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THE EFFECT OF LIQUIDITY CONSTRAINTS ON CONSUMPTION: A CROSS-SECTIONAL ANALYSIS

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ABSTRACT

This paper examines the effect of liquidity constraints on consumption expenditures using a single-time cross-section data set. A reduced-form equation for consumption is estimated on high-saving households by the Tobit procedure to account for the selectivity bias. Since high-saving households are not likely to be liquidity constrained, the estimated equation is an appropriate description of how desired consumption dictated by the life cycle-permanent income hypothesis is related to the variables available in the cross-section data. When the reduced-form equation is used to predict desired consumption, the gap between desired consumption and measured consumption is most evident for young households.

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1. Introduction

The basic postulate of the life cycle-permanent income hypothesis is that households behave as if they maximize a dynamic utility function subject only to the lifetime budget constraint without being constrained by imperfect capital markets. This postulate, if true, casts serious doubts on the effectiveness of macroeconomic stabilization policies such as temporary tax cuts. If, on the other hand, households are subject to borrowing constraints (or, to use James Tobin's terminology, liquidity constrained), short-run stabilization policies will have some influence on aggregate demand.[1]

Because of the forward-looking nature of the life cycle-permanent income hypothesis, convincing empirical testing of the postulate is impossible unless the hypothesis is coupled with a sensible assumption about how expectations are formed. Recently, Hall(1978), Sargent(1978), Flavin(1981), and Hayashi(forthcoming) have tested the life cycle-permanent income hypothesis on U.S. aggregate time-series data under the assumption that expectations are rational. Their test results are mixed, mainly because of the low power of time-series tests.

Subsequently, Hall and Mishkin(1982) turned to panel data to find that food consumption is more sensitive to current disposable income than is predicted by the hypothesis. This work is followed by Bernanke(1981) who examined expenditure on automobiles using a different data set. He found no evidence against the life cycle-permanent income-rational expectations hypothesis.

The basic testing strategy common to the above-mentioned work is to look at the relationship between current disposable income and changes in consumption. The life cycle-permanent income-rational expectations hypothesis predicts no correlation between the two; a statistically significant correlation implies that households are liquidity constrained. It would be highly desirable to extend this analysis to total consumption (as opposed to food consumption or durable goods expenditure), but unfortunately no panel data exist in this country for total consumption for more than one period. Cross-section data on total consumption do exist in this country, but one needs a different line of approach to test the hypothesis on such data.

A natural approach would be to derive two consumption functions -- one from the life cycle-permanent income hypothesis (i.e., the household's intertemporal optimization _without_ borrowing constraints) and the other from the alternative hypothesis of liquidity constraints (i.e., intertemporal optimization _with_ borrowing constraints) -- and see which consumption function fits the data better. There are at least two problems with this approach. First, we have the familiar problem that we, as econometricians, cannot observe the household's expectations about future income, so that any variable that helps predict future income can show up in the consumption function, which makes it very difficult to distinguish one consumption function from the other. Second, neither the life cycle-permanent income hypothesis nor the alternative hypothesis of liquidity constraints delivers an explicit formulation of the level of consumption. Even under the assumption that the dynamic utility function is time-separable with constant degree of relative risk aversion, no closed-form solution for optimal consumption rule has been derived when future labor income is stochastic. Moreover, the life cycle-permanent income hypothesis is not very specific about how the family structure should be incorporated in the consumption function. The problem becomes even less tractable if the additional constraint of imperfect capital markets is imposed. For example, work by Levhari, Mirman, and Zilcha(1980) shows that the optimal consumption rule under uncertainty with borrowing constraints is quite complicated.

This paper is an attempt to evaluate the quantitative importance of liquidity constraints using a single-time cross-section data set compiled by the Board of Governors of the Federal Reserve System in the early 1960s. The basic idea is to select by some *a priori* criterion a subset of households in the sample which are not likely to be liquidity constrained. Consumption by such households must largely be the result of intertemporal optimization without borrowing constraints. A very general reduced-form equation for consumption is estimated for such households by the Tobit procedure to account for the selectivity bias. The same equation is estimated by OLS (ordinary least squares) on the entire sample. If the two estimates of the same reduced-form equation for consumption are different, one would conclude that some of the households in the sample are liquidity constrained. A statistical test of this can be carried out using a Hausman(1978) type specification test. The test procedure is valid even if measurement errors have a nonzero mean and/or are correlated with the variables in the reduced-form equation. Since the Tobit estimate of the reduced-form equation is consistent even if some of the households in the population are subject to borrowing constraints, we can use it to predict desired consumption, namely the level of consumption dictated by the life cycle-permanent income hypothesis.

The plan of the paper is as follows. Section 2 discusses some theoretical issues concerning the formulation of the life cycle consumption function, and presents a reduced-form equation for desired consumption which simply is a regression of consumption on the variables available in our cross-section data. Section 3 explains how the Tobit procedure can be applied to consistently estimate the reduced-form equation for desired consumption in the presence of liquidity constrained households in the sample. Section 4 is a brief description of the data. In section 5, parameter estimates by OLS and by Tobit are presented and the Hausman test is carried out. We then calculate desired consumption predicted by the Tobit estimate of the reduced-form equation and compare it to actual consumption. Also in section 5, a diagnostic test of the normality and heteroskedasticity assumptions which are used to justify the Tobit procedure are also undertaken. Section 6 contains concluding remarks.

2. Formulation of the "Life Cycle" Consumption Function

In this paper we do not attempt to estimate any "structural" equation for consumption derived from the household's intertemporal optimization without borrowing constraints. Since this non-theoretical approach is somewhat unconventional, we devote this section to justify it. One of the most popular versions of the life cycle-permanent income hypothesis is to write the optimal consumption rule for a household as

$$c^* = g\ (W + H), \tag{2.1}$$

where c^* is the household's optimal consumption, W is assets, the coefficient g is the propensity to consume out of total wealth (lifetime resources) W+H. This propensity would depend on the age of the household head. Human wealth H is defined as the present discounted value of current and expected future after-tax labor income. This consumption function can be derived from the standard deterministic intertemporal utility maximization problem (without borrowing constraints) with time-additive preference where the instantaneous utility function is of the form c^A/A, $(A < 1)$. Permanent income is usually defined as the interest rate times lifetime resources W+H.

