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Consumption

ABSTRACT

Macroeconomic research on consumption has been influenced profoundly by rational expectations. First, rational expectations together with the hypothesis of constant expected real interest rates implies that consumption should evolve as a random walk. Much of the research of the past decade has been devoted to testing the random walk hypothesis and to explaining its failure. Three branches of the literature have developed. The first relies on the durability of consumption to explain deviations from the random walk property. The second invokes liquidity constraints which block consumers from the credit market transactions needed to make consumption follow a random walk when income fluctuates up and down. The third branch dispenses with the assumption that expected real interest rates are constant. It attempts to explain deviations from the random walk in terms of intertemporal substitution.

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## *Introduction and scope*

No specialty in macroeconomics has been more profoundly influenced by the rational expectations revolution than has the study of consumption. From the early 1950s, when the life cycle-permanent income hypothesis came to dominate the profession's thinking about consumption, until the late 1970s, the consumption field was largely dormant. In the following decade, however, a substantial upsurge of new work has occurred. Though almost all of the new work embodies the hypothesis of rational expectations, much more has been added to our thinking than just the simple idea that consumers make consumption plans on the basis of all available information about future income.

My survey of this work will start with the initial impact of rational expectations--the development of the Euler equation characterization of optimal consumption behavior and the empirical tests of it. Tests have been applied by a number of authors using data for the United States and for a number of other countries. Roughly speaking, the Euler equation says that consumption should evolve as a random walk; that is, the change in consumption should not be predictable. The empirical work testing this proposition says, in sum, that consumption is fairly close to a random walk, but certain variables have enough predictive power that the hypothesis is rejected in formal statistical tests.

One interesting branch of the ensuing research has asked whether the predictability of the change in consumption can be explained by the inability of consumers to borrow when income is temporarily low. The investigation of "liquidity constraints" has occupied quite a number of investigators, most of whom have reached the conclusion that liquidity

constraints do help to explain aspects of the data not explained by the simple rational expectations life cycle-permanent income hypothesis. They typically find that most of the movements of consumption are consistent with the simple model; only a minority of consumers are constrained.

Another branch has sought to explain departures from the simple random walk by examining the implications of the durability of consumption goods. Durability turns out to compete with liquidity constraints, in that models containing both features do not rely very heavily on liquidity constraints to explain the predictability of consumption.

The third branch of the literature I will examine considers a more refined version of the Euler equation. As a matter of theory, changes in expected real returns should influence the rate of change of consumption. When asset markets offer high returns, consumers should defer consumption. That is, the rate of growth of consumption of individual households should be positively correlated with the expected return. Rejection of the simple random walk model might be the result of this correlation. However, the aggregation of interest-rate effects is a complicated issue; there is no simple relation between expected real returns and the rate of growth of aggregate consumption

There are some important topics related to consumption that I have excluded from this discussion. In particular, the literature stimulated by Robert Barro's work on Ricardian equivalence is outside my domain. On this, see Bernheim's (1987) survey and synthesis.

## *1. Rational expectations and the Euler equation*

Work on consumption from the time of Keynes' *General Theory* focussed on the development of a consumption function, that is, a structural relation between income (and possibly the interest rate) and consumption.

Friedman's permanent income hypothesis and Modigliani's life-cycle hypothesis were seen as suggestions about the way that income variables might enter the consumption function. The main point was that temporary changes in income should have less impact on consumption than should permanent changes. Probably the most impressive evidence on the point was in Friedman's examination of cross-section data on family income and consumption. When it came to building a consumption function, however, Friedman and his followers (such as Darby (1972)) made consumption a distributed lag of current and past income. Muth (1960) had shown that a geometric distributed lag was optimal under rational expectations only with a certain special stochastic process for income, but the consumption function literature did not pursue this point until many years later. In aggregate U.S. data, the distributed lag from income to consumption had a peculiar feature--either most of the weight applied to current income, or the lag came out to be almost infinitely long.

Ando and Modigliani's empirical consumption function (1963) took a more structural view of expectations. They reasoned that the unemployment rate was an additional variable that the public might consider in deciding whether the current level of real income was representative of its permanent level.

The opening shot in the rational expectations revolution was Robert Lucas' (1976) famous critique of econometric policy models, presented in

1973. The models he criticized consisted of sets of structural equations. One of the three structural equations he found wanting was the consumption function. And his criticism was profound. It was not that the typical consumption function was mis-specified. Rather, he said, there isn't any such thing as a consumption function. There is a structural relation between permanent income and consumption, but the consumption function asserts a structural relation between observed income and permanent income, and there is no reason to expect a stable relation of that type. Changes elsewhere in the economy--for example, in stabilization policy--could alter the optimal way for a consumer to make an inference about permanent income from observed income. Development of consumption functions has little purpose. In particular, a model for policy analysis based on a consumption function is self-defeating.

