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Permanent Income, Current Income, and Consumption

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This article reexamines the consistency of the permanent-income hypothesis with aggregate postwar U.S. data. The permanent-income hypothesis is nested within a more general model in which a fraction of income accrues to individuals who consume their current income rather than their permanent income. This fraction is estimated to be about 50%, indicating a substantial departure from the permanent-income hypothesis. Our results cannot be easily explained by time aggregation or small-sample bias, by changes in the real interest rate, or by nonseparabilities in the utility function of consumers.

KEY WORDS: Euler equation; Instrumental variables; Monte Carlo study; Nonseparable utility; Real interest rate; Time aggregation.

1. INTRODUCTION

During the past decade, much effort has been directed at the question of whether the response of consumption to income is consistent with the permanent-income hypothesis. Hall (1978) showed that a central implication of the theory is that consumption should follow a random walk. He argued that, to a first approximation, postwar U.S. data are consistent with this implication. In contrast, Flavin (1981) reported that consumption is "excessively sensitive" to income, a conclusion that has been widely interpreted as evidence that liquidity constraints are important for understanding consumer spending (Dornbusch and Fischer 1987). Yet Mankiw and Shapiro (1985) showed that Flavin's procedure for testing the permanent-income hypothesis can be severely biased toward rejection if income has approximately a unit root. Nelson (1987) recently reappraised the evidence on the permanent-income hypothesis and concluded that it is generally favorable.

Other recent research has examined the permanent-income theory from a different point of view. Campbell (1987) studied the implications of the theory for savings behavior, and Campbell and Deaton (1989) and West (1988), following Deaton (1987), looked at its implications for the "smoothness" (the standard deviation of the change) of consumption. These works argued that, although some of the qualitative implications of the model are fulfilled, consumption appears to be too smooth and there is weak evidence that saving moves too little to be consistent with the theory.

The first goal of this article is to provide a simple framework for understanding these disparate results. We nest the permanent-income hypothesis in a more general model in which some fraction of income λ accrues to individuals who consume their current income, while the remainder $(1 - \lambda)$ accrues to individuals who consume their permanent income. [Similar ideas were explored by DeLong and Summers (1986), Flavin (1981), Hall and Mishkin (1982), Hayashi (1982), and Summers (1982).] We argue that the model is consistent with the empirical findings in the existing literature. We show how to estimate λ and test the permanent-income hypothesis that $\lambda = 0$ using an instrumental variables (IV) approach. Our test is valid whether or not income has a unit root, and it is more powerful than the standard unrestricted test for consumption following a random walk. By lagging our instruments two periods, we are able to avoid econometric difficulties that would otherwise be created by time aggregation of our data. We also show how to test our framework against an even more general time series representation for consumption and income.

The second goal of this article is to generalize the preceding approach to handle alternative versions of the permanent-income hypothesis. We can allow for changes in the real interest rate (Bean 1986; Grossman and Shiller 1981; Hall 1988; Hansen and Singleton 1983; Mankiw 1981). We can also allow for nonseparability in the utility function between consumption and other goods. Following previous work, we examine interactions with labor supply (Bean 1986; Eichenbaum, Hansen, and Singleton 1988; Mankiw, Rotemberg, and Summers 1985), durable goods (Bernanke 1985; Startz 1986), and government purchases (Aschauer 1985; Bailey 1971; Bean 1986; Kormendi 1983). We examine whether these alternative formulations of preferences can explain the apparent excess sensitivity of consumption to income.

The organization of the article is as follows. Section 2 describes our model and IV test procedure in more detail and relates our approach to the existing literature. Section 3 reports empirical results for the basic model. Section 4 presents some Monte Carlo results to shed light on the finite-sample properties of our tests. Section 5 extends the model to allow for the effects of time-varying real interest rates and nonseparabilities in the utility function. Section 6 concludes, and a brief Appendix gives some details about the construction of our Monte Carlo experiment.

2. AN INSTRUMENTAL VARIABLES APPROACH TO THE PERMANENT-INCOME HYPOTHESIS

Consider an economy in which there are two groups of agents, who receive disposable income Y_{1t} and Y_{2t}. Total disposable income Y_t is just the sum of the disposable income of these two groups; $Y_t = Y_{1t} + Y_{2t}$. We assume that the first group receives a fixed share λ of total disposable income, so $Y_{1t} = \lambda Y_t$ and $Y_{2t} = (1 - \lambda)Y_t$.

Agents in the first group consume their current disposable income, so $C_{1t} = Y_{1t}$. Taking first differences, $\Delta C_{1t} = \Delta Y_{1t} = \lambda \Delta Y_t$. Agents in the second group, by contrast, consume their permanent disposable income; $C_{2t} = Y_{2t}^P = (1 - \lambda)Y_t^P$. By the argument of Hall (1978), as elaborated by Flavin (1981), we then have $\Delta C_{2t} = \mu + (1 - \lambda)\varepsilon_t$, where μ is a constant and ε_t is the innovation between time $t - 1$ and time t in agents' assessment of total permanent income Y_t^P. Since ε_t is an innovation, it is orthogonal to any variable that is in agents' information set at time $t - 1$.

The change in aggregate consumption can now be written as

$$\Delta C_t = \Delta C_{1t} + \Delta C_{2t} = \mu + \lambda \Delta Y_t + (1 - \lambda)\varepsilon_t. \quad (1)$$

Our empirical strategy will be to estimate λ and test the permanent-income hypothesis that $\lambda = 0$ by running the regression (1). Note, however, that (1) cannot be estimated by ordinary least squares (OLS). The error term ε_t is orthogonal to lagged variables but not necessarily to ΔY_t, so an OLS estimate of λ will generally be inconsistent.

It is tempting to argue that ΔY_t and ε_t are positively correlated so that the OLS estimate is upward biased and gives an upper bound on the true value of λ. This is not necessarily true for general multivariate time series processes for Y_t, however. In the Appendix, we present a stylized model of consumption and income in which ΔY_t and ε_t can be negatively correlated, causing downward bias in the OLS estimate of λ.

The solution to this problem is to estimate (1) by IV rather than OLS. Any lagged stationary variables are potentially valid instruments, since they are orthogonal to ε_t if the model is correct. Of course, good instruments must also be correlated with ΔY_t. If ΔY_t is completely unpredictable, then there are no instruments that are orthogonal to ε_t but correlated with ΔY_t, and the procedure breaks down. In this case, permanent income and current income are equal, so the parameter λ is unidentified. More generally, if ΔY_t is only slightly predictable, it will be hard to obtain a precise estimate of the parameter λ.

Equation (1), estimated by IV, can be thought of as a restricted version of a more general two-equation system in which ΔC_t and ΔY_t are regressed directly on the instruments. If we have K instruments, Z_{1t} through Z_{Kt}, then the general system is

$$\begin{aligned}\Delta C_t &= \beta_0 + \beta_1 Z_{1t} + \cdots + \beta_K Z_{Kt} + \eta_{Ct} = Z_t\beta + \eta_{Ct}\\ \Delta Y_t &= \gamma_0 + \gamma_1 Z_{1t} + \cdots + \gamma_K Z_{Kt} + \eta_{Yt} = Z_t\gamma + \eta_{Yt}.\end{aligned} \quad (2)$$

The permanent-income hypothesis implies that the vector $\beta = 0$ (i.e., $\beta_1 = \cdots = \beta_K = 0$). This can be tested directly, and without any need for predictability of ΔY_t, by OLS estimation of the first equation of (2). But as Flavin (1981) argued, it is hard to interpret a rejection of the permanent-income hypothesis in this framework; an estimate of λ is much more informative about the economic importance of deviations from the theory. For this reason, we focus on IV estimation of (1).

When there is more than a single instrument, Equation (1) places overidentifying restrictions on (2). These state that predictable changes in consumption and income, and therefore the vectors β and γ, are proportional to one another ($\beta = \lambda\gamma$, or $\beta_1/\gamma_1 = \cdots = \beta_K/\gamma_K = \lambda$). We regard the presence of overidentifying restrictions as an advantage of our framework over that of Flavin (1981), which includes enough extra lags to make the model just-identified. But if we are to put much weight on the estimate of λ that we obtain from (1), it is important to test the restrictions. A simple way to do this is to add $K - 1$ instruments as right-side variables in the IV regression and to test the joint significance of these extra variables. We shall use this Wald test.

An alternative is a Lagrange multiplier (LM) test. One can regress the residual from the IV regression on the instruments and then compare T times the R^2 from this regression, where T is the sample size, with the χ^2 distribution with $(K - 1)$ df. We use the R^2 from the residual regression as an informal diagnostic statistic, but we do not use the LM approach to test the model because it is harder to generalize this approach to handle conditional heteroscedasticity and autocorrelation in the equation error.

