yet to be addressed. First, the linear approximation of the underlying nonlinearity may be so poor as to substantively distort inferences. The second problem is less obvious, but potentially more harmful. I show in the paper that any conditional heteroscedasticity of the error in the original, nonlinear, Euler equation is transformed by the linearization process into a correlation between the regressors and the error of the resulting linear equation. This induces bias and inconsistency in the least squares and related methods that have been used to estimate the linearized models. I address these two problems by directly estimating the original, nonlinear Euler equation using the numerical solution of the relevant generalized method of moments (GMM) minimization problem.

An additional concern addressed in this paper is the choice of the consumption proxy. Cross-sectional and panel data sets of households provide limited information on consumption, and thereby force researchers to settle on an approximation of actual consumption. The Panel Survey of Income Dynamics (PSID) has been a widely used survey. This annual household survey tracks families over multiple years, collecting a wealth of information including household characteristics, income, and food expenditure data. Because the expenditure section of the PSID is limited to food spending estimates, intertemporal analyses that use these data are forced to assume that the utility function is separable between food consumption and all other consumption items. If the separability assumption is valid, the econometric tests of the intertemporal theory can proceed. To this point, no clear evidence has been given to justify this separability assumption.[1] To shed some light on the validity of food expenditures as a consumption proxy, this study uses data from the Consumer Expenditure Survey (CES) that allows a more comprehensive measure of consumption by including expenditures on nondurables and services. Results using this more comprehensive measurement are compared to the food expenditure proxy estimates. The comparisons presented here are mixed, but in general do not support the argument that food is an appropriate consumption proxy within intertemporal models.

The theory of intertemporal optimization of consumers' lifetime well-being has been the generally accepted explanation of consumers' intertemporal saving and consumption decisions. According to the theory, consumers will determine their current levels of consumption based on expected lifetime wealth, while current income, apart from the new information it brings, is inconsequential. Alternative consumption models such as the Keynesian-myopic model, which sets current consumption equal to a proportion of current income, have been strongly refuted over the years. Still, intertemporal models have been questioned in light of the repeated failures of empirical studies to confirm some of the fundamental liquidity restrictions of the hypothesis. Namely, liquidity variables including past levels of

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[1] The most compelling argument is that of the limitations to human caloric intake reflected by the Engel relationship between food expenditures and income.

income have not been found to be orthogonal to the expectations error of the stochastic Euler equations. Frequently, borrowing constraints are blamed for the orthogonal test failures, particularly in aggregate data studies.

The studies by Zeldes (1989) and Runkle (1991) are of interest here. The two studies, using PSID data, have explicitly tested the intertemporal model under the condition that borrowing constraints may be binding for a subset of the population. Zeldes uses a linearlized versions of the Euler equations and a two-stage least squares estimator, and finds evidence of borrowing constraint behavior. In contrast, Runkle (1991), who also fits PSID data to a linearlized model but uses a GMM estimator, finds no evidence that a fraction of the population is constrained. He explains that the failure of aggregate data studies to confirm the stochastic properties of the intertemporal model is the fault of aggregation bias and not of borrowing constraints. He further contends that micro data studies that have not econometrically accounted for the potential measurement error in consumption data have estimated the wrong covariance matrix, and therefore have made incorrect statistical inferences.

I reexamine the stochastic implications of a nonlinear Rational Expectations-Life Cycle Hypothesis (RE-LCH) model while addressing the econometric concern of serial correlation resulting from measurement error. The econometric tests of the pure RE-LCH are performed by splitting the sample of families in two groups: an unconstrained and a borrowing constrained subsample. Families are sub-setted conditional on their financial health. If the pure RE-LCH is to be accepted, stochastic implications of the hypothesis should hold for each subsample as well as the full sample of families. The nonlinear Euler equation results, while using the comprehensive consumption proxy, concur with Zeldes' findings that a fraction of sampled consumer units are borrowing constrained, and thus the pure RE-LCH can not be unconditionally accepted for the population. The parameter estimates from this study, however, are more sharply estimated then those shown in the Zeldes study. Additionally, the nonlinear fit allows direct estimation of the subjective rate of time preference, which, along with the standard orthogonality tests of the stochastic implications, provide a more convincing argument that binding borrowing constraints are present among a substantial fraction of American consumer units. Here, the higher rates of time preference estimated from the financially strapped units reflect the wedge driven between the intertemporal consumer equilibrium condition. The model is also estimated using the food expenditure proxy and the results compared. Evidence is offered to suggest that the food proxy is a relatively noisy series that prevents sharp parameter estimates and conclusive results from the orthogonality tests.

The paper is organized as follows. The life-cycle model with constraints are discussed in section II, econometric issues are addressed in section III, the data are described in section IV, empirical results are presented in section V, and the paper is concluded in section VI.

II. THE RATIONAL EXPECTATIONS-LIFE CYCLE MODEL

The "pure" RE-LCH describes the intertemporal consumption decisions of agents with multiple period planning horizons. It is "pure" in the sense that all the underlying assumptions of the standard intertemporal model remain valid,[2] including the intrinsic assumption that capital markets which facilitate

[2] King (1983) provides a comprehensive survey of the intertemporal theory.

intertemporal trade are perfectly competitive. If it is not valid to make these strong market assumptions, it is important to examine the stochastic implications of the hypothesis with the perfectly competitive market assumption relaxed.

By splitting the sampled families into two subsamples conditional on the likelihood of facing a binding borrowing constraint, a distinction can be made of whether prior rejections of the pure RE-LCH are caused by the explicit assumption that claim markets are perfectly competitive, when indeed they may not be, or whether other model assumptions—underlying or auxiliary—are the cause for rejection.[3]

Life Cycle Model with Complete Capital Markets:

Assuming that the utility function is time separable, the standard intertemporal optimization problem for each consumer is to maximize:

$$U_{i,t} = E_{i,t}\sum_{t=0}^{T}\beta_i^t U(C_{i,t},\eta_{i,t}) \qquad (1)$$

subject to the sequence of wealth constraints:

$$A_{i,t+k} = (1+r_{i,t+k-1})A_{i,t+k-1} + (Y_{i,t+k} - C_{i,t+k}), \qquad (2)$$

along with the deprivation assumption placed on consumption, and the terminal condition placed on end-of-life assets:[4]

$$C_{i,t+k} \text{ and } A_{i,T} \geq 0, \text{for } k = 0,\ldots,T-t \qquad (3)$$

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3 For instance, Runkle (1991) contends that the auxiliary assumption that preferences are homogeneous is invalid, and therefore have resulted in aggregation bias.

4 The deprivation assumption is implicitly applied if it is assumed that the marginal utility at zero consumption is infinite $\left(MU(0) = \infty\right)$. The constraint on end-of-life assets negates any intergenerational resource allocation. Since this is a period-to-period analysis, this need not be a concern here.

where

E_t = mathematical expectation conditional on $I_{i,t}$,

$I_{i,t}$ = information available to consumer unit *i* at time *t*,

β_i = *i*th consumer unit's discount rate, or $(1/(1+\delta_i))$,

δ_i = *i*th consumer unit's subjective rate of time preference,

T = Expected economic lifetime

$U(\cdot)$ = instantaneous utility function (strictly concave),

$C_{i,t}$ = *i*th consumer unit's consumption in period *t*,

$\eta_{i,t}$ = *i*th consumer unit's specific preference shocks,

$Y_{i,t}$ = *i*th consumer unit's income in period *t*,

$A_{i,t}$ = *i*th consumer unit's nonhuman wealth in period *t*, and

$r_{i,t}$ = *i*th consumer unit's one-period *ex post* real after-tax rate of return.

