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Testing the Cross-Section Implications of Friedman's Permanent Income Hypothesis

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ABSTRACT

We use modern household data and econometric methods to conduct some of the original tests of the Permanent Income Hypothesis (PIH) suggested and used by Friedman (1957). The data and methods are superior to those available to Friedman, allowing us to refine Friedman's tests and perform tests he could not do. The results provide overall but not universal support for PIH.

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1. Introduction

In his original tests of his Permanent Income Hypothesis (PIH), Friedman (1957) used both microeconomic cross-section and macroeconomic time series data. The micro tests proceeded by first dividing the entire sample of households into subgroups according to various possible classification variables (such as occupation, industry, and education) presumably related to household permanent income and then checking whether cross-group consumption patterns corresponded to theoretical predictions. A deficiency of Friedman's tests was that data limitations prevented proper tests of significance. Indeed, Friedman himself said the major shortcoming of his tests was 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).

Little effort seems to have been made in the past decades to reexamine Friedman's original tests despite the availability of new household surveys.[1] Presumably, this omission reflects the profession's current interest in Euler equation methods and also possibly the view that modern developments in the theory of household choice have rendered Friedman's early version of that theory obsolete. However, Friedman's tests seem worth pursuing. Many of the tests are fully consistent with the most general versions of the household choice problem, and the others are consistent with somewhat more restricted versions, especially those in which the role of uncertainty is limited. Also, the tests rely on very different identifying restrictions than the currently popular Euler equation tests and so provide a useful complement to Euler equation methods. Euler equation tests have produced decidedly mixed evidence on the validity of the PIH.[2] Given this ambiguity of

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[1]Indeed, the last detailed examination of Friedman's tests was by Mayer (1972).

[2]For example, Zeldes (1989), Shea (1995), and Lusardi (1996) among others, find that consumption is excessively sensitive to predictable income changes, contrary to the PIH. By contrast, Altonji and Siow (1987), Runkle (1991), Attanasio and Weber (1995), and DeJuan and Seater (1999), among others, find no evidence of excess sensitivity. It should be noted, however, that Euler equation tests may have low power due to difficulties in isolating the predictable component of income at the household level. As is typical in

overall results, alternative approaches seem useful as ways of improving the robustness of the overall set of tests being performed on the PIH.

In this paper, we revive Friedman's classification tests, using comprehensive US household expenditure data from the Consumer Expenditure Survey (CEX). The CEX data are much superior to those available to Friedman in that they span several years, contain comprehensive information on household socioeconomic-demographic variables, and provide detailed and independent measure of household consumption expenditure and income. In addition, developments in the literature since Friedman's original publication allow us to use improved procedures and conduct additional tests. We include the significance tests that Friedman could not perform, new overidentifying restrictions tests resulting from a modern instrumental variables interpretation of some of his tests, and one test for the importance of liquidity constraints suggested in the modern literature on that topic.

Besides offering complementary tests to Euler equation methods, the revived tests present an interesting exercise in economic history. Usually, empirical economic history consists of applying new methods to old data, either to test some economic theory or to interpret the past. Here we do things the other way around, applying new data to old methods. In doing so, we both test Friedman's important hypothesis and breathe new life into several of his clever, even brilliant, insights into the implications of the PIH.

The paper is organized as follows. Section 2 briefly reviews the PIH model and its testable implications. Section 3 discusses the data. Section 4 presents the empirical results. Section 5 concludes.

2. Model and Tests

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many of these tests, one needs to find variables or instruments in households's information sets that are good predictors of future income growth. Finding such instruments is generally a formidable task at the household level such that the use of poor instruments can possibly bias the tests of the PIH (Shea, 1995). Furthermore, there is the familiar question of whether the predicted income generated by the instruments do in fact correspond to household's actual expectations of future income.

The following simple but standard model motivates Friedman's (1957) PIH test:

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

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

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

where C and Y represent measured 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. Friedman added the following cross-section identifying assumptions to give these equations substantive content:

(4) $$\sum_{i} Y_{it}^{T} = \sum_{i} C_{it}^{T} = 0$$

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

where $\rho(.)$ denotes the correlation coefficient between the variables in parentheses. Equation (4) states that both transitory income and transitory consumption sum to zero across households.[3] Equation (5) states that the transitory components of income and consumption are uncorrelated with one another and with their corresponding permanent components.[4] Given these equations, we can derive the following testable

[3]These assumptions may seem excessively strong because aggregate shocks can cause the sum to be non-zero. However, as we discuss later, the data used in this study are not based on a single year cross-section survey but instead are a pooled cross-section of households over 1980-1991, a 12-year period that included three recessions and six consecutive years of high real growth. Aggregate shocks may well have largely averaged out over this sample period.

[4]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 found mixed results. For example, Bodkin (1959) found large MPCs from the National Service Life Insurance dividend payments paid to World War II veterans in 1950. Friedman (1960), however, noted that the dividend payments may be correlated with omitted variables that are in turn correlated with permanent income (i.e., omitted variable bias) such that Bodkin's estimated MPC of dividend payments is upward bias. Bird and Bodkin (1965) subsequently reestimated the consumption function with measures of permanent income added in the regression. They found a relatively small MPC and concluded that the results are consistent with PIH. In a similar study, Kreinin (1961) examined the consumption behavior of Israeli recipients of World War II lump-sum personal restitution payments from Germany and found the MPC of restitution payments are insignificantly different from zero. A number of recent papers based on Euler equation framework have also 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 cut. The results in Browning and Collado (2001) and Hsieh (1999), among others, found that consumption expenditures do not overreact to this type of income changes while Parker (1999) and Souleles (1999) found some overreactions.

implications of PIH.

2.1 Consumption's Income Elasticity and the Relative Variances of Y^P and Y^T.

Consider the regression of measured consumption C_{it} on measured income Y_{it}, where all variables are in logarithms:

(6) $$C_{it} = \eta_0 + \eta_{CY} Y_{it} + \nu_{it}$$

η_0 is the intercept, η_{CY} is the slope of the regression (i.e., the income elasticity of consumption), and ν is the random disturbance term. Using our earlier relationships, the estimate of η_{CY} is given by:

(7) $$\eta_{CY} = \frac{cov(C_{it}, Y_{it})}{var\, Y_{it}}$$

$$= \frac{cov(C_{it}^P + C_{it}^T,\ \ Y_{it}^P + Y_{it}^T)}{var\, Y_{it}^P + var\, Y_{it}^T}$$

$$= \frac{var\, Y_{it}^P}{var\, Y_{it}^P + var\, Y_{it}^T} = P_Y \leq 1.$$

The second line of (7) uses the definitions of measured consumption and income shown in (2) and (3) respectively, and the third line uses the assumption in (5). As is clear from (7), to the extent that measured income is an imperfect indicator of permanent income, the PIH predicts that the income elasticity of consumption (η_{CY}) is less than unity. In particular, the magnitude of η_{CY} depends on the relative variation in permanent and transitory incomes; the larger the fraction of the variation in measured income that is attributable to the variation in permanent component of income, the closer η_{CY} is to unity, and conversely. Friedman used this concept to explain why estimates of η_{CY} differ across household groups. For example, using data from different household surveys, he found that η_{CY} for farmers is distinctly lower than for nonfarmers. He interpreted this result as validating the PIH on the grounds that farmers experience more income variation than nonfarmers, and that much of the income variations are due to transitory factors.

To test the PIH, one must obtain an independent estimate of the relative importance of permanent factors in observed income variance (P_Y) for each household group and then test whether $\eta_{CY} = P_Y$. An estimate of η_{CY} is easily obtained using the slope coefficient of the regression of consumption on income.

The difficulty question is how to measure P_Y. Friedman (1957) proposed two measures of P_Y, depending on what assumption one chooses to make about the income process. The assumptions are (i) the *mean assumption*, which supposes that, for a given group of households, the permanent component of each household's income changes in the same proportion as does the average income of the group, and (ii) the *variability assumption*, which supposes that the cross-section variance of the permanent component of household income is proportional to the cross-section variance of measured income. It can be shown that, under the mean assumption, the elasticity of incomes in adjacent periods ($\eta_{Y_1Y_2}$) is an unbiased estimate of P_Y and that, under the variability assumption, the correlation coefficient of incomes in adjacent periods ($\rho_{Y_1Y_2}$) is such an estimate. The derivations, being rather long, are relegated to the Appendix.[5] We thus have our first testable implication:

Test #1 (Strong Form): $\eta_{CY}=\eta_{Y_1Y_2}$ (mean assumption) and $\eta_{CY}=\rho_{Y_1Y_2}$ (variability assumption).

Although the theory predicts equality of η_{CY} to either $\eta_{Y_1Y_2}$ or $\rho_{Y_1Y_2}$, testing for strict equality would be overly restrictive for at least two reasons. First, sampling error may prevent $\eta_{Y_1Y_2}$ or $\rho_{Y_1Y_2}$ exactly equaling η_{CY} for each household group. Second and probably more important, we define consumption in this study as expenditures on nondurable goods and services, whereas the complete measure also would include the imputed rent/services of durable goods. Unfortunately, our data set has incomplete data on household stocks of durables, making it impossible to obtain reliable estimates of the imputed rent on durables. We therefore must use an imperfect measure of consumption that may bias the estimate of η_{CY} away from its true value.

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[5]If the transitory components of income are serially correlated, then $\eta_{Y_1Y_2}$ would be a biased estimate of P_Y. However, $\eta_{Y_1Y_d}$ 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 expect the estimate of $\eta_{Y_1Y_2}$ to overestimate the true P_Y, and strict equality of η_{CY} and $\eta_{Y_1Y_2}$ may be rejected by the data. Nonetheless, as discussed below, η_{CY} and $\eta_{Y_1Y_2}$ are still expected to be positively correlated if the PIH is true.

Because of these difficulties, we also conduct the less demanding test of whether there is a positive relationship between η_{CY} and either $\eta_{Y_1Y_2}$ or $\rho_{Y_1Y_2}$:

Test #1 (Weak Form): $d\eta_{CY}/d\eta_{Y_1Y_2} > 0$ (mean assumption) and $d\eta_{CY}/d\rho_{Y_1Y_2} > 0$ (variability assumption). There is nothing algebraically that would lead one to expect a positive relationship.

