

IDIOSYNCRATIC ASSET RETURN AND WAGE RISK OF US HOUSEHOLDS

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This paper documents the degree of idiosyncratic asset return risk, serial correlation, and correlation with wage risk for US households. Novel panel-data measures for returns on household assets are proposed. Sizeable idiosyncratic return risk is documented to exist concurrently with permanent heterogeneity in household-specific returns and exhibits negative serial correlation. On average, idiosyncratic permanent risk to wages and transitory risk to total asset returns are correlated. This arises primarily from correlated wage and return risk to primary housing assets, and is age-dependent. The estimates inform the covariance structure of idiosyncratic asset returns and wage risk.

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JEL classification: D14, D31, E21, E24, G11, J31

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1 Introduction

Uninsured idiosyncratic risk in labor income is a common structural assumption in quantitative studies of inequality (Aiyagari, 1994; Caballero, 1991; Huggett, 1996). Considerable attention has been devoted to the estimation of uninsured labor income risk over the life cycle (Baker, 1997; Haider, 2001; Guvenen, 2007; Blundell et al., 2008; Moffitt and Gottschalk, 2011). More recently, attention has returned to the possibility that heterogeneity in returns can explain wealth inequality (Kesten, 1973). However, due to the absence of household-level panel data on returns, much less is known regarding the nature of idiosyncratic heterogeneity in asset returns. This is further complicated in models that include both labor income and return heterogeneity (Cagetti and De Nardi, 2009; Benhabib et al., 2011, 2015; Cao and Luo, 2017) due the potential correlation of uninsured idiosyncratic risk.

This paper fills this gap by proposing new panel-data measures of household-level returns on assets in the US. Three questions are asked using these returns. First, what is the degree of idiosyncratic return heterogeneity in household-level asset returns? Second, is idiosyncratic asset return risk correlated with labor income risk? Third, does idiosyncratic risk display serial correlation? Empirical evidence is provided for the entire household asset portfolio and by asset classes.

These questions are examined using joint system estimation of a permanent-transitory wage process with an asset return process that allows for serial correlation and correlation across innovations. These dual processes are estimated using an iterative generalized method of moments (GMM) estimator on household-level micropanel data on asset returns and wages from the newly revised Panel Study of Income Dynamics (PSID) from 1999–2019.

A contribution of this study is the proposed panel-data measures of asset returns for the US, which are currently absent and exist only recently for Scandinavian countries (Bach et al., 2020; Fagereng et al., 2020). The asset returns measures are also the first to examine total household assets, not just total taxable assets, as well as more granulated returns by asset class. Unlike administrative tax data which observes returns only when realized, returns are observed in every period which avoids imputing returns from aggregates which could understate heterogeneity. These measures are also the first to include capital gains that are net of investment and rental income for housing assets which are shown to be important to understanding the nature of idiosyncratic risk. The joint examination of asset returns and wage risk is also directly comparable to previous studies as the PSID is a main data source of estimates of US idiosyncratic labor income.

Despite the potential importance of the covariance structure of idiosyncratic risk for portfolio allocation and consumption insurance, the evidence of the correlation between asset returns and labor income is limited. As noted by Benhabib et al. (2019), the primary reason for this is that “data on stochastic returns are relatively hard to find” (p. 20). In the absence of household-level data, studies have used occupational-level wages (Davis and Willen, 2000),¹ or aggregate asset returns (Heaton and Lucas, 2000; Campbell et al., 2001).² The few exceptions focus on returns to specific asset classes. For example, Cocco et al. (2005) document that aggregate income, but not idiosyncratic income, is correlated with changes in primary housing prices in the PSID between 1970 and 1992. However, appreciations in asset prices are not the same as returns as appreciations could reflect households’ net investment in response to income shocks. In this paper, asset appreciation, capital gains net of investment, and total returns are documented to differ. This allows for the first examination of the correlations between idiosyncratic labor income and total asset returns for each asset class.

