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ABSTRACT

This paper develops and tests a new set of stochastic implications of optimal consumption behavior in the presence of borrowing constraints. In a departure from previous models, the theory shows that liquidity constraints imply a distinctive intertemporal relationship between durable and nondurable goods consumption. The presence of binding, liquidity constraints are manifested as part of an error correction term from the long-run cointegrating relationship between durables and nondurables. When liquidity constraints are binding, the error correction term will have predictive power for the future change in nondurable consumption. Empirical tests of the implications using aggregate data support the hypothesis that liquidity constraints, rather than rule-of-thumb behavior, best explain the excess sensitivity of consumption to predictable changes in income.

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The proposition that individuals choose consumption based on intertemporal considerations has both theoretical and intuitive appeal. Unfortunately, most tests of the strongest form of this proposition - the life cycle-permanent income hypothesis - reject the theory. Researchers frequently appeal to liquidity constraints to explain the discrepancy between the theory and actual behavior.[1] Efforts to formalize the notion of liquidity constrained consumers have not, however, produced testable implications as striking as those derived for the permanent income hypothesis (e.g. Robert Hall (1978)). The difficulty in deriving testable implications stems from the unobservability of the key variable in the model - the shadow price of borrowing. As a result, most testing has relied on proxies or sample-splitting methods for identifying liquidity constraints. For example, Flavin (1985) uses the unemployment rate as a proxy for liquidity constraint, while Zeldes (1989), Runkle (1991), and Flavin (1991) use low asset holdings (as indicators of possible liquidity constraints) to split their samples, and Jappelli (1990) uses survey questions. Flavin (1985), Zeldes (1989), and Jappelli (1990) find some evidence for borrowing constraints, while Runkle (1991) and Flavin (1991) find no evidence for borrowing constraints.

This paper develops and tests a new set of stochastic implications of optimal consumption behavior in the presence of borrowing constraints. Households are assumed to be forward-looking and to maximize expected lifetime utility, subject to current assets, current income, and expected future income. They are assumed unable, however, to borrow to smooth consumption over time. The departure from previous models is that liquidity constraints are shown to imply a distinctive relationship between household stocks of durable goods and nondurable consumption. In particular, if individuals face borrowing constraints,

[1]See, for example, Flavin (1981), Hall and Mishkin (1982), Hayashi(1982), and Wilcox (1989).

then the lagged deviation of the marginal utility of household *durable* good holdings from its long-run relationship to the marginal utility of nondurable consumption should have predictive power for the current change in the marginal utility of *nondurable* consumption.

Durable goods provide services over an extended time period, so the capital market imperfection affects the timing of durable goods expenditures differently from nondurable consumption expenditures. If durable goods expenditures cannot be debt-financed, then forecastable increases in income and the sustainable level of household expenditure are preceded by reductions in expenditures on durables. Consumers temporarily run down their durables stocks and reallocate expenditures to current nondurable consumption; they anticipate a subsequent increase in sustainable expenditure levels and they plan a future augmentation in durable goods stocks and expenditures.

Alternatively, in the case where durable goods expenditures can be debt-financed, forecastable increases in income are preceded by a rise in durables expenditures in anticipation of the subsequent increase in debt-service capacity. In either case, optimal household policy in the presence of capital market imperfection implies that changes in durable and nondurable goods purchases will precede changes in nondurable consumption expenditure. Hence, in this model, changes in nondurable consumption expenditure are forecastable from corresponding prior changes in durable and nondurable goods expenditures. This is in distinct contrast to the implications of optimal durable and nondurable consumption behavior in perfect capital market models; changes in consumption there are unforecastable.

In the theoretical section of this paper, both nondurable and durable consumption are incorporated into a stochastic version of a liquidity constrained household optimization model, Heller and Starr (1979). We specify a borrowing constraint that prohibits debt financing of nondurables and allows a fraction φ (between zero and one) of durables to be debt-financeable. When φ is equal to zero, then the constraint implies that financial assets must be nonnegative; when φ is equal to one, then *total* assets (financial assets plus the value of durables) must be nonnegative. For all values of φ, we show that, when liquidity constraints are binding, the behavior of the marginal utility of durables relative to nondurables in period t contains information about the change in nondurable utility from period t to t+1. When φ is near zero, so that durables cannot be debt financed, an expected large increase in income should be preceded by an increase in the marginal utility of durables relative to the marginal utility of nondurables. When φ is near one, an increase in income should be preceded by a decrease in the marginal utility of durables relative to nondurables. For all values of φ, the model implies a particular set of relationships in a cointegration and error correction framework.

The predictions of the theory are sharp enough to distinguish between a liquidity constraint model and a "Keynesian" rule-of-thumb model, where consumption varies directly with current income. Borrowing constraints do not, in general, imply Keynesian rule-of-thumb behavior. The presence of borrowing constraints represents a modification of the permanent income hypothesis (Heller and Starr (1979), Zeldes (1989)). Consumers display permanent income behavior relative to endogenously determined subperiods of their lives, and do not generally make consumption proportional to current income. To take a concrete example, consider a graduate student who is not able to borrow against future income. If he experiences an unexpected temporary rise in current income, he will not consume the entire increment immediately. Rather, he increases current and nearby expenditures to smooth his consumption over the remainder of his time as a graduate student. Eventually, when he receives his first paycheck as an assistant professor, his consumption rises significantly because he now makes consumption proportional to the sustainable debt-free level corresponding to this stage of his life. Thus, liquidity constrained forward-looking consumers differ from those who do not face liquidity constraints; they smooth consumption *within* stages of their lives, where the stages are defined by the level of consumption sustainable without debt.

Hall (1978), Hayashi (1987), and Campbell and Mankiw (1989) have suggested that the excess sensitivity of consumption to predictable changes in income could be accounted for by a fraction of the population behaving as Keynesian non-optimizing rule-of-thumb consumers. According to the model presented here, on the contrary, if consumers face liquidity constraints, but are forward-looking nevertheless, then predictable changes in income should not be statistically significant predictors of consumption, once the effects of liquidity constraint have been accounted for through lagged values of the marginal utility of durables and nondurables as explanatory variables. Alternatively, if some consumers really were Keynesian, then predictable changes in income would remain significant.

We test the theory by studying the predictive power of the lagged marginal utility of durables and nondurables for the current change in the marginal utility of nondurables in aggregate data. The results show the lagged variables to be significant and consistent with a large fraction of durables being financeable. Further, predictable changes in current income are no longer statistically significant determinants of consumption, after accounting for the effects of lagged durable and nondurable consumption. Thus, the results suggest that consumers behave as rational forward-looking optimizers in a constrained environment, rather than follow a nonoptimizing rule of thumb.

1. Theory

1.1 Optimal Consumption Paths with Liquidity Constraints: Simple Case

We will first develop our intuition in the context of a simple model based on work by Chah (1990). To highlight the effect of liquidity constraints, we assume that interest rates and relative prices are constant, and that the interest rate equals the rate of time preference.

Section 1.2 will show that the conclusions are not substantially altered when other features are included.

Consider a consumer who faces a stochastic income stream. The consumer chooses consumption and asset holdings to maximize expected lifetime utility, subject to the constraint that assets must be nonnegative. The consumer solves the following problem:

$$\max_{C,K,A} E_0 \sum_{t=0}^{\infty} (1+\rho)^{-t} U(C_t,K_t)$$

subject to

$$A_t = (1+r)A_{t-1} + Y_t - C_t - P_d d_t$$

$$d_t = K_t - (1-\delta)K_{t-1}$$

$$A_t + \varphi P_d K_t \geq 0$$

$$A_{-1}, K_{-1} \text{ given}$$

$$t = 0,1,2,...$$

where

A_t = financial wealth at the end of period t

C_t = consumption of nondurables during period t

K_t = stock of durables at the end of period t

d_t = purchases of durables during period t.

Y_t = labor income during period t

P_d = relative price of durables in terms of nondurables, assumed constant

r = constant real interest rate

ρ = subjective rate of time preference

δ = physical depreciation of durables

φ = fraction of durables that can be financed

U is increasing and concave in C and K, and $U_c(0,K) = U_k(C,0) = \infty$.

E_0 is the expectation based on period 0 information.