Evidence rejecting the strong form of Test #1 but supporting the weak form is in itself not decisive evidence in favor of the PIH. Other theories of consumption can be consistent with values of $d\eta_{CY}/d\eta_{Y_1Y_2}$ and $d\eta_{CY}/d\rho_{Y_1Y_2}$ between zero and one, and evaluating against the PIH requires further tests. Consider two examples: Keynes's absolute income hypothesis (AIH) and Campbell and Mankiw's (1990) Rule-of-Thumb hypothesis (ROT). Both hypotheses are contained in the relation $C = a + bY$. For the AIH, $0<a$ and $0<b<1$, implying that $\eta_{CY} = bY/(a+bY) < 1$. For ROT, $a=0$ and $b=1$, implying that $\eta_{CY} = 1$. In either case, $d\eta_{CY}/d\eta_{Y_1Y_2} = 0$ and $d\eta_{CY}/d\rho_{Y_1Y_2} = 0$. Any finding of $0 < d\eta_{CY}/d\eta_{Y_1Y_2}$ or $d\eta_{CY}/d\rho_{Y_1Y_2} < 0$ rejects pure AIH and ROT. However, it is possible that households may be of more than one type. Some may follow PIH, whereas others follow AIH or ROT. For PIH households, $d\eta_{CY}/d\eta_{Y_1Y_2} = 1$ and $d\eta_{CY}/d\rho_{Y_1Y_2} = 1$; for AIH or ROT households, $d\eta_{CY}/d\eta_{Y_1Y_2} = 0$ and $d\eta_{CY}/d\rho_{Y_1Y_2} = 0$. On average, then, we would find $0< d\eta_{CY}/d\eta_{Y_1Y_2} <1$ and $0<d\eta_{CY}/d\rho_{Y_1Y_2}<1$, exactly what the weak form of Test#1 predicts. Results consistent with the weak form of Test#1, then, could reflect pure PIH behavior subject to data limitations or mixed PIH and AIH/ROT behavior even without data limitations. Deciding which possibility holds requires other tests. It has been known for many decades that the AIH is inconsistent with other aspects of the data, such as the cross-section versus time-series behavior of the data, discussed by Friedman (1956) and others. We thus can discard the AIH. What about ROT? One way to distinguish it from the PIH would be tests of the importance of liquidity constraints. ROT requires that households (i) have infinite rates of time preference and (ii) be subject to liquidity constraints. With finite time preference, households would set C less than current Y. Without liquidity constraints, households would set C equal to infinity. Even under a less extreme version of ROT, with very large but finite rates of time preference, households would want C much larger than current Y and would be prevented from having such high C only by restrictions on their borrowing. Liquidity constraint

therefore is necessary for ROT. If the data reject the strong form of Test#1 but do not reject the weak form, we can test the presence of ROT households by conducting a test of liquidity constraint. If such a test rejects liquidity constraint as a significant variable in explaining consumption, then it also rejects ROT. Otherwise, ROT remains a valid possibility. We discuss a test of liquidity constraint below.

2.2 Income Elasticities of Consumption and Relative Transitory Income Variances

According to (7), households with high variances of transitory income relative to the variance of permanent income should have lower income elasticities of consumption than households with relatively low variances of transitory income:

Test #2: $d\eta_{CY} / d(\text{var } Y^T/\text{var } Y^P) < 0$.

We can test this implication if we can divide households into groups with relatively high and low variances of transitory income.

2.3 Proportionality Hypothesis

According to PIH, consumption equals permanent income; equivalently, the elasticity of consumption with respect to permanent income equals one: $\eta_{CY}^{P} = 1$. In contrast, as noted in (7), the elasticity of consumption with respect to measured income is less than or equal to one (i.e., $\eta_{CY} \leq 1$), and, as long as there is any transitory income at all, η_{CY} will be strictly less than one. Thus two more tests of PIH can be conducted by estimating both elasticities and seeing if $\eta_{CY} \leq \eta_{CY}^{P} = 1$:

Test #3: $\eta_{CY}^{P} = 1$.

Test #4: $\eta_{CY} \leq \eta_{CY}^{P}$.

As before, η_{CY} is the slope coefficient of the regression of consumption on income. In contrast, η_{CY}^{P} is not so easily obtained because permanent income Y^P is unobservable. We overcome this difficulty with instrumental variables estimation. The instrument for permanent income is the mean income for groupings of households, a classification variable likely to be correlated with Y^P but not with transitory income or transitory consumption. For example, we could use occupation as a classification variable and group

households by their occupation (e.g., manager, clerk, etc.). We then would compute the mean income for all households within a given occupation and use that as an instrument for the permanent income of the households in that occupation. The identifying assumption is that the instrument is valid. In particular, if positive and negative transitory incomes of households offset each other within each group, so that mean transitory income is zero for each group, then differences in mean income among groups should reveal, on average, differences in mean permanent income (Mayer, 1972).

This approach to testing the proportionality hypothesis is not new, but framing it in terms of instrumental variables is. Previously, researchers used the *method of group means* (Ando and Modigliani, 1960; Mayer, 1972), introduced by Wald (1940) to obtain consistent parameter estimates when variables are observed with error. The method turns out to be identical to instrumental variables (IV) estimation. In the IV framework, one regresses consumption on income, including a dummy variable to indicate which group each household belongs to. In the group mean framework, one finds the mean consumption and income values for each group and then regresses mean consumption on mean income. With either method, the resulting slope parameter is an estimate of η_{CY}^{P} (Eisner, 1958). One then can use the estimate to test whether $\eta_{CY}^{P}=1$ and $\eta_{CY} \leq \eta_{CY}^{P}$. See the Appendix for further discussion.

An advantage to framing the estimation of η_{CY}^{P} in terms of instrumental variables is that it immediately suggests the possibility of testing overidentifying restrictions. Only one parameter is estimated, namely, η_{CY}^{P}; if there are *n* groups, then there are *–1* extra pieces of information that one can treat as overidentifying restrictions. These tests provide information on the validity of the model or of the instruments, and we include them in our results. Using an overidentifying restrictions test in the framework of Friedman's tests is new to the present study.

2.4 Income Change and Consumption

Suppose that households are classified according to their changes in income over two adjacent time periods. Groups with income increases and decreases will tend to have positive and negative transitory income, respectively. Also, the groups with income increases will have higher mean incomes in the second

period than will the groups with income decreases. PIH implies that consumption is proportional to permanent income, so the average propensity to consume of the income-increase groups should be lower than those of the income-decrease groups:

Test #5: With households grouped by size of income change, the intercepts of the regression of current consumption on current income for each group should be inversely related to income change, being highest for the group with the largest income decline and lowest for the group with the largest income rise (Friedman, 1957).

Furthermore, classifying households according to changes in income they experienced is, to a large extent, classifying them by their transitory income. Differences in transitory income within the resulting groups consequently are reduced compared to the sample as a whole. According to PIH, the income elasticity of consumption η_{CY} measures the proportion of the differences of income within the group that is attributable to factors considered permanent, so η_{CY} should be higher for the individual income-change groups than for the whole (unclassified) sample:

Test #6: η_{CY} (group i) > η_{CY} (whole sample) $\forall$ i.

Finally, it can be shown by a rather tedious technical argument that the regression slopes should be the same for the various income-change groups no matter what the magnitude of the change in income (Friedman, 1957, p.109):

Test #7: η_{CY} (group i) = η_{CY} (group j) $\forall$ i, j.

2.5 Summary of Implications to be Tested

We thus have several testable implications of PIH: (i) the income elasticity of consumption η_{CY} is equal to P_Y (= $varY^P/varY$), (ii) the income elasticity of consumption η_{CY} is inversely related to the variance of relative transitory relative to the variance of permanent income, $varY^T/varY^P$, (iii) the permanent income elasticity of consumption η_{CY}^P is equal to one, (iv) the income elasticity of consumption η_{CY} is less than the permanent income elasticity of consumption η_{CY}^P, (v) the regression lines of consumption on current income for household groups with income increases is higher (have greater intercepts) than those for groups with income decreases, (vi) the regression line of the whole (unclassified) sample of households is flatter than the

lines of the individual income-change groups, and (vii) the regression line of the income-change groups will be parallel (will have equal slopes).

3. Data

The data used in this study are drawn from the US Consumer Expenditure Survey (CEX) for the years 1980-1991. The CEX provides detailed and extensive data on consumption expenditures, income, socioeconomic and demographic characteristics of US households. About 5000 households are interviewed every quarter, and households can stay in the survey for at most five consecutive quarters. After their fifth quarterly interview, households are dropped and replaced by new households; approximately 20 percent 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 are used as a reference to compare responses in the following interviews. In effect, a maximum of four quarterly interviews is available per 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 in the second and fifth (last) interviews, and the amount reported is based on incomes receive twelve months prior to the interview period. We construct measures of disposable income and consumption from these data. We measure 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. We deflate all variables using the 1982 base-year CPI deflator. The Appendix provides further details about the data.

To estimate $\eta_{Y_1Y_2}$ and $\rho_{Y_1Y_2}$, two income data points are required for each household in the survey.

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 twelve months (four quarterly interviews) prior to the fifth interview.

The sample was restricted in standard ways to improve the measurement of consumption and income. We restrict our sample to households with four quarterly interviews, classified as complete income respondents, and identified as having valid data on characteristics variables. Except when households are grouped by type of occupation or type of employee, we only retain households reporting as "employee" because income and consumption data for self-employed workers are known to be seriously underestimated and/or inaccurately reported. To maintain survey respondent confidentiality, household incomes in the CEX are set to a predetermined amount whenever it exceeds a specified critical value, i.e., the survey is topcoded. The topcoding procedure varies across different survey years. For example, in the 1980-1981 survey, the amount of federal tax paid is set to \$0 when the actual amount paid by the household equals or exceeds \$75,000. In the 1984-1985 survey, in contrast, a critical value of federal tax paid is set at \$100,000 and if the actual amount paid equals or exceeds this critical value, the amount paid is set to \$100,000. To reduce the complications involved with the topcoding procedures, topcoded observations are excluded from the sample.[6]

The CEX provides more detail about some variables (such as occupation and industry) over the years 1980-82 than in subsequent years. Consequently, when those variables are important in our tests, we perform the tests twice, once for the entire sample period of 1980-91 and once for the restricted period of 1980-82.

