Three Alternative Approaches to Test the Permanent Income Hypothesis in Dynamic Panels*

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Abstract

In this paper we consider three alternative approaches to test the Permanent Income Hypothesis (PIH) in the context of dynamic panels: the aggregate consumption approach, the Euler equation approach and finally Friedman (1957)'s original characteristic tests. Our empirical evidence, using the British Household Panel Survey (BHPS) data, strongly supports the PIH. This analysis can, thus, be considered as supporting the view that empirical tests of PIH, based on aggregate time-series data, might suffer from misspecification or overlook some fundamental characteristics of micro data.

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1 Introduction

The Permanent Income Hypothesis focuses on the behavior of a representative agent with an infinite time horizon. According to this theory, consumers plan their expenditures on the basis of their lifetime income expectations rather than on the basis of income received period by period. Some recent attempts to test the PIH on aggregate data have used representative-consumer models (Hall, 1978, Flavin, 1981, Mankiw and Shapiro, 1985, West, 1988, Deaton and Campbell, 1989, Campbell and Mankiw, 1990 and Galì, 1991). This type of model does not seem to fit the data very well and when tested, the restrictions it implies are rejected. Another approach is to test PIH on micro data by directly testing whether the first order condition (Euler equation) of intertemporal choice of consumption is continuously satisfied (Zeldes, 1989, Runkle, 1991, Attanasio and Weber, 1993 and DeJuan and Seater, 1999). Generally, empirical results of this type of model provide evidence in favor of the PIH. One of the reasons for the contrasting evidence is probably related to problems of aggregation bias and insufficient allowance made for the dependence of consumption on individual characteristics, which causes a violation of the results of the empirical analyses on aggregate data (Attanasio and Weber, 1993, Attanasio and Browing, 1995 and DeJuan and Seater 1999).

The principal justification of our analysis is to try to create a linkage between the theory and empirical application. We test the PIH using three alternative approaches on the same set of panel data. We estimate a model for aggregate consumption, an Euler equation specification and finally we revise some of Friedman's characteristic tests that seem to have been more or less forgotten in the recent literature. We use data from the British Household Panel Survey (BHPS). The BHPS is a real, balanced panel with information on consumption, income and several socio-economic household and individual characteristics, from 1991 to 1999.

The use of a panel data set increases the efficiency of econometric estimates (more degrees of freedom and a reduction in collinearity among explanatory variables) and allows heterogeneity among households to be modelled. We estimate models using a Pooled estimator, the Fixed Effect estimator and Arellano and Bond' s (1991) GMM technique. Our empirical evidence strongly supports the PIH. This analysis can, thus, be considered as supporting the view that empirical tests of PIH, based on aggregate data, might suffer from misspecification or overlook some fundamental characteristics of micro data (Attanasio and Weber, 1993, Attanasio and Browing, 1995 and Seater, 1998).

This study is organized as follows. In the first section, we propose an overview of the theory and look at the most representative models of intertemporal choice. Firstly we analyze models based on aggregate consumption, then models based on the Euler equation and finally models for the characteristic tests. In the second section, we outline the econometric methodology. In the last part we present empirical results and conclusion.

2 Overview of the theory

2.1 Testing PIH with aggregate data

Early empirical studies using aggregate consumption expenditure were mainly inspired by Keynes (1936). In the Absolute Income Hypothesis (AIH) he stresses the dominant role of real disposal income, y, in determining current real consumption, c. He suggests the consumption function should be approximated by a linear relationship

$$c = a + by, \tag{2.1}$$

where a is autonomous consumption and b is the marginal propensity to consume (MPC). The implications of the AIH model are: autonomous consumption greater than zero, MPC less or close to unity, MPC is less than average propensity to consume (APC) and APS increases as income rises. Furthermore, when government spending fell after WWII, the AIH predicted that the economy would move toward recession, and consumption would decrease. Kuznets (1946) uses time series data dating back to the Civil War to test the AIH and finds that the MPC is less than APC in budget data and short-run time series data but is equal to APC in the long run; average propensity to save (APS) and APC did not rise secularly, whereas private demand increased sharply and APS was sharply lower than during the interwar period. These results motivated various economists to find a plausible alternative relationship consistent with short-run and long-run implications. The permanent income hypothesis (PIH) by Friedman (1957) and the life cycle hypothesis (LCH) by Ando and Modigliani (1963) are the most remarkable examples in this innovative field of research.

Both authors adopt a precise microeconomic framework to analyze the optimal behavior of a forward looking rational consumer. The main difference between the LCH and PIH, lies in the time horizon considered. The PIH focuses on the behavior of a representative agent with infinite life. The LCH refers to the aggregation of finitely-lived overlapping generations and introduces different behavior of consumers with respect to their age. Common assumptions of the models are that, at any time t, the representative consumer has full information about future real disposal labor income y and can issue or redeem a risk-free bond at a constant after tax real rate r against future income.

According to the PIH, income is defined as "the amount that a consumer can consume while wealth remains unchanged"[1]:

$$y^p = rW, \tag{2.2}$$

where W, wealth at a certain point of time, is defined as discounted income receipts.

Under the LCH, in any period t the total income of one person of age T will be proportional to the present value of the total resources accruing to him for the rest of his life

$$c_t^T = \Omega_t^T v_t^T. \tag{2.3}$$

where Ω is a proportionality factor which depends on the form of the utility function, on the rate of return on assets, on the age of the person, but not on the total resources v.

The theoretical definitions (2.2) and (2.3) themselves are not sufficient to generate testable proprieties. In the time series studies, Friedman provides a formal representation arguing that a weighted average of past and current income is a plausible estimate of the permanent income (income approach)[2]. The PIH is, therefore, defined by a relation between consumption and expected income, emphasizing the dynamic nature of the consumption-income relationship. The estimate of permanent income, y_p^*, can be expressed as:

$$y_p^*(T) = \int_{-\infty}^{T} w(t-T)\, y_m(t)\, dt, \tag{2.4}$$

[1] Friedman (1945) "Income from Independent professional practicise".

[2] Friedman (1957) "A theory of consumption function".

where y_m is measured income; $w(t-T)$ is a weighting function such that:

$$\int_{-\infty}^{T} w(t-T) = 1. \tag{2.5}$$

Friedman defines the weighting pattern as an exponential one:

$$w(t-T) = \beta e^{\beta(t-T)}, \tag{2.6}$$

where β is the subjective discount rate. This form makes the weighting pattern equivalent to the form of adaptive expectations that Philip Cagan (1955) used to estimate the expected rate of price changes in the hyperinflation era. The adaptive expectation hypothesis states that the consumer learns from his or her past and suggests that expected income be a proxy for permanent income in the explanation of current consumption.

In order to provide an empirical specification for the LCH, Modigliani and Ando (1963) introduce a number of rather drastic simplifying assumptions on the life pattern of earnings. Assuming adaptive expectations and that aggregate income follows an exponential growth process, the distinction between PIH and LCH blurs.

The resulting empirical relationships, which are estimated using data sets from the 1950s and 1960s, are structurally stable and have a successful forecasting record. But their performance gradually deteriorates as the economic disturbances in the early 1970s begin to reflect themselves in the corresponding data. This experience, together with other advances in theoretical and econometric modelling, had a considerable impact on the work that followed.

