How does Household Consumption Respond to Income Shocks?*

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Abstract

We use the Italian Survey of Household Income and Wealth (SHIW) to document how the consumption of nondurables and durables, capital income and real as well as finacial wealth change in response to a labor income shock. We find that nondurable consumption changes by about 11 cents in response to a 1 Euro change in after-tax labor income. We also find that the value of real assets (especially real estate) strongly co-move with income.

We then explore whether a simple partial equilibrium Friedman-style permanent income model is consistent with the empirical facts. Our preliminary findings suggest that the PIH model provides a reasonably good approximation of the facts in the data, but only if transitory income shocks are the predominant source of income changes and if measurement error in income is substantial. We conclude, however, that an explicit model of housing is required to rationalize the strong co-movement of income and real estate wealth.

1 Introduction

In micro-founded macro models households face one fundamental decision problem, namely how to choose consumption and saving in the presence of

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both deterministic labor income changes as well as labor income shocks. The feasible consumption-savings choices of households crucially depend on the menu of financial and real assets available to them. Existing models differ starkly with respect to the assumptions regarding this menu, ranging from the total absence of assets (so-called hand-to-mouth consumer models) to the presence of a full set of state contingent assets without any short sale constraints (as in the complete markets model, the underlying abstraction of any representative agent macro model). The assumptions the model builder makes about the structure of markets are crucial not only for the positive predicitions of the model (e.g. the joint income-consumption dynamics, the response of the macro economy to shocks, the pricing of financial assets) but also for normative policy analysis. The desirability of soical insurance policies (e.g. unemployment insurance, a redsitributive tax code) depend crucially on how well households can privately (self-) insure against idiosyncratic income shocks, which in turn is determined by their access to and the sophistication of asset markets. Thus, it is important to determine empirically what actual households do when they receive income shocks, and to study which consumption-savings model provides the best approximation to this observed behavior.

This paper therefore has two goals. First, we use a unique *panel* data set that contains detailed information about household income, consumption and wealth, the Italian Survey of Household Income and Wealth (SHIW) to document how various household choices (consumption of nondurables and durables, capital income and wealth accumulation) change in response to an income change. The choice of these variables is motivated by the sequential budget constraint of a standard incomplete markets model, as well as the availability of the corresponding data in the SHIW. We find that nondurable consumption responds to an (after-tax) labor income change of 1 Euro by about 11 cents and that purchases of consumer durables (which in the data mainly consist of vehicles and furniture) by an additional 6 cents. We also find a negative correlation between income changes and transfers (which include both public transfers such as unemployment insurance, disability insurance payments etc. as well as private transfers such as gifts and regular transfers from other households). Interestingly, private transfers account for most of this negative correlation. The order of magnitude of these transfers is small, however; on average a household with a decline of after-tax labor income of 1 Euro receives 4 cents in extra transfers. Finally we observe that changes in income are associated with significant adjustments in the value of assets that households own, in particular real estate, the predominant form of wealth in Italy. In decomposing this change in real estate wealth into net changes in mortgages, price changes of continuously held properties and net new additions we find that the last two channels (the correlation of income changes and house price changes as well as net changes of real estate) are both important contributors to the strong positive correlation between changes in labor income and real asset values.

Our second objective is to explore whether various versions of a standard incomplete markets model can account for the empirical evidence in the first part. We first evaluate the simplest variant of such a model, a formal version of the permanent income hypothesis, in which households can freely borrow and save with a risk-free bond, face no binding borrowing constraints, have quadratic utility and face both purely transitory and purely permanent shocks. In that model the consumption and wealth responses to an income shock are simple functions of the ratio between the variance of the transitory and the permanent shock, as well as the share of the transitory shock that is due to measurement error. We show that the comovement between income, consumption and financial wealth changes over two-year horizons predicted by the model is consistent with that observed in the data, but only if transitory income shocks are the predominant source of income changes and if measurement error in income is substantial. Furthermore, our data contains a longer panel dimension for a significant fraction of households and thus allows us to measure correlations between income, consumption and wealth changes over longer horizons. We show that even qualitatively our version of the permanent income hypothesis is at odds with the data as it strongly predicts that the correlation between income and consumption changes strengthens with the time horizon and that of income and wealth changes weakens. Essentially, as the time horizon increases, income changes are driven more and more by permanent shocks. In the data the evidence about how income-consumption change and income-wealth change correlations vary with the time horizon over which these changes occur is at best mixed, and tends to be counterfactual at least along the income-wealth dimension.

The paper is organized as follows. In the next section we briefly place our contribution into the existing empirical and theoretical-quantitative literature. The data we use as well as the empirical results we derive are discussed in section 3. In section 4 we present and evaluate a simple partial equilibrium incomplete markets model against the empirical facts documented in section 3. Section 5 presents further evidence on the importance of adjustments in the value of real estate associated with income changes, and section 6 concludes. The appendix contains a discussion of

2 Related Literature

This paper builds on the large literature that has used household level data sets to evaluate or formally test the empirical predictions of Friedman's (1957) permanent income hypothesis and related partial equilibrium incomplete markets models. Hall and Mishkin (1982) and Altonji and Siow (1987) represent seminal contributions, and the early body of work is discussed comprehensively in Deaton (1992). How strongly consumption responds to income shocks of a given persistence is the central question of this literature.[1]

How strongly consumption responds to income shocks has also been estimated, for the U.S., in the context of tests of perfect consumption insurance, see e.g. Mace (1991), or Cochrane (1991).

Dynarski and Gruber (1997) and Krueger and Perri (2005, 2006) take a more agnostic view and present the correlation between income and consumption changes as a set of stylized facts that quantitative models ought to match. The spirit of our empirical analysis is similar to these studies. For Italy, in a sequence of papers Jappelli and Pistaferri (2000, 2006, 2008a, 2008b) employ the SHIW data to study the dynamics of household income, and the latter three the joint dynamics of household income and consumption.[2]

Recently Blundell et al. (2008) have constructed a consumption and income panel by skillfully merging data from the CEX and the PSID, and used this panel to estimate the extent to which households can insure consumption against transitory and permanent income shocks. Kaplan and Violante (2008) evaluate whether a class of incomplete markets models can rationalize the empirical estimates for consumption insurance that Blundell et al. (2008) obtain.

Finally, Aaronson et al. (2008) investigate the consumption response to an increase in the real wage in the U.S. Similar to our study they find that the adjustment in real estate wealth is a crucial feature in their data, and they construct a model with housing wealth to account for the facts.

[1] How strongly households' consumption responds to *predictable* changes in income is the subject of studies on excess sensitivity. The excess smoothness literature studies how strongly household consumption adjusts in response to permanent income shocks. See e.g. Luengo-Prado and Sorensen (2008).

[2] See Padula (2004) for another empirical study that uses the same Italian data.

3 Evidence

3.1 Data Description

The data set we use is the Survey of Household Income and Wealth (henceforth SHIW) conducted by the Bank of Italy. The survey is conducted every two years and it includes about 8000 households per year, chosen to be representative of the whole Italian population. From 1987 on the SHIW has a panel structure and a fraction of households in the sample is present in the survey for repeated years. This data set is valuable and unique for our purposes as it contains *panel* information for many categories of income, consumption and wealth for each household.[3] The panel dimension on income is particularly helpful for assessing the nature (i.e. permanent or temporary) and symmetry of income changes. The fact that the data contains, for the same household, panel information on income, consumption and wealth is crucial for inferring how a given household adjusts its consumption in response to an income change of a given type, and which components of wealth absorb the rest of the income fluctuations.[4] Table A1 in the appendix displays the total sample size of the data as well as the share of the households in each wave of the SHIW that was present already in previous waves. We observe that the panel dimension of the data set since 1989 is substantial and has grown over time, with the fraction of all households in the 2006 wave already being present in previous waves exceeding 50%.