The problem faced by this consumer differs from a PIH model only in the type of constraints he faces. The first two constraints are the standard equations for the evolution of financial assets and durables stocks, respectively. The third constraint represents the imperfection in the capital market: it restricts the consumer's net worth to be nonnegative in every period. The parameter φ in the constraint represents the fraction of durables that the consumer is able to finance. If φ is equal to zero, the consumer cannot borrow against future income to finance current expenditures for durable consumption; the consumer is thus constrained to have nonnegative financial assets. At the other extreme, if φ is equal to one, durables purchases are fully financeable, and only total assets, the sum of financial assets and the value of the durable stock, must be nonnegative. A durables purchase in this case does not adversely affect current liquidity since the increase in financial liabilities incurred is offset by the increase in physical assets. In such an environment, the consumer is constrained only to have total net worth positive. Finally, if durables are partially financeable, φ will have a value between zero and one. We expect φ to be close to one because of the existence of well-developed capital markets for most durable goods.

The timing of the model is as follows. The consumer receives his labor income and interest income, and purchases consumption goods. Goods purchased during the period yield utility during the same period. Any saving is added to financial wealth, where it earns interest between the end of one period and the beginning of the next. The consumer is not allowed to purchase so much that he drives his eligible net worth below zero.

Solving the asset evolution equation for C_t and substituting, the Lagrangean for the problem is:

$$L = E_0 \sum_{t=0}^{\infty} (1+\rho)^{-t}\{\, U[(1+r)A_{t-1} + Y_t - P_d\,(K_t - (1-\delta)K_{t-1}) - A_t, K_t]$$
$$+ \mu_t[A_t + \varphi P_d K_t]\}.$$

The first-order conditions are:

(1) $E_t\, U_c(t+1) = U_c(t) - \mu_t,$

(2) $U_k(t) = P_d\,[U_c(t) - \frac{1-\delta}{1+r} E_t U_c(t+1)] - \varphi P_d \mu_t,$

$t = 1,2,\ldots$

with complementary slackness conditions,

(3) $\mu_t \geq 0,$

(4) $(A_t + \varphi P_d K_t)\mu_t = 0.$

$t = 1,2,\ldots$

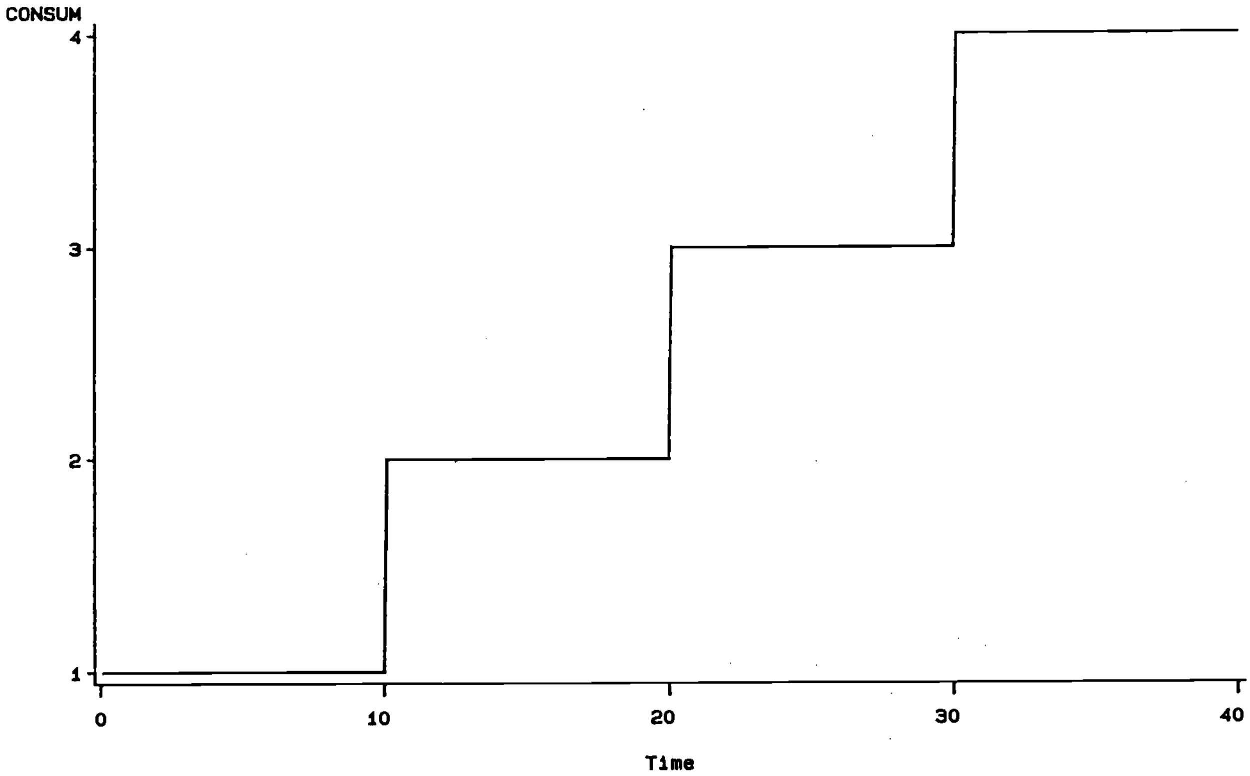
U_c denotes the derivative of the utility function with respect to C, and U_k denotes the derivative with respect to K. In the absence of liquidity constraints, equation (1) is the usual relationship between marginal utilities across periods. With a perfect capital market, the expected marginal utility of consumption is constant over time since $\rho = r$ and μ_t is always zero. In contrast, the expected marginal utility will not be constant in the presence of binding liquidity constraints. In conjunction with equation (3), equation (1) implies that in the presence of liquidity constraints the expected marginal utility of nondurable consumption cannot be rising over time (Heller and Starr (1979)). If the liquidity constraint is binding at the end of period t, so that μ_t is strictly positive, then the expected marginal utility of nondurable consumption declines from period t to period t+1. Concavity of the utility function implies that nondurable consumption must be expected to increase over time. Figure 1, taken from Heller and Starr (1979), shows a typical consumption plan in the case where there are no durable goods. It is assumed that the bulk of income is not received during the early periods and that the consumer has perfect foresight. The path consists of periods of constant nondurables consumption with increasing consumption between stages. At the end of the transition periods, 10, 20, and 30, the consumer has run net assets to zero because he knows income will increase in the next period. Heller and Starr discuss the optimal path for nondurable consumption in detail.

The introduction of durables adds interesting facets to the consumer's problem. Equation (2) above sets the marginal utility of durables equal to the marginal cost, where the marginal cost is measured by the weighted difference in the marginal utility of nondurables from one period to the next, as well as the value of the Lagrange multiplier at the end of the period. The informational content of durable stocks is best seen by combining equations (1) and (2) to yield:

$$(5) \qquad U_c(t) = \frac{1+r}{r+\delta}\frac{1}{P_d}U_k(t) + \frac{\varphi(1+r)-(1-\delta)}{r+\delta}\mu_t.$$

When μ_t is zero in equation (5), we obtain the usual equality between the marginal rate of substitution between nondurable and durable goods and their relative price, $\frac{1+r}{r+\delta}P_d^{-1}$. Nonzero values of μ_t, in contrast, affect the intratemporal relationship between the two goods in period t because they alter the shadow price of durables relative to nondurables. How that shadow price is altered depends on the financeability of durables. If φ is zero, the consumer

Figure 1
Nondurable Consumption in the Presence of Liquidity Constraints



cannot borrow to purchase durable goods, and the coefficient on μ_t is negative. Hence, during a period when the consumer runs his financial assets to zero, the marginal utility of nondurables will be low relative to the marginal utility of durables. Concavity of the utility function implies that nondurable consumption will be high relative to durable consumption.

The intuition for this result is as follows. Suppose the consumer learns that he will experience a substantial increase in income in the following period. The optimal policy is to run financial assets to zero this period, because the shadow price of liquidity, μ_t, is high this period relative to next period. Because this shadow price is high this period, it is optimal to substitute from durables into nondurables. The nature of durables (that they yield their services slowly) and the assumption that they are not counted as assets, leads to this result. With borrowing constraints, the durable goods must be paid for "up-front," even though the utility yield of durables extends over many periods. Thus, when the borrowing constraint is binding, the user cost of durables this period is very high because durables employ liquid assets which could be used to increase nondurable consumption. Thus, the optimal policy is as follows: in the current severely liquidity constrained period, the consumer should liquidate some of his durables in order to finance nondurables consumptions; next period when income increases, the consumer can then invest in durables. Thus, durable consumption falls temporarily in anticipation of a rise in income.