A theory of consumption based on the rational expectation hypothesis (REH) is firstly explored by Lucas (1976) and then formalized by Hall (1978). The empirical models that test the PIH using a proxy for expected income under RE are often called life cycle-permanent income models in order to emphasize that no distinction can be made between the two models in their aggregate implications.

Under the REH current consumption depends on permanent income

$$c_t = y_t^p \equiv \frac{r}{1+r}\left[A_t + \sum_{i=0}^{\infty} (1+r)^{-i} E_t y_{t+i}\right], \tag{2.7}$$

where y_t^p is permanent income, r is the (constant) return on nonhuman wealth, A is nonhuman wealth, and y is labor income. E_t is the expectational operator conditional on all the information available to the representative consumer at time t. The evolution of assets over time is governed by

$$A_{t+1} = (1 + r) (A_t + y_t - c_t) . \tag{2.8}$$

The first difference of equation (7) can be written as

$$\Delta c_t = r \sum_{i=1}^{\infty} (1 + r)^{-i} (E_{t+1} - E_t) y_{t+i}, \tag{2.9}$$

so that changes in consumption are driven by innovation in labor income. More precisely, in this infinite horizon model, the change in consumption is simply the annuity value of the present discounted value of change in the expected value of future labor incomes.

Several studies follow the RE approach to test PIH on aggregate data. Hall (1978) analyzes the impact of uncertainty in the intertemporal choice of consumption. Consumers maximize expected utility under uncertainty keeping the expected discounted marginal utility of consumption constant. The stochastic implication of Hall's model implies that when a consumer maximizes expected future utility, his or her conditional expectation of the future utility is a function of today's level of consumption alone and all other information is irrelevant. In other words, apart from trend, marginal utility obeys a random walk. Moreover, if the marginal utility is a linear function of consumption, then the implied stochastic proprieties of consumption are also those of a random walk apart from trend. "Previous research on consumption has suggested that lagged income might be a good predictor of current consumption, but, this hypothesis is inconsistent with the intelligent, forward-looking behavior of consumers that forms the basis of the PIH" (Hall, 1978).

Flavin (1981) tests the validity of the PIH, as expressed in equation (9), estimating the following system of simultaneous equations:

$$\Delta c_t = \gamma + \beta_1 \Delta y_t + \beta_2 \Delta y_{t-1} + \theta \varepsilon_t + u_t, \tag{2.10}$$

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \varepsilon_t, \tag{2.11}$$

where γ is the productivity growth term, β_1 and β_2 represent the excess sensitivity of changes in consumption with respect to changes in income, θ is the warranted change in consumption, and ε_t is the innovation in the income process. The term u_t represents the measurement error in the consumption change and the effects of the information that the consumer may have on permanent income that is not captured by the autoregressive specification of income. If the PIH is valid, β_i $(i = 1, 2)$ should be zero[3]. If β_i are non-zero, say positive, then according to the excess sensitivity hypothesis, consumption responds even to predictable changes in income. Flavin uses US quarterly data from 1949 to 1979 to estimate (10)-(11) after detrending the variables. The results of the regressions contradict the PIH, since the coefficients β_i are found to be significantly greater than zero.

Deaton (1992) raises a strong criticism of Flavin' s model, arguing that the econometric methodology applied by Flavin biased the results toward the rejection of the PIH. According to Deaton, labor income is not only stationary around its trend, as supposed by Flavin. The first difference of labor income is stationary, so labor income itself is difference stationary. Mankiw and Shapiro (1985) made the original point. In their analysis, they assume that disposable personal income follows a non-stationary process and use quarterly time-series data from 1959 to 1983 to test the hypothesis that consumption is a function of income. They consider various specifications for the income generating process and show evidence against Flavin' s assessment. They demonstrate that disposal personal income fits a random walk plus drift and conclude that Flavin' s detrending procedure generates spurious findings of excess sensitivity[4].

Further evidence against the PIH is given by Deaton and Campbell (1989) and West (1988). They provide an alternative explanation to the reason why consumption is smooth, which differs from the PIH. According to the PIH, consumption is smooth because permanent income is smoother than measured income. On the other hand, the "Deaton paradox" shows that permanent income is in fact less smooth than measured income. Deaton and Campbell (1989), using a VAR analysis find positive correlation between the change in consumption and the lagged change in income; a correlation that would be zero if the PIH model were true. They interpret this finding concluding that the consumer is "excessively sensitive" to anticipated changes in income, whereas is "excessively insensitive" to unanticipated changes in

[3]The income equation (11) is already a reduced form; substituting from the income equation can derive the reduced form for consumption, equation (10).

[4]The detrending procedure proposed by Flavin eliminates the deterministic trend and not the stochastic trend such as a random walk plus drift process.

income. They believe consumption is slow to adjust to innovations in income, thus changes in consumption are related to averages of previous innovations and this explains both smoothness and correlation.

Galì (1991) tests PIH with US aggregate data developing a procedure based on a long-run restriction implied by the consumer's intertemporal budget constraint. The relevance of his approach is that it does not require any assumption on the stochastic proprieties of labor income. Starting from model (7), he defines the variability of consumption relative to the variability implied by the PIH model as

$$\psi = \left[\frac{Var\left(\Delta c\right)}{Var\left(\xi\right)} \right]^{\frac{1}{2}}, \tag{2.12}$$

where ξ is the innovation in permanent income defined by

$$\xi \equiv y^p - E_{t-1} y_t^p = r \sum_{i=1}^{\infty} \left(1 + r\right)^{-i} \left(E_{t+1} - E_t\right) y_{t+i}. \tag{2.13}$$

The standard PIH model implies $\Delta c_t = \Delta y_t^p = \xi_t$ so that ψ is equal to one. Galì shows how the restriction implied by the budget constraint on the consumption time-series allows one to identify the variance ratio ψ and construct a consistent estimator for it. His empirical results support the finding of "excess of smoothness" providing empirical evidence in favor of the "Deaton paradox".

On the other hand, Quah (1989) provides a decomposition of labor income into permanent and temporary component and shows that when agents distinguish permanent and transitory movement in their labor income, the PIH correctly predicts the observed smoothness in consumption. Although Quah (1989) resolves the "Deaton paradox", the empirical results using aggregate data, generally do not provide evidence in favor of the life-cycle permanent income hypothesis (LCPIH).

2.2 Testing PIH with micro data

Attanasio and Browing (1995) and Attanasio and Weber (1993) among others emphasize the importance of testing PIH and LCH with micro data. Simple permanent income, life cycle models assume intertemporally additive preferences, perfect capital markets and rational expectations. These models, however, are rejected by the data when estimated, under the assumption of a representative consumer, on aggregate time series. Attanasio and Browing claim one of the main reasons for these rejections are the aggregation bias and the insufficient allowance for the dependence of consumption on demographic characteristics. In order to overcome these problems they suggest using micro data and conditioning the model on household-specific factors that may affect consumption decisions. "Consumption cannot be studied in isolation: consumption and saving choices are determined together with a number of other choices, ranging from labor supply to household formation and fertility decision, to planned bequest" (Attanasio, 1998). This leads to the necessity of a coherent and flexible optimization model that includes a variety of factors and that incorporates as much information about individual behavior as is available.