Since the focus of this project is on the effects of earnings changes for households who are active in the labor market we select only households who are in the survey for at least two consecutive periods and whose head is between the age 25 and 55 and is not retired. This leaves us with a sample of about 12600 households over the period 1987-2006. In figure A1 in the appendix we display the cumulative distribution function over observed income changes and income growth rates to demonstrate that the data contains substantial variation along the dimension of the data we are

[3] A recent paper by Jappelli and Pistaferri (2006) makes intensive use of the panel dimension for income and consumption in this data set for estimating a stochastic process for household income and one for household consumption mobility.

[4] The US consumer expenditure (CEX) survey has a panel dimension but the fact that it is short (only two periods) and observation periods for income and consumption do not perfectly coincide (see Gervais and Klein (2006) for a treatment of this problem) makes it of limited use for our purposes. The US panel study on income dynamics (PSID) on the other hand contains a long panel for income but only has information on food consumption, again making it hard to comprehensively assess the full impact of income shocks on consumption. Both surveys contain some, but not fully comprehensive information on household wealth, too.

interested in. We fully acknowledge that a possibly large share of this observed variation may be due to measurement error, and thus will address this issue explicitly when comparing the stylized facts from the data to the predictions of the models we use to assess these facts.[5]

In addition to the panel dimension of the data set we also have reason to believe that the quality of the consumption data may be superior to that of the American CEX, for example. For the U.S. CEX it is well-known that mean household or per capita real consumption shows no growth between 1980 and 2006 whereas income from the same data set does show healthy growth (as does NIPA consumption growth for the US). The Italian income and consumption data, on the other hand, display exactly the same trend, and they follow the corresponding trends in NIPA quite closely (see Jappelli and Pistaferri, 2008a).

3.2 Organization of the Data and Measurement

In order to organize our empirical findings we place them into the context of a sequential budget constraint of a standard incomplete markets model in which the household can self-insure by buying and selling a limited set of assets:

$$c_{nt} + c_{dt} + a_{t+1} + e_{t+1} = y_t + r_{at}a_t + r_{et}e_t + a_t + e_t + T_t, \tag{1}$$

where c_{nt}, c_{dt} denote consumption expenditures on nondurables (including rent and imputed rent for housing) and durable consumption, respectively. a_{t+1} and e_{t+1} denote the *values* of the net asset position of financial and real estate wealth at the end of period t, whereas y_t measures after-tax labor income, T_t net private and public transfers, and $r_{at}a_t, r_{et}e_t$ denote capital income from financial assets and real estate, correspondingly. Our Italian data is rich enough that we can measure all these variables for our households in the sample. For the exact variable definitions, please see Appendix A.

Denoting by $\Delta^N x$ the difference between a variable x today and N periods ago we obtain, setting $N = 2$ (since the SHIW is carried out biannually):

$$\begin{aligned} & \Delta^2 c_{nt} + \Delta^2 c_{dt} + \Delta^2 a_{t+1} + \Delta^2 e_{t+1} \\ = \; & \Delta^2 y_t + \Delta^2 r_{at}a_t + \Delta^2 r_{et}e_t + \Delta^2 T_t \\ & + \Delta^2 a_t + \Delta^2 e_t \end{aligned} \tag{2}$$

[5] Altonji and Siow (1987), in their critique of Hall and Mishkin (1982) point out the potential quantiative importance of measurement error in income changes or income growth for the type of regressions conducted in this paper.

Note that due to the biannual nature of our data set the last two terms $\Delta^2 a_t$ and $\Delta^2 e_t$ cannot be observed in the data. This fact is clarified in figure 1 which shows the frequency and exact timing with which different variables are observed in the SHIW data set.

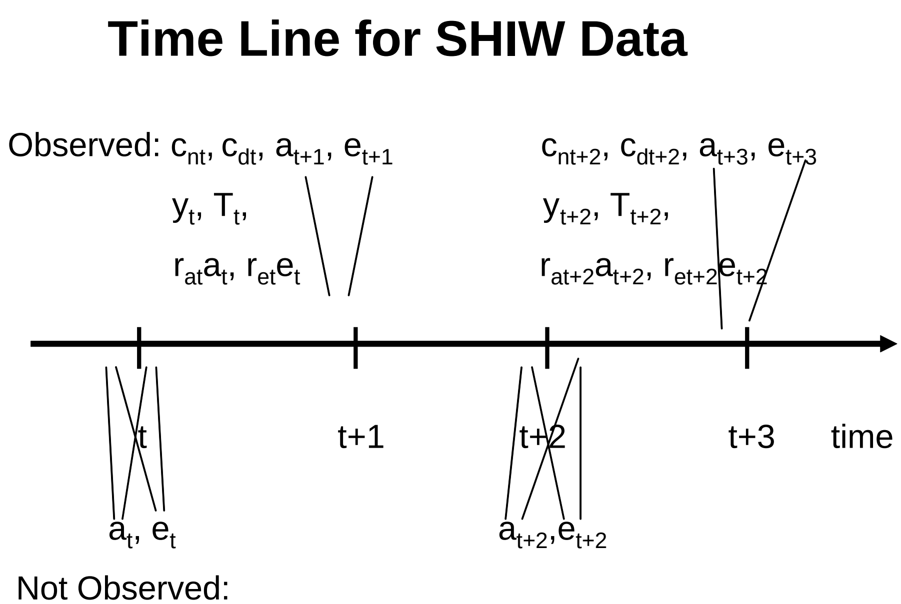

Figure 1: Timing of Observations in the SHIW

The empirical question we want to answer now is how the observable differences in the budget constraint co-move with $\Delta^2 y_t$? To visualize these responses we order the population with respect to income changes and sort them into twenty equally sized bins. For each of the 20 bins we then compute the average change in each observable component of the budget constraint and plot it against the corresponding income change.

Prior to this we first express all variables in adult equivalent units by dividing each observation by the appropriate OECD equivalence scale.[6] Sec-

[6] The equivalization procedure has only minor impacts on the results. For labor income

ond, we attempt to purge the data from aggregate effects and predictable individual changes in each variable. We do so by regressing each on time dummies, a quartic in age, education dummies, regional dummies, and age-education interaction dummies. Our empirical exercise is then carried out on the residuals from these first-stage regressions.

3.3 Empirical Results

Figures 2-4 contain the results of this exercise, for nondurable and durable consumption, non-labor income components and all forms of household wealth.

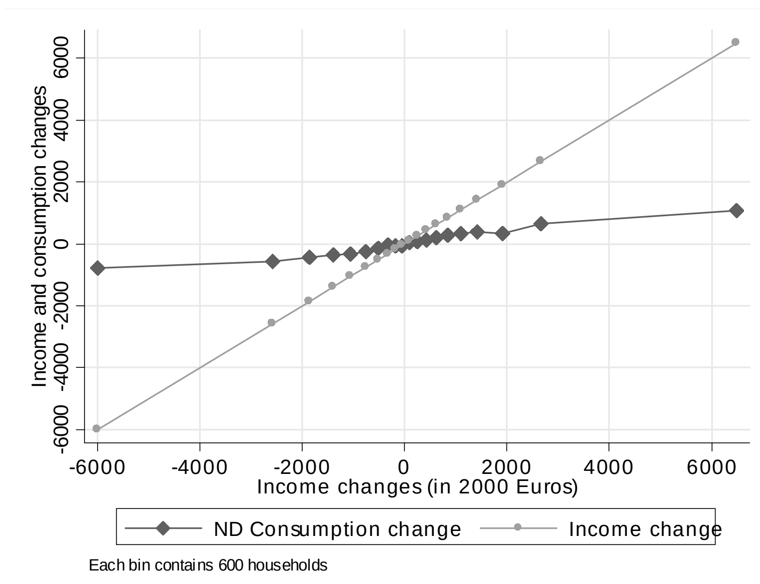

Figure 2: Co-Movement of Consumption and Income

From figure 2 we observe that nondurable consumption changes are positively correlated with income changes. In addition, that relationship appears to be fairly linear, although a slightly larger response to income increases than to income declines can be observed. As we make precise below by running formal bivariate regressions, on average a 1 Euro increase (decline) in

y_t, for example, more than 99% of the cross-sectional variation of equivalized income growth is due to variation in the growth rate of raw income.

after-tax labor income is associated with an 11 cents increase (decline) in expenditures on nondurable consumption.