The nature of the optimal path changes dramatically as φ approaches one. When durables are fully financeable, the coefficient on μ_t in equation (5) is equal to one. In this case, the consumer *increases* his durables stocks in the period before the increase in income. The consumer finds it optimal to do this because although he can begin to enjoy the benefits of the durables this period, he does not begin to pay the rental cost (consisting of interest and depreciation) until the following period.

Further algebraic manipulation of equations (1) and (5) demonstrates why durables have predictive power for nondurables in the presence of liquidity constraints. Consider the resulting equation:

$$(6) \qquad U_c(t+1) - U_c(t) = -\mu_t + \varepsilon_{t+1}$$

$$= -\frac{r+\delta}{\varphi(1+r)-(1-\delta)}\left[U_c(t) - \frac{1+r}{r+\delta}\frac{1}{P_d}U_k(t)\right] + \varepsilon_{t+1}.$$

ε_{t+1} is an expectational error and is uncorrelated with information available at time t. If liquidity constraints are never binding, so that μ_t is always equal to zero and the term in brackets in equation (6) is always equal to zero, no information available in period t can predict the change in the marginal utility between periods t and t+1 (Hall (1978)). If, however, liquidity constraints are binding in some periods, then the deviations from the lagged linear combination of $U_c(t)$ and $U_k(t)$ will have predictive power for $\Delta U_c(t+1)$; these deviations, in fact, are proportional to the value of the Lagrange multiplier on the borrowing constraint. This relationship is the key theoretical result and testable implication of our paper; in this model, it is logically equivalent to the presence of a binding liquidity constraint.

The set of equations derived above is equivalent to an error correction framework, as long as the Lagrange multiplier μ_t is stationary. This result is easily demonstrated by noting several characteristics of the equations. First, the standard result given in equation (1) implies that the first difference of the marginal utility of nondurable consumption is stationary and integrated of order zero (I(0)). Thus, the marginal utility of nondurable consumption is integrated of order one (I(1)). It is easy to show that the marginal utility of durables has the same characteristics. Second, equation (5) implies that a particular linear combination of the marginal utilities of the two kinds of consumptions is also stationary, since the ratio of the marginal utilities should always equal the ratio of prices, which are currently assumed to be constant. Hence, the marginal utility of nondurables should be cointegrated with the marginal utility of durables. Therefore, it follows that equation (6), which is derived directly from equations (1) and (5), is an error correction model, where the error correction term is the expression in brackets. The equation shows that the change in consumption responds to last period's deviation from the cointegration relationship, which is proportional to the Lagrange multiplier. Unlike the familiar treatment where the error correction equation is an outcome of optimization under adjustment costs, the error correction mechanism here comes from optimization in the face of liquidity constraints.

Figures 2, 3, and 4 illustrate optimal paths of nondurables and durables for various income paths and different values of φ, under the assumption of perfect foresight. In each case, the utility function is $\log(C_t) + .2 \log(K_t)$, the period length is taken to be a month, the annualized rate of interest and rate of time preference are five percent, and the annual depreciation rate of durables is 20 percent.

Figure 2 shows the optimal paths when $\varphi = 0$, so that the consumer cannot borrow to buy durables, and when income is received in three lumps. Income is received in months 1, 25, and 49, as shown in the first panel of Figure 2. The second panel shows the optimal path of durables and nondurables. Eight months before the arrival of income the consumer begins decumulating his durable stocks and increasing his nondurable expenditures.[2] This policy is optimal because, as shown in the bottom panel of the figure, the Lagrange multiplier becomes positive and begins increasing for eight months before the arrival of the income. In every period in which the multiplier is positive, financial assets are equal to zero. The multiplier hits its peak in the month before income is received, that is, in months 24 and 48.

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[2]The eight month figure is specific to the parameter values chosen for the example, and is not a general result.

Figure 2
Financial Asset Constraint
Lump-Sum Income Path

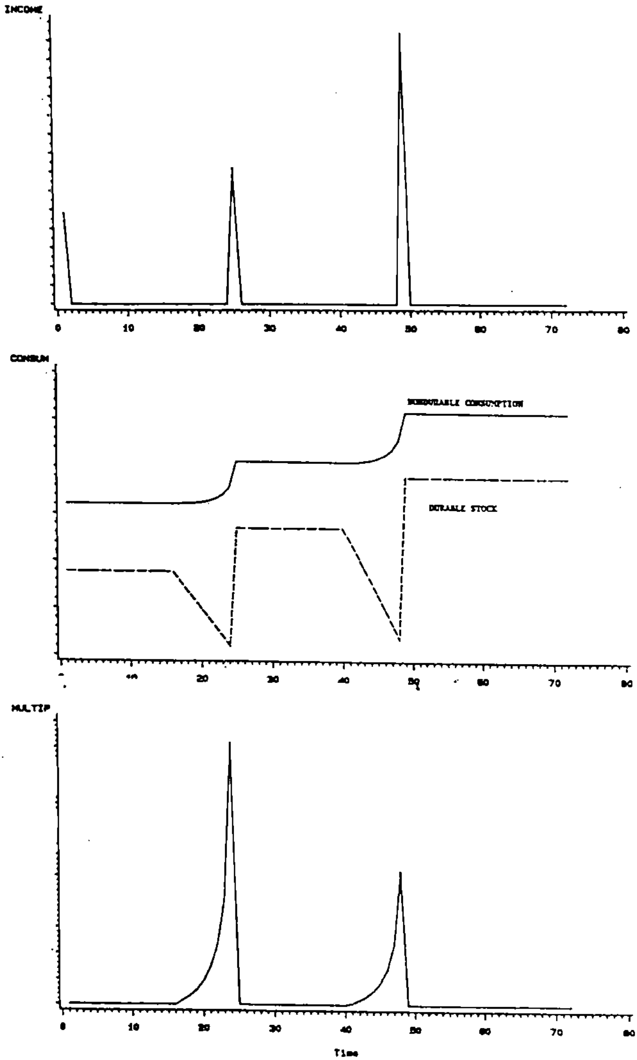


Figure 3 shows the optimal paths of consumption when φ is still zero, but the income path changes. In this case, the consumer faces a steady flow of income, with a raise every two years. The second panel shows that the paths of both nondurables and durables are starkly different from the previous case. The paths differ so much because of the time path of income. In the situation depicted in Figure 3, the consumer must slowly build up his durable stock after a rise in income, because the increase is spread out over a two year period and he cannot borrow against future income. Nondurable consumption rises relatively smoothly in every period, since some of the liquidity during the early periods after a raise is spent accumulating durables. The decumulation effect for durables, however, is still evident in the four months before a rise in income, as the consumer substitutes out of durables into nondurables. The third panel shows that the multiplier is always positive, so that financial assets are always at zero. The consumer maintains his financial assets at zero because he knows that income in the future will never be lower than it is today.

Figure 4 demonstrates the effect of allowing the consumer to borrow to purchase durables. Here φ is equal to 1. The income path assumed is identical to the one in Figure 3; in this case, changing to a lump sum path does not substantially change the nature of the consumption trajectories. The key aspect to note in the second panel is that while nondurable consumption jumps simultaneously with income, the durable stock jumps to its new level one period earlier. As explained above, this effect is due to the assumption that the consumer begins paying the debt service on durables in the month after purchase. We believe this timing structure is consistent with many credit arrangements; payments are due monthly and start in the first month after purchase. Not shown in the figure are the paths for financial net worth and total net worth. Financial net worth is negative and decreasing most of the time. Total net worth starts out positive, declines to zero in period 24, remains at zero through period 48, and then begins to rise.

