Consumption Commitments and The Consumption Elasticity to Permanent Income

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Abstract

In this paper, I propose consumption commitments – goods that are costly to adjust – as the key mechanism behind the concavity of consumption to permanent income. Households choose the consumption path given their expectation of permanent income. When the uncertainty realizes, those that did not reoptimize their bundle show depressed consumption. To support this claim, I provide empirical using PSID data. First, conditioning on the same permanent income today, households that experienced faster permanent income growth consume less. Second, those households have larger shares of easy-to-adjust goods in their bundles. Lastly, all results disappear or weaken when looking at only households that adjusted their consumption bundle. To quantify the mechanism relevance, I simulate a life-cycle model in which some goods are subject to non-convex adjustment costs. The model can account for all the facts documented in the data.

Keywords: Permanent Income, Consumption Commitments

JEL - Classification: D11, D31, E21

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1 Introduction

Since Milton Friedman's *A Theory of the Consumption Function (1957)*, economists have formalized the consumption-savings trade-off under income risk by adopting a permanent-transitory income notion. However, current models are at odds with the empirical evidence on the consumption response to income shocks.[1] Firstly, consumption is excessively sensitive to anticipated transitory income shocks. Secondly, consumption is excessively smooth to unexpected permanent income shocks.[2] In a recent working paper, Straub (2019) shows that current models also cannot rationalize the empirical evidence on how the levels of consumption and permanent income are related in the cross-section. In the data, consumption under-responds to permanent income relative to what the benchmark theory predicts.

In this paper, I investigate the mechanism behind the consumption under-response to permanent income. Empirically, I show that consumption commitments – goods subject to transaction costs and infrequently adjusted – are essential to understanding this fact. Households commit themselves to an expenditure path given some expectation about their permanent income. However, once the uncertainty is resolved, many households do not adjust their consumption bundles, which generates a depressed consumption. Using proxies for adjusting, I show that households who reset their bundle behave more closely to what benchmark theories predict. To do Quantitatively, I propose a model nesting different explanations proposed by the literature to quantify the strength and importance of consumption commitments.

Understanding the mechanism behind the consumption under-response is crucial for understanding the sources and implications of important aggregated trends. For example, Straub (2019) and Mian, Straub, and Sufi (2021) use non-homothetic preferences to generate consumption concavity in permanent income and analyze implications for the rising income and wealth inequality, for decreasing natural interest rate, and of increasing financial deregulation. However, other mechanisms can generate the same empirical fact, such as health shocks at old ages (De Nardi, French, and Jones, 2016) or behavioral explanations, and would imply different aggregated implications.

In my empirical results, I use data from the Panel Survey of Income Dynamics (PSID) from 1999 to 2019. Permanent Income is current assets plus the discounted future expected path of

[1]With current consumption theories, I mean models in which the permanent-transitory notion is central to their predictions, such as the Certainty Equivalence Model (Hall, 1978), the Standard Incomplete Model (SIM) (Deaton, 1991; Carroll, 1997), and their variation.

[2]Examples of studies with excessively sensitive results are Flavin (1981), Hsieh (2003), and Ganong and Noel (2019). For excessively smooth results, see Campbell and Deaton (1989), Blundell, Pistaferri, and Preston (2008), and Kaplan and Violante (2010). An extensive survey of the empirical literature can be found at Jappelli and Pistaferri (2017).

income (Jappelli and Pistaferri, 2017; Abbott and Gallipoli, 2019). I estimate the latter by assuming an income process and forecasting the income profile for each household. Consistent with Straub (2019), I recover a consumption elasticity with respect to permanent income of around 0.60. I further document the existence of path dependence on the consumption response to permanent income. Household consumption today depends on when its lagged permanent income. I also present evidence that the not consumed permanent income goes into asset accumulation. First, I show that households' reported assets and implied assets constructed using the reported income and expenditure data are consistent.[3] To be done Second, I show that using regressions that ...

I use the detailed consumption categories available in the PSID since 1999 to estimate demand systems. This exercise captures how past permanent income is associated with the expenditure allocation among different goods, conditioned on a given level of total expenditures. High past expenditures are associated with less easy-to-adjust goods consumption and higher hard-to-adjust goods consumption. I further show that households that adjusted their consumption bundle show little or no path dependence. These facts push for an explanation in which households can freely adjust some goods but are locked up in some hard-to-adjust goods (such as housing).

Think better how to test A concern with my exercise would be if agents knew some of the realized income growth and the Permanent Income measure did not capture it. I perform several robustness exercises to show that this is not the case. For example, if the permanent income hypothesis predicts that consumption at period t forecasts future income growth even after controlling for my expected income growth measure. I test this possibility and show that consumption is correlated negatively with the realized income growth after controlling for expected income growth. This result provides evidence that my measure well captures household income expectations.

To be done Quantitatively, I explore the implication of the described mechanism by extending a standard incomplete markets life cycle model (Deaton, 1991; Carroll, 1997; Gourinchas and Parker, 2002) to include two consumption goods, one of which is hard-to-adjust. I model the hard-to-adjust good assuming that the agent has to pay an adjustment cost to change the consumed quantity (Grossman and Laroque, 1990; Berger and Vavra, 2015). I show that this modified model can account for the facts documented in the data. For comparison, I also calibrate a canonical one-good model and show that it fails to account for the documented facts.

To be done Finally, I study the model aggregate implications.

Related Literature My paper relates to three strands of the literature. First, it adds to the

[3] A concern is whether the PSID poorly measures the long-run path of consumption, income, and assets. This exercise is also helpful in showing the quality of the data for long-run analysis at the household level.

vast empirical literature that tests the Permanent Income Hypothesis (PIH). Starting with Friedman (1957), this literature focuses on predictions about consumption responses to transitory or permanent income changes. The PIH predictions have been tested on aggregate time series (Hall, 1978; Flavin, 1981; Campbell and Deaton, 1989) and microdata Hall and Mishkin (1982); Altonji and Siow (1987); Shea (1995). I contribute to this literature in two dimensions. First, I use the recent data of the PSID that has broad information on household expenditure. Using these later years is an improvement relative to studies that use only food or imputed consumption. Second, I show that the aggregate bundle masks substantial heterogeneity among less aggregated consumption categories, and this heterogeneity helps distinguish between different consumption theories. Bils and Klenow (1998) and Aguiar and Hurst (2013) also look at less aggregated consumption categories but in a different context.

Second, I add to recent works that estimate the consumption elasticity to Permanent Income (or, in other words, how consumption level is related to the level of Permanent Income). Abbott and Gallipoli (2019) construct a measure of permanent income by estimating human wealth nonparametrically and, in their working paper version, explore how it relates to the consumption level. Straub (2019) estimates the elasticity of consumption to Permanent Income using an IV approach. Both find an elasticity of around 0.7, which is at odds with an elasticity of 1.0 that benchmark theories predict (Carroll, 2019; Straub, 2019). I document that when a household learn about its Permanent Income is important to understand the consumption to Permanent Income. Straub (2019) proposes that age-dependent elasticity (high intertemporal elasticity of substitution for older households) is the key mechanism behind consumption under-response. Alternatively, I propose consumption commitments as the mechanism behind this under-response.

Third, I add to the literature that studies the implications of household-level adjustment costs to consumption dynamics. Chetty and Szeidl (2007) study implications for individual risk preferences. Berger and Vavra (2015); Chetty and Szeidl (2016) study implications for the aggregate consumption dynamic. Kaplan and Violante (2010) use a model in which households can hold two assets, one subject to adjustment costs, to study consumption responses to fiscal stimulus. I also contribute to the broad literature studying the dynamics of durables consumption (Fernandez-Villaverde, Krueger et al., 2011), housing consumption (Yang, 2009), and their interaction (Hurst and Stafford, 2004; Berger, Guerrieri, Lorenzoni, and Vavra, 2018; Beraja, Fuster, Hurst, and Vavra, 2019). I show how a lock-in mechanism can explain the consumption under-response to Permanent Income.

Roadmap. Section 2 presents a simple 2-period model to illustrate the mechanism. Section 3 introduces the empirical strategy and the data. Section 4 presents the estimate of the response of consumption growth to permanent income growth. Section 4.4 has robustness checks. Section 6 concludes. The appendix contains all proofs, as well as additional empirical and quantitative results. Section 5 extends the standard incomplete markets life cycle model to include two consumption goods.

2 Illustration of the Mechanism

I begin by studying a 2-period model to provide intuition and reference values to interpret the empirical results of Section 4. I explore the quantitative predictions of a fully specified model in Section 5.

2.1 Simple 2-period Model

Consider a partial equilibrium model in which a household earns a known income path $\{y_1, y_2\}$ and chooses savings s and the consumption path of two types of goods, durable goods $\{d_1, d_2\}$ and non-durable goods $\{n_1, n_2\}$. Furthermore, assume that the aggregated consumption good is defined using a Cobb-Douglas aggregator, $c = g(n, d) = n^\theta d^{1-\theta}$, in which θ is the aggregated good elasticity with respect to non-durable goods. Before the first period – or period 0 – the household chooses consumption paths and savings to maximize lifetime utility subject to each period's budget constraint and the Cobb-Douglas aggregator:

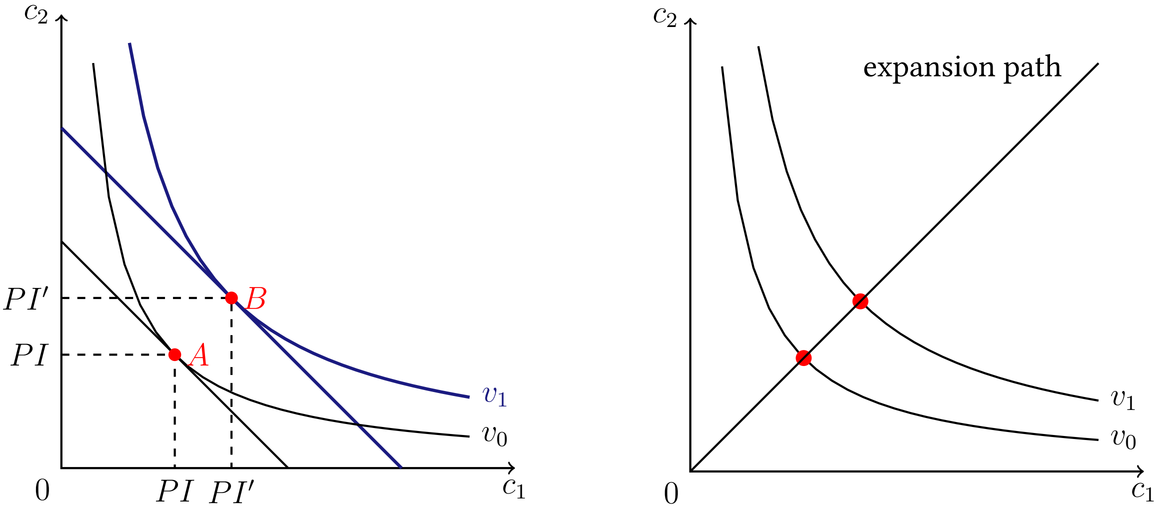
$$
\begin{aligned}
v_0 = \max u(c_1) + u(c_2) \quad \text{ s.t. } \; & c = n^\theta d^{1-\theta} \\
& n_1 + d_1 + s = y_1 \\
& n_2 + d_2 = y_2 + s \; .
\end{aligned}
$$

In this simplified problem, all goods' optimal allocations are a linear function of total wealth, $y_1 + y_2$. Permanent income is defined as the annuity value of total wealth (Jappelli and Pistaferri, 2017; Abbott and Gallipoli, 2019), which is equal to half the total wealth in this model, $PI = \frac{1}{2}(y_1 + y_2)$. Therefore, in each period, consumption is a linear function of permanent income, which implies a consumption elasticity with respect to permanent income of 1, $\mathcal{E}_{C,PI} = 1$.[4]

Suppose that at the beginning of period 1, an MIT shock increases permanent income ($PI' > PI$). In this case, the household will re-optimize its consumption bundle, and aggregate consumption will increase proportionally to the increase in permanent income. Panel 1a of Figure 1 shows

[4]The allocations are $n_1 = n_2 = \theta PI$, $d_1 = d_2 = (1-\theta)PI$, and $c_1 = c_2 = PI \times$ constant

this case. Both c_1 and c_2 increase proportionally to the increase in permanent income, going from point A to point B. In Panel 1b of Figure 1, I draw the expansion path of the household when permanent income increases, which is linear. In other words, the slopes of indifference curves are constant along rays beginning at the origin, and the intertemporal Engel curve is linear. In most consumption models used in macroeconomics, the consumption elasticity with respect to permanent income is close to 1, and the intertemporal Engel curve is close to linear.