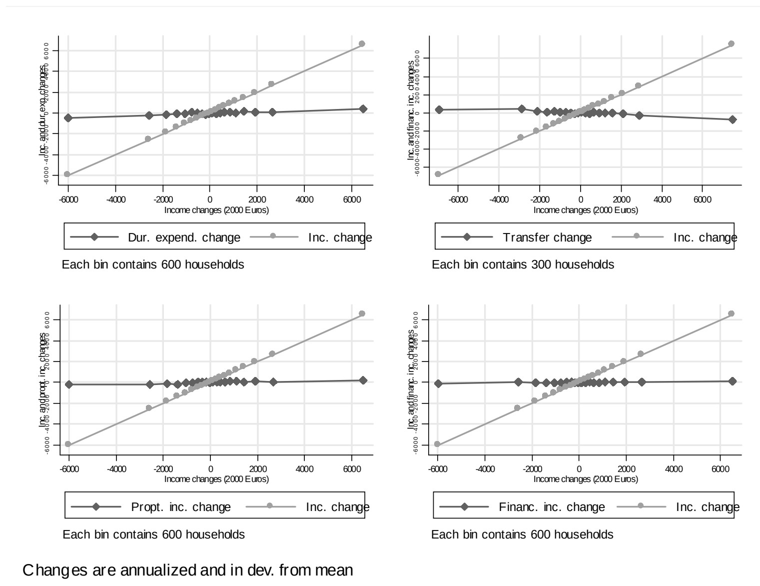

Figure 3: Co-Movement of Income and Other Elements of the Budget Constraint

In figure 3 we display the co-movement of after-tax labor income with other parts of household income, in particular transfer income (the upper right panel), and capital income from both real assets and financial assets (the lower two panels). The upper left panel shows the change in consumption expenditures on consumer durables (mainly cars and furniture) for each income change bin. We observe that expenditures on consumer durables change about 6 cents to the Euro with income, again with a pattern that is roughly linear in income. Labor and capital income changes are, broadly speaking, uncorrelated with each other. On the other hand, there is a visible, significant, but quantitatively small negative correlation between labor income changes and the change in net public and private transfers received by households. This negative correlation is especially noticeable for households with large income increases. Overall, with each additional Euro in labor income is associated a reduction of transfers of about 4 cents.

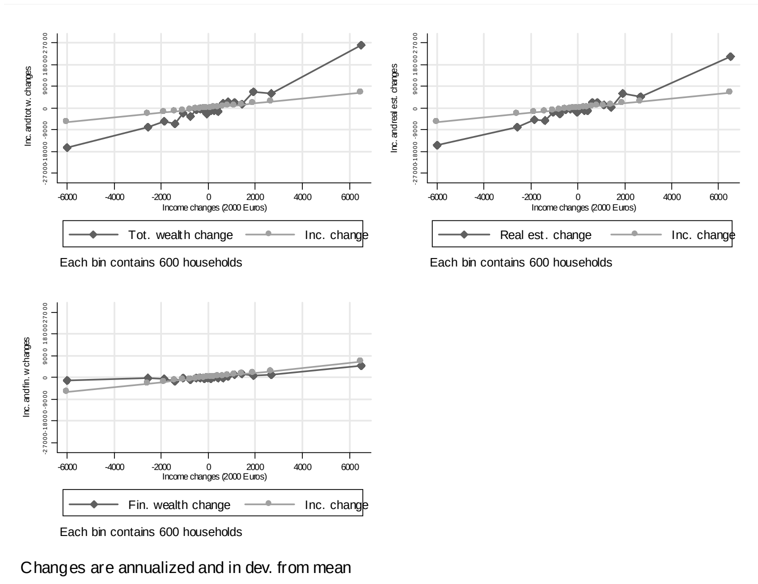

Figure 4: Co-Movement of Income and Wealth Changes

So far, the net response of all elements of the budget constraint to a 1 Euro change in income is about 10 cents. It there must be that labor income changes are associated with large changes in the value of financial or real assets, for the budget constraint to hold.[7] From figure 4 we observe that this is indeed the case, and that most of the co-movement in labor income and asset values (the upper left panel) comes from changes in real wealth, which is mainly composed of real estate and, to a lesser extent, the value of ownership of private businesses. As the second and third panel of 4 show, changes in the value of financial assets are strongly associated with income changes only for the group with the largest income increase. Substantial changes in the value of real assets, on the other hand, are associated with labor income changes throughout the entire distribution of income changes.

In order to formally evaluate the magnitude of the average response of the various components of the budget constraint to income changes we now run bivariate regressions of the changes in consumption, transfers and wealth on the changes in income. In table I we display the regression coefficients

[7] Remember that in the data the two elements $\Delta^2 a_t$ and $\Delta^2 e_t$ of the budget constraint are not observable. Even if they were, nothing in the construction of the questionnaire insures that *households' responses* to the survey questions obey the budget constraint (although their economic choices have to).

for nondurable consumption and wealth changes. Since the OLS estimates, in particular for the wealth observations, may be influenced by a few large outliers that report large positive or negative changes in wealth, we also report the LAD estimates resulting from minimizing the sum of the absolute values of the residuals, rather than the sum of squared residuals.[8] By putting less weights on extreme observations LAD estimates are more robust to the influence of outliers.

We observe that nondurable consumption as well as all components of wealth significantly co-move with after-tax labor income. The consumption response is in the order of 11 to 17 cents for the Euro, and the response of financial wealth 18 to 26 cents. The correlation of labor income and the value of real assets is large, and significantly exceeds 1 Euro for each Euro in income changes.[9] Given the apparent importance in adjustments of the value of real assets associated with income changes, in section 5 below we investigate in greater detail what factors lie underneath these large responses in Δe to Δy.

Table I: $\Delta x = \beta \Delta y + \varepsilon$

Δx	Δc_n	Δa	Δe	$\Delta(a+e)$
β_{OLS}	0.11	0.18	3.67	3.85
	(26.8)	(3.8)	(26.9)	(26.1)
R^2_{OLS}	0.05	0.01	0.05	0.05
β_{QR}	0.17	0.26	1.44	1.81
	(58.0)	(31.9)	(43.8)	(43.3)
R^2_{QR}	0.04	0.01	0.01	0.02
Obs.	12636	12636	12636	12636

t-stats are in parentheses

In table II we quantitatively confirm the visual evidence from figure 3 that changes in other sources of income are only weakly correlated with labor income changes. This table also splits total net transfers T into government and private transfers and indicates that the latter, T_F, account for the majority of the (not very large) negative correlation between labor income changes

[8]Equivalently, LAD estimates provide the best fit of the median, rather than the mean, of the data, conditional on the covariates.

[9]Note that this large change in the real value of assets is not necessarily inconsistent with the budget constraint. If income changes Δy are positively correlated with previous changes in the real value of assets $\Delta a_{-1}, \Delta e_{-1}$ (which we do not observe, due to the biannual structure of the data set), then the right hand side of the budget constraint increases by more than 1 Euro for each Euro in Δy.

and changes in transfers.[10] The adjustment of private transfers for a Euro in lower labor income is in the order of 3 cents. The existence and negative correlation with labor income changes of changes in private transfers may lend some qualitative support to models that permit household to engage in more explicit insurance arrangements than the simple self-insurance through asset trades that standard incomplete markets models envision (e.g. models with private information or limited commitment). Note, however, that the magnitude of these transfer changes and their correlation with labor income changes is quantitatively small.

Finally table II documents that adjustments in expenditures on consumer durables such as vehicles and furniture associated with income changes are statistically significant, but quantitatively modest as well.[11]

Table II: $\Delta x = \beta \Delta y + \varepsilon$

	Δc_n	Δc_d	ΔT	ΔT_F	Δra	Δre
β	0.11	0.06	−0.04	−0.03	0.01	0.02
	(26.8)	(12.2)	(−7.7)	(−5.1)	(2.43)	(6.1)
R^2	0.05	0.01	0.01	0.01	0.01	0.01
Obs.	12636	12636	6216	6216	12636	12636

t-stats are in parentheses

In the next section we now assess whether, as a first check of theory, the standard formalized version of the permanent income hypothesis in the spirit of Friedman (1957) provides a reasonable approximation of the data. This analysis also provides some guidance along what dimension this basic model ought to be extended to match the observed facts well.

