A Simple Test of Friedman's Permanent Income Hypothesis
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Friedman's Permanent Income Hypothesis (PIH) predicts that the income elasticity of consumption should be higher for households for which a large fraction of the variation of their income is permanent than for households facing more transitory variations in income. We test this prediction using modern household data from the US Consumer Expenditure Survey. The results offer some support for the PIH.

'Just because something's old doesn't mean you throw it away.'
(Geordie to Scotty in 'Relics', *Star Trek: The Next Generation*)

INTRODUCTION AND MOTIVATION

The simplest form of the Permanent Income Hypothesis (PIH) asserts that households base their consumption decisions on their permanent rather than current income, where permanent income is the expected annuity obtainable from the discounted value of lifetime resources (Friedman 1957).[1] The PIH has many powerful implications, one of which is that the elasticity of consumption with respect to current income should vary systematically with the degree of permanence in the changes to households' income. In particular, the elasticity should be higher the greater is the fraction of the variation in household income that is due to permanent changes. Friedman tested this implication with household data from various budget studies conducted in the 1940s and 1950s and found support for the PIH. However, aside from his own work, the elasticity test was not used; nowadays, with the ascension of Euler equation tests, Friedman's elasticity test has been forgotten.[2]

The present paper revives and improves Friedman's income elasticity test. Because of the limitations of the data available to him, Friedman could not perform formal tests of significance. He himself stressed this weakness of his work, remarking on the 'almost complete absence of statistical tests of significance', which forced him to resort

again and again to intuitive judgements about the likelihood that a particular difference could or could not be regarded as attributable to sampling fluctuation. It would be highly desirable to have such judgements supplemented by formal tests of statistical significance whenever possible.
(Friedman 1957, p. 214)

Our data are from the US Consumer Expenditure Survey (CEX) and are much superior to what was available to Friedman, spanning several years, containing comprehensive information on household socioeconomic and demographic variables and providing detailed and independent measures of

household consumption expenditure and income.[3] These data allow us to perform formal statistical tests of significance. In addition, developments in the statistical and econometric literature allow us to sharpen Friedman's elasticity test by using both parametric and non-parametric methods, by constructing bounds on estimated parameters and by controlling for outlying observations.

The remainder of this paper is organized as follows. Section I provides a brief review of the PIH and its testable implication. Section II describes the data. Section III presents the test results, and Section IV concludes.

I. THE INCOME ELASTICITY IMPLICATION OF THE PERMANENT INCOME HYPOTHESIS

We first derive a strong restriction implied by the PIH for the elasticity of current consumption with respect to current income and then explain how to use the restriction to test the PIH.

The elasticity restriction

We derive the testable implications of Friedman's PIH from the following simple but standard model:

$$(1) \qquad C_{it}^P = Y_{it}^P,$$

$$(2) \qquad C_{it} = C_{it}^P + C_{it}^T,$$

$$(3) \qquad Y_{it} = Y_{it}^P + Y_{it}^T,$$

where C and Y represent current consumption and income, while the superscripts P and T denote their permanent and transitory components, respectively. The subscript i indexes households and t the time period. Equation (1) asserts that permanent consumption is proportional to permanent income. Equations (2) and (3) define current income and consumption as the sum of their corresponding permanent and transitory components. Friedman added the following identifying assumptions to give these equations substantive content:

$$(4) \qquad \sum_i Y_{it}^T = \sum_i C_{it}^T = 0,$$

$$(5) \qquad \rho(C_{it}^P, C_{it}^T) = \rho(Y_{it}^P, Y_{it}^T) = \rho(C_{it}^T, Y_{it}^T) = 0,$$

where $\rho(\cdot)$ denotes the correlation coefficient between the variables in parentheses. Equation (4) states that both transitory income and transitory consumption sum to zero across households.[4] Equation (5) states that the transitory components of income and consumption are not correlated with one another or with their corresponding permanent components.[5]

The current income elasticity of consumption η_{CY} is the marginal propensity to consume divided by the average propensity:

$$(6) \qquad \eta_{CY} = \frac{\partial C / \partial Y}{C / Y}.$$

The PIH has implications for both numerator and denominator and thus for η_{CY} itself. The marginal propensity to consume equals the slope coefficient β_1 in a cross-section regression of current consumption C_{it} on current income Y_{it}:

(7) $C_{it} = \beta_0 + \beta_1 Y_{it} + v_{it}$,

where v_{it} is a random disturbance term. The PIH implies that the estimated value of β_1 is

$$
\begin{aligned}
\beta_1 &= \frac{\mathrm{cov}(C_{it}, Y_{it})}{\mathrm{var}\, Y_{it}} = \frac{\mathrm{cov}(C_{it}^P + C_{it}^T, Y_{it}^P + Y_{it}^T)}{\mathrm{var}\, Y_{it}} \\[2mm]
&= \frac{\mathrm{cov}(C_{it}^P, Y_{it}^P)}{\mathrm{var}\, Y_{it}} = \frac{\mathrm{var}\, Y_{it}^P}{\mathrm{var}\, Y_{it}^P + \mathrm{var}\, Y_{it}^T} \equiv P_Y,
\end{aligned}
$$
(8)

where P_Y denotes the fraction of the cross-section variation in current income that can be attributed to the cross-section variation of the permanent component of income. The third equality of (8) uses the definitions of current consumption and income shown in (2) and (3) respectively, and the fourth equality uses the assumptions in (5). The average propensity to consume C/Y in the denominator of (6) can be estimated by dividing consumption by income. According to the PIH, the probability limit of that estimate equals 1:

(9) $$p\lim_{n\to\infty} \left[\frac{\overline{C}}{\overline{Y}} \right] = p\lim_{n\to\infty} \left[\frac{\frac{1}{n}\sum_{i=1}^{n} C_{it}}{\frac{1}{n}\sum_{i=1}^{n} Y_{it}} \right] = \frac{\left[p\lim_{n\to\infty}\frac{1}{n}\sum_{i=1}^{n} C_{it} \right]}{\left[p\lim_{n\to\infty}\frac{1}{n}\sum_{i=1}^{n} Y_{it} \right]} = \frac{\left[p\lim_{n\to\infty}\frac{1}{n}\sum_{i=1}^{n} Y_{it}^P \right]}{\left[p\lim_{n\to\infty}\frac{1}{n}\sum_{i=1}^{n} Y_{it}^P \right]} = 1,$$

where overbars indicate sample means. It follows that the elasticity of current consumption with respect to current income η_{CY}, evaluated at the point of the sample means of C and Y, can be written as

(10) $$p\lim \eta_{CY} = p\lim \frac{\partial C/\partial Y}{\overline{C}/\overline{Y}} = p\lim \frac{P_Y}{1} = P_Y.$$

The intuition here is straightforward. On average, a fraction P_Y of a change in current income is permanent, so the optimal estimate for the permanent component of a given change in current income is P_Y times the change in current income. Equation (1) then implies that consumption changes by the same amount.