Figure 3
Financial Asset Constraint
Flow Income Path

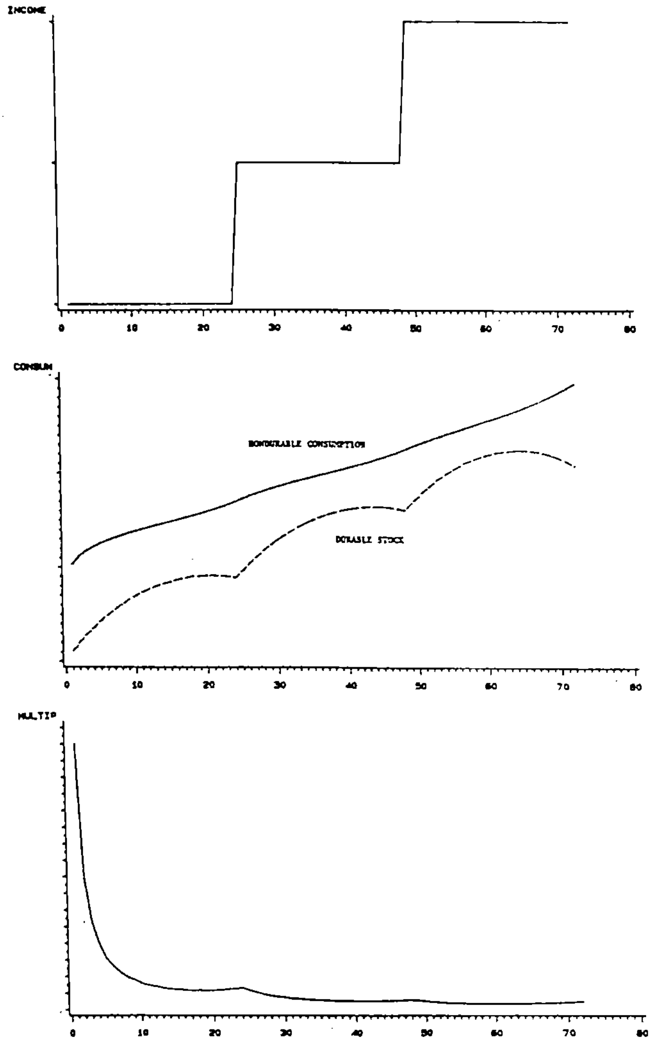
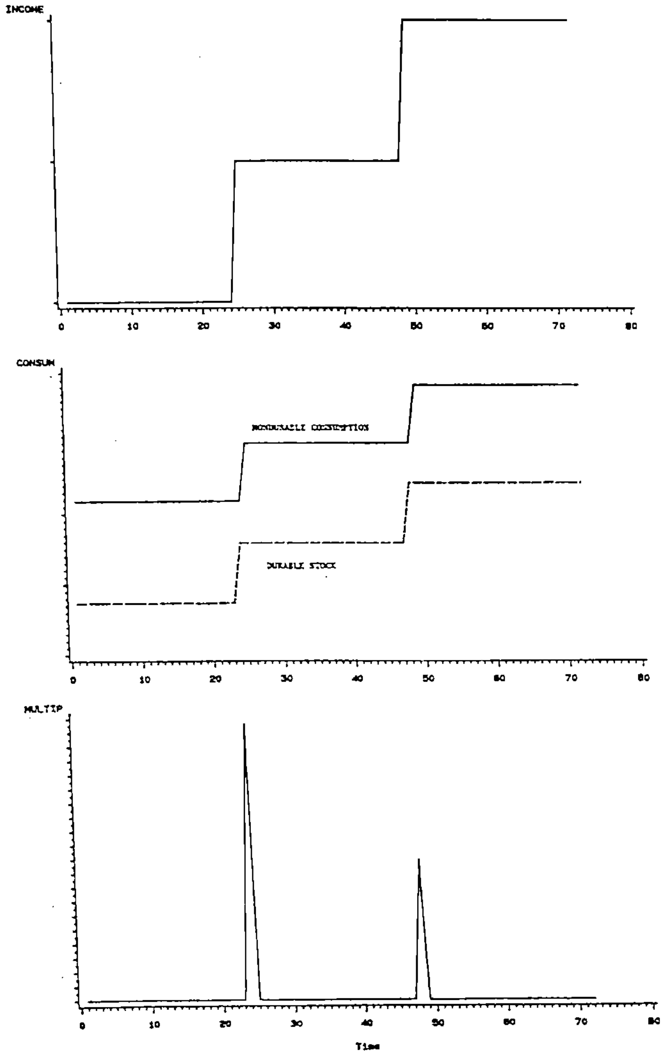


Figure 4
Total Asset Constraint
Flow Income Path



The three figures just presented illustrate the theoretical results discussed above: that under various forms of liquidity constraints, the stock of durables and its relationship to current nondurable consumption has predictive power for the future change in nondurable consumption. In the next section we will show that the insights gained from the simple case continue in a more complicated economic environment.

1.2 Generalization of the Theory

In this section we derive the stochastic implications of liquidity constraints under more general assumptions. We now assume non-constant relative prices and variable interest rates.

The Lagrangian for the more general model is:

$$L = E_0 \sum_{t=0}^{\infty} (1 + \rho)^{-t} \{ U[(1 + r(t-1))A_{t-1} + Y_t - P_d(t) (K_t - (1-\delta)K_{t-1})$$

$$- A_t, K_t] + \mu_t [A_t + \varphi P_d(t) K_t]\}.$$

In the general problem, the necessary conditions are:

$$(1') \quad E_t \frac{1+r(t)}{1+\rho} U_c(t+1) = U_c(t) - \mu_t,$$

$$(2') \quad U_{k,t} = P_d(t) [U_c(t) - \frac{1-\delta}{1+\rho} E_t((1+\pi(t+1)) U_c(t+1))] - \varphi P_d(t) \mu_t,$$

$$t = 1,2,...$$

where $1+\pi_{t+1}$ equals $P_d(t+1)/P_d(t)$, the gross inflation rate of the relative price of durables.

The slackness conditions are identical to the ones in Section 1.1. Equations (1') and (2') are similar to those presented earlier. The key difference is that the relationships between the marginal utilities of consumption have variable coefficients that depend on relative prices and interest rates.

In order to derive implications without specifying a general equilibrium model, we assume that both r(t) and $P_d(t+1)$ are known at time t. Without this assumption, we would have to specify the conditional covariances between r and P_d on the one hand, and the marginal utility of nondurables on the other. Note that r_t is the real interest rate on assets held between period t and t+1. With these assumptions, equations (5) and (6) from the simple case presented above become:

$$(5') \qquad U_c(t) = \frac{1+r(t)}{R^k(t)} \frac{1}{P_d(t)} U_k(t) + \frac{\varphi(1+r(t))-(1-\delta)(1+\pi(t+1))}{R^k(t)} \mu_t.$$

$$(6') \qquad U_c(t+1) - \frac{1+\rho}{1+r(t)} U_c(t) = \frac{1+\rho}{1+r(t)} \mu_t + \varepsilon_{t+1}$$

$$= -\frac{1+\rho}{1+r(t)} \frac{R^k(t)}{\varphi(1+r(t)) - (1-\delta)(1+\pi(t+1))} [U_c(t) - \frac{1+r(t)}{R^k(t)} \frac{1}{P_d(t)} U_k(t)] + \varepsilon_{t+1}.$$

where $R^k(t) = 1+r(t)-(1-\delta)(1+\pi(t+1))$. These equations yield the same basic insight: when liquidity constraints are binding, the lagged relationship between durable stocks and nondurable flows has predictive power for the future change in the marginal utility of nondurables. The relationship is the term in square brackets, now stated to include variable prices. When φ is unity, the relationship should enter with a time-varying coefficient of negative $\frac{1+\rho}{1+r(t)}$, since the expression involving φ is equal to $R^k(t)$; when φ is zero, the relationship should enter with a time-varying positive coefficient.

Two potential factors, not yet discussed, could alter the predictions discussed above. The first is the relative illiquidity of durables. Due to "lemons" problems, a resale of a durable good usually leads to a capital loss. Thus, in the case when φ is substantially below one, consumers would not decrease their durable holdings as much as the theory would predict. This effect would lead to a smaller correlation than predicted. The second factor is the possibility of adjustment costs on durables (Bernanke (1985), Bertola and Caballero (1990)). If consumers take time to adjust their holdings of durables or follow S-s rules, then the lag structure of the relationship would be altered. In this case, the lagged relationship between durables and nondurables would have predictive power for the change in the marginal utility of durables. It should be noted, however, that in the absence of liquidity constraints, adjustment costs do not lead the durable-nondurable relationship to predict the change in nondurables.[3] Hence the testable implications of the liquidity constraint theory are distinct from an adjustment cost model.