Equation (1) also implies that for *any* value of λ the R^2 of the regression of ΔC_t on instruments must be less than the R^2 of the regression of ΔY_t on instruments, unless ε_t and ΔY_t are strongly negatively correlated. [To see this, note that the R^2 in the consumption equation is $\lambda^2\text{var}(Z_t\gamma)/(\lambda^2\text{var}(\Delta Y_t) + (1 - \lambda)^2\text{var}(\varepsilon_t) + 2\lambda(1 -$

$\lambda)\text{cov}(\Delta Y_t, \varepsilon_t))$, which is less than or equal to the R^2 in the income equation when $(1 - \lambda)^2\text{var}(\varepsilon_t) + 2\lambda(1 - \lambda)\text{cov}(\Delta Y_t, \varepsilon_t) \geq 0$.] This means that a small R^2 for changes in consumption cannot be interpreted as strong evidence in favor of the permanent-income hypothesis. If the R^2 for changes in income is small, it is very possible that consumption is close to a random walk as measured by R^2, but the permanent-income hypothesis is far from true as measured by the coefficient λ.

The choice of instruments is critically important in our approach. Perhaps the most obvious instruments are those that summarize the history of Y_t. Flavin (1981) used lagged values of detrended Y_t in her test of the model. Mankiw and Shapiro (1985), however, showed that this leads to statistical problems when the Y_t process has a unit root. Lagged values of ΔY_t are valid instruments but, as we show, they do not explain a large fraction of the variance of ΔY_t because the univariate time series process for Y_t is close to a random walk.

Campbell (1987) emphasized that the history of C_t should also provide good instruments for ΔY_t. This is because, according to the permanent-income hypothesis, C_t summarizes agents' information about the future of the Y_t process. If agents have better information about Y_t than is contained in that variable's own history, then C_t will help to forecast Y_t. Lagged levels of C_t cannot be used as instruments because they are nonstationary; the permanent-income hypothesis and our alternative model imply, however, that C_t and Y_t are cointegrated (Engle and Granger 1987) so that savings, $S_t \equiv Y_t - C_t$, is stationary. Lagged values of S_t or ΔC_t are likely to increase the precision with which the parameter λ can be estimated.

When lagged ΔY_t, ΔC_t, and S_t are used as instruments, the unrestricted system (2) becomes an error-correction model for consumption and income of the type proposed by Davidson, Hendry, Srba, and Yeo (1978) and Davidson and Hendry (1981). They interpreted their error-correction models in terms of disequilibrium adjustment of consumption to income; our approach suggests an alternative interpretation, involving forward-looking consumption behavior of at least some agents. As discussed previously, our interpretation places testable restrictions on the error-correction framework.

Financial variables are also appealing instruments. There is considerable evidence that changes in stock prices and interest rates help to forecast changes in income (Fischer and Merton 1984; Litterman and Weiss 1985; Sims 1980). Hall (1978) found that stock prices also forecast changes in consumption. We use both stock prices and interest rates in our empirical work.

Our model (1) has the potential to reconcile several of the empirical results in the existing literature. It displays Flavin's (1981) "excess sensitivity" of consumption to income, since consumption moves more closely with income when $\lambda > 0$. Our model also makes saving equal to $(1 - \lambda)$ times its value under the permanent-income hypothesis so that it can explain why saving seems to be insufficiently variable, as found by Campbell (1987). Finally, our model can explain the otherwise puzzling smoothness of consumption growth (Campbell and Deaton 1989; Deaton 1987; Flavin 1988; West 1988). More details on this point are given in Section 4.

3. ISSUES OF SPECIFICATION AND EMPIRICAL RESULTS FOR THE BASIC MODEL

Before we can estimate our model, we need to address several issues of specification that arise from the nature of the aggregate time series on consumption and income.

We have not yet distinguished between different components of consumption. In fact, the permanent-income hypothesis is normally tested using consumption expenditure only on nondurables and services, excluding expenditure on durables. The implicit assumption is that permanent-income consumers have a utility function that is separable between durable and nondurable goods so that consumption of nondurables and services can be treated without also modeling purchases of durable goods.

We begin by making this same assumption so that we can use nondurables and services consumption in our tests. (In Sec. 5, we bring durables back into the analysis.) In our approach, however, the use of a component of consumption causes two problems. Unless we rescale the data, the coefficient λ will be the fraction of income accruing to current-income consumers times the share in consumption of nondurables and services, and the difference between the consumption measure and income will be nonstationary. We adopt a simple solution, which is to multiply nondurables and services consumption by the mean ratio of total consumption to nondurables and services consumption (1.12 in our data). This multiplication does not affect any of the statistical tests (except those using lagged S as an instrument), but it preserves our original interpretation of λ.

Our discussion so far has been couched in terms of levels and differences of the raw series C_t and Y_t. This is appropriate if these series follow homoscedastic linear processes in levels, with or without unit roots. In fact, however, aggregate time series on consumption and income appear to be closer to log-linear than linear. The mean change and the innovation variance both grow with the level of the series. A correction of some sort appears necessary.

One approach, which was used by Campbell and Deaton (1989), is to divide ΔC_t and ΔY_t by the lagged level of income, Y_{t-1}. This scaling method is used in Table 2, Section 3.1.

A second approach is to take logs of all the variables in the previous section. (Hereafter, we use lowercase letters to denote log variables.) Equation (1) should hold in logs when $\lambda = 0$ if aggregate consumption is chosen by a representative agent with a power-utility function facing a constant riskless real interest rate (Bean 1986; Hall 1988; Hansen and Singleton 1983; Nelson 1987). The instruments discussed in Section 2 remain stationary, but we now use the difference between log consumption and log income, the log consumption–income ratio, rather than saving.

This approach has the advantage that the log equation generalizes straightforwardly to cases in which the real interest rate varies or the utility function is nonseparable, whereas the levels equation does not. The difficulty with taking logs is that the parameter λ can no longer be precisely interpreted as the fraction of agents who consume their current income; if one is willing to approximate the log of an average by an average of logs, however, the interpretation of the model is not substantially affected. The log scaling method is used in Table 3, Section 3.2.

Another data problem is that consumption and income are measured as quarterly averages rather than at points in time. If the permanent-income hypothesis holds in continuous time, then measured consumption is the time average of a random walk. The results of Working (1960) imply that it will have a first-order serial correlation of .25, which could lead us to reject the model even if it is true. Christiano, Eichenbaum, and Marshall (1987) and Hall (1988) argued that a continuous-time version of the permanent-income model fits postwar U.S. data better than a discrete-time version.

We deal with this problem by lagging the instruments more than one period so that there is at least a two-period time gap between the instruments and the variables in Equation (1). The time average of a continuous-time random walk is uncorrelated with all variables lagged more than one period, so by using twice-lagged instruments we obtain a test of the model that is valid for time-averaged data.

The extra lag in the instruments also helps meet several other potential objections. First, Goodfriend (1986) noted that aggregate variables are not in individuals' information sets contemporaneously because of delays in government publication of aggregate statistics. Since such delays are typically no more than a few months, lagging the instruments an extra quarter largely avoids this problem. (The problem is not completely avoided, since the data are revised over a long period of time. We use as instruments financial variables such as nominal interest rates, which are known contemporaneously, and this fully circumvents the problem.)

Second, it is sometimes suggested that those goods labeled nondurable in the National Income Accounts are, in fact, partly durable. Durability would introduce a first-order moving average term into the change in consumer expenditure (Mankiw 1982); this would not affect our procedure using twice-lagged instruments. Third, there may be white-noise errors in the levels of our consumption and income variables. These could be due to "transitory consumption" or to measurement errors. White-noise errors in levels become first-order moving average errors in our differenced specification and could be correlated with once-lagged instruments, but they cannot be correlated with twice-lagged instruments.

These arguments for twice-lagging our instruments also imply that the error terms in Equations (1) and (2) have a first-order moving average structure. If we ignore this and use standard OLS and IV procedures, the coefficient estimates remain consistent but the standard errors are inconsistent. Fortunately, a straightforward standard-error correction is available (White 1984); White's methods can also be used to allow for conditional heteroscedasticity in the error terms of (1) and (2). We report heteroscedasticity-consistent and autocorrelation-consistent standard errors, but for our data these corrections make almost no difference. Taking account of the moving average error structure tends to reduce the reported standard errors very slightly; taking account of heteroscedasticity tends to increase them very slightly.