The equality of η_{CY} and P_Y is the restriction we seek, and it provides the basis for a very strong test of the PIH. The income elasticity and the variance ratio are conceptually distinct. One is a relation between consumption and income; the other describes an aspect of the income-generating process. The definitions of the two quantities imply no necessary connection between them; the equality of one to the other is entirely a result of the PIH. Friedman used this implication of the PIH to explain why the estimate of η_{CY} for farmers is distinctly lower than that for non-farmers. Farmers experience more income variation than non-farmers, and much of the income variations are due to transitory factors (e.g. income variation over the crop cycle), implying that P_Y is relatively low for farmers.

Using the elasticity restriction to test the PIH

Our goal here is to use the elasticity restriction to test the PIH. To do that, we need independent estimates of η_{CY} and P_Y that we can check for equality. The income elasticity is a relation between consumption and income, so we easily can obtain an estimate of η_{CY} by regressing the log of current consumption on the log of current income. We noted earlier that P_Y, measures the fraction of the variance of income contributed by the permanent component and hence has nothing to do with consumption behaviour. We therefore can estimate P_Y from income data alone, as long as we are willing to put an appropriate restriction on the income process.

We use two alternative restrictions suggested by Friedman (1957, pp. 184–5): the *mean assumption* and the *variability assumption*. The *mean assumption* states that, for a given group of households, the permanent component of each household's income changes between the two periods in the same proportion as the average income of the group; i.e.,[6]

$$\frac{Y_{i2}^P - Y_{il}^P}{Y_{i2}^P} = \frac{\overline{Y}_2 - \overline{Y}_1}{\overline{Y}_2}$$

(11) $$\Rightarrow \frac{Y_{i1}^P}{Y_{i2}^P} = \frac{\overline{Y}_1}{\overline{Y}_2}$$

$$\Rightarrow Y_{il}^P = \theta Y_{i2}^P,$$

where $\theta = \overline{Y}_1/\overline{Y}_2$, Y_{il}^P is the permanent component of income for household i in period 1, and $\overline{Y}_1$ is the average income of the group in period 1. This assumption also implies that the relative position of a household's permanent income remains unchanged in the two periods. The elasticity of incomes in adjacent periods $(\eta_{Y_1 Y_2})$ evaluated at the point of the sample means can be written as

$$(12) \quad \eta_{Y_1 Y_2} = \frac{\text{cov}(Y_{i1}, Y_{i2})/\text{var}(Y_{i2})}{\overline{Y}_1/\overline{Y}_2} = \frac{\text{cov}(Y_{il}^P + Y_{il}^T, Y_{i2}^P + Y_{i2}^T)/\text{var}(Y_{i2})}{\overline{Y}_1^P/\overline{Y}_2^P},$$

where we have used (3) and (4) to obtain the second equality. If the transitory components of income are serially uncorrelated (i.e., $\text{cov}(Y_{il}^T, Y_{i2}^T) = 0$), then we can use (5) and (11) to rewrite (12) as

$$(13) \quad \eta_{Y_1 Y_2} = \frac{\text{cov}(\theta Y_{i2}^P + Y_{il}^T, Y_{i2}^P + Y_{i2}^T)/\text{var}(Y_{i2})}{\theta \overline{Y}_2^P/\overline{Y}_2^P} = \frac{\theta \, \text{var}(Y_{i2}^P)/\text{var}(Y_{i2})}{\theta} = P_Y.$$

Thus, according to the mean assumption, $\eta_{Y_1 Y_2}$ is an unbiased estimate of P_Y.[7]

The *variability assumption*, on the other hand, states that the fraction of the cross-sectional variation in current income contributed by the permanent components is the same in different periods; i.e.,

$$(14) \qquad P_{Y_1} = \frac{\text{var}(Y_{i1}^P)}{\text{var}(Y_{i1})} = P_{Y_2} = \frac{\text{var}(Y_{i2}^P)}{\text{var}(Y_{i2})} = P_Y.$$

Essentially, it requires that the cross-sectional variances of current income, permanent income and transitory income change equiproportionally. This

restriction is reasonable for changes in income arising from aggregate fluctuations. It seems natural to expect economic growth to leave the cross-sectional coefficients of variation for all three types of income unchanged and so also to cause proportional changes in their cross-sectional variances. Similarly, business cycles cause expansions or contractions in the whole economy and so resemble growth changes except that they are temporary. There is, however, no reason to believe that transitory income cannot become more or less variable relative to permanent income independently of economic growth or the business cycle. As a result, the variability assumption is stronger than the mean assumption, as Friedman and Kuznets (1945) themselves remarked when first proposing it.

Given (14), and that $P_{Y_1} = \text{cov}(Y_{i1}, Y_{i2})/\text{var}(Y_{i1})$, the variability assumption implies that the correlation coefficient of incomes in adjacent periods $(\rho_{Y_1 Y_2})$ is an unbiased estimate of P_Y.[8] That is,

$$(15) \qquad \rho_{Y_1 Y_2} = \sqrt{P_{Y_1} P_{Y_2}} = P_Y.$$

In summary, the distinctive testable implications of the PIH are: $\eta_{CY} = \eta_{Y_1 Y_2}$ (mean assumption) and $\eta_{CY} = \rho_{Y_1 Y_2}$ (variability assumption).

II. DATA

The data used in this study are drawn from the 1980–1996 US Consumer Expenditure Survey (CEX). The CEX provides detailed and extensive data on consumption expenditure, income, socioeconomic and demographic character-istics for a large cross-section of American households. About 4500 households are interviewed every quarter, and households can stay in the survey for up to five consecutive quarters. After their fifth quarterly interview households are dropped from the survey and replaced by new households; approximately 20% of the sample is new every quarter (US Bureau of Labor Statistics 1990). Information collected in the first interview are not available in the public-use tape, but is used as a reference to compare responses in the following interviews. In effect, a maximum of four quarterly interviews are available for each household in the survey.

There are about 500 types of expenditure data collected in the CEX every quarter, and the amount reported covers the three months prior to the interview period. Income data, on the other hand, are collected only in the second and fifth (last) interviews, and the amount reported is based on incomes received 12 months prior to the interview period. We constructed measures of disposable income and consumption from these data. We measured consumption as expenditure on nondurable goods and services, using the definitions from the US National Income and Product Accounts. Disposable income, the income measure used in this study, is before-tax income minus income taxes (federal, state and local), property taxes, deductions for retirement (social security, government, self-employed, private pensions and railroad retirement) and occupational expenses. Data on consumption and income are converted to real 1982 dollars using the 1982 base-year CPI deflator.

The sample was selected in standard ways to improve the measurement of consumption and income. We restricted our sample to households that had

four quarterly interviews, were classified as complete income respondents, were identified as having valid data on characteristic variables, reported changes in age between the second and fifth interview of less than or equal to a year and reported annual income and consumption of at least $1200. Also, care was taken to assure consistency in our data sample despite changes in some variable definitions/categories in the CEX across years.