There are several theoretical and practical problems associated with the formulation (2.1), especially when we do not have longitudinal data on consumption.[2] First, if the family size affects instantaneous utility, the propensity to consume out of lifetime resources will depend on the future family size planned by the household. Such information is not usually available.

Second, neither human wealth nor permanent income is observable. Since they depend on expectations about future income, any variables that help predict future income will show up with significant coefficients if neither permanent income nor human wealth is included in the consumption function. One way to get around this is to explicitly specify the stochastic process for after-tax labor income and find a closed-form representation of H as a distributed lag function of current and past labor income.[3] A practical problem with this is that we need longitudinal information on after-tax labor income extending for more than a few years back in order to get a realistic distributed lag representation of human wealth. A theoretical problem is the fact that income tax is a nonlinear function of the household's income. Since non-labor income is a part of the household's income, the stochastic process for after-tax labor income is affected by the planned time path of saving. It follows from this that human wealth will depend on assets in a nonlinear fashion as well as on current and past labor income.

Third, the derivation of the consumption function (2.1) from optimization assumes that the household has no subjective uncertainty about future after-tax labor income. This is clearly unrealistic, especially for the young. If the household faces a stochastic stream of after-tax labor income, we can no longer obtain a convenient closed-form solution like (2.1). In fact, it seems that no operational definition of permanent income or human wealth is possible except for the tautological one that permanent income is something that is proportional to the optimal consumption. Another source of complication arises when risky assets whose rates of return are stochastic are present. It is true that, as Hakansson(1970) and Merton(1971) have shown, one can still obtain a closed-form solution for the optimal consumption rule like (2.1) if the stochastic rates of return are independently distributed over time. This, however, does not carry over to the case where future after-tax labor income is uncertain or stochastic.

The foregoing argument seems to suggest that any attempt to explicitly formulate the optimal consumption rule as a function of the variables that are typically available in cross-section data is bound to be misspecified. For this reason we choose to take a non-theoretical approach which can be briefly stated as follows. Let x be a vector of the variables that are available in our cross-section data and let c^* be the optimal consumption which is the solution to the household's (possibly stochastic) intertemporal optimization problem without borrowing constraints. Suppose we have a random sample of (c^*,x) from a common distribution and write the least squares projection of c^* on x as $x'a$. Thus c^* can be written as

$$(2.2) \qquad c^* = x'a + e,$$

where e is uncorrelated with any elements of x. This error term e summarizes the household-specific component of the optimal consumption c^*. For example, if the household is more risk averse than the average household with the same value of x, the error term will tend to be negative. We can think of (2.2) as a reduced-form representation of the optimal consumption for the household's intertemporal optimization without borrowing constraints. Because of the non-theoretical nature of our approach, it is difficult to give an economic interpretation to each of the regression coefficients. However, the predicted value x'a does have a clear interpretation; it is the optimal consumption for a typical household whose observed characteristic is summarized by x. Furthermore, it is conceivable that a particular version of the life cycle-permanent income hypothesis places a certain restriction on the regression coefficients. For example, if the proportionality assumption common in the usual formulation of the hypothesis is true, one would expect that x'a is linearly homogeneous in scale variables like assets and disposable income. Our approach is similar in spirit to Sim's(1980) vector autoregressive modelling on time-series data. One advantage of our non-theoretical approach is that we do not have to commit ourselves to any particular version of the life cycle-permanent income hypothesis.

3. Methodology

In this paper we make a clear distinction between desired consumption c* and actual consumption c. Desired consumption comes from the household's intertemporal optimization (or the life cycle-permanent income hypothesis) where the lifetime budget constraint is the only relevant constraint. Thus desired consumption is a function of: current asset holdings, the parameters that characterize the stochastic process for current and future labor income, the household's dymamic utility function, and the rate of interest. At the end of the previous section we have presented the "reduced-form" equation for consumption (2.2) which relates the vector of observable variables x to desired consumption c*. Actual consumption, however, may not be the same as desired consumption, because the household may not be able to borrow as much as it wants to finance current consumption. If borrowing constraints are currently binding, actual consumption will be lower than desired consumption. Otherwise, desired consumption will be equal to actual consumption. We will say that households are _liquidity constrained_ or _subject to borrowing constraints_ if their current actual consumption is less than their current desired consumption. Households which are not liquidity constrained will be called the _life cycle households_.

The relationship between desired consumption and actual consumption can be better understood if we consider the simple case of the household's intertemporal optimization with deterministic labor income. The typical age profile of labor income is represented by the single-peaked curve in Figure 1. The optimal consumption path without borrowing constraints is the smooth solid curve in the figure. Without bequest or inheritance, the present discounted value as of age zero of labor income must be equal to the present discounted value as of age zero of the optimal consumption. Now assume the extreme case of borrowing constraints where no borrowing is possible. Then the time path of optimal consumption with borrowing constraints will look like the dotted curve in the figure.[4] The reason that the dotted curve lies above the solid curve after age t_2 is that the household which was liquidity constrained until t_2 saved "too much." Now consider a young household of age t_1. If it is not liquidity constrained, actual consumption is equal to desired consumption c_1^* in the figure. If it is liquidity constrained, actual consumption is c_1 as indicated in the figure, and desired consumption is close to, but greater than, c_1^* because the liquidity constrained household has been saving too much (consuming too little). Now consider two households A and B of the same age t_3. Household A was not liquidity constrained in the early stage of its life cycle, so that its actual consumption is equal to its desired level c_{3A}^*. Household B was liquidity constrained until age t_2. Its actual consumption at age t_3 is c_{3B}^* as indicated in the figure. According to our definition, household B is <u>not</u> currently liquidity constrained because its desired consumption is also c_{3B}^*. Since desired consumption depends on <u>current</u> asset holdings and current and future labor income, the fact that household B was liquidity constrained in the past is totally irrelevant in deciding current desired consumption as long as current assets and current and future labor income are given. The reason c_{3B}^* is greater than c_{3A}^* is that household B has more assets than household A due to the past over-saving. Our definition of liquidity constrained households is the relevant one from the viewpoint of macroeconomic stabilization policies because household A (the life cycle consumer) and household B (which was liquidity constrained in the past) will increase their consumption by the same amount if they receive the same amount of tax cuts.[5]