(a) Optimal Allocation

(b) Expansion Path

Figure 1: Model without Friction

2.2 Simple Model with a Non-adjustable Good

Suppose the same thought experiment as before. Before period 1, the household chooses allocations. In period 1, an MIT shock increases permanent income. However, assume a new friction: at $t = 1$, the household cannot adjust d_1, only n_1. At $t = 2$, the household can adjust both goods, n_2 and d_2. In the full quantitative model of Section 5, I relax the extreme assumption of complete non-adjustment by assuming that the household can adjust durable consumption if it pays a fixed adjustment cost.

The maximization problem that the household solves in period 1 after the MIT shock is

$$\tilde{v}_1(d_1) = \max u(c_1) + u(c_2) \quad \text{s.t.} \quad \begin{aligned} & u(c) = c^{1-\sigma}/1-\sigma \\ & c = n^{\theta} d^{1-\theta} \\ & n_1 + d_1 + s = y_1 \\ & n_2 + d_2 = y_2 + s \\ & d_1 \text{ is given.} \end{aligned}$$

Assuming for convenience log-utility, the allocation on the non-durable good is constant across periods, $n_1 = n_2$. Also, the optimal allocations are still a function of total wealth, $y'_1 + y'_2$, but also a function of the original commitment of the durable good consumption, d1. Because the consumption of d_1 is fixed, the household divides the extra income between other adjustable goods, d_2, n_1, and n_2.[5]

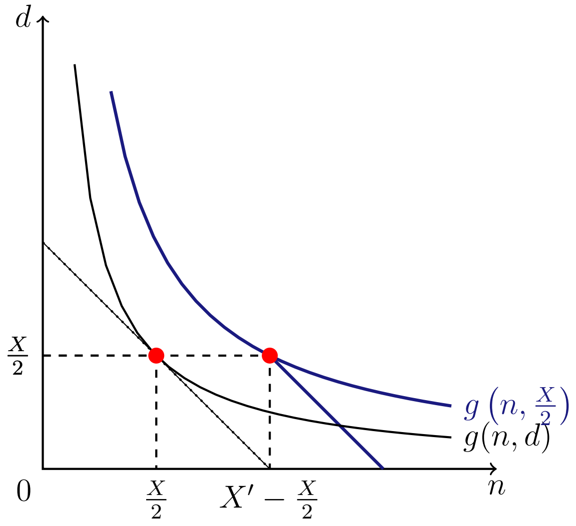
Panel 2a of Figure 2 displays the intraperiod allocation of expenditure between the two types of goods. There is a kink in the budget constraint since the household is committed to consuming a pre-determined quantity of d_1. Any increase in expenditure happens in the adjustable good, n_1, which causes the substitution rate between goods to be different from the slope of the budget constraint. In the second period, the household can adjust expenditure on both goods, which equalizes the between-goods substitution rate to the budget constraint slope.

The consumption elasticity to permanent income is no longer 1.[6] Panel 2b of Figure 2 shows the intertemporal impact of the adjustment friction. Since increases in the aggregated consumption bundle in period 1 have to be done by increases in the adjustable good, it strengthens the period's allocation distortion. Consequently, the household shifts consumption to period 2 since both goods are adjustable and the aggregate consumption bundle is optimal. The slopes of indifference curves are no longer constant along rays beginning at the origin, and the intertemporal Engel curve is concave.

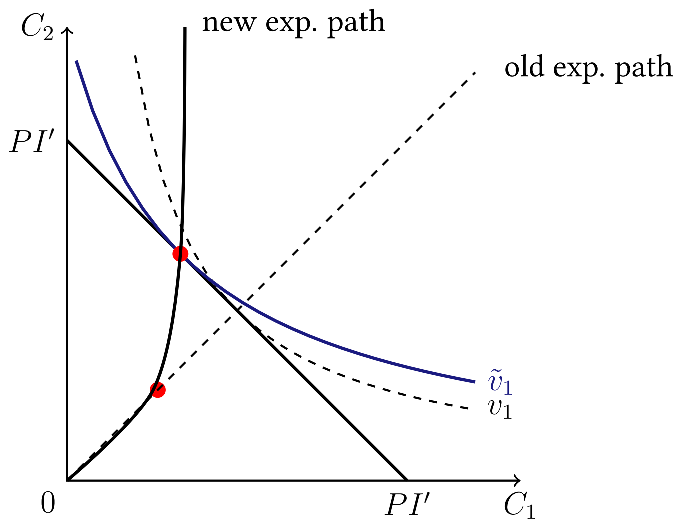
The two main implications I test on the PSID data in Section 4 can be understood through this simple model and the diagrams in Figure 2. First, for two households with the same level of permanent income (or total wealth $y'_1 + y'_2$), the consumption elasticity to permanent income will be lower for the one whose permanent income grew faster. In other words, the consumption response in period 1 will be a function of the expected permanent income in period 0 as in Panel

[5]The allocations are $n_1 = n_2 = \frac{\theta}{1+\theta}(y'_1 + y'_2 - d_1)$, $d_2 = \frac{1-\theta}{1+\theta}(y'_1 + y'_2 - d_1)$, and $c_1 = (d_1)^{1-\theta}(PI' - d_1)^{\theta} \times$ constant.

[6]Using $d_1 = (1-\theta)PI$ and assuming PI' close to PI, we find that $\frac{\partial \log c_1}{\partial \log PI'} = \theta \frac{PI'}{PI' - d_1} \approx \frac{2\theta}{1+\theta} < 1$



(a) Intratemporal Allocation



(b) Expansion Path

Figure 2: Model with Adjustment Friction

2b. Second, for the household whose permanent income grew faster, its consumption bundle skews toward more non-durable (or adjustable) goods as in Panel 2a. Both predictions hold for constrained households. However, households that are not constrained, i.e., those that adjusted their consumption bundle, should display no path dependence.

3 Data and Empirical Strategy

In the previous section, I illustrated how consumption commitments can generate non-homotheticities in the consumption response to permanent income. I also highlighted two testable implications from the model. In this section, I explain my empirical strategy to test these implications. In Subsection 3.1, I describe the Panel Study of Income Dynamics (PSID) data. In Subsection 3.2, I introduce my empirical strategy.

3.1 Data

My data source is the Panel Study of Income Dynamics (PSID). In the main analysis, I use data from the 1999 – 2019 waves, which have broad consumption, income, and wealth measures collected by the PSID. This unique feature of the data allows analyses focusing on the long-run path of consumption, income, and wealth within a household. In addition, I use data from the 1980 - 2019 waves of the PSID to estimate the income process used to compute expected income growth.[7] Finally, I use the CPI to express all monetary values in 2017 US dollars.

Expenditures Following Kaplan, Violante, and Weidner (2014) and Blundell, Pistaferri, and Saporta-Eksten (2016), I construct total expenditure using food (food at home, food away from home, and delivered food), utilities (gas for home, electricity, water and sewer, and other utilities), transportation (gasoline, parking, public transportation, taxi, and other transportation expenditure), medical expenses (doctors, hospitals, prescription drugs, and health insurance), childcare, education, insurance (auto insurance and home insurance), vehicle repair, vehicle, and shelter. Spending on shelter reflects rent payments for renters and implicit rent for homeowners. Since the PSID only started asking about implicit rent in the 2017 wave, I set it to 6 percent of the respondent's house value. Spending on vehicles reflects service flow, and I set it to 10 percent of the respondent's vehicle net worth.

For robustness, I also consider other expenditure measures. First, I construct nondurable expenditures, excluding spending on vehicles and shelter except insurance and vehicle repair. These last two are services expenditures and are easy to adjust. Second, I construct broad expenditures using more categories included in the 2005 wave (home repairs, home furnishings, clothing, vacations, recreation, and telecommunications) and expenditure on donations. Third, I construct an expenditure measure defining shelter expenditure as the sum of all housing expenditures (rent, mortgage payments, and property taxes) and vehicle expenditure as the sum of down payments, lease payments, loan payments, and additional vehicle costs.[8] My base expenditure measure relative to total after-tax income averages 58.3 percent for the whole sample. For the broad expenditure measure, this average is 76.2 percent. Aguiar, Bils, and Boar (2020) compute the same averages and find 58.3 and 73.2 percent, respectively.

Earnings I construct two measures of income. First, household after-tax labor income is the sum of household labor earnings plus government transfers minus payroll taxes. Household labor earnings are the sum of the head and the spouse's total labor income, excluding business and farm income and adding the labor component of income from any unincorporated business. Government transfers are the sum of any head and spouse's government transfer income from AFDC, supplemental security income, other welfare payments, unemployment benefits, worker's

[7] The PSID was conducted annually until 1996 and biennially since 1997. From waves before 1999, I use only odd survey years for consistency.

[8] Since the 2019 wave, the PSID staff created two aggregated consumption variables. Both sum all the subcategories into a total household consumption sum, differing only on how to compute expenditure on shelter. The first variable, Total Consumption, considers shelter expenditure as the sum of rent for renters and implicit rent for homeowners. The second variable, Total Expenditure, considers shelter expenditure as the sum of rent for renters, mortgage payments, and property taxes. The first measure differs from my baseline only in how I treat vehicle expenditure. I explore the second measure as a robustness exercise.

compensation, or social security benefits. My measure of payroll taxes comes from the NBER's TAXSIM.[9]

My second measure of household income is a broad measure of income, in which I add asset income to the previous measure of total labor income. Asset income is the sum of any head and spouse's business income, farm income, dividends, interest, rents, trust funds, and royalties.[10] Again, I compute the taxes using the NBER's TAXSIM (payroll and federal and state income taxes).