Empirical evidence of household-level heterogeneity in asset returns has been documented for primary housing by Case and Shiller (1989) and Flavin and Yamashita (2002).³ These studies have documented that the variability in household-level housing returns is two to three times larger than that derived from aggregate housing price returns. Idiosyncratic heterogeneity in housing returns can arise, for example, due to bargaining power in negotiations, the behavior of real estate agents, and profits from home improvements.

Similarly, evidence on returns heterogeneity has been documented for private business wealth (Quadrini, 2000; Kartashova, 2014; Moskowitz and Vissing-Jørgensen, 2002; Bach et al., 2020) and for returns to total household assets (Bach et al., 2020; Fagereng et al., 2020). Bach et al. (2020) estimate that the share of idiosyncratic risk represents 78.9 percent and 27.2 percent of the standard deviations for overall private business wealth and overall assets, respectively. The findings across these studies support evidence of sizeable idiosyncratic risk above and beyond aggregate risk.

This paper documents sizeable transitory idiosyncratic risk in returns to total household assets. The standard deviation of the transitory innovation to total household assets is estimated to be

¹Davis and Willen (2000) find a positive correlation with stock returns.

²Heaton and Lucas (2000) highlight the positive correlation between equity returns and the income of self-employed persons. Campbell et al. (2001) find a positive correlation of 0.32 to 0.52 for different levels of educational attainment between aggregate labor income risk and lagged excess returns on the New York Stock Exchange value-weighted stock market.

³Returns to primary housing wealth have also been examined using the PSID by Palia et al. (2014) and for expected returns using Swedish administrative tax data by Bach et al. (2020). However, returns to wealth include households’ decisions on endogenous leverage, a dimension removed in this paper.

8.96 percentage points. This transitory idiosyncratic asset return risk exists concurrently with household-specific (between-household) returns recently documented in Fagereng et al. (2020) and Snudden (2021). Thus, quantitative macro models seeking to capture the dynamics of returns heterogeneity would need to model both the household-specific and the transitory idiosyncratic components. This is analogous to models that allow for idiosyncratic innovations to labor income around a life-cycle earnings profile.

Sizeable idiosyncratic asset returns risk is also documented for the idiosyncratic returns processes for private businesses, primary and secondary housing, and public equities. The standard deviation of the transitory innovation to primary housing assets is the smallest at 10.95 percentage points. This is followed by secondary housing, public equities, and private business assets of 36.2, 24.71 and 108.9 percentage points, respectively. This confirms that a high share of idiosyncratic risk in asset returns exists in the US, similar to that in the Swedish data of Bach et al. (2020).

Permanent shocks to wages are positively correlated with transitory shocks to private business and primary housing returns. On average, a correlation of 0.07 is documented between the idiosyncratic risk to returns on total household assets and wages for heads of households. This correlation is dependent on the age of the head and increases to 0.17 for households above the age of 43. However, a correlation of idiosyncratic risk to wages and returns is not exhibited for spouses or within household measures of wages. The correlation of idiosyncratic wage and return risk for the household is thus dependent on age and marital status.

A negative moving average coefficient is documented for idiosyncratic risk to total asset returns. This arises from a negative moving average coefficient for capital gains to primary housing and public equities. The serial correlation is absent only for younger and non-college educated households, as they have lower shares of housing and public equity in their portfolio allocation. Young households also experience positive correlations between transitory shocks to wages and returns.

Despite the importance of the covariance structure of the idiosyncratic risk for portfolio allocation and consumption insurance, the lack of panel data has precluded direct evidence of the nature of the idiosyncratic return risk. The covariance matrix of the idiosyncratic risks measured in this paper maps directly into standard models of portfolio choice. The results document the idiosyncratic background risks associated with portfolio allocations of financial assets (Merton, 1971; Gollier and Pratt, 1996; Heaton and Lucas, 1996; Bertaut and Haliassos, 1997). This also lends credence to studies of the background risks from housing (Grossman and Laroque, 1990; Brueckner,

1997; Fratantoni, 2001; Flavin and Yamashita, 2002; Cocco, 2005; Yao and Zhang, 2005) and private business assets (Heaton and Lucas, 2000) that explain the stockholding puzzle. Notably, the empirical evidence supports the existence of idiosyncratic background risks from all asset classes and highlights correlations with permanent labor income not previously accounted for.