Estimation of $\eta_{Y_1 Y_2}$ and $\rho_{Y_1 Y_2}$ requires two income data points for each household. The CEX data meet this requirement, and the two observations used are taken from the second and fifth interviews. To estimate η_{CY}, we used income reported in the fifth interview and constructed consumption expenditure by summing household expenditures 12 months (four quarterly interviews) prior to the fifth interview. The household observations were pooled across years to obtain a large enough sample size for each group, with a minimum of 15 observations required for each household group. To ensure that estimates of $\eta_{Y_1 Y_2}$ and $\rho_{Y_1 Y_2}$ for each group within a given classification reflected income variations of the group, we also restricted the sample to households that remained in the same group throughout the survey period.

Data limitations and their implications

Two limitations of our data require discussion: measurement error, and exclusion of imputed services of durable goods.

Measurement error is inevitable in survey data, but it turns out the elasticity test is immune to it. Our regression uses consumption as a dependent variable. As such, measurement error in consumption is just one more component of the estimation residual and does not bias the estimated coefficient of the independent variable. In contrast, measurement error in income could be serious. Income is an independent variable in the estimation of η_{CY}, $\eta_{Y_1 Y_2}$ and $\rho_{Y_1 Y_2}$, so measurement error will lead to biased and inconsistent estimates. As it turns out, however, the three quantities are affected identically, which in turn leaves the elasticity test unaffected. The test checks for equality of η_{CY} on the one hand and of $\eta_{Y_1 Y_2}$ or $\rho_{Y_1 Y_2}$ on the other; identical changes in the quantities will not alter the equality relation. See the Appendix for the formal proof.

The *omission of service flows from durables* is more of a problem. The CEX does not report service flows, and its data on household stocks of durables are incomplete, making construction of service flows impossible. It seems possible that durables are a luxury good to some extent. Food and clothing are necessities, whereas many household durables are not. Service flows from durables therefore may be more sensitive than nondurables and services to changes in permanent income. In that case, omitting service flows from durables may bias downward the estimated current income elasticity of consumption. Estimation of $\eta_{Y_1 Y_2}$ or $\rho_{Y_1 Y_2}$ will be unaffected, because those quantities depend only on the income-generating process and not on any aspect of consumption behaviour. As a result in this asymmetry, the elasticity test may show a tendency to reject the PIH falsely through underestimation of η_{CY}. We still would expect to see a positive relation between η_{CY} and either $\eta_{Y_1 Y_2}$ or $\rho_{Y_1 Y_2}$, if the PIH is true. There is nothing algebraical that would lead one to expect a positive relationship, so finding one does constitute a weak test of the PIH.

III. EMPIRICAL STRATEGY AND RESULTS

We now turn to our central empirical question: is the income elasticity of consumption (η_{CY}) higher for households for which a large fraction of the variation of their income is permanent than for households experiencing more transitory variations in income ($P_Y = \mathrm{var}\,Y^P/(\mathrm{var}\,Y^P + \mathrm{var}\,Y^T)$)? As discussed, depending on the assumption one makes about the income process, P_Y can be estimated by either $\eta_{Y_1 Y_2}$ or $\rho_{Y_1 Y_2}$. We performed our basic tests using the following four CEX classifications of households: Occupation, Industry, Education and State.[9]

Figures 1 and 2 present scatter plots for each classification variable, showing η_{CY} plotted against either $\eta_{Y_1 Y_2}$ (Figure 1) or $\rho_{Y_1 Y_2}$ (Figure 2).[10] Although there are some outliers, the plots clearly indicate a positive relation between the variables. To examine the relationship rigorously, we performed two types of test: regressions and rank correlations. For the first type of test we estimated the following cross-section regressions:

$$(16) \qquad \eta_{CY,g} = \alpha_0 + \alpha_1\, \eta_{Y_1 Y_2,g} + \varepsilon_g,$$

$$(17) \qquad \eta_{CY,g} = \alpha_0 + \alpha_1\, \rho_{Y_1 Y_2,g} + \varepsilon_g,$$

where g indexes groups within a classification variable (e.g. managers or clerks within occupation), and ε_g is the group-specific random disturbance term. The statistical equivalent of the PIH implication that η_{CY} equals either $\eta_{Y_1 Y_2}$ or $\rho_{Y_1 Y_2}$ is the joint hypothesis that $\alpha_0 = 0$ and $\alpha_1 = 1$. As mentioned, limitations of the data may introduce unavoidable biases that would lead to the rejection of one or both parts of this joint hypothesis. The PIH still implies a positive relation between η_{CY} and either $\eta_{Y_1 Y_2}$ or $\rho_{Y_1 Y_2}$, so we also tested the simple hypothesis that α_1 is significantly greater than zero and, if so, whether it is insignificantly different from one. Furthermore, η_{CY}, $\eta_{Y_1 Y_2}$ and $\rho_{Y_1 Y_2}$ are estimated parameters and so are subject to estimation error. That alone implies that the point estimate of α_1 will be biased downward and hence will provide only an approximate lower-bound estimate for the true value. For this reason, whenever the estimate of α_1 was significantly less than one we also performed the reverse regression of $\eta_{Y_1 Y_2}$ on η_{CY} and/or $\rho_{Y_1 Y_2}$ on η_{CY} to obtain an approximate upper bound for α_1 (Maddala 1992). Finally, we computed the Spearman rank correlation between η_{CY} on the one hand and $\eta_{Y_1 Y_2}$ and $\rho_{Y_1 Y_2}$ on the other. This non-parametric statistic is limited to testing for a positive relation between the variables, but it is attractive because it is robust to both the functional form of the relation and the distributional properties of the data.

Table 1 reports the cross-section regression estimates of (16) and (17) using the ordinary least squares (OLS) procedure. Heteroscedasticity-consistent standard errors are shown in parentheses. For each classification variable, two row entries are shown, the first referring to the *mean assumption* ($\eta_{CY} - \eta_{Y_1 Y_2}$) and the second to the *variability assumption* ($\eta_{CY} - \rho_{Y_1 Y_2}$).