This new approach tests directly whether the first order condition (Euler equation) is continually satisfied. Testing PIH by Euler equation allows for a lot of factors in the analysis (i.e. labor and demographic factors) as well as for studying the effects of these factors on the marginal utility of consumption without losing empirical tractability. An example of models based on the Euler equation specification is DeJuan and Seater (1999). Consider the intertemporal choice of consumer i who chooses the path of consumption in order to maximize the expected utility function:

$$E_{it} \sum_{t=t_0} V\left(C_{it}, H_{it}, t\right), \tag{2.14}$$

subject to the budget constraint

$$A_{it+1} = \left(1 + r_{it}\right) A_{it} + Y_{it} - C_{it}, \tag{2.15}$$

where C_{it} is consumer i' s consumption in period t, H_{it} is the vector of household characteristics, E_{it} the expectations conditional on the information available at time t and $V(.)$ is the utility function. In budget constraint (16), r_{it} is the real after-tax interest rate, A_{it} is the household non-human wealth and Y_{it} is the real disposal income.

Furthermore, H_{it}, includes three components: those that cause transitory consumption denoted T_{it}, those that affect the household's intertemporal rate of substitution, R_i; and those that affect the household choice in other ways,

X_{it}. Assuming no liquidity constraint and isoelastic utility function, DeJuan and Seater formulate the following explicit specification of the Euler equation

$$\ln \left(\frac{C_{it+1}}{C_{it}} \right) = \beta_0 + \beta_1 r_{it+1} + \beta_2 \ln \left(\frac{F_{it+1}}{F_{it}} \right) + \beta_3 R_i + e_{it+1}, \qquad (2.16)$$

where F_{it} represents a vector of household characteristics that change over time and across individuals and e_{it+1} is a compound error term that includes a time invariant individual effect. In order to be able to test the validity of LCPIH against the validity of the AIH, DeJuan and Seater provide an alternative model. Following Campbell and Mankiw (1990), they assume consumers can be divided in two groups: consumers in the first group behave according to the PIH as represented by equation (17), the second group simply consume their current income. An approximation of the latter model is given by the following equation

$$\ln \left(\frac{C_{it+1}}{C_{it}} \right) = B_0 + B_1 r_{it+1} + B_2 \ln \left(\frac{F_{it+1}}{F_{it}} \right) + B_3 R_i + B_4 \ln \left(\frac{Y_{it+1}}{Yit} \right) + e'_{it+1}. \qquad (2.17)$$

If the LCPIH is to be valid, the estimated coefficient B_4 should not be significantly different from zero. DeJuan and Seater estimate model (2.17) using a panel data set of CEX (Consumer Expenditure Survey) from 1986 to 1991 and their results support the LCPIH.

The availability of micro data also allows for a test of the presence of liquidity constraints. If an agent is liquidity constrained, he consumes his entire disposal income; for this type of consumer the consumption function is the extreme Keynesian one. Zeldes (1989), Runkle (1991) and Mariger and Shaw (1993) test for the validity of LCPIH against the alternative of prevalent liquidity constraint.

Runkle (1991) uses data from the Panel Study Income Dynamic (PSID), from 1968 to 1982, and tests for the validity of the LCPIH using an Euler equation specification very similar to the one used in DeJuan and Seater (1999). Furthermore, he tests for liquidity constraint and splits the sample using two criteria: whether a household owns or rents its residence and whether the annualized value of the household's asset income is greater or less than two months income. Assuming that homeowners and people with liquid wealth probably would not be liquidity constrained, past income should not have much power in predicting their consumption growth. In the regressions the income variable is never significant in explaining consumption growth. Runkle' s empirical results, therefore, strongly support the LCPIH and they also do not support the view that certain consumers are liquidity-constrained and others are not.

Testing PIH with panel data provides general support to the thesis. However, allowing for portfolio allocation opens other avenues of further research. A critique of the Euler equation approach comes from Miller (1997). The PIH does not typically impose sufficiently strong identification conditions on the budget constraint to achieve consistent estimations with panel data. In order to overcome the under-identification problem, Miller proposes a model that imposes more structure on the market incompleteness and tests the assumption that the preferences over consumption are time additive. The model proposed by Miller is based on assumptions of complete and competitive markets (CCM) and incorporates uncertainty in a sufficiently simple way to yield a tractable econometric model.

2.3 Testing PIH with characteristic tests

In "A theory of consumption function" Friedman (1957) states a formal model for PIH:

$$c^p = k\left(i, w, u\right) y^p, \tag{2.18}$$

$$y = y^p + y^t, \tag{2.19}$$

$$c = c^p + c^t, \tag{2.20}$$

$$\rho_{y^{\mathrm{p}} y^{\mathrm{t}}} = \rho_{c^{\mathrm{p}} c^{\mathrm{t}}} = \rho_{y^{\mathrm{t}} c^{\mathrm{t}}} = 0, \tag{2.21}$$

$$\mu_{y^{\mathrm{t}}} = \mu_{c^{\mathrm{t}}} = 0, \tag{2.22}$$

where y represents current income, y^p the permanent component of current income and y^t the transitory one. In the same way, c represents current consumption, c^p the permanent component of consumption and c^t the transitory one. The ratio of non-human wealth to income is given by w and u is a variable which determines the consumer tastes and preferences versus additions to wealth. Equations (2.18)-(2.20) represent the theoretical model whereas equations (2.21)-(2.22) serve as an important part to make the theoretical model operational and empirically testable through characteristics tests. In equation (2.22) ρ is the correlation coefficient between the variables designed by its subscript. The first two correlations represent nonstocasticity of the permanent component of income and permanent component of consumption respectively. They are based on the definition of the transitory component. The third correlation represents nonautocorrelation, this is a crucial postulate because empirical findings do not always support this assumption. Nonautocorrelaion indicates that transitory income does not affect consumer unit's planned consumption. Finally, in equation (2.21) μ is the mean of the variable designed by its subscript. The mean of the transitory components of consumption and income are equal to zero; this condition turns out to be plausible as long as the probability distribution in question is sufficiently comprehensive[5].

The characteristic tests are based on model (2.18)-(2.22) and test the key proprieties of PIH, such as proportional hypothesis, difference in income elasticities between permanent and transitory components, zero income elasticity of consumption for transitory income against the alternative of validity of AIH[6]. The tests are performed with neither a consumption function nor an Euler equation, no assumptions are necessary on the time series proprieties for income, and it is not necessary to construct a series for permanent income or any form of expectation.

Since permanent and transitory components of income and consumption are not measurable the characteristic tests use qualitative external information in order to proxy transitory and permanent components by qualitative instrumental variables. The sample of households is divided according to criteria that identify whatever aspect of permanent income is relevant to the test in question. For instance, if we assume a priori that education is positively correlated with the level of permanent income, classifying individuals by level of education is a way to classify them by permanent income.

The characteristic test refers to a type of test that targets on a specific aspect of the empirical model. In other words a characteristic test is to match data characteristics with characteristics of the empirical model. "While the conventional view on testing in economics is about rejecting candidate hypotheses there are other types of testing in Economics and Econometrics. Confirmationalist tests secure a basis for belief of look for satisfactoriness of

[5]This assumption denies systematic shocks at time t within a characteristic group of individuals. Further developments of my research will focus on the implications of leaving aside this assumption in the definition of the characteristic tests.