The evidence also directly informs the covariance structure and the magnitude of the uninsured idiosyncratic risks to returns and labor income found in quantitative models used to study wealth inequality and social mobility (Cagetti and De Nardi, 2009; Benhabib et al., 2011, 2015; Cao and Luo, 2017). Transitory idiosyncratic risk to returns on assets exists concurrently with the household-specific returns documented by Fagereng et al. (2020) and Snudden (2021). Evidence supports correlated idiosyncratic risk to labor and asset returns previously not accounted for (Cagetti and De Nardi, 2009; Benhabib et al., 2011, 2015). Studies that account for asset allocation in private business and primary housing assets should also account for correlated shocks between assets returns and labor income.

The structure of this paper is as follows. Section 2 introduces the model of idiosyncratic wages and asset returns. Section 3 proposes innovative measures of asset returns. Section 4 reports the estimates and conducts tests of robustness and sensitivity to life-cycle and demographic characteristics. Section 5 summarizes and discusses the implications of the findings.

2 Empirical Model

An idiosyncratic permanent-transitory wage process is adopted from the literature on idiosyncratic wage risk (Lillard and Weiss, 1979; Baker, 1997; Haider, 2001; Guvenen, 2007; Blundell et al., 2008; Moffitt and Gottschalk, 2011). The idiosyncratic wage process is estimated in a system with an asset return process. Both the wage and return processes allow for serial correlation of the transitory innovations. The system estimation allows for correlation across wage and return innovations.

Idiosyncratic heterogeneity in before-tax real returns is calculated as follows. Real returns are regressed on a set of indicators for year and observable household characteristics, Z_{it} , portfolio shares are interacted with year fixed effects, P_{it} , and there is an indicator for each of the asset classes if the household sold an asset within an asset class, S_{it} . Observable household characteristics include age, marital status, family size, number of children, presence of an outside dependent, race, education level, region interacted with year, and an indicator for income from a family member other than the head or spouse. The idiosyncratic component of the return to total household assets

is denoted by $\tilde{r}_{a,it}$:

$$r_{a,it} = f(Z_{it}, P_{it}) + \beta S_{it} + \tilde{r}_{a,it}, \quad (1)$$

where $f(\cdot)$ is a function that includes the year fixed effects and its interaction with portfolio shares. The inclusion of portfolio shares accounts for changes in the asset portfolio, something that is not required for each asset class. The return on assets for the specific asset category j is thus modelled as

$$r_{j,it} = f(Z_{it}) + \beta_j s_{j,it} + \tilde{r}_{j,it}, \quad (2)$$

where $s_{j,it}$ indicates if asset j was sold. The estimates of equation (2) for each asset class as well as the measure of the idiosyncratic returns, $\tilde{r}_{j,it}$, are detailed in Appendix C.

Similarly, log-real wages, W_{it} , are deconstructed into a part explained by observable characteristics and the idiosyncratic component, \tilde{W}_{it} :

$$W_{it} = g(Z_{it}) + \tilde{W}_{it}, \quad (3)$$

where $g(\cdot)$ is again a function of the observable household characteristics, Z_{it} . The identical set of observable household controls is used for the calculation of log-real wages as returns.

Idiosyncratic wages are modelled as the sum of a permanent component W_{it}^p , which follows a martingale with innovation $v_{it} \stackrel{iid}{\sim} (0, \sigma_v^2)$ and a transitory component $u_{it} \stackrel{iid}{\sim} (0, \sigma_u^2)$ that follows a moving average process α_w , where $u_{it} \perp v_{it} \forall i, t$:

$$\tilde{W}_{it} = W_{it}^p + u_{it} + \alpha_w u_{it-1},$$

$$W_{it}^p = W_{it-1}^p + v_{it},$$

$$W_{i0}^p, \quad \text{given.}$$

Combining the above equations to remove W_{it}^p gives the change in idiosyncratic wages,

$$\Delta \tilde{W}_{it} = v_{it} + \Delta u_{it} + \alpha_w \Delta u_{it-1}, \quad (4)$$

where Δ is a difference operator.