It is further assumed that the instantaneous utility function is additively separable in consumption and leisure. The preference shock vector appearing in the utility function may contain observed and unobserved factors that shift the instantaneous utility function. Seasonality or changes in the demographic characteristics of the consumer units are examples of factors that can shift the function.

It can be shown that the maximization of (1) subject to (2) gives the following set of standard stochastic first-order conditions:

$$\frac{MU_{i,t+1}}{MU_{i,t}}\beta_i(1+r_{i,t})-1=e_{i,t+1} \qquad (4)$$

where $e_{i,t+1}$ represents the expectational or forecast error with the property $E(e_{i,t+1}|I_t)=0$, and MU is the first derivative of U. The forecast error results from new information received between the periods *t* and *t+1* about labor income, the real after-tax rate of return, and preference shocks.

Life Cycle Model with Incomplete Capital Markets:

Once the perfect competitive market assumption is relaxed, a distinction must be made between Keynesian-myopic behavior and life-cycle behavior under borrowing constraints. Although the two behaviors are theoretically different, observationally each will predict a strong response in consumption resulting from a change in current income.[5] To empirically distinguish the two behaviors, the sample is split between likely and unlikely borrowing constrained families, and the intertemporal model fitted and tested for each subsample. If anything is to be salvaged from the RE-LCH, it should be shown that an identifiable fraction of the population unconditionally obeys the dictates of the intertemporal theory. If this fraction consists entirely of identifiable, nonborrowing constrained consumers, it will in itself provide strong evidence that prior rejections are the result of these constraints and not Keynesian-myopic behavior.

The perfect competitive capital market assumption is relaxed by introducing an exogenous borrowing constraint. Specifically, I assume a quantity constraint in the form:

$$\boldsymbol{A}_{i,t} \geq \boldsymbol{B}_{i,t} \quad (5)$$

where $\boldsymbol{A}_{i,t}$ represents an individual's liquid asset holdings at time *t*, and $\boldsymbol{B}_{i,t}$ is an *a priori* floor set on the level of liquid assets necessary before the borrowing constraint

5 See Zeldes (1989) for discussion about differences between testing hypotheses of the Keynesian model and the life-cycle models with binding borrowing constraints.

binds. It is reasonable to argue that $\boldsymbol{B}_{i,t}$ should be set to zero to trigger the constraint. This would seem particularly true if consumers face rising interest schedules that differentiate borrowing rates from saving rates. Whenever current income falls short of the planned level of consumption, an optimizing consumer will prefer disinvesting all liquid assets and consuming the proceeds before contracting for borrowed funds.[6] However, for the split-sample test it is not imperative to exactly identify when the constraint is triggered. What is necessary is a criterion that will identify *potential* borrowing constrained units so as to purge them from the full sample of families under investigation. Consequently, we can allow $\boldsymbol{B}_{i,t}$ to take on positive values, while identifying borrowing constrained units who, at any particular time in the sampled period, may hold some liquid balances for transactions.

Including the additional exogenous borrowing constraint into the standard intertemporal optimization problem of (1), the following set of augmented stochastic Euler equations can be written:

$$\frac{MU_{i,t+1}\beta_i(1+r_{i,t})}{MU_{i,t}}(1+\lambda_{i,t})-1=e'_{i,t+1}, \tag{6}$$

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[6] Although the constraint is assumed exogenous in this study, an endogenous constraint would seem more appropriate. The exogenous constraint implies that consumers have no power in which to influence lending institutions on how much they can borrow, or at what rate they are charged. In the long-run, this assumption is difficult to justify when many loan approvals are contingent on an individual's credit and earnings history. Perhaps the most appropriate method to enter an endogenous constraint is through a variable rate of interest that is a function of a consumer's debt to asset ratio and loan default history. However, such information is not available from the data source I use. The Survey of Consumer Finance of the Federal Reserve Board is a rich source of data on household debt and assets that provide such information. Unfortunately, the SCF does not collect consumption information. In the short-run, however, consumers have little if any affect on their financial health, and thus the assumption of an exogenous constraint would seem reasonable.

where $\lambda_{i,t}$ represents the lagrangian multiplier associated with the borrowing constraint. This quantity constraint is similar to those imposed by Zeldes (1989), Runkle (1991), and Whited (1992). The multiplier has the standard economic interpretation. If the constraint in period t is binding $(\lambda_{i,t} > 0)$, then its value represents the increase in lifetime utility given a one dollar decrease in the current borrowing constraint.

III. ECONOMETRIC ISSUES

Econometric Specification:

To make the problem tractable, it is necessary to impose a preference specification on equations (4) and (6). It is assumed that preferences can be modeled by the constant relative risk aversion utility function:

$$\frac{C_{i,t}^{1-\alpha}\exp(\eta_{i,t})}{1-\alpha} \qquad (7)$$

where α is the Arrow-Pratt parameter of relative risk aversion assumed equal across the sample.[7] The specification is flexible enough to permit observable and unobservable household-specific preference shift variables to enter the Euler equations through the vector $\eta_{i,t}$.[8] Allowing the subjective rate of time preference to vary across households and incorporating the preference specification into (4) and (6), the standard nonborrowing constrained Euler equations become

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7 The constant relative risk aversion utility function has been widely used in similar studies including those by Mankiw (1981), Hansen and Singleton (1982), Shapiro (1984), Zeldes (1989) and Runkle (1991).

8 In this particular specification, I follow the leads of Hayashi (1985c) and Zeldes (1989).

$$\left(\frac{C_{i,t+1}}{C_{i,t}}\right)^{-\alpha} \beta_i (1+r_{i,t}) \exp(\eta_{i,t+1} - \eta_{i,t}) - 1 = e_{i,t+1}, \qquad (8)$$

and the borrowing constrained Euler equations become

$$\left(\frac{C_{i,t+1}}{C_{i,t}}\right)^{-\alpha} \beta_i (1+r_{i,t}) \exp(\eta_{i,t+1} - \eta_{i,t})(1-\lambda_{i,t}) - 1 = e'_{i,t+1} \qquad (9)$$

The variables of the preference shift vector $\eta_{i,t}$ may include both observable and unobservable variables that can vary across families and time. The observable variables include the age of the reference person[9] ($AGER$) and the size of the family (FS). The unobserved factors include a family component that is fixed across time (FC_i), an aggregate component (AC_t) that is constant across families but varies across time, and a white noise component ($u_{i,t}$) that is orthogonal to the other unobserved factors. $u_{i,t}$ is assumed to have the properties:

$$\begin{aligned} E[u_{i,t}] &= 0 \\ E[u_{i,t}, u_{j,s}] &= \sigma_u^2 \quad \text{if } i = j, t = s \\ &= 0 \quad \text{otherwise.} \end{aligned} \qquad (10)$$

The representation of $u_{i,t}$ is broad. It will capture a shock to the utility function or will reflect white-noise measurement error in the consumption data. At this juncture, the precise cause of this white-noise term—preference shock or measurement error—is inconsequential when addressing the econometric issues of the Euler equations. After collecting these terms, the preference shift vector becomes

[9] The reference person is loosely defined as the head of the household. It is the first person mentioned when asked to "Start with the name of the person or one of the persons who owns or rents the home."