In sum, this section has shown that the introduction of variable prices and interest rates do not change the conclusions of the earlier section. The next section presents empirical tests based on the theory.

2. Empirical Test

The theoretical section suggests a simple empirical exercise: determine whether the deviations from the long-run relationship between durable stocks and nondurable flows have predictive power for future changes in nondurable consumption. Although this test is simple in principle, complications arise in the empirical implementation. We will discuss these complications in the following section.

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[3]Adjustment costs on durables could lead lagged consumption to predict future consumption if the utility function were nonseparable in durables and nondurables. Bernanke (1985), however, tested this hypothesis, but could find no evidence to support these effects.

2.1 Empirical Implementation

A. Level of Aggregation

Ideally, one would test the theory using household data. Unfortunately, no available data set contains all of the data required. The Panel Study of Income Dynamics (PSID) (used by Hall and Mishkin (1982) and Zeldes (1989)) and the Survey of Consumer Finances (used by Flavin (1991)) do not contain information on the holdings of durable stocks. Other micro data sets that include both durables and nondurables do not consist of panels covering at least two adjacent periods. Thus, we are forced to use aggregate data, until the micro data becomes available. We feel that while the theory is best tested on micro data, the aggregate data can nonetheless provide some insight into whether the effects are present.

Macroeconomists typically use the representative agent framework to reconcile micro models with aggregate data. That framework, however, depends crucially on the assumption of perfect capital markets. When the permanent income hypothesis is the null hypothesis, the representative agent assumption is valid. If liquidity constraints are present, though, one can no longer appeal to the representative consumer inasmuch as differences in asset positions across agents will imply differing liquidity and corresponding differing shadow prices of borrowing.

What then, can be learned from aggregate data about the nature of liquidity constraints? The model in Section 1 assumes that all households face liquidity constraints, but they differ in the date at which the constraint is binding. Then all households satisfy the behavioral equations in the last section, whether or not facing a currently binding constraint. Those whose constraints are not currently binding will have zero values of μ_t in the relevant equations. Thus, the conditions for aggregation are similar to those discussed by MaCurdy (1986). In particular, we must first assume that the individual-specific component of consumption is distributed independently across consumers, and is independent of the time component. Second, we require conditions under which the average of the marginal utility function can be written as the function of the averages of consumption. In the case in which the function is logarithmic, the conditions involve the time invariance of higher moments of the cross-section distribution of consumption (MaCurdy (1986)). If these conditions are satisfied, then aggregate data can be informative.

B. Specification of Marginal Utilities

We assume that the utility function takes the CES form:

$$U = C_t^{1-1/\alpha}\eta_t + K_t^{1-1/\beta}v_t,$$

where α and β are parameters, and η and v are shocks to the utility function that are observable to the agents but unobservable to the econometrician. The possibility of the existence of shocks to the utility function is important for the choice of estimation method, and will substantially complicate the analysis. Implicit in this functional form is the assumption that durables and nondurables are separable in the utility function. This assumption is consistent with Bernanke's (1985) findings for aggregate data.

With this functional form, the key equations from the last section become:

$$(1'') \quad \frac{1+r(t)}{1+\rho}\left(\frac{C_{t+1}}{C_t}\right)^{-1/\alpha}\frac{\eta_{t+1}}{\eta_t} = 1 - \frac{\mu_t}{(1-1/\alpha)\ C_t^{-1/\alpha}\eta_t} + \varepsilon_{t+1}$$

$$(5'') \quad \frac{1+r(t)}{R^k(t)}\frac{1}{P_d(t)}\frac{(1-1/\beta)K_t^{-1/\beta}v_t}{(1-1/\alpha)C_t^{-1/\alpha}\eta_t}$$

$$= 1 - \frac{\varphi(1+r(t))-(1-\delta)(1+\pi(t+1))}{R^k(t)} \frac{\mu_t}{(1-1/\alpha)C_t^{-1/\alpha}\eta_t}$$

For convenience we take logarithms of the equations above and use the approximation ln(1 + x) ≅ x, for small x. In this case x involves either the expectational error ε and the term involving μ_t, or the real interest rate r, all of which should be small. In logs, the first-order condition for nondurable consumption is:

$$(7) \qquad \Delta \ln C_{t+1} = \text{constant} + \alpha r_t + \alpha \Delta \ln \eta_{t+1} - \alpha \varepsilon_{t+1} + \alpha \frac{\mu_t}{(1-1/\alpha)\ C_t^{-1/\alpha}\eta_t},$$

while the cointegration relationship between durable stocks and nondurable flows is:

$$(8) \qquad \ln C_t = \text{constant} + \alpha/\beta \ln K_t + \alpha \ln P_d(t) + \alpha \ln R^k(t) - \alpha\, r_t$$

$$+ \alpha \ln \eta_t - \alpha \ln v_t - \alpha \frac{\varphi(1+r(t))-(1-\delta)(1+\pi(t+1))}{R^k(t)} \frac{\mu_t}{(1-1/\alpha)C_t^{-1/\alpha}\eta_t}.$$

The resulting error correction model is:

$$(9) \qquad \Delta \ln C_{t+1} = \text{constant} + \alpha\, r_t + \alpha \Delta \ln \eta_{t+1} - \alpha \varepsilon_{t+1} - \frac{R^k(t)}{\varphi(1+r(t))-(1-\delta)(1+\pi(t+1))} Z_t,$$

where Z is the error correction term, specified as follows:

$$(10) \qquad Z_t = \alpha \ln \eta_t - \alpha \ln v_t - \alpha \frac{\varphi(1+r(t))-(1-\delta)(1+\pi(t+1))}{R^k(t)} \frac{\mu_t}{(1-1/\alpha)C_t^{-1/\alpha}\eta_t}.$$

Note that if φ is close to 1 then the expression $\varphi(1+r(t))-(1-\delta)(1+\pi(t+1))$ is equal to $R^k(t)$, so that the coefficient on the error correction term is a constant parameter.

These equations show how the introduction of unobservables in the utility function complicates the analysis. Suppose that both η_t and v_t are stationary or trend stationary. Under this assumption, the cointegrating relationship between durables and nondurables should still hold, but the error term of the cointegrating equation will contain not only μ_t but also η_t and v_t. The presence of the additional elements will not affect the consistency properties of the estimates of the cointegrating vector, but will affect the inferences derived from the error correction equation. To be specific, even in the absence of binding liquidity constraints, the error correction term may have predictive power for the change in nondurables, because the error correction term, which contains ln η_t, may be correlated with the error term in equation (9), which contains $\Delta\ln\eta_{t+1}$. If ln η_t is white noise, the correlation between ln η_t and $\Delta\ln\eta_{t+1}$ will be -0.5. Thus, if we allow for the presence of unobservables in the utility function, we must estimate the error correction equation (9) using instruments for the error correction term that are not correlated with $\Delta\eta_{t+1}$ or ε_{t+1}.

The cointegration relationship breaks down if one or both of the unobservable shocks is not stationary (and not cointegrated). In this case, no linear combination of durables, nondurables, and prices will be stationary, so we cannot estimate an error correction model. The estimation equation can, however, be modified to allow for the nostationarity. Taking first differences of (7) and (8), and assuming that the fraction involving R^k and φ is approximately constant, we combine the equations to yield:

(11) $\Delta\ln C_{t+1}$

$$= \text{constant} + \Delta\ln C_t + \alpha\Delta r_t + \alpha\Delta\ln\eta_{t+1} - \alpha\Delta\ln\eta_t - \alpha\Delta\varepsilon_{t+1}$$

$$- \frac{R^k(t)}{\varphi(1+r(t))-(1-\delta)(1+\pi(t+1))}[\Delta \ln C_t - \alpha/\beta \, \Delta \ln K_t - \alpha \, \Delta \ln P_d(t)$$

$$- \alpha \, \Delta \ln R^k(t) + \alpha \, \Delta r_t - \alpha \Delta \ln \eta_t + \alpha \Delta \ln v_t].$$

This first-difference version contains the same basic results as the error correction equation. If φ is near one, then the change in nondurable consumption will depend negatively on the lagged change in nondurable consumption and positively on the lagged change in the durable stock. If φ is equal to one, then the lagged change in nondurable consumption does not enter, since the terms involved cancel. On the other hand, if φ is small the change in nondurable consumption depends positively on the lagged change in nondurable consumption and negatively on the lagged change in the durable stock. In either case, the lagged changes have predictive power for the change in nondurable consumption. The unobservable shocks η and v in equation (11), however, still demand an instrumental variables procedure.