3.1 Basic Empirical Results

To estimate our model, we use standard U.S. quarterly time series data, obtained from the Data Resources, Inc., data bank. In the model, Y_t is measured as disposable income per capita in 1982 dollars, and C_t is per capita consumption of nondurables and services in 1982 dollars. Our data set runs from 1948:1 through 1985:4. We begin our sample in 1953:1, the date used by Blinder and Deaton (1985), Campbell (1987), and Campbell and Deaton (1989), which avoids the Korean War. The data are reproduced in Table 1.

Table 2 reports results for the 1953:1–1985:4 sample period. The table has six columns. The first gives the row number and the second the instruments used. (A constant term is always included as both an instrument and a regressor but is not reported in the tables.) The third and fourth columns give the adjusted R^2 statistics for OLS regressions of $\Delta C_t/Y_{t-1}$ and $\Delta Y_t/Y_{t-1}$, respectively, on the instruments. In parentheses we report the p value for a Wald test of the hypothesis that all coefficients in these regressions are 0 except the intercept. The fifth column gives the IV estimate of λ, with an asymptotic standard error. The final column gives the adjusted R^2 statistic for an OLS regression of the residual from the IV regression on the instruments. In parentheses we report the p value for a Wald test of the overidentifying restrictions placed by Equation (1) on the general system (2).

The first row of Table 2 shows that we obtain a coefficient of about .3 when we estimate Equation (1) by OLS. The remaining rows give IV results for various

Table 1. Data Used in Model Estimation

Date	Income (Y)	Consumption (C)	Deflator	Interest (i)	Labor supply	Durables stock	Government spending
1947:1	4.88558	4.21778	.22673	.38000	.64136	M	1.24969
1947:2	4.76555	4.27112	.22793	.38000	.63609	1.21891	1.25449
1947:3	4.85526	4.25025	.23351	.73700	.63347	1.23702	1.25500
1947:4	4.77418	4.18989	.23955	.90700	.63994	1.25810	1.23127
1948:1	4.86962	4.21238	.24186	.99000	.64036	1.28158	1.24588
1948:2	4.99313	4.24146	.24433	1.00000	.63675	1.30362	1.34139
1948:3	5.06964	4.22118	.24733	1.05000	.63955	1.32534	1.39549
1948:4	5.05895	4.23543	.24728	1.14000	.63373	1.34665	1.45741
1949:1	4.93803	4.22730	.24562	1.17000	.61981	1.36552	1.46732
1949:2	4.91568	4.22322	.24432	1.17000	.60679	1.38753	1.52192
1949:3	4.90273	4.18113	.24312	1.04300	.59794	1.41467	1.54753
1949:4	4.89711	4.19210	.24411	1.07700	.58869	1.44179	1.52053
1950:1	5.22830	4.23461	.24293	1.10300	.59279	1.46915	1.49749
1950:2	5.18347	4.30690	.24362	1.15300	.60911	1.49715	1.46250
1950:3	5.18420	4.35546	.24891	1.22000	.62921	1.53888	1.51014
1950:4	5.27487	4.30384	.25302	1.33700	.63626	1.58434	1.61337
1951:1	5.21469	4.37145	.26158	1.36700	.64576	1.61954	1.86453
1951:2	5.33300	4.33526	.26332	1.49000	.64839	1.64406	2.06759
1951:3	5.34674	4.37619	.26450	1.60300	.64299	1.65539	2.25017
1951:4	5.33178	4.38512	.26818	1.61000	.64074	1.66325	2.36053
1952:1	5.30529	4.37472	.26922	1.56700	.64518	1.67141	2.41680
1952:2	5.33503	4.43234	.27086	1.64700	.63878	1.68163	2.47440
1952:3	5.42638	4.47293	.27281	1.78300	.64040	1.68811	2.52155
1952:4	5.44156	4.51333	.27422	1.89300	.65354	1.69535	2.52020
1953:1	5.48636	4.53394	.27504	1.98000	.65726	1.71106	2.59631
1953:2	5.54655	4.54928	.27572	2.15300	.65489	1.72804	2.63888
1953:3	5.51065	4.52542	.27795	1.95700	.64591	1.74189	2.62811
1953:4	5.50733	4.49124	.27892	1.47300	.63726	1.75526	2.63513
1954:1	5.48922	4.51332	.27986	1.06000	.62362	1.76714	2.46237
1954:2	5.44050	4.53334	.28054	.78700	.61607	1.77671	2.33887
1954:3	5.50211	4.58315	.27998	.88300	.61034	1.78665	2.28758
1954:4	5.58059	4.62084	.27995	1.01700	.61522	1.79989	2.23064
1955:1	5.58971	4.64856	.28083	1.22700	.62138	1.82001	2.22079
1955:2	5.67952	4.68028	.28142	1.48300	.63099	1.84722	2.17249
1955:3	5.75105	4.69838	.28237	1.85700	.63457	1.87788	2.19226
1955:4	5.82709	4.76691	.28279	2.34000	.63902	1.90665	2.15640
1956:1	5.85143	4.79215	.28427	2.32700	.63929	1.92880	2.15324
1956:2	5.87124	4.78707	.28667	2.56700	.63917	1.94494	2.17372
1956:3	5.87356	4.78672	.29008	2.58300	.63447	1.95758	2.14878
1956:4	5.91751	4.81365	.29050	3.03300	.63888	1.96759	2.16877
1957:1	5.90184	4.81441	.29350	3.10000	.63534	1.97885	2.22891
1957:2	5.91756	4.81877	.29548	3.13700	.62964	1.98966	2.23269
1957:3	5.92251	4.84437	.29857	3.35300	.62603	1.99618	2.22560
1957:4	5.88822	4.83930	.29990	3.30300	.61331	2.00026	2.21033
1958:1	5.82731	4.79621	.30335	1.76000	.59851	2.00072	2.23261
1958:2	5.84817	4.83655	.30374	.95700	.58696	1.99727	2.25974
1958:3	5.94780	4.88784	.30470	1.68000	.59107	1.99324	2.27519
1958:4	6.00034	4.90419	.30521	2.69000	.59792	1.99112	2.30809
1959:1	5.99108	4.92915	.30772	2.77300	.60727	1.99461	2.26817
1959:2	6.06529	4.97411	.30858	3.00000	.61662	2.00422	2.25659
1959:3	6.00966	5.00224	.31047	3.54000	.61059	2.01587	2.23742
1959:4	6.03473	5.02137	.31291	4.23000	.60930	2.02359	2.21745
1960:1	6.05084	5.00996	.31333	3.87300	.61201	2.02467	2.19929
1960:2	6.06427	5.04606	.31585	2.99300	.61041	2.02885	2.23251
1960:3	6.03554	5.00839	.31730	2.36000	.60546	2.03707	2.24635
1960:4	5.99456	5.01024	.31924	2.30700	.59606	2.04086	2.25435
1961:1	6.02736	5.02805	.32070	2.35000	.59015	2.03896	2.29804
1961:2	6.09642	5.08196	.31963	2.30300	.59061	2.03419	2.30395
1961:3	6.12375	5.05665	.32161	2.30300	.59430	2.03068	2.31772
1961:4	6.20247	5.11192	.32258	2.46000	.59783	2.03047	2.37758