Though Lucas was scornful of existing econometric policy evaluation models, his message was not completely destructive of all model-building or empirical research. There are structural relationships in the economy, but the consumption function is not among them. For consumption, the structural relation, invariant to policy interventions and other shifts elsewhere in the economy, is the intertemporal preference ordering. The view of consumption that flowed from Lucas' work is that today's level of consumption is the level chosen by consumers so as to maximize expected lifetime utility, given all available information about current and future income and prices. The consumer uses all available knowledge about the behavior of other actors in the economy, including the government, in processing the information.

Lucas' critique of the consumption function was overshadowed by his critique of the Phillips curve, where he generalized and formalized a point

made very effectively several years earlier by Friedman (1968). The next step in the development of the rational expectations view of consumption was Hall's (1978) test of a general implication of Lucas' view. Hall neither tried to repair the traditional consumption function nor estimate the deep parameters of utility. Rather, he formulated a simple empirical test of the idea that consumers maximize the expected value of lifetime utility subject to an unchanging real interest rate. The basic idea is to look at the Euler equation describing the optimal behavior of such a consumer. The Euler equation characterizes the equality of the marginal rate of substitution between consumption this year and consumption next year to the relative price of the two. That relative price is simply the present discounted cost of a unit of future consumption. Mathematically, the consumer seeks to maximize

$$E_t \sum_s \left(\frac{1}{1+\delta}\right)^s u(c_{t+s})$$

subject to

$$\sum_s \left(\frac{1}{1+r}\right)^s (c_{t+s} - w_{t+s}) = A_t$$

The notation is

$E_t$  = mathematical expectation conditional on all information in  $t$ ;

$\delta$  = rate of subjective time preference;

$r$  = real rate of interest, a constant over time;

$u(\cdot)$  = one-period utility function, strictly concave;

$c_t$  = consumption;

$w_t$  = earnings from sources other than savings

$A_t$  = assets apart from human capital.

On the possible relaxation of the assumption of intertemporal separability, see Browning (1986). Derivation of results with constant expected real interest rates in general equilibrium appears in Christiano, Eichenbaum, and Marshall (1987).

The Euler equation expressing the equality of the marginal rate of substitution to the price ratio is:

$$E_t u'(c_{t+1}) = \frac{1+\delta}{1+r} u'(c_t)$$

That is, marginal utility next year is expected to be the same as marginal utility this year, except for a trend associated with the constant rate of time preference,  $\delta$ , and the constant real interest rate,  $r$ . Another way to express the same idea is

$$u'(c_{t+1}) = \frac{1+\delta}{1+r} u'(c_t) + \epsilon_t$$

Here  $\epsilon$  is a random variable whose expectation at time  $t$  (when consumption,  $c_t$ , is being chosen) is zero. In particular,  $\epsilon$  is uncorrelated with  $u'(c_t)$ , so this equation is a regression. If the functional form of  $u(\cdot)$  were known, this equation could be the basis of a test of optimization. For the optimizing consumer, no variable observed in year  $t$  would receive a non-zero coefficient if added to the equation. Were a variable found that helped predict next year's marginal utility, and that variable were known to the consumer at the time  $c_t$  was chosen, then the consumer would be shown to have failed to optimize.



Hall's original work did not try to make use of information about the functional form of the utility function. Instead, he argued that the Euler equation could be approximated closely by assuming a quadratic utility function, in which case it could be written as

$$c_{t+1} = \lambda c_t + \epsilon_t$$

In this framework, the basic test of optimization involves placing additional variables on the right-hand side and computing the t or F-test for their exclusion.

Chang (1987) considered the issue of when simple random-walk relations hold exactly. Zeldes (1986) computed consumption functions numerically with non-negativity constraints and concluded that the quadratic specification can be misleading in some circumstances.

Hall found that lagged real disposable income had little predictive power for consumption; the hypothesis that only  $c_t$  helped predict  $c_{t+1}$  among variables dated t and earlier was accepted. However, he showed that the Euler-equation restriction was rejected for the stock market. The recent change in the real value of the stock market has statistically significant predictive power for the future change in consumption.

Flavin (1981) examined the relation between income and consumption in the rational expectations framework and found sufficient predictive power to reject the strict optimization hypothesis. Her theoretical work involved the development of an explicit structural consumption function, based on the hypothesis that real income obeys a stable stochastic process. Thus, her model itself is subject to Lucas' criticism, which points out

that the stochastic process of income is a result of the interaction of all the actors in the economy and is not a deep structural characteristic of the consumer alone. However, her test turned out to be identical to the type of test proposed by Hall. She found rejection of optimization because she included more lagged values of income than Hall had tried, and because of a few other minor changes.