[6]It may also be interesting to investigate the validity of the characteristic tests aganist a simple theory of smoothing consumption.

empirical models and confirm the characteristics of empirical models, using Econometrics as a measuring device to reassure the theorist in is or her belief" (Kim et al, 1995). It seems that characteristic tests are proposed to secure belief that consumption is determined by permanent income. Friedman himself points out that the consistency of the PIH with data supports the belief that PIH is a useful tool to explain "the major apparent anomalies that arise if the observed regression between measured consumption and measured income is interpreted as a stable relation between permanent components". He performs sixteen characteristic tests using both time series and cross-sectional data and argues that the division of permanent and temporary income is partly arbitrary and may depend on the particular assumption we test.

Mayer (1972) describes the characteristic tests as "tests of direction", rather than rigorous tests of the full theory: the tests' results in Friedman's empirical analysis follow the direction predicted by PIH, but not necessarily by the amount predicted by the theory.

In a recent paper, DeJuan and Seater (1999) revive Friedman's characteristic tests. They use two data sets of the Consumer Expenditure Survey (CEX) from 1980 to 1981 and from 1986 to 1991 and they provide a rigorous specification of the consumer choice model. Their empirical results generally support the main implications of the PIH.

3 Econometric specification

3.1 Aggregate consumption

Recalling Flavin' s specification, we test the null of validity of the PIH against the hypothesis of excess sensitivity of changes in consumption, estimating (3.23)-(3.24) in two steps. Distinguishing between anticipated and unanticipated errors, first we estimate equation (3.24) and calculate the values of the anticipated error term ε_{it}, then we estimate equation (3.23):

$$\Delta c_{it} = \gamma + \phi \Delta y_{it} + \theta \hat{\varepsilon}_{it} + u_{it}, \tag{3.23}$$

$$y_{it} = \lambda + \delta y_{it-1} + \varepsilon_{it}, \tag{3.24}$$

where ϕ is the excess sensitivity parameter. We estimate equation[7] (3.24) by pooling, fixed effect and by GMM. The pooling method ignores any heterogeneity in the panel either across single units or over time. On the other hand, assuming that there is a time invariant individual effect in the error term of equation (3.24), such that

$$\varepsilon_{it} = \alpha_i + \eta_{it}, \tag{3.25}$$

and treating α_i as fixed, we estimate equation (3.24) by FE or by GMM. Notice that the FE is unbiased only if all regressors in a given model are strictly exogenous with respect to the error term. Equation (3.24) has a dynamic specification because the lagged dependent variables are included as regressors, thus

$$E(y_{it-1}, \alpha_i) \neq 0, \tag{3.26}$$

and the FE leads to unbiased estimates. In order to provide consistent estimates, we turn to the Arellano and Bond (1991) GMM that leads to consistent estimates even when the time dimension is fixed. Instruments from time $t-2$ and before can be used to estimate model (3.24).

We, therefore, calculate $\hat{\varepsilon}_{it}$ and estimate equation (3.23) by pooling, FE and GMM. As we notice above, in Flavin's model, u_{it} represents the effects of the information that the consumer may have about permanent income that are not captured by the autoregressive specification of income and the measurement error in the consumption change. Since income is a decision variable and u_{it} comprehends the forecast error which arises from new information, new information that affects consumption choice may affect income choice. The income variables, therefore, may be correlated with the error term in equation (3.23),

$$E(\Delta y_{it}, u_{it}) \neq 0, \tag{3.27}$$

and GMM is the only method that provides consistent estimates. The lagged values of income and consumption variables are valid instruments and yield consistent estimates.

There is another issue related to the estimation of equation (3.23): since $\hat{\varepsilon}_{it}$ is included as an explanatory variable, the results of the estimates are affected by the problem of "generator regressor"[8]. The estimates provide

[7] We do not detrend the data as suggested by Flavin.

[8] Pagan (1984).

incorrect standard errors. In time series analysis, when a generated regressor is included in the model, standard errors turn out to be underestimated and consequentially the values of the t-statistic are overestimated. The way to calculate the correct standard error in panel data will be the object of future studies.

3.2 Euler equation approach

For convenience we rewrite equation (2.17):

$$\ln\left(\frac{C_{it+1}}{C_{it}}\right) = B_0 + B_1 r_{it+1} + B_2 \ln\left(\frac{F_{it+1}}{F_{it}}\right) + B_3 R_i + B_4 \ln\left(\frac{Y_{it+1}}{Yit}\right) + e'_{it+1}.$$

Estimating (2.17) we test the null hypothesis of validity of the PIH against the alternative of validity of the AIH. Notice that since the compound error term, e'_{it}, comprehends the forecast error: both the income and the interest rate variables may be correlated with the error term in equation (2.17), such that

$$E(\Delta \ln Y_{it}, e'_{it}) \neq 0, \tag{3.28}$$

and

$$E(r_{it}, e'_{it}) \neq 0. \tag{3.29}$$

Moreover, in this model the household's tax rate is also a choice variable, because it depends on the household's income. The compound error term includes transitory consumption, the composition of consumption and thus the tax rate depends on the compound error term. We attempt to overcome these problems by estimating model (2.17) using GMM. As suggested by Arellano and Bond (1991), assuming that the level of the net income variable is exogenous to the model, lagged values of net income are valid instruments as well as lagged values of current consumption.

We also include time dummies and individual dummies combined with time dummies in the estimation of model (2.17). Time dummies catch the aggregate time-specific component in the compound error term. Such a component could arise from unanticipated macroeconomic shocks that lead all the households to make common mistakes in forecasting future economic variables. Combining individual dummies with time dummies provides a separate set of year dummies for each household characteristic. This set of dummies catch unanticipated macroeconomic shocks that lead all households, who belong to the same characteristic group, to make common mistakes in forecasting future economic variables. We perform the Wald test of joint significance of all the dummies as a group under the null that their estimated coefficient are all zero.

3.3 Characteristic tests

All the characteristic tests in Friedman's original work are derived as follows:

Suppose that there are G groups and for each group $g = 1, 2, ..G$:

$$C_{it} = \alpha + \beta Y_{it} + u_{it,} \tag{3.30}$$

where C_{it} is current consumption and Y_{it} is current income. Measured income and consumption can be partitioned into systematic (permanent) and temporary components:

$$Y_{it} = Y_{it}^{p} + Y_{it}^{t}, \tag{3.31}$$

$$C_{it} = C_{it}^{p} + C_{it}^{t}. \tag{3.32}$$

The Permanent Income model is a model with errors in variables. If the sample is sufficiently large such that the sampling error can be neglected, the permanent income model, unlike other linear models of "errors in variables", assumes strict proportionality between the systematic components per household inside the group:

$$C_{it}^{p} = kY_{it}^{p}. \tag{3.33}$$

According to model (31), the OLS regression of consumption on income yields:

$$\beta = \frac{Cov\left(C_{it}, Y_{it}\right)}{Var\left(Y_{it}\right)}. \tag{3.34}$$