$$\eta_{it} = a_0' AGER + a_1 AGER^2 + b\ FS + FC_i + AC_t + u_{it} \qquad (11)$$

To account for the aggregate component AC_t, quarterly time dummy variables (QTR_t) are included. The most obvious aggregate variation in quarterly data that these time variables will capture is seasonality.[10] Notwithstanding the seasonal correlation, these time variables capture other macroeconomic changes that are unique to each quarter—but constant across the sample—that the real after-tax rate of interest fails to capture. Consequently, the inclusion of these time variables ensure that the expected value of the Euler equations' residual vector has mean zero for the short panel sample. Incorporating this information into (8) and (9), the set of equations to estimate become

$$\left(\frac{C_{i,t+1}}{C_{i,t}}\right)^{-\alpha} \beta\ (1+r_{i,t}) \exp\left(\sum_t d_t QRT_t + a\ AGER_{i,t} + b\ \Delta FS_{i,t} + u_{i,t+1} - u_{i,t}\right) - 1 = e_{i,t+1} \qquad (12)$$

$$\left(\frac{C_{i,t+1}}{C_{i,t}}\right)^{-\alpha} \beta\ (1+r_{i,t})(1+\lambda_{it}) \exp\left(\sum_t d_t QRT_t + a\ AGER_{i,t} + b\ \Delta FS_{i,t} + u_{i,t+1} - u_{i,t}\right) - 1 = e'_{i,t+1} \qquad (13)$$

where ΔFS represents the change in family size.

By taking first differences, note that the potential family fixed time effect component FC_i cancels out. However, the unobserved white noise difference $(u_{i,t+1} - u_{i,t})$ remains within these fitted Euler equations, and if present, produces serially correlated residuals. In addition to this specification, some authors have

10 The CES collects expenditure information from households who are asked to report expenditures for the three-month period preceding the month-of-interview. Since this three-month "collection period" may not coincide with a calendar quarter, applying estimated seasonal factors is not straightforward.

suggested an additional unobserved term that captures *persistent* household-specific effects.[11] A persistent household effect would include, for example, differences in the subjective rate of time preference among sampled households. In this instance, the unobserved persistent term, denote it as ψ_i, enters directly into the Euler equations. Note that ψ_i differs from FC_i in that it enters into the *change* in preferences and not the parent preference vector. As will be discussed later, no evidence of persistent household-specific effects appeared in the samples examined, and thus ψ_i is not considered in the final estimation.

Conditional Heteroscedastic Error in the linearlized Model:

It may be fruitful at this point to compare the nonlinear estimation of (2) with the frequently estimated log linear form. The log linear growth equations are derived by rearranging (12), taking logs on each side of the equations, and approximating log (1+*x*) by a second-order Taylor expansion. This produces the standard log linear consumption growth equation:

$$\ln\left(\frac{C_{t+1}}{C_t}\right) = a_o + \frac{1}{\alpha}\ln(1+r_t) + v_{t+1} \qquad (14)$$

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[11] See Runkle for the econometric issues involved when persistent household effects are present.

where

$$a_0 = \tfrac{1}{\alpha}(\ln\beta + \tfrac{1}{2}\sigma_e^2),$$
$$v_{t+1} = \tfrac{1}{\alpha}(\tfrac{1}{2}e_{t+1}^2 - \tfrac{1}{2}\sigma_e^2 - e_{t+1}),$$
$$E(e_{t+1}|I_t) = 0,$$
$$\sigma_e^2 = E(e_{t+1}^2).$$

Note that the log linear Euler equation's residual $v_{i,t+1}$ becomes $\tfrac{1}{\alpha}\left(\tfrac{1}{2}e_{t+1}^2 - \tfrac{1}{2}\sigma_{e;i}^2 - e_{t+1}\right)$, where $\sigma_{e;i}^2$ is the variance of the expectational error indexed for individual i.[12] Conditional heteroscedasticity will emerge if $\sigma_{e;i}^2 \neq \sigma_{e;j}^2$, when $i \neq j$. Hence, linearizing the model forces the identification assumption that instrumental variables are uncorrelated with this heteroscedastic variance term residing within the residual.

How valid is this identification assumption? It is easy to argue that the level of uncertainty about consumption growth rises as the level of household wealth declines. For instance, less wealthy families who lack financial security are more uncertain about their futures than more wealthy families, and consequently we would expect the error variance to increase with the decline in wealth. Other economic and demographic variables may also play a part in the heteroscedastic variance. Families headed by younger, less established persons may indeed be more uncertain about their future than established families headed by middle aged persons, and consequently the error variance may decline as households mature. Certainly income will be correlated with the heteroscedastic variance term. Families with higher incomes will have more budgetary discretion with respect to consumption and saving decision which will result in larger error variance for higher

12 The individual indexing is dropped from the other terms to reduce notational clutter.

income families. With these seemingly obvious correlations, it is difficult to justify that the conditional heteroscedastic variance term of the expectations error is uncorrelated with time t variables. In the presence of the conditional heteroscedastic variance, the parameter estimates of the linearlized models will be both biased and inconsistent. To avoid this pitfall, I abandon linear approximations, and estimate the set of nonlinear Euler equations using a GMM criterion function.

Econometric Procedure and Tests:

To estimate the nonlinear Euler equations, I use the GMM technique introduced and described in Hansen (1982) and Hansen and Singleton (1982), where the optimal weighting matrix of the GMM minimization problem follows Newey and West (1987). In short, the GMM estimator constructs sample orthogonality conditions implied by the rational expectations hypothesis: $E\left[\left(e_{i,t+1}\right)\left(x_{i,t}\right)\right] = 0$ where x_{it} is a vector of instrumental variables. These variables are a subset of the variables contained within the consumer's information set at period t (I_t). The GMM estimates of the parameters -α and β along with parameters of the preference shift vector are those that numerically minimize the weighted sum of squares: $\left[\left(e_{i,t+1}\right)\left(x_{i,t}\right)\right]' W_{it} \left[\left(e_{i,t+1}\right)\left(x_{i,t}\right)\right]$ where W_{it} is an optimally chosen weighting matrix computed from the covariance matrix of $\left[\left(e_{i,t+1}\right)\left(x_{i,t}\right)\right]$.[13]

13 Gallant (1987) provides a *SAS* illustration of the procedure.

Econometric Tests:

The orthogonality tests performed here are twofold. First, I test the pure RE-LCH for the full sample as well as for each subsample by fitting the Euler equations of (12) and (13). Second, a more traditional and direct test for binding borrowing constraints is conducted by determining the statistical significance of the change in lagged income in each of the samples. Each test is described below.

Test of the Pure RE-LCH:

To accept the pure RE-LCH, the overidentifying restrictions must hold unconditionally for any subsample drawn from the population. The fitting of the Euler equations of (12) to the full sample and each split subsample should produce similar parameter estimates and the model restrictions placed on the data should be satisfied. The fitting of the two subsamples, conditional on liquidity holdings, distinguishes whether a rejection of the hypothesis is the fault of borrowing constraints or by other model assumptions. If the model assumptions remain intact along with the auxiliary assumptions for the unconstrained subsample but the perfectly competitive financial market assumption is invalid for the borrowing constrained subsample, we would expect economically plausible parameter estimates and an overall acceptance of the model restrictions for the former, while rejecting for the latter. In contrast, a rejection of the hypothesis for *any* subsample drawn would suggest Keynesian-myopic behavior, and the intertemporal theory of consumption behavior would be unconditionally refuted. There are two steps in the hypothesis test. First, the rational-expectations model is fit to data from the subsample of financially healthy families—the unconstrained group. If the model is accepted for this subsample, then it is reasonable to apply the same auxiliary model assumptions to any defined sample of the population including the subsample of borrowing constrained units, and perform the hypothesis tests. A rejection of the model for the borrowing constrained subsample provides strong evidence that binding constraints are present and affect intertemporal choice.