4 Theory

4.1 The Permanent Income Hypothesis

We now want to investigate whether versions of a standard incomplete markets model are consistent with the facts displayed in the previous section. In this section we summarize the empirical predictions of a model based on the permanent income hypothesis for the question at hand, and evaluate to

[10] Note that the lower number of observation in the bivariate transfer regression is due to the fact that data on transfers are not available in the early survey years.

[11] For the U.S. Aaronson et al. (2008) find that purchases of consumer durables respond strongly to changes in household income induced by an increase in the minimum wage.

what extent the empirical evidence presented above is consistent with this model. In the next section we then study a calibrated version of a standard incomplete markets life cycle model with a precautionary savings motive.

Suppose that households have a quadratic period utility function, can freely borrow and lend[12] at a fixed interest rate r, discount the future at time discount factor β that satisfies $\beta(1+r) = 1$ and faces an *after-tax* labor income process of the form

$$\begin{aligned} y_t &= \bar{y} + z_t + \varepsilon_t + \gamma_t \\ z_t &= z_{t-1} + \eta_t \end{aligned}$$

where $\bar{y}$ is expected household income, $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$ is a transitory income shock, $\eta_t \sim N(0, \sigma_\eta^2)$ is a permanent income shock and $\gamma_t \sim N(0, \sigma_\gamma^2)$ is classical measurement error in income. The shocks $(\varepsilon_t, \eta_t, \gamma_t)$ are assumed to be uncorrelated over time and across each other. where (ε, η) are uncorrelated i.i.d. shocks with variances $(\sigma_\varepsilon^2, \sigma_\eta^2)$.

Aggregating across wealth components and focusing on nondurable consumption the household faces a budget constraint of the form

$$c_t + w_{t+1} = y_t + (1+r)w_t$$

where $w_t = a_t + e_t$ is total and c_t are expenditures on nondurable consumption, including (imputed) rent for housing. We show in the appendix how a model that includes housing explicitly can be reduced to the formulation studied in this section as long as there are competitive rental markets, and the stock of housing can be adjusted without any frictions or binding financing constraints. In addition, for the empirical implementation of this model we include transfers T_t as part of after-tax labor income.

4.1.1 Empirical Predictions

As is well known, the realized changes in income, consumption and wealth of this model are given by (see e.g. Deaton, 1992):

$$\begin{aligned} \Delta c_t &= \frac{r}{1+r}\varepsilon_t + \eta_t \\ \Delta w_t &= \frac{\varepsilon_t}{1+r} \\ \Delta y_t &= \eta_t + \Delta\varepsilon_t + \Delta\gamma_t \end{aligned} \tag{3}$$

[12] Of course a No-Ponzi condition is required to make the household decision problem have a solution.

where $\Delta x_t = x_t - x_{t-1}$.

Equipped with these results we can now deduce the consumption and wealth responses to income changes, as measured by the same bivariate regressions we ran for our Italian data. First, since we have available a full panel and the survey is carried out only two periods, we need to work with changes of variables over N periods, which are given by:

$$\Delta^N x_t = x_t - x_{t-N} = \Delta x_t + \Delta x_{t-1} + \ldots + \Delta x_{t-N+1}.$$

Using (3) we find that

$$\begin{aligned}
\Delta^N c_t &= \sum_{\tau=t-N+1}^{t} \left(\frac{r\varepsilon_\tau}{1+r} + \eta_\tau \right) \\
\Delta^N w_t &= \sum_{\tau=t-N+1}^{t} \frac{\varepsilon_\tau}{1+r} \\
\Delta^N y_t &= \sum_{\tau=t-N+1}^{t} \eta_\tau + \Delta^N \varepsilon_t + \Delta^N \gamma_t
\end{aligned} \tag{4}$$

and thus the bivariate regression coefficients of N-period consumption and wealth changes on N-period income change are given as

$$\begin{aligned}
\beta_c^N &= \frac{Cov\left(\Delta^N c_t, \Delta^N y_t\right)}{Var\left(\Delta^N y_t\right)} = \frac{Cov\left(\sum_{\tau=t-N+1}^{t}\left(\frac{\varepsilon_\tau}{1+r} + \eta_\tau\right), \sum_{\tau=t-N+1}^{t} \eta_\tau + \Delta^N \varepsilon_t + \Delta^N \gamma_t\right)}{Var\left(\sum_{\tau=t-N+1}^{t} \eta_\tau + \Delta^N \varepsilon_t + \Delta^N \gamma_t\right)} \\
&= \frac{N\sigma_\eta^2 + r\sigma_\varepsilon^2/(1+r)}{N\sigma_\eta^2 + 2\left(\sigma_\varepsilon^2 + \sigma_\gamma^2\right)} \\
\beta_w^N &= \frac{Cov\left(\Delta^N w_t, \Delta^N y_t\right)}{Var\left(\Delta^N y_t\right)} = \frac{Cov\left(\sum_{\tau=t-N+1}^{t} \frac{\varepsilon_\tau}{1+r}, \sum_{\tau=t-N+1}^{t} \eta_\tau + \Delta^N \varepsilon_t + \Delta^N \gamma_t\right)}{Var\left(\sum_{\tau=t-N+1}^{t} \eta_\tau + \Delta^N \varepsilon_t + \Delta^N \gamma_t\right)} \\
&= \frac{\sigma_\varepsilon^2}{(1+r)\left[N\sigma_\eta^2 + 2\left(\sigma_\varepsilon^2 + \sigma_\gamma^2\right)\right]}.
\end{aligned}$$

Conditional on a real interest rate r these regression coefficients can be expressed exclusively as functions of the ratio of the size of permanent to transitory shocks $Q = \frac{\sigma_\eta^2}{\sigma_\varepsilon^2 + \sigma_\gamma^2}$ and the share of transitory income shocks attributed to measurement error[13], $M = \frac{\sigma_\gamma^2}{\sigma_\varepsilon^2 + \sigma_\gamma^2}$. Using these definitions we

[13] The estimated coefficient β_c^N can be decomposed into the regression coefficient ob-

find

$$\beta_c^N = \frac{NQ + (1-M)\frac{r}{1+r}}{NQ+2} \quad (5)$$

$$\beta_w^N = \frac{1-M}{(1+r)\,[NQ+2]}. \quad (6)$$

Straightforwardly, the larger is the size of the permanent shock, relative to the transitory shock, as measured by Q, the larger is the consumption response β_c^N and the smaller the wealth response β_w^N. Second, increasing the period length N acts exactly like an increase in Q (notice that N and Q appear in the expressions above as a product exclusively). Transitory shocks are mean-reverting of the horizon of N years, whereas all permanent shocks during the N year accumulate in income income changes, see equation (4). Therefore an increase in N effectively increases the persistence of income shocks, and thus the PIH implies that the coefficient β_c^N is increasing in N and β_w^N is decreasing in N.

Finally, larger measurement error lowers both coefficients due to the standard attenuation bias: it increases the variance of observed income, but leaves consumption and wealth unaffected since it is only income variation observed by the econometrician, but not experienced by the household.

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tained if income was measured without error, β, and the attenuation bias stemming from measurement error:

$$\beta_c^N = \beta * \frac{1}{1+\frac{2\sigma_\gamma^2}{N\sigma_\eta^2+2\sigma_\varepsilon^2}}$$

where

$$\begin{aligned}\beta &= \frac{Cov\left(\sum_{\tau=t-N+1}^{t}\left(\frac{\varepsilon_\tau}{1+r}+\eta_\tau\right), \sum_{\tau=t-N+1}^{t}\eta_\tau+\Delta^N\varepsilon_t\right)}{Var\left(\sum_{\tau=t-N+1}^{t}\eta_\tau+\Delta^N\varepsilon_t\right)} \\ &= \frac{N\sigma_\eta^2+r\sigma_\varepsilon^2/(1+r)}{N\sigma_\eta^2+2\sigma_\varepsilon^2}\end{aligned}$$

so that

$$\begin{aligned}\beta_c^N &= \frac{N\sigma_\eta^2+r\sigma_\varepsilon^2/(1+r)}{N\sigma_\eta^2+2\sigma_\varepsilon^2} * \frac{1}{1+\frac{2\sigma_\gamma^2}{N\sigma_\eta^2+2\sigma_\varepsilon^2}} \\ &= \frac{N\sigma_\eta^2+r\sigma_\varepsilon^2/(1+r)}{N\sigma_\eta^2+2\sigma_\varepsilon^2+2\sigma_\gamma^2}\end{aligned}$$

We observe how the size of the bias in β_c^N is decreasing in N and Q. Thus another useful aspect of the longer panel dimension of the Italian data set is that it allows us to use income changes over longer time periods which mitigates the problem of (classical) measurement error in income.