The regression coefficient measures the difference in consumption associated with a one dollar difference in measured income. Under the PIH, the size of this difference in consumption depends on two things:

$$\beta = \frac{Cov\left(C_{it}, Y_{it}\right)}{Var\left(Y_{it}\right)} = \frac{Cov\left(C_{it}, Y_{it}\right)}{Var\left(Y_{it}^{p}\right)} \times \frac{Var\left(Y_{it}^{p}\right)}{Var\left(Y_{it}\right)} = kP_{Y}, \tag{3.35}$$

where

$$P_{Y} = \frac{Var\left(Y_{it}^{p}\right)}{Var\left(Y_{it}\right)}, \tag{3.36}$$

and where we assume

$$k = \frac{Cov\left(C_{it}^{p}, Y_{it}^{p}\right)}{Var\left(Y_{it}^{p}\right)} = \frac{Cov\left(C_{it}, Y_{it}^{p}\right)}{Var\left(Y_{it}^{p}\right)}, \tag{3.37}$$

first, how much of the difference in measured income is also a difference in permanent income, since only difference in permanent income are regarded as affecting consumption systematically; second, how much of permanent income is devoted to consumption. P_Y measures the first, k the second. If P_Y is equal to one, transient factors are either entirely absent or affect the incomes of all the members of the group by the same amount: β is equal to k. If P_Y is equal to zero, there are no differences in permanent income, and the difference in measured income is associated with no systematic difference in consumption: β is equal to zero.

An estimate of P_Y can be obtained from data on income of identical consumer units in different years. Since permanent income is not directly observable, Friedman proposes two alternative statistical estimates of P_Y. First, under the mean assumption, permanent component of each household's income changes in the same proportion as does the average income of the group over two different time periods, t and s:

$$Y_{it}^{p} = mY_{is}^{p}, \tag{3.38}$$

where $m = \frac{\bar{Y}_t}{\bar{Y}_s}$ and $\bar{Y}_t = \frac{1}{N_g}\sum_{i=1}^{N_g} Y_{it}$ is the mean of measured income and N_g is the number of individuals in the group g.

If we also assume that there is no correlation between transitory income in two different time periods:

$$Cov\left(Y_{it}^{t}, Y_{is}^{t}\right) = 0. \tag{3.39}$$

The regression coefficient of measured income at time s on measured income at time t, denoted by B_{st}, can be written as:

$$\begin{aligned} B_{st} &= \frac{Cov\left(Y_t, Y_s\right)}{Var\left(Y_t\right)} = \frac{Cov\left(Y_t^p + Y_t^t, Y_s^p + Y_t^t\right)}{Var\left(Y_t\right)} = \frac{Cov\left(Y_t^p + Y_t^t, mY_t^p + Y_s^t\right)}{Var\left(Y_t\right)} \\ &= m\frac{Cov\left(Y_t^p, Y_t^p\right)}{Var\left(Y_t\right)} = mP_Y. \end{aligned} \tag{3.40}$$

Furthermore define P_Y as:

$$P_{Y_t} = B_{st}\frac{\bar{Y}_s}{\bar{Y}_t} = r_{ts}\frac{\sigma_t \bar{Y}_s}{\sigma_s \bar{Y}_t}, \tag{3.41}$$

$$P_{Y_s} = B_{ts}\frac{\bar{Y}_t}{\bar{Y}_s} = r_{st}\frac{\sigma_s \bar{Y}_t}{\sigma_t \bar{Y}_s}, \tag{3.42}$$

where σ_t is the standard deviation of measured income at time t; r_{st} is the correlation coefficient between measured income at time t and s.

If the values of the permanent component are in a common ratio, P_Y can be estimated by

$$P_{y_t} = b_{st}, \tag{3.43}$$

$$P_{y_s} = b_{ts}, \tag{3.44}$$

where b_{ab} is the regression coefficient in the regression of the logarithm of income at time a on the logarithm of income at time b.

Second, under the variability assumption we assume that the fraction of the total variability contributed by the permanent component P_Y is the same in years t and s,

$$P_Y = \sqrt{P_s P_t} = r_{st}. \tag{3.45}$$

Then, P_Y is estimated simply by the correlation coefficient between measured incomes in two different years.

More specifically, under the mean assumption we estimate P_Y by running the regression of current income at time period t on income at time $t-1$ for each group g[9],

$$y^g_{it} = \delta_0 + \delta_1 y^g_{t-1} + \varepsilon_{it}. \tag{3.46}$$

We denote, the estimates of P^g_y for each group g by $\eta^g_{y_{it}y_{it-1}}$ $g = 1, .., G$.

Next, under the variability assumption, we estimate P^g_y by the correlation coefficient between two adjacent years for each group, which is denoted by $\rho^g_{y_{it}y_{it-1}}$. Notice that in our panel, we have the same group of observations for seven years. There is empirical evidence, confirmed by our data, that the correlation coefficient between two adjacent years is greater than the correlation coefficient between two non-adjacent years[10]. Actually, the difference in the numerical results reflects an implicit difference in the definition of the permanent income component[11]. Nevertheless, the numerical decline of coefficients

[9] Friedman (1957): " The size of correlation between two successive years provides some evidence of importance of the permanent component in producing differences in measured income".

[10] Friedman (1957) pp.186-187

[11] Suppose that we have data on income for three consecutive years and denote P_3 as the fraction of variance contributed by permanent income in year 3. If we estimate by

is on the whole moderate; hence the results are not likely to be affected by the precise definition of the permanent component that is adopted. For this reason, we estimate $\mathrm{P}P_y^g$ under the variability assumption simply calculating the average of the correlation coefficients between two adjacent periods.

3.3.1 The first test

According to the PIH, if transitory factors are either entirely absent or affect all members of the group by the same amount, the value of P_y is equal to the income elasticity of consumption and close to one:

$$P_y = \eta_{cy} \leq 1. \tag{3.47}$$

The first test is to estimate the values of the income elasticity and P_y and compare them. The value of the income elasticity is computed on the basis of the following approximations. If transitory income and transitory consumption average zero over all households within a group, the average propensity to consume equals k:

$$\frac{\bar{\bar{C}}}{\bar{\bar{Y}}} = k, \tag{3.48}$$

where $\bar{\bar{C}} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T} C_{it}$ and $\bar{\bar{Y}} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T} Y_{it}$.

It follows that the elasticity of current consumption with respect to current income evaluated at the point of the sample means, can be written as:

$$\eta_{cy} = \beta\frac{\bar{\bar{C}}}{\bar{\bar{Y}}} = P_Y.$$

The sample has to be divided according to some characteristic variables for which the relative variance of permanent income and transitory income are likely to differ: occupation, region, education, job status, economic status and marital status[12]. For each group g, the estimates of P_y and η_{cy} are

$\sum_3$ the correlation coefficient between income at time 3 and income at time 2, we implicitly define the permanent component as the component that is attributable to common factors affecting income in two or more successive years and the transitory component is attributable to factor affecting income in one and only one year.

[12] Detailed information about the definition of the classification variables and the frequency of the observations within each group are provided in the data appendix.

obtained. The values of η_{cy} are then regressed on P_y:

$$\eta^g_{c_{it}y_{it}} = \alpha_0 + \alpha_1 \eta^g_{y_{it}y_{it-1}} + \varepsilon, \tag{3.49}$$

$$\eta^g_{c_{it}y_{it}} = \alpha_0 + \alpha_1 \rho^g_{y_{it}y_{it-1}} + \varepsilon. \tag{3.50}$$

According to the PIH, the estimated coefficient α_1 must be equal to one but because of the lack of data on the imputed rent of durable goods, we propose a weak form of the test, that is whether there is any positive relationship between P_y and η_{cy}.