The unexplained component of the return is assumed to be a transitory component $u_{j,it}^r \stackrel{iid}{\sim}$

$(0, \sigma_{u_j^r}^2)$ with moving average parameter $\alpha_{r,j}$ and an initial condition $\epsilon_{j,i}^r \stackrel{iid}{\sim} (0, \sigma_{\epsilon_j^r}^2), \forall i, t, j$:

$$\tilde{r}_{j,it} = u_{j,it}^r + \alpha_{r,j} u_{j,it-1}^r + \epsilon_{j,i}^r.$$

For the return to total household assets and for each risky asset category, a null variance is estimated for permanent innovations. In the absence of permanent shocks to the return on assets, the household-specific return, $\epsilon_{j,i}^r$ identifies and is interpreted as the initial condition of the return that persists across a household's lifetime. This is exactly the household-specific component documented and estimated by Fagereng et al. (2020) and Snudden (2021). The change in the unexplained component of the return on assets is given by

$$\Delta \tilde{r}_{j,it} = \Delta u_{j,it}^r + \alpha_{r,j} \Delta u_{j,it-1}^r. \quad (5)$$

Correlations are modelled between the transitory shocks to the return on assets, $u_{j,it}^r$, and real wages, u_{it} , denoted, ρ_{uu} . Also, a potential correlation exists between the permanent shock to wages, v_{it} , and the transitory shock to the return on assets, u_{it}^r , denoted as ρ_{vu} .

Equations (4) and (5) are estimated in a system via an iterated GMM with heteroskedastic and serial correlation robust standard errors and weight matrix. An identity weight matrix is used to obtain the first-step parameter estimates. The results are robust to a two-step GMM or alternative assumptions of the initial matrix. In total, there are 7 parameters to identify: shock variances σ_u^2 , σ_v^2 , and $\sigma_{u^r}^2$; correlations ρ_{uu} and ρ_{vu} ; and moving average processes $\alpha_{r,j}$ and α_w .

The system of equations (4) and (5) is over-identified using eleven moment conditions including all available variances, covariances, and first and second lagged covariances, such as $\text{cov}(\Delta \tilde{r}, \Delta \tilde{r}_{t-1})$, $\text{cov}(\Delta \tilde{r}, \Delta \tilde{W}_{t-1})$, $\text{cov}(\Delta \tilde{r}, \Delta \tilde{r}_{t-2})$, $\text{cov}(\Delta \tilde{r}, \text{and} \Delta \tilde{W}_{t-2})$. All moment conditions are used for model specifications that include serial correlation, and the robustness of this assumption is discussed later in the paper. Appendix B provides proof of identification for all parameters.

The objective is to find the most parsimonious system that captures the structure in the data for each equation system. The three shock variances are included within all models: σ_u^2 , σ_v^2 , $\sigma_{u^r}^2$. Each of sixteen model-parameter combinations is estimated, one for each combination of the moving average and shock correlations, $\alpha_{r,j}$, α_w , ρ_{uu} , and ρ_{vu} . The most parsimonious system is defined as one of the sixteen model specifications that exhibits both individual parameter significance and fails to reject the null of the valid over-identifying restrictions of the Hansen J-test (Hansen, 1982; Hall, 2005). For the few cases where more than one specification satisfies all criteria, χ^2 -difference tests

(Bentler, 1990) are used to select among the nested models, the significance levels are discussed in detail, and additional robustness is examined (see Section 4.6).

3 Data

The Panel Study of Income Dynamics (PSID) is used to calculate before-tax real returns and log-real wages. The dataset provides household-level unbalanced panel data, using surveys conducted every two years between 1999 and 2019.