In spite of recent attempts by sevaral authors (see e.g., Livari, Mirman and Zilcha[1980]), deriving an operational, closed-form optimal consumption rule under uncertainty with borrowing constraints remains an elusive subject. No attempt is made in this paper to formulate or estimate an optimal consumption rule for the households whose intertemporal optimization is constrained by borrowing constraints. Our basic strategy here is to try to estimate the reduced-form equation (2.2) for desired consumption and compare the value of consumption predicted by it with actual consumption.

In this paper actual consumption is calculated as disposable income minus saving (i.e., net changes in assets). Since disposable income (and possibly saving) is measured with error, measured consumption CON differs from actual consumption by measurement error u:

$$CON = c + u . \tag{3.1}$$

Since the measurement error u consists of measurement error for disposable income and (possibly) for saving, it may be correlated with the vector x of observable variables. The least squares projection of u on x (which will include labor income and assets as its elements) is written as:

$$(3.2) \qquad u = x'd + v ,$$

where v is, by construction, uncorrelated with any elements of x.

If the life cycle hypothesis is true, we have

$$(3.3) \qquad c^* = c \quad \text{or} \quad c^* + u = CON .$$

Combining (2.2),(3.1)-(3.3) gives

$$(3.4) \qquad CON = x'b + (e + v),$$

where $b = a + d$ and the error term e+v is uncorrelated with x by construction. This equation, too, will be called the reduced-form equation for desired consumption. No attempts will be made in this paper to identify a and d separately. It will turn out in section 5 that b is the parameter we should be interested in. If no households in the population are liquidity constrained, then (3.4) applies to all households in the sample. Provided that the error term is identically and independently distributed across households, an asymptotically efficient estimator of b is obtained by ordinary least squares (OLS) and an asymptotically efficient estimator of Var(e+v) is the sum of squared residuals divided by the sample size. If, on the other hand, some of the households in the population are liquidity constrained, then the reduced-form equation (3.4) does not apply to such households with the same parameter values and the OLS estimate of b will be biased and inconsistent.

Is there any way to consistently estimate the reduced-form equation (3.4) even if some of the households in the population are liquidity constrained? Clearly, identification of b rests on whether or not one can observe consumption by the life cycle households. In the context of single-time cross-section, some a priori criterion has to be utilized to identify at least some of the households that are not liquidity constrained. One such criterion popular in the literature (Kowalewski and Smith[1979] and Bernanke[1981]) is the level of liquid assets or the ratio of it to consumption. The idea, of course, is that a household with ample liquid assets relative to consumption will have no difficulty executing the optimal consumption rule dictated by the life cycle-permanent income hypothesis. Another plausible criterion is the saving rate. It would be unlikely that the household's saving rate is positive and yet its desired consumption exceeds actual consumption. However, consumption is not the only item the household has to finance; debts of various kinds must be paid off on schedule. Following Tobin and Dolde(1971) and Kowalewski and Smith(1979), we will call payments on mortgages and noninstallment debts the contractural saving.

The crucial identifying assumption in this paper is that the household is not liquidity constrained if the ratio of measured consumption to disposable income minus contractural saving plus .2 times the amount of liquid assets is less than .85. In other words we assume

$$(3.5) \qquad c^* + u = CON \quad \text{if} \quad CON < U = .85*(YD + .2*LIQ),$$

where YD = measured disposable income minus contractural saving, and LIQ = liquid assets. (A more precise definition of these variables will be given in the next section.) For later reference, we will call the households which satisfy the sample separation criterion (3.5) the non-limit observations and the households which do not the limit observations. We choose this particular threshold value U for sample separation because it is undoubtedly lower than any reasonable estimate of the amount that the household can spend for current consumption; if consumption is less than that very conservative estimate of U, we can conclude that the household is not subject to borrowing constraints.[6]

Now, since c is never greater than c*, condition (3.5) implies:

$$(3.6) \qquad CON < U \quad \text{if and only if} \quad c^* + u < U.$$

Now define the following <u>limited dependent variable</u>:

$$(3.7) \qquad y = \begin{cases} CON & \text{if} \quad CON < U. \\ U & \text{otherwise.} \end{cases}$$

Then (3.6) and (3.7) imply that

$$(3.8) \qquad y = \begin{cases} x'b + e + v & \text{if} \quad x'b + e + v < U, \\ U & \text{otherwise,} \end{cases}$$

since $c^* + u = x'b + e + v$ by (3.1) and (3.4).

The model (3.8) is the one considered by Tobin(1958) and Amemiya(1973), and the parameters of the model can be estimated by maximum likelihood procedure (Tobit) under the assumption that (1) the expectation of e+v conditional on x and U is zero, (2) the distribution of e+v conditional on x and U is normal and homoskedastic. In our empirical analysis the vector x will consists not only of the variables available in our cross section data set (age, family size, assets, disposable income, and liquid assets) but also some of their squared terms. Thus we can expect that assumption (1) above is (at least approximately) satisfied. Since assumption (2) is something that cannot be justified on *a priori* basis, we will carry out a diagnostic Lagrange multiplier test of homoskedasticity and normality at the end of section 5. If there is any clear violation of assumption (1), hopefully the Lagrange multiplier test will be able to detect it.