From equation (5) we observe that the share of measurement error is quantitatively unimportant for β_c^N for plausible values of r. True transitory shocks to income translate into consumption with a factor $\frac{r}{1+r} \approx 0$, while measurement error has an impact of exactly 0. Thus, to a first approximation the share M of measurement error does not affect β_c^N. On the other hand, true transitory income shocks translate into changes in wealth one for one, whereas measurement error does not have any impact on the changes in wealth. Therefore the degree of measurement error M has a strong impact on β_w^N, as (6) shows.

4.1.2 Evaluating the Empirical Predictions

There are several ways equations (5)-(6) can be exploited to evaluate whether this basic incomplete markets model is consistent with the empirical facts presented above. First, we let $N = 2$, that is, we look at the minimal panel dimension, which in turn contains the maximal number of households in the data. For concreteness, we assume a real interest rate of 2%. Equations (5)-(6) show that the exact value of the real interest rate affects the predicted values for (β_c^2, β_w^2) only insignificantly. We then ask what values of Q, M are needed to assure that the model predicts the same regression coefficients as in the data. From table I above we recall an OLS estimate of $\beta_c^2 = 0.11$ and LAD estimates for β_w^2 of 0.26 when w is interpreted exclusively as financial wealth, and of 1.81 when interpreted as the sum of real and financial wealth.

In figure 5 we plot the model-implied consumption and wealth regression coefficients against the degree of measurement error, for a value of $Q = 0.12$. The reason for this choice will be apparent momentarily. As discussed above the value of M has negligible impact on the model-implied β_c^2, but a strong impact on β_w^2. For $Q = 0.12$ and a measurement error of $M = 0.41$ the model exactly matches the empirically observed regression coefficients, if wealth is interpreted exclusively as financial wealth.[14]

This finding could be interpreted as minimum success of the model. But three problems emerge immediately.

First, there are no values for M and Q that make the model consistent

[14] Given equations (5)-(6) we can simply solve for Q, M given the observed β_c^2, β_w^2 as

$$\begin{aligned} Q &= \frac{\beta_c^2 - r\beta_w^2}{1 - \beta_c^2 + r\beta_w^2} = 0.12 \\ M &= 1 - \frac{2(1+r)\beta_w^2}{1 - \beta_c^2 + r\beta_w^2} = 0.41. \end{aligned}$$

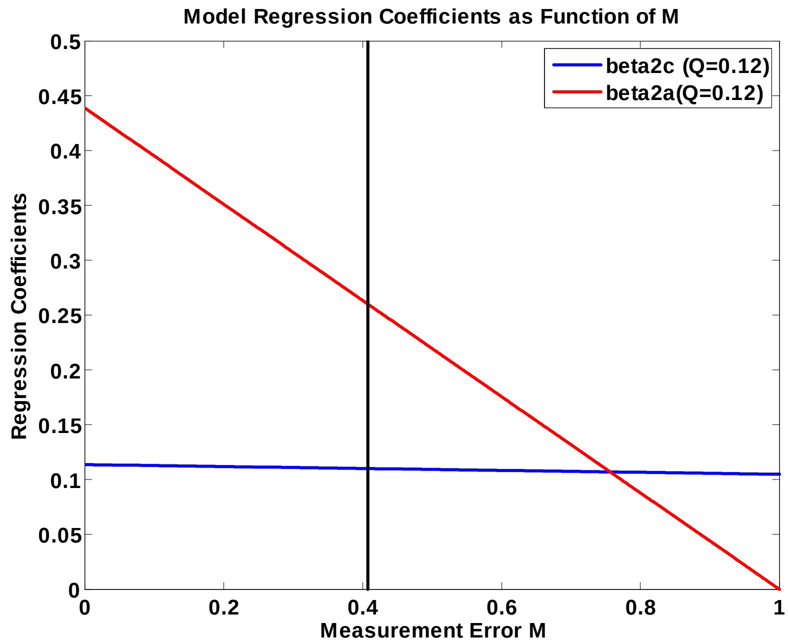

Figure 5: Model Regression Coefficients

with the observed income-wealth correlations if wealth is interpreted more broadly to include real estate wealth, an interpretation that is mandated by a model that includes real estate explicitly (see appendix C). We therefore, in section 5 investigate further what lies behind these correlations. Second, the required value Q to match the empirically observed consumption coefficient β_c^2 (which hardly depends on the degree of measurement error) is implausibly low. With the panel dimension for income one can estimate Q directly from the data, conditional on our assumption about the particular form of the income process. Jappelli and Pistaferri (2008a,b) do exactly this for the Italian data and find $Q \approx 1/2$. With such a value for Q the model significantly overpredicts the consumption response to income shocks, regardless of the size of the measurement error (see figure 5).[15] In the next section we therefore investigate whether an extension of the current model that includes a precautionary savings motive and thus implies that con-

[15] In appendix B we show that, if the first stage regression that controls for household observables fails to perfectly purge predicted income changes from the data, then the PIH predicts a lower regression coefficient for consumption than the one derived here.

sumption responds to permanent income shocks less than one for one (see Carroll, 2001) can rationalize the observed coefficients with a Q more in line with the data.

A third problem with the PIH arises when we exploit that the model has implications about how the consumption response to income shocks changes with the time horizon of the shock N. An increase in N means that more permanent shocks have accumulated, and that consumption should respond more strongly to a given income change. In table III we summarize how the model-implied consumption regression coefficients vary with N. Since the Italian data has a full panel dimension for income and consumption we can derive the same statistic from the data and collect it in table III as well, for $N = 2, 4, 6, 8$. The estimates from the data are derived from those 1989 households in the data that are in the SHIW for (at least) four consecutive interviews. The model numbers are derived under the assumptions that $r = 2\%$, $M = 0.44$ and $Q = 0.09$, the values needed for the model to exactly match the data (for these 1989 households) for $N = 2$ and wealth being interpreted as financial wealth

Table III: Regression Coefficients

	β_c^N		β_w^N		
N	Model	Data	Model	Dta $a+e$	Dta a
2	0.09	0.09	0.25	2.2	0.25
4	0.16	0.08	0.23	2.8	0.38
6	0.22	0.14	0.21	2.1	0.34
8	0.27	0.15	0.20	2.8	0.40

(Sample Size 1989; for wealth LAD estimates)

We observe that, as discussed earlier, the model predicts the expected increase in the consumptio coefficients and the decline in the wealth coefficients with the time horizon N. While for consumption the data suggest, broadly speaking, a similar qualitative pattern, the wealth coefficients in the data do not decline with N, independently how wealth is measured.

4.2 Precautionary Saving and Borrowing Constraints

The permanent income model abstracts from borrowing constraints and prudence in the utility function (by assuming that $u'''(c) = 0$). We now add these model elements that are well-known to give rise to precautionary savings behavior and thus may have the potential to reduce, quantitatively, the response of consumption to income shocks.