3.1 Measurement

Returns to assets are observed for primary housing, ph , secondary housing, oh , private businesses, b , public equity, s , risk-free assets, f , and other assets, o .⁴ The return to total household assets for household i at time t , $r_{a,it}$, is given as

$$r_{a,it} = \frac{\sum_{j \in J} \{y_{j,it} + yg_{j,it}\}}{\sum_{j \in J} a_{j,it-1}}, \quad (6)$$

where $J = \{b, ph, oh, s, f, o\}$, $y_{j,it}$ and $yg_{j,it}$ are dividends and capital gains, respectively, on asset j , and $a_{j,it-1}$ is the value of asset j for household i in time $t-1$.

In the PSID for private businesses, primary and secondary housing assets, and stocks, both asset values at the time of the survey as well as the flow of investment and income between the two surveys are reported in every wave. Thus, unlike previous studies, capital gains can be observed for these assets in every period. Capital gains for the primary residence are defined as the change in the reported value of the primary residence between the two years if the house was not sold, or the difference from the selling price and the last reported value if the primary residence was sold, less the value of renovations and upgrades. Capital gains to stocks, private businesses, and secondary housing wealth are defined as the difference in the respective asset values less net investments.

Net investment is the amount of money put into that asset class, $ib_{j,it}$, less the amount of money sold or taken out of that asset class, $is_{j,it}$. For example, for a private business, a household's net investment is the difference between how much money the household put into the business and how much money the household got from selling all or part of the business. In the case of complete liquidation (say in the case of bankruptcy), the asset value would equal zero and the net

⁴A detailed description of the returns calculations can be found in Appendix A

investment would equal the amount received from liquidation. Thus, returns are observed in cases of total liquidation.

Asset values are available for every period for holdings of public equity and for the primary residence. Asset values are available for private businesses and secondary housing, starting in the 2011 wave. Prior to 2011, net worth is reported for secondary housing and private business assets, but asset values are not reported. Fortunately, however, net worth and net investment are reported for the full sample as well as the asset values after 2012. By definition, the change in the asset value, $\Delta a_{j,it}$ is the sum of the changes in net worth, $\Delta w_{j,it}$ and debt, $\Delta d_{j,it}$. Thus, it is proposed to impute the asset values for secondary housing and private businesses prior to 2011 using the change in net wealth and net investment as follows:

$$a_{j,it} = a_{j,it+1} - \Delta w_{j,it+1} - \gamma_{j,b} i b_{j,it+1} + \gamma_{j,s} i s_{j,it+1} \quad (7)$$

for $j \in \{b, oh\}$. $\gamma_{j,b}$ and $\gamma_{j,s}$ represent the share of investment that is financed by debt. For example, when $\gamma_{j,b} = 1$ purchases of additional secondary housing are debt financed. This closely approximates the relationship between debt and investments for the years between 2012 and 2020, when all values are observed, and $\gamma_{j,b}$ and $\gamma_{j,s}$ can be estimated. The imputations only influence the asset values of private business and secondary housing assets prior to 2010. The baseline analysis assumes that $\gamma_{j,b} = \gamma_{j,s} = 1$, but the results are robust to estimated values or when using the later part of the sample, which is discussed in Section 4.6.

The method used for the returns to primary housing follows Flavin and Yamashita (2002) but also builds upon it in three ways. First, the tax rate is household- and year-specific and is calculated using the National Bureau of Economic Research tax simulator (Feenberg and Coutts, 1993). Second, capital gains include net investment, which includes major improvements and upgrades. This data is not available for the sample covered by Flavin and Yamashita (2002). Third, rental income is acknowledged as a source of income. Failure to account for rental income can understate the return to housing. These three improvements were also not considered for the return to housing in Fagereng et al. (2020). Similar to the returns to primary housing, the measure of returns to secondary housing includes capital gains, the value of housing services, maintenance costs, and rental income.

The return to assets in asset class j is given by

$$r_{j,it} = \frac{y_{j,it} + yg_{j,it}}{a_{j,it-1}}, \quad (8)$$

for $j \in \{b, ph, oh, s, f\}$. For risk-free and other assets, net investment is not observed and capital gains are assumed to be zero: $yg_{f,it} = yg_{o,it} = 0$. All models are estimated in real returns by deflating the nominal returns by the annualized total consumer price index provided by the Federal Reserve (CPI).