In the estimation, we will estimate a general error-correction model, augmented by lagged differences in the consumption variables. The inclusion of these lags can account for the presence of nonstationarity as well as any additional dynamics resulting from adjustment costs. The estimating equation is specified as follows:

$$(12) \quad \Delta \ln C_t = \text{constant} + \theta_1 r_t + \theta_2(t) Z_{t-1} + \theta_3 \Delta \ln C_{t-1} + \theta_4 \Delta \ln K_{t-1},$$

where r_t is the real interest rate for nondurable consumption, Z is the error correction term from the cointegrating equation, C is nondurables consumption, K is the stock of durables. and τ_t is the error term containing ε_t and $\Delta \ln \eta_t$. Note that we allow θ_2, the coefficient on the error correction term, to be a function of time. The theory predicts the following relationship between θ_2 and φ:

$$\text{(13)}\quad \theta_2(t) = -\frac{R^k(t)}{\varphi(1+r(t))-(1-\delta)(1+\pi(t+1))}.$$

If φ is equal to one, then θ_2 will be a constant, equal to minus one. We will estimate two versions of equation (12). We will first estimate equation (12) under the assumption that θ_2 is a constant. If θ_2 is significantly different from zero, we will then estimate equation (11) using nonlinear instrumental variables, treating φ as a parameter in the nonlinear coefficient specified in (12). The reason for estimating the linear relationship first to determine whether the coefficient is nonzero is that there exists no value of φ for which θ_2 is zero.

The theory has several predictions on the signs of the coefficients. As in the standard case, the coefficient on the real interest rate should be positive. The sign on the other coefficients depend on the value of φ. First, if φ is near one, and if the lagged differences are also important, the coefficient on $\Delta\ln C_{t-1}$ should be zero or negative and the coefficient on $\Delta\ln K_{t-1}$ should be positive. Alternatively, if φ is near zero, the coefficient on $\Delta\ln C_{t-1}$ should be positive and the coefficient on $\Delta\ln K_{t-1}$ should be negative.

In contrast, a pure permanent income hypothesis model should find ΔC_t to be unpredictable, so that RHS variables dated t-1 or earlier (including the error-correction term) should not generally be statistically significant. A Keynesian rule-of-thumb model would include a measure of disposable income on the RHS, and should similarly find lagged variables insignificant after extracting the effect of current disposable income.

2.2 Empirical Results

A. Characteristics of the Data

We use monthly data from 1959:1 to 1989:12 for real per capita personal consumption expenditures and disposable income, as well as the real per capita net stock of durables, split into motor vehicles and parts and all other. Motor vehicles and motor vehicle parts are combined into a single aggregate denoted *cars*. Non-auto durables constitute the aggregate *other durables*. The durables stock is constructed using the Bureau of Economic Analysis data on durable stocks; see the data appendix for details. Typically, the literature aggregates nondurables and services to form one consumption good. Evidence presented by Ghose (1990), however, shows that this aggregation is invalid because the prices of nondurables and services are not cointegrated. We therefore separate nondurables and services. We use monthly data because we believe the monthly frequency corresponds most closely to the frequency at which consumers make decisions. Debt service on consumer debt is paid at monthly intervals, so the effect of variation in the immediacy of liquidity constraint should be evident at this frequency.

The other variables used are the commercial paper rate, the implicit price deflators for nondurables expenditures, services expenditures, new car expenditures, and durable goods expenditures, and the real price of refined petroleum. All variables were taken from Citibase.

We first examine the time series properties of the variables. This preliminary analysis is important for determining the order of integration of the variables, as well as the nature of the unobservable shocks. Table 1 presents augmented Dickey-Fuller tests and Table 2 presents correlations of first differences of the variables. Consider first the consumption expenditure and income series, given in the first three rows of Table 1. The test statistics in the first two columns show that whether trends are included or not, we cannot reject a unit root. On the other hand, we can reject the presence of a second unit root, based on the test statistics given in the third and fourth columns for the first differences. Thus, we characterize consumption expenditure variables and the income variable as integrated of order one.

The statistics are not so clear for the three durable stock variables (all durables, cars, other durables). When no trend is included, one cannot reject a unit root for any of the

Table 1
Unit Root Tests

Variable (in logs)	ADF Test on levels		ADF Test on differences	
	no trend	with trend	no trend	with trend
Services	-2.12	-1.01	-9.63	-9.86
Nondurables	-0.953	-1.79	-8.56	-8.57
Income	-1.09	-1.36	-8.50	-8.55
Durable Stock	-0.162	-3.19	-2.374	-2.33
Motor Vehicles	-0.405	-2.35	-3.100	-3.071
Other Durables	0.0051	-4.27	-2.082	-2.068

The critical values are: at the 5% level, 2.88 without trend and 3.43 with trend; at the 10% level, 2.57 without trend and 3.13 with trend. Four lags were included in each test.

variables. With a trend included, one can reject a unit root in the case of the total durable stock and the other durables. However, as shown in the third and fourth columns, for the first difference of the total durable stock and the other durables, one cannot reject a unit root. Thus, the other durable stock is apparently integrated of order two, while the stock of cars is integrated of order one.

Table 2 shows the autocorrelations for the first four monthly lags of the differences. Several characteristics of the variables are noteworthy. First, contrary to the pure permanent income hypothesis (absent observable shocks to utility), the first difference of nondurable consumption is not white noise. For both services and nondurables, the first autocorrelation is significantly negative. On the other hand, the correlation with the second lag is essentially zero. Further autocorrelations for services are insignificant, while the third autocorrelation is slightly positive in the case of nondurables. The last three rows show the correlation for the durables stocks. The high positive correlation of the change in durables stocks excluding motor vehicles at the the first and second lags is consistent with the finding of a unit root in the differences. The correlations for the motor vehicle and parts stock, while still positive, are somewhat lower.

Recall that the liquidity constrained consumption theory above implies cointegration of nondurables or services with durables. Since the results suggest that the other durable stock has a different order of integration from nondurables, for the remainder of the analysis cars will be the durable goods aggregate used.

Table 3 presents results on cointegration. The cointegrating relationship is estimated using ordinary least squares, and the test statistics are Granger-Engle tests using four lags. The first two columns test for cointegration between nondurables or services on the one hand and the set of variables consisting of a linear trend, the stock of cars, and the relative price of nondurables or services to the price of cars. All the coefficients in the regression have the

Table 2
Autocorrelations

Variable (in logs)	Correl. of $\Delta x_t, \Delta x_{t-1}$	Correl. of $\Delta x_t, \Delta x_{t-2}$	Correl. of $\Delta x_t, \Delta x_{t-3}$	Correl. of $\Delta x_t, \Delta x_{t-4}$
Services	-0.190 (-3.70)	0.034 (0.64)	-0.022 (-0.41)	-0.054 (-1.04)
Nondur.	-0.380 (-7.89)	0.048 (0.93)	0.108 (2.10)	-0.066 (-1.28)
Income	-0.086 (-1.65)	-0.148 (-2.87)	0.012 (.230)	-0.016 (-0.314)
Durable Stock	0.925 (47.3)	0.880 (35.7)	0.840 (27.9)	0.820 (28.7)
Motor Vehicles	0.832 (28.8)	0.723 (20.1)	0.648 (16.3)	0.636 (15.8)
Other Durables	0.978 (92.4)	0.966 (74.0)	0.948 (59.6)	0.932 (51.1)

t-statistics in parentheses

Table 3
Cointegration Tests

Independent Variables	Dependent Variable: Services	Nondurables	Services	Nondurables
Constant	2.81 (36.9)	2.46 (29.7)	2.79 (34.7)	2.76 (21.2)
Trend	.0015 (38.8)	-.0002 (-4.59)	.0016 (36.7)	-.0002 (-3.70)
Cars	0.362 (39.2)	0.441 (30.7)	0.337 (28.4)	0.449 (23.1)
Relative Price	-0.424 (-23.6)	-0.312 (-16.9)	-0.424 (-22.7)	-0.378 (-13.5)
Real Oil Price			-0.78 (-3.3)	0.37 (.089)
Commercial Paper Rate			0.407 (1.15)	1.41 (2.87)
Dependent Var. Price Inflation			0.572 (1.83)	0.211 (1.24)
Car Price Inflation			0.240 (4.14)	0.224 (2.71)
R^2	0.998	0.985	0.998	0.986
Test Statistic	-4.46	-3.06	-4.07	-3.06