The intuitive idea for using Tobit runs like this: Since we are confident that the households with ample liquid assets or with high saving ratio are not liquidity constrained, we would like to use their consumption data to estimate the reduced-form equation for consumption. But since we suspect that *at least some* of those households which do not have ample liquid assets or whose saving ratio is low are liquidity constrained, we do not use their consumption data except for the fact that their consumption is high relative to their liquid assets or disposable income.

Thus two different estimators of the reduced-form equation for consumption can be obtained. The OLS estimator is efficient under the null hypothesis that all households in the population share the same reduced-form equation (3.4) with common parameter values. The Tobit estimator is consistent (and asymptotically normal) even if some of the households are liquidity constrained. The test procedure that immediately comes to mind is Hausman's(1978) specification test which is to compare the efficient OLS estimate and the consistent but inefficient Tobit estimate.

It should be noted that for testing purposes we can allow the possibility that measurement error has nonzero mean and/or is correlated with any elements of the vector of the right hand side variables x. It should also be noted that a perfect split of the sample into liquidity constrained households and life cycle households by the sample separation rule CON < U is not needed here. We are not assuming that every household in the limit observations is liquidity constrained. All that is necessary for the consistent estimation of the reduced-form equation (3.4) by Tobit is that the sample separation rule CON < U does not pick up liquidity constrained households; there may well be life cycle households that do not satisfy CON < U. For example, young life cycle households whose desired consumption exceeds current disposable income would not satisfy CON < U.

It is true, however, that because of measurement errors there can be a non-zero probability that liquidity constrained households get in the non-limit observations under the sample separation rule CON < U. To illustrate this, suppose, somewhat unrealistically, that the reduced-form equation for the liquidity constrained is

$$c = YD^*, \qquad (3.9)$$

where YD* is the true value of disposable income minus contractural saving. If measurement error u consists entirely of measurement error for current disposable income so that u = YD - YD* where YD is measured disposable income minus contractural saving, then (3.9) implies that measured consumption CON is equal to measured disposable income minus contractural saving and the probability of mis-selection is zero.[7] If, on the other hand, measurement error for saving is nonzero so that u consists of measurement errors for disposable income and for saving, then (3.9) implies CON = YD + s, where s is the measurement error for saving. If s is normally distributed, the probability that some liquidity constrained households satisfy CON < U is not zero, so that the Tobit procedure will end up estimating a mixture of (3.4) and (3.9).

This problem of mis-selection does not appear to be a serious one for the following reasons. First, since the unique feature of the data set we will use in the subsequent analysis is its exhaustive coverage of various kinds of assets, the variance of measurement error for saving is likely to be small relative to that for disposable income. Second, even though it may not literally be a consistent estimate of (3.4), the Tobit estimate will be a very close approximation. If the true density function of the error term does not have long tails like a normal distribution, the probability of liquidity constrained households ending up in the non-limit observations may well be zero, in view of the high value of saving ratio (15%) used for the threshold value

U, and the normality assumption will still be a good approximation. Even if the density function of the error term does have long tails, the probability of mis-selection will be negligibly small. Third, it should be noted that the Tobit estimate is consistent and asymptotically normal under the null hypothesis that there are no liquidity constrained households in the population. Thus the Hausman specification test is still valid.

4. The Data

The cross-section data for the calculations reported in this paper came from the 1963/64 Survey of Financial Characteristics of Consumers conducted by the Board of Governers of the Federal Reserve System. A complete description of the survey is in Projector and Weiss(1966). The survey collected detailed information for income, the value of various categories of assets as well as for socio-economic characteristics of the households for two years 1962 and 1963. The quality of data is believed to be very good relative to other available data sets.[8]

The variables used in the analysis are as follows.

CS = contractural saving during 1963 in installment and mortgage debts,

YD = 1963 disposable income excluding capital gains, after estimated federal income and payroll taxes,[9] minus CS,

ASSET = total market value of financial and physical assets (including the acturial value of life insurance, pensions, annuities, royalities, real estates, and automobiles), at the beginning of 1963,

SAVING = saving during 1963, defined as net changes in assets (including automobiles and houses) after the exclusion of capital gains,

CON = measured consumption during 1963, defined as YD - SAVING,

LIQ = amount of net liquid assets, defined as demand deposits, plus saving accounts, plus bonds, plus common stocks,

HOUSE = market value of houses at the beginning of 1963 (HOUSE = 0 for non-homeowners),

U = .85*(YD + .2*LIQ), the threshold value for creating the limited dependent variable (see [3.7] in section 3),

AGE = age of the household head as of December 1962,

FSZ = family size.

The following households are excluded from the initial sample of 2164 households. (1) households with missing data for the relevant variables (373 cases), (2) the self-employed and farmers (428 cases), (3) households whose 1963 disposable income minus contractural saving is less than $1,000 (96 cases), (4) households whose assets are greater than or equal to one million dollars (38 cases), (5) households with negative consumption (27 cases), (6) households whose consumption-disposable income ratio is greater than or equal to 5 (5 cases) and (7) households whose head is 65 or over (166 cases). This reduced the sample size to 1031 observations. The self-employed and farmers are eliminated as their income is least accurately reported and is likely to be understated. In the subsequest analysis, we will deflate the equation by YD (disposable income minus contractural saving) to avoid heteroskedasticity. The reason for excluding low- and high-income households is to avoid extreme values when the heteroskedasticity correction is made.[10] Old households are eliminated for the same reason: Since their disposable income is likely to be small relative to their consumption, their consumption-disposable income ratio would tend to be high. The sample mean, standard deviation, and skewness of the variables listed above for the sample of 1031 observations are reported in Table 1. Table 2 displays the sample means for four groups broken down by the age of the household.