Table 1. Continued

Date	Income (Y)	Consumption (C)	Deflator	Interest (i)	Labor supply	Durables stock	Government spending
1962:1	6.24296	5.14013	.32359	2.72300	.59874	2.03454	2.40363
1962:2	6.27165	5.16418	.32551	2.71300	.60558	2.04151	2.40007
1962:3	6.28431	5.18746	.32652	2.84000	.60582	2.04944	2.41860
1962:4	6.28623	5.21647	.32801	2.81300	.60329	2.05900	2.41155
1963:1	6.32452	5.23097	.32850	2.90700	.60211	2.07200	2.41743
1963:2	6.34284	5.23522	.33045	2.93700	.60684	2.08741	2.40543
1963:3	6.38556	5.28674	.33187	3.29300	.60793	2.10330	2.44738
1963:4	6.45822	5.30397	.33331	3.49700	.60874	2.11877	2.44534
1964:1	6.56546	5.37869	.33429	3.53000	.60772	2.13684	2.45714
1964:2	6.72218	5.44858	.33534	3.47700	.61359	2.15838	2.46763
1964:3	6.78314	5.51641	.33588	3.49700	.61495	2.18151	2.44622
1964:4	6.83432	5.53415	.33785	3.68300	.62020	2.20199	2.44172
1965:1	6.85957	5.56927	.33886	3.89000	.62828	2.22576	2.42729
1965:2	6.94248	5.62133	.34182	3.87300	.63188	2.25548	2.47843
1965:3	7.10620	5.68395	.34334	3.86300	.63469	2.28551	2.52508
1965:4	7.19893	5.79894	.34589	4.15700	.64200	2.31869	2.59014
1966:1	7.22455	5.82494	.34935	4.60300	.65174	2.35753	2.62307
1966:2	7.24639	5.87023	.35234	4.58000	.65637	2.39422	2.66664
1966:3	7.30101	5.89561	.35537	5.03000	.65886	2.42583	2.75248
1966:4	7.34805	5.89897	.35828	5.20000	.66197	2.45672	2.79369
1967:1	7.44569	5.94680	.35977	4.51300	.66125	2.48417	2.87523
1967:2	7.49742	5.98697	.36124	3.65700	.65960	2.51256	2.88781
1967:3	7.53774	6.01066	.36464	4.29300	.66250	2.54145	2.90987
1967:4	7.56970	6.03447	.36764	4.74300	.66509	2.56685	2.92225
1968:1	7.65269	6.11180	.37221	5.04000	.66623	2.59644	2.95057
1968:2	7.75597	6.17389	.37665	5.51300	.67049	2.63188	2.99573
1968:3	7.73693	6.24437	.38067	5.19700	.67583	2.67048	2.99009
1968:4	7.76578	6.26095	.38559	5.58000	.67775	2.70948	2.97214
1969:1	7.75618	6.30893	.38911	6.08700	.68325	2.74788	2.93729
1969:2	7.82881	6.34077	.39456	6.19000	.68782	2.78574	2.94439
1969:3	7.96853	6.36647	.39947	7.01000	.69073	2.81902	2.90857
1969:4	8.00947	6.41156	.40395	7.34700	.69011	2.84785	2.87498
1970:1	8.02603	6.45822	.40949	7.21000	.68621	2.87225	2.83508
1970:2	8.13888	6.45990	.41447	6.66700	.68003	2.89366	2.78281
1970:3	8.20859	6.49944	.41903	6.32700	.66844	2.91342	2.78261
1970:4	8.16038	6.51225	.42508	5.35000	.66602	2.92426	2.76816
1971:1	8.26115	6.53007	.42816	3.83700	.66607	2.93693	2.74517
1971:2	8.35206	6.54842	.43366	4.24000	.66685	2.96126	2.71988
1971:3	8.33750	6.54298	.43970	5.00300	.66528	2.98905	2.72548
1971:4	8.33773	6.57955	.44421	4.23000	.66795	3.02152	2.71949
1972:1	8.37182	6.64694	.44873	3.43700	.67749	3.05928	2.75602
1972:2	8.43172	6.73449	.45228	3.77000	.68265	3.10039	2.73854
1972:3	8.57118	6.79625	.45682	4.22000	.68524	3.14388	2.69339
1972:4	8.87077	6.90623	.46128	4.86300	.69132	3.19329	2.68629
1973:1	8.96435	6.93268	.46917	5.70000	.69946	3.25411	2.71080
1973:2	9.01244	6.92354	.47929	6.60300	.70479	3.31674	2.68635
1973:3	9.05882	6.94883	.48907	8.32300	.70718	3.37093	2.61934
1973:4	9.13036	6.92469	.50214	7.50000	.70960	3.41612	2.65246
1974:1	8.94794	6.84646	.52061	7.61700	.70982	3.45171	2.66393
1974:2	8.84027	6.86936	.53375	8.15300	.70600	3.48272	2.71627
1974:3	8.86587	6.88820	.54571	8.19000	.70704	3.51241	2.67386
1974:4	8.81416	6.86987	.55791	7.36000	.69824	3.52720	2.66465
1975:1	8.70663	6.89620	.56752	5.75000	.68085	3.53085	2.68436
1975:2	9.11515	6.98965	.57508	5.39300	.67461	3.53928	2.67653
1975:3	8.94636	6.99172	.58787	6.33000	.67851	3.55555	2.69131
1975:4	9.00677	7.01893	.59842	5.62700	.68463	3.58116	2.70604
1976:1	9.12551	7.12268	.60404	4.91700	.69398	3.61629	2.67999
1976:2	9.15069	7.16242	.61053	5.15700	.69220	3.65652	2.66466
1976:3	9.18713	7.22475	.61970	5.15000	.69526	3.69448	2.65368
1976:4	9.23729	7.31401	.62897	4.67300	.69737	3.73195	2.64484

Table 1. Continued

Date	Income (Y)	Consumption (C)	Deflator	Interest (i)	Labor supply	Durables stock	Government spending
1977:1	9.23724	7.36923	.64017	4.63000	.70159	3.77499	2.64416
1977:2	9.31823	7.35246	.65369	4.84000	.71109	3.82372	2.67099
1977:3	9.46127	7.39824	.66393	5.49700	.71725	3.87320	2.69707
1977:4	9.50629	7.47344	.67462	6.11000	.72140	3.92325	2.68353
1978:1	9.59864	7.53365	.68425	6.39300	.72499	3.96829	2.67230
1978:2	9.72958	7.59562	.70076	6.47700	.74049	4.01674	2.70513
1978:3	9.76257	7.62299	.71464	7.31300	.74464	4.07050	2.74298
1978:4	9.84869	7.67436	.72827	8.57000	.74957	4.12011	2.73321
1979:1	9.88883	7.71162	.74374	9.38300	.75358	4.16546	2.70665
1979:2	9.81814	7.70323	.76393	9.37700	.75105	4.20167	2.70049
1979:3	9.81998	7.70566	.78661	9.67300	.75704	4.23490	2.71185
1979:4	9.78962	7.75969	.80645	11.84300	.75549	4.26449	2.70524
1980:1	9.81595	7.73971	.83051	13.35300	.75640	4.28626	2.72479
1980:2	9.61143	7.66157	.85202	9.61700	.74390	4.28887	2.74895
1980:3	9.67674	7.68811	.87297	9.15300	.73743	4.28011	2.72313
1980:4	9.78812	7.72600	.89470	13.61300	.74304	4.28055	2.70160
1981:1	9.78548	7.69669	.91909	14.39000	.74553	4.29079	2.73246
1981:2	9.72818	7.72141	.93555	14.90700	.74204	4.30058	2.72650
1981:3	9.82208	7.70878	.95393	15.05300	.73787	4.30596	2.73537
1981:4	9.75594	7.70331	.96918	11.75000	.73467	4.30525	2.75272
1982:1	9.69981	7.70314	.98171	12.81300	.72283	4.30088	2.74102
1982:2	9.74316	7.72184	.99072	12.42000	.71988	4.30169	2.71364
1982:3	9.72807	7.73648	1.00728	9.31700	.71186	4.30307	2.76146
1982:4	9.75745	7.78814	1.01971	7.90700	.70495	4.30997	2.82979
1983:1	9.77949	7.82414	1.02654	8.10700	.70476	4.32086	2.77436
1983:2	9.85544	7.91070	1.03956	8.39700	.71183	4.34086	2.77569
1983:3	9.93365	7.97305	1.04994	9.14000	.72069	4.37353	2.78009
1983:4	10.15146	8.02433	1.06066	8.80000	.72973	4.41342	2.72465
1984:1	10.35944	8.05561	1.07360	9.17000	.74016	4.46294	2.75275
1984:2	10.39417	8.14273	1.08135	9.79700	.74662	4.51935	2.86523
1984:3	10.45891	8.15188	1.09262	10.32000	.75114	4.57471	2.86979
1984:4	10.47521	8.17191	1.10355	8.80300	.75461	4.62805	2.90546
1985:1	10.46415	8.21839	1.11382	8.18300	.75721	4.68520	2.91530
1985:2	10.67280	8.25570	1.12592	7.46000	.75953	4.74619	2.96360
1985:3	10.53715	8.28293	1.13536	7.10700	.76167	4.81482	3.05426
1985:4	10.57744	8.34597	1.15021	7.16700	.76853	4.88168	3.11990

NOTE: Income is total disposable income per capita in 1982 dollars. Consumption is consumption of nondurables and services per capita in 1982 dollars. The deflator is the ratio of nominal consumption of nondurables and services per capita to the consumption measure in 1982 dollars. The interest rate is a three-month treasury-bill rate. Labor supply is man-hours per capita in nonagriculatural establishments. The stock of durable goods is computed in two steps. We first constructed an end-of-quarter per capita stock series from the annual stock at the beginning of the sample period and the series on consumer durable purchases in 1982 dollars, assuming a depreciation rate of 6% per quarter. We then measured the stock of consumer durables during a quarter as the average of the end-of-quarter stock and the previous end-of-quarter stock. Government spending is measured as total government purchases per capita in 1982 dollars.

choices of instruments. In all cases we include at least lags 2–4 of the instruments; in some rows we add lags 5 and 6 for a total of five instruments.