We envision a single household with monetary utility function $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ that faces the tight borrowing constraint $w_{t+1} \geq 0$. In addition we cast the model in a life-cycle context. Households live for 61 periods (from age 20 to 80 in real time). Prior to retirement at age 65, income of a household of age t is given by $y_t = \bar{y}_t \tilde{y}_t$ where the stochastic part of income $\tilde{y}$, in logs, is specified as a random walk plus a transitory shock.

$$\begin{aligned} \log(\tilde{y}_t) &= z_t + \varepsilon_t \\ z_t &= z_{t-1} + \eta_t \end{aligned} \quad (7)$$

with $\varepsilon_t \sim N(-\frac{\sigma_\varepsilon^2}{2}, \sigma_\varepsilon^2)$ and $\eta_t \sim N(-\frac{\sigma_\varepsilon^2}{2}, \sigma_\eta^2)$. The means of the innovations are chosen such that $E(\tilde{y}) = 1$. After retirement households receive a constant fraction of their last pre-retirement permanent income $\bar{y}_t \exp(z_t)$ as pension. The income component $\bar{y}_t$ denotes the deterministic mean income at age t and follows the typical hump observed in the data.[16]

The purpose of this section is to evaluate the potential of precautionary savings models to deliver smaller consumption responses to income shocks. Rather than carrying out an explicit calibration of the model we select parameter values that are plausible (relative to the existing literature) and constitute a minimal deviation form the pure PIH discussed above. With this objective in mind we select a CRRA of $\sigma = 2$ and choose $\rho = r = 2\%$, where $\rho = \frac{1}{\beta} - 1$ is the time discount rate of households. Jappelli and Pistaferri (2008) estimate $\sigma_\varepsilon^2 = 0.04$ and $\sigma_\eta^2 = 0.02$ from SHIW data. Households start their life with $w_0 = 0$ and $z_{-1} = 0$.

In table IV we display the model-implied regression coefficients for various versions of the model, as well as the data (first column). The three columns termed PIH collect the results from the original PIH model discussed in the previous section, but now evaluated at the empirical estimates for σ_ε^2 and σ_η^2 from Jappelli and Pistaferri (2008). The next column presents the results for this model if income in *logs* (rather than levels, as previously assumed) follows the process in (7). The column labelled PIH3 casts the PIH into a life cycle framework, and the last two rows present the results from the precautionary savings model, both in an infinite horizon (SIM1) and in a life cycle context (SIM2).

[16] The mean life cycle profile will be estimated directly from Italian data in future versions of this paper. The current version uses the U.S. profile estimated by Hansen (1993).

Table IV: Regr. Coef. with Precautionary Sav.

	Data	PIH	PIH2	PIH3	PSM1[17]	PSM2
β_c^2	0.11	0.34	0.33	0.37	0.18	0.29
β_w^2	0.26	0.33	0.35	0.40	0.55	0.49

We observe that a model with precautionary savings motive can lower the consumption response to income shocks substantially, albeit not quite to the low level observed in the data. This is especially true for households at later ages, since then the borrowing constraint ceases to bind for most households and they have accumulated substantial wealth that permits them to insulate consumption partially even from permanent income shocks.

Figure 6 displays the consumption regression coefficients by age, both for the life cycle version of the PIH as well as the precautionary saving model. For the PIH, these coefficients go up later in life since even transitory shocks become permanent for households near the end of their lives. For the precautionary saving model the effect of the binding borrowing constraint is clearly visible early in life, making it hard for households to smooth even transitory negative income shocks (recall that they start with zero initial wealth). On the other hand, once households have started to accumulate wealth for life cycle and precautionary reasons their consumption is more effectively insured against income shocks than under the PIH: the regression coefficients fall significantly below those implied by the benchmark PIH model.

We conclude that while the predictions of standard incomplete markets models are not altogether implausible for consumption, it is hard to square with the empirical facts of how wealth changes correlate with labor income changes. Since most of the wealth response appears to be concentrated in real estate wealth we now turn to a more detailed investigation of the data in this dimension.

[17] For a model with infinite horizon and $r = \rho$, wealth diverges over time. The results for the consumption and wealth regressions are therefore sensitive to the period at which we measure income, consumption and wealth in the model simulation. For the table we take observations corresponding to a household that has lived for 25 years. Because of the nonstationarity and the implied sensitivity to the simulation time horizon we stress the life cycle version of the model when discussing the results, for which nonstationarity is not an issue since households die.

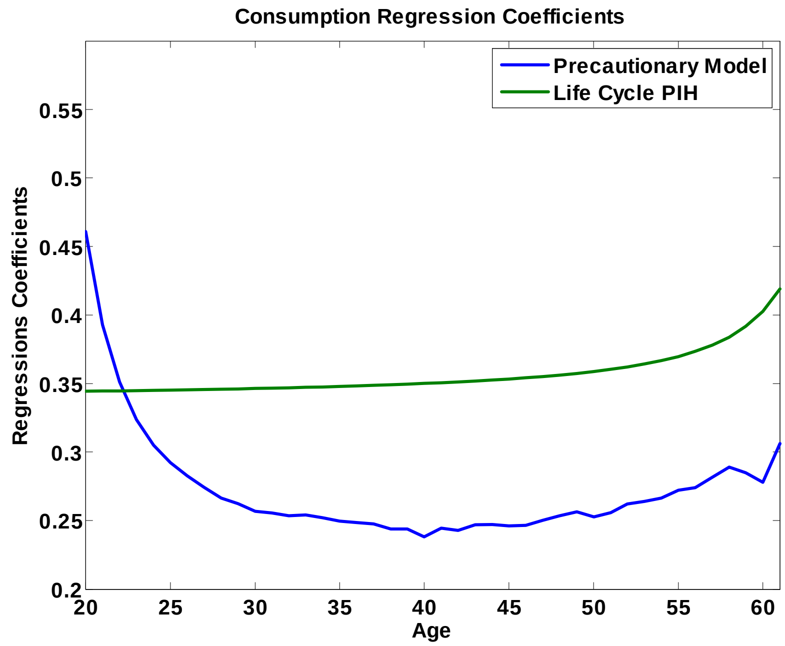

Figure 6: Consumption Regression Coefficients as a Function of Age

5 More Evidence of The Importance of Real Estate Adjustments

In Italy real estate is the predominant form of wealth held by private households. The median wealth household in 2006 owned about 140,000 Euro worth of real estate, relative to financial wealth of about 7000 Euro. As a point of comparison, median annual household income amounted to about 26,000 Euro. Mortgage debt, on the other hand is not very prevalent. Despite substantial increases in the last years the mortgagee debt to disposable income ratio is a mere 20%. Consequently, real estate is by far the most important component of total net worth of the median household. With 69% the home ownership rate is high and comparable to that of the U.S. As a further indicator of the importance of real estate wealth in a typical households' portfolio, note that about 30% of all Italian households won more than one property, with the average number of properties being owned equal to 1.44 (the median number is 1, though). It is therefore not entirely surprising that adjustments in the real value of real estate may play an important role in a households' response to an income shock.

The total net value of real estate owned by a household is given by the sum of the current market values of all properties owned net of the value of all outstanding mortgages, i.e.

$$e = \sum_{i=1}^{\#N} p_i - m$$

where p_i is the price of owned property i, $\#N$ the number of properties owned and m total outstanding mortgage debt. Changes in the real value of owned real estate could then be due to a) house price changes of continuously owned properties, b) net new purchases (net changes in newly acquired minus sold properties) c) adjustments in value of mortgages (and thus equity shares) in owned properties.

Thus we can express the change in the value of real estate wealth as

$$\begin{aligned}\Delta^2 e_{t+1} &= \sum_{i=1}^{N^*} \Delta^2 p_{it} + \left(\sum_{i=1}^{N^{new}} p_{it} - \sum_{i=1}^{N^{old}} p_{it-2} \right) - \Delta^2 m_t \\ &\equiv \Delta P + \Delta Q - \Delta m\end{aligned}$$

where N^* is the number of continuously owned properties between period $t-2$ and t, N^{new} is the number of newly purchased properties and N^{old} the number of sold properties between period $t-2$ and t.

Since we have detailed information about the self-assessed market value of each property a household owns, the year in which it was bought and the current use (primary residence, vacation home, rental property etc.) we can in principle construct all three components of changes in real estate wealth, $\Delta P, \Delta Q, \Delta m$.