The results for the Occupation, Industry, Education and State classification variables are qualitatively similar.[11] The joint hypothesis of ($\alpha_0 = 0$, $\alpha_1 = 1$) is rejected; however, the estimated values of α_1 are positive and highly significant, ranging from 0.324 (State) to 2.493 (Education), and the estimated bounds for α_1 include the hypothesis that $\alpha_1 = 1$, except for Education. The Spearman corre-
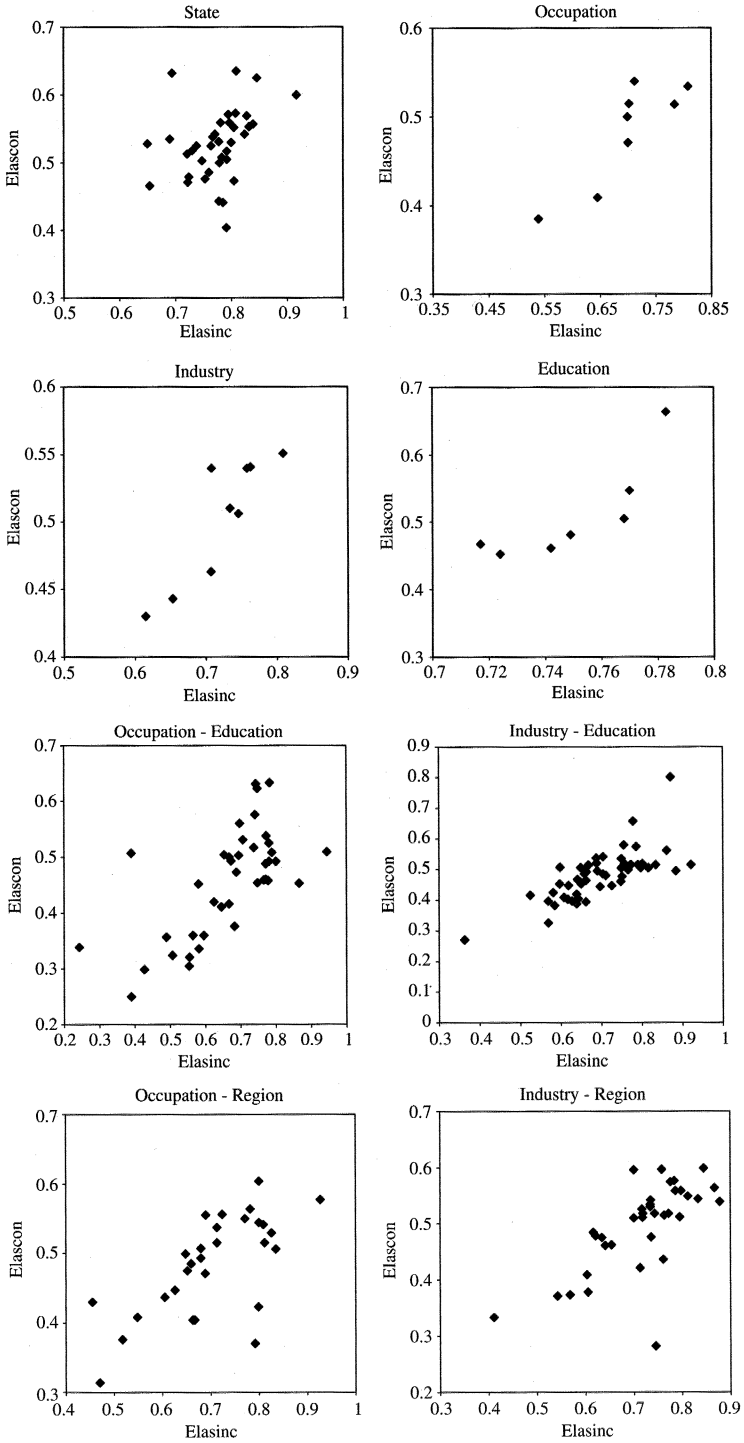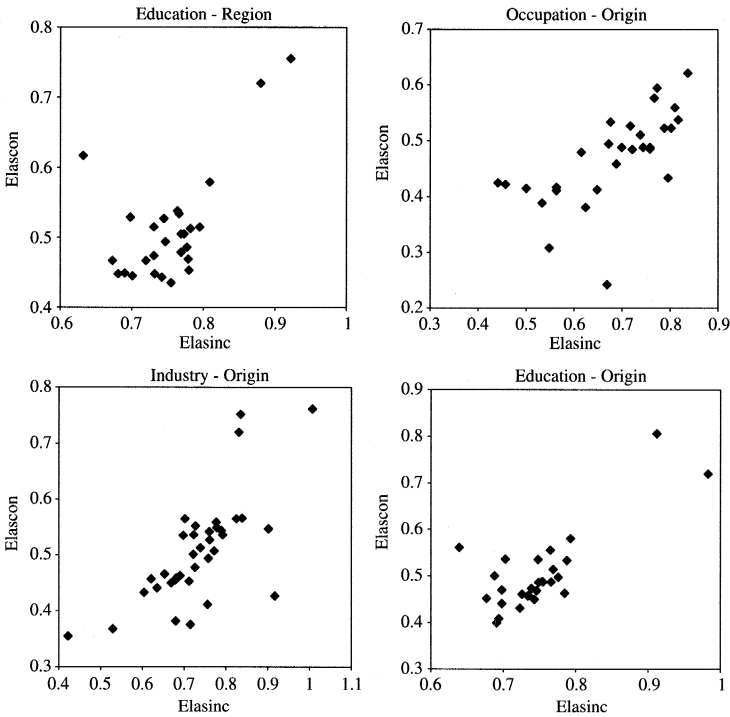
FIGURE 1. Continued on p. 35.

FIGURE 1. Scatter plots of η_{CY} and $\eta_{Y_1 Y_2}$
Elascon (vertical axis) denotes the elasticity of consumption with respect to income, η_{CY}.
Elasinc (horizontal axis) denotes the elasticity of incomes in adjacent periods, $\eta_{Y_1 Y_2}$.

lation coefficients are all significantly greater than zero at the 10% level. Thus, the strong null hypothesis of the PIH is rejected, but the weaker null is not.

A limitation of Occupation, Education and Industry as classification variables is that the number of groups available in the CEX within each of these variables is small (no more than nine groups—see column (9)), leaving the test with few degrees of freedom. To remedy this problem, we examined various cross-classifications of households using the following alternative pairs of variables: Occupation–Education, Occupation–Region, Occupation–Origin, Education–Region, Education–Origin, Industry–Education, Industry–Region and Industry–Origin.[12] Through cross-classification we have not only more degrees of freedom available for the test, but also finer groupings of households. For example, within Occupation and Education we have groups consisting of managers with more than four years of college education, managers with college education, managers with high school education, etc.

The estimation results for the two-way cross-classifications are shown in the remaining rows of Table 1. It is apparent that the relations between η_{CY} and $\eta_{Y_1 Y_2}$ and between η_{CY} and $\rho_{Y_1 Y_2}$ are uniformly positive across classification variables. The estimated values of α_1 are highly significant, the bounds for α_1 contain one, and the Spearman rank correlations are significantly positive in all cases. The strict equality between the variables is still rejected, as indicated by the F-value in column (6).