The CEX data are more accurate and complete than anything available to Friedman. Still, some measurement error remains, and sometimes it may be related to variables of interest. For example, in one of our tests, we use self-employment as a classification variable. Income almost certainly is less accurately reported for the self-employed than employees, leading to a spuriously high difference in income variance

[6]The findings of this study, however, are robust to the inclusion of the topcoded observations.

between the two groups. Measurement error in income also affects the estimates of η_{CY} and $\eta_{Y_1Y_2}$, which figure in some of our tests. We discuss some of these problems below.

4. Empirical Results

Our tests of PIH concern permanent and transitory income, and of course we do not have observations on those quantities. We proxy them by household characteristic variables, constructing various subsets of the total sample of households according to criteria that identify whatever aspect of permanent income is relevant to the test in question. For example, we assume education is positively correlated with the level of permanent income; thus, classifying households by level of education is a way of classifying them by permanent income. Similarly, we assume professions with highly variable current income also have larger variances of transitory income relative to the variance of permanent income than do professions with less variable current income. We explain the details of the particular subsets below as we discuss each test. In all cases, we are relying on our prior beliefs about the relation between unobservable permanent or transitory income on the one hand and observable household characteristics on the other. These priors can be viewed as a kind of information about the data.

4.1 Equality of η_{CY} and P_Y.

We conduct two sets of tests of whether η_{CY} equals P_Y. The first set estimates the following cross-section regressions:

$$\eta_{CY,g} = \alpha_0 + \alpha_1 \eta_{Y_1Y_2,g} + \epsilon_g$$

(8)

$$\eta_{CY,g} = \alpha_0 + \alpha_1 \rho_{Y_1Y_2,g} + \epsilon_g$$

where g indexes groups within a classification variable (e.g., managers, clerks, etc. within occupation), and ϵ_g is the group-specific random disturbance term. In estimating (8), the main coefficient of interest is α_1. In particular, we want to test whether α_1 is significantly greater than zero and if so, whether it is insignificantly

different from one.[7] Because the η_{CY}, $\eta_{Y_1Y_2}$, and $\rho_{Y_1Y_2}$ are themselves estimated parameters, there will be an inherent downward bias in the estimate of α_1 due to estimation error in $\eta_{Y_1Y_2}$ and $\rho_{Y_1Y_2}$. For this reason, whenever the estimate of α_1 is significantly less than one, we perform a reverse regression of $\eta_{Y_1Y_2}$ on η_{CY}, and/or $\rho_{Y_1Y_2}$ on η_{CY} to obtain an approximate upper-bound for α_{one} (Maddala, 1992) and then see if 1 falls between the resulting bounds on α_1.

Our second set of tests computes the Spearman rank correlation coefficient between η_{CY} and $\eta_{Y_1Y_2}$, and between η_{CY} and $\rho_{Y_1Y_2}$. This test is limited to testing for a positive relation between the variables only, but it is attractive in that it is nonparametric and is robust to outlying observations and to the functional relation between the variables being tested.

We perform our test using data from the 1980-82 and 1980-91 CEX. Within each of those two sets of data, household observations are pooled across years to obtain a sufficiently large sample size for each group. To ensure that estimates of $\eta_{Y_1Y_2}$ and $\rho_{Y_1Y_2}$ for each group within a given classification reflect income variations of the group, we restrict the sample to households that remained in the same group throughout the survey period. We perform our tests on fifteen alternative CEX classifications of households, namely, Occupation (1980-1982 and 1980-1991), Industry (1980-1982 and 1980-1991), Education (1980-1991), Race (1980-1991), Region (1980-1991), Origin or Ancestry (1980-1991), cross-classification of Occupation by Education (1980-1991), Occupation by Region (1980-1991), Education by Region (1980-1991), Occupation by Race (1980-1991), Education by Race (1980-1991), Occupation by Ancestry (1980-1991), and Education by Ancestry (1980-1991).[8]

For the occupation and industry variables, we use two different sample periods. In the 1980-1982

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[7]It is important to note that measurement error in income affects the estimates of η_{CY} and $\eta_{Y_1Y_2}$ but not the test for a positive association between them. In particular, the estimates of η_{CY} and $\eta_{Y_1Y_2}$ are biased downward and are scaled by the same factor as a result of random measurement error. Consequently, the scaling factors cancel and the test for a positive association between the elasticities is unbiased. See the Appendix for a complete discussion.

[8]Detailed descriptions of these classification categories are in the Appendix.

CEX, occupation and industry are coded according to the three-digit SIC codes; this coding changes to the one-digit SIC codes in the 1982-1991 CEX. We used both one-digit and three-digit classifications in our tests; the latter have much more detailed classifications of occupation and industry, leading to larger cross-section sample sizes for our tests. There are 34 usable occupation and 32 industry groups in the 1980-82 CEX. The 1980-91 CEX uses much broader groups so that no classification contains more than eight groups. To get a larger number of narrower groups, we added the cross-classification of occupation by education which has 40 usable groups, occupation by region with 28 groups, education by region with 24 groups, occupation by race with 22 groups, education by race with 23 groups, occupation by ancestry with 29 groups, and education by ancestry with 25 groups.[9]

Table 1 reports the test results. A positive relation between η_{CY} and $\eta_{Y_1Y_2}$ and between $\eta_{Y_1Y_2}$ and $\rho_{Y_1Y_2}$ receives almost universal support. In all cases except Region, the estimated values of α_1 are significantly greater than zero, and the rank correlation coefficients are significantly different from zero. The much stronger test of whether $\alpha_1 = 1$ supports the PIH in some cases. Under the mean assumption, α_1 is insignificantly different from 1 in three out of the fifteen classifications, and the interval defined by the original and reverse regressions contains the value of 1 in nine out of the thirteen remaining classifications. Under the variability assumption, α_1 is insignificantly different from 1 in four out of the fifteen classifications, and the interval defined by the original and reverse regressions contains the value of 1 in nine out of the eleven remaining classifications. In summary, the confidence interval about the estimated value of α_1 contains 1 in twenty-five out of thirty cases, that is, 83 percent of the time. The three parts of this test

[9]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. Nonetheless, it is impossible to guarantee total absence of selection bias for any classification variables, so we examine several alternatives variables and judge the weight of the evidence. Note that some classification variables we use, such as race and origin/ancestry, are not choice variables at all and cannot suffer from selection bias problems. Others, such as education and region (part of the country where one lives) are also less likely to be subject to selection bias.

(regression test of a positive relation, rank correlation test of a positive relation, regression test of equality to one) taken together support the PIH overall. However, there is some evidence that α_1 may be less than 1, which is consistent with there being only a fraction of households that choose consumption according to the PIH and the remainder following Rule-of-Thumb behavior. We pursue this possibility below.

4.2 Inverse Relation Between η_{CY} and var Y^T.

We follow earlier researchers in presuming that self-employment is an appropriate indicator of variance of transitory income. The self-employed definitely have a much higher variance of current income than do employees, and, given the nature of much self-employment income (derived from farming, small businesses, and so on), it seems reasonable to suppose that much of that variation arises from transitory factors. Thus our identifying assumption for this test is that self-employment correlates with variance of transitory income. If that assumption is valid, then PIH predicts that the self-employed will have lower income elasticities of consumption than do employees.[10]

Table 2 reports various statistics for the CEX household sample divided between the self-employed and employees. Descriptive statistics of income are reported in columns 2 to 6. Both average income and income dispersion are higher for the self-employed group. The estimated values of the correlation coefficient of incomes $\rho_{Y_1Y_2}$ and the elasticity of incomes $\eta_{Y_1Y_2}$ in consecutive years, shown in columns 4 and 5, indicate that under the variability assumption and the mean assumption, respectively, a larger proportion of income variation among self-employed households is accounted for by the transitory factor.

The important question is whether self-employed households have a lower η_{CY} than the employees, as predicted by PIH. Column 6 of Table 2 reports the estimated value of η_{CY} for each group. The t_1 statistics

[10]Income almost certainly is less accurately reported for the self-employed than employees. The implication for our test is unclear, depending on the nature of the inaccuracy. A simple tendency to understate income would not affect the income elasticity of consumption, if the understatement was proportional to income itself. An increase in random measurement error with no tendency toward overstatement or understatement would reduce the relation between measured consumption and measured income, biasing downward the estimated consumption elasticity for the self-employed and against our test. However, if consumption is mis-reported in the same direction as income, the latter inaccuracy would tend to cancel the former and leave the test approximately unbiased.

in column 7 reject the null hypothesis that η_{CY} is the same for the two groups in favor of the alternative hypothesis that η_{CY} is significantly lower for the self-employed. Hence, the results support PIH.

4.3 Proportionality Hypothesis

Many studies in the 1950s and 1960s tested the proportionality hypothesis ($\eta_{CY} \leq \eta_{CY}^{P} = 1$), usually rejecting it (Mayer, 1972). However, those early tests had three major limitations. First, the tests were carried out on data known to be unreliable (e.g., Ando and Modigliani, 1960). Second, many studies had to derive consumption by subtracting savings from income because the surveys did not measure consumption directly. Survey data on income and savings almost certainly are measured with error, so the constructed consumption data have measurement errors in common with the income data, rendering tests of PIH biased and inconsistent. Third, and perhaps most important, the tests typically relied on cross-sectional surveys covering one period only. If the survey was conducted in an "abnormal" year, the usefulness of the data is dubious. Modern household survey data solve all three problems because the data are quite accurate, consumption and income are measured independently, and the data span several years. Such data enable much stronger tests of the proportionality hypothesis than were possible previously.

4.3.1. Methodology

We use the 1980-1991 CEX for this test. We pool data from different years to ensure a large enough sample size for each group and to guard against possible abnormalities in a given year. We restrict the sample in each classification group to households that remain in the same group throughout the survey period so that the group mean income properly represents the group mean permanent income.

The group mean income measures that serve as instrumental variables for permanent income should (i) be correlated with the permanent component of income, (ii) be uncorrelated with the transitory component of income, (iii) be uncorrelated with the transitory component of consumption, and (iv) have no independent influence on household consumption, and similarly for group mean consumption. Several classification variables are available in the CEX, but one can never be sure that the resulting group mean incomes and consumption satisfy the required conditions for instrument validity. For this reason, Ando and Modigliani

(1960) suggested that "the best we can do is to repeat the test for a variety of criteria and rely on the consensus of the results."[11]

We use seven "traditional" classifications (see, e.g., Eisner, 1958; Ando and Modigliani, 1960; Mayer, 1972):

(1) Occupation. Occupation is an observable household characteristic likely to be correlated with permanent income. Occupation may be correlated with transitory income in a given year, but using data from several years should mitigate the problem.