To obtain a first sense of the relative importance of the three components we now split the sample into three subsamples. The first is our original sample, in the second sample we collect all households that do not adjust their real estate position (i.e. that have $\Delta Q = 0$). The third subsample consists of households that do not own real estate (in both years that constitute one differenced observation). These households (a subset of the second sample) may still have some real wealth, since real wealth also contains shares owned in private businesses, but since real estate constitutes about 90% of real wealth, for most of these households $e_{t+2} = e_t = 0$.

In table V we summarize the regression results obtained from the full sample and the sample of nonadjusters. First, we observe that mortgages do not co-vary significantly with income changes, indicating the minor importance of the Δm channel. This result may have been anticipated because of the relative unimportance of mortgages in Italy, and the fact that prepayment of mortgages and taking out second mortgages is highly uncommon. In fact, to the extent that there is any correlation between income changes and changes in the value of outstanding mortgages, it goes into the wrong direction. The regression coefficient for Δm is positive, suggesting that households with positive income changes increase the value of their outstanding mortgages, although the magnitude is small. This finding presents evidence against the view that income increases are used to purchase real estate with leverage, resulting in a more than one for one increase in the gross value of real estate, relative to the income change. See appendix C for the details.

Table V: Wealth Changes by Household Type

	Δc_n	Δa	Δe	$\Delta(a+e)$	Δm
β^{Full} [12636]	0.11	0.26	1.44	1.81	0.01
	(26.8)	(31.9)	(43.8)	(43.3)	(43.3)
β^{NonAdj} [8825]	0.16	0.48	1.05	1.54	0.02
	(27.2)	(7.1)	(22.5)	(25.8)	(6.3)

t-stats are in parentheses

Second, overall the magnitude of the wealth income change correlation is significantly smaller for nonadjusters than for adjusters when wealth is measured as including real estate. Plausibly, nonadjusters rely more strongly on the adjustment of financial wealth. However, the magnitude of the regression coefficient for Δe is still large for the group of households not adjusting the properties owned. Mechanically, this must mean that for these households there is a strong positive correlation between reported income changes and reported price changes of the continually owned properties. This correlation could possibly stem from a strong positive correlation of local housing and local labor markets or a strong positive correlation between income changes and household activities that result in changes in house values (such as repairs, extensions etc.).[18]

Motivated by the observation in table V that the group on nonadjusters adheres to the permanent income hypothesis in table VI we display how

[18] We will investigate the exact source of this strong positive correlation in future versions of this paper. Note, however, that the magnitude of expenditures for housing repairs or renovations appears to be very small in the data, casting doubt on the quantitative importance of this channel.

the nonadjusting households' consumption and wealth regression coefficients change as we vary the time horizon of the income change. We again choose M, Q in the model to match with $N = 2$ observations exactly. Comparing the results to those for the entire sample in table III we find that this group adheres to basic qualitative predictions of the permanent income model to a better extent. As the PIH predicts

This in turn suggests that the group of households that *does* adjust its stock of real estate in conjunction with income changes displays behavior most at odds with this model, which in turn calls for a model in which housing is modelled explicitly (and which deviates from the simple extensions of the PIH discussed in Appendix C).

Table VI: Nonadjusting Households

	β_c^N		β_w^N	
N	Model	Data	Model	Data (a)
2	0.15	0.15	0.48	0.48
4	0.25	0.11	0.42	0.52
6	0.33	0.17	0.37	0.34
8	0.39	0.19	0.34	0.34

(Sample Size 1304; for wealth LAD estimates)

To conclude this section we study households that do not possess real estate and therefore provides the natural (certainly nonrandom) subset of the population to which the PIH can be applied without adjustments. From table VII we observe that these households (which tend to be poor) nondurable consumption responds to income more strongly and that financial wealth absorbs a significant portion of the income shock. Other forms of real wealth (i.e. shares in private businesses) play a minor role for these households. The table suggests that for this subgroup of the population both qualitatively and quantitatively the PIH may not be a bad approximation, at least when basic income, consumption and wealth correlations are considered.[19]

[19] Computing the correlations for longer horizons on this subsample is problematic because of small sample size. Requiring non-ownership and presence in the sample for 4 surveys reduces the number of households to less than 500.

Table VII: Wealth Changes by Household Type

	Δc_n	Δa	Δe	$\Delta(a+e)$
β^{Full} [12636]	0.11	0.26	1.44	1.81
	(26.8)	(31.9)	(43.8)	(43.3)
β^{NoRE} [3142]	0.22	0.76	0.06	0.82
	(21.3)	(6.2)	(0.29)	(3.26)

t-stats are in parentheses

6 Conclusion

How do households respond to an income shock? In this paper we presented evidence that Italian households surveyed in the SHIW adjust nondurable consumption by 11 cents for each Euro, on average, a response that is consistent with the permanent income hypothesis if (and only if) the overwhelming magnitude of income shocks are transitory in nature. We also documented a large positive correlation between labor income shocks and adjustments in the value of real estate.

Future research has to address in more detail the forces behind this large correlation. It also has to investigate whether the findings in this paper can be generalized to other industrialized countries, a task that is complicated by the lack of appropriate panel data elsewhere.[20]

[20] The construction of panel consumption data from panel income data with minimal consumption content and cross-sectional consumption data, as in Blundell et al. (2008) may present an alternative to the use of a full panel.

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A Variable Definitions

Nondurable consumption c_{nt} is defined as all household expenditures during a year, *minus* expenditures on transportation equipment (cars, bikes etc.), valuables (such as art, jewelry, antiques), household equipment (such as furniture, rugs, TV's, cell phones and other electronics), expenditure for home improvement, insurance premia and contribution to pension funds. It includes rent paid by renters and imputed rent of home owners on all properties that are not rented out. Imputed rent also appears as income from real assets in $r_{et}e_t$ on the right hand side of the budget constraint. Expenditures on durables c_{dt} include expenditures for transportation equipment, valuables and household equipment, all as defined above.

Labor income y_t is measured after taxes and includes fringe benefits received by employees and business income by entrepreneurs. Transfers T_t include both transfer payments from the government (such as unemployment benefits) as well as gifts, loans and other transfers between private households.

Financial assets a_{t+1} add bank deposits, stock and bond holdings and other direct holdings of financial assets (including assets held in private pension funds), net of outstanding debt. It does not include the value of entitlements to government pension payments. The net income from financial assets (interest payments, dividends etc.) forms financial income $r_{at}a_t$. Finally, real assets e_{t+1} include the value of real estate property, the value of valuables (as defined above) and the net value of ownership in private businesses and partnerships. Income from real assets, $r_{et}e_t$, consists mainly of rent (both actual and imputed) received from owned real estate.

B Predictable Income Changes

To the extent that our first stage regression that conditions the data on observables such as age, education etc. has failed to capture all predictable movements in income, the empirical estimates may partially reflect the consumption response to predictable income changes.[21] The PIH model of course implies that consumption should not respond to predictable changes in income at all. Denoting the predictable part of income by $\bar{y}_t$ the model

[21] On the other hand, It is possible that some of the variation the first stage regression picks up may have been predicted by the econometrician, but not by the household itself.

now implies, for an income process

$$\begin{aligned} y_t &= \bar{y}_t + z_t + \varepsilon_t + \gamma_t \\ z_t &= z_{t-1} + \eta_t \end{aligned}$$

the model solution

$$\begin{aligned} \Delta y_t &= \eta_t + \Delta \bar{y}_t + \Delta \varepsilon_t + \Delta \gamma_t \\ \Delta c_t &= \frac{r}{1+r}\varepsilon_t + \eta_t \\ \Delta a_{t+1} &= \frac{\varepsilon_t}{1+r} - \frac{1}{1+r}\sum_{s=1}^{\infty}\frac{\Delta \bar{y}_{t+s}}{(1+r)^{s-1}}. \end{aligned}$$