Several authors have recently noted that cross-section regression based on OLS procedures such as that just presented are fraught with robustness issues,
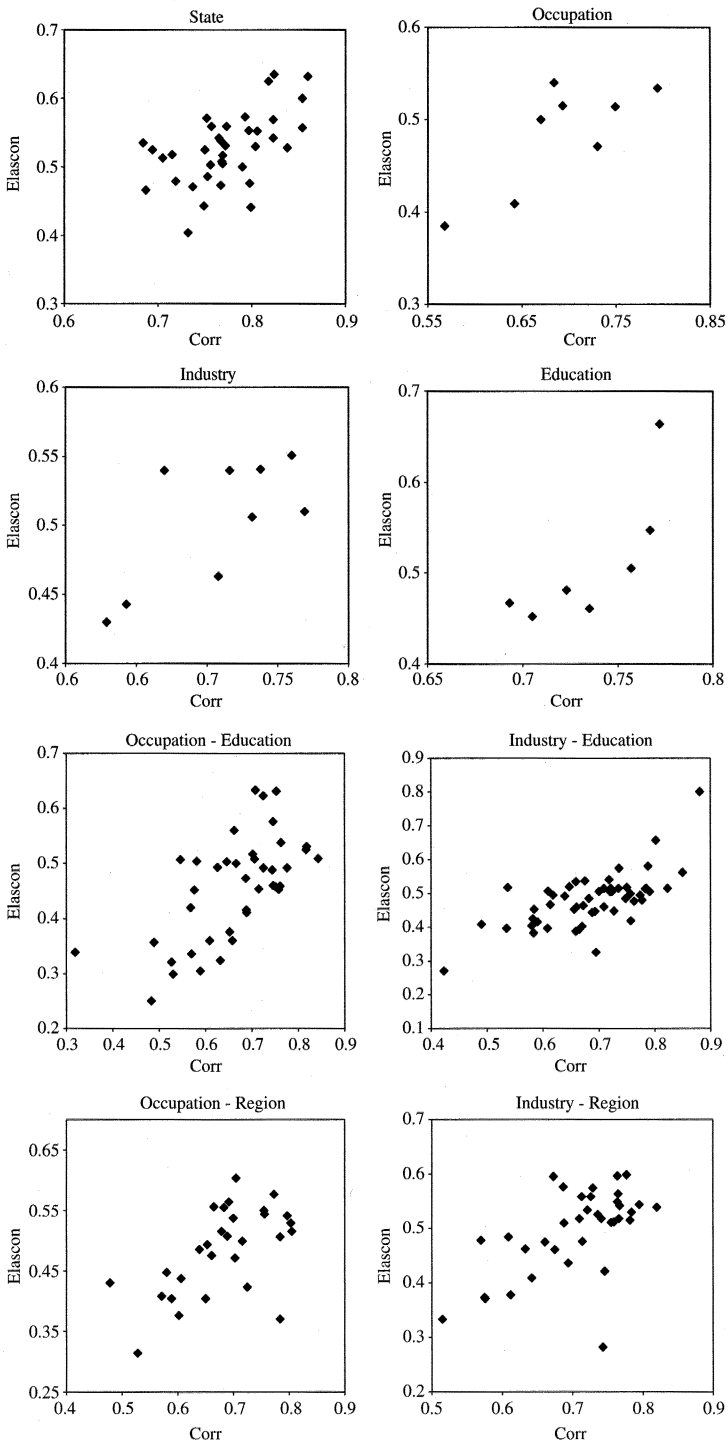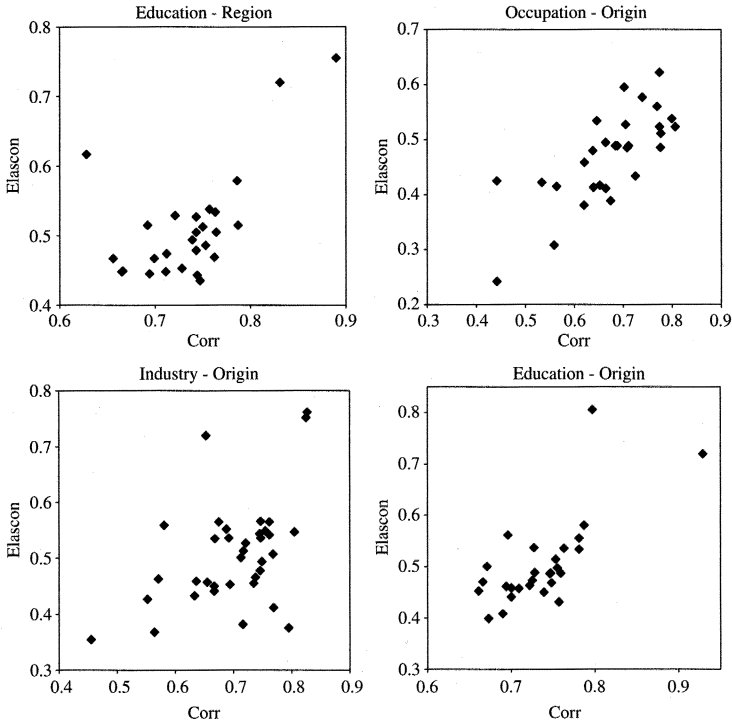
FIGURE 2. Continued on p. 37.

FIGURE 2. Scatter plots of η_{CY} and $\rho_{Y_1 Y_2}$

Elascon (vertical axis) denotes the elasticity of consumption with respect to income, η_{CY}. Corr (horizontal axis) denotes the correlation coefficient of incomes in adjacent periods, $\rho_{Y_1 Y_2}$.

particularly with regard to outliers (see e.g. Zaman *et al.* 2001; Temple 1998). Outlier observations are a concern in this study, for visual inspection of the scatter plots in Figures 1 and 2 suggests that there are a few observations that are not following the general pattern of the data. To examine the sensitivity to outliers of the relationship between η_{CY} and either $\eta_{Y_1 Y_2}$ or $\rho_{Y_1 Y_2}$, we re-estimated (16) and (17) using Least Trimmed Squares (LTS), a robust regression estimator advocated by Rousseeuw (1984). LTS differs from OLS principally in that it works by minimizing the residual sum of squares over half of the smallest ordered squared residuals, as opposed to minimizing all the residual sum of squares as in OLS. Rousseeuw and Leroy (1987) showed that the LTS estimator achieves a 50% breakdown point, which means that it continues to give reasonable results even when 50% of the sample are bad observations. The OLS estimator, on the other hand, has a 0% breakdown point and therefore is extremely sensitive to a small percentage of outlying observations. For more details about the statistical properties of the LTS estimator as well as a comparison of strengths and weaknesses of alternative robust estimators, see Rousseeuw and Leroy (1987).

Application of the LTS technique reveals that there are a few observations with unusually high standardized LTS residuals (regression outliers) and high robust distances (leverage points), which together imply the presence of

TABLE 1

INCOME ELASTICITY OF CONSUMPTION AND RELATIVE VARIANCES OF PERMANENT AND TRANSITORY INCOME: TESTING THE EQUALITY OF η_{CY} AND P_Y