5. Results

In the subsequent analysis, the vector x in the reduced-form equations (3.4) and (3.8) consists of the following sixteen variables:[11] the constant, AGE-45, (AGE-45)**2, FSZ, ASSET, ASSET*(AGE-45), ASSET*((AGE-45)**2), ASSET*FSZ, YD, YD*(AGE-45), YD*((AGE-45)**2), YD*FSZ, LIQ, ASSET**2, YD**2, and HOUSE. To avoid misspecification, no a priori (linear or nonlinear) constraints are imposed on this reduced-form equation for consumption. The discussion in section 2 implies that we have no believable restrictions to be imposed on the equation. To account for possible differences in the consumption behavior by low- and high-income households, squared terms in ASSET and LIQ are included in the equation. It is possible to calculate disposable income in 1962 from our data set. Disposable income in 1962 was not included in our equation because it was highly correlated with disposable income in 1963 and a serious multicollinearily problem arose when both variables were included. The reason for including HOUSE is to treat homeowners and non-homeowners symmetrically; the calculated consumption CON does not include service flows from houses which will be represented by the HOUSE variable in the equation with a negative coefficient. We include liquid assets LIQ in order to make it plausible the assumption that the error term e+v is orthogonal to U (which involves LIQ).

Not surprisingly, inspection of the residuals from a preliminary regression analysis revealed considerable heteroskedasticity across households of different income sizes. Since the Tobit estimation to be carried out shortly will assume that the error term e+v is identically distributed across households, a heteroskedasticity correction is necessary. To this end, disposable income YD is used to deflate the equations (3.4) and (3.8). In other words the reduced-form equation we actually estimate is a projection of CON/YD on x/YD. Of course, there is no guarantee that this deflation by YD completely removes heteroskedasticity in the error term e+v. Later in this section we will carry out a Lagrange multiplier test for heteroskedasticity and non-normality. The paramter estimates obtained from applying OLS to the deflated equation are reported in Table 3. In interpreting the results, it should be kept in mind that the coefficient b in (3.4) is the sum of a in (2.2) and d in (3.2). We note that no variables that involve AGE are aresignificant. We would expect that consumption depends on age to a large extent if the household is trying to isolate consumption from income movements.

Of the whole sample of 1031 households, 455 households satisfied the criterion that CON < U = .85*(YD + .2*LIQ). Table 4 displays the sample mean and standard deviation of the variables for the non-limit observations (455 cases) and for the limit observations (576 cases). Although the sample separation rule CON < U does not necessarily favor high-income households since it is based on the <u>ratio</u> of CON to YD + .2*LIQ, it ended up selecting relatively rich households into the 455 non-limit observations. As would be expected, the average age is considerably higher for the non-limit observations.

The model (3.8) (after the deflation by YD) is estimated by maximum likelihood under the assumption that the error term is normal and homoskedastic, and results are reported in Table 5. Unlike the OLS case, the HOUSE coefficient picked up the right sign, but it is not significant. Some of the constant term and the squared terms have significant coefficients, which would imply that the proportionality assumption common in the usual formulation of the life cycle-permanent income hypothesis is unwarranted. We also note that two of the variables that involve AGE have coefficients whose t ratio is over two (in absolute value). The negative ASSET coefficient of -.017 might at first sight seem puzzling. The partial derivative of the estimated equation with respect to ASSET evaluated at (AGE, FSZ, ASSET) = (45, 3, 10000), for example, is about -.005. This number, however, does not really represent the effect of an increase in ASSET on consumption, because when ASSET increases, disposable income must also increase.

The two sets of point estimates -- OLS and Tobit -- appear to be different from each other. As Hausman(1978) has shown, the right distance between the two sets of estimates is given by the difference in the variance matrices for the two estimates, as the efficient estimator of b, b_{OLS}, is asymptotically uncorrelated with the difference $b_{TOBIT} - b_{OLS}$, under the null hypothesis that equation (3.4) applies to all households in the population with the same parameter value. This fact can also be directly verified by looking at the Taylor expansion of the estimators around the true value of b. As Hausman(1978) has shown, the Wald-type statistic:

$$(b_{TOBIT}-b_{OLS})'(V_{TOBIT}-V_{OLS})^{-1}(b_{TOBIT}-b_{OLS})$$

is asymptotically distributed as chi-squared with 16 degrees of freedom under the null hypothesis of no mis-specification. In this expression, V_{TOBIT} and V_{OLS} are the sample size times consistent estimates of the asymptotic variance matrices of b_{TOBIT} and b_{OLS}, respectively. In the present case the statistic is 745.9, which emphatically rejects the null hypothesis that all households in the population share the same reduced-form equation for consumption.[12] Technically speaking, the primary reason for such a huge statistic appears to be that the standard errors of the Tobit estimate are not much higher than those of the OLS estimate.

A less formal but probably more interesting way to evaluate the importance of liquidity constraints is to compare the sample mean of predicted desired consumption $x'b_{TOBIT}$ to the sample mean of measured consumption on the entire sample of 1031 observations. It can be easily shown from equations (2.2), (3.1)-(3.4) that the population mean of c*-c can be consistently estimated by the sample mean of $x'b_{TOBIT}$-CON, if the Tobit estimate is a consistent estimate of b and the sample mean of x converges in probability.

Furthermore, if the (unconditional) expectation of the measurement error u is zero, then the sample mean of $x'b_{TOBIT}$ is a consistent estimate of the population mean of c*. This is why our interest has been centered around the consistent estimation of b. The weighted mean of $x'b_{TOBIT}$ is 1.005 and the weighted mean of measured consumption is .950. The effect of liquidity constraints is to reduce consumption to about 5.5% below the desired level, on the average. From the viewpoint of macroeconomic stabilization policies, a more relevant measure is the unweighted mean of consumption. The unweighted mean of measured consumption is $7,045 which is about 2.7% below the unweighted mean of predicted desired consumption $x'b_{TOBIT}$ of $7,244. Thus, the quantitative importance of liquidity constraints does not seem as large as the difference between the Tobit and the OLS estimates of the reduced-form equation for consumption might suggest.