Flavin's structural model enables her to interpret her findings quantitatively. In her results, the parameter describing the excess response of consumption to the contemporaneous change in income is about 0.36. She pointed out that the relatively small values of coefficients found by Hall on lagged income in the reduced-form consumption regression signify much larger structural coefficients. As a general matter, Flavin found even more evidence than did Hall to reject the pure optimization model with a constant real interest rate.

Goodfriend (1986) pointed out that Flavin's procedure rests on the hypothesis that aggregate income is immediately observable. If, instead, there is a one-quarter lag before aggregate income becomes public, one would expect rejection roughly along the lines found by Flavin.

Mankiw and Shapiro (1985) criticized Flavin's work on the grounds that her detrending procedure would induce the finding of excess sensitivity even if it were absent from the original data. They considered an example in which income is a random walk. Optimal consumption is also a random walk. Hall's test applied to the original data will not reject optimization. However, with detrended data, income and consumption will be cyclical and will flunk Hall's test. They noted that Flavin's test is indecisive in the original data, because income is essentially a random walk before detrending.

Stock and West (1987) challenged Mankiw and Shapiro's interpretation of excess sensitivity as arising from a spuriously detrended random walk. They argued that by detrending a random walk with drift, Flavin induced a change in the large sample distribution from a normal to a nonstandard distribution of the type associated with unit roots. Using theoretical results of Sims, Stock, and Watson (1987), they noted that, in contrast, Hall's original tests based on lagged consumption were valid even with preliminary detrending of the data. The key difference between Hall's and Flavin's procedure is that Hall included lagged consumption as a regressor, whereas Flavin did not. Stock and West presented the results of Monte Carlo experiments to support their argument, which is otherwise based on asymptotic theory. In addition, results obtained by Deaton (1986) cast doubt on the hypothesis that the bias identified by Mankiw and Shapiro can fully explain the finding of excess sensitivity of consumption to income.

Deaton's work also casts doubt on the likelihood of success of models that try to fit a stochastic process to income and then infer the appropriate response of consumption to the innovations in that process. He noted that a non-stationary process for real income--specifically, a first-order autoregressive process in the first difference--seems to provide a reasonable description of the income process. But for that process, the observed response of consumption to an income innovation is much too small, rather than too big. Subtle differences in the income process have major implications for the consumption response. Accordingly, results obtained within a restricted class of income processes may not give reliable statistical tests of the hypothesis of excess sensitivity. Campbell and Deaton (1987) pursued the idea and fitted a number of low-order

ARIMA models of income. Most of them have the property that the innovation in consumption should have a larger variance than the innovation in income. They also reached the same conclusion by examining the autocorrelations of income. However, both of their procedures are biased toward the conclusion that consumption is excessively smooth, so their findings are inconclusive.

West (1986) used a variance bounds technique to examine the question of the relative variabilities of consumption and income. He concluded that the evidence is ambiguous, though possibly it favors excess smoothness of consumption. In a related paper, Christiano (1987) finds that small influences on consumption through intertemporal substitution associated with variations in real returns could explain an apparent excess smoothness of consumption.

Nelson (1987) re-examined Hall's original empirical results and Flavin's later work. He argued that a more reasonable approximation could be achieved by assuming logarithmic utility and a log-normal distribution for later consumption given earlier consumption. He demonstrated that the current change in income is a statistically significant predictor of the coming change in consumption in that framework. Nelson also confirmed that Flavin's strong results on excess sensitivity may be the result of her procedure for detrending the data.

Jacobson (1981) showed that measures of consumer attitudes had predictive power even in the presence of the stock-market value included in Hall's original study.

Miron (1986) showed that the results obtained by Flavin and others rejecting the simple random walk hypothesis could be reversed by using seasonally unadjusted data and an explicit model of seasonal effects, as

opposed to the use of seasonally adjusted data.

Kormendi and LaHaye (1986) carried out tests of the explanatory power of lagged income changes for the current change in consumption for a panel of 30 countries. They failed to reject the hypothesis of no explanatory power for the panel as a whole. Using Flavin's approach, they found that consumption appears to be undersensitive to changes in permanent income.

### *Time aggregation*

Evans (1982), Christiano (1984), and others have pointed out that the data employed to test the Euler equation are time averages, whereas the theory deals with consumption chosen at isolated points in time. Working (1960) derived the time series properties of a time-average of a random walk. The first difference of the time average is a first-order moving average process with a serial correlation of about 0.25. Tests of the Euler equation can be modified to take account of this property--it implies particular coefficients for lagged consumption and invalidates the most recent observation on real income in the test regression. Hall (1987) treated the time aggregation problem at some length, but neither he nor any other author has repeated the Euler equation tests to take account of time aggregation. Estimation problems with time-aggregated data are discussed in detail in Hansen and Singleton (1986).