Critical values for 3 variables plus a trend are -4.15 for the 5% level and -3.85 for the 10% level. t-statistics are reported in parentheses, but are not valid because of serial correlation.

predicted signs, with nondurables or services moving positively with the stock of cars, and negatively with the relative price of nondurables or services to cars. According to the test statistics, one can reject noncointegration in favor of cointegration in the case of services. Thus, except for a deterministic trend, the marginal rate of substitution between services and cars is equal to the relative price in the long-run. On the other hand, one cannot reject noncointegration at the usual significance levels for nondurables. This result might be attributable to a nonstationary unobservable shock to the marginal utility of nondurables, or to the notorious low power of cointegration tests. Columns (3) and (4) show the results when we include variables that might enter the rental cost of durables. These variables are a nominal interest rate, measured by the commercial paper rate, the inflation rate of the price of the dependent variable, and the inflation rate of car prices. We have also added real oil prices, since Caballero (1991) has had some success with this variable. As shown by the R^2's and test statistics, these variables do not substantially change the conclusions from the simple model.

We now summarize the findings of this subsection. We first found that nondurable consumption, service consumption, and the stock of cars are integrated of order one. Since the evidence points to two unit roots in the case of the other durable stock, we do not use it in the subsequent analysis. We also found that the growth rates of nondurable consumption and services were negatively correlated with the first lag, and were not highly correlated with other lags. Thus, we can already reject the pure permanent income hypothesis. Finally, evidence for cointegration is stronger in the case of services than in the case of nondurables.

B. Tests for Liquidity Constraints

This section presents tests of the permanent income hypothesis against the liquidity constraint alternative, and further compares the liqiudity constraint hypothesis to the

Keynesian rule-of-thumb hypothesis. The principal equation estimated is (12). The error correction terms, which are essential regressors below, are the residuals from the equations reported in columns (1) and (2) of Table 3.

We will first present ordinary least squares estimates of the error correction model. These estimates are valid if there are no unobservable shocks and if interest rates are constant. We present them as a first step in analyzing the data.

The estimates are presented in Table 4. The first two columns show the regression of the change in services and nondurables consumed on the error correction term alone. In both cases, the error correction term is significantly negative. Interpreted in the context of our model, the estimates imply that holdings of durables increase in anticipation of a rise in income, suggesting that a significant fraction of durables is financeable. Columns (3) and (4) include one lag of the change in nondurables (or services) and cars. In both cases, all three variables are significant at a level of ten percent or better. Furthermore, the coefficient on the error correction term remains negative, and the lagged change in the dependent variable enters negatively while the lagged change in cars enters positively. Thus, the differences reinforce the effect from the error correction term: they both show that durable stocks increase in anticipation of a rise in consumption of nondurables or services. Furthermore, the sign on the coefficient of the change in cars is opposite the sign of the coefficient on the lagged change in the nondurable, as predicted.

Thus, one can overwhelmingly reject the pure permanent income hypothesis with no unobservable shocks and constant interest rates in favor of a liquidity constraint hypothesis. The pure liquidity constraint hypothesis, however, may be too restrictive. One could argue that the results in Table 4 do not point to liquidity constraints, but rather to unobservable shocks to the utility function or nonconstant interest rates. Even with perfect capital markets if a white noise shock caused the marginal utility of nondurables to increase during period t,

Table 4
Ordinary Least Squares Regressions

Independent Variables	Dependent Variable			
	Δlog S(t)	Δlog N(t)	Δlog S(t)	Δlog N(t)
Constant	0.002 (11.0)	0.001 (2.75)	0.002 (6.57)	0.0006 (1.05)
Error correction term (t-1)	-0.049 (-2.28)	-0.108 (-3.90)	-0.037 (-1.70)	-0.068 (-2.34)
Dependent Variable (t-1)			-0.196 (-3.68)	-0.339 (-6.66)
Δlog cars(t-1)			0.187 (2.75)	0.245 (1.86)
R^2	0.014	0.040	.064	.153

t-statistics are in parentheses. Z is the error correction term from the relevant cointegrating equation reported in columns 1 and 2 of Table 3, S denotes services consumption, and N denotes nondurables consumption.

the representative consumer would purchase more nondurables relative to durables during that period. Since the shock would no longer be present in period t+1, the growth rate of nondurable consumption from period t to t+1 would be lower than average. Thus the growth rate from t to t+1 would be negatively related to the error correction term in period t, as well as the lagged value of the dependent variable, as a result of unobservable shock rather than a liquidity constraint.

We attempt to prevent this misconstruction by allowing for variable interest rates and by using an instrumental variables procedure. The set of valid instruments depends on our assumptions about the shock to nondurable utility. Essentially, we are attempting to extract only that part of the error correction term that is correlated with μ_t and uncorrelated with the shocks to utility. If we assumed that the shock was not serially correlated, then any variables lagged two periods or more would be valid as instruments. We are not, however, willing to make such a strong assumption. Instead, we proceed under the following assumptions, based in part on our analysis of the data in the previous section: the current shocks to nondurable (or service) utility are essentially uncorrelated with lagged shocks to durable good utility and financial variables. The instruments used are lags two through six of (1) the log change in real disposable income; (2) the commercial paper rate; (3) the real interest rate, measured as the difference between the commercial paper rate and the inflation rate of either nondurables or services; and (3) the log change in the stock of cars. Note that we do not use lagged values of the change in nondurables, services, or the error correction term as instruments.

Table 5 presents both the linear and nonlinear estimates of equation (12) for services and for nondurables. Consider first the results of the linear estimation reported in Part A. In both equations, the error correction term enters significantly with a negative coefficient, the coefficient on the lagged dependent variable is negative, but not significantly different from zero, and the coefficient on the lagged change in cars is positive and very significant. The

Table 5: Tests for Liquidity Constraints
Instrumental Variables Estimation

A. Linear Estimation.

Explanatory Variables	Dependent Variables	
	Δ log services	Δ log nondurables
Constant	0.0022 (3.25)	-0.0017 (-1.58)
Real interest rate (t)	-0.334 (-1.96)	0.350 (1.84)
Error correction term (t-1)	-0.159 (-2.11)	-0.196 (-2.21)
Dependent variable (t-1)	-0.238 (-1.04)	-0.175 (-0.92)
Δlog cars (t-1)	0.338 (3.23)	0.666 (2.89)
p-value for test of overident. restric.	0.03	0.07

t-statistics are in parentheses. The error correction term is from the relevant cointegrating equation reported in columns 1 and 2 of Table 3. The instruments used are lags two through six of: the log change in real disposable income, the commercial paper rate, the real interest rate (described in the text), and the log change in the stock of cars.

implications of these results are twofold. First, even after extracting the effects of unobservable shocks to the utility function, the lagged behavior of cars and nondurables have predictive power for the change in nondurable consumption. Thus, we can reject the permanent income hypothesis in favor of the liquidity constraint alternative. Second, the sign of the coefficients suggests that the stock of cars rise in anticipation of an increase in nondurable and service consumption. As discussed earlier, this pattern of behavior suggests a high value of φ. We will discuss the value of φ in more detail in the context of the nonlinear estimation below.

With regard to the other aspects of the equations, the equation for nondurables seems more reasonable than the equation for services. The coefficient on the real interest rate has the wrong sign in the equation for services, but the right sign in the equation for nondurables. It is not clear what would lead to this result for services. Furthermore, in the test for overidentifying restrictions, one can reject the restrictions for services at the three percent level or higher, while one can reject the restrictions at the seven percent level or higher for nondurables. Thus, the equation seems to be a better approximation for nondurables behavior.