Test of the Borrowing Constraint Hypothesis:

If borrowing constraints are binding, the correctly specified Euler equations include the positive lagrangian multiplier $\lambda_{i,t}$ associated with the constraint as presented in (13). Although the CES data do not permit explicit modeling of $\lambda_{i,t}$, the data do allow an indirect test for the presence of the positive $\lambda_{i,t}$. If the borrowing constraint is binding, $\lambda_{i,t}$ is strictly positive and negatively correlated with household financial variables dated in period *t*. It follows then that the composite residual term in $e'_{i,t+1}$ (13) will be correlated with lagged financial variables if the constraint binds. It is straightforward to use the orthogonality test between the Euler residuals and the instrumental variables that include household financial, or liquidity, information. That is, any liquidity variable dated in period *t* or earlier that relaxes the consumer unit's borrowing constraint will in turn not be orthogonal to the multiplier λ residing within the composite error term. Consequently, liquidity variables that place additional restrictions on the sample data will not be statistically validated if a borrowing constraint is binding.

IV. DATA DESCRIPTION AND SAMPLE SPLITTING CRITRIA

The data are drawn from the quarterly Interview portion of the 1990-91 CES.[14] The Interview survey collects data from detailed expenditure questions on approximately 60 to 70 percent of total household expenditures and the remaining expenditures are collected using global type questions. Because these data are collected over a three-month period instead of the 12 month PSID method, measurement error resulting from recall is comparatively low.[15] The Interview survey also collects household characteristic, income, and asset and liability information. Unlike the three-month expenditure collection method, however, income data collection requires recall of the prior 12 month period. These questions are detailed and exhaustive in that they collect all sources of income, whether they are received on a regular basis, such as wages and salaries, or an irregular basis, such as proceeds from sale of assets or lottery winnings.

Most data on asset and liabilities are collected in the last interview. The majority of these questions target the account balances as of the prior month of the interview, while some alternative questions collect changes in these account balances over the prior year. Although the asset and liability questions are detailed, they are not collected frequently enough over the interview period to provide data for quality panel data analysis of asset-holding behavior.[16] The lack of asset and

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[14] For a complete description of the Consumer Expenditure Survey, see “BLS Handbook of Methods,” Chapter 18.

[15] PSID data attained annual estimates by extrapolating from a weekly average food expenditure estimate. Hence, any recall error is magnified.

[16] An additional shortfall is that unrealized capital gains are not collected nor are values of assets that were acquired before the 12 month period preceding the interview. One

liability information tracked over the complete four quarters represents the greatest shortfall of the CES data for life-cycle analyses. For this study, asset levels are solely used as a measure to select families for split-sample analysis. There is a caveat. Because these questions determine asset levels in the last of the four quarters of interview, using these data will risk violating the orthogonality conditions implied by the rational expectations hypothesis. For consistent parameter estimates, I assume that the asset levels of the unconstrained group are relatively stable over the interviewed periods, and known by the consumer unit for that period. This assumption allows me to use these data to split the sample.

Sample Selection:

The Interview portion of the CES provides as many as four quarterly interviews per participating consumer unit. Two waves of families are selected for this study. The first eligible wave consists of families who participated in their first quarterly interview in the first calendar quarter of 1990, and completed their fourth and final quarterly interview in the last quarter of 1990. The second wave experienced their first quarterly interview in the second calendar quarter of 1990 and their last interview in the first quarter of 1991. Placing these two waves together cover the consumption periods from last quarter 1989 through last quarter 1990. Families are selected for analysis if they participated in four complete quarterly interviews during this time frame.

Additional restrictions are also applied. Excluded are families headed by individuals under the age of 25, as well as units who did not provide complete

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exception are the values of real-estate properties. Respondents are asked to approximate that value each property would sell for on “today’s market.”

reports of their incomes. The under 25 age group are excluded since these consumer units are characterized by sporadic reporting of income and expenditures. The sporadic reporting in part may be explained by parental support for these young households. The exclusion of incomplete income reporters is self-evident. If the goal is to test the sensitivity of consumption to changes in income, a full measure of consumer unit income is necessary.[17]

This initial selection provides a sample of 1,518 unique families. To reduce the effect of expenditure and income reporting error, an additional 226 units who had consumer unit members self-employed are excluded.[18] I conjecture here that the line between consumption and business expenses becomes more blurred for the self-employed, and thus reducing the accuracy of expenditure reports. Four additional units are deleted in the sample because of nonpositive expenditures.[19] This left a full sample size of 1,288 unique families, each providing three quarterly expenditure growth records.

Sample Splitting Criteria:

In order to perform the split-sample tests, the full sample of 1,288 families must be subdivided into the unconstrained and the borrowing constrained groups.

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17 Incomplete reporting of income is determined by criteria set by the Bureau of Labor Statistics when processing income data. An example of an incomplete income reporter is one who reports receiving wage or salary income but who does not report the income amounts. Currently, BLS does not make any income imputations on missing data.

18 A consumer unit is identified as self-employed if any of its members received self-employed income during the interview period.

19 Because medical expenditures are measured as net out-of-pocket costs, a consumer unit may have zero, or negative expenditures because medical expense reimbursements exceed all other expenditures.

To split the samples, I use the ratio of liquid assets to normal income. This criterion is chosen because it closely characterizes borrowing constrained units described within the life-cycle hypothesis. Liquid assets are defined as the sum of checking and savings account balances, U.S. government savings bonds, and the estimated market value of marketable securities.[20] I define normal income as that part of income that is received on a regular basis. This includes wage and salary, interest and rent, pension, unemployment compensation and other such income sources. If a consumer unit has liquid assets equal to two months worth of annual income, the consumer unit is selected for the unconstrained subsample. In the empirical analysis, I allow minimal asset holdings to ensure that only those consumers who are selected for the nonborrowing constrained group are indeed unconstrained. This follows since some consumers, constrained or not, hold some liquid assets to make efficient day-to-day transactions. By this criterion, there are 430 families in the unconstrained group and 850 families in the constrained group.[21]

Proxy for Consumption:

The preferred consumption argument within the Euler equation would contain expenditures on nondurables and services, as well as the service flow received from the stock of durables. Although the CES provides expenditure reports on practically

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20 Marketable securities include stocks, non-government bonds, mutual funds and other such securities. This liquidity information is collected at the last interview. The respondents are asked to give accounts and market values as of the last day of the previous month of interview.

21 This suggest that as much as two-thirds the sample is constrained. This sample proportion of two-thirds constrained is close to what Zeldes finds in his PSID sample. Although the sample proportions are only suggestive, they are in large disagreement with the proportional estimates of 20 percent found by Hall and Mishkin (1982).

all consumer items, it does not provide the array of information necessary to compute service flow values received from the stock of durables. Here it is assumed that durable consumption is separable, within the utility function specified in (1), from nondurables and services.[22] In this paper, comparisons are made using a comprehensive measure that includes nondurables and services and one that captures total food and beverage expenditures. Results from these two different proxies are used to gauge the effectiveness of the food proxy, that has been used in many micro studies, to mirror changes in total consumption. A complete description of the consumption proxy variables and other variables of the estimation are provided in the data appendix.