### *Findings for countries other than the United States*

Daly and Hadjimatheou (1981) repeated Hall's basic Euler equation test using data for the United Kingdom. They found substantial predictive power for lagged disposable income and lagged liquid assets; they rejected the exclusion of those variables from the Euler equation unambiguously. Their work was criticized by Cuddington and Hurd (1981) on the grounds that they presented only the final results of an extensive search for successful predictors. However, Muellbauer (1983) found a similar rejection for the U.K. using only consumption lagged once and income lagged once and twice.

Cuddington (1981) examined Canadian data and found significant predictive power for real money balances, real private wealth, real GNP, and the unemployment rate.

Johnson (undated) rejected the Euler equation optimization condition with Australian data. He found predictive power for certain measures of lagged income and the unemployment rate.

### *Findings in cross-sectional data*

In principle, variations in income and consumption experienced by individual families should provide more powerful tests of models of consumption. However, some of the advantages of the proliferation of observations available in cross sections are lost because of measurement problems. In the U.S., for example, there is no body of data that reports on the total consumption of families in successive years. Much of the

research on U.S. data has been done with data on income and food consumption from the Panel Study of Income Dynamics.

Hall and Mishkin (1982) examined this body of data within the framework of a rational expectations theory of consumption. Their model hypothesizes that consumption at the level of the individual family has a transitory measurement error or other source of noise not explained by the theory. In the presence of such an error, the simple regression test of the Euler equation is restricted: It must impose a unit coefficient on lagged consumption and cannot use further lags of consumption as candidates for failure of the hypothesis of unpredictability. Hall and Mishkin regressed the first difference of food consumption on the lagged change in income and found a coefficient of  $-.010$  with a standard error of  $.002$ . The rejection of optimization is strong statistically, though the magnitude of the departure from the theoretical value of zero is small.

Hall and Mishkin also estimated a structural model of consumption similar to Flavin's. Their model departs from hers in two ways. First, it permits current consumption to respond to the immediate future innovation in income. This modification is suggested by the timing of the data and also by the possibility that families have some advance information about income changes. The results confirm that such advance information is available to families. Second, the model permits a fraction of consumption to move in proportion to actual current income instead of permanent income. If a fraction of the sample is liquidity constrained, their income will move in this way. The results suggest that about 20 percent of consumption is linked to current rather than permanent income. With these two modifications, the model is successful in explaining the entire pattern of covariances of income and food consumption found in the

data.

Hayashi (1985) studied a panel of Japanese households in a similar framework. In addition to food consumption, the panel reports data on four other categories of consumption. Hayashi found that lagged income has significant predictive power for the change in consumption, in contradiction to the Euler equation characterization of optimization. He formulated a more general model to explain the predictive power of income, which included the possibility of liquidity constraints and also the possibility that consumption in one period provides satisfaction in succeeding periods. He incorporates the latter effect by making the utility function depend on a distributed lag of past expenditures. His results show that the durability of consumption is an important part of the explanation of the failure of the simple Euler equation. After taking account of durability, he found a sharp estimate that 15 percent of households are liquidity constrained.

Altonji and Siow (1987) considered the problem of errors in measuring income in panel studies. They show that income measurement errors are important quantitatively, but that the generally favorable findings in panel studies of the life cycle-permanent income model are confirmed when the errors are considered explicitly.

Working with highly detailed data from a Norwegian panel, Mork and Smith (1986) found results generally favorable to the life cycle-permanent income model.



*Restrictions imposed by the rational expectations permanent income model on the joint behavior of income and consumption*

Sargent (1978) was the first to investigate the problem of formulating optimal consumption behavior as a restriction on a general time-series model of income and consumption. However, as pointed out by Flavin (1981), Sargent's version of the permanent income model did not take account of the fact that current saving finances future consumption. As a result, the restrictions he derived and tested were not a satisfactory characterization of optimal consumption. Flavin derived the restrictions implied by the standard permanent income model. The cross-equation restrictions on the coefficients of lagged variables turn out to be exactly those tested by Hall (1978)--the exclusion of all variables other than lagged consumption in the autoregressive representation for consumption. She showed that there are no restrictions operating across the coefficients of the two autoregressions. However, if one interprets the univariate time series model of income literally, in the sense that no lagged variable other than income is useful in forecasting income, the model also implies an important restriction on the covariance matrix of the innovations of consumption and income. That matrix is singular; the two innovations are proportional to one another and the theory relates their constant of proportionality to the coefficients of the income process. Sargent did not consider the restrictions on the covariance matrix. Flavin argued that the singularity should not be expected in actual data, where a more elaborate model would be appropriate. In that model, consumers use information to forecast future income that is not conveyed by the current and past levels of income. Then the innovation in

consumption is not perfectly correlated with the innovation in income, nor does theory prescribe the numerical relation between the two innovations. If people respond to the information contained in other variables in addition to income, the measured correlation of the innovations in income and in consumption should be less than one. It is tempting to interpret the residual in an income autoregression as proportional to the innovation in permanent income. However, if people respond to variables in addition to the ones in the econometrician's right-hand variables, the residual in an income equation will be an error-ridden measure of the innovation in permanent income. Flavin's analysis of the covariance matrix of the income and consumption residuals indicates that the magnitude of the measurement error is far from negligible.