Wealth Following Kaplan et al. (2014) and Aguiar et al. (2020), liquid assets are the sum of checking and savings (checking or savings accounts, money market funds, certificates of deposit, government bonds, and treasury bills) and stocks (shares of stock in publicly-held corporations, stock mutual funds, and investment trusts). Liquid debt is all debts other than mortgages (credit card charges, student loans, medical or legal bills, or loans from relatives). Net liquid wealth is liquid assets minus liquid debt. Net illiquid wealth is the sum of the household's home equity (the home value minus mortgages), plus the value of other real estates (net of debt), the value of any business or farm (net of debts), the value of any vehicles (net of debt), and holdings of IRAs and other pensions. Net worth is the sum of net illiquid and net liquid wealth.

Sample Selection To construct my panel in the PSID, I define the focal person in the household as the head (or reference person). I consider all households whose head is between 25 and 80 years old, but I focus on working-age heads in most regressions. To minimize the bias caused by outliers and measurement error, I trim total income below $2,000.00 or above the 99th percentile of its wave distribution and total expenditure below the 1st or above the 99th percentile of its wave distribution. After the previous sample selection and considering only entries without missing information in any of the used demographic characteristics, the sample has 18,213 observations corresponding to 5,724 households. Appendix B.1 presents some sample descriptions.

[9] In the PSID, when the head or spouse works any actual hours in their business/farm, the earned income is arbitrarily divided into labor and asset income (half for each). The IRS does not follow that process for taxing an individual's business/farm income. Following Kimberlin, Kim, and Shaefer (2014), both business/farm labor and asset income are treated as wages/salary for TAXSIM purposes and not as property income.

[10] Because I explore two ways of accounting for expenditure on shelter, I also consider two ways of accounting for the implicit rent for homeowners. When expenditure on shelter is the sum of rent for renters and implicit rent for homeowners, I follow Aguiar et al. (2020) and add 6 percent of the respondent's assessed home equity value in their total income to account for the implicit rent on their home. When expenditure on shelter is the sum of rent for renters, mortgage payments, and property taxes, I do not include implicit rent as income.

3.2 Estimating Permanent Income

Permanent Income for household i at time t is its current assets, $A_{i,t}$, plus its discounted future expected path of income, $Y_{i,t}$:

$$\mathrm{PI}_{i,t} = A_{i,t} + \mathbb{E}_{i,t}\left[\sum_{j=1}^{J_i} \frac{Y_{i,t+j}}{R^j}\right]. \tag{1}$$

The expectation is computed using all available information for the household i at time t, such that $\mathbb{E}_{i,t}[\cdot] = \mathbb{E}[\cdot|I_{i,t}]$ with $I_{i,t}$ denoting the information set. J_i is the household's expected death period. R is a discount rate.

To compute permanent income, it is necessary to have an estimate of the expected path of income for each household. I assume lagged income and some demographic characteristics describe the information set. The household and the econometrician have the same information set. Let $g(\mathbf{Y}_i^{t-1}, \mathbf{X}_{i,t})$ be the function that approximates the expectation process formation, where $\mathbf{Y}_i^{t-1}$ is a vector with past income realizations, and $\mathbf{X}_{i,t}$ is a vector with some demographic characteristics. For the exposition, $g(\cdot)$ is the same for every household, but I later allow it to be group-specific (e.g., industry- or occupation-specific). Given the information set assumption, I restrict $g(\cdot)$ to linear autoregressive processes, which are the best linear approximation (under quadratic loss) to the conditional mean $E(Y_t|\mathbf{Y}_i^{t-1}, \mathbf{X}_{i,t})$. I estimate all equations by OLS (in other words, I use the "linear least squares forecast").

When estimating the process parameters to construct future expected income in period t, I restrict the sample to observations collected before t. This deal with the fact that, for example, the income realization in 2000 is not in the household's information set in 1980. Thus, the log income $\ln Y_{i,\tau}$ in period $\tau \in \{t-x, \cdots, t\}$ is described by an autoregressive income process with parameters θ^t. The t-subscript is the last year in the sub-sample (i.e., the year that indexes the information set). For each permanent income estimate, I use the same number of sample years when estimating the income process.

As a benchmark, I use an 2-nd order autoregressive process. For $\tau \in \{t-x, \cdots, t\}$, the log income follows

$$\ln Y_{i,\tau} = \theta_0^t + \rho_1^t \ln Y_{i,\tau-1} + \rho_1^t \ln Y_{i,\tau-2} + \mathbf{X}_{i,\tau}\theta_1^t + \epsilon_{i,\tau}\ , \tag{2}$$

in which log income is a function of two lagged incomes, demographic characteristics, $\mathbf{X}_{i,\tau}$, and an error term, $\epsilon_{i,\tau}$. The latter captures in-sample forecast error, $\ln Y_{i,\tau} - \mathbb{E}_{i,t}[\ln Y_{i,\tau}]$, and approximation error, $\mathbb{E}_{i,t}[Y_{i,\tau}] - g(\ln Y_{i,\tau-1}, \ln Y_{i,\tau-2}, \mathbf{X}_{i,\tau}; \theta^t)$. Subsection 4.4 addresses concerns that my expectation measure captures households' expectations imperfectly. Firstly, I compute several point forecast evaluation statics in the in-sample and out-of-sample forecast errors (e.g., bias, error variance, mean squared error, and predictive R square). Secondly, I test whether the forecast errors are unforecastable using other variables available in the household's information set.

Using the estimated income process, I construct the expected income path for each household:

$$\begin{aligned} \mathbb{E}\Big[\ln Y_{i,t+1}\Big|I_t\Big] &= \mathbb{E}\Big[\ln Y_{i,t+j}\Big|\ln Y_{i,t}, \ln Y_{i,t-1}, \mathbf{X}_{i,t}\Big] \\ \ln \widehat{Y}^t_{i,t+1} &= \widehat{\theta}^t_0 + \widehat{\rho}^t_1 \ln Y_{i,t} + \widehat{\rho}^t_2 \ln Y_{i,t-1} + \mathbf{X}_{i,t}\widehat{\theta}^t_1 \ , \end{aligned} \tag{3}$$

in which $\ln \widehat{Y}^t_{i,t+1}$ is the expected log income in period $t+1$ using the information set in t. Then, to forecast log income in periods after $t+1$, I iterate forward equation 3, updating income and age but keeping other variables constant at their period t realization.[11]

For a significant fraction of households, retirement wealth, mainly through social security wealth, is the primary source of income when older. So, the expectation of household income when retired has to be forecasted. When forming expectations, I assume households under 63 years old retire at 65, and their income is 45% of their last pre-retirement income forecast.[12] For households who are retired or disabled, I forecast their future income using the estimated income process. Also, for households who are working after 65, I forecast their future income using the estimated income process.

I express expected future income in present value terms using a constant interest rate and age-specific survival probabilities. First, I set the interest rate R to 5%[13]. Second, I obtain death probability from the US Life Tables computed by the National Vital Statistics System. For example, for a household aged 30 in 2020, I discount the expected income at age 65 by $\frac{0.79}{(1.05)^{30}}$, the survival probability divided by the compounded discount rate. I further assume that individuals die with certainty after 100 years old.

Lastly, I use net worth (the value of assets net of the debt value) as my empirical measure of assets. Combining all the elements, the empirical implementation of permanent income for

[11]For instance, the expected log incomes in period $t+2$ and $t+3$ are:

$$\begin{aligned} \ln \widehat{Y}^t_{i,t+2} &= \widehat{\theta}^t_0 + \widehat{\rho}^t_1 \ln \widehat{Y}_{i,t+1} + \widehat{\rho}^t_2 \ln Y_{i,t} + \mathbf{X}_{i,t+1}\widehat{\theta}^t_1 \\ \ln \widehat{Y}^t_{i,t+3} &= \widehat{\theta}^t_0 + \widehat{\rho}^t_1 \ln \widehat{Y}_{i,t+2} + \widehat{\rho}^t_2 \ln \widehat{Y}_{i,t+1} + \mathbf{X}_{i,t+2}\widehat{\theta}^t_1 \ . \end{aligned}$$

Observe that: 1) the previous estimates are used in the forecast equation, and 2) the income process parameters are fixed and indexed by the subscript t, meaning that only variables in the information set are used in the estimation.

[12]This replacement rate is consistent with data presented by Diamond and Gruber (1999). They also simulated the retirement incentives for a "typical" household in the US social security, showing that the system causes a disincentive to additional work after 65 years old.

[13]My results are robust to different values of R.

household i in period t, $\text{PI}_{i,t}$, is:

$$\widehat{\text{PI}}_{i,t} = \text{net worth}_{i,t} + \sum_{j=1}^{age_i(t+j)=100} \frac{\psi\Big(age_i(t), age_i(t+j)\Big)}{(1.05)^j} \widehat{\text{Y}}^t_{i,t+j}.$$

$age_i(t)$ returns the age of household i as a function of the time period. $\psi(a_1, a_2)$ returns the survival probability of an individual aged a_1 surviving until age a_2.

Mapping to the data The PSID runs biannually after 1999, the years I focus my analysis. So I assume that the income at period t is a function of income at $t-2$ and $t-4$, cubic in age, dummies for educational attainment, marital status, census region, and occupation and industry groups. I use the data from the past 16 years to estimate the income process. As robustness, I allow the parameters of the income process to vary by occupation or industry.

Measurement error Survey data is subject to measurement error, which biases downward the estimated coefficient. Using noisy data to construct permanent income will also imply a noisy measure. Under classical measurement error, my measure of permanent income is unbiased. Moreover, instrumental variables can deal with measurement errors. The formal discussion is in Appendix A.

[14]

3.3 Econometric approach

I measure the consumption elasticity to permanent income by estimating the following linear regression

$$\log c_{i,t} = \beta_0 + \beta_1 \log \widehat{\text{PI}}_{i,t} + \boldsymbol{X}_{i,t}\beta_3 + \epsilon_{i,t} \; , \tag{4}$$

in which $\boldsymbol{X}_{i,t}$ is a vector of demographic controls for household i at time t. In particular, it has cubic in age, year fixed-effect, and dummies for education groups, marital status, census region, and family size.

My identification strategy relies on the assumption that idiosyncratic taste shocks or consumption measurement errors are orthogonal to the permanent income measure, conditional on demographic controls and time-fixed effects. The demographic variables control for some of the

[14]Using logit models, Pfeffer and Griffin (2015) ask which variables forecast extreme fluctuations in measured wealth in the PSID. They find that demographic variables account for a greater share of the variation. Moreover, "measurement issues" have small predictive power. With measurement issues, they refer to i) wealth having some imputed component or ii) a change in the interview respondent (e.g., the head in some wave and the spouse in another).

correlations related to preference heterogeneity, in line with Attanasio and Weber (1995). The time-fixed effects control for any business cycle impacts.