Instrumental Variables of the Sample Orthogonality Conditions:

The GMM criterion function of the rational expectations model requires a vector of instrumental variables. These variables should be carefully selected so as to capture a subset of the CU's information set that it uses to predict consumption. Liquidity variables, such as income, will be among the list of valid instrumental variables if and only if consumer units are unconstrained from optimally borrowing. To test liquidity responsiveness, two sets of estimates are performed using two alternative instrumental variables lists. The first list—call it the *standard instrumental variables list*—includes non-liquidity variables. These variables include the number of weeks worked and hours per week worked for the reference person and spouse, the age of the reference person and spouse, the number of persons in the consumer unit, the change in the number of persons in the consumer

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22 This follows the lead of Hall (1978), Mankiw (1981), Flavin (1985) and others.

unit, quarterly time dummies, and real after-tax rate of returns lagged one, two and three periods.[23] The employment status data and the family composition data are lagged one period to avoid violating the implied orthogonality conditions. These variables are relatively well measured and are similar to the set used in both the Zeldes and Runkle studies. Note that because the *ex post* rate of return is not known when forecasts are made, it may be correlated with the forecast error. Hence, lagged values of this variable are used as a substitute in the instrumental variables list. Recall that I am using the *ex post* real after-tax rate of return, and thus the real market rate of return must be adjusted by family-varying marginal tax rates. Because these marginal tax rates are not provided from the data source, they have been computed from information on income and household composition characteristics. See the data appendix for a description of this computation.

To test the significance of liquidity variables, I augment this standard instrumental variables list by the change in lagged income.[24] Call this list the *augmented instrumental variable list*. Income measured here is from all sources—normal and transitory.[25] For this study, transitory income includes lottery winnings, income from sale of assets, tax refunds and alike. I call these transitory because they are irregularly received income components. This comprehensive measure is used to capture any liquidity effects that may relax a binding borrowing

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23 Because the reference person is not necessarily the head of the household, it is important to use information about the spouse when using CES data.

24 This follows Flavin's (1985) liquidity constraint test where she used unemployment within her aggregate data study as well as the orthogonal tests of Hall (1978) and those who followed.

25 As a BLS employee, I have been provided the non-censored data. Because of confidentiality restrictions, the public-use micro data are censured, or what BLS calls topcoped. The topcoding rules apply to some expenditures and all income data.

constraint. There is one caveat to the income measurement. Income for a participating consumer unit is measured twice: once at the first quarterly interview and again at the fourth quarterly interview. At both of these interviews, the respondent is asked about all sources of income received for the 12 month period preceding the interview. Because there is this partial overlap in income and expenditure collection, the orthogonality condition can not be strictly guaranteed here. That is, income received over the recent months of interview could contain new information about lifetime wealth that induces a change in the level of consumption. However, I regard any new information embedded in income to be known at the beginning of the collection period. This strong assumption permits the construction of the sample orthogonality conditions to proceed. Based on the orthogonal tests from the unconstrained sample, I find no evidence to invalidate this assumption.

V. EMPIRICAL RESULTS

We know from Section *III* that the presence of either unobserved preference shift shocks or measurement error can produce serially correlated errors. Presented in Table 1 are the autocorrelations of residuals $\hat{e}_{i,t}$ computed from the Euler equations fitted to the full sample. Here the only statistically significant autocorrelation is the first autocorrelation, which in turn supports the earlier assumption that the Euler equations' errors follow an MA(1) process.[26] Additionally, this MA(1) process supports the assumption that persistent household-specific effects are not present within these data. If persistent effects are present

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[26] The autocorrelations were computed from the unconstrained subsample, and the MA(1) process was accepted for this sample as well.

but not captured by the model, the serial correlation of the residuals would extend across several periods, and not completely dampen after just one. With this finding, the weighting matrix W_{it} of the GMM criterion function is constructed with an MA(1) error process.

Tables 2 through 4 present the GMM results from the full sample as well as the unconstrained and borrowing constrained subsamples. In these tables, the GMM results are shown for the two consumption proxies considered: nondurables and services (CNDS), and food and beverages (CFD). For each of these proxies, GMM estimates are computed from the standard and the augmented (liquidity) instrumental variables lists. Each column contains the chi-square test statistic, and beneath these test statistics, the corresponding *p*-value is shown.[27] It is this test statistic which is used to judge the acceptability of the overidentifying restrictions of the model.

Model Fit for the Pure RE-LCH:

To test the pure RE-LCH conditional on the liquid asset holdings, equation (12) is fitted to the unconstrained subsample using CNDS. Although this is a conditional test of the hypothesis, I use this subsample first to confirm the auxiliary and underlying assumptions of the rational expectations model. Given this model is accepted, I can apply the same model to sample data where binding constraints are suspected. I show the unconstrained GMM results for the CNDS proxy in the first column of Table 3. The model results from the standard instrumental variables list are accepted based on both the satisfaction of the overidentifying restrictions and the plausibility of the parameter estimates. With the chi square of 3.4, the

[27] The *p*-value is the computed probability that a X^2_{df} random variable is greater than the computed test statistic under the hypothesis that the overidentifying restrictions hold.

overidentifying restrictions are accepted at the 1, 5 and 10 percent levels of significance. Moreover, the preference parameter β is estimated at 0.9807 which implies a subjective rate of time preference of just under 2 percent. Based on the average annual return for three-month T-bills in 1990, the real rate of return equaled just over 2 percent. Confidence is placed in this estimate if it is reasonably within the neighborhood of the real rate of return. The preference parameter $-\alpha$ is estimated at -0.1741, which translates to an Arrow-Pratt estimate of 0.17. This estimate is close to but less than the parameter estimate found by Hansen and Singleton (1982), and its value implies the standard risk aversion and concavity of the utility function. I compare this with the results from Hansen and Singleton since they too fit a similar nonlinear model. The Arrow-Pratt parameter estimates of this study are lower than the range of estimates shown in the Zeldes and Runkle studies.[28] Both of these preference parameters of this study are statistically significant.

With an accepted model with which to work, I proceed to test the pure RE-LCH unconditional on the sample selected. I do this by fitting the full sample of families to the Euler equations of (12) with CNDS as the proxy. The GMM results are shown in Table 2. For the standard instrumental variables list, the overidentifying restrictions are clearly rejected for this sample, although the preference parameter estimates remain plausible. The subjective rate of time preference is approximately 2.7 percent which is a slightly higher rate of time preference than the strictly unconstrained sample. If the model rejection is brought about by a subsample who are constrained, this higher rate of time preference is

[28] The Arrow-Pratt parameter estimate ranged from -0.7 to 2.7 in the Zeldes study and 1.4 to 4.4 in the Runkle study.

expected.[29] The parameter -α is estimated with the appropriate negative sign, but the degree of risk aversion is slightly less than that found in the unconstrained sample, 0.1421 compared to 0.1741. Both preference parameter estimates are again found statistically significant.