The total return on assets used in this paper is most similar to the measure of the return to individual “net worth” in Fagereng et al. (2020), who use the asset value in the denominator but net interest payments in the numerator. Total household assets in this paper also include information on durable wealth and other valuables, such as collections that are reported by the household that would not be reported in the European administrative tax datasets (Bach et al., 2020; Fagereng et al., 2020). It also differs in that net investment and asset values are observed in each period as opposed to only observing realized capital gains. The final innovation is that the PSID allows for a more detailed decomposition of returns by asset class.

Wages, $W_{k,it}$, are calculated as total labor income, $Y_{k,it}$, over total hours worked, $H_{k,it}$:

$$W_{k,it} = (Y_{k,it}/CPI_t)/H_{k,it}. \quad (9)$$

Where k denotes the person for whom the wage is calculated. This can be for the head, spouse, or the household, which is the sum for the head and spouse. Robustness is also considered where both head and spouse wages are included separately, referred to as the wage of individuals. Total labor income includes labor income from businesses, farming, as well as non-business income. Non-business labor income includes salaries, hourly work, bonuses, and tips. The measure of the head’s wages is the baseline measure considered in the analysis.

3.2 Sample Selection

The baseline analysis considers households with a continuous marital status. Observations are dropped if there is a change in the head or spouse. By including only households with a continuous marital status, no attempt is made to model the asset return risk associated with divorce and marriage. Observations are biennial from 1999 to 2019, as per the survey frequency. Three consecutive waves of available data on asset returns and wages are required and four in the case of the

moving average process for either wages or returns. This is necessary for the identification method described in Appendix B. Households are kept if the head was born after 1920 and the head’s age is between 20 and 70. The mean and median head’s age is 44 and 45, respectively. Households in the supplemental Survey of Economic Opportunity are also excluded.

Observations are dropped if any component of the wages or asset returns or demographic data is missing, unknown, or not reported. This includes net investments into and out of direct holdings of public stocks, which is the most likely variable to be missing. No observations used in this study were found to be top coded or truncated at a high value. The requirement that there must be an observed household wage means that, in the sample, there are very few household heads who are students or retired. The main results are robust to excluding heads who retire or become students.

Outliers are treated in a similar way to that of Blundell et al. (2008) and Fagereng et al. (2020). A household is dropped if real labor income is below \$100 or if the level or growth of the real wage is beyond the 99 percent confidence interval. To account for extreme values that could skew the distribution, the top and bottom 5 returns observations are dropped. Then, returns observations are dropped if the asset value is below \$500 or the change or level of the returns to assets is beyond the 99 percent confidence interval. The exception is for private business returns, which are excluded if the asset value is below \$5000. This selects towards private businesses with physical assets rather than small professional service businesses; this is explored in detail in the discussion on robustness in Section 4.6.

In addition to the above requirements, another event is attributed to measurement error and removed from the sample. For direct holdings of public equities, secondary housing and private businesses, an observation is dropped if the household reported ownership in the last period, but the current period’s asset value is zero and the household did not report selling any of the asset. This requirement excludes a small number of households in the bottom tail of the return to assets, and the main results are robust to this assumption.

3.3 Data Summary

Wage growth and the level of returns for individuals are summarized in Table 1. The mean real wage growth is 3 percent, with a standard deviation of 39.7 percent. The return to total household assets, $r_{a,it}$, are described as *Total Assets* and have a mean of 3.2 percent and a standard deviation of 10.8 percentage points. For all asset returns, the between-household standard deviation is larger than the within-household standard deviation. In contrast to real wage growth, which is left skewed,

the returns to assets are right skewed. Real wage growth and returns display more kurtosis than a normal distribution, except for risk-free assets.