The main conclusions we draw from Table 2 are as follows. First, each set of instruments has some forecasting power for scaled income changes two quarters ahead, but this forecasting power is particularly modest when income changes themselves are used as instruments (the adjusted R^2 statistics are only in the range 2% to 4%), reflecting the fact that the univariate income process is close to a random walk. Better forecasting power is obtained from consumption changes, interest rates, and saving; together these variables deliver an adjusted R^2 statistic of more than 11% in row 9. We also tried using lagged changes in real stock prices as instruments but found no forecasting power for either consumption growth or income growth. Hall's (1978) finding that stock prices forecast consumption appears to be due to his inclusion of the first lagged stock price.

Second, several instrument sets have significant forecasting power for consumption; this is evidence against the permanent-income hypothesis. The permanent-income hypothesis is rejected particularly strongly when lags 2–6 of consumption changes or nominal interest-rate changes are used as instruments. The adjusted R^2 statistics for consumption are quite small in absolute terms, but they often exceed the adjusted R^2 for income.

Previously, we argued that our model (1) would normally imply a smaller R^2 for consumption growth than for income growth. The predictability of consumption growth is therefore surprisingly high. One possible explanation is that income growth is measured with error. Measurement error uncorrelated with our instruments will not bias the IV estimate of λ but will reduce the forecastability of income growth.

Third, our IV procedure estimates the parameter λ to be between .3 and .7. The t statistic on λ is more than 2.8 in every row of the table except the second. The significance level for the IV test of the permanent-income hypothesis always exceeds the significance level for the corresponding OLS test.

Table 2. Basic Permanent-Income Model (scaled levels)

Row	Instruments (Z)	OLS regressions on Z: ΔC equation	OLS regressions on Z: ΔY equation	λ estimate (standard error)	Test of restrictions
1	None (OLS)	—	—	.296 (.044)	—
2	$\Delta Y_{t-2}, \ldots, \Delta Y_{t-4}$	−.005 (.210)	.021 (.013)	.330 (.161)	−.023 (.986)
3	$\Delta Y_{t-2}, \ldots, \Delta Y_{t-6}$	.020 (.109)	.042 (.022)	.422 (.141)	−.034 (.984)
4	$\Delta C_{t-2}, \ldots, \Delta C_{t-4}$	.018 (.124)	.048 (.009)	.361 (.126)	−.014 (.526)
5	$\Delta C_{t-2}, \ldots, \Delta C_{t-6}$	.084 (.001)	.082 (.024)	.476 (.130)	−.016 (1.000)
6	$\Delta i_{t-2}, \ldots, \Delta i_{t-4}$	.060 (.000)	.025 (.005)	.637 (.144)	−.015 (.591)
7	$\Delta i_{t-2}, \ldots, \Delta i_{t-6}$	.118 (.000)	.086 (.001)	.552 (.140)	−.026 (.516)
8	$\Delta Y_{t-2}, \ldots, \Delta Y_{t-4}$, $\Delta C_{t-2}, \ldots, \Delta C_{t-4}$, S_{t-2}	.007 (.239)	.084 (.000)	.317 (.110)	−.042 (.909)
9	$\Delta Y_{t-2}, \ldots, \Delta Y_{t-4}$, $\Delta C_{t-2}, \ldots, \Delta C_{t-4}$, $\Delta i_{t-2}, \ldots, \Delta i_{t-4}$ S_{t-2}	.075 (.000)	.110 (.000)	.410 (.087)	−.035 (.159)

NOTE: This table reports instrumental-variables estimates of Equation (1) in the text; $\Delta C = \mu + \lambda \Delta Y$, using instrumental variables Z. The variables C, Y, and S have been divided by the first lag of Y. The statistics in columns 3 and 4 are adjusted R^2 values from OLS regressions of ΔC and ΔY on Z [Eq. (2)], and significance levels for tests of the hypothesis that all coefficients except the constant are 0 (in parentheses). The statistics in column 5 are the instrumental variables estimate of λ, with an asymptotic standard error (in parentheses). Column 6 gives the adjusted R^2 from a regression of the IV residual onto the instruments and the significance level for a Wald test of the overidentifying restrictions of the IV model. All standard errors and test statistics are heteroscedasticity and autocorrelation consistent.

Finally, there is no evidence against our model (1) with a free parameter λ. The tests in the last column of Table 2 uniformly fail to reject the model against the more general alternative (2).

3.2 How Robust Are the Results?

The results of Table 2 are robust to the measures of consumption and income used. We obtain extremely similar results when we use consumption and income growth rates rather than scaled changes (Table 3); the estimates of λ are very slightly higher in this table, but the general pattern is the same. We also obtain similar results when we use total consumption rather than consumption of nondurables and services and when we use the Blinder–Deaton (1985) data on consumption of nondurables and services and total disposable income or disposable labor income. The distinction between these two income concepts seems to be unimportant empirically.

Our estimates of λ are more sensitive to sample period. As reported in detail in the National Bureau of Economic Research working paper version of this article (Campbell and Mankiw 1987), the addition of the four years 1949–1952 to the sample period makes the estimates of λ small and insignificant, but this is entirely due to one quarter, 1950:1, in which there was a large payment of National Service Life Insurance (NSLI) benefits to World War II veterans. Disposable income grew 6.5%, or 26% at an annualized rate, in that quarter. It seems inappropriate to treat this episode as being generated by the same time series process as the rest of the data. [The special NSLI payments were analyzed in several early works on the permanent-income model, with inconclusive results. See Mayer (1972) for a review.]

When we exclude 1950:1 from the sample, we get similar results to those reported for 1953–1985. The only comparable episode in the 1953–1985 period is the temporary tax rebate of 1975:2, which caused disposable income to grow 4.6%, or 18% at an annualized rate. Excluding this quarter from the sample has no important effects on the estimates of λ. We conclude that the empirical results of Hall (1978), Flavin (1981), and Nelson (1987), which use the 1950:1 observation, should be treated with caution.

Finally, we note that a split of the 1953–1985 sample in 1969:2 gives similar estimates of λ in both subsamples but much greater statistical significance in the second subsample. As discussed in Campbell and Mankiw (1987), income growth is close to unpredictable in the first subsample.

4. MONTE CARLO RESULTS

The evidence in Section 3 suggests that postwar U.S. data can reject the permanent-income hypothesis. In this section, we use Monte Carlo methods to examine the small-sample distribution of our test statistics. The problem of small-sample bias has been a serious one in tests of the permanent-income hypothesis (Mankiw and Shapiro 1985), and it can be particularly dangerous when using IV methods (Nelson and Startz 1988).

Table 3. Basic Permanent-Income Model (logs)

Row	Instruments (z)	OLS regressions on z: Δc equation	OLS regressions on z: Δy equation	λ estimate (standard error)	Test of restrictions
1	None (OLS)	—	—	.328 (.048)	—
2	$\Delta y_{t-2}, \ldots, \Delta y_{t-4}$	−.003 (.168)	.021 (.013)	.379 (.178)	−.023 (.988)
3	$\Delta y_{t-2}, \ldots, \Delta y_{t-6}$	.022 (.096)	.043 (.020)	.477 (.158)	−.035 (.986)
4	$\Delta c_{t-2}, \ldots, \Delta c_{t-4}$	.022 (.093)	.050 (.008)	.406 (.135)	−.012 (.453)
5	$\Delta c_{t-2}, \ldots, \Delta c_{t-6}$	.089 (.001)	.088 (.022)	.526 (.142)	−.016 (1.000)
6	$\Delta i_{t-2}, \ldots, \Delta i_{t-4}$	.062 (.000)	.025 (.001)	.713 (.156)	−.016 (.607)
7	$\Delta i_{t-2}, \ldots, \Delta i_{t-6}$	.122 (.000)	.087 (.001)	.615 (.156)	−.025 (.535)
8	$\Delta y_{t-2}, \ldots, \Delta y_{t-4}$, $\Delta c_{t-2}, \ldots, \Delta c_{t-4}$, $c_{t-2}-y_{t-2}$	.010 (.203)	.089 (.000)	.351 (.120)	−.040 (.858)
9	$\Delta y_{t-2}, \ldots, \Delta y_{t-4}$, $\Delta c_{t-2}, \ldots, \Delta c_{t-4}$, $\Delta i_{t-2}, \ldots, \Delta i_{t-4}$, $c_{t-2} - y_{t-2}$	.080 (.000)	.115 (.000)	.454 (.095)	−.031 (.136)

NOTE: This table reports instrumental-variables estimates of a log version of Equation (1) in the text; $\Delta c = \mu + \lambda \Delta y$, using instrumental variables z. Lowercase letters denote log variables. The statistics in columns 3 and 4 are adjusted R^2 values from OLS regressions of Δc and Δy on z [Eq. (2) in the text] and significance levels for tests of the hypothesis that all coefficients except the constant are 0 (in parentheses). The statistics in column 5 are the instrumental-variables estimate of λ, with an asymptotic standard error (in parentheses). Column 6 gives the adjusted R^2 from a regression of the IV residual onto the instruments and the significance level for a Wald test of the overidentifying restrictions of the IV model. All standard errors and test statistics are heteroscedasticity and autocorrelation consistent.