(1)	α_0 (2)	α_1 (3)	$\alpha_1 > 0?$ (4)	$\alpha_1 = 1?$ (5)	F-statistic ($H_0: \alpha_0 = 0, \alpha_1 = 1$) (6)	Bound for α_1 (7)	R^2 (8)	No. of groups (9)	Spearman (10)
State									
$\eta_{CY} - \eta_{Y_1Y_2}$	0.276 (0.117)	0.324 (0.149)	Yes	No	470.74 [0.000]	$0.32 \leqslant \alpha_1 \leqslant 2.94$	0.110	37	0.476 [0.003]
$\eta_{CY} - \rho_{Y_1Y_2}$	0.057 (0.121)	0.606 (0.156)	Yes	No	580.14 [0.000]	$0.61 \leqslant \alpha_1 \leqslant 2.07$	0.293	37	0.549 [0.000]
Occupation									
$\eta_{CY} - \eta_{Y_1Y_2}$	0.064 (0.051)	0.600 (0.071)	Yes	No	185.28 [0.000]	$0.60 \leqslant \alpha_1 \leqslant 1.00$	0.738	8	0.857 [0.007]
$\eta_{CY} - \rho_{Y_1Y_2}$	0.039 (0.085)	0.644 (0.117)	Yes	No	110.79 [0.000]	$0.64 \leqslant \alpha_1 \leqslant 1.00$	0.595	8	0.619 [0.100]
Education									
$\eta_{CY} - \eta_{Y_1Y_2}$	−1.359 (0.580)	2.493 (0.783)	Yes	No	93.61 [0.000]	$2.49 \leqslant \alpha_1 \leqslant 3.70$	0.674	7	0.893 [0.007]
$\eta_{CY} - \rho_{Y_1Y_2}$	−0.871 (0.463)	1.877 (0.643)	Yes	Yes	66.20 [0.000]		0.596	7	0.821 [0.023]
Industry									
$\eta_{CY} - \eta_{Y_1Y_2}$	0.005 (0.046)	0.690 (0.061)	Yes	No	401.04 [0.000]	$0.69 \leqslant \alpha_1 \leqslant 1.00$	0.778	9	0.912 [0.001]
$\eta_{CY} - \rho_{Y_1Y_2}$	0.051 (0.140)	0.639 (0.192)	Yes	No	147.99 [0.000]	$0.64 \leqslant \alpha_1 \leqslant 1.35$	0.475	9	0.686 [0.041]

Occupation and Education									
$\eta_{CY} - \eta_{Y_1Y_2}$	0.160 (0.066)	0.444 (0.096)	Yes	No	195.63 [0.000]	$0.44 \leqslant \alpha_1 \leqslant 1.00$	0.443	40	0.653 [0.001]
$\eta_{CY} - \rho_{Y_1Y_2}$	0.079 (0.072)	0.567 (0.103)	Yes	No	169.20 [0.000]	$0.57 \leqslant \alpha_1 \leqslant 1.37$	0.414	40	0.630 [0.001]
Occupation and Region									
$\eta_{CY} - \eta_{Y_1Y_2}$	0.188 (0.057)	0.422 (0.084)	Yes	No	257.62 [0.000]	$0.42 \leqslant \alpha_1 \leqslant 1.00$	0.447	29	0.649 [0.000]
$\eta_{CY} - \rho_{Y_1Y_2}$	0.156 (0.089)	0.482 (0.132)	Yes	No	168.89 [0.000]	$0.48 \leqslant \alpha_1 \leqslant 1.46$	0.329	29	0.534 [0.003]
Occupation and Origin									
$\eta_{CY} - \eta_{Y_1Y_2}$	0.146 (0.063)	0.478 (0.091)	Yes	No	168.38 [0.000]	$0.48 \leqslant \alpha_1 \leqslant 1.12$	0.423	29	0.777 [0.000]
$\eta_{CY} - \rho_{Y_1Y_2}$	0.041 (0.096)	0.639 (0.137)	Yes	No	190.64 [0.000]	$0.64 \leqslant \alpha_1 \leqslant 1.16$	0.549	29	0.711 [0.000]
Education and Region									
$\eta_{CY} - \eta_{Y_1Y_2}$	-0.094 (0.197)	0.803 (0.260)	Yes	Yes	410.54 [0.000]		0.372	27	0.404 [0.003]
$\eta_{CY} - \rho_{Y_1Y_2}$	-0.136 (0.207)	0.880 (0.281)	Yes	Yes	350.55 [0.000]		0.368	27	0.470 [0.000]
Education and Origin									
$\eta_{CY} - \eta_{Y_1Y_2}$	-0.223 (0.184)	0.971 (0.246)	Yes	Yes	263.40 [0.000]		0.585	28	0.551 [0.002]
$\eta_{CY} - \rho_{Y_1Y_2}$	-0.328 (0.050)	1.131 (0.211)	Yes	Yes	196.02 [0.000]		0.501	28	0.613 [0.001]

TABLE 1
CONTINUED

(1)	α_0 (2)	α_1 (3)	$\alpha_1 > 0$? (4)	$\alpha_1 = 1$? (5)	F-statistic (H_0: $\alpha_0 = 0$, $\alpha_1 = 1$) (6)	Bound for α_1 (7)	R^2 (8)	No. of groups (9)	Spearman (10)
Industry and Education									
$\eta_{CY} - \eta_{Y_1 Y_2}$	-0.031 (0.104)	0.728 (0.149)	Yes	No	310.50 [0.000]	$0.73 \leqslant \alpha_1 \leqslant 1.16$	0.623	53	0.772 [0.000]
$\eta_{CY} - \rho_{Y_1 Y_2}$	-0.022 (0.124)	0.722 (0.173)	Yes	No	189.67 [0.000]	$0.72 \leqslant \alpha_1 \leqslant 1.72$	0.418	53	0.594 [0.000]
Industry and Region									
$\eta_{CY} - \eta_{Y_1 Y_2}$	0.102 (0.037)	0.549 (0.054)	Yes	No	288.19 [0.000]	$0.55 \leqslant \alpha_1 \leqslant 1.14$	0.480	36	0.707 [0.000]
$\eta_{CY} - \rho_{Y_1 Y_2}$	0.054 (0.079)	0.625 (0.112)	Yes	No	203.00 [0.000]	$0.63 \leqslant \alpha_1 \leqslant 1.77$	0.353	36	0.552 [0.000]
Industry and Origin									
$\eta_{CY} - \eta_{Y_1 Y_2}$	0.050 (0.090)	0.623 (0.132)	Yes	No	202.61 [0.000]	$0.62 \leqslant \alpha_1 \leqslant 1.28$	0.487	36	0.708 [0.000]
$\eta_{CY} - \rho_{Y_1 Y_2}$	0.137 (0.127)	0.529 (0.188)	Yes	No	95.70 [0.000]	$0.53 \leqslant \alpha_1 \leqslant 2.52$	0.210	36	0.398 [0.016]

Notes: α_0 and α_1 are the estimated coefficients of equations (16) and (17). $\alpha_1 > 0$ and $\alpha_1 = 1$ report the outcomes of 5% significance level t-tests of whether α_1 is positive and equal to one, respectively. Numbers in parentheses are heteroscedasticity–consistent standard errors, and those in brackets are p-values. F-stat tests the joint null hypothesis of $\alpha_0 = 0$ and $\alpha_1 = 1$. Spearman is the rank correlation coefficient test for a positive relation between η_{CY} and P_Y.

influential outliers or so-called *bad leverage points*. Specifically, three classification groups have three influential outliers, three groups have two outliers, six groups have one outlier and the remaining 12 groups have no influential outlier. Following the recommendation of Rousseeuw, we ran OLS without these influential outliers to obtain the robustly fitted regression line. The results are nearly the same as the OLS results in Table 1. The robust regression fits are slightly better, and the estimates of α_1 are marginally larger, giving rise to narrower bounds for α_1. Accounting for outliers thus increases both the magnitude and the precision of the point estimate of α_1. The estimates of α_1 are positive and highly significant. None the less, α_1 remains significantly different from one (except for a few cases), and the joint hypothesis ($\alpha_0 = 0$, $\alpha_1 = 1$) continues to be rejected. All in all, outliers do not seriously alter our earlier results.[13]

The overall conclusions from our tests are that both the parametric (regression-based) and non-parametric (Spearman rank correlation) tests support the implication of the PIH that η_{CY} is positively correlated with $\eta_{Y_1 Y_2}$ or $\rho_{Y_1 Y_2}$. The strongest implications of the PIH—that α_1 individually equals one and that α_0 and α_1 satisfy the joint hypothesis ($\alpha_0 = 0$, $\alpha_1 = 1$)—are rejected.