Table 1. Summary Statistics for Asset Returns and Wage Growth

	Obs	Indiv.	Mean	Standard Deviation			25p	75p	Skew-ness	Kurtosis
				Total	Within	Between				
Wage Growth	29716	4941	3.0	39.7	15.0	37.9	-12.9	20.3	-0.2	6.2
Total Assets	19233	3153	3.2	10.8	4.7	9.9	-1.9	6.3	1.9	13.3
Private Business	1432	314	48.8	137.8	92.5	117.9	-14.2	46.5	4.1	25.4
Primary Housing	24172	3690	5.7	12.3	4.5	11.6	0.1	10.4	0.9	8.2
Secondary Hous.	2470	522	13.5	44.3	23.5	39.3	-6.6	20.2	3.1	17.4
Risk Free	29531	5046	-1.8	0.8	0.4	0.7	-2.4	-1.5	0.2	3.0
Public Equities	11798	2268	7.3	34.8	18.0	30.9	-3.0	2.6	3.8	23.9

Note: Real wage growth and return on assets for individuals (Indiv.) in percentage points, 1999-2019. Conditional on the minimum of four consecutive return observations, three for the return to private businesses and secondary housing, and the presence of both wage and return observations. 25p and 75p refer to the corresponding percentiles.

The mean return to private business assets is 48.8 percentage points, which is significantly larger than the 7.3 percentage point mean return to public equities. This is also reflected in the standard deviation of the return to private business assets, which is 137.8 percentage points, significantly larger than the 34.8 percentage point standard deviation to public equities. The higher return to private business assets is consistent with the evidence from Kartashova (2014) using the Survey of Consumer Finances, which documented that the similar returns found by Moskowitz and Vissing-Jørgensen (2002) was due to the time period examined. Relative to the evidence in the above papers, these estimates are derived using panel data with net investment, and the higher return to private business assets is found to be robust over time.

The mean return to primary housing assets is 5.7 percentage points, with a standard deviation of 12.3 percentage points. The standard deviation is similar to but slightly lower than the 14 percentage points for the period 1968 to 1992 calculated by Flavin and Yamashita (2002). The inclusion of individualized tax rates, net investment, and rental income in this paper results in lower variability in returns between 1998 and 2020 compared to the return measure of Flavin and Yamashita (2002). However, it still reinforces the finding that housing indexes underestimate idiosyncratic risk on housing. For example, the Case and Shiller and Freddie Housing index, has standard deviations of 7.7 and 6.4 percent, respectively, between 1998 and 2014. This highlights a major advantage of the PSID which does not need to resort to extrapolating primary housing returns from aggregated indexes, such as in Fagereng et al. (2020), which may understate the degree of household heterogeneity in the returns.

The mean return to secondary housing assets is larger than primary housing assets, with a mean of 13.5 percentage points and a standard deviation of 44.3 percentage points. Secondary housing assets are owned by 15.7 percent of households with wage observations suggesting that this asset class is important to capture overall return heterogeneity for households. The mean return to risk-free assets is -1.8 percentage points, reflecting the amount in low-interest accounts and the low nominal policy rate over the second half of the sample.

4 Empirical Results

This section presents the estimates of idiosyncratic risk to asset returns and their correlation with idiosyncratic labor risk. There are three main questions. What is the degree of idiosyncratic risk to the returns on assets? Is idiosyncratic asset returns risk correlated with labor income risk? Is there serial correlation in asset returns? These questions are examined for each asset class. The full sample is then divided by household characteristics to see if the results pertain to specific subsamples.

4.1 Returns to Total Household Assets and by Asset Classes

The results for the system estimation of equations (4) and (5) using the head's wage, total household assets and for each asset class are summarized in Table 2. For all returns, the variances of the shocks to head's wages and returns are significant at the 5 percent level. For every return measure, the null hypothesis of valid over-identification restrictions is unable to be rejected.