(2) Education. Education presumably is closely related to permanent income (Ando and Modigliani, 1960). It also seems likely that education is unrelated to either transitory income or consumption between groups. Zellner (1960), however, argues that education is correlated with both family size and household saving opportunities so that education influences consumption through channels other than the level of permanent income, thus biasing the test. Mayer (1972) noted that education is highly correlated with occupation, so it probably suffices to classify households by either one alone. Nonetheless, we use both variables to facilitate comparison with earlier studies.

(3) Region. Region or geographic location is a permanent characteristic of households that did not move during the survey period. Location may not be independent of transitory income or transitory consumption in any single year because natural disasters, unusual weather, and such are likely to be related to transitory income and transitory consumption. Using data from several years should mitigate the problem.

(4) Age. Younger households on average should have higher permanent incomes than older households because of economic growth. A possible problem with age as a classification variable is that it

[11]Family size is an example of a variable that almost certainly does not satisfy the required conditions. It probably satisfies the first three requirements, but, for a given level of permanent income, families with children are likely to consume more than childless families. To make the present value of lifetime consumption equal lifetime wealth, families with children would have less consumption before and after they have children. Family size thus would be a poor instrument for permanent income. Consequently, variables strongly correlated with family size also are likely to be problematic.

is correlated with changes in family structure, with both young and old families having no children present.

(5) Consumption. Vickery (1947) suggests grouping households by consumption. His argument is that, under the PIH, consumption is a homogeneous and proportional function of permanent income, so grouping households by consumption entails grouping them by permanent income.[12]

(6) Housing expenditures. Finally, we group households by housing expenditure, which we measure by annual rent payments for renters and the amount of rent for a similar house for homeowners. This measure is an attractive classifying variable because it represents a long-term commitment of funds and so should be strongly related to permanent income. We also expect it to be unaffected by purely transitory changes in income because of the significant costs of changing living quarters. We keep renters and homeowners separate.

Nelson and Startz (1990) and Stock, Wright and Yogo (2002) among others, have noted that instrumental variable estimation can be misleading when the instruments are weakly correlated with the original income variable. We therefore follow their advice of checking the strength of the instrument variables by reporting the F-statistics from the first-stage regression.

The housing variable also allows us to test the importance of liquidity constraints in determining household consumption expenditure, something that Friedman did not examine in his original tests. For liquidity-constrained households, the income elasticity of consumption η_{CY} should equal 1, contrary to the proportionality hypothesis. To test this implication of liquidity constraints, we must identify liquidity-

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[12]Mayer (1972) argues that the presence of transitory consumption may introduce a bias in favor of the proportionality hypothesis:

> "Suppose that a household has positive transitory consumption. This tends to shift it to a higher consumption class. Thus in the higher consumption classes, there is a factor raising consumption relative to income. And similarly, negative transitory consumption lowers consumption relative to income in the lower consumption classes. Hence, the income elasticity of consumption, when interpreted as a relationship between permanent income and permanent consumption, is biased upwards." (p.186)

Reid (1962) suggests classifying households by consumption over several periods rather than just a single period to minimize transitory consumption bias. This suggestion, however, cannot be applied to the CEX because there is only one year of consumption data available per household in the survey. If transitory consumption is small relative to permanent consumption, the bias is negligible.

constrained households. We follow Runkle (1991) in using house ownership for this purpose. Runkle suggests that renters are more likely than house owners to be liquidity constrained. Owners are more likely than renters to have accumulated substantial financial wealth, and houses themselves can be converted to liquid assets through mortgage and home equity loans. Owners therefore should be less affected by liquidity constraint than renters. If liquidity constraints are important determinants of household consumption, and if Runkle is right that house ownership is a good indicator for presence or absence of liquidity constraint, we should see a much higher value of η_{CY} for renters than homeowners. We would have liked to test liquidity constraints with other variables that have been used previously in the literature, especially those (unlike home ownership) that have been found to support the importance of liquidity constraints, such as household wealth (Zeldes, 1989). Unfortunately, the CEX does not report data on such variables; in particular, it does not report a comprehensive measure of household wealth, leaving us restricted to the use of house ownership as a proxy for liquidity constraint. Still, conducting any test at all of liquidity constraint in the context of Friedman's version of PIH tests is new and better than nothing.

4.3.2 Results

The regression results for each classification variable are presented in Table 3. Columns 3 and 4 report the estimated overall and permanent income elasticities of consumption (based on instrumental variable estimation), η_{CY} and η_{CY}^{P}, with heteroscedasticity-consistent standard errors shown in parentheses. Column 5 shows the significance level for the test of the null hypothesis that $\eta_{CY} = \eta_{CY}^{P}$ against the alternative that $\eta_{CY} < \eta_{CY}^{P}$. Column 6 shows the significance level for the test of the null hypothesis that $\eta_{CY}^{P}=1$ against the alternative that $\eta_{CY}^{P}\neq 1$. Column 7 reports the F-statistics from the first-stage regression as a test of instrument strength.

The statistics in column 7 suggest that instrument weakness is not a problem. It is apparent in columns 3 and 4 that η_{CY} and η_{CY}^{P} are always significantly greater than zero, and that η_{CY}^{P} is significantly greater than η_{CY} no matter what classification is used as an instrumental variable. These findings uniformly support the proportionality hypothesis (Test #4). The stronger test (Test #3), that η_{CY}^{P} equals one, yields

mixed results. Column 6 indicates that η_{CY}^{P} is insignificantly different from one when households are classified by housing expenditures of homeowners, housing expenditures of renters, consumption class, and region but is significantly different from one when households are classified by age, education, occupation, and race. As in the tests of equality between η_{CY} and P_Y, the weaker test uniformly supports the PIH but the stronger test gives mixed evidence. The test of the overidentifying restrictions casts further light on these results, as explained momentarily.

We find no evidence that liquidity constraint is important. The income elasticity η_{CY} for renters is almost the same as that for owners and is significantly less than 1 both statistically and economically. These results are inconsistent with Campbell and Mankiw's (1990) Rule-of-Thumb hypothesis, which requires significant liquidity constraints, and suggest that our earlier result in section 4.1 - that the regression coefficient α_1 in equations (8) is less than one - does not reflect the presence of Rule-of-Thumb households but rather arises from PIH behavior in the presence of data limitations of the types discussed in section 2.1.[13]

4.3.3 Tests of overidentifying restrictions

Column (8) reports the significance level for the test of overidentifying restrictions. The overidentifying restrictions are rejected three-quarters of the time, that is, for six of the eight classifications with housing expenditures of homeowners and housing expenditures of renters being the exceptions. These results are predominately inconsistent with the proportionality hypothesis, but there is a possible difficulty. As always, a statistical test of an econometric model is actually a joint test of the model itself and also of any maintained hypotheses used to identify the model. Rejection of the overidentifying restrictions indicates invalidity of at least one element of the joint hypothesis. In the case at hand, one possibility is that the

[13]Gourinchas and Parker (2002) report evidence that the PIH is more consistent for households approaching retirement age than for young households. One possible explanation for this evidence is that younger households are more likely to be liquidity constrained. We therefore refined our test of liquidity constraint by dividing the sample into two groups according to age of the household's head: age 24-39 and age 40-65. The results (available from the authors upon request), however, indicated no significant difference between the two household groups and no difference from the results for the sample as a whole reported in Table 3.

proportionality hypothesis is incorrect, and the other possibility is that the instruments are not valid. A case can be made for the latter here. If the proportionality hypothesis is invalid, we have some difficulty explaining why Test #4 uniformly favors it, why Test #3 favors it when the instrument is housing expenditures of homeowners, housing expenditures of renters, consumption class, or region, and why two of the eight overidentifying restriction tests fail to reject it. Competing theories of consumption (e.g., the Keynesian absolute income theory or the rule of thumb theory) do not lead to the proportionality hypothesis. In contrast, if the instruments are imperfect, then these conflicting results are not at all difficult to explain. An imperfect instrument may correlate with permanent income but also have some correlation with the unexplained residual and so lead to rejection of the overidentifying restrictions. Valid instruments do not have this problem. So a possible interpretation of the overidentifying restriction tests is that the two housing expenditure classifications are the only valid instruments.[14] It is especially noteworthy that Test #3 supports the proportionality hypothesis for both instruments for which the overidentifying restrictions are accepted. None of this proves that the rejection of the overidentifying restrictions for most instruments arises because the instruments are invalid rather than the theory, and obviously one must be extremely cautious with after-the-fact criticism of the validity of instruments. The strict interpretation of the overidentifying restriction tests is that, overall, they reject the proportionality hypothesis. Nonetheless, it also seems true that instrument invalidity is a possible explanation for the overidentifying restriction rejections. The use of overidentifying restrictions in the framework of Friedman's cross-section tests of the PIH is new to this study, and our conclusion is that the limited results we have suggest that further investigation along these lines would be very useful.

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[14]Note that invalidity of some of the instruments used here for Tests # 3 and #4 (proportionality hypothesis) implies nothing about the validity of the earlier Tests #1 and #2 (equality of η_{CY} and P_Y, or the inverse relation between η_{CY} and var Y^T). Here, we use mean income and consumption within classification groups as instruments in the traditional sense for permanent income and consumption. Invalidity of those instruments for some classifications probably means the instruments are correlated with transitory income or consumption. In conducting Tests #1 and #2, we did not construct instruments in the traditional sense but merely used classification variables as a basis for constructed measures of variances, correlations, and elasticities, which have no necessary relation to group mean income or consumption.

4.4 Income Change and Consumption

Following Friedman (1957), we divide the households in our sample into five classes, according to whether their incomes changed -25% or more, -25% to -5%, -5% to 5%, 5% to 25%, or 25% or more. Columns 2 and 3 of Table 4 report the estimated value of intercept and income elasticity of consumption for each income-change group. The intercepts generally are inversely related to the amount of income change, with that for the *up more than 25%* group being the major exception. The elasticities are of similar magnitude except for the two groups for which income changed by more than 25 percent. The two extreme income-change groups may have special characteristics, as we discuss momentarily.[15] The results for the three remaining groups agree with PIH. We cannot reject equality of the three income elasticities, as shown by the *p*-value of F_1 statistic, and we can reject the hypothesis that there is no difference between the income elasticities of the three groups and that of the overall sample, as shown by the *p*-value of the F_2 statistic. The F_3 statistic rejects the null hypothesis that the three intercepts are equal in favor of the alternative hypothesis that the intercepts are inversely related to the amount of income change. Thus, the intercepts and slopes for the three moderate income-change classes are consistent with all implications of PIH. Still, even though these three classes behave according to PIH, they are only three out of the five total classes (but at the same time most households in the sample do fall within them), so their support for PIH is less than overwhelming.