IV. CONCLUDING REMARKS

In this paper, we use modern US household data from the 1980–96 Consumer Expenditure Survey to test a key implication of Permanent Income Hypothesis (PIH) as originally advanced by Friedman (1957), namely that the income elasticity of consumption should be higher for households for which a large fraction of the variation of their income is permanent than for households facing more transitory variations in income. Our data are far superior to what was available to Friedman, allowing us to check statistical significance and conduct tests he could not perform.

Reassessing Friedman's test is interesting and useful both substantively and historically. On the substantive side, the test is simple but intuitive, and clearly different from either the Euler equation tests or the older consumption function tests; they therefore increase the dimensionality of the battery of tests of the PIH, which in turn increases the robustness of the overall set of tests available. On the historical side, the test revives the use of clever insights into the nature of the PIH by its founder.

In terms of the substantive results, our test results support the PIH and thus complement the other tests of the PIH based on micro data such as Runkle (1991), Attanasio and Weber (1995) and DeJuan and Seater (1999), which also offer support to the PIH. However, the strongest implications of the PIH are rejected, a result that deserves further exploration. We regard our reassessment of Friedman's original PIH test as promising, not only because of its implications regarding possible validity of the PIH, but more importantly because it suggests useful avenues for further research, and simply because it is interesting to see how old ideas fare when confronting new data. Friedman's old ideas are not obviously outmoded, and that is indeed an interesting result.

APPENDIX

Effects of measurement error

As noted in Section II, measurement error affects the estimates of η_{CY}, $\eta_{Y_1 Y_2}$ and $\rho_{Y_1 Y_2}$ equally, so that the test for equality of η_{CY} to either $\eta_{Y_1 Y_2}$ or $\rho_{Y_1 Y_2}$ is not biased for or against the PIH. To show this, we first need to examine the effects of measurement error on the income elasticity of consumption, η_{CY}, which is estimated by the slope coefficient of the regression of the log of current consumption on the log of current income.

Designate the true levels of current consumption and current income for household i by C_i^* and Y_i^* and the measured levels by C_i and Y_i, so that

(A1) $C_i = C_i^* U_i$,

(A2) $Y_i = Y_i^* V_i$,

where U_i and V_i represent measurement errors. The characteristics of the measurement errors are assumed to be

(A3) $\log U_i = u_i \sim N(0, \sigma_u^2)$,

(A4) $\log V_i = v_i \sim N(0, \sigma_v^2)$,

(A5) $E(u_i v_i) = 0$,

(A6) $E(u_i u_{i+j}) = 0 \quad for \quad j \neq 0$,

(A7) $E(v_i v_{i+j}) = 0 \quad for \quad j \neq 0$.

These assumptions state that each error is a log-normal random variable with zero mean and constant variance. The assumptions also rule out autocorrelation in the errors.

In the presence of measurement error, the regression of log C^* on log Y^* becomes

(A8) $(c_i - u_i) = \eta_{CY}(y_i - v_i) + \varepsilon_i$,

where $(c_i - u_i) = (\log C_i - \log U_i)$ and $(y_i - v_i)$ is defined analogously. Rearranging terms gives

(A9) $c_i = \eta_{CY} y_i + w_i$,

where η_{CY} is the slope coefficient or the income elasticity of consumption, and $w_i = \varepsilon_i + u_i - \eta_{CY} v_i$ is the compound error term. Let $\hat{\eta}_{CY}$ denote the OLS estimate of η_{CY}. Using least squares algebra, we have

(A10) $\hat{\eta}_{CY} = \dfrac{\sum c_i y_i}{\sum y_i^2} = \dfrac{\sum (c_i^* + u_i)(y_i^* + v_i)}{\sum (y_i^* + v_i)^2}$,

(A11) $p \lim \hat{\eta}_{CY} = \dfrac{\text{cov}(c^*, y^*)}{\text{var}(y^*) + \text{var}(v)} = \dfrac{\sigma_{c^* y^*}}{\sigma_{y^*}^2 + \sigma_v^2}$.

Since $\eta_{CY} = \sigma_{c^* y^*} / \sigma_{y^*}^2$, we can rewrite $p \lim \hat{\eta}_{CY}$ as

(A12) $p \lim \hat{\eta}_{CY} = \dfrac{\eta_{CY}}{1 + \sigma_v^2 / \sigma_{y^*}^2}$.

Thus, $\hat{\eta}_{CY}$ will underestimate η_{CY} as a result of measurement error in Y.

Now, let us examine the effects of measurement error on the elasticity of incomes in adjacent periods $\eta_{Y_1 Y_2}$, which is estimated by the slope coefficient of the regression of the log of previous period income on the log of current period income. (Note that we are

referring to Y_2 as the current-period income and Y_1 as the previous-period income.) To simplify notation, designate Y_1 by Z and Y_2 by Y so we can rewrite $\eta_{Y_1 Y_2}$ as η_{ZY}. As before, let variables with and without asterisks denote the true and observed values, so that

(A13) $Z_i = Z_i^* Q_i$,

(A14) $Y_i = Y_i^* V_i$,

where V_i and Q_i represent measurement error. The characteristics of the measurement errors are assumed to be

(A15) $\log Q_i = q_i \sim N(0, \sigma_q^2)$,

(A16) $\log V_i = v_i \sim N(0, \sigma_v^2)$,

(A17) $E(v_i q_i) = 0$,

(A18) $E(q_i \, q_{i+j}) = 0 \quad for \quad j \neq 0$,

(A19) $E(v_i \, v_{i+j}) = 0 \quad for \quad j \neq 0$.