Table 6 carries out a similar comparison by the age of the household head. As would be expected, the effect of borrowing constraints is most evident for young households. Not only the discrepancy between predicted desired consumption and measured consumption is largest for the young, but also their average ratio of predicted desired consumption to disposable income exceeds one. For only 19% (52 cases out of 271) of the households whose heads are 33 or younger, measured consumption is greater than the predicted desired consumption $x'b_{TOBIT}$. Overall, the results in Table

6 agree quite well with the intuitive idea one would get from Figure 1.

The important assumption in the preceding analysis is that the error term e+v (after the devlation by YD) is normal and homoskedastic. We now carry out a Lagrange multiplier test for non-normality and heteroskedasticity. Following Lee(1981) we assume that the error term w = e+v (after the deflation by YD) is a member of the general Pearson family of distributions whose density function can be written as

$$f(w) = \exp\left[\int_0^w \frac{c_3 - z}{c_5 - c_3 z + c_4 z^2}\, dz\right] \Big/ \int_{-\infty}^{\infty} \exp\left[\int_0^z \frac{c_3 - t}{c_5 - c_3 t + c_4 t^2}\, dt\right] dz.$$

The variance under this general Pearson distribution is $c_5/(1-3c_4)$. There are several different ways to incorporate heteroskedasticity into this distribution. We assume that the variance is a linear function of ASSET and YD so that c_5 is written as

$$c_5 = c_0^2 + c_1*\text{ASSET} + c_2*\text{YD}.$$

The normality assumption is that $c_1 = c_2 = 0$, and the homoskedasticity assumption is that $c_3 = c_4 = 0$. Our null hypothesis, therefore, is that $c_1 = c_2 = c_3 = c_4 = 0$. The Lagrange multiplier test is based on the fact that the score vector under the null hypothesis has mean zero and its variance is the elements of the information matrix that correspond to the parameters constrained by the null hypothesis. Its attractive feature is that we do not have to compute the maximum likelihood estimates under the alternative hypothesis. The reader is referred to Engel(forthcoming) for an excellent exposition of the Lagrange multiplier principle. To calculate the Lagrange multiplier statistic, a consistent estimate of the relevant information matrix is necessary; we used the formula given by Lee(1981) to obtain such an estimate. In the present case, the statistic, which is distributed asymptotically as chi-squared with four degrees of freedom under the null hypothesis ($c_i = 0$, $i=1,2,3,4$), turned out to be 10.7. Thus we can accept the joint hypothesis of normality and heteroskedasticity at a 2.5% level of significance.

We conclude this section by examining the robustness of our results with respect to the choice of the LIQ coefficient in the definition of U, the threshold value for the sample separation. Table 7 contains the results similar to the ones in Table 6 for two cases where U = .85*(YD + .5*LIQ) and where U = .85*YD. The results with U = .85*(YD + .5*LIQ) are remarkably similar to the case where U = .85*(YD + .2*LIQ). However, when U is simply .85*YD, the estimated reduced-form equation underpredicted consumption for households whose heads are between 54 and 64 years of age. But even in this case the weighted average for the whole sample of desired consumption of .984 is still higher than the weighted average of measured consumption of .950. Also reported in Table 7 is the consumption predicted by the OLS estimate of b. It is clear that, unlike any of the Tobit estimates presented above, the discrepancy between measured consumption and predicted consumption has no relationship with the age of the household.

6. Conclusion

The basic message of this paper can be summarized as follows. The sample was divided into high- and low-saving households. The coefficients in the reduced-form equation for consumption (i.e., the regression of consumption on the variables available in our cross-section data) for the high-saving households appeared to be quite different from those for the rest, even after the selectivity (or sample selection) bias, which arises from a sample separation procedure based on the dependent variable, is removed by the Tobit procedure. When the Tobit estimate of the reduced-form equation for the high-saving households was used to predict consumption for the whole sample, it tended to overpredict actual consumption. Our interpretation of this finding was that the low-saving households were unable to consume as much as they want due to borrowing constraints. This is admittedly not the only interpretation, but is the one that seems to be most natural.

One might want to comment on this by saying that the high- and low-saving households are simply two different types of consumers with respect to their preferences. Our responce to this is two-fold. First, the error term in our reduced-form equation for consumption does include the individual differences in preferences that cannot be captured by the right hand side variables. The error term for the high-saving households tend to be negative. This is precisely the selectivity bias that can be removed by the Tobit procedure under the assumption that the error term is normal and homoskedastic -- an assumption that was accepted by the Lagrange multiplier test. Second, if it is in fact the case that two household groups differ with respect to their preferences, one would like to explain <u>why</u> they are different; in particular, one would have to explain why the saving rate is the relevant criterion in dividing households into two different types of consumers.

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Footnotes

1. See Tobin(1980) for his latest account of liquidity constraints and their implication to macroeconomic stabilization policies. In this paper we use the words "liquidity constraints" and "borrowing constraints" interchangeably. We will not use the word "quantity constraints", bacause it is usually used to describe the situation where labor supply is exogenously given to the household. This paper assumes that households are quantity constrained, i.e., they are "income takers". Although this is a standard assumption in the literature on consumption function, it would be preferable to treat both consumption and labor supply as choice variables. Unfortunately, our data have no information on labor supply or wage rate.

2. If longitudinal data on total consumption were available, we would operate on the Euler equation (the first order condition for intertemporal optimality), as Hansen and Singleton (forthcoming) did using aggregate time series data.

3. See Hansen and Sargent(forthcoming) for more details on this approach.

4. See e.g., Tobin and Dolde(1971) and Flemming(1973) for a derivation of the optimal consumption path with borrowing constraints.