We also calculate the Spearman and Pearson statistics as an alternative way to figure out whether there is any positive relation between $\eta^g_{c_{it}y_{it}}$ and $\eta^g_{y_{it}y_{it-1}}$ or $\rho^g_{y_{it}y_{it-1}}$.

3.3.2 The second test

The second test is based on a common-sense intuition that the annual income of the self-employed is more volatile than that of the employees. It is also well established that income elasticities of the former are empirically smaller than those of the latter. The significance of this difference would then provide evidence in favor of the PIH. Households with more transitory income should have lower income elasticity of consumption than households with less transitory income. We, therefore, divide the sample in two groups, employed and self-employed, and test whether the self-employed have a lower income elasticity of consumption than employees.

3.3.3 The third and forth test

According to the proportionality hypothesis, the PIH predicts that the elasticity of permanent consumption with respect to permanent income is equal to one. The value of the elasticity of consumption with respect to current income is less than or equal to one and, as long as there is some transitory income, it is strictly less than one. In light of this, two new relationships can be tested:

$$\eta_{c_{it}y_{it}} < \eta_{c^p_{it}y^p_{it}}, \tag{3.51}$$

$$\eta_{c^p_{it}y^p_{it}} < 1. \tag{3.52}$$

In order to avoid the difficulty of measuring permanent income, we use to the "test by group-means" method proposed by Ando and Modigliani (1960). If the mean of the transitory components of consumption and income average out at zero for each group, then the differences between mean consumption and mean income should reveal a difference between permanent income and permanent consumption. The proxy for the elasticity of consumption with respect to permanent income is the mean group elasticity of consumption evaluated at the sample mean.

Following earlier studies[13], we classify the whole sample by occupation, education and region. Then, for each characteristic variable, we calculate the group-mean income elasticity of consumption, by

$$\bar{\bar{c}} = \gamma \, \bar{\bar{y}} + \varepsilon, \tag{3.53}$$

and $\eta_{\bar{\bar{c}}\bar{\bar{y}}}$ is estimated by $\hat{\gamma}$. The overall income elasticity, $\eta_{c_{it}y_{it}}$, is estimated regressing measured consumption against measured income for whole sample. We carry out the third test, as follows: we test the null hypothesis that $\eta_{\bar{\bar{c}}\bar{\bar{y}}} = \eta_{c_{it}y_{it}}$ against the alternative of validity of the proportionality hypothesis that $\eta_{c_{it}y_{it}} < \eta_{\bar{\bar{c}}\bar{\bar{y}}}$ using the t-statistic:

$$t_3 = \left(\frac{\eta_{c_{it}y_{it}} - \eta_{\bar{\bar{c}}\bar{\bar{y}}}}{\sigma_{\eta_{c_{it}y_{it}}} + \sigma_{\eta_{\bar{\bar{c}}\bar{\bar{y}}}}} \right), \tag{3.54}$$

assuming that $\eta_{c_{it}y_{it}}$ and $\eta_{\bar{\bar{c}}\bar{\bar{y}}}$ are independent.

In the forth test, we test the null hypothesis that $\eta_{\bar{\bar{c}}\bar{\bar{y}}}$ is equal to one against the alternative that it is different from unity, using the t-statistic,

$$t_4 = \left(\frac{\eta_{\bar{\bar{c}}\bar{\bar{y}}} - 1}{\sigma_{\eta_{\bar{\bar{c}}\bar{\bar{y}}}}} \right). \tag{3.55}$$

4 Empirical results

4.1 Data

In this study, we use data of the British Household Panel Survey (BHPS). The BHPS is a microeconomic survey that provides information on 8,167

[13] See Ando Modigliani (1960), Mayers (1972) and DeJuan and Seater (1999).

individuals from 1991 to 1999 and data on household consumption of non-durable goods such as food, heating and fuel. The monthly mortgage or housing rent cost is the only information available on imputed rent of durable goods. Unfortunately, the expenditures on durable goods are not recorded continuously but only discrete values are available. In the Survey there is detailed information on family income but the official survey does not include data on taxation. Therefore, we refer to an unofficial survey "British Panel Survey Derived Current and Annual Net Household Income Variables" that goes from 1991 to 1997 for data on annual disposal income. The total household annual net income variable includes information about net labor income, investment income, benefit and pension income and transfer income. Information about household characteristics comprehend those that vary over time and across household, such as size and type of the household and those that vary only across individuals, such as the sex and race. Data on the real after-tax interest rate for each household are derived using the formula

$$r_{it} = i_t\,(1 - \tau_{it}) - \pi_t, \tag{4.56}$$

where i_t is the nominal interest rate, τ_{it} is the average tax rate for household i and π_t is the inflation rate. We use the one-year LIBOR (London InterBank Offered Rate) index for the nominal interest rate[14].

We select a sample of 2,978 households that respond to all the waves and have an annual income greater than \$100. We consider only the households responding to all the waves in order to select a balanced panel, whereas we decide not to include the very few cases of households with annual net income less than \$100 in order to avoid outliers in the sample. All the data are deflated with the 1987 base-year Retail Price Index.

4.2 Aggregate consumption

Table 1 presents the results of the estimates of model (3.23)-(3.24). The second column of table 1 contains the estimates of δ by pooling, Fixed Effect and GMM. The coefficient is always statistically different from zero and either by OLS or by GMM its value turns out to be reasonably high. The last

[14]In the empirical literature the one-year Treasury Security index is commonly used, in the U.K. the Treasury Securities are quoted at three months, five, ten and twenty years. The one-year LIBOR index compares most closely t the one-year Treasury Security index .

three columns of the table show the result of the estimates of (3.23). The third column shows the results derived by OLS whereas the fourth and the fifth column show estimates by Fixed Effect and GMM respectively. In particular, the first row shows the income coefficient obtained regressing change in consumption against change in income and the unanticipated error calculated after pooling the data. In the second and third row, the values of the anticipated error are derived after estimating (3.24) by Fixed Effect and by GMM respectively. Notice that, even though Table 1 shows the estimates by OLS, Fixed Effect and GMM, the results derived by GMM are the only consistent either in the case of (3.23) or in the case of (3.24). None of the income variables is significant in explaining the rate of growth of consumption, this provides strong support for the PIH. In the light of the previous studies, our result represents an important finding. We have seen how the PIH has been generally rejected when tested at the aggregate level. In this case we test PIH with a model suitable for aggregate consumption but with panel data and we find empirical evidence in favor of the PIH. This result supports the thesis that the process of aggregation might vitiate the results of the previous studies and lead to a rejection of the PIH.