In the presence of measurement error, the regression of $\log Z^*$ on $\log Y^*$ becomes

(A20) $(z_i - q_i) = \eta_{ZY}(y_i - v_i) + \varepsilon_i$,

where $(z_i - q_i) = (\log Z_i - \log Q_i)$ and $(y_i - v_i)$ is defined analogously. Rearranging terms gives

(A21) $z_i = \eta_{ZY} \, y_i + n_i$,

where η_{ZY} is the slope coefficient or the elasticity of incomes in adjacent periods, and $n_i = \varepsilon_i + q - \eta_{ZY} v_i$ is the compound error term. Let $\hat{\eta}_{ZY}$ denote the OLS estimate of η_{ZY}. Using least squares algebra, we have

(A22) $\hat{\eta}_{ZY} = \dfrac{\sum z_i y_i}{\sum y_i^2} = \dfrac{\sum (z_i^* + q_i)(y_i^* + v_i)}{\sum (y_i^* + v_i)^2}$,

(A23) $p \lim \hat{\eta}_{ZY} = \dfrac{\text{cov}(z^*, y^*)}{\text{var}(y^*) + \text{var}(v)} = \dfrac{\sigma_{z^* y^*}}{\sigma_{y^*}^2 + \sigma_v^2}$.

Since $\eta_{ZY} = \sigma_{z^* y^*} / \sigma_{y^*}^2$, we can rewrite $p \lim \hat{\eta}_{ZY}$ as

(A24) $p \lim \hat{\eta}_{ZY} = \dfrac{\eta_{ZY}}{1 + \sigma_v^2 / \sigma_{y^*}^2}$.

Thus, $\hat{\eta}_{ZY}$ will underestimate η_{ZY} as a result of measurement error in Y.

    Overall, we can see that the degree of underestimation in (A12) and (A24) depends on the *same* factor $\sigma_v^2 / \sigma_{y^*}^2$. In this regard, measurement error in Y will not bias the test of equality of η_{CY} and η_{ZY} for/against the mean assumption of the PIH.

    For the variability assumption, the results are the same as long as we suppose that the variance of the measurement error increases in proportion with the variance of income, which certainly is reasonable for changes in income arising from macro-economic sources and is perhaps acceptable for other sources of change in income as well. In that case, the regression coefficient obtained from the variability assumption is the coefficient obtained under the mean assumption but multiplied by the ratio of standard errors of the two income terms. If the measurement-error standard errors increase in the same proportion as the income standard errors, then the ratio in question is unaffected by the presence of measurement error.

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NOTES

1. Equivalently, permanent income is the hypothetical constant value of income having the same present value as the expected actual income stream.
2. Its absence is notable, for example, in Deaton's (1992) superb review of the empirical literature on consumption.
3. In many early tests of the PIH, including Friedman's (1957), the data on consumption are derived by subtracting saving from income. If saving is measured with error, this procedure creates a common error term in income and consumption, leading to a biased test of the PIH.
4. Aggregate shocks can cause the sum of transitory components to be non-zero in any given time period. As we discuss later, we avoided this problem by using a pooled cross-section of households over 1980–96, a 17-year period that included three recessions and six consecutive years of high real growth. We expected aggregate shocks to have largely averaged out over such a long period.
5. Of the three correlations in (5), the third seems most controversial. It says that transitory consumption and transitory income are not correlated across households. Empirical attempts to test this assumption based on household data have obtained mixed results. Bodkin (1959) found large marginal propensity to consume (MPC) from the National Service Life Insurance dividend payments paid to Second World War veterans in 1950, but Friedman (1960) noted that the dividend payments may be correlated with omitted variables that are in turn correlated with permanent income (i.e. omitted variable bias), so that Bodkin's estimated MPC of dividend payments is upwardly biased. Bird and Bodkin (1965) subsequently re-estimated the consumption function with measures of permanent income included. They found a relatively small MPC and concluded that the results were consistent with the PIH. In a similar study, Kreinin (1961) examined the consumption behaviour of Israeli recipients of Second World War lump-sum personal restitution payments from Germany and found the MPC out of restitution payments insignificantly different from zero. Recent papers using the Euler equation framework have examined a related issue about the response of household consumption to a particular type of income that is both predictable and transitory, e.g. income tax refunds and income tax cuts. The results in Browning and Collado (2001) and Hsieh (2003), among others, found that consumption expenditures do not overreact to this type of income change; whereas Parker (1999) and Souleles (1999) found some overreactions.
6. Suppose we group households by their occupation—managers, craftsmen, farmers, etc. Among craftsmen, for example, the mean assumption maintains that, on average, the permanent component of each craftsman's income should change in the same proportion as the average income of all craftsmen.
7. If the transitory components of income are serially correlated, then $\eta_{Y_1 Y_2}$ would be a biased estimate of P_Y. However, $\eta_{Y_1 Y_d}$ will be an unbiased estimate of P_Y for d sufficiently large that the transitory component in period d is uncorrelated with that in period 1. Carroll and Samwick (1997, 1998) addressed the issue of serial correlation in the transitory component by using the d-year income difference panel data in their estimation of the variances of the permanent and transitory components of income. In contrast to Carroll and Samwick's data, our data-set has only two income observations per household, making it impossible for us to check if our results are sensitive to the choice of d. If the transitory components are serially correlated, then we would expect the estimate of $\eta_{Y_1 Y_2}$ to overestimate the true P_Y, and strict equality of η_{CY} and $\eta_{Y_1 Y_2}$ might be rejected by the data. None the less, as discussed later, η_{CY} and $\eta_{Y_1 Y_2}$ are still expected to be positively correlated if the PIH is true.
8. The estimate of $\rho_{Y_1 Y_2}$ will be subject to the same bias noted in footnote 7 if the transitory components of income are serially correlated.
9. For Occupation, the categories available in the CEX are Managerial and professional specialty; Technical, sales and administrative support; Service; Farming, forestry and fishing; Precision production, craft and repair; Operators, fabricators and labourers; Armed forces; and Self-employed. For Industry, the categories are Agriculture, forestry, fisheries and mining; Construction; Manufacturing; Transportation, communications and other public utilities; Wholesale and retail trade; Finance, insurance and real estate; Professional and related services; Other services; and Public administration. For Education, the categories are Elementary; Less than high school; High school graduate; Less than college

graduate; College graduate; More than 4 years of college; Never attended school. For State, data are available only for the 37 most populous US states.

10. Results are qualitatively similar to those reported here if income is conditioned on age and time (i.e., variables that vary deterministically over the life cycle) and then the analysis is conducted on the residuals after controlling for such variables.

11. The issue of self-selection arises when using classification variables such as Occupation and Industry. However, it should be noted that our test here concerns the information value of current income fluctuations. Irrespective of the reason why the household chose to be a manager or a farmer, its consumption according to the PIH should respond less to current income fluctuations if those represent transitory rather than permanent income variation. The test therefore seems free of selection bias, at least on this account. Of course, it is not possible to guarantee total absence of selection bias for any classification variables, so we examine several alternative variables and judge the weight of the evidence. Note that some classification variables we use, such as education and state (the part of the country where one lives), are less likely to be subject to selection bias.

12. The Origin variable is categorized in the CEX as European, Spanish and Afro-American. For Region, they are Northeast, Midwest, South and West. Ideally, we would have cross-classified the households using more than two variables, but doing so would have decreased dramatically the number of observations in each household group, leading to imprecise estimates of η_{CY}, $\eta_{Y_1 Y_2}$ and $\rho_{Y_1 Y_2}$.

13. The robust estimation results are available from the authors upon request.

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