Aguiar and Bils (2015) find evidence of non-classical measurement error in the Consumer Expenditure Survey (CE). In particular, they found that richer households are more likely to underreport their spending. This type of measurement error should not be a concern to my exercise. First, I use data from the PSID, which has been shown not to display evidence of a downward trend in the coverage expenditure data (Blundell et al., 2016). Second, my exercise looks at how average consumption is related to average permanent income in the cross-section. The exercise does not look at how the estimated elasticity changes over time or across the permanent income distribution. Third, I recover a similar elasticity using different consumption measures. However, if non-classical measurement errors were important in my exercise, the estimated elasticity would be different for these different consumption measures. I discuss the implications of non-classical measurement error in more detail when discussing the results.

4 Empirical Results

In this section, I present my empirical results. Subsection 4.1 provides evidence of the under-response of consumption to permanent income. After documenting the basic facts, it digs into the mechanism behind this data pattern. First, I show that consumption depends on when its lagged permanent income. Second, I use demand systems to show that high past expenditures are associated with less easy-to-adjust goods consumption and higher hard-to-adjust goods consumption. Subsection 4.2 provides evidence that the under-consumed income goes to asset accumulation. First, I show that the household's budget constraint holds in the data, i.e., the reported consumption and income are consistent with its reported assets. Second, I show that households that are locked in accumulate more assets.

Throughout the paper, I report bootstrap estimates of the standard errors since permanent income is a generated regressor.

4.1 Consumption Elasticity to Permanent Income

Table 1 reports the OLS estimates of equation 4. The first column displays the consumption response to the estimated permanent income measure. For each 1% increase in permanent income, the household's consumption increases by 0.7%. Straub (2019) and Abbott and Gallipoli (2019) also find similar estimates. This number is odd with the prediction of benchmark consumption models, which predicts an elasticity close to 1. A possible concern is that measurement error in income biases downward my estimates. For that, I instrument the log of permanent income with lagged income. The second column shows that, once instrumented, the consumption elasticity to permanent income is still far from the elasticity of benchmark models. Column 1 of Table 1 is my baseline specification. It uses the consumption categories available in the PSID since 1999. The results hold using different measures of consumption, which is shown in Table 9 of Appendix B.

Table 1: Path Dependence on the Expenditure Response to Permanent Income

	(1)	(2)	(3)
	log(expenditure)	log(expenditure)	log(expenditure)
log(PI)	0.57	0.54	0.42
	(0.01)	(0.01)	(0.01)
$\log(\mathrm{PI}_{t-10})$			0.19
			(0.02)
N	54970	15180	15180

The model in Section 2 gives some reference values to interpret my empirical results. The results in Table 1 show that consumption growth under-responds to income growth relative to the prediction of a stylized Permanent Income Hypothesis model. However, a concern is that I am not dealing with measurement errors, and this would bias my estimates toward zero. Another concern is that the realized income growth is a combination of transitory and permanent income and that I am restricting the consumption response to be the same for both shocks. This restriction goes against the predictions of the theory and the empirical evidence. For example, Blundell et al. (2008) find that a 10 percent permanent income shock induces a 6.4 percent permanent change in consumption. In contrast, a 10 percent transitory income shock is associated with a 0.5 percent permanent change in consumption. To address these concerns, I proposed in Subsection X an IV strategy that relies on restrictions on the income process to identify permanent income changes. I address concerns about the quality of my expected income growth measure in Subsection 4.4.

Age Groups

Table X reports the IV estimates of equation (4). I instrument period t average income growth with period $t-2$ average income growth. For example, I instrument the average income growth between 1999 and 2009 with the average income growth between 1997 and 2007. The first, second, and third columns display the consumption growth response to, respectively, expected income growth, realized income growth, and both measures.[15] The consumption response to expected

[15]Because the specification in column (1) has no realized income growth as a regressor, the estimation method is OLS.

consumption growth is small in column (1) and, once controlling for realized income growth, it is not statistically significant. However, consumption presents a stronger response to realized income growth than observed in Table 1. Column (3) shows that, for each 1 log point average income growth, consumption growth increases 0.421 after controlling for expected income growth at period t. The IV estimates are capturing the consumption response to permanent income growth. This response should be stronger than the response to realized income growth, which is a mixture of permanent and transitory shocks and measurement error. The magnitude of the consumption response is robust when using different measures in columns (4), (5), and (6). The first stage F is high and does not raise any concerns about weak instruments.

Table 2: Consumption Response by Age Groups

	(1) All Sample	(2) 25<age<35	(3) 35<age<45	(4) 45<age<55	(5) 55<age<65
log(PI)	0.57	0.64	0.65	0.59	0.48
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
N	54970	14770	17556	15704	11475

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Table 3: Path Dependence on Consumption Response by Age Groups

	(1) All Sample	(2) 35<age<45	(3) 45<age<55	(4) 55<age<65
log(PI$_t$)	0.42	0.58	0.49	0.34
	(0.01)	(0.03)	(0.02)	(0.02)
log(PI$_{t-10}$)	0.19	0.09	0.18	0.23
	(0.02)	(0.04)	(0.03)	(0.03)
N	15180	4322	5900	6054

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Measurement error

Table X highlights the importance of dealing with measurement error and identifying permanent income shocks. Consumption growth responds strongly to income growth in column (3) of Table X compared to column (3) of Table 1. The estimated coefficients are statistically different, with the IV being almost twice as larger. These results are consistent with the prediction of the Permanent Income Hypothesis. First, consumption should respond only to the unexpected income component. The agent optimally chooses consumption given their future expectation, so he should have already incorporated any known income growth in current consumption. Second, consumption should strongly respond to permanent income changes. Permanent changes impact more the present value of future income than transitory changes. However, I also document that consumption growth under-responds to income growth, given the prediction of a stylized Permanent Income Hypothesis model – the Certainty Equivalent model of Section 2. Throughout the rest of the article, I use as my baseline results column (3) from Table X.

Different Income Process

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Different Expenditure Measures

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Different Asset Measures

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4.2 Asset Accumulation

So far, I have used PSID data on income and expenditure to document that the pass-through of income shocks to consumption is smaller than the one predicted by the Permanent Income Hypothesis. Income and consumption are tied together by the budget constraint, thus households must be saving if they are not consuming. An advantage of using the PSID is that, since 1999, it also collects biannually broad measures of wealth. In this subsection, I construct an implied net worth given the reported savings (income - consumption). This exercise is a consistency check on the data that aims to alleviate any concern with its quality. I also document the portfolio evolution of households followed over a certain amount of time by the survey.

The budget constraint for a household at period t is

$$C_t + A_{t+1} = (1 + r_t)A_t + Y_t \ ,$$

in which the left-hand side is the total expenditure, consumption plus next-period assets, and the right-hand side is cash on hand, last period assets after capital gains plus income. The budget constraint holds with equality since I am using it as an accounting identity.

The budget constraint can be expressed also as

$$A_{t+1} - A_t = Y_t - C_t + r_t A_t \ ,$$

in which the left-hand side is the total increase in assets and the right-hand side is savings, income minus consumption, plus capital gains on assets. Summing over T-periods, one gets

$$A_T - A_0 = \sum_{t=j}^{T}(Y_j - C_j) + \sum_{t=j}^{T} r_j A_j \, . \tag{5}$$

The asset increase between period t and period T is equal to the sum of each period savings and capital gains on assets.

I use this last form of expressing the budget constraint to construct a synthetic net worth, the net worth implied by the reported consumption and income. In the computation, I use my total expenditure[16] and income measures. However, I need to make some assumptions in the computation. First, I restrict the sample to households observed for 20 years. Second, the PSID is a biannual survey, so I approximate $(Y_t - C_t) + (Y_{t+1} - C_{t+1}) \approx 2 \times (Y_t - C_t)$. Third, the consumption categories that have been present on every PSID wave since 1999 capture about 70% of expenditures surveyed in the Consumer Expenditure Survey (CEX) and the US National Income and Product Accounts (NIPA). I scale-up consumption by 0.77, $C_t/0.77$. I use this slightly larger value given that it fits better the net worth distribution.

For last, A_t in Equation (5) is an aggregate measure that captures different asset classes.[17] It is worth remembering that total income includes asset income, as business income, farm income, dividends, interest, rents, trust funds, and royalties from the head and spouse. I compute capital gains for each asset class. I aggregate home equity, other real estate net worth, and farm and business net worth into a broad category and assume that their capital gain is given by the CPI-deflated price change of the S&P Case-Shiller U.S. National Home Price Index. The stock return is given by the CPI-deflated change of the Wilshire 5000 Price Index, which already excludes dividends distribution. The Individual Retirement Accounts (IRAs) return is constant and given by a 5% annual return. The return of vehicle net worth is a 15% annual depreciation rate. The checking or savings account return is the FED fund rate. I assume that the "other debt" interest rate is a 10% annual rate. For last, I assume that all the savings go into home equity. My results do not change when savings go into the private pensions account.

[16] In Subsection 3.1, I discussed two measures of consumption. For this exercise, I am using the consumption measure with reported expenditure in shelter and vehicles and without the implicit return of durable goods.

[17] In all PSID waves since 1999, one has measures of i) net-worth of farm or business, ii) checking or savings accounts, money market funds, certificates of deposit, governmental savings bonds, or treasury bills, iii) stocks, mutual funds, or investment trusts, iv) private annuities or Individual Retirement Accounts (IRAs), v) net worth of vehicles, vi) home equity (house value - mortgage balances), vii) Net worth of real estate, viii) other assets (bond funds, cash value in a life insurance policy, a valuable collection for investment purposes, or rights in a trust or estate), ix) other debt (credit card charges, student loans, medical or legal bills, or loans from relatives). The "other debt" was divided into different questions since the wave 2011. Student loans and credit card charges are the main components of this aggregate category.

Figure 3: Asset Path Implied by Expenditure and Income

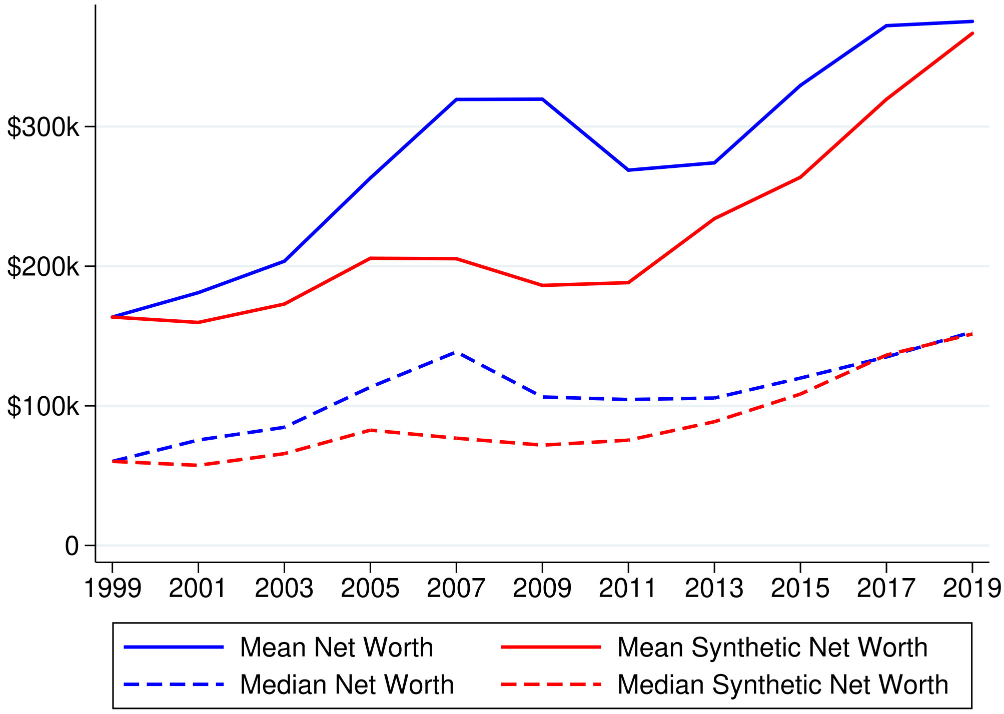

Figure 3 plots the mean reported net worth (blue line) and the mean synthetic net worth (red line). Both series move closely and have a similar level. However, the synthetic net worth does not capture well the increase and later decrease in net worth around the 2008 Financial Crisis. A possible explanation for the lower level of the synthetic measure is that the capital gains that I am using are too small for someone at the top of the wealth distribution. Indeed, Fagereng, Holm, Moll, and Natvik (2021) documents for Norway that wealthier households own assets that experience more capital gains. Figure 3 also plots the median reported net worth (blue dashed line) and the median synthetic net worth (red dashed line). Both series walks closely.