One possible explanation of why the two outlier groups exhibit behavior inconsistent with PIH is that they consist largely of households whose income changes are primarily changes in permanent income rather than transitory income. For example, those groups may contain a relatively large number of households with members who had just changed occupations, changed industries, and the like. Table 5 examines this possibility, presenting in columns 2 to 4 the percentages of households in each group that experienced changes in household characteristics relevant to determining permanent income. The households in the two

[15]Friedman (1957) found similar phenomena in his analysis of the 1947-1948 Consumer Finances data, for which the behavior of the *down more than 25 percent* group consistently deviated from that of all other groups.

extreme income-change groups constitute the outliers in virtually every type of household characteristic. Thus there is reason to believe their income changes were largely permanent rather than transitory and thus are inappropriate for inclusion in this particular test of PIH.[16]

Overall, this test gives moderate support to PIH.

4.5 Summary and Interpretation the Results

Table 6 summarizes the results of the various tests. In cases where there were several versions of the same test (e.g., Test 3 with different instrument sets), we classify the whole test as (i) supporting the PIH if the results supported the PIH at least 75% of the time, (ii) rejecting the PIH if the results reject the PIH at least 75% of the time, and (iii) mixed if the results fall between the previous two extremes. Looking across the various tests, we see that most support the PIH, some give mixed results, and only one — the overidentifying restrictions sub-test of the proportionality hypothesis — rejects the PIH. The latter test barely rejects, with the total number of rejections being right on the boundary of the Mixed and Reject regions, and, as discussed above, there is reason to believe that the overidentifying restrictions rejections arise from bad instruments rather than from failure of the PIH itself. On the whole, the tests fail to reject the implications of the PIH.

The complete set of test results is difficult to reconcile with any existing alternatives to the PIH. We know of no competing theory of household choice that produces all the implications of the PIH that we have examined, and in several cases the PIH seems to be the only existing theory that yields the implications being tested. Even if any particular test is not completely supportive of the PIH, it is hard to think of an alternative that would be consistent with the full array of test results that we have. In a sense, the array of tests acts as

[16]Another possibility is that households in the two extreme income-change groups (especially those whose incomes fell) were liquidity-constrained. Such households would have behaved in a way that violates the simple unconstrained version of PIH we are testing. Both groups held small amounts of liquid financial assets and tended to be renters rather than owners; see columns 5-10 of Table 5. This possibility is unconvincing, however, because liquidity-constrained households should be more sensitive to current income than unconstrained households, not less. Yet the slope coefficients for the two extreme income-change groups both are less than for the other groups. It thus seems more likely that the "deviant" behavior of these two groups is that their observed current income changes reflect atypically large changes in permanent income rather than that they are liquidity-constrained.

a meta-test and is favorable to the PIH.

5. Conclusion

We have used modern household data to revive Friedman's (1957) classification tests of the Permanent Income Hypothesis. Modern data and econometric methods both are superior to what was available to Friedman, allowing us to check statistical significance and conduct tests Friedman could not perform. The tests require different identifying restrictions than either the once-popular consumption function tests or the now-favored Euler equation tests and so complement those workhorses of the empirical literature.

All in all, our tests support PIH. We have performed a wide variety of tests, and in each test the majority of results have favored PIH, sometimes strongly so. In this regard, they are consistent with and complement several recent Euler equation tests of the PIH using micro data that offer strong support for the PIH (Runkle, 1991; Attanasio and Browning, 1995; Attanasio and Weber, 1995; and DeJuan and Seater, 1999). Unsurprisingly, the sharpest tests are the least supportive of the PIH, but taking the full set of tests as a whole suggests rather strong support for the PIH. The majority of tests support the PIH, sometimes quite strongly. Other tests do not give unqualified support to the PIH but also are not strongly at variance with it. Only one test rejects the PIH outright, but even it does so only weakly (being on the boundary of the rejection region) and may be the result of invalid instruments rather than failure of the PIH. Other theories of household choice may yield one or two of the set of PIH implications that we have tested, but none that we know of yields the entire set. Indeed, several implications of the PIH are unique to it, being implied by no existing alternative. Overall, the PIH does rather well in explaining the patterns in the CEX data.

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Table 1
Income Elasticity of Consumption and Relative Variances of Permanent and Transitory Income: Testing the Equality of η_{CY} and P_Y

Assumption	α_0	α_1	$\alpha_1>0$?	$\alpha_1=1$?	Reverse α_0	Reverse α_1	Include $\alpha_1=1$?	Spearman
Occupation: CEX 1980-82								
Mean	0.319 (0.061)	0.240 (0.092)	Y	N	0.395 (0.139)	0.655 (0.238)	Y	0.405*
Var	0.245 (0.071)	0.368 (0.116)	Y	N	0.495 (0.098)	0.350 (0.163)	Y	0.321*
Industry: CEX 1980-82								
Mean	0.175 (0.073)	0.475 (0.105)	Y	N	0.183 (0.072)	0.996 (0.137)	Y	0.556*
Var	0.236 (0.134)	0.377 (0.185)	Y	N	0.529 (0.059)	0.329 (0.110)	Y	0.392*
Occupation: CEX 1980-91								
Mean	-0.152 (0.116)	0.891 (0.166)	Y	Y	-	-	-	0.857*
Var	-0.369 (0.089)	1.235 (0.142)	Y	Y	-	-	-	0.857*
Industries: CEX 1980-91								
Mean	-0.032 (0.032)	0.698 (0.048)	Y	N	0.073 (0.057)	1.370 (0.081)	N	0.900*
Var	-0.080 (0.077)	0.788 (0.116)	Y	Y	-	-	-	0.717*
Education: CEX 1980-91								
Mean	-0.257 (0.090)	1.017 (0.138)	Y	Y	-	-	-	0.964*
Var	-0.433 (0.295)	1.298 (0.439)	Y	Y	-	-	-	0.857*
Education and Occupation: CEX 1980-91								
Mean	0.124 (0.059)	0.405 (0.101)	Y	N	0.415 (0.097)	0.589 (0.230)	Y	0.504*
Var	0.138 (0.109)	0.386 (0.186)	Y	N	0.497 (0.085)	0.364 (0.193)	Y	0.429*

Table 1 (Continued)

Assumption	α_0	α_1	$\alpha_1>0$?	$\alpha_1=1$?	Reverse α_0	Reverse α_1	Include $\alpha_1=1$?	Spearman
Region: CEX 1980-91								
Mean	0.528 (0.231)	-0.104 (0.338)	N	N	-	-	-	-0.105
Var	0.665 (0.211)	-0.304 (0.317)	N	N	-	-	-	-0.400
Region and Occupation: CEX 1980-1991								
Mean	0.063 (0.054)	0.539 (0.098)	Y	N	0.295 (0.115)	0.865 (0.258)	Y	0.699*
Var	0.014 (0.115)	0.627 (0.191)	Y	N	0.417 (0.073)	0.538 (0.158)	Y	0.581*
Region and Education: CEX 1980-1991								
Mean	0.060 (0.079)	0.553 (0.114)	Y	N	0.348 (0.081)	0.774 (0.184)	Y	0.624*
Var	0.077 (0.156)	0.543 (0.233)	Y	N	0.547 (0.058)	0.283 (0.134)	Y	0.400*
Race: CEX 1980-91								
Mean	-0.157 (0.019)	0.850 (0.023)	Y	N	0.210 (0.017)	1.121 (0.038)	N	0.800*
Var	-0.692 (0.117)	1.643 (0.169)	Y	N	0.462 (0.014)	0.520 (0.028)	N	0.800*
Race and Occupation: CEX 1980-1991								
Mean	-0.003 (0.075)	0.651 (0.118)	Y	N	0.247 (0.070)	0.929 (0.168)	Y	0.784*
Var	0.185 (0.135)	0.348 (0.216)	Y	N	0.481 (0.086)	0.329 (0.204)	Y	0.210
Race and Education: CEX 1980-1991								
Mean	0.094 (0.071)	0.506 (0.094)	Y	N	0.198 (0.101)	1.142 (0.213)	Y	0.749*
Var	0.196 (0.162)	0.380 (0.231)	Y	N	0.556 (0.087)	0.301 (0.183)	Y	0.399*

Table 1 (Continued)

Assumption	α_0	α_1	α_1>0?	α_1=1?	Reverse α_0	Reverse α_1	Include α_1=1?	Spearman
Ancestry: CEX 1980-91								
Mean	-0.208 (0.116)	0.946 (0.171)	Y	Y	-	-	-	0.800*
Var	-0.063 (0.108)	0.742 (0.158)	Y	Y	-	-	-	0.800*
Ancestry and Occupation: CEX 1980-91								
Mean	0.023 (0.054)	0.634 (0.086)	Y	N	0.169 (0.082)	1.094 (0.184)	Y	0.776*
Var	0.053 (0.106)	0.617 (0.175)	Y	N	0.329 (0.064)	0.644 (0.141)	Y	0.566*
Ancestry and Education: CEX 1980-91								
Mean	-0.019 (0.042)	0.660 (0.058)	Y	N	0.218 (0.092)	1.075 (0.204)	Y	0.802*
Var	0.028 (0.093)	0.611 (0.135)	Y	N	0.411 (0.074)	0.570 (0.169)	Y	0.585*

Notes: α_0 and α_1 are the estimated coefficients of equation (8). α_1>0 and α_1=1 report the outcomes of 10 percent significance level *t*-tests of whether α_1 is positive and equal to one, respectively. Reverse α_0 and α_1 are the coefficients from exchanging the dependent and independent variables in (8). Include α_1=1 indicates whether the interval defined by the original and reverse regression estimates of α_1 contains one. Spearman is the rank correlation coefficient test for a positive relation between η_{CY} and P_Y. An asterisk (*) indicates statistically significant at 10 percent level. Numbers in parentheses are heteroscedasticity-consistent standard errors.