By rejecting the pure RE-LCH for the full sample, I focus on the cause of the rejection by fitting the borrowing constrained sample to the same model. These results are presented in Table 4 and show that the overidentifying restrictions are overwhelmingly rejected by the reported chi-square of 75.3. For this fit, the preference parameter estimates are clearly implausible for the pure RE-LCH. Here, -α is estimated with the wrong sign which suggests that the utility function is not concave. However, this parameter estimate is found statistically insignificant.[30] As a comparison, the parameter estimates in both the Zeldes and Runkle studies are statistically insignificant for this group as well. The estimate for β is statistically significant, but the subjective rate of time preference is the highest among the three estimates—just under 4 percent. This rate is substantially above the average annual market rate of return during this period, but it is not unexpected when binding constraints are present.[31] The higher rate of time preference reflects the

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[29] For instance, if consumers are constrained today, then the constraint forces a wedge between today's and tomorrow's level of marginal utility. Hence, an optimizing, but constrained, life-cycle saver will discount future consumption more substantially.

[30] For the model fit of the borrowing constrained group (selected by the ratio "total wealth to income"), Zeldes finds similar results. His Arrow-Pratt estimate is -0.68, though statistically insignificant.

[31] Varying rates of time preference are examined by Lawrance (1991) and Moehrle (1994). Lawrance finds higher rates of time preference when she classifies a selected PSID sample by income percentiles. Lower income families have higher rates of time preference than higher income families. Her results are interesting in that she finds no evidence of borrowing constraints among the low income even though they exhibit significantly higher rates of time preference. Moehrle finds varying rates of time preference across age groups, and this variation in rates is substantially greater for low liquidity wealth families.

wedge forced between the standard intertemporal consumer equilibrium when a binding borrowing constraint is present. Because this time preference rate is not available from the linearized models of Zeldes and Runkle, no comparisons can be made with these earlier panel studies. Nevertheless, the higher rate is consistent with what would emerge in a borrowing constrained environment.

Results Using the Food Consumption Proxy

The rejection of the model for the full and borrowing constrained sample strongly supports the alternative hypothesis of borrowing constrained behavior. But before proceeding, it would be convenient at this point to compare these results using CNDS with those from CFD. The comparison provides a tool to judge the reliability of prior micro data studies using food expenditures as the consumption proxy. The testing procedure follows the same steps as before, and the GMM results from the standard instrumental variables list are shown in the third columns of the same tables.

The conclusions run parallel to the CNDS results: the overidentifying restrictions are accepted for the unconstrained while rejected for the full and borrowing constrained samples. The preference parameters are not as sharply estimated, however. Except for the borrowing constrained sample, the preference parameter estimates are smaller than those from the CNDS fits. The summary statistics of these data do reveal that the sample variance is much larger for CFD than CNDS, and this may contribute to the looser fit.[32] Table 5 shows the sample statistics for both these proxies across the three samples examined. Notice that for

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[32] This may also help to explain why there are large differences among the parameter estimates in both the Zeldes and Runkle studies. See footnote 28 for the range of estimates presented in each.

each sample the standard error is larger for the CFD variable than it is for CNDS. These larger standard errors are also accompanied by larger mean growth rates, particularly for the borrowing constrained group. This higher variability in the food sample data may reflect either the survey-respondent-recall error that is associated with global questions, or a greater sensitivity of food expenditure growth to current income changes. The latter suggestion obviously weakens the life-cycle theory. These issues are addressed later in this section.

Tests for the Presence of Borrowing Constraints:

The previous test results using either nondurables and services or food consumption data suggest that binding borrowing constraints are present among some families and therefore influence consumption growth. Thus for constrained families, the multiplier appearing in (13) is positive and reflects the increase in lifetime utility if the borrowing constraint is relaxed by a one dollar unit. With the presence of this positive multiplier within the rational expectations model, a straightforward empirical test for binding borrowing constraints is enabled. If the constraint is binding, any time period *t* financial variable that relaxes the constraint will in turn be correlated with the multiplier, and correspondingly with the composite residual in which the multiplier resides. Hence, a more direct test for binding borrowing constraints is a test of whether the change in last period's income serves as a valid instrumental variable for the fit of the nonlinear model. If constraints are binding, changes in lagged income will influence consumption growth by its direct affect on lagged consumption. For a constrained consumer unit, any increase in income will be immediately and fully used for consumption.[33] If

[33] Any lagged liquidity variable that relaxes the constraint is likely to be correlated with the lagrangian multiplier $\lambda_{i,t}$ and thereby correlated with the composite residual. For the liquidity variables available from the CES, changes in lagged income is the only variable best measured for this test.

binding constraints are present, this additional liquidity restriction placed on the sample data will be outright rejected. The results of this test using the augmented variable list are shown in the second columns of tables 2 through 4. This additional model restriction which was "excluded" from the standard instrumental variable list is shown in the table row titled "Chi Square: Exclusion restriction." For the CNDS fits, the liquidity restriction is satisfied for the unconstrained sample, while it is clearly rejected for the full and borrowing constrained samples. These results are consistent with what are found using the standard instrumental variables list, and further confirm borrowing constraints as the cause of the model rejections for the full and borrowing constrained samples.

The liquidity restriction test is also performed on the consumption proxy, CFD. With the previous results in hand, the CFD results suggest that food expenditures are not an appropriate proxy for consumption. The exclusion restrictions are not satisfied for the full or unconstrained sample, but are oddly satisfied for the borrowing constrained sample. Although this is completely in opposition of what would be expected with borrowing constrained behavior, it is not surprising given the consumption proxy used. I offer two explanations for this contradicting result.

First, food expenditures reveal a much greater variability in the sample data than do the composite expenditures, nondurables and services. Looking at table 5, the sample mean growth in food expenditures was just under 16 percent (1.159 growth rate) with a standard error of 2.24. In comparison, the growth for nondurables and services was much less, at 7 percent (1.072 growth rate), and the standard error , 0.39, was substantially lower. Certainly the relatively large growth rate of food spending alone is bothersome, but coupled with the size of its standard error casts this as a questionable series within an intertemporal model. It is then an understatement to say that reported food expenditures are a noisy series, and it would appear that most of this noise is attributed to measurement error.

The cause of the measurement error is by no means elusive. Recall from the previous section that the majority of expenditure reports from the CES are collected from detailed expense questions, while food expenditures are collected from global questions.[34] By the simple nature of global questions, survey respondents will be less accurate in their responses about actual food spending than they will about expenditures collected from detailed questions. Global questions ask respondents to estimate their usual expenses over a specified period of time, while detailed questions ask respondents to recall specific expense items and the period in which they were made. Because the latter does not require estimation on the part of the respondent, the quality of the data from detailed-question responses are much higher.

This large period-to-period variation in observed food expenditure reports is not unique to the CES. Runkle noted large variation in PSID food expenditures which led him to smooth his data by selecting only those families who had estimated expenditure growth that did not exceed 300 percent or declines of more than 75 percent. Even after this smoothing, however, Runkle estimated that as much as 76 percent of the variation in PSID food spending growth resulted from measurement error. It also should be noted that with the food expenditure data, any small reporting error is magnified since these data are collected as weekly estimates in both the CES and PSID, and then multiplied to either obtain quarterly or annual

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[34] The global questions for food expenditures begin by asking respondents " ... what has been your usual weekly expense at the grocery store or supermarket." Additional questions are asked to determine the food amounts for the weekly expense estimates. See the data appendix.

estimates. In light of the contradicting results between Zeldes and Runkle and the results presented here using CFD, the extremely noisy nature of household survey food expenditures appear to substantially cloud the borrowing constraint hypothesis tests of intertemporal models.