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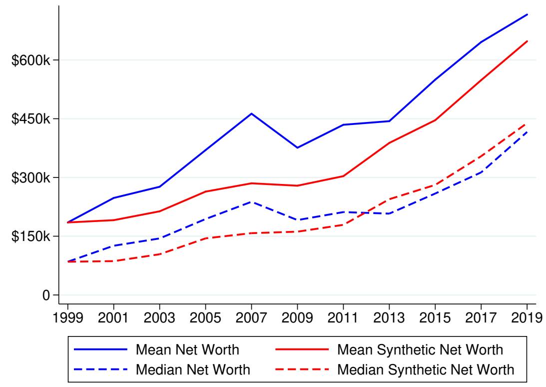
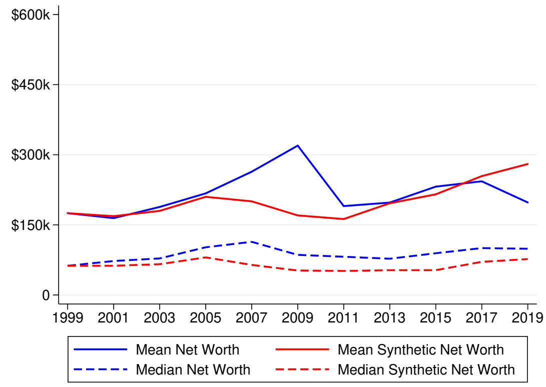
Figure 4: Asset Accumulation



(a) Positive PI growth



(b) Negative PI growth

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Table 4: Savings Response to Permanent Income

	(1) Savings Rate	(2) Savings Rate	(3) Savings Rate
log(PI)	0.13	0.14	0.21
	(0.01)	(0.01)	(0.02)
log(PI_{t-10})			-0.12
			(0.03)
N	49363	14701	14701

4.3 Expenditure Components

In the previous two subsections, I showed that households consume less from permanent income shocks than predicted by the Permanent Income Hypothesis and that income not consumed goes into wealth accumulation (housing and/or private pensions). In the current subsection, I explore the detailed categories available in the PSID. Households that experience higher unexpected permanent income growth consume more easy-to-adjust goods (as food, leisure, clothing) and less hard-to-adjust ones (as housing). In other words, households cannot optimally choose their consumption bundle and are locked in some consumption path for some goods.

I estimate demand systems to capture how past income growth is associated with the expenditure allocation among different goods, conditioned on a given level of total expenditures. Based on the almost ideal demand system (AIDS) of Deaton and Muellbauer (1980), I estimate

$$w_{hjt} = \alpha_{jt} + \beta_j \Delta \log y_{it} + \gamma_j \ln X_{ht} + \Gamma_j \mathbf{Z}_h + u_{hjt} \ , \tag{6}$$

in which h indexes household, j indexes expenditure component, t indexes time, $\mathbf{Z}_h$ are demographic controls, and w_{hjt} is the expenditure share of component j. I allow the past income growth from period $t-s$ to period t, $\Delta \log y_{it}$, to enter the specification. As in the previous section, I distinguish between realized and expected income growth. In the AIDS specification, the log of each component price index and the overall price index are normally used as controls. I use year-fixed effects to capture all the relative price effects.

In the AIDS specification, total expenditure appears on the right as a control and in the denominator on the left, making this specification vulnerable to measurement error. I deal with the measurement issue instrumenting realized income growth with past realized income growth and total expenditure with lagged total expenditure.[18] I assume that past permanent income shocks and the error term in the AIDS specification are not correlated. The discussion at the end of Subsection 3.3 should alleviate some concerns.

Table 5: Consumption Categories' Shares

	(1) Nondurable Share	(2) Shelter Share	(3) Nondurable Share	(4) Shelter Share
log(exp)	-11.09	4.70	-11.52	5.26
	(0.49)	(0.54)	(0.66)	(0.72)
Δ log(exp)			6.16	-8.52
			(1.55)	(1.68)
Engel Curve	0.79	1.18	0.78	1.20
Observations	26,046	26,046	9,588	9,588

Kleibergen-Paap rk Wald F statistic): 429.952 Kleibergen-Paap rk Wald F statistic): 12.490

Table 5 presents the results. Households with the same current expenditure level at period t,

[18]The standard practice is instrumenting log expenditure with some income polynomial and education dummies. I do not follow this practice because of two reasons. First, current income and past realized income growth are correlated. Using current income as an instrument would absorb the explanation of past realized income growth. Second, I use schooling to construct my measure of expected income growth. Using education dummies as an instrument would absorb the explanation of my expected income growth measure. These instruments for expenditure would make it harder to interpret the estimated coefficients.

but whose income paths were different, display different expenditure composition. The third column shows that households that expected higher income growth at period $t-10$ consume more shelter services, education services, recreation goods, trip services, and household improvements. These households consume fewer transportation services (bus fares and train fares, taxicabs, gas, and parking), food, and insurance. I discuss the expenditure on vehicles at the end of this subsection.

The first column shows that households that experienced higher unexpected permanent income growth between periods $t-10$ and t consume fewer shelter services and education services. These households consume more food away or delivered, trips services, and clothing. These results are consistent with households freely adjusting some goods (as food, leisure, clothing) but being locked in some hard-to-adjust ones (as education, housing).

An expenditure sub-component that does not follow the "locked-in" history is vehicles. One would expect that it would behave like the expenditure on shelter since both have hard-to-adjust characteristics. However, they have different adjustment costs since it is cheaper to change of car than of house. This result shows that the magnitude of the adjustment cost is central to understand the lock-in story. I estimate demand systems to capture how past expenditure growth is associated with the expenditure allocation among different goods, conditioned on a given level of total expenditures. The results still hold, even though these regressions are full of measurement error.

Reset Consumption Bundle

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Figure 5: Consumption Categories

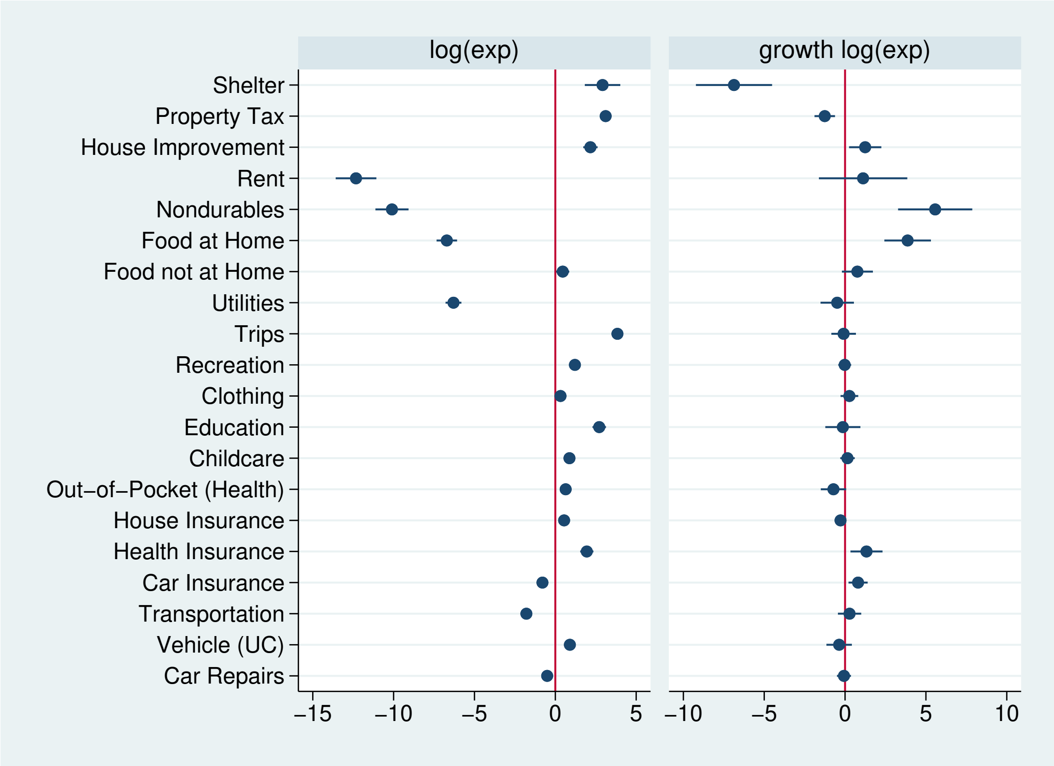

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Table 6: Heterogeneous Effect by Moved or Not

	(1) log(expenditure)	(2) Savings Rate
log(PI)	0.39	0.26
	(0.02)	(0.03)
$\log(\mathrm{PI}_{t-10})$	0.25	-0.15
	(0.02)	(0.04)
Moved $\times$ log(PI)	0.14	-0.07
	(0.02)	(0.04)
Moved $\times$ $\log(\mathrm{PI}_{t-10})$	-0.12	0.10
	(0.03)	(0.05)
N	14531	14531

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Table 7: Heterogeneous Effect by Moved or Not

	(1) Nondurable Share	(2) Shelter Share
log(exp)	-11.59	3.58
	(0.99)	(1.05)
Δ log(exp)	10.01	-16.97
	(2.54)	(2.85)
Moved $\times$ log(exp)	2.98	-2.84
	(1.03)	(1.11)
Moved $\times$ Δ log(exp)	-8.82	14.56
	(2.73)	(3.08)
N	10163	10163

4.4 Additional Results

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Parent-Child Pairs

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Asset when Dying

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Quality of the Expected Income Growth Measure

A possible concern with my empirical results is that my measure of expected income growth does not correctly measure agents' expectations. Indeed, I assume that a household information set, $\mathcal{I}_t$, is well captured by its geographic location and its head and spouse's schooling, industry, occupation, and age. However, the econometrician does not observe the information set, being my measure just an approximation of the true expectation. As noticed by Cunha, Heckman, and Navarro (2005) and Blundell et al. (2008), if part of this unexpected income growth were known in advance by the agent, then the permanent income hypothesis would argue that they should already be incorporated into current plans and would not directly affect consumption growth. In this case, the under-response of consumption that I estimate would be capturing advance information.