Table 1 about *here*

4.3 Euler equation specification

Table 2 presents the estimates of equation (2.17). In the column headed (1), we present the results of the regression of the change in consumption against the change in net income and real after-tax interest rate. The coefficient of income is not statistically different from zero whereas the coefficient of the interest rate is significantly different from zero but its value is quite low. The former result is in conformity with the prediction of the PIH and with the findings of the recent literature testing PIH by Euler equation. On the other hand, Zeldes (1989), Runkle (1991) and Attanasio and Weber (1995) find a higher value of the interest rate coefficient. In our case, a low coefficient may reflect the lack of enough intertemporal variation in the data, due to the short time dimension of the panel. In the column headed (2) we include time dummies in the model in order to capture the effects of aggregate shocks. The coefficient of income remains insignificant whereas the coefficient of the interest rate is quite high. According to the result of the Wald test[1] the year dummies, as a group, are statistically significant. The significance of the time dummies means that the aggregate shocks are not negligible and influence the choices of consumption mainly through the interest rate. In the column headed (3) we combine time dummies with individual dummies (i.e. the sex of the head of the household) in this way we estimate the model with a separate set of year dummies for each household characteristic. The results do not change significantly except for a slight increase in the value of all the coefficients. The dummies, as a group, are statistically significant.

Table 2 about *here*

In the column headed (4) we present the results of the estimation including the variation in the size and in the type of household as explanatory variables. All the coefficients are significant except for the income one. The value of the coefficient of the interest rate is low and very close to the result of the first regression. As in the previous studies, Attanasio and Browing (1995), Miller and Sieg (1997), DeJuan and Seater (1999), the variables of change in size and type of family are both significant. Changes in consumption are positively related to the change in the size of the household and negatively related to the change in the type of household. In the next column, we present the results of the regression including time dummies. In this case, the time dummies are not significant either as a group or singularly, the only significant coefficients are those of the change in type and in size of household. A similar result is presented in the last column, where individual dummies are combined with time dummies, the only significant coefficients are the ones of the change in type and in size of household, all the dummies are not statistically significant.

In summary, the income variable coefficient in all the regressions are not significantly different from zero. These findings provide further evidence in favor of the PIH and are in conformity with the previous analyses testing the PIH by Euler equation specification, on panel data. Particularly, our result outlines two important things: the importance of testing PIH with micro data and the significance of taking into account the household characteristics in the analysis of intertemporal choice of consumption.

4.4 Characteristic tests

Table 3A presents the results of the estimates of equations (50) and (51) estimating P_y under the mean assumption. They show evidence of positive relation between $\eta_{c_{it}y_{it}}$ and $\eta_{y_{it}y_{it-1}}$in all the cases except for marital status. Excluding this case, all the value of α_1 are significantly greater than zero and Spearman and Pearson correlation coefficients are significantly different from zero. The stronger test of whether α_1 equals one supports the PIH apart from the case of job status. Table 3B presents the results of equations (50) and (51) estimating P_y under the variability assumption. All the cases, except for education and marital status, pass the weak version of the test whereas only education and job status do not pass the strong version of the test.

The case of marital status is quite peculiar because, either under the mean or under the variability assumption α_1 turns out not to be greater than zero but equal to one. This result can be explained by the low frequency of groups inside the marital status classification. The data generally support the implication of the PIH outlined in the first test whereas marital status does not turn out to be a valid proxy for permanent income.

Table 3 about *here*

Table 4 presents the results of the second test. Information about the average current income and the standard deviation confirm the intuition that income for self-employed is more volatile than income for employees. The fifth and sixth column show the estimates of P_y under the variability assumption, where ρ_{yy_1} is the average of correlation coefficients between two adjacent periods and ρ_{yy_3} is the correlation coefficient between the first and the forth year. Column 7 gives the estimates of P_y obtained under the mean assumption. The numerical value of P_y is always greater in the case of employees. This indicate that either under the mean assumption or under the variability assumption a large proportion of income variation among self-employed is accounted for by the transitory factor. Hence, the data confirm that classifying people as employees and self-employed is a valid proxy for permanent and transitory income. In order to perform the second test we calculate first the value of the income elasticity for employees and self-employed and then the t-statistic t_1. The numerical value of income elasticity is lower for self-employed and the result is also supported by the evidence provided by the

t_1-test. Our empirical results are consistent with the implications of the PIH suggested by the second test.

Table 4 about *here*

Table 5 presents the results of the third and the forth test. The overall elasticity of consumption is numerically lower than the mean-group elasticity. This result is also supported by the outcome of the t-test. The values of t_3 leads to rejection of the null, equality of elasticities, in favor of the hypothesis that the overall income elasticity is lower than the mean-group elasticity. The last column of the table presents the results of the fourth test. The mean-group elasticities are insignificantly different from unity regardless of what characteristic is used. These findings uniformly support the proportionality hypothesis.

Table 5 about *here*

5 Summary and conclusions

In this paper we have presented empirical evidence in favor of the PIH.

We use three different approaches to test for the PIH with the same data set of the BHPS. First, we test for the validity of PIH against the hypothesis of "sensitivity of consumption" using a model for aggregate consumption. Second, we test for the validity of the PIH against the validity of the AIH using the Euler equation specification. Finally, we use characteristic tests for testing some of the most important implications of the PIH aganist the vality of the AIH.

The PIH receives general support from our data. This result is in conformity with the recent studies that use micro data to test the PIH and sharply contrasts the results of the analyses conducted on aggregate data. The most relevant result is that testing a model suitable for aggregate consumption with panel data provides evidence in favor of the PIH. Our analysis can be considered as a piece of evidence of the thesis that empirical tests of PIH, based on aggregate data, might suffer from misspecifications or overlook some fundamental characteristics of micro data and therefore vitiate the results that lead to rejection of the PIH.

Data Appendix

The panels for each group within the classification variables are derived from a sample of households of the BHPS. We select 2,978 households responding to all the seven waves of the Survey. Each group is derived by dividing the whole sample according to classification variables. Each group contains at least 50 households which belong to that particular group for all the survey time span.

Consumption Consumption is defined by the aggregation of expenditure on total food and grocery bills, the expenditures on oil, gas and electricity and the expenditure due to mortgage or rent housing costs.

Total household annual net income Total household annual net income is a variable recorded in "British Panel Survey Derived Current and Annual Net Household Income Variables". It is defined as the sum of total household annual net labor income (total annual household labor income minus household annual national insurance contributions, total household annual occupational pension contributions and minus total household annual income tax after credits[15]), total household annual investment income, total household annual benefit, total household annual pension income and total household annual transfer income.

Occupation Occupation is an individual variable that records the present job according to socio economic class, we divide the sample referring to the occupation of the head of the household. We select twenty groups with the following frequencies: high service class 213; low service class 302; routine non-manual workers 168; personal service workers 97; small proprietors with employee and without employee 89; foreman and technicians 112; routine manual workers 357; managers of large business 112; managers of small business 50; professional self-employed and professional employee 67; intermediate non-manual workers 160; intermediate non-manual foreman 54; junior non-manual workers 263; personal service workers 69; foreman manual 73;

[15] The total household annual income tax after credits is equal to total household annual income tax before credits minus total household annual credits on income tax.

skilled manual workers 193; semi-skilled manual 144; unskilled manual workers 112; own account workers 74; farmers (employers), farmers (own account), smallholders and agricultural workers 50.

Region or Metropolitan Area Region or Metropolitan Area provides information about the residence of household. We select eighteen groups with the following frequencies: Inner London 70; Outer London 146; Regions of South East 502; Regions of South West 248 East Anglia 131; East Midlands 254; West Midlands Conurb 98; Regions of West Midlands 152; Greater Manchester 104; Merseyside 58; Regions of North West 126; South Yorkshire 84; West Yorkshire 91; Regions of Yorkshire and Humber shire 87; Tyne and Wear 74; Regions of North 120; Wales 148; Scotland 259.