The issue of the singularity of the covariance matrix of a set of variables under certain information assumptions with rational expectations was also considered at a more general level by Hansen and Sargent (1981). Campbell (1986) considered the restrictions imposed by optimal consumption behavior on a three-variable system comprising consumption, labor income, and capital income (the latter defined as the constant expected real interest rate times the level of assets). He showed that the restrictions implied by theory can be stated as parameter restrictions on a vector autoregression. The first restriction is that capital income evolves according to the intertemporal budget constraint with constant expected real interest rate (the actual return *ex post* can be random). This restriction is a statement about the technology, not about consumption behavior. The second restriction is that either the change in consumption, or, equivalently, the statistic

$$s_t - \Delta x_t - (1 + r) s_{t-1}$$

(where  $s_t$  is saving and  $x_t$  is labor income) is unpredictable. This statistic is the innovation in consumption plus the innovation in capital income, so it is unpredictable for essentially the same reasons that the change in consumption is unpredictable.

Campbell's test is close to a test of the unpredictability of consumption changes, and has the same partial character because he does not test the constancy of expected real rates. The advantage of his framework is that it can be used to assess the quantitative importance for savings behavior of deviations from the permanent income theory.

Campbell also made the interesting observation that the level of saving can be written as the present discounted value of expected future declines in non-capital income. That is, the permanent income model explains saving only through the income-smoothing motive, which makes saving positive only when income exceeds its permanent level and is consequently expected to decline in the future. In fact, saving is higher on average than the model predicts.

The movements of saving also differ somewhat from those of the optimal forecast of the decline in labor income, but the two variables have about the same standard deviations. Campbell argued that if consumption were excessively sensitive to income, then saving would have a lower standard deviation than would the optimal forecast. He concluded that the failure of the permanent income model should not be described as excess sensitivity.

Campbell and Clarida (1986) obtain results for Canada and Britain that

are quite similar to those for the U.S.

### *Liquidity constraints*

The notion that consumption is more sensitive to income than is consistent with the permanent income hypothesis has long been associated with the idea that households are unable to dissave during periods of abnormally low income. Instead of continuing a normal level of consumption by drawing down financial assets or borrowing, they must reduce consumption. Such households face liquidity constraints because they do not hold liquid assets or collateral suitable for borrowing.

Hayashi (1985) has provided a very complete survey of the literature on liquidity constraints. My remarks here are selective.

Muellbauer (1983) and Zeldes (1985) developed the theory of the response of consumers to liquidity constraints within the framework of the rational expectations permanent income model. As they noted, it is an oversimplification to say that liquidity-constrained consumers simply spend all of their disposable income. Rather, the liquidity constraint has a shadow price which functions as an interest rate. In circumstances where an unconstrained consumer would maintain consumption by dissaving, a consumer influenced by liquidity constraints will behave as if he faced a higher interest rate. The consumer will substitute away from current consumption because it is, in effect, more expensive. Although an Euler equation can be derived for the consumer facing a liquidity constraint, it includes a term involving the shadow price of the constraint. The determination of that shadow price involves a

consideration of the entire intertemporal planning problem of the consumer and does not decompose in a simple way. Because the current shadow price is almost certainly correlated with current and past income, the simple Euler equation proposition of unpredictable changes in consumption does not hold for the liquidity-constrained consumer.

Runkle (1983) and Zeldes examined liquidity constraints in panel data for individual households. They applied the simple Euler equation test in log form; that is, they test the hypothesis that the rate of growth of consumption is unpredictable except for a term involving market interest rates. They showed that for households with low net worth, who are candidates for liquidity constraints, the hypothesis is rejected. Runkle found that the rate of growth of consumption is positively related to net worth in families with assets below \$1500, while Zeldes found that consumption growth is negatively related to real disposable income. The latter finding was also reported by Hall and Mishkin (1982) and other authors who interpreted their findings as supporting liquidity constraints, but without developing a formal model of the effect of the constraints.