The results in Table 5 already point into the direction that the measure of expected income growth explains expenditure in categories in which the planing (or expectation) component are important, as housing, education, and health. To further alleviate concerns with my measure, I provide evidence that advanced information is not a serious problem. By the permanent income hypothesis, current consumption is a function of the expected income growth and should forecast future income growth. In other words, if known, income growth should be positively correlated with consumption at t even after controlling for my expected income growth measure. This result shows that my measure captures at least some of the household income growth expectations. In the appendix B.7, I explore further this result.

5 Quantitative Model

In the previous sections, I documented how consumption response to permanent income shocks depends on past consumption commitments, mainly housing choices made in the past. In this section, I draw some lessons from these finds. The literature has found that high-wealth households have high-wealth children, with luxury bequests being an important source of perpetuating wealth in the dynasty. How much is this intergeneration wealth persistence explained by preferences and restrictions on the household's budget set?

I answer this question by revisiting the canonical incomplete markets model that has been the benchmark model for studying consumption data. To this end, I write a life-cycle model in which households must insure idiosyncratic labor risk using a single risk-free bond, subject to a borrowing constraint. In addition, they choose two consumption commodities, housing, which is subject to nonconvex adjustment cost, and nondurable, which is freely adjustable. The model also has other sources of intergeneration wealth persistence.

5.1 Environment

I consider the problem of a continuum of households. Each period corresponds to one year in the model, such that j index the age of the household. Households are "born" at age $j = 1$, corresponding to a biological age of 25, retire at model age $R = 40$ (biological age 65), and die with certainty at model age $J = 65$ (biological age 90). After retiring, agents face a positive mortality rate from age j to $j + 1$. They discount flow utility at the rate β.

Households have preferences over an aggregated consumption bundle composed of two consumption commodities, housing flow and nondurable. Specifically, agents have flow utility over the consumption bundle c, which uses as inputs housing consumption h and nondurable consumption n. I assume a Cobb-Douglas aggregator following Berger and Vavra (2015), which implies that the elasticity of substitution between consumption inputs is 1. Estimates of the elasticity of substitution tend to be around slightly above one.

$$c = g(h, n) = h^{\nu}\, n^{1-\nu}$$

Dynan, Skinner, and Zeldes (2004), Straub (2019), and others have identified in the data that households with higher lifetime incomes save more than predicted by simple homothetic preference models. The main reasons for this saving behavior are intergenerational transfers (such as bequests) and other expenses later in life (such as health expenditures). I capture these different motives using non-homothetic preferences as Straub (2019) and luxury bequest motives as De Nardi (2004). In particular, preference for a household at age j is given by

$$u_j(c) = \frac{c^{1-\sigma_j} - 1}{1 - \sigma_j}$$

where $\sigma_j > 0$ is an age-dependent elasticity. As Straub (2019) the age profile in consumption elasticities follows a simple exponential decay, $\sigma_{j+1}/\sigma_j = \sigma_{slope}$ during one's working life and flat thereafter. The model is parameterized such that σ_j is lower for higher ages, which implies that consumption when older has high-income elasticity. In other words, high-income households have a back-loaded consumption profile. Preferences over bequests are given by

$$\mathcal{B}(a, h) = \frac{\phi_1}{1 - \sigma} \left(1 + \frac{a + h}{\phi_2}\right)^{1-\sigma}$$

in which a is a risk-free bond and h is the housing stock. I assume that both are perfectly substitute in the bequest function, implying that households are indifferent between leaving bonds or housing stock to their children.

Households are subject to idiosyncratic labor income risk. The labor productivity process follows a Markov process plus a common deterministic, age-related component. In particular, for household i at age j, the process is

$$\begin{aligned} z_t^i &= b_1 t + b_2 t^2 + \bar{z}^i + \alpha_t^i + \epsilon_t^i \\ \alpha_t^i &= \rho \alpha_{t-1}^i + \xi_t^i \end{aligned}$$

where b_1 and b_2 define the age-specific deterministic component, $\bar{z}^i$ is an individual-specific fixed effect, α_t^i is a persistent component of productivity that follows an AR1 process, and ϵ_t^i is a transitory independent and identically distributed iid component. The fixed effect $\bar{z}^i$ is a function of the agent's parent household fixed effect, and the shocks ν_t^i and ϵ_t^i are independent of each other iid across i and j. Each shock follows a Normal distribution with respective variance $\sigma_i^2, i = \bar{z}, \epsilon, \xi$. The total labor income is given by $w \times exp(z)$, where w denotes the aggregate market wage per efficiency unit of labor.

Households invest in a risk-free asset, which carries a risk-free rate r, and in housing stock, which provides utility flow and depreciates at a rate delta each period. To adjust the latter (and, consequently, the housing consumption), households must pay nonconvex adjustment costs

(Grossman and Laroque, 1990; Berger and Vavra, 2015),

$$\mathcal{A}(h, h_{-1}) = \begin{cases} 0 & \text{doesn't adjust} \\ \kappa h_{-1} & \text{does adjust} \end{cases}$$

However, they can adjust their nondurable consumption freely. For last, households are subject to a borrowing constraint, which is a function of their housing stock.

Once retired, household i lives off of financial wealth, ai, and social security benefits, Si. The benefits are calibrated as X.The household can also sell its housing stock and consume some of its value.

- Agent's problem in recursive form

$$V(s) = \max\ u(g(n, h)) + (1 - \psi_t)\beta\mathcal{B}(a, h) + \psi_t\beta\mathbb{E}\{V(s')|s\} \tag{7}$$

subject to

$$a' = \begin{cases} w * \exp(z) + (1 + r)a - n & \text{doesn't adjust} \\ w * \exp(z) + (1 + r)a - n - h - \kappa h_{-1} & \text{does adjust} \end{cases}$$

$$a' \geq -\mu d$$

$$n, d > 0$$

- State vector $s = \{a, h_{-1}, \bar{z}, \alpha, \epsilon, t\}$

- Partial equilibrium, $w = 1$ and $r = 0.04$

6 Conclusion

In this paper I provide evidence for the under-response of consumption growth to income growth. I also construct a measure of expected income growth assuming the household information set is well captured by some observable variables and show that consumption growth does not respond to this measure. To understand the economic mechanism, I provide evidence that this under-response is associated with housing consumption. I show that agents with positive income growth accumulate asset faster. I also show that households that experience higher unexpected permanent

Parameters	Description	One-Good Model	Two-Good Model
	Preferences		
β	Discount factor	0.95	0.95
σ	CRRA	2.00	2.00
θ	Consumption aggregator	NA	0.88
ϕ_1	Bequest preference (weight)	-9.50	-9.50
ϕ_2	Bequest preference (luxury)	11.60	11.60
	Income Process		
b_1	Linear trend	0.03	0.03
b_2	Quadratic trend	-0.0007	-0.0007
$\sigma_{\bar{z}}$	Fixed-effect variance	0.17	0.17
σ_{ϵ}	Transitory variance	0.12	0.12
σ_{ν}	Persistant variance	0.02	0.02
ρ	Persistance parameter	0.98	0.98
	Other		
κ	Adjustment cost	NA	0.25
μ	Collateral	NA	0.00

income growth consume more easy-to-adjust ones (as food, leisure, clothing) and less hard-to-adjust ones (such as housing). These facts push for an explanation in which households can freely adjust some goods but are locked up in some hard-to-adjust ones.

As a future step, I want to quantitatively explore the implication of the described mechanism extending a standard incomplete markets life cycle model to include two consumption goods, one of which is hard-to-adjust. I will model the hard-to-adjust good by assuming that the agent pays an adjustment cost to change the quantity consumed. Then, I will check if this modified model can account for the facts documented in the data and compare it to a canonical one-good model. I also use the model to test other explanations of the consumption excessive smoothness to permanent income. For example, Straub (2019) documents a concave relationship between consumption and permanent income. In his quantitative model, non-homothetic preferences are the key mechanism to generate this concavity. I suspect that his preferences are capturing a greater concavity generated by housing consumption. As noticed by Chetty and Szeidl (2007), if agents follow an (S,s) policy rule over housing consumption, the shape of the value function over wealth, v(W), changes relative to a benchmark (no housing) in two ways. First, within the (S,s) band, the curvature of the value function is greater than it would be if housing were freely adjustable. Second, there are non-concavities at the edges of the (S,s) band.

There are two avenues related to this project that are worth exploring in the future. First, I would like to understand how under-response of consumption and asset accumulation interact with intergenerational transfers (as bequest). Second, I would like to understand how the under-response of consumption interacts with uncertainty. The residual of equation (2) is a natural first place to look if one wants to construct a measure of uncertainty.

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A Measurement Error in Income

Let $Y_{i,t}$ be the observed income for household i in period t, which is a noisy measure of its actual income, $Y^*_{i,t}$. The measurement error is log-additive, such that

$$\log Y_{i,t} = \log Y^*_{i,t} + v_{i,t}.$$

Denote logged variables as lowercase, $x_{i,t} = \log(X_{i,t})$. I assume that the unobservables, $y^*_{i,t}$ and $v_{i,t}$, are mutually independent with variances σ^2_* and σ^2_v.

To simplify the notation, I will drop the i subscript. Let one-lagged income be a sufficient statistic for the household's information set, so the best linear forecast for y^*_{t+1} is

$$\widehat{y}_{t+1} = \rho y_t = \rho y^*_t + \rho v_t \ ,$$

where v_t is a measurement error. Clearly, $\widehat{y}_{t+1}$ is an unbiased forecast for y^*_{t+1} since $E(\widehat{y}_{t+1}) = \rho y^*_t$. Moreover, the difference between y^*_{t+1} and $\widehat{y}_{t+1}$ will be a forecast error, $y^*_{t+1} - \rho y^*_t$, and the measurement error, ρv_t.

In my empirical application, I measure expected income using income forecasts from an autoregressive process. To see how measurement error will impact my permanent income measure, index the year of the information set as 0 such that $\widehat{Y}_1$ is the forecast 1 year ahead, $\widehat{Y}_2$ is the forecast 2 years ahead, and so on. Given my already-stated assumption,

$$\begin{aligned}
\widehat{Y}_1 &= \exp(\widehat{y}_1) = \exp(\rho y^*_0 \ + \rho v_0) \ \ = \ \exp(\rho y^*_0) \exp(\rho v_0) \\
\widehat{Y}_2 &= \exp(\widehat{y}_2) = \exp(\rho^2 y^*_0 + \rho^2 v_0) = \exp(\rho^2 y^*_0) \exp(\rho^2 v_0) \\
&\vdots \\
\widehat{Y}_j &= \exp(\widehat{y}_j) = \exp(\rho^j y^*_0 + \rho^j v_0) = \exp(\rho^j y^*_0) \exp(\rho^j v_0)
\end{aligned}$$

My empirical measure of PI will be

$$
\begin{aligned}
\widehat{\mathrm{PI}}_t &= \sum_{j=1}^{J} \frac{\widehat{Y}_j}{R^j} = \sum_{j=1}^{J} \frac{\exp(\rho^j y_0^*)\exp(\rho^j v_0)}{R^j} \\
&\approx \sum_{j=1}^{J} \frac{\exp(\rho^j y_0^*)}{R^j}(1+\rho^j v_0) \\
&= \sum_{j=1}^{J} \frac{\widehat{Y}_j^*}{R^j} + v_0 \sum_{j=1}^{J} \left(\frac{\rho^j}{R^j}\right) \exp(\rho^j y_0^*) \\
&= \sum_{j=1}^{J} \frac{\widehat{Y}_j^*}{R^j} + v_0 f(y_0^*) \,,
\end{aligned}
$$

in which I used the approximation $\exp(\rho^j v_0) \approx 1 + \rho^j v_0$ in the second line. $f(y_0^*)$ is a general function of y_0^*.