Monte Carlo experiments can protect us from excessive reliance on asymptotic distribution theory.

If our Monte Carlo experiment is to be convincing, we need to use a data-generating process that both obeys the restrictions of our model and matches the moments of the U.S. consumption and income data. We have chosen to match the moments of the data measured in logs, since these are more familiar to most readers and are independent of the units of measurement. Our objective then is to generate data with the following properties:

1. Log income and consumption are each first-order integrated processes.
2. The log consumption–income ratio is stationary, so consumption and income are cointegrated.
3. Growth rates of income are not useful for forecasting growth rates of income or consumption two or more quarters ahead. (This is an exaggeration of the properties of the actual data; in fact, income growth rates do help to forecast income growth rates, but with a very modest R^2, as shown in Table 3.)
4. Growth rates of consumption and the log consumption–income ratio do forecast growth rates of income two or more quarters ahead (with an R^2 of 5% to 15%).
5. When we impose the permanent-income hypothesis, the growth rate of consumption is not forecastable by any variables two or more quarters ahead.
6. The standard deviation of consumption growth (.0053 in our data) is about half the standard deviation of income growth (.0094 in our data).
7. The standard deviation of the log consumption–income ratio (.0236 in the data) is more than twice the standard deviation of income growth, and this ratio follows a first-order autoregressive [AR(1)] process with a coefficient between .9 and .95.
8. The contemporaneous correlation of income growth and consumption growth is .58. (In combination with property 6, this gives an OLS regression coefficient of .33 when consumption growth is regressed on income growth.)

To obtain properties 1–5, we use a continuous-time model first developed by Campbell and Kyle (1988). Details are given in the Appendix. Labor income and an information variable evolve according to a linear vector-diffusion process with constant innovation variance; this process is restricted in such a way that the univariate process for labor income is a Brownian motion (a continuous-time random walk). Consumers observe the information variable, however, and can therefore forecast future changes in labor income. A fraction λ of consumption is set equal to current income, while a fraction $(1 - \lambda)$ obeys a continuous-time version of Flavin's (1981) permanent-income model. Total income is the sum of labor income and endogenous capital income. Observed variables are time averages of the underlying continuous processes.

To obtain properties 6–8, we calibrate the free parameters of the model. There are five in total but one determines the overall variability of consumption and income, one is the coefficient λ, which we set equal to 0 or .5, and one is the interest rate, which we fix at .01

per quarter; this leaves two free parameters to match relative standard deviations, cross-correlations, and autocorrelations.

Having chosen the parameters of the model, we use the methods of Campbell and Kyle (1988) to calculate the moments of the implied processes for time-averaged consumption and income. Table 4 compares some important moments of the actual data with those generated by versions of the continuous-time model setting $\lambda = 0$ or .5.

It is striking that the model in which $\lambda = 0$ (artificial data set 1) is unable to account for the low standard deviation of consumption growth, whereas the model in which $\lambda = .5$ (artificial data set 2) matches this feature of the data quite well. This is evidence that the presence of current-income consumers can account for the findings of Campbell and Deaton (1989). The intuition for this result was given by Flavin (1988). When consumers have superior information about the future path of income, the revision in permanent income and the change in current income are less than perfectly correlated. This means that a weighted average of the two can be less variable than either one taken alone. The model in which $\lambda = .5$ makes aggregate consumption a "diversified portfolio" of the consumption of two types of agents, and this reduces its variability.

In artificial data set 2, this effect is particularly powerful because the revision in permanent income and the change in current income are actually negatively correlated. The negative correlation also generates downward bias in the OLS estimate of λ in Equation (1).

More important for our present purposes, both versions of the continuous-time model have the property that lagged income-growth rates do not forecast future income-growth rates and are therefore invalid instruments; lagged consumption-growth rates and consumption–income ratios, by contrast, do have forecast power for income growth (and consumption growth when $\lambda =$ .5).

In Table 5, we report the results of a Monte Carlo experiment using the data-generating processes summarized in Table 4. For each process, we generated 1,000 time series of length 125 and applied the econometric methods of Tables 2 and 3. The instrument sets used are lags 2–4 of income growth, lags 2–6 of income growth, lags 2–4 of consumption growth, lags 2–6 of consumption growth, and the lag 2 consumption–income ratio plus lags 2–4 of consumption and income growth. For each instrument set, we report the mean adjusted R^2 statistics for the consumption and income forecasting equations, and the mean IV estimate of λ with the mean standard error, the rejection rates for nominal 5% and 1% OLS and instrumental-variables tests of the permanent-income hypothesis, and the empirical 5% and 1% critical values of the IV test.

Table 4. Calibration of a Monte Carlo Experiment

Statistic	*Actual data*	*Artificial data set 1 (true λ = 0)*	*Artificial data set 2 (true λ = .5)*
$\sigma(\Delta y_t)$	.009	.010	.010
$\sigma(\Delta c_t)$	.005	.010	.005
$\mathrm{Corr}(\Delta y_t, \Delta c_t)$	.58	.42	.66
$\mathrm{Corr}(\Delta y_t, \Delta y_{t-1})$	.06	.24	.24
$\mathrm{Corr}(\Delta c_t, \Delta c_{t-1})$	.16	.25	.35
$\mathrm{Corr}(\Delta y_t, \Delta y_{t-i})$	−.18–.19	0	0
$\mathrm{Corr}(\Delta c_t, \Delta y_{t-i})$	−.18–.13	0	0
$\mathrm{Corr}(\Delta y_t, \Delta c_{t-i})$	−.16–.23	.07–.29	.10–.13
$\mathrm{Corr}(\Delta c_t, \Delta c_{t-i})$	−.23–.20	0	.09–.13
$\sigma(c_t - y_t)$	.024	.018	.021
$\mathrm{Corr}\ (c_t - y_t, c_{t-1} - y_{t-1})$	.95	.82	.94

NOTE: Artificial data are generated from the model described in the Appendix. Artificial data set 1 has parameters $\lambda = 0$, $a = .3$, and $\rho = .75$. Artificial data set 2 has parameters $\lambda = .5$, $a = .1$, and $\rho = 1.5$. The time index i runs from 2 to 6 in the rows where i is not specified.

In panel A of Table 5, the true value of λ is 0; the permanent-income hypothesis holds. The instruments used in the first two rows have no forecasting power for income, and the result is a severe upward bias in the IV estimate of λ. The mean estimates are close to the mean OLS estimate of .405. In the remaining rows, the instruments do forecast income and the bias in the IV estimator is much smaller. This confirms the theoretical analysis of Nelson and Startz (1988).

The rejection rates of the IV tests in panel A are not too far from their theoretical values when three instruments are used, but they increase with the number of instruments. When seven instruments are used in the final row, the true size of a nominal 5% test is almost 10%, whereas the true size of a nominal 1% test is over 4%. Overall, the table suggests that the IV procedure should be used only when the instruments have some forecasting power for the right-side variable and that one should keep the number of instruments to a minimum.

Panel B dramatically confirms the dangers of using the IV procedure when the instruments do not forecast income. In this panel, the true value of λ is not 0 but .5. In the first two rows, however, the instruments are lagged income-growth rates, which forecast neither consumption nor income and do not identify λ. Nevertheless, the IV test using three income instruments rejects the hypothesis $\lambda = 0$ at the 5% level 25% of the time and at the 1% level 10% of the time and the situation is even worse with five income instruments.

In the remaining rows of panel B, the instruments do forecast income growth, and the advantage of the IV procedure becomes more apparent. The IV estimator has only a small downward bias. The IV method tests the permanent-income model against a one-dimensional alternative, whereas the OLS test is against a multidimensional alternative. The IV test therefore has more power against this particular alternative, and it rejects far more often than the OLS test. This is true whether one uses the theoretical critical values or the empirical critical values from panel A.

Our Monte Carlo results point to the same conclusion as the theoretical analysis of Nelson and Startz (1988).