Flavin (1985) examined the issue of liquidity constraints in time series data in an extended version of her earlier model. She considered two explanations of her earlier finding that the innovation in consumption is excessively sensitive to the innovation in income. First, consumers may be myopic--that is, they may behave as if they faced extremely high interest rates at all times. Second, some consumers at some times may face liquidity constraints. She noted that the two alternative explanations can be distinguished by studying the relation of excess sensitivity to variables that measure the incidence of liquidity constraints. For this purpose, she uses the unemployment rate. In the null hypothesis derived

from the rational expectations-permanent income hypothesis, the unemployment rate helps predict future income, but has no direct influence on consumption in the absence of liquidity constraints. Flavin found that when the unemployment rate is included in the model as an additional variable to forecast income but is constrained to have no direct effect on consumption, the excess sensitivity of consumption to current income is large and statistically significant, as before. However, when the unemployment rate, interpreted as an indicator of liquidity constraints, is permitted to have a direct impact on consumption, the measured excess sensitivity of consumption to income falls substantially in magnitude and becomes insignificant. Because of the high degree of correlation between the unemployment rate and income, the empirical results do not provide clear-cut conclusions, but Flavin interpreted the results as providing some support for a role of liquidity constraints.

Muellbauer and Bover (1986) developed a more elaborate model of liquidity constraints in time series data and conclude that the model provides a good description of U.S. data.

Browning (1987) tested for liquidity constraints in a novel way. Under the assumptions that married couples plan to have children sooner or later, and that there is no shift of preferences for drinking and smoking as a result of the arrival of children, life-cycle theory predicts that there should be no change in alcohol and tobacco consumption when children arrive. British panel data support this proposition.

## *Durable goods*

At the most basic level, the theory of durables consumption is no different from the theory of non-durables. Households consume a flow of services from durables and that flow should be determined in the same way as the flow of other types of consumption. However, a number of authors have gone beyond this simple statement to build and estimate models that deal with the joint behavior of income and the acquisition of stocks of durables.

Mankiw (1982) developed the most basic model in a time-series setting. He noted that the stock of durables should evolve according to the same Euler equation as the flow of consumption of non-durables. If the deterioration of the stock of durables occurs at a constant rate, the purchases of durables should obey a first-order autoregressive, first-order moving average process; the parameter of the moving average process depends only on the rate of deterioration. He obtained strong rejection of that hypothesis. He found that the stochastic process for durables purchases is close to a random walk, which implies that the quarterly deterioration rate for durables is about 100 percent. Although he did not pursue the idea, he notes that it appears that a model with adjustment costs would also be rejected by the data.

Bernanke (1984) examined purchases of automobiles within a four-year panel of households. He assumes that households choose an optimal stock of autos through the standard rational expectations permanent income model and then purchase autos at a rate given by a partial adjustment process. He did not try to justify the partial adjustment assumption through consideration of optimization, though a model of adjustment costs

probably could yield his model as the outcome of optimization. The estimation method is similar to the one used by Hall and Mishkin (1982). His empirical findings reveal an adjustment rate of about 70 percent per year. His most interesting finding is that there is no evidence of excess sensitivity of auto purchases to transitory income. It appears that partial adjustment of consumption to current income is a competing explanation of facts that lead other investigators to conclude that liquidity constraints are important.

Bernanke (1984) developed a complete model with adjustment costs. Using quarterly U.S. data for durables, nondurables, and income, he found substantial excess sensitivity of both durables and nondurables within a model that posits constant real interest rates.

Mankiw (1985) studied durables in a framework that considers substitution between durables and nondurables and also intertemporal substitution. He found evidence of high elasticities of substitution in both dimensions. As a result, movements of real interest rates are an important influence making durables purchases depart from the predictions of a model that assumes constant real interest rates. He was unable to reject the hypothesis that income and consumption have the relation predicted by the simple rational expectations permanent income model.

Bar-Ilan and Blinder (1986) developed a theory of durables purchases that takes explicit account of the lumpiness of durables. They showed that individual households will determine a range for the stock of each type of durable, and make purchases or sell existing durables if the stock falls outside the range. They tackled the difficult problem of developing implications of the model for aggregate data, with somewhat mixed results.



The effect of changes in interest rates on consumption and saving has always been an important topic of research on consumption. With the exception of Boskin (1978), there has been relatively little research on the traditional question of the role of the interest rate in the consumption function. The answer to that question is complicated because changes in the interest rate have both an income and a substitution effect. By contrast, the Euler equation formulation that has dominated research since the rational expectations revolution provides a way to measure the pure substitution effect of changes in interest rates.