Economic status Economic status records information about each household. In dividing the sample with respect to this variable we select six groups with the following frequencies: self-employed 118; single or couple, all in full-time work 350; couple, one in full-time work, one part-time 70; couple, one in full-time work, one not working 59; one or more in part-time work 32; head of the household or spouse aged 60 or over 626.

Education Education is an individual variable that provides information about the highest present academic qualification. In dividing the sample we refer to information regarding the head of the household. We select seven groups with the following frequencies: higher degree 50; 1st degree 225; HND, HNC, teaching 172; A level 400; O level 625; CSE 126; none of these 166.

Marital status Marital status is an individual variable. We divide the sample in five groups referring to information about the head of the household, with the following frequencies: married 1369; living as couple 50; widowed 323; divorced 136; never married 303.

Job status Job status is an individual variable about the current labor force status. We divide the sample in five groups referring to information about the head of the household, with the following frequencies: employed 1047; self employed 144; in paid employed 999; retired 489.

Type of household Households are divided in: single non elderly; single elderly; couple with no children; couple with dependent children; couple with non-dependent children; lone partner with dependent children; lone partner with non-dependent children; couple plus unrelated adults; other household.

Table Appendix

Table1. The PIH Test Results based on Model (3.23)-(3.24)*

	δ	ϕ		
Methods		OLS	FE	GMM
OLS	0.826	0.178	0.158	0.121
	(0.007)	(0.112)	(0.152)	(0.167)
FE	0.169	0.134	0.167	0.133
	(0.056)	(0.117)	(0.148)	(0.168)
GMM	0.731	0.142	0.179	0.075
	(0.032)	(0.116)	(0.142)	(0.164)

*: Note: δ is the slope parameter of regression (3.24) and ϕ is the excess sensitivity parameter of regression (3.23). Standard errors in parenthesis.

Table2. The PIH Test Rsults based on the Euler equation (2.17)*

Variables	(1)	(2)	(3)	(4)	(5)	(6)
r_{it}	0.0105	1.2599	1.5230	0.0118	0.5653	0.4663
	(0.0019)	(0.7364)	(0.8522)	(0.0026)	(0.6167)	(0.5621)
$\Delta \ln Y_{it}$	0.0375	0.0322	0.0506	-0.0077	-0.0023	-0.0518
	(0.0327)	(0.0372)	(0.0377)	(0.0391)	(0.1202)	(0.0998)
Δ lnSize$_{it}$				0.8861	2.1492	2.4606
				(0.4882)	(1.3310)	(1.1141)
Δ lnType$_{it}$				-0.9794	-1.8381	-1.8107
				(0.4989)	(0.9211)	(0.8448)
Wald Test[1]		32.027	19.121		4.2131	8.3013
		[0.000]	[0.000]		[0.648]	[0.217]
Wald Test[2]			23.753			16.9764
			[0.000]			[0.150]

*: Note: (1) shows the results of the regression (2.17) including only $\Delta \ln Y_{it}$ and r_{it} as explanatory variables; in (2) we include time dummies and in (3) we combine time dummies with individual dummies. In (4) we present the results of the regression of (12)

with $\Delta \ln Y_{it}$, r_{it}, $\Delta \ln \text{Size}_{it}$ and $\Delta \ln \text{Type}_{it}$ as explanatory variables; in (5) we include time dummies, whereas in (6) time dummies are combined with individual dummies. Wald test[1] tests the joint significance of the time dummies, Wald test[2] tests the joint significance of the time dummies combined with the individual dummies. P-values of Wald tests in brackets. Standard errors in parenthesis.

Table3 : The PIH Test Results based on the First Test*

(3A) Estimating P_y under the Mean Assumption

Variables	α_0	α_1	$\alpha_1 > 0$	$\alpha_1 = 1$	Spearman	Pearson
Occupation	-0.176	0.924	y	y	0.476*	0.546*
	(0.293)	(0.354)				
Region	-0.254	0.983	y	y	0.353*	0.545*
	(0.341)	(0.405)				
Education	-0.357	1.113	y	y	0.771*	0.776*
	(0.368)	(0.453)				
Job status	-1.640	2.635	y	n	0.768*	0.4*
	(0.061)	(0.077)				
Economic status	-0.709	1.364	y	y	0.771*	0.718*
	(0.539)	(0.661)				
Marital status	-0.440	1.067	n	y	0.6	0.675
	(0.672)	(0.824)				

(3B) Estimating P_y under the Variability Assumption

Variables	α_0	α_1	$\alpha_1 > 0$	$\alpha_1 = 1$	Spearman	Pearson
Occupation	-0.348	1.121	y	y	0.577**	0.643**
	(0.278)	(0.334)				
Region	-0.246	0.968	y	y	0.352**	0.486**
	(0.394)	(0.465)				
Education	0.630	0.328	n	n	0.429	0.472
	(0.124)	(0.225)				
Job status	-2.548	3.727	y	n	0.44**	0.699**
	(0.070)	(0.086)				
Economic status	-1.317	2.058	y	y	0.829**	0.751**
	(0.756)	(0.906)				
Marital status	-0.315	0.924	n	y	0.8	0.487
	(0.940)	(1.174)				

*: Note: α_0 and α_1 are intercept and slope of regression (50) and (51). Standard error in parenthesis. Columns headed $\alpha_1 = 1$ and $\alpha_1 > 0$ report the outcomes of one-side test at 5% significance. Spearman and Pearson denote the Spearman and Pearson correlation coefficients and coefficients highlighted with ** are significant at the 5% level of significance.

Table4: The PIH Test Results based on the Second Test*

Type of employment	N	$\bar{Y}$	S	ρ_{yy_1}	ρ_{yy_3}	$\eta_{y_t y_{t-1}}$	η_{cy}
Employees	1047	13864	6600	0.831	0.684	0.830	0.553
						(0.011)	(0.020)
Self-employed	144	14840	10045	0.749	0.537	0.713	0.239
						(0.041)	(0.055)
t_1	-4.1868						

*: Note: N denotes the sample size, $\bar{Y}$ is the mean income and S the sample standard deviation. ρ_{yy_1} is the average of the correlation coefficients calculated between two adjacent years; ρ_{yy_3} is the correlation coefficient between the first and the forth year; η_{ab} is the elasticity between a and b; t_1 is the t value for the test of the null hypothesis that the income elasticities of the self employed and employed people are equal against the alternative hypothesis that the elasticity for self employed is less than the elasticity for employed. Standard errors in parenthesis.

Table5: The PIH Test Results based on the Third and Forth Test*

Whole Sample	η_{cy}	Variables	$\eta_{\bar{\bar{c}}\bar{\bar{y}}}$	t_3	t_4
	0.587	Education	0.874	-19.133	-0.126
	(0.01)		(0.005)		
		Occupation	0.872	-19	-0.128
			(0.005)		
		Region	0.877	-26.363	-0.123
			(0.001)		

*: Note: t_3 tests the null that the overall elasticity is equal to the mean-group elasticity against the alternative that the overall elasticity is less than the mean group elasticity. t_4 tests the null that the mean-group elasticity is equal to one against the alternative that it is different from unity. Standard error in parenthesis.

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