5. This ignores the fact that income tax is a nonlinear function of the household's income.

6. The reason that LIQ has a coefficient of .2 in (3.5) is that we wanted to guard against the possibility that some of the liquid assets reported in our data is not readily cashable. Since the distribution of liquid assets in our

data is very skewed (see Table 1), our particular choice of the LIQ coefficient did not considerably affect the composition of households satisfying CON < U. See Table 7 for the results when the LIQ coefficient is .5 or 0. The reason that YD+.2*LIQ is further multiplied by .85 is to reduce the probability that measured consumption by liquidity constrained households satisfies CON < U due to measurement error for saving. This point is further discussed in the last two paragraphs of section 3 of the text.

7. This carries over to a more general case where actual consumption is the minimum of c* and some upper ceiling k: c = min(c*,k). It is easy to show that "CON < U" implies "c = c*" whenever k is greater than YD*-CS+.2*LIQ.

8. I also looked at a University of Michigan Survey Research Center panel study entitled Consumer Durables and Installment Debts, 1967-1970, which has longitudinal data on saving and income. It turned out that calculated consumption (defined as income minus saving) was negative for more than two cases out of ten.

9. The data set contains no information about taxes. Federal income tax was calculated by following the instructions in a handbook entitled Your Federal Income Tax (1964 edition, U.S. Internal Revenue Service publication No.17). The tax deductability of mortgage payments was incorporated in the calculation. Other taxes were ignored. Property tax could be a substantial omission, but this will be picked up by the variable HOUSE in the reduced-form equation. The derivation of the variables used in this paper is in part based on the asset and saving data constructed by Kim Kowalewski of Federal Reserve Bank of Cleveland, who also used the same data set from Projector and Weiss(1966). The FORTRAN program that I used for deriving the variables is available upon request.

10. It turned out that if households in (4),(5) and (6) were not deleted, the normality and homoskedasticity assumption was decisevely rejected by the Lagrange multiplier test.

11. Education and the sex of the household head are available from the data set, but they are not included in the equation to maintain the number of the right hand side variables manageable in our computation of Tobit estimates. If the two variables were to be included, we would have to also include the interaction terms between the two variables and YD and ASSET.

12. The Hessian matrix of the log of likelihood function evaluated at b_{TOBIT} was used to calculate V_{TOBIT}. To calculate V_{OLS}, we used the Tobit estimate of Var(e+v). If the OLS estimate of Var(e+v) is used to evaluate V_{OLS}, some of the diagonal elements of $V_{TOBIT}-V_{OLS}$ become negative. If the hypothesis is that both the coefficients in the equation and the variance of the error term e+v are the same, the relevant Hausman statistic is 1744.

TABLE 1: Sample Statistics

Sample Size = 1031.

variable name	mean	standard deviation	skewness
CON	$7,045	7353	4.93
ASSET	$28,177	83535	6.82
YD	$7,629	6912	4.00
LIQ	$12,991	60220	8.47
HOUSE	$14,349	32584	15.75
CS	$726	1288	7.83
FSZ	3.7	1.94	1.17
AGE	42.8	11.7	.01

TABLE 2: Sample Statistics for the Four Age Groups

variable	18-33	34-43	44-53	54-64
CON	$4,808	$7,299	$7,617	$8,747
ASSET	$4,970	$16,897	$30,961	$65,820
YD	$5,209	$7,521	$8,373	$9,764
LIQ	$733	$4,845	$13,007	$37,183
HOUSE	$5,329	$14,202	$17,369	$21,705
CS	$570	$869	$870	$574
FSZ	3.6	4.6	3.7	2.6
AGE	27.8	38.6	48.3	58.8
#cases	271	261	274	225

TABLE 3: OLS Estimate

	1	AGE-45	(AGE-45)**2	FSZ
1	400 (2.3)	-6.34 (-.97)	-.376 (-.74)	4.62 (.13)
ASSET	-.00805 (-.84)	-.000606 (-1.6)	$.0^{5}350$ (.16)	.00843 (5.5)
YD	.779 (12.8)	$.0^{4}101$ (.01)	$.0^{4}669$ (.39)	.0127 (1.2)
LIQ	.00311 (.30)			
ASSET**2	$-.0^{7}179$ (-1.9)			
YD**2	$-.0^{5}368$ (-1.6)			
HOUSE	.00747 (1.0)			

estimate of Var(e+v) = .130
(22.7)

R^2 = .936, mean of the dependent variable (CON/YD) = .950, sample size = 1031.

Note: Numbers in parentheses are t ratios. The point estimate of the coefficient of ASSET, for example, is -.00805 which is the (2,1) element of the above matrix. The point estimate of the coefficient of YD*((AGE-45)**2) is .0000669.

TABLE 4: Sample Statistics of the Two Subsamples

variable name	non-limit observations (CON $<$ U) 455 cases		limit obsevations (CON $\geq$ U) 576 cases	
	mean	standard deviation	mean	standard deviation
CON	$7,360	7393	$6,796	7318
ASSET	$49,888	117968	$11,026	29061
YD	$9,709	8745	$5,987	4367
LIQ	$26,961	87653	$1,956	12383
HOUSE	$19,946	44644	$9,927	16844
CS	$739	1209	$716	1348
FSZ	3.4	1.7	3.9	2.1
AGE	45.4	11.3	40.7	11.6

TABLE 5: Tobit Estimate

	1	AGE-45	(AGE-45)**2	FSZ
1	437 (2.2)	-20.3 (-2.3)	.785 (1.2)	-5.19 (-.01)
ASSET	-.0168 (-1.5)	$-.0^{4}867$ (-.19)	$.0^{4}569$ (2.1)	.00308 (1.4)
YD	.841 (10.9)	.00273 (1.2)	-.000206 (-1.1)	.0302 (2.2)
LIQ	.00760 (.61)			
ASSET**2	$.0^{7}125$ (1.4)			
YD**2	$-.0^{5}539$ (-1.5)			
HOUSE	-.00371 (-.32)			

estimate of Var(e+v) = .0921
(6.4)

Log of likelihood function = -391.6, sample size = 1031.