The Euler equation for consumption with a variable real interest rate first appeared in the finance literature. Rubinstein (1976) contributed most of the basic model. The marriage of a constant-elasticity utility function with log-normally distributed returns provides a first-order condition in a highly tractable form. Breeden (1977, 1979) developed the intertemporal consumption model in the form that has been employed by countless authors in the past decade. The basic relation derived by Breeden can be written as:

$$\Delta \log c_t = \frac{1}{\alpha} r_t + k + \epsilon_t$$

Here  $\alpha$  is the coefficient of relative risk aversion,  $r_t$  is the mean of the distribution of the log of the value in  $t+1$  of a unit investment made at  $t$ ,  $\epsilon_t$  is a normally distributed disturbance, and  $k$  is a constant related to the covariance of  $r_t$  and  $\Delta \log c_t$ , to the variances of both variables, and to the rate of time preference. Breeden and his successors in the finance literature (Grossman and Shiller (1982a, 1982b), Shiller (1982), Ferson

(1980), Breeden (1983), and many others, many cited in the last reference) considered this equation to be part of a system with one equation for each type of investment. They defined the consumption beta of an investment as a normalization of the covariance of its return with the change in the log of consumption. Most of the literature in finance in this area has been devoted to measuring consumption betas and testing the relations among the betas and the mean returns of different investments.

Within the macroeconomic literature on consumption, the finance paper that has had the greatest influence is Hansen and Singleton (1983). They estimated both single equations and systems of equations for multiple investments, using monthly consumption and returns data. Their estimates of the coefficient of relative risk aversion,  $\alpha$ , span a range centered on unity. They also tested and rejected the restrictions among the constants and the covariances, but this finding has more relevance for finance than for consumption. Additional results along this line appear in Eichenbaum, Hansen, and Singleton (1986).

Hansen and Singleton's framework has been adopted by Summers (1982), Mankiw, Rotemberg, and Summers (1985), and Bean (1986) with similar results. Browning (1986a) has reached a similar specification by a somewhat different route. However, these subsequent papers have interpreted the coefficient of the expected real interest rate,  $r_t$ , on the right-hand side of a consumption growth equation as dealing with the propensity of consumers to substitute intertemporally from one period to the next. That is, they think of the equation in the form,

$$\Delta \log c_t = \sigma r_t + k + \epsilon_t$$

Here  $\sigma$  is the intertemporal elasticity of substitution. A one-percent

Here  $\sigma$  is the intertemporal elasticity of substitution. A one-percent rise in the expected real interest rate,  $r_t$ , causes the consumer to substitute  $\sigma$  percent of consumption from this year to the next. Formally, the difference is just the replacement of the reciprocal of the coefficient of relative risk aversion,  $1/\alpha$ , by  $\sigma$ , but a large difference of interpretation goes with that change.

Hall (1987) considered the question of the relation between these interpretations. The model underlying both the finance research and the macroeconomic research is founded upon an intertemporally separable utility function,

$$\sum e^{-\delta t} c_t^{1-\alpha}$$

The parameter  $\alpha$  controls the curvature of the one-period utility function and hence controls both the degree of risk aversion (the higher is  $\alpha$ , the less willing is the consumer to substitute consumption among states of the world) and the degree of intertemporal substitution (the higher is  $\alpha$ , the less willing is the consumer to substitute consumption among time periods). It is known that additive separability of the utility function together with the maximization of expected utility means that risk aversion and intertemporal substitution are controlled together by the curvature of the one-period utility function (Selden (1978)).

Hall argued that the coefficient in an equation with the growth of consumption on the left and the expected real return from a particular investment on the right is the intertemporal elasticity of substitution, not the reciprocal of the coefficient of relative risk aversion. Risk aversion can be estimated in a system of two or more equations with investments of

different riskiness, in which case the coefficient of relative risk aversion can be measured from the differences in the constants (as in Grossman and Shiller (1982)).

Hall's argument on this point is not conclusive because there does not seem to be a convenient class of utility functions in which the two parameters are cleanly separated, except in the special case of only two periods. For the special case, Selden's results show that it is unambiguously the elasticity of intertemporal substitution and not the reciprocal of the coefficient of relative risk aversion that appears as the coefficient of the expected real interest rate in the consumption growth equation.

Viewed in this light, the previous research has found intertemporal elasticities of around one. Fluctuations in expected interest rates are a prime source of movements in consumption, according to the results. However, Hall questioned the finding of a substantial elasticity. Through the use of additional data for the interwar period and for the 1980s, when fluctuations in expected real rates were larger, and through a choice of instrumental variables that considers the timing of the data, he found values of the intertemporal elasticity of close to zero, with reasonably small standard errors.

Muellbauer and Bover (1986) suggested a possible source of a downward bias in estimates of the intertemporal elasticity of substitution. They point out that aggregation may induce a negative correlation between the constant in the consumption growth equation and the interest rate--higher interest rate shift consumption toward groups, such as the elderly, with lower values of the constant.