Table 2
Income Elasticities of Consumption and Relative Variance of Transitory Incomes

Type of Employees	$\overline{Y}$ ($)	$s_{\overline{Y}}$ ($)	$\rho_{Y_1Y_2}$	$\eta_{Y_1Y_2}$	η_{CY}	t_1
Self-Employed	25,888	20,278	0.523	0.530	0.304	4.339*
Employees	24,232	14,619	0.691	0.705	0.456	

Notes: $\overline{Y}$ is average income. $s_{\overline{Y}}$ is standard deviation of income. $\rho_{Y_1Y_2}$ is correlation between incomes in periods 1 and 2. η_{ab} is the elasticity of *a* with respect to *b*. t_1 is the *t*-statistic for testing the null hypothesis $\eta_{CY}^{SE} = \eta_{CY}^{EM}$ against the alternative hypothesis $\eta_{CY}^{SE} < \eta_{CY}^{EM}$. An asterisk (*) indicates statistically significant at 10 percent level.

Table 3
Tests of Proportionality Hypothesis

Class	No. of Groups	η_{CY}	η_{CY}^{P}	t_1	t_2	1st Stage F-stat	Test of OI
Age	42	0.455 (0.009)	0.861 (0.019)	0.000	0.000	32.650 [0.0001]	2.750 [0.0001]
Consumption Class	52	0.455 (0.009)	0.987 (0.008)	0.000	0.110	288.820 [0.0001]	2.060 [0.0001]
Education	7	0.458 (0.009)	0.703 (0.015)	0.000	0.000	267.480 [0.0001]	5.380 [0.0001]
Occupation	8	0.440 (0.011)	0.652 (0.015)	0.000	0.000	237.560 [0.0001]	29.900 [0.0001]
Housing Tenure: Renter	21	0.378 (0.016)	0.952 (0.026)	0.000	0.080	53.780 [0.0001]	1.110 [0.331]
Housing Tenure: Owner	21	0.375 (0.039)	0.982 (0.062)	0.000	0.764	9.500 [0.0001]	0.540 [0.947]
Race	4	0.456 (0.009)	0.703 (0.027)	0.000	0.002	141.520 [0.0001]	8.190 [0.0003]
Region	4	0.456 (0.009)	1.033 (0.102)	0.000	0.767	18.530 [0.0001]	19.340 [0.0001]

Notes: t_1 reports the *p*-value of *t*-test for the null hypothesis $\eta_{CY}=\eta_{CY}^{P}$ against the alternative hypothesis $\eta_{CY}<\eta_{CY}^{P}$. t_2 reports the *p*-value of the *t*-test for the null hypothesis $\eta_{CY}^{P}=1$ against the alternative hypothesis $\eta_{CY}^{P}\neq 1$. 1st stage F reports the *F*-statistic and *p*-value (in bracket) of the first stage regression of income against the instruments. Test of OI reports the chi-square statistic and *p*-value (in bracket) for test of overidentifying restriction. Numbers in parentheses are heteroscedasticity-consistent standard errors.

Table 4
Income Change and Consumption

Income-Change Class	Intercept	Income Elasticity of Consumption	F_1	F_2	F_3
down more than 25%	6.920 (0.136)	0.297 (0.014)	0.070	0.007	0.038
down 5% to 25%	3.549 (0.133.)	0.626 (0.013)			
down 5% to up 5%	3.115 (0.105)	0.665 (0.010)			
up 5% to 25%	3.271 (0.123)	0.647 (0.012)			
up more than 25%	4.168 (0.106)	0.552 (0.010)			
All Classes	5.234 (0.087)	0.456 (0.009)			

Notes: F_1 reports the *p*-value of *F*-statistic for testing the equality of the income elasticities across income-change classes. F_2 reports the *p*-value of *F*-statistic for testing the equality of class income elasticities to income elasticity for all classes. F_3 reports the *p*-value of *F*-statistic for testing the equality of intercepts across income-change classes. Numbers in parentheses are heteroscedasticity-consistent standard errors.

Table 5
Income-Change Class and Household Characteristics

Income-Change Class	Change in Occupation	Change in Industry	Change in Earners Composition	Liquid Assets				Owner	Renter
				$0	<$250	$250-$500	>$500		
> 25%	27%	22%	20%	23%	22%	20%	17%	67%	32%
-25% to -5%	22	15	15	18	23	21	22	72	27
-5% to 5%	23	15	13	13	13	17	18	71	28
5% to 25%	23	17	14	21	20	23	24	71	29
> 25%	24	19	19	25	21	20	20	63	26

Source: Consumer Expenditure Survey 1980-1991.

Table 6
Summary of Test Results

Test	Result
Test #1	
Strong form: $\eta_{CY} = \eta_{Y1Y2}$ or ρ_{Y1Y2}	
t-test	M
reverse regression	S
Weak form: $d\eta_{CY}/\eta_{Y1Y2} > 0$ or $d\eta_{CY}/d\rho_{Y1Y2} > 0$	S
Test #2: $d\eta_{CY}/d(\text{var } Y^T/\text{var } Y^P) < 0$	S
Test #3: $\eta_{CY}^P = 1$	M
Test #4: $\eta_{CY} \leq \eta_{CY}^P$	S
Absence of liquidity constraint	S
Overidentifying restrictions	R
Test #5: Regression intercepts of groups inversely related to magnitude of income change	S
Test #6: η_{CY} (group i) > η_{CY} (whole sample) $\forall$ i	S
Test #7: η_{CY} (group i) = η_{CY} (group j) $\forall$ i, j	M

Note: S = Support, M = Mixed, R = Reject. See text for definitions of Support, Mixed, and Reject.

Appendix

A1. Data

We define consumption expenditure on nondurable goods and services as the sum of expenditures on the following categories: food; alcoholic beverages; utilities, fuels, and public services; household operations; house furnishings and equipment, excluding furniture, appliances, floor coverings and household equipment; apparel and services; transportation fuel and services; entertainment, excluding televisions, radios, sound, and other equipment; health and personal care; reading; education; and tobacco and smoking. Annual consumption expenditure is constructed by summing household expenditures twelve months (four quarterly interviews) prior to the fifth interview. Household income before-tax is the sum of regular income (wages and salaries, income/loss from farm and nonfarm business, social security, railroad retirement, pensions, workmen's compensation, interest on savings accounts and other assets, rental income and income from roomers, and regular support from alimony), value of in-kind benefits (unemployment compensation, food stamps, and public assistance or welfare payments), and other income (money received from care of foster children, cash scholarships and fellowships, and stipends not based on working). Disposable income is defined as household 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. Liquid asset is the sum of amounts in checking and savings account, when both are reported. All nominal variables are deflated to 1982 dollars.

A2. Classification Groups

In all the classification groups, we include groups with at least 15 household observations.

(1) *Occupation, 1980-81*: 34 occupation groups listed by occupation code and description: (102) Accountants; (112) Engineers; (132) Health Workers except Practitioners; (142) Teachers except College and University; (152) Engineering and Science Technicians; (162) Writers, Artists, and Entertainers; (172) Other Professional, Technical, and Kindred Workers; (202) Managers and Administrators in Manufacturing; (212) Managers and Administrators in Retail Trade; (232) Bank Officers and Financial Managers; (252) Managers and Administrators in Other Industries; (261) Self-Employed Farmers; (302) Sales Workers in Retail Trade; (332) Insurance Agents, Brokers/Underwriters, and Real Estate Agents; (352) Sales Workers in Wholesale Trade; (362) Bookkeepers; (372) Mail Handlers and Postal Clerks; (382)

Secretaries, Stenographers, and Typists; (392) Other Clerical Workers; (402) Foremen; (412) Carpenters; (432) Brick Masons, Roofers, Plumbers, and Painters; (451) Self-Employed Mechanics and Repairers; (462) Blacksmiths, Machinists, Crane Men, and Sheet Metal Workers; (492) Bakers, Cabinetmakers, Shoe Repair, Telephone Installers, and Jewelers; (502) Operatives (excluding Transport) in Durable Goods Manufacturing; (512) Operatives (excluding Transport) in Non-Durable Goods Manufacturing; (552) Operatives in Other Non-Manufacturing Industries; (562) Motor Vehicle Drivers; (622) Laborers (except Farm) in Other Industries; (702) Cleaning Service Workers, except Private Households; (712) Food Service Workers, except Private Households; (722) Health Service Workers, except Private Households; (742) Protective Service Workers, except Private Households.

(2) *Industry, 1980-81*: 32 industry groups listed by industry code and description: (17) Agricultural Production; (67) General Building Contractors; (68) General Contractor, except Building; (69) Special Trade Contractors; (189) Electronic Computing Equipment; (197) Machinery, except Electrical; (208) Electrical Machinery, Equipment, and Supplies; (219) Motor Vehicles and Motor Vehicle Equipment; (227) Aircraft and Parts; (228) Ship and Boat Building and Repairing; (319) Apparel and Other Fabricated Textile Products; (339) Printing and Publishing, except Newspaper; (407) Railroads and Railway Express Service; (417) Trucking Service; (448) Telephone (Wire and Radio); (467) Electric Light and Power; (527) Food and Related Products (Wholesale Trade); (609) Department and Mail Order Establishments; (628) Grocery Stores; (639) Motor Vehicle Dealers; (669) Eating and Drinking Places; (707) Banking; (717) Insurance; (718) Real Estate and Real Estate Insurance Law Offices; (838) Hospitals; (857) Elementary and Secondary Schools; (858) Colleges and Universities; (888) Engineering and Architectural Services; (907) Postal Service; (917) Federal Public Administration; (927) State Public Administration; (937) Local Public Administration.

(3) *Education, 1980-91*: never attended school, elementary, less than high school, high school graduate, less than college, college graduate, and more than college.

(4) *Industry, 1980-91*: 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; public administration.

(5) *Occupation, 1980-91*: managers and professional specialty; technicians, sales, and administrative; service; farming, fishing, and forestry; precision production, crafts, and repair; operatives, fabricators, and laborers; armed forces; and self-employed.

(6) *Race, 1980-91*: White; Black; Asian or Pacific Islander; American Indian, Aleut, Eskimo.

(7) *Ancestry of the reference person, 1980-1991:* European (German, Italian, Irish, French, Polish, Russian, English, Scottish, Welsh); Spanish (Mexican American, Chicano, Mexican, Puerto Rican, Cuban, Central and South American, Other Spanish); Afro-American; Others.