As a second explanation for the contradicting borrowing constraint results, Hall (1978) concluded that intertemporal maximizing consumers may not optimally react to market signals instantaneously, but rather may delay the full adjustment when receiving the new information about lifetime wealth. This adjustment delay may come about from difficulties experienced by some consumer units to interpret the economic news. If we accept this hypothesis, it then follows that the more uncertain consumers are about market signals, the more likely their observed behavior will appear myopic. Hence, Hall's hypothesis coupled with the contradicting results between CNDS and CFD implies that the changes in some components of total consumption may not be solely determined by new information received about permanent income but by current income levels. Eating out at restaurants may be an example of one of these components. Putting aside the high variability in food expenditures for the moment, changes in expenditures on food away from home, an easily adjusted and high income elastic expenditure, may more closely track the changes in current income than permanent income.[35] If consumers become less certain of their future prospects, they may quickly adjust these types of expenditures to hedge against an unpredicted and large fall in liquidity and consumption. Hence, there may be a strong precautionary savings motive by leery consumers. If this scenario is true, then the RE-LCH can be best described as loosely explaining consumption behavior. Given the high variability of food

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[35] Published reports from the Consumer Expenditure Survey of BLS do show that the variation in food away from home expenditures classified by income level is much more volatile than food at home expenditures.

expenditures, however, the empirical findings here that show food expenditures excessively sensitive to changes in lagged income is more suggestive than evidence against the model.

VI. SUMMARY

This paper contributes to the voluminous amount of theoretical and empirical thought that has gone into the study of intertemporal consumption choice. To say the least, there has been an evolution of analysis in regard to modeling and testing the fundamental stochastic assumptions of the theory reaching back to Hall's (1978) seminal paper. Results from many studies have been contradictory, however. Some have found little or no statistical evidence to reject the "pure" hypothesis, while others have found little support for it. Many who have found evidence to reject the hypothesis have identified either borrowing constraints or aggregation bias as the cause. For instance, to avoid aggregation bias and thereby focus on borrowing constraints, Zeldes (1989) and Runkle (1991)—among others—have used micro data sets within linear models to test the implications of the hypothesis. This study has taken this approach, but has directly estimated the original nonlinear Euler equation using a GMM estimator. The direct nonlinear estimation avoids estimating from a bias and inconsistent estimator that emerges when the error is characterized as conditionally heteroscedastic. Examples are given in the paper to strongly suggest that the variance of a family's forecast error will be related to variables frequently used as regressors in linearized models. This conditional variance is then shown to appear in the linearized model's residual which will thereby induce the bias and inconsistency of parameter estimates.

Comparative evidence from two alternative consumption proxies is also offered to show that food expenditures are less than suitable in an intertemporal model. Standard liquidity restriction tests presented in this paper show that the food expenditure proxy produces economically inconsistent results. The difficulty with the food series is not necessarily its inability to mirror total consumption movements but the relative noisiness of the series. This conclusion seems particularly viable when compared with results derived from the more comprehensive nondurables and service consumption proxy. The relative noisiness of food expenditure data appear to result from the method in which the survey household data are collected. As a survey remedy for the poor Interview food estimates, the Bureau of Labor Statistics does conduct a Diary expenditure survey which specifically targets food expenditures and other small frequently purchased items. However, the sample respondents from the Diary survey are not tracked over multiple periods, and therefore these data are not aptly usable in this analysis.

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DATA APPENDIX

Variable Descriptions

Variables	Descriptions
CFD	Food and beverage consumption including food at home, food away from, alcoholic and nonalcoholic beverages: These data are collected using global questions such as "Since the first of the month, three months ago, what has been your usual weekly expense at the grocery store or supermarket." Because grocery and supermarket expenses will also include nonfood items, estimates are given by the respondents for the nonfood items as well.
CNDS	Nondurable and service consumption: Definitions are matched as close to NIPA as possible. CES nondurable expenditures used are as follows: food and alcoholic beverages, nondurable apparel expenditures (excluding jewelry and alike), gasoline and other fuels, tobacco, drug preparations and sundries, and stationary and writing supplies.
	The following lists some exceptions in matching the CES with NIPA. Toilet articles and preparations are not shown separately in CES, but some expenditures will appear in personal care products. Cleaning and polishing are void in the Interview survey. Nondurable toys and sport equipment are not separated in the CES and therefore not used. Stationary and writing supplies are not all inclusive in the CES; for

instance postage stamps are not collected. Net Foreign remittances are not applicable. Other expenditures of NIPA are also not applicable.

Service expenditures include housing rental equivalence, housing rental expenditures, other lodging expenditures, utilities and services, domestic services and household operations, transportation (including vehicle finance charges, maintenance, repairs, insurance, rents and leases, and public transportation), medical care, personal care, personal business, recreation, education, and contributions.

r The *ex post* real after-tax rate of return: Because of differences in marginal tax rates, $r_{i,t}$ varies across time and households. $r_{i,t}$ will vary across households because of differences in marginal tax rates. To measure the real after-tax rate of return, I deflate the nominal rate of return on the riskless asset, the 3-month T-Bill, by the change in the Consumer Price Index. This real rate of return is then adjusted by individual marginal tax rates (τ_{it}) to derive a cross-sectional and time varying rate of return. τ_{it} is the summation of estimated federal, state and local marginal tax rates. The estimated marginal federal tax rates are provided by taxable adjusted gross income (AGI) from the *U.S. Treasury, Internal Revenue Service.* These marginal tax rates account for filing status, number of exemptions, and average allowable deductions. To carry out the rate computations, AGI's are computed for each consumer unit. I compute AGI based on household composition, income level, and taxable deductions. The *IRS* produces tables of average taxable deductions by income levels, and these data are used to estimate household tax deductions. The state and local marginal tax rates are also based on AGI. These rates are gathered from the tables provided in the *U.S. Statistical Abstracts* published by the *Department of Commerce.* The real rate of return can be stated as:

$$r_{i,t} = \frac{(1+R_t)(1-\tau_{it})P_t}{P_{t+1}}$$

where R_t is the risk free nominal rate of interest, P_t is a measure of the price level at time *t*, and τ_{it} is the estimated marginal tax rate. The calendar quarter average of the general CPI-U measures price levels (*P*) in each quarter.

QRT Time variables assigned to the quarters to capture macroeconomic shocks, particularly seasonality present in quarterly expenditure data.

AGER Age of the reference person: Reference person is the first member mentioned by respondent when asked to “Start with the name of the person or one of the persons who owns or rents the home.” It is with respect to this person that the relationship of other consumer unit members are determined.

ΔFS Change in the number of members in the consumer unit measured from the previous quarter.

DY Change in total income (liquidity variable): Total 12 months of income measured from the prior month of the last interview less total 12 months of income measured from the prior month of the first interview. Total income includes income received on a regular and irregular bases. Regular received income includes wages and salary, pensions and social security payments, interest, rents, royalties, trusts, and supplemental insurance income and other pubic assistance. Irregular income includes tax refunds from federal, state, and local governments, receipt from sale of personal or real properties, lottery winnings, and lumpsum payments from alimony, child support, trusts, and royalties. Lagged income values are adjusted by the general Consume Price Index.