Browning (1986) took a very different approach to intertemporal

substitution. He adapted non-parametric techniques developed by Varian to test the hypothesis that the observed sequence of consumption and interest rates are consistent with consumer choice under certainty. Under Browning's null hypothesis, all variations in consumption are attributed to intertemporal substitution and none to income surprises. He rejects the hypothesis for Canadian, U.K., and U.S. data, but there are extended sub-periods when the hypothesis cannot be rejected.

### *Transitory consumption and shifts in preferences*

Flavin (1981), Hall and Mishkin (1982), and numerous other authors have noted that consumption may have a stochastic component not explained by the permanent income hypothesis. In panel data, the evidence for such a component is overwhelming; the component accounts for more of the variation of the first difference of consumption than does the component associated with changes in permanent income. Further, in panel data, there is a presumption that at least part of the component is truly transitory consumption, because it arises from measuring consumption over a fairly brief period, so that changes in household inventories and the lumpiness of many purchases influences measured consumption.

In time series data, where a general equilibrium analysis is mandatory, the diagnosis and treatment of transitory consumption is a much more difficult issue. Garber and King (1984) pointed out just how strong are the identifying assumptions needed to validate Euler-equation models in time series data. In effect, shifts in preferences or other

sources of changes in consumption other than changes in income or wealth must either be assumed away, or special and questionable assumptions must be made about their stochastic properties. The easiest assumption, though very special, is that shifts in preferences occur as a random walk, so that the corresponding stochastic component in the first difference of consumption is unpredictable. Then the Euler equation has an extra stochastic term that satisfies the assumptions already made about the term that comes from the innovation in income or wealth. MaCurdy (1987) has set up a framework for studying consumption and labor supply in the presence of stochastic shifts of a very general type.

If shifts in preferences are anything but a random walk, then the Euler equation is probably not identified. Certainly the methods generally used for estimating the Euler equation are no longer valid. If shifts in preferences are stationary, though possibly serially correlated, then the first difference of consumption will have a component that is negatively serially correlated. The disturbance in period  $t$  will include the innovation in preferences in period  $t-1$  and possibly earlier as well. Because the earlier innovation shifted consumption, and a shift in consumption feeds back into income, variables dated  $t-1$  are no longer uncorrelated with the disturbance. In simple regression tests of the Euler equation with a fixed real interest rate, lagged income is no longer an appropriate regressor. The finding of significant coefficients for lagged income is no longer evidence against the rational expectations permanent income model. In more elaborate tests with variable expected real returns, lagged income is no longer eligible as an instrumental variable.

Hall (1986) attacked this problem by using an instrument that he considers truly exogenous: military spending. His objective was to

isolate shifts in consumption associated with preference shifts from those associated with changes in well-being. He reasoned that changes in well-being cause movements along an expansion path for consumption of goods and leisure. The slope of the expansion path is revealed by the changes in the two variables brought about by changes in military spending. Then random shifts in preferences cause the two variables to depart from the expansion path. In other words, the residuals in the estimated consumption-work effort relation are a measure of the stochastic component of consumption associated with preference shifts. He found that the residuals are a dominant source of fluctuations in consumption itself, and account for an important but not dominant fraction of fluctuations in total GNP. The only support in the work for the Euler equation approach is that the random shifts are at least approximately a random walk.

### *Conclusions*

It is reasonably well established that the simple conclusion from the rational expectations permanent income model with constant expected real interest rate is inconsistent with the data: The rate of change of consumption can be predicted by past values of real income and past values of a number of financial variables. Much of the recent literature on the macroeconomics of consumption can be seen as attempts to explain this finding.

*Durable goods and the durability of consumption* seem to explain the finding reasonably well. Hayashi's model with durable consumption leaves

only a small role for liquidity constraints, and Mankiw's and Bernanke's models with durable goods accept the hypothesis of no explanatory power from lagged income.

*Liquidity constraints* can also explain the finding in a reasonably convincing way. Not only is the predictive power of income rationalized by only a modest incidence of liquidity constraints, but ancillary tests give reasonable results as well—for example, the predictive power of lagged income is concentrated among households with few liquid assets, according to Runkle and Zeldes, and unemployment displaces income as a predictor, according to Flavin. However, a model combining liquidity constraints and durable goods assigns all of the explanation for the predictive power of lagged income to durability and none to liquidity constraints, according to Bernanke.

*Intertemporal substitution* does not seem to be an important part of the explanation of the predictive power of lagged income and other variables. It is a controversy whether the intertemporal elasticity of substitution is large enough to make changes in expected interest rates an important factor in fluctuations in consumption growth. However, no author has been to show that the predictive power of other variables disappears when intertemporal substitution is considered.



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