N-period changes are therefore given by

$$\begin{aligned} \Delta^N c_t &= \sum_{\tau=t-N+1}^{t}\left(\frac{r\varepsilon_\tau}{1+r} + \eta_\tau\right) \\ \Delta^N y_t &= \sum_{\tau=t-N+1}^{t}\eta_\tau + \Delta^N \bar{y}_t + \Delta^N \varepsilon_t + \Delta^N \gamma_t \\ \Delta^N a_{t+1} &= \sum_{\tau=t-N+1}^{t}\frac{\varepsilon_\tau}{1+r} - \frac{1}{1+r}\sum_{s=1}^{\infty}\frac{\Delta^N \bar{y}_{t+s}}{(1+r)^{s-1}} \end{aligned}$$

and the regression coefficients implied by the model now read as

$$\begin{aligned} \beta_c^N &= \frac{N\sigma_\eta^2 + r\sigma_\varepsilon^2/(1+r)}{N\sigma_\eta^2 + 2\left(\sigma_\varepsilon^2 + \sigma_\gamma^2\right) + Var\left(\Delta^N \bar{y}_t\right)} \\ \beta_w^N &= \frac{-\sum_{s=1}^{\infty}\frac{Cov\left(\Delta^N \bar{y}_t, \Delta^N \bar{y}_{t+s}\right)}{(1+r)^s} + \sigma_\varepsilon^2/(1+r)}{N\sigma_\eta^2 + 2\left(\sigma_\varepsilon^2 + \sigma_\gamma^2\right) + Var\left(\Delta^N \bar{y}_t\right)} \end{aligned}$$

Thus the consumption response to income shocks goes down in presence of predicted income changes, the extent to which is determined by how large the cross-sectional variance in the N-period change in the predictable component of income is, relative to the variance of the permanent and transitory income shocks. Note that the wealth response to income changes now depends also crucially on the covariance of current and future predicted income changes.

C Housing in the Standard Incomplete Markets Model

We now introduce housing explicitly into the standard incomplete markets model. We first model the housing choice of households without any frictions in the adjustment of real estate position and no explicit borrowing constraints.[22] Also, households have access to a competitive rental market where housing services s_t can be rented for a rental price R_t per unit of house. Households buy real estate h_{t+1} at price per unit of p_t, as well as nondurable consumption cn_t and financial assets a_{t+1}. Houses depreciate at rate δ. The household decision problem is then given by

$$\begin{aligned} & \max_{\{cn_t, s_t, a_{t+1}, h_{t+1}\}} \sum_t \beta^t v(cn_t, s_t) \\ cn_t + a_{t+1} + R_t s_t + p_t h_{t+1} &= y_t + (1+r_t)a_t + p_t(1-\delta)h_t + R_t h_t \quad (8) \end{aligned}$$

where $v(cn_t, s_t)$ gives the period utility from consuming nondurables cn_t and housing services s_t.

C.1 Analysis

It is straightforward to show that this household problem can be solved in three stages. In the first stage the intratemporal consumption allocation problem between nondurables and housing services is solved

$$\begin{aligned} & \max_{cn_t, s_t} v(cn_t, s_t) \\ cn_t + R_t s_t &= c_t \end{aligned}$$

where c_t is the expenditure on housing services. The solution characterized by the two equations

$$\begin{aligned} \frac{v_s(cn_t, s_t)}{v_{cn}(cn_t, s_t)} &= R_t \\ cn_t + R_t s_t &= c_t \end{aligned}$$

Define the indirect utility function resulting from this maximization problem as

$$u(c_t; R_t) = v(cn_t(c_t, R_t), s_t(c_t, R_t))$$

[22] Of course an appropriate no-Ponzi condition has to be imposed to make the household problem have a solution.

This is the period utility function used in the main text.

In a second stage the household decides how to split its savings between financial and real assets. Without any frictions in the real estate market (or the financial asset market, for that matter) a simple no-arbitrage argument implies that the rental price and the price of real estate have to satisfy the condition.

$$R_{t+1} = p_t \left[(1 + r_{t+1}) - \frac{p_{t+1}(1-\delta)}{p_t} \right]$$

Under this condition one can consolidate both assets into one

$$w_{t+1} = a_{t+1} + p_t h_{t+1}.$$

Exploiting the outcome of steps i) and ii) the intertemporal household problem then reads as

$$\max_{\{c_t, w_{t+1}\}} \sum_t \beta^t u(c_t; R_t)$$
$$c_t + w_{t+1} = y_t + (1 + r_t) w_t$$

where consumption expenditures and wealth are measured as

$$\begin{aligned} c_t &= cn_t + R_t s_t \\ w_{t+1} &= a_{t+1} + p_t h_{t+1} \\ &= a_{t+1} + e_{t+1}. \end{aligned}$$

As long as c_t and w_t are measured empirically consistent with the theory, the analysis can proceed as in the main text, without explicit consideration of the households' housing choice.

C.2 Adding Financing Constraints

Suppose the household can only finance a fraction $1 - \gamma$ of the value of real estate purchased in the current period,

$$a_{t+1} \geq -(1-\gamma) p_t h_{t+1}.$$

The effect of such a constraint on the dynamics of the stock of real estate was studied, among others, by Fernandez-Villaverde and Krueger (2002), Campbell and Hercowitz (2006) and Aaronson et al. (2008). The presence of such a constraint may significantly alter the response of housing wealth to a change in income. Suppose that households find it optimal to be at the constraint in period t, then $a_{t+1} = -(1-\gamma)p_t h_{t+1}$. Substituting this into the budget constraint (8) yields

$$c_t + \gamma p_t h_{t+1} = y_t + (1+r_t)a_t + p_t(1-\delta)h_t + R_t h_t.$$

Therefore if households are constrained in periods $t-1$ and t we have

$$\frac{\Delta c_t}{\Delta y_t} + \frac{\gamma \Delta p_t h_{t+1}}{\Delta y_t} = 1.$$

It is straightforward to observe $\frac{\Delta p_t h_{t+1}}{\Delta y_t} > 1$, that is expenditures on non-durables and net new housing can exceed the income change since households can leverage home purchases. But also note that this implies that

$$\frac{\Delta a_{t+1}}{\Delta y_t} = -(1-\gamma)\frac{\Delta p_t h_{t+1}}{\Delta y_t}$$

and thus one would expect large adjustments in the value of mortgages (or other financial debt), too. This is not what the empirical analysis in section 5 of the main text reveals.

Table A1
Panel households of the SHIW, 1987-2006

Year of first interview	Year of survey									
	1987	1989	1991	1993	1995	1998	2000	2002	2004	2006
1987	8027	1206	350	173	126	85	61	44	33	30
1989		7068	1837	877	701	459	343	263	197	159
1991			6001	2420	1752	1169	832	613	464	393
1993				4619	1066	583	399	270	199	157
1995					4490	373	245	177	117	101
1998						4478	1993	1224	845	636
2000							4128	1014	667	475
2002								4406	1082	672
2004									4408	1334
2006										3811
Cross-sectional sample size	8027	8274	8188	8089	8135	7147	8001	8011	8012	7768
Percentage of total sample		14.6	26.7	42.9	44.8	37.3	48.4	45.0	45.0	50.9

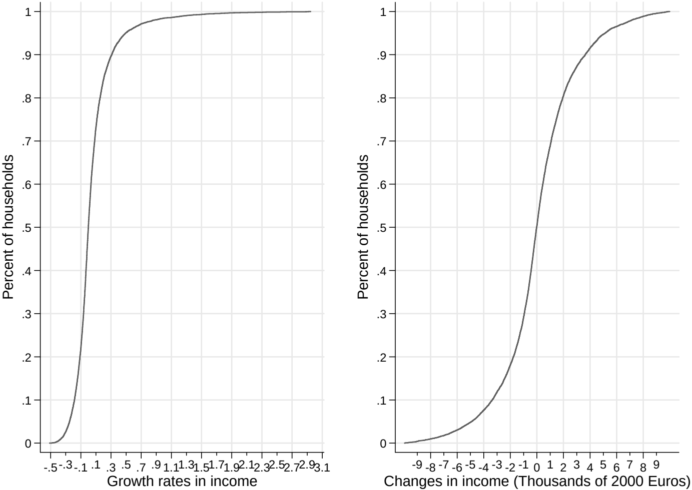
Percent of households
Growth rates in income
Percent of households
Changes in income (Thousands of 2000 Euros)

Figure A1