(8) *Region, 1980-91*: Northeast, Midwest, South, West.

(9) *Housing Tenure, 1980-1991*: homeowner, renter.

A3. Implications of the Mean and Variability Assumptions

We show that the mean and variability assumptions imply $P_Y = \eta_{Y_1Y_2}$ and $P_Y = \rho_{Y_1Y_2}$, respectively. See Friedman and Kuznets (1945, pp. 325-338) for a complete discussion.

A3.1. Mean Assumption. Suppose we specify a level of income Y* and then in period t+1 we choose a household *i* earning that level of income, so that $Y_{it+1} = Y^*$. Household *i*'s current income Y_{it+1} consists of a permanent component Y_{it+1}^P and a transitory component Y_{it+1}^T. Because we have used current income to select this household, the household's permanent and transitory incomes are correlated with its current income. [This follows immediately by noting that the covariances of current income with both permanent and transitory income are positive: $\text{cov}(Y_t, Y_t^P) = \text{cov}(Y_t^P + Y_t^T, Y_t^P) = \text{var } Y_t^P > 0$ and similarly for transitory income.] We thus cannot use current income to estimate either permanent or transitory income for household *i*. Nevertheless, the household's current income in any *other* period is an unbiased estimator for its permanent income in that same period. Under suitable restrictions, the other period's current income also can be used as the basis of an unbiased estimator for permanent income in period t+1.

To see these results, suppose for now that permanent income differs across households but is constant over time. (The intertemporal constancy of permanent income is for expository ease, allowing us to present a simple case that shows the intuition behind the mean assumption. After we have presented the simple case, we drop the restriction on permanent income and derive the general result.) Consider the subsample of households whose current income is some arbitrary value Y*, and choose any household *i* from that subsample. The value of transitory income Y^T in period t+1 has no relation to its value in any other period, so the expected value of household *i*'s transitory income in period t, conditional on information available in period t+1, is simply zero, irrespective of its value in period t+1. We therefore have $E(Y_{it}^P \mid \Omega_{it+1}) = E(Y_{it}^P \mid \Omega_{it+1}) + E(Y_{it}^T \mid \Omega_{it+1}) = E(Y_{it}^P + Y_{it}^T \mid \Omega_{it+1}) = E(Y_{it} \mid \Omega_{it+1}) = Y_{it}$, where the information set Ω_{it+1} consists

of all current income values Y_{it-k}, k any non-negative integer, for a household *i* with $Y_{it+1} = Y^*$. Thus observed current income in period t is an unbiased estimator of the permanent component of the income Y_{it} of any household *i* chosen on the basis of its current income in period t+1. Because we have assumed temporarily that permanent income does not change over time, Y_{it} also is an unbiased estimator for the permanent component of period t+1 income Y_{it+1}.

We now drop the assumption that permanent income is constant over time. In that case, we must adjust Y_{it} using the mean assumption to make Y_{it} an unbiased estimator of Y_{it+1}^{P}. Doing that will lead to the result that $P_Y = \eta_{Y_1 Y_2}$. We start with the difference between the expected value of household *i*'s permanent income in period t+1 and average income for the whole sample:

$$EY_{it+1}^{P} - \bar{Y}_{t+1} = E\left[Y_{it}^{P}\left(1 + \frac{\Delta Y_{it}^{P}}{Y_{it}^{P}}\right)\right] - \bar{Y}_t\left(1 + \frac{\Delta \bar{Y}_t}{\bar{Y}_t}\right)$$

By the mean assumption,

$$\frac{\Delta Y_{it}^{P}}{Y_{it}^{P}} = \frac{\Delta \bar{Y}_t}{\bar{Y}_t}$$

so we can write

$$\begin{aligned} EY_{it+1}^{P} - \bar{Y}_{t+1} &= E\left[Y_{it}^{P}\left(1 + \frac{\Delta \bar{Y}_t}{\bar{Y}_t}\right)\right] - \bar{Y}_t\left(1 + \frac{\Delta \bar{Y}_t}{\bar{Y}_t}\right) \\ &= (EY_{it}^{P} - \bar{Y}_t)\left(1 + \frac{\Delta \bar{Y}_t}{\bar{Y}_t}\right) \\ &= (Y_{it} - \bar{Y}_t)\left(\frac{\bar{Y}_{t+1}}{\bar{Y}_t}\right) \end{aligned}$$

$$\Rightarrow \quad EY_{it+1}^{P} = \bar{Y}_{t+1} + (Y_{it} - \bar{Y}_t)\left(\frac{\bar{Y}_{t+1}}{\bar{Y}_t}\right)$$

$$\Rightarrow \quad EY_{it+1}^{T} = Y_{it+1} - \bar{Y}_{t+1} - (Y_{it} - \bar{Y}_t)\left(\frac{\bar{Y}_{t+1}}{\bar{Y}_t}\right)$$

The difference between household *i*'s income in period t+1 and the sample average income in the same period is the sum of two components: (1) the difference between household and sample average transitory income and (2) the difference between household and sample average permanent income; that is,

$$Y_{it+1} - \bar{Y}_{t+1} = (Y^T_{it+1} - \bar{Y}^T_{t+1}) + (Y^P_{it+1} - \bar{Y}^P_{t+1})$$

$$= Y^T_{it+1} + (Y^P_{it+1} - \bar{Y}^P_{t+1}) \qquad \text{because } \bar{Y}^T_{t+1} = 0$$

Therefore, the expected fraction T_Y of $Y_{it+1} - \bar{Y}_{t+1}$ due to the transitory component is

$$T_Y = \frac{Y_{it+1} - \bar{Y}_{t+1} - (Y_{it} - \bar{Y}_t)\left(\frac{\bar{Y}_{t+1}}{\bar{Y}_t}\right)}{Y_{it+1} - \bar{Y}_{t+1}}$$

$$= 1 - \frac{(Y_{it} - \bar{Y}_t)\bar{Y}_{t+1}}{(Y_{it+1} - \bar{Y}_{t+1})\bar{Y}_t}$$

$$= 1 - P_Y$$

where P_Y is the fraction due to the permanent component.

Finally, we show that $\eta_{Y_t Y_{t+1}} = P_Y$. Multiply both sides of the previous expression for T_Y by the denominator of that expression:

$$T_Y(Y_{it+1} - \bar{Y}_{t+1})\bar{Y}_t = (Y_{it+1} - \bar{Y}_{t+1})\bar{Y}_t - (Y_{it} - \bar{Y}_t)\bar{Y}_{t+1}$$

$$= Y_{it+1}\bar{Y}_t - Y_{it}\bar{Y}_{t+1}$$

$$Y_{it}\bar{Y}_{t+1} = Y_{it+1}\bar{Y}_t - T_Y(Y_{it+1} - \bar{Y}_{t+1})\bar{Y}_t$$

$$= (1 - T_Y)Y_{it+1}\bar{Y}_t + T_Y\bar{Y}_{t+1}\bar{Y}_t$$

$$Y_{it} = (1 - T_Y)\frac{\bar{Y}_t}{\bar{Y}_{t+1}}Y_{it+1} + T_Y\bar{Y}_t$$

$$= \left(P_Y\frac{\bar{Y}_t}{\bar{Y}_{t+1}}\right)Y_{it+1} + (1 - P_Y)\bar{Y}_t$$

$$= bY_{it+1} + a$$

which is a regression of Y_{it} on Y_{it+1} with intercept a and slope coefficient

$$b = P_Y\frac{\bar{Y}_t}{\bar{Y}_{t+1}}$$

$$\Rightarrow \quad P_Y = b\frac{\bar{Y}_{t+1}}{\bar{Y}_t}$$

$$= \frac{dY_{it+1}}{dY_{it}}\frac{\bar{Y}_{t+1}}{\bar{Y}_t}$$

$$= \eta_{Y_t Y_{t+1}}$$

where the last elasticity is evaluated at the point of sample mean (i.e., at $\bar{Y}_{t+1}/\bar{Y}_t$).

A3.2. Variability Assumption. The steps are similar to those for the mean assumption and so are presented with less explanation. The variability assumption is that

$$\frac{\sigma_{Y_t^P}}{\bar{Y}_t^P} = a\frac{\sigma_{Y_t}}{\bar{Y}_t}$$

where *a* = constant. Because $\bar{Y}_t^P = \bar{Y}_t$ (because transitory income for the whole sample averages to zero), we have

$$\frac{\sigma_{Y_t^P}}{\bar{Y}_t^P} = \frac{\sigma_{Y_t^P}}{\bar{Y}_t} = a\frac{\sigma_{Y_t}}{\bar{Y}_t}$$

$$\Rightarrow \quad \sigma_{Y_t^P} = a\sigma_{Y_t}$$

Consider a change in σ_{Y_t} to $\sigma_{Y_{t+1}} = k\sigma_{Y_t}$, where k > 0. Then

$$\frac{Y_{it}^P - \bar{Y}_t^P}{\sigma_{Y_t^P}} = \frac{Y_{it+1}^P - \bar{Y}_{t+1}^P}{\sigma_{Y_{t+1}^P}}$$

This follows from the definition of σ:

$$\sigma^2_{Y_t^P} \equiv E\left(Y_t^P - \bar{Y}_t^P\right)^2$$

Multiplying both sides by k^2 gives

$$k^2\sigma^2_{Y_t^P} \equiv E\left[k\left(Y_t^P - \bar{Y}_t^P\right)\right]^2$$

Therefore, to increase σ by k, we must increase the differences $(Y_t^P - \bar{Y}_t^P)$ by k, on average. We then can write

$$\frac{Y_{it+1}^P - \bar{Y}_{t+1}^P}{\sigma_{Y_{t+1}^P}} = \frac{k(Y_{it}^P - \bar{Y}_t^P)}{k\sigma_{Y_t^P}} = \frac{Y_{it}^P - \bar{Y}_t^P}{\sigma_{Y_t^P}}$$

as asserted. We can rearrange this equality as

$$Y_{it+1}^{P} - \bar{Y}_{t+1}^{P} = (Y_{it}^{P} - \bar{Y}_{t}^{P}) \frac{\sigma_{Y_{t+1}^{P}}}{\sigma_{Y_{t}^{P}}}$$

$$\leftrightarrow \quad Y_{it+1}^{P} - \bar{Y}_{t+1} = (Y_{it}^{P} - \bar{Y}_{t}) \frac{\sigma_{Y_{t+1}^{P}}}{\sigma_{Y_{t}^{P}}}$$

$$\Rightarrow \quad Y_{it+1}^{P} = \bar{Y}_{t+1} + (Y_{it}^{P} - \bar{Y}_{t}) \frac{\sigma_{Y_{t+1}^{P}}}{\sigma_{Y_{t}^{P}}}$$

$$= \bar{Y}_{t+1} + (Y_{it} - \bar{Y}_{t}) \frac{\sigma_{Y_{t+1}^{P}}}{\sigma_{Y_{t}^{P}}}$$