Note: Numbers in parentheses are t ratios. The maxmum likelihood estimation was carried out by the Newton-Raphson method described in Amemiya(1973).

TABLE 6: Comparison of the Averages for Measured and Predicted Desired Consumptions for the Four Age Groups

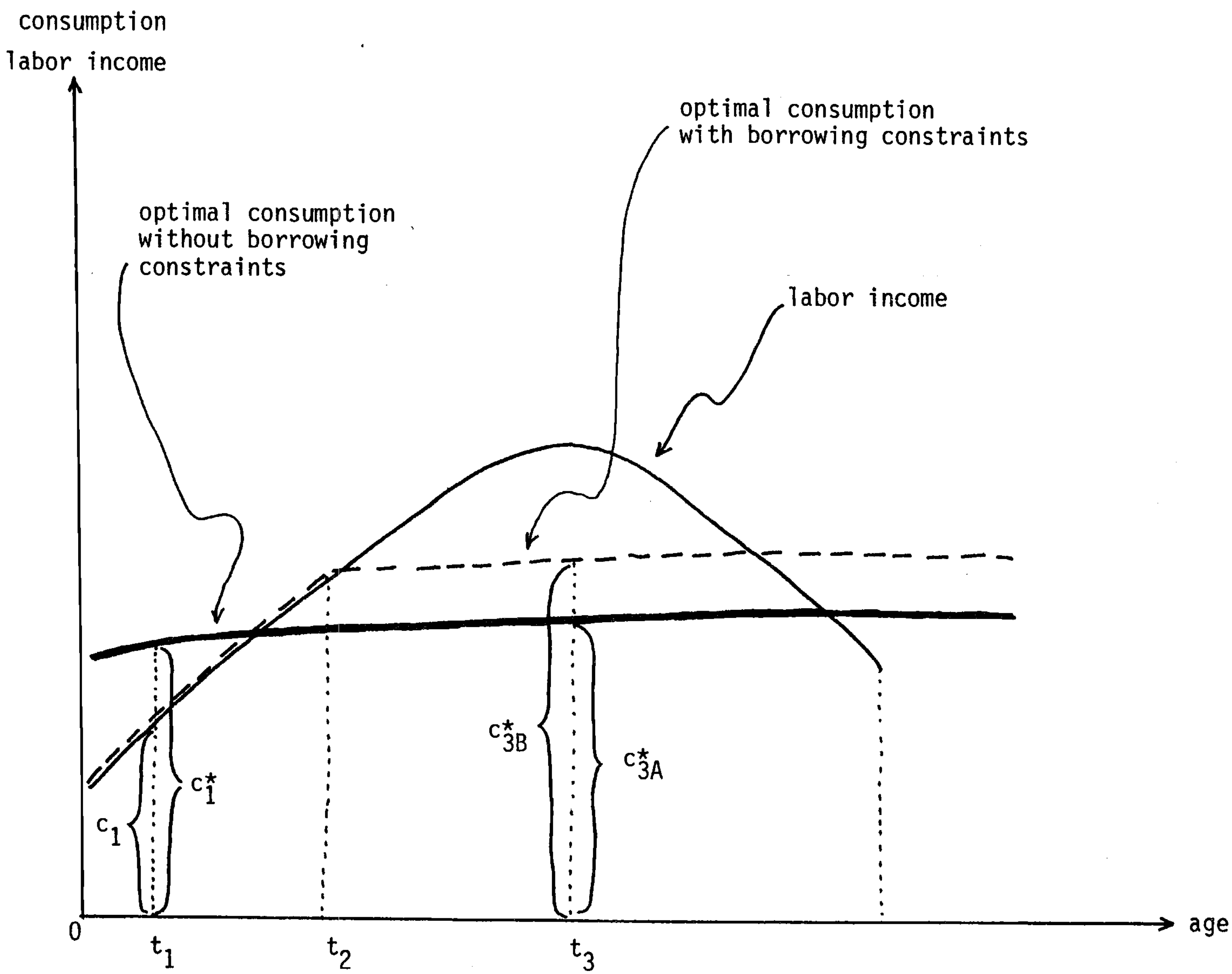
age brackets	18-33	34-43	44-53	54-64	ALL
measured consumption (weighted)	.942	.968	.937	.956	.950
predicted desired consumption (weighted)	1.069	1.017	.971	.957	1.005
measured consumption (unweighted)	$4,808	$7,299	$7,617	$8,747	$7,045
predicted desired consumption (unweighted)	$5,304	$7,373	$7,756	$8,808	$7,244
YD	$5,209	$7,521	$8,373	$9,764	$7,629
#cases where CON < U (non-limit cases)	86	106	132	131	455
#cases where CON < x'b	52	82	91	82	307
#cases	271	261	274	225	1031

Note: Predicted desired consumption x'b is evaluated at the Tobit estimate of b with U = .85*(YD + .2*LIQ)

TABLE 7: Predicted Desired Consumption with Different Threshold Values

age brackets	18-33	34-43	44-53	54-64	ALL
with U = .85*(YD + .5*LIQ):					
weighted	1.067	1.019	.981	.962	1.009
unweighted	$5,248	$7,391	$7,873	$8,884	$7,282
with U = .85*YD:					
weighted	1.041	1.001	.961	.924	.984
unweighted	$5,189	$7,279	$7,654	$8,204	$7,031
with OLS estimate of b					
weighted	.947	.956	.949	.950	.950
unweighted	$4,816	$7,076	$7,772	$8,809	$7,045

FIGURE 1


consumption
labor income
optimal consumption
with borrowing constraints
optimal consumption
without borrowing
constraints
labor income
c*3B
c*3A
c*1
c1
0
t1
t2
t3
age