Table 5. Monte Carlo Results

Instrument set (z)	Mean adjusted R^2 statistics: Δc on z	Mean adjusted R^2 statistics: Δy on z	Mean λ estimate	Rejection probabilities: OLS 5% (OLS 1%)	Rejection probabilities: IV 5% (IV 1%)	Empirical critical values IV 5% (IV 1%)
A. Artificial data set 1 (true λ = 0)						
None (OLS)			.405			
Δy_{t-i} (i = 2 − 4)	.001	.001	.399	.052	.051	1.994
			(1.014)	(.017)	(.010)	(2.548)
Δy_{t-i} (i = 2 − 6)	.001	.000	.396	.066	.120	2.303
			(.558)	(.011)	(.023)	(2.851)
Δc_{t-i} (i = 2 − 4)	.001	.039	.034	.063	.058	2.010
			(.555)	(.016)	(.010)	(2.530)
Δc_{t-i} (i = 2 − 6)	.000	.042	.105	.065	.088	2.190
			(.379)	(.013)	(.021)	(2.839)
Δy_{t-i} (i = 2 − 4)	.005	.146	.058	.073	.098	2.447
δc_{t-i} (i = 2 − 4)			(.212)	(.016)	(.042)	(3.273)
$c_{t-2} - y_{t-2}$						
B. Artificial data set 2 (true λ = .5)						
None (OLS)			.356			
Δy_{t-i} (i = 2 − 4)	.002	.002	.359	.070	.252	—
			(.468)	(.023)	(.106)	
Δy_{t-i} (i = 2 − 6)	.003	.002	.363	.077	.435	—
			(.252)	(.024)	(.196)	
Δc_{t-i} (i = 2 − 4)	.018	.023	.390	.218	.459	—
			(.364)	.090	(.307)	
Δc_{t-i} (i = 2 − 6)	.020	.027	.378	.191	.623	—
			(.252)	(.084)	(.427)	
Δy_{t-i} (i = 2 − 4)	.131	.165	.441	.817	.980	—
Δc_{t-i} (i = 2 − 4)			(.086)	(.655)	(.958)	
$c_{t-2} - y_{t-2}$						

NOTE: This table reports the results of a Monte Carlo simulation with 1,000 artificial data sets of length 125. The data were generated from the model described in the Appendix. In artificial data set 1 (panel A), true λ = 0, and in artificial data set 2 (panel B), true λ = .5. Columns 2 and 3 give the empirical mean adjusted R^2 when Δc and Δy are regressed on the instruments z. Column 4 gives the empirical mean instrumental variables estimate of λ in the equation $\Delta c = \mu + \lambda \Delta y$ and the empirical mean asymptotic standard error. Column 5 gives the empirical rejection probabilities for a 5% (1%) test of the hypothesis that all coefficients are 0 when Δc is regressed on z. Column 6 gives the empirical rejection probabilities for a 5% (1%) test of the hypothesis that λ = 0. Column 7 in panel A gives the empirical 5% and 1% critical values for the t statistic on λ.

The IV test should be used only with a moderate number of instruments that have adequate forecasting power for income. Our regressions, however, seem to satisfy the conditions for reasonable small-sample behavior of the IV test. Table 5 suggests that the results of Tables 2 and 3 cannot be explained by small-sample bias. This is not surprising, given the rule of thumb of Nelson and Startz (1988) that with a single instrument the R^2 for income growth should exceed $2/T$, or .016 for our data. In Tables 2 and 3, we have multiple instruments, so this condition is not directly applicable, but it is encouraging to note that our adjusted R^2 statistics are usually well above .02 and range up to .11.

5. GENERALIZATIONS OF THE PERMANENT-INCOME HYPOTHESIS

In this section, we examine whether generalizations of the permanent-income hypothesis, along some dimension, can explain the rejection of the simple model in Section 3.

5.1 Changes in the Real Interest Rate

Hall's (1978) random walk theorem for consumption rests on the crucial assumption that the real interest rate is constant. Any rejection of the theory might be attributable to the failure of this assumption. For example, Michener (1984) showed how variation through time in the real interest rate can make consumption appear excessively sensitive to income, even though individuals intertemporally optimize in the absence of borrowing constraints. It is therefore important to examine whether the departure from the theory documented previously is an artifact of the assumed constancy of the real interest rate.

The generalization of the consumer's Euler equation to allow for changes in the real interest rate is now well known (Grossman and Shiller 1981; Hall 1988; Hansen and Singleton 1983; Mankiw 1981.) The log-linear version of the Euler equation is

$$\Delta c_t = \mu + (1/a)r_t + \varepsilon_t. \qquad (3)$$

where r_t is the real interest rate contemporaneous with Δc_t and, as before, the error term ε_t may be correlated with r_t but is uncorrelated with lagged variables. According to (3), high ex ante real interest rates should be associated with rapid growth of consumption. If higher income growth is associated with higher real interest rates, this could explain the deviation from the permanent-income hypothesis documented previously.

To examine this possibility, we consider a more general model in which a fraction λ of income goes to individuals who consume their current income and the remainder goes to individuals who satisfy the general Euler equation (3). We estimate by IV

$$\Delta c_t = \mu + \lambda \Delta y_t + \theta r_t + \varepsilon_t, \tag{4}$$

where $\theta = (1 - \lambda)/a$. We thus include the actual income growth and the ex post real interest rate in the equation but instrument using twice-lagged variables. The nominal interest rate we use is the average three-month treasury-bill rate over the quarter, the price index is the deflator for consumer nondurables and services, and we assume that there is a 30% marginal tax rate on interest. (We obtained similar results when we assumed a marginal tax rate of 0.) The results for two alternative instrument sets are in panel A of Table 6.

We find no evidence that the ex ante real interest rate is associated with the growth rate of consumption. The coefficient on the real interest rate is consistently less than its standard error. Moreover, the coefficient on current income remains substantively and statistically significant. In contrast to the suggestion of Michener (1984), the excess sensitivity of consumption to income cannot be explained by fluctuations in the real interest rate.

5.2 Nonseparabilities in the Utility Function

The random walk theorem for consumption will also fail if consumption is not separable in the utility function from other goods. With constant real interest rates, the marginal utility of consumption is a martingale even under nonseparability; that is, it is still true that

$$E_t U'(C_{t+1}, X_{t+1}) = \gamma U'(C_t, X_t) \tag{5}$$

for some constant γ. Yet predictable changes in the other good, X, must lead to predictable changes in consumption to maintain the martingale property of marginal utility. If changes in X are correlated with changes in income, nonseparability could in principle explain the apparent excess sensitivity of consumption to income documented in Section 3.

We test for nonseparability in a very simple way. We include the change in log X as an additional regressor in our equation. This functional form can be formally justified if the utility function is Cobb–Douglas (Bean 1986) or a log-linear approximation to a more general specification. As before, we estimate the equation using twice-lagged instrumental variables.

Various nonseparabilities have been proposed. Mankiw et al. (1985) and Eichenbaum et al. (1988) considered nonseparability between consumption and labor supply. In panel B of Table 6, we include the change in log labor supply as a right-side variable with

Table 6. Alternative Versions of the Permanent-Income Model

Row	Instruments (z)	OLS regressions on z: Δc	Δy	r or Δx	λ (standard error)	θ (standard error)	Test of restrictions
				A. Real interest rates			
1	$\Delta c_{t-2}, \ldots, \Delta c_{t-4}$	.046	.049	.467	.451	.049	−.010
	$r_{t-2}, \ldots, r_{t-4}$	(.018)	(.004)	(.000)	(.109)	(.081)	(.242)
2	$\Delta i_{t-2}, \ldots, \Delta i_{t-4}$	.077	.026	.448	.668	−.022	−.022
	$r_{t-2}, \ldots, r_{t-4}$	(.000)	(.010)	(.000)	(.173)	(.093)	(.616)
				B. Labor supply			
3	$\Delta c_{t-2}, \ldots, \Delta c_{t-4}$	.029	.079	.221	.364	.047	−.037
	$\Delta l_{t-2}, \ldots, \Delta l_{t-4}$	(.031)	(.001)	(.000)	(.200)	(.137)	(.838)
4	$\Delta i_{t-2}, \ldots, \Delta i_{t-4}$	.086	.062	.150	.497	.087	−.028
	$\Delta l_{t-2}, \ldots, \Delta l_{t-4}$	(.000)	(.000)	(.000)	(.212)	(.175)	(.919)
				C. Durable goods			
5	$\Delta c_{t-2}, \ldots, \Delta c_{t-4}$	.026	.046	.753	.258	.103	.006
		(.136)	(.012)	(.000)	(.143)	(.095)	(.757)
6	$\Delta i_{t-2}, \ldots, \Delta i_{t-4}$	.115	.053	.727	.590	.076	−.011
	$\Delta d_{t-2}, \ldots, \Delta d_{t-4}$	(.000)	(.001)	(.000)	(.137)	(.091)	(.035)
				D. Government spending			
7	$\Delta c_{t-2}, \ldots, \Delta c_{t-4}$	−.001	.043	.046	.357	.051	−.035
	$\Delta g_{t-2}, \ldots, \Delta g_{t-4}$	(.185)	(.008)	(.004)	(.133)	(.087)	(.639)
8	$\Delta i_{t-2}, \ldots, \Delta i_{t-4}$	.040	.013	.037	.664	.103	−.035
	$\Delta g_{t-2}, \ldots, \Delta g_{t-4}$	(.001)	(.016)	(.016)	(.170)	(.094)	(.976)