The expected fraction of the difference $(Y_{it+1} - \bar{Y}_{t+1})$ arising from transitory income is

$$T_{Y}^{\prime} = \frac{Y_{it+1} - \bar{Y}_{t+1} - (Y_{it} - \bar{Y}_{t}) \frac{\sigma_{Y_{t+1}^{P}}}{\sigma_{Y_{t}^{P}}}}{Y_{it+1} - \bar{Y}_{t+1}}$$

$$= 1 - \frac{(Y_{it} - \bar{Y}_{t}) \frac{\sigma_{Y_{t+1}^{P}}}{\sigma_{Y_{t}^{P}}}}{Y_{it+1} - \bar{Y}_{t+1}}$$

$$= 1 - P_{Y}^{\prime}$$

Note that

$$\frac{\sigma_{Y_{t+1}^{P}}}{\sigma_{Y_{t}^{P}}} = \frac{a\sigma_{Y_{t+1}}}{a\sigma_{Y_{t}}} \quad \text{by the variability assumption}$$

$$= \frac{\sigma_{Y_{t+1}}}{\sigma_{Y_{t}}}$$

$$\Rightarrow \quad T_{Y}^{\prime} = 1 - \frac{Y_{it} - \bar{Y}_{t}}{Y_{it+1} - \bar{Y}_{t+1}} \frac{\sigma_{Y_{t+1}}}{\sigma_{Y_{t}}}$$

$$\Rightarrow \quad T_{Y}^{\prime}(Y_{it+1} - \bar{Y}_{t+1}) = (Y_{it+1} - \bar{Y}_{t+1}) - (Y_{it} - \bar{Y}_{t}) \frac{\sigma_{Y_{t+1}}}{\sigma_{Y_{t}}}$$

$$\Rightarrow \quad (Y_{it} - \bar{Y}_t)\frac{\sigma_{Y_{t+1}}}{\sigma_{Y_t}} = (1 - T'_Y)(Y_{it+1} - \bar{Y}_{t+1})$$

$$\Rightarrow \quad Y_{it} = \bar{Y}_t - \frac{\sigma_{Y_t}}{\sigma_{Y_{t+1}}}(1 - T'_Y)\bar{Y}_{t+1} + \frac{\sigma_{Y_t}}{\sigma_{Y_{t+1}}}(1 - T'_Y)Y_{it+1}$$

$$= \bar{Y}_t - \frac{\sigma_{Y_t}}{\sigma_{Y_{t+1}}}P'_Y\bar{Y}_{t+1} + \frac{\sigma_{Y_t}}{\sigma_{Y_{t+1}}}P'_Y Y_{it+1}$$

$$= a + b\,Y_{it+1}$$

which is a regression of Y_{it} on Y_{it+1}. The regression slope coefficient is

$$b = \frac{\sigma_{Y_t}}{\sigma_{Y_{t+1}}}P'_Y$$

which implies

$$P'_Y = b\frac{\sigma_{Y_{t+1}}}{\sigma_{Y_t}}$$

Because *b* is a regression coefficient, we have

$$b = \rho_{Y_t Y_{t+1}}\frac{\sigma_{Y_t}}{\sigma_{Y_{t+1}}}$$

$$\Rightarrow \quad P'_Y = \left(\rho_{Y_t Y_{t+1}}\frac{\sigma_{Y_t}}{\sigma_{Y_{t+1}}}\right)\frac{\sigma_{Y_{t+1}}}{\sigma_{Y_t}}$$

$$= \rho_{Y_t Y_{t+1}}$$

A4. Effects of Measurement Error on Slope Coefficient Estimation

For our case, we are regressing logC on logY and would like to obtain an estimate of the elasticity of consumption with respect to income. (In particular, we are regressing consumption in period 2 against income in period 2.)

Consider the following simple linear regression. Think of β as the elasticity of consumption with respect to income:

(A4.1)
$$C_{true} = \beta\ Y_{true} + \epsilon$$

Suppose the available data on C and Y are measured with error, i.e.

(A4.2)
$$C_{obs} = C_{true} + \nu$$

(A4.3)
$$Y_{obs} = Y_{true} + \xi$$

where ν and ξ (measurement error of C and Y, respectively) are iid with mean 0 and constant variance. Applying (A4.2) and (A4.3) to (A4.1), we obtain:

$$C_{obs} - \nu = \beta\,(Y_{obs} - \xi) + \epsilon$$

$$C_{obs} = \beta\, Y_{obs} + \omega$$

$$C_{obs} = \beta\, Y_{obs} + (\epsilon + \nu - \beta\xi)$$

where ω equals the sum of the iid errors. Let *b* denote the OLS estimate of β (based on observed C and observed Y). Using least squares algebra, we have:

$$b = \frac{\Sigma\, C_{obs}\, Y_{obs}}{\Sigma\, Y_{obs}^2} = \frac{\Sigma(C_{true} + \nu)(Y_{true} + \xi)}{\Sigma(Y_{true} + \xi)^2}$$

(A4.4)
$$plim\ b = \frac{cov(C_{true} Y_{true})}{var(Y_{true}) + var(\xi)} = \frac{\sigma_{C_{true}Y_{true}}}{\sigma^2_{Y_{true}} + \sigma^2_{\xi}}$$

Note, however, that

(A4.5)
$$\beta = \frac{\sigma_{C_{true}Y_{true}}}{\sigma^2_{Y_{true}}}$$

Clearly, plim $b \neq \beta$. In particular, from (A4.4) and (A4.5):

(A4.6)
$$plim\ b = \frac{\beta}{1 + \sigma^2_{\xi}/\sigma^2_{Y_{true}}}$$

Therefore, *b* will underestimate β as a result of measurement error in C and Y.

Now consider:

$$Y^{pd.1}_{true} = \alpha\ Y^{pd.2}_{true} + \epsilon$$

where α is the elasticity of income in adjacent period. (According to the mean assumption, α provides an estimate of the fraction of the variation in measured/observed income that can be attributed to the variation in permanent income.) Once again, suppose the available data on Y (income) in period 1 and Y (income) in period 2 are measured with error, i.e.

$$Y_{obs}^{pd.1} = Y_{true}^{pd.1} + \zeta$$

$$Y_{obs}^{pd.2} = Y_{true}^{pd.2} + \xi$$

where ζ and ξ (measurement error of Y in period 1 and Y in period 2 respectively) are iid with mean 0 and constant variance. Let *a* denote the OLS estimate of α. Using the same algebra (i.e., taking plim of *a*) in the previous page, it can be shown that:

$$plim\ a = \frac{cov(Y_{true}^{pd.1} Y_{true}^{pd.2})}{var(Y_{true}^{pd.2}) + var(\xi)} = \frac{\sigma_{Y_{true}^{pd.1} Y_{true}^{pd.2}}}{\sigma^2_{Y_{true}^{pd.2}} + \sigma^2_{\xi}}$$

Note, however, that

$$\alpha = \frac{\sigma_{Y_{true}^{pd.1} Y_{true}^{pd.2}}}{\sigma^2_{Y_{true}^{pd.2}}}$$

Then plim $a \neq \alpha$:

(A4.7)

$$plim\ a = \frac{\alpha}{1 + \sigma^2_{\xi}/\sigma^2_{Y_{true}^{pd.2}}}$$

Therefore, as a result of measurement in Y in period 1 and Y in period 2, *a* will underestimate α.

Note that both C and Y in the derivation of (A4.6) are based on period 2. Thus (A4.6) and (A4.7) are the same. So, as a result of measurement error, *b* and *a* will underestimate β and α but by the same scale factor. Hence, measurement error will not bias the relationship between *b* and *a* for/against PIH.

A5. IV and Group Mean Estimation

To see the relation between IV and Group Mean estimation, consider the following simple example. Suppose that education is a valid classification variable and education has two levels: *less than college* and *college graduate*. Consider the following linear model:

$$C_i = \eta_0 + \eta_{cy} Y_i + e_i$$

where C_i is the logarithm of consumption, Y_i is the logarithm of income, η_0 and η_{cy} are the unknown parameters, and e_t is an iid error term.

In the group means case, let $C_i = \bar{C}_i$ and $Y_i = \bar{Y}_i$. Applying least squares method and solving for $\hat{\eta}_{\overline{cy}}$:

$$\hat{\eta}_{\overline{cy}} = \frac{\bar{C}_1\bar{Y}_1 + \bar{C}_2\bar{Y}_2}{\bar{Y}_1^2 + \bar{Y}_2^2}$$

For the instrumental variable (IV) case, let Z_i contain the set of instrumental variables, then the IV estimator can be written as

$$\hat{\eta}^{IV}_{cy\,P} = (Y'Z\,(Z'Z)^{-1}Z'Y)^{-1}\;Y'Z\,(Z'Z)^{-1}Z'C$$

This IV estimator is for the case where there are more instruments (q) than regressors (p), i.e., overidentified case. If q = p, then $\hat{\eta}^{IV}_{cy} = (Z'Y)^{-1}Z'C$.

Education is a qualitative variable and has two levels. The Z matrix, therefore, has two columns with 0-1 elements; the elements of the first column is equal to 1 for household observation with *less than college*, and 0 otherwise, and vice versa for the second column. Therefore, $Z'Z$ is a diagonal 2 x 2 matrix; the upper diagonal contains the number of *less than college* households and the lower diagonal contains the number of *college graduate* households. $Z'Y$ and $Z'C$, on the other hand, contain the sum of Y and C for each education group. After some algebra and matrix manipulations, it can be shown that $\hat{\eta}^{IV}_{cy}$ reduces to $\hat{\eta}_{\overline{cy}}$. That is, the group means estimator is an IV estimator of $\eta_{cy\,P}$. We therefore can interpret estimates obtain from modern IV estimation such as the two-stage least squares estimate, as group mean estimates.