Part B of Table 5 presents the results of the nonlinear estimation. The estimate of φ is almost identical in both cases, with a value of 1.18 for services and a value of 1.14 for nondurables. The point values are greater than the theoretical range for φ, which is zero to one, but both are within two standard deviations from one. One possible explanation for the very high value of φ is the manner in which φ enters the time-varying coefficient. The absolute value of the coefficient is decreasing in φ and is very steep near the point where φ equals $(1-\delta)(1+\pi)/(1+r)$, since the denominator vanishes at that point. Thus, any misspecification that biases the coefficient to zero will bias the estimate of φ upward. However, we believe that a value of φ near one is consistent with the credit arrangements in

Table 5: Tests for Liquidity Constraints
Instrumental Variables Estimation

B. Nonlinear Estimation

Explanatory Variables/ Parameters	Dependent Variables	
	Δ log services	Δ log nondurables
Constant	0.0022 (3.18)	-0.0016 (-1.57)
φ	1.18 (12.1)	1.14 (14.5)
Coefficent on:		
Real interest rate (t)	-0.336 (-1.97)	0.343 (1.82)
Dependent variable (t-1)	-0.267 (-1.17)	-0.186 (-0.98)
Δlog cars (t-1)	0.346 (3.30)	0.645 (2.88)
p-value for test of overident. restric.	0.04	0.05

t-statistics are in parentheses. The error correction term is from the relevant cointegrating equation reported in columns 1 and 2 of Table 3. The instruments used are lags two through six of: the log change in real disposable income, the commercial paper rate, the real interest rate (described in the text), and the log change in the stock of cars.

existence for new cars. The other aspects of the nonlinear equations are very similar to the results from the linear estimation. The coefficients on the other terms are very similar, and the p-values for the tests for overidentifying restrictions are only slightly different.

In sum, when we test the permanent income hypothesis against a precisely specified alternative hypothesis of liquidity constraints, we can reject the null hypothesis. Furthermore, the values of the coefficients are generally consistent with the alternative theory, and suggest that a large fraction of durables is financeable.

2.3 Tests for Rule-of-Thumb Behavior

The next step is to determine whether the liquidity constraint hypothesis or the Keynesian hypothesis is a better description of the data. Hall (1978), Hayashi (1987), and Campbell and Mankiw (1989) suggest that a model in which a certain percent of the consumers follow permanent income behavior, while the rest follow Keynesian behavior. According to their model, when the change in consumption is regressed on the predictable change in income, the coefficient gives the percent of the consumers who are Keynesian.

We first reproduce the results obtained by Campbell and Mankiw using our data definitions and instruments. We estimate the effect of the current growth rate of real disposable income on the growth rate of services and nondurables, separately, using the instruments employed above. The results are given in columns 1 and 3 of Table 6. In the case of services, the coefficient estimate is 0.203 with a t-statistic of 2.67; in the case of nondurables, the coefficient estimate is 0.288 with a t-statistic of 1.85. These estimates are somewhat lower than those obtained by Campbell and Mankiw, most likely because our data are higher frequency. The estimates we obtain, however, support the hypothesis that consumption is excessively sensitive to predictable changes in income.

Are predictable changes in income still significant when we include them in the

Table 6
Test of Rule-of-Thumb Behavior versus Liquidity Constraints
Instrumental Variables Estimation

Explanatory Variables	Dependent Variables			
	Δ log services		Δ log nondurables	
Constant	0.002 (7.50)	0.0021 (3.14)	0.0005 (1.06)	-0.0015 (-1.32)
Δ log dispos. income (t)	0.203 (2.67)	0.092 (1.06)	0.288 (1.85)	0.062 (0.305)
Real interest rate (t)		-0.292 (-1.74)		0.328 (1.64)
Error correction term (t-1)		-0.130 (-1.71)		-0.172 (-1.45)
Dependent variable (t-1)		-0.219 (-1.00)		-0.189 (-0.978)
Δlog cars (t-1)		0.292 (2.69)		0.601 (1.94)

t-statistics are in parentheses. The error correction term is from the relevant cointegrating equation reported in columns 1 and 2 of Table 3. The instruments used are lags two through six of: the log change in real disposable income, the commercial paper rate, the real interest rate (described in the text), and the log change in the stock of cars.

liquidity constraint model, as the Campbell-Mankiw model would suggest? Columns 2 and 4 of Table 6 present estimates of the linear model estimated in Table 5, with the log change in disposable income added. In both cases the coefficient on income drops precipitously, and is no longer significant. On the other hand, the coefficients on the liquidity constraint terms fall only slightly in absolute value, and generally remain significantly different from zero. These results can be interpreted as a rejection of the Keynesian rule-of-thumb model in favor of a liquidity constraint model. It is neither necessary nor useful to characterize household behavior as rule-of-thumb to account for the data.

We should add that these results are entirely consistent with Wilcox's (1989) tests using increases in Social Security benefits. In all of his specifications, he includes lagged changes in durables and nondurables when he tests for the significance of predictable changes in benefits. According to his Table 2, only durables goods and not nondurable goods are sensitive to predictable changes in benefits. Furthermore, his estimates show that lagged changes of durables predict the change in nondurables.

2.3 Summary

The theory and the results provide the following description of the behavior of consumers. Most consumers are forward-looking in their behavior, and smooth consumption as much as capital markets permit. When they receive news of a future increase in income, they increase their durable holdings in anticipation. They cannot, however, increase their nondurables or services consumption because they cannot finance them. The anticipatory movement of durables contains more information about the current change in the marginal utility of nondurables and services than does the predicted current change in income.

3. Conclusions

We have developed and tested here the stochastic implications of a forward-looking model of rational optimizing consumers subject to liquidity constraints. This paper should be viewed as a contribution to the body of evidence including Flavin (1985), Zeldes (1989), and Jappelli (1990) that argues that liquidity constraints dominate myopia as an explanation for the excess sensitivity of consumption to predictable changes in income. The theoretical model agrees with the LCH-PIH model that households seek to smooth consumption. It differs in that liquidity constraints imply incomplete ability to smooth the variation in consumption due to predictable variation in current income. The presence of a binding liquidity constraint distorts the long-run relationship between durable and nondurable consumption. These deviations from the long-run relationship have predictive power for future changes in nondurables consumption.

Empirical tests of the model confirm the predictions of the theory. The change in nondurable consumption and service consumption are significantly related to the lagged behavior of durables. This is a test of the direct implications of the liquidity constrained model. The addition of predictable changes in income to the model show them to be no longer statistically significant. Consumers are forward-looking, but the horizon over which they can smooth their consumption is limited by capital market imperfections. These results provide evidence against Keynesian rule-of-thumb behavior in favor of forward-looking behavior under liquidity constraints. We demonstrate that the excess sensitivity of consumption to predictable changes in income is attributable to liquidity constraints.

Data Appendix

In this appendix we describe how we constructed the durables stock. For both the case of total durables and motor vehicles and parts, we used the Bureau of Economic Analysis estimates of the end of the year stock. We consider the BEA estimates to be superior those obtained using investment series and assuming constant exponential depreciation. In the case of motor vehicles and parts, the BEA data are quite accurate because they use the Polk data on the number and age of autos registered. For all types of durables, straight-line depreciation schedules are used.

We estimated monthly stocks of durables as follows. In all cases, we used straight-line depreciation. The within-year rate of depreciation of new purchases was assumed constant for all years. We chose the monthly rate of 0.003 for both total durables and motor vehicles and parts, because this was the only value that did not generate spurious seasonality. On the other hand, we allowed the rate of depreciation of carry-over stock from the year before to vary year to year. The value was chosen so that the estimated value of the stock by year end was equal to the BEA value. The estimated monthly straightline depreciation ranged from .0170 to .0191 for all durables, and from .0214 to .0280 for motor vehicles and parts. The stock of durables other than motor vehicle and parts was set equal to the difference of total durables and motor vehicles and parts.

In the theoretical model, we assume exponential depreciation for simplicity. The only case when we must have a value for this depreciation rate, δ, is when we perform the nonlinear estimation. For cars, we choose a value of δ of .028 per month, which is the exponential rate that is the closest approximation to the straight-line rates for within and across years that we estimate from the BEA data.

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