Any regression that uses a Permanent Income measure constructed using Y_t as an explanatory variable will suffer attenuation bias. I deal with this problem using two approaches. First, the classical measurement error implies that $E[v_0 f(y_0^*)] = E[f(y_0^*)E[v_0|f(y_0^*)]] = 0$ and traditional instrumental variables can be used.[19] For example, y_{-1} is a good instrument. Second, I perform an IV estimation for each forecast before constructing PI. In detail, since $\widehat{y}_1 = \rho y_0^* + \rho v_0$, I instrument $\widehat{y}_1$ with, for example, y_{-1}. With a corrected measure for $\widehat{y}_1^*$, I construct PI.

[19]In the univariate case, the IV estimator is

$$
\frac{\mathrm{Cov}(z,y)}{\mathrm{Cov}(z,x)} = \frac{\mathrm{Cov}(z,y^*)}{\mathrm{Cov}(z,x)} + \frac{\mathrm{Cov}(z,f(y^*)v)}{\mathrm{Cov}(z,x)} = \frac{\mathrm{Cov}(z,y^*)}{\mathrm{Cov}(z,x)} + \frac{E[zvf(y^*)]}{\mathrm{Cov}(z,x)} = \frac{\mathrm{Cov}(z,y^*)}{\mathrm{Cov}(z,x)}
$$

B Additional Tables and Figures

B.1 Sample Description

B.2 Alternative Definitions

Table 8: Different Measures of Permanent Income

	log(expenditure)
log(PI), AR(1) process	0.57
	(0.01)
log(PI), industry-specific AR(1)	0.58
	(0.01)
log(PI), occupation-specific AR(1)	0.56
	(0.01)
log(PI), AR(1) with total income	0.60
	(0.01)
log(PI), AR(2) process	0.55
	(0.02)

Sample: 53327, 39427.

Column 1 of Table is my baseline specification. It shows that consumption growth, for every 1 log point increase in realized income growth, average consumption growth increases 0.226 after controlling for the expected income growth. Columns (4), (5), and (6) display the specification of column (3) but using other measures of consumption. Column (4) uses an alternative measure of total consumption with differently constructed expenditure in shelter and vehicles. Column (5) uses non-durable consumption. Column (5) uses a broad measure of consumption constructed using the set of goods available in the PSID after the 2005 wave. All results are in line with the baseline result in column (3). Consumption does not respond to the expected income growth and under-responds to the unexpected component of income.

Table 9: Different Measures of Expenditure

	log(PI)
log(exp), categories available in 1999	0.57
	(0.01)
log(exp), categories available in 1999, alt. measure	0.53
	(0.01)
log(exp), categories available in 2005	0.62
	(0.01)
log(exp), categories available in 2005, alt. measure	0.58
	(0.01)
log(exp), nondurables categories	0.47
	(0.01)

Sample: 54752 42323

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

Table 10: Different Measures of Asset

	log(PI)
PSID Measuerd Net Worth	0.59
	(0.01)
Net Worth plus Retirement Accounts	0.58
	(0.01)
Price-adjusted Net Worth	-
	-

Sample: 55320.

The table "Different Measures of Expenditure" presents the results of a study on the relationship between different measures of wealth and logarithm of personal income (log(PI)). The table presents three different measures of wealth: PSID Measured Net Worth, Net Worth plus Retirement Accounts, and Price-adjusted Net Worth. The first two rows of the table show the correlation coefficient between each measure of wealth and log(PI), along with the corresponding standard error in parentheses. The third row, Price-adjusted Net Worth, does not have a correlation coefficient and standard error because it is not included in the study. This table suggests that there is a positive correlation between these measures of wealth and log(PI).

B.3 Measurement Error

Table 11: Baseline Correcting for Measurement Error

	OLS		IV	
	(1)	(2)	(3)	(4)
	log(expenditure)	log(expenditure)	log(expenditure)	log(expenditure)
log(PI)	0.57	0.59	0.61	0.79
	(0.01)	(0.02)	(0.01)	(0.02)
N	54970	54970	54970	54970

Kleibergen-Paap Wald rk F statistic 1676.73 Kleibergen-Paap Wald rk F statistic 616.34

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Table 12: Path Dependence Correcting for Measurement Error

	OLS		IV	
	(1) log(expenditure)	(2) log(expenditure)	(3) log(expenditure)	(4) log(expenditure)
log(PI)	0.44	0.48	0.51	0.64
	(0.02)	(0.02)	(0.03)	(0.03)
log(PI$_{t-10}$)	0.15	0.16	0.14	0.30
	(0.01)	(0.02)	(0.03)	(0.04)
N	15180	15180	15180	15180

Kleibergen-Paap Wald rk F statistic 148.55 Kleibergen-Paap rk Wald F statistic): 156.30

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Table 13: Savings Response Correcting for Measurement Error

	OLS		IV	
	(1)	(2)	(3)	(4)
	Savings Rate	Savings Rate	Savings Rate	Savings Rate
log(PI)	0.22	0.24	0.19	0.24
	(0.02)	(0.03)	(0.03)	(0.04)
$\log(\mathrm{PI}_{t-10})$	-0.13	-0.14	-0.11	-0.18
	(0.03)	(0.04)	(0.04)	(0.05)
N	14402	14402	14402	14402

Kleibergen-Paap rk Wald F statistic): 183.059 Kleibergen-Paap Wald rk F statistic 193.70

Instrument, expenditure.

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Table 14: Consumption Response by Age Groups

	(1) All Sample	(2) 25<age<35	(3) 35<age<45	(4) 45<age<55	(5) 55<age<65
log(PI)	0.61	0.63	0.64	0.61	0.54
	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
N	54970	14770	17556	15704	11475

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Table 15: Path Dependence on Consumption Response by Age Groups

	(1) All Sample	(2) 35<age<45	(3) 45<age<55	(4) 55<age<65
$\log(\mathrm{PI}_t)$	0.51	0.65	0.56	0.40
	(0.03)	(0.05)	(0.04)	(0.04)
$\log(\mathrm{PI}_{t-10})$	0.14	0.02	0.11	0.22
	(0.03)	(0.06)	(0.04)	(0.05)
N	15180	4322	5900	6054

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B.4 Results by Ownership

Table 16: Heterogeneous Effect by Own or Not

	(1) log(expenditure)	(2) Savings Rate
log(PI)	0.49	0.16
	(0.03)	(0.04)
$\log(\mathrm{PI}_{t-10})$	0.15	0.01
	(0.03)	(0.04)
Own $\times$ log(PI)	-0.07	0.12
	(0.03)	(0.04)
Own $\times$ $\log(\mathrm{PI}_{t-10})$	0.04	-0.14
	(0.03)	(0.05)
N	14164	14164

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Table 17: Heterogeneous Effect by Own or Not

	(1) Nondurable Share	(2) Shelter Share
log(exp)	-2.24	-3.76
	(1.04)	(1.21)
Δ log(exp)	-0.16	-2.01
	(1.39)	(1.57)
Moved $\times$ log(exp)	-13.38	11.01
	(1.10)	(1.23)
Moved $\times$ Δ log(exp)	4.30	-6.23
	(1.96)	(2.09)
N	9831	9826

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B.5 Parent-Child Pairs

Table 18: Child-Parent Pairs

	OLS		IV	
	(1)	(2)	(3)	(4)
	Child's log(exp)	Child's log(exp)	Child's log(exp)	Child's log(exp)
Child's log(PI)	0.558	0.559	0.532	0.802
	(0.019)	(0.019)	(0.022)	(0.040)
Dad's log(PI)	0.057	0.069	0.072	0.141
	(0.013)	(0.014)	(0.026)	(0.029)
Dad's log(PI$_{t-10}$)	0.039	0.042	0.047	0.051
	(0.015)	(0.015)	(0.031)	(0.036)
N	7846	7846	7846	7846

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Bequest

Table 19: Bequest

	(1) wrt bequest	(2) wrt bequest	(3) log(bequest)	(4) log(bequest)
log(PI)	0.174	0.063	0.626	0.623
	(0.035)	(0.084)	(0.135)	(0.462)
log(PI$_{t-10}$)		0.240		0.209
		(0.094)		(0.472)
N	523	190	197	65

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Table 20: Transfers

	All Sample		Reported Child	
	(1)	(2)	(3)	(4)
	Wrt. Help Child	log(Help Child)	Wrt. Help Child	log(Help Child)
log(PI)	0.038	0.427	0.042	0.431
	(0.011)	(0.120)	(0.013)	(0.120)
log(PI$_{t-10}$)	0.011	0.381	0.028	0.378
	(0.014)	(0.104)	(0.016)	(0.105)
N	15421	542	13064	538

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Table 21: Donations

	(1) Wrt. Donations	(2) log(Donations)
log(PI)	0.219	0.717
	(0.014)	(0.055)
$\log(\text{PI}_{t-10})$	0.161	0.290
	(0.019)	(0.068)
N	15421	9257

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Table 22: Donations

	OLS		IV	
	(1)	(2)	(3)	(4)
	log(net worth)	log(net worth)	log(net worth)	log(net worth)
log(PI)	2.010	2.305	1.712	3.343
	(0.085)	(0.204)	(0.122)	(0.813)
log(PI$_{t-10}$)		-0.193		-1.818
		(0.216)		(0.984)
N	643	270	643	270

Table 22 presents the results of two different regression models, OLS and IV, that were used to analyze the relationship between donations and net worth. The dependent variable in both models is log(net worth), and the independent variables are log(PI) and log(PI$t - 10$). The OLS model (columns 1 and 2) estimates the effect of log(PI) and log(PI$t - 10$) on log(net worth) using ordinary least squares. The IV model (columns 3 and 4) uses instrumental variables to estimate the same effect. The coefficients for log(PI) and log(PI$_{t-10}$) are presented in columns (1) and (2) of the OLS model and columns (3) and (4) of the IV model. The standard errors for each coefficient are presented in parentheses beneath the corresponding coefficient. The sample size, N, for both models is 643.