NOTE: Panel A of this table reports instrumental-variables estimates of Equation (6) in the text; $\Delta c = \mu + \lambda\Delta y + \theta r$, using instrumental variables z. The other panels report instrumental-variables estimates when $\Delta c = \mu + \lambda\Delta y + \theta\Delta x$, where x is labor supply, durable goods, or government spending. The statistics in columns 3, 4, and 5 are adjusted R^2 values from OLS regressions of Δc, Δy, and r or Δx and Z, and significance levels for tests of the hypothesis that all coefficients except the constant are 0 (in parentheses). The statistics in columns 6 and 7 are the instrumental-variables estimates of λ and θ, with asymptotic standard errors (in parentheses). Column 8 gives the adjusted R^2 from a regression of the IV residual onto the instruments and the significance level for a Wald test of the overidentifying restrictions of the IV model. All standard errors and test statistics are heteroscedasticity and autocorrelation consistent.

coefficient θ [i.e., we estimate a version of Eq. (4) with the change in labor supply replacing the real interest rate]. Labor supply is measured as per capita man-hours in nonagricultural establishments. The results suggest no important nonseparability between consumption and labor supply. Even though there is substantial predictable variation in the quantity of labor supplied, it is apparently not associated with predictable changes in consumption.

Bernanke (1985) and Startz (1986) proposed that the marginal utility of nondurable goods may be affected by the stock of consumer durable goods. In panel C of Table 6, we enter this stock as the X variable. We first constructed an end-of-quarter stock series from the annual stock at the beginning of the sample period and the series on consumer durable purchases, assuming a depreciation rate of 6% per quarter. We then measured the stock of consumer durables during a quarter as the average of the end-of-quarter stock and the previous end-of-quarter stock. (Other timing assumptions lead to similar results.) We find substantial predictable changes in the stock of durables but no evidence that these changes coincide with predictable changes in consumption.

It is often suggested that changes in government purchases of goods and services affect the marginal utility of private consumption (Aschauer 1985; Bailey 1971; Kormendi 1983). Indeed, Aschauer suggested that allowing for such an effect can save the consumption Euler equation from a statistical rejection. In panel D of Table 6, we examine this possibility by entering the change in the log of total government purchases per capita as a right-side variable. Again, we find no evidence of nonseparability in the utility function. Moreover, the estimate of λ we obtain remains statistically and substantively significant. In contrast to Aschauer, we find that nonseparability between private and public purchases does not improve the performance of the consumption Euler equation.

6. CONCLUSIONS

Our analysis of U.S. postwar quarterly data leads us to the following conclusions:

1. There is evidence against the implication of the permanent-income hypothesis that changes in consumption are unforecastable. When the change in consumption (scaled by lagged income or measured in logs) is regressed on its own lags 2–6 in the 1953–1985 period, the null hypothesis that all the coefficients are 0 can be rejected at the .1% level. Although the adjusted R^2 of this regression is small (less than 9%), a small R^2 should not be viewed as supportive of the permanent-income hypothesis, since the R^2 of the comparable regression for the change in disposable income is also small. Similar results can be obtained using lagged nominal interest rates as instruments.

2. The forecastability of consumption can be explained by a model in the spirit of Flavin (1981), in which a fraction λ of income goes to individuals who consume their current income rather than their permanent income. This more general model is not statistically rejected. Our estimates suggest that λ is approximately .5, indicating a substantial departure from the permanent-income hypothesis.

3. The result that consumption tracks income too closely cannot be explained by the time-averaged nature of the data, by short delays in publication of aggregate statistics, or by partial durability of goods labeled "nondurable" in the National Income Accounts. Our test of the permanent-income model is robust to all of these problems because, in common with Hall (1988) but in contrast with much of the rest of the literature, we lag our instruments by two quarters instead of one.

4. The large estimate of λ cannot be explained by small-sample bias in our IV estimation. Although IV procedures are vulnerable to small-sample bias when the instruments are poor forecasters of the independent variables, in our application we have quite good forecasting power for future income growth. A carefully calibrated Monte Carlo experiment does not generate enough small-sample bias to account for our results.

5. Our results cannot be explained by appealing to more general versions of the permanent-income hypothesis. We have allowed for changes in the real interest rate and for nonseparability in the utility function between consumption and other goods—labor supply, consumer durables, and government purchases—but these generalizations do not help the model.

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APPENDIX: CONSTRUCTION OF A MONTE CARLO EXPERIMENT

Following Campbell and Kyle (1988, model B), suppose that labor income $yl(t)$ and an information variable $x(t)$ evolve in continuous time as

$$\begin{bmatrix} dyl \\ dx \end{bmatrix} = \begin{bmatrix} 0 & a \\ 0 & -a \end{bmatrix} \begin{bmatrix} yl \\ x \end{bmatrix} dt + \begin{bmatrix} \sigma & 0 \\ -\rho\sigma & [2\rho - \rho^2]^{1/2}\sigma \end{bmatrix} \begin{bmatrix} dz_1 \\ dz_2 \end{bmatrix}. \quad \text{(A.1)}$$

Here dz_1 and dz_2 are the increments to mutually orthogonal Brownian motions. Campbell and Kyle showed that (A.1) implies that the univariate process for $yl(t)$ is a Brownian motion, but the univariate process for $x(t)$ is an Ornstein–Uhlenbeck [continuous-time AR(1)] process that reverts to its zero mean at rate a. Knowledge of $yl(t)$ does not help to forecast $x(t)$, but

$x(t)$ does help to forecast $yl(t)$. If E_t denotes expectation conditional on $x(t)$ and $yl(t)$, then

$$rE_t \int_{s=0}^{\infty} e^{-rs} yl(t+s)\, ds = yl(t) + \phi x(t), \quad (A.2)$$

where $\phi = 1 - r/(r + a)$.

We now define total income as $y(t) \equiv yl(t) + rw(t)$, where the second term is capital income received from real wealth $w(t)$. We suppose that consumption is determined by

$$\begin{aligned} c(t) &= \lambda y(t) + (1 - \lambda)[rw(t) \\ &\quad + E_t \int_{s=0}^{\infty} e^{-rs} yl(t + s)\, ds] \\ &= y(t) + (1 - \lambda)\phi x(t) \quad \text{from (A.2).} \quad (A.3) \end{aligned}$$

The evolution of real wealth is given by

$$dw(t) = y(t) - c(t) = -(1 - \lambda)\phi x(t). \quad (A.4)$$

One interesting feature of this model is that the innovation to current labor income $dy(t)$ has covariance $\sigma^2(1 - \phi\rho)$ with the innovation to permanent income. If ϕ and ρ are large enough (as they are in artificial data set 2), this covariance can be negative. OLS estimates of λ are then downward biased, as they appear to be in the data.

Equations (A.1)–(A.4) are written in terms of log variables, even though the model appears to be appropriate for levels. This can be justified either as a simple way to generate artificial data that satisfy properties 1–8 in the text or by using a log-linear approximation of the budget constraint to state the permanent-income model in log terms (Campbell and Mankiw 1989).

Campbell and Kyle (1988) showed how to calculate the time series process for time averages of variables which obey (A.1)–(A.4). To calibrate our Monte Carlo experiment, we fixed on $\sigma = .012$ and $r = .01$. We set $\lambda = 0$ or .5 and then searched over the following values of a and ρ: $a = .05, .1, .2, .3, .4, .5, .75, 1.0$; $\rho = .25, .5, .75, 1.0, 1.25, 1.5, 1.75$. The parameter values that best matched the moments of the observed data were $\lambda = 0$, $a = .3$, and $\rho = .75$ (artificial data set 1) or $\lambda = .5$, $a = .1$, and $\rho = 1.5$ (artificial data set 2).

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