Table 1: Autocorrelations of residuals $\hat{e}_{i,t}$

Variable	*Estimate*	*Standard error*	*t-statistic*
Constant	0.000134	0.00769	0.1736
$\hat{e}_{i,t-1}$	-0.350430	0.02764	-12.67732
$\hat{e}_{i,t-2}$	-0.004279	0.027565	-0.155236

Table II: GMM estimates for full sample
(3,684 observations on 1,288 unique consumer units)
Fit for Euler equations (4.5) and (4.6), 1990 Data

Consumption definition:	*nondurables & services*		*food & beverages*	
	standard instrumental variable list	*augmented instrumental variable list*	*standard instrumental variable list*	*augmented instrument variable list*
-*a*	-0.1421*	-0.0883***	-0.0743	-0.0575**
Starting value = -0.50	(0.0822)	(0.0315)	(0.0675)	(0.0231)
b	0.9734***	0.9714***	0.9657***	0.9667***
Starting value = 0.97	(0.0039)	(0.0019)	(0.0041)	(0.0020)
Age of reference person (*a*)	-0.0002***	-0.0002***	-0.0002***	-0.0002***
Starting value = 0.00	(4.3E-5)	(2.5E-5)	(3.4E-5)	(2.6E-5)
Change in family size (*b*)	0.0031	0.0014	-0.0039	0.0028
Starting value = 0.00	(0.0035)	(0.0018)	(0.0049)	(0.0021)
Time dummy 1 (d_1)	-0.0145*	-0.0096***	0.0024	0.0018
Starting value = 0.00	(0.0077)	(0.0030)	(0.0035)	(0.0018)
Time dummy 2 (d_2)	-0.0118***	-0.0107***	-0.0035	-0.0048**
Starting value = 0.00	(0.0022)	(0.0011)	(0.0058)	(0.0023)
Time dummy 3 (d_3)	0.0043**	0.0037***	0.0017	0.0009
Starting value = 0.00	(0.0021)	(0.0013)	(0.0033)	(0.0016)
Chi Square:				
Overidentifying restrictions	52.9119	133.1580	70.6541	117.1110
Degrees of freedom	7	8	7	8
Probability value	5.4E-9	6.3E-25	1.5E-9	1.3E-21
Liquidity variable:	None	DY	None	DY
Chi Square:				
Exclusion restriction	-	80.2461	-	46.4569
Degrees of freedom	-	1	-	1
Probability value	-	1.5E-9	-	1.5E-9
Concave utility function?	Yes	Yes	Yes	Yes

Standard errors are in parentheses under coefficients. * indicates significance at the 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. All significance levels are computed for values from zero except *b* which is computed from 1.

Table III: GMM estimates for nonborrowing constrained sample
(1,314 observations on 438 unique consumer units)
Fit for Euler equations (4.5) and (4.6), 1990 data

Consumption definition:	*nondurables & services*		*food & beverages*	
	standard instrumental variable list	*augmented instrumental variable list*	*standard instrumental variable list*	*augmented instrument variable list*
-*a*	-0.1741*	-0.1407**	-0.1220	-0.0742**
Starting value = -0.50	(0.0967)	(0.0619)	(0.0938)	(0.0339)
b	0.9807***	0.9791***	0.9658***	0.9697***
Starting value = 0.97	(0.0070)	(0.0050)	(0.0102)	(0.0042)
Age of reference person (*a*)	-0.0003***	-0.0003***	-0.0003***	-0.0003***
Starting value = 0.00	(0.0001)	(7.4E-5)	(9.3E-5)	(4.4E-5)
Change in family size (*b*)	0.0094	0.0080	0.0192	0.0114
Starting value = 0.00	(0.0102)	(0.0074)	(0.0169)	(0.0066)
Time dummy 1 (d_1)	-0.0201*	-0.0161**	0.0058	-0.0024
Starting value = 0.00	(0.0117)	(0.0076)	(0.0087)	(0.0036)
Time dummy 2 (d_2)	-0.0035	-0.0042	0.0128	-0.0043
Starting value = 0.00	(0.0052)	(0.0038)	(0.0175)	(0.0068)
Time dummy 3 (d_3)	0.0064	0.0060**	0.0008	0.0042**
Starting value = 0.00	(0.0051)	(0.0038)	(0.0083)	(0.0034)
Chi Square:				
Overidentifying restrictions	3.3885	7.1896	9.51033	38.7150
Degrees of freedom	7	8	7	8
Probability value	0.8469	0.5163	0.2181	5.5E-6
Liquidity variable:	None	DY	None	DY
Chi Square:				
Exclusion restriction	-	3.8011	-	29.2047
Degrees of freedom	-	1	-	1
Probability value	-	0.0514	-	6.5E-8
Concave utility function?	Yes	Yes	Yes	Yes

Standard errors are in parentheses under coefficients. * indicates significance at the 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. All significance levels are computed for values from zero except *b* which is computed from 1.

Table IV: GMM estimates for borrowing constrained sample
(2,550 observations on 850 unique consumer units)
Fit for Euler equations (4.5) and (4.6), 1990 data

Consumption definition:	*nondurables & services*		*food & beverages*	
	standard instrumental variable list	*augmented instrumental variable list*	*standard instrumental variable list*	*augmented instrument variable list*
-*a*	0.0840	-0.0280*	-0.0760	-0.0722**
Starting value = -0.50	(0.0798)	(0.0168)	(0.0657)	(0.0368)
b	0.9620***	0.9702***	0.9661***	0.9662***
Starting value = 0.97	(0.0052)	(0.0011)	(0.0036)	(0.0011)
Age of reference person (*a*)	-0.0002***	-0.0003***	-0.0002***	-0.0002***
Starting value = 0.00	(3.6E-5)	(1.0E-5)	(5.0E-5)	(5.0E-5)
Change in family size (*b*)	-0.0031	0.0005	0.0020	0.0020
Starting value = 0.00	(0.0027)	(0.0007)	(0.0032)	(0.0025)
Time dummy 1 (d_1)	0.0046	-0.0050***	0.0015	0.0014
Starting value = 0.00	(0.0065)	(0.0015)	(0.0031)	(0.0028)
Time dummy 2 (d_2)	-0.0052	-0.0105***	-0.0078***	-0.0079***
Starting value = 0.00	(0.0039)	(0.0009)	(0.0027)	(0.0023)
Time dummy 3 (d_3)	0.0023	0.0027***	2.3E-5	-6.6E-5
Starting value = 0.00	(0.0016)	(0.0005)	(0.0026)	(0.0023)
Chi Square:				
Overidentifying restrictions	75.2655	405.8230	36.7756	36.5673
Degrees of freedom	7	8	7	8
Probability value	1.5E-9	1.1E-82	5.2E-6	1.4E-5
Liquidity variable:	None	DY	None	DY
Chi Square:				
Exclusion restriction	-	330.5575	-	0.2083
Degrees of freedom	-	1	-	1
Probability value	-	1.5E-9	-	0.6547
Concave utility function?	No	Yes	Yes	Yes

Standard errors are in parentheses under coefficients. * indicates significance at the 10 percent level, ** indicates significance at the 5 percent level, and *** indicates significance at the 1 percent level. All significance levels are computed for values from zero except *b* which is computed from 1.

Table 5. Summary Statistics for Consumption Proxy, by Sample

	Full Sample		*Unconstrained Sample*		*Borrowing Constrained Sample*	
Variable	Mean	Standard error	Mean	Standard error	Mean	Standard error
CFD	1.1593	2.2446	1.1244	0.6970	1.1772	2.7174
CNDS	1.0722	0.3913	1.0979	0.4378	1.0589	0.3643