B.6 Prob of Adjustment

Table 23: Prob of Adjustment

	(1) Moved Past 10 Yrs	(2) Moved Past 10 Yrs	(3) Might Move	(4) Might Move
$\lvert\log(\mathrm{PI}/\mathrm{PI}_{t-10})\rvert$	0.235	0.180	0.102	0.022
	(0.018)	(0.026)	(0.017)	(0.030)
Own $\times$ $\lvert\log(\mathrm{PI}/\mathrm{PI}_{t-10})\rvert$		0.007		0.048
		(0.035)		(0.036)
Own		-0.336		-0.346
		(0.026)		(0.023)
N	15421	14980	15075	14653

The table "Probability of Adjustment" presents data on the likelihood of individuals moving or potentially moving in the past 10 years, as well as the impact of home ownership on this likelihood. The first column, labeled (1), indicates the probability of individuals who have moved in the past 10 years, with a value of 0.235 and a standard error of 0.018. The second column, labeled (2), shows the same probability for individuals who have also moved in the past 10 years, with a value of 0.180 and a standard error of 0.026. The third and fourth columns, labeled (3) and (4), respectively, display the probability of individuals who might move in the future, with values of 0.102 and 0.022 and corresponding standard errors of 0.017 and 0.030. Additionally, the table includes information on the effect of home ownership on the probability of adjustment, with the interaction term and own variable having values of 0.007 and -0.336, respectively, in the second and fourth rows. The sample size for all columns is provided as 15421, 14980, 15075, and 14653.

Figure 6: Probability of Moving

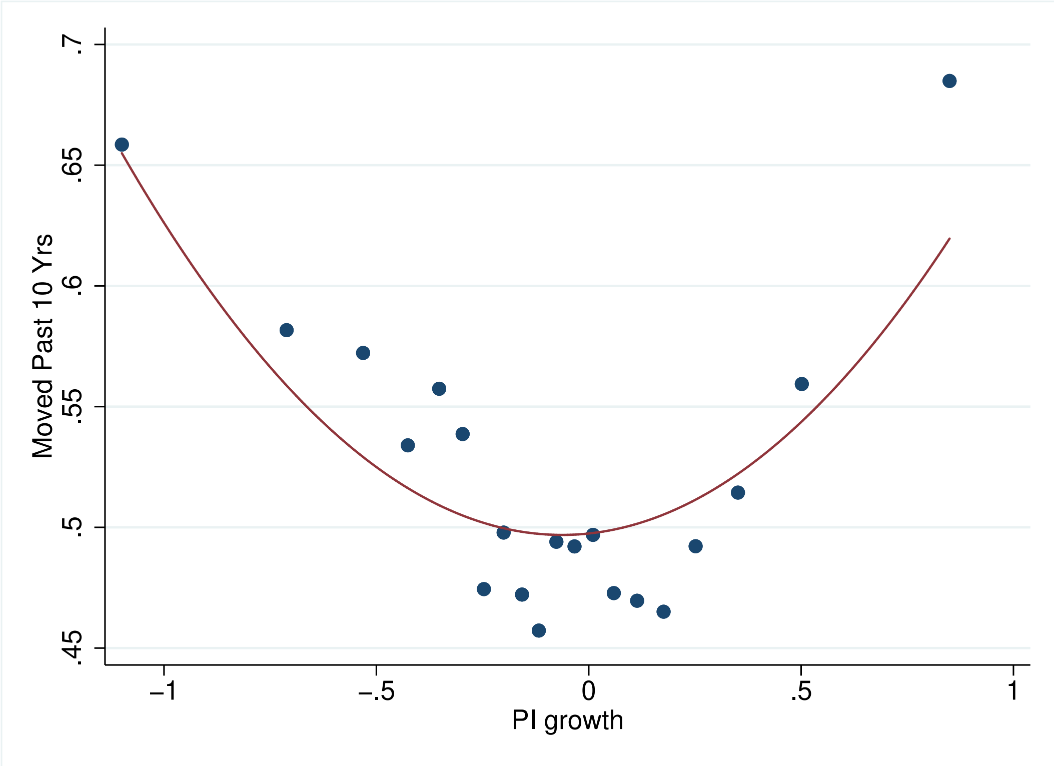

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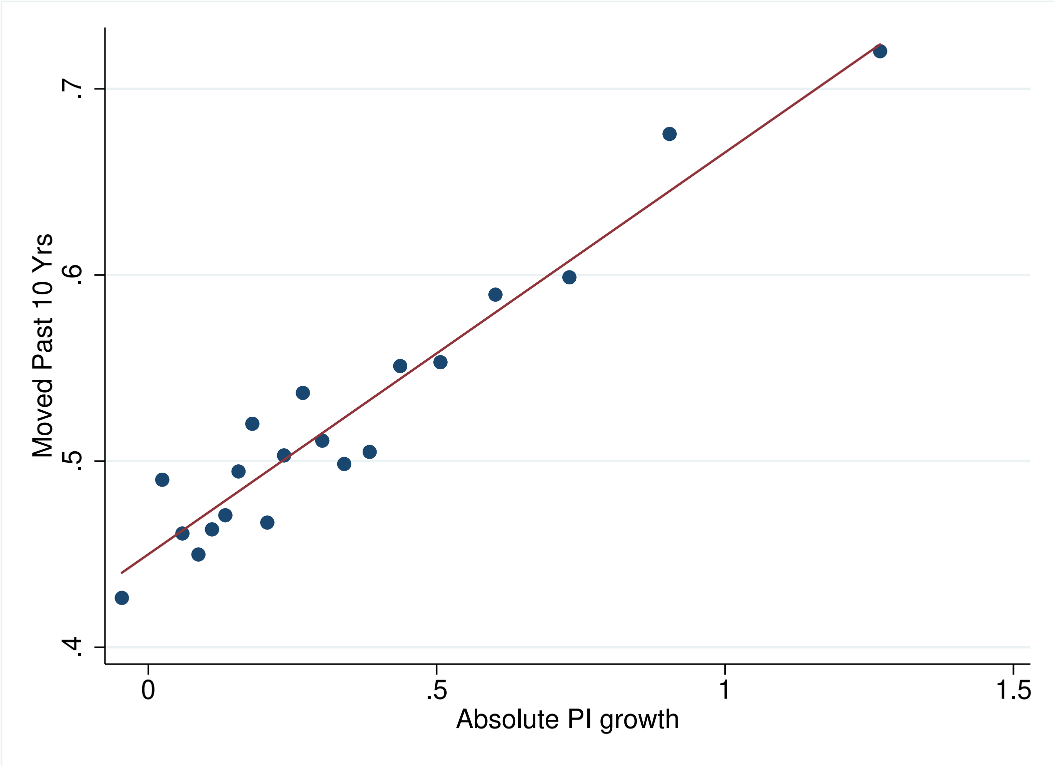
Figure 7: Probability of Moving



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B.7 Quality of the Expected Income Growth Measure

Table 24: Income Growth Forecast Equation

	(1) Error_{t+2}	(2) Error_{t+4}	(3) Error_{t+6}	(4) Error_{t+8}	(5) Error_{t+10}	(6) MSE
log(c/y)	-0.006	0.010	0.019	0.023	0.023	0.144
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.038)
N	43586	35110	27885	21804	16589	14830

The table "Income Growth Forecast Error" presents the errors of forecasting income growth at different periods of time. The table has two main sections, the first section shows the error values for different forecast periods, which are t+2, t+4, t+6, t+8, and t+10, and the second section shows the mean squared error (MSE) value. The first section is divided into two columns, the first column shows the error values, and the second column shows the standard errors of the error values in parentheses. The second section shows the number of observations (N) used in the analysis. The table also shows that error values are determined based on log(c/y) which is a measure of income growth.

C Computational Appendix

I solve the method using first-order conditions, as previously done by Kaplan et al. (2014). As the problem is non-convex, first-order conditions are necessary but not sufficient. I proceed by examining all solutions to each set of first-order conditions, then determine the optimal solution by evaluating the value functions at each candidate solution. I do it at each point in the state space. This includes considering solutions at all corners and evaluating the value functions at these points. I solve the model recursively from the last period of life to $j = J$.

Last-period problem: For a household in its last period of life $j = J$, the optimal decision of not adjusting their housing satisfies:

$$-(1-\nu)(c)^{-\sigma}(rh_{-1})^{\nu}(x-a')^{-\nu} + (1-\psi)\beta\frac{\theta_1}{\theta_2}\left(1+\frac{a+h_{-1}}{\theta_2}\right)^{-\sigma} = 0$$

where $x = w + (1+r)a$ is the cash-on-hand. For those that adjust their housing, their optimal decision satisfies:

$$\begin{aligned} -\nu(c)^{-\sigma}(rh)^{\nu-1}(x-a'-h)^{1-\nu} + (1-\psi)\beta\frac{\theta_1}{\theta_2}\left(1+\frac{a+h}{\theta_2}\right)^{-\sigma} &= 0 \\ \frac{\nu}{1-\nu}\frac{x-a'-h}{rh} &= 1 \end{aligned}$$

where $x = w + (1+r)a + (1-\kappa)h_{-1}$.

Retirement-period problem: For a household during its retirement period $R \leq j < J$, the optimal decision of not adjusting their housing satisfies:

$$\begin{aligned} -(1-\nu)(c)^{-\sigma}(rh_{-1})^{\nu}(x-a_+)^{-\nu} + (1-\psi)\beta\frac{\theta_1}{\theta_2}\left(1+\frac{a+h_{-1}}{\theta_2}\right)^{-\sigma} \\ + \psi\beta(1-\nu)(c_+)^{-\sigma}(rh)^{\nu}(n_+)^{-\nu} = 0 \end{aligned}$$

where $x = w + (1+r)a$ is the cash-on-hand. For those that adjust their housing, their optimal decision satisfies:

$$\begin{aligned} -(1-\nu)(c)^{-\sigma}(rh_{-1})^{\nu}(x-a_+)^{-\nu} + (1-\psi)\beta\frac{\theta_1}{\theta_2}\left(1+\frac{a+h_{-1}}{\theta_2}\right)^{-\sigma} \\ + \psi\beta(1-\nu)(c_+)^{-\sigma}(rh)^{\nu}(n_+)^{-\nu} = 0 \\ \frac{\nu}{1-\nu}\frac{x-a'-h}{rh} = 1 \end{aligned}$$

where $x = w + (1+r)a + (1-\kappa)h_{-1}$.

Working-period problem: A household during its working period $1 \leq j < R$ faces income uncertainty, but no mortality risk. Thus, its optimal decision of not adjusting its housing satisfies:

$$-(1-\nu)(c)^{-\sigma}(rh_{-1})^{\nu}(x-a_+)^{-\nu}+\beta(1-\nu)\mathbb{E}_t\Big[(c_+)^{-\sigma}(rh)^{\nu}(n_+)^{-\nu}\Big]=0$$

where $x = w + (1+r)a$ is the cash-on-hand. For those that adjust their housing, their optimal decision satisfies:

$$\begin{aligned}-(1-\nu)(c)^{-\sigma}(rh_{-1})^{\nu}(x-a_+)^{-\nu}+\beta(1-\nu)\mathbb{E}_t\Big[(c_+)^{-\sigma}(rh)^{\nu}(n_+)^{-\nu}\Big]&=0\\ \frac{\nu}{1-\nu}\frac{x-a'-h}{rh}&=1\end{aligned}$$

where $x = w + (1+r)a + (1-\kappa)h_{-1}$.