The first column of Table 2 reports the baseline estimates for the head's wage and returns to total household assets. The standard deviations for the permanent and temporary shocks to head's wages are 22.74 and 18.03 percentage points, respectively, and are significant at the 1 percent level. These estimates are consistent with previous findings on idiosyncratic wage risk (Lillard and Weiss, 1979; Baker, 1997; Haider, 2001; Guvenen, 2007; Blundell et al., 2008; Moffitt and Gottschalk, 2011). The standard deviation for the transitory idiosyncratic shock to the return on total household assets is estimated to be 8.96 percentage points. This documents that transitory idiosyncratic risk to returns on assets exists concurrently with the household-specific returns (Fagereng et al., 2020; Snudden, 2021) and are important to capture the degree of return heterogeneity (Cagetti and De Nardi, 2009; Benhabib et al., 2011, 2015; Cao and Luo, 2017).

The permanent idiosyncratic shock to head's wages is found to be significantly correlated with

Table 2. Idiosyncratic Return Risk is Sizeable and Correlated with Permanent Wage Innovations

Asset Return	Total	Business	Prim. Hous.	Sec. Hous.	P. Equities	Risk-Free
σ_u	22.74	31.80	24.19	24.19	19.68	24.31
(Temporary wage shock)	(6.70)	(13.71)	(6.68)	(10.85)	(8.16)	(6.76)
σ_v	18.03	31.64	20.16	31.73	19.04	19.72
(Permanent wage shock)	(7.22)	(17.41)	(6.81)	(14.18)	(9.15)	(6.88)
σ_{ur}	8.96	108.90	10.95	36.16	24.71	0.41
(Temporary return shock)	(2.33)	(43.97)	(2.46)	(11.17)	(10.21)	(0.08)
α^w	0.10	-	0.09	-	0.17	0.09
(Wage moving average)	(0.042)	-	(0.035)	-	(0.066)	(0.036)
α^r	-0.14	-	-0.14	-	-0.21	0.12
(Return moving average)	(0.045)	-	(0.036)	-	(0.122)	(0.024)
ρ_{vur}	0.07	0.30	0.07	-	-	-
(Corr. v wage u returns)	(0.032)	(0.102)	(0.026)	-	-	-
Observations	6,586	564	8,803	985	2,294	3,871
Persons	1,791	159	2,013	270	705	2,282
J-test p-value H_0 : Valid	0.664	0.301	0.708	0.502	0.086	0.335

Note: Estimates are from system estimation using iterative GMM. Idiosyncratic returns are in percentage points; idiosyncratic head's wages are in percent change. Prim. and Sec. refer to primary and secondary housing (hous.), respectively. P. refers to public and corr. refers to correlation. Heteroskedastic and serial correlation robust standard errors are in parentheses.

the transitory shock to total asset returns. The moving average coefficient for the transitory shock to the return on total household assets is found to be -0.14 and statistically significant at the 1 percent level. The moving average coefficient for the transitory shock to head's wages is found to be 0.10 and statistically significant at the 1 percent level. Only in models that include the moving average processes for returns are the J-tests of valid over-identifying restrictions not rejected at the 10 percent level.

The second column of Table 2 shows the system estimations for idiosyncratic returns to private business assets and head's wages. The standard deviations for the permanent and temporary shocks to the wages of business owners are 31.64 and 31.8 percentage points, respectively. The standard deviation for the transitory shock to the return to private business assets is the highest of any asset class, with a standard deviation of 108.9 percentage points. There is a positive correlation coefficient of 0.30 for the permanent shock to head's wages and the transitory shock to the return to private business assets. The correlation coefficient is significant at the 1 percent level and consistent with the finding of a positive correlation between aggregate equity returns and the income of self-employed persons, Heaton and Lucas (2000).

The third and fourth columns of Table 2 show the system estimations for primary and secondary housing assets. The standard deviations for the temporary shocks to the return on primary and

secondary housing assets are estimated to be 10.95 and 36.16 percentage points, respectively. The return to primary housing assets exhibits significant correlation with the permanent shocks to wages. This confirms that a part of correlation between primary housing price appreciation and overall income in the PSID documented by Cocco et al. (2005) is due to idiosyncratic risk and is robust to return measures that include net investment. In contrast, the idiosyncratic return on secondary housing assets is not correlated with either the permanent or transitory shock to head's wages. Transitory shocks to primary housing returns and head's wages exhibit moving average coefficients similar to that for total returns.

The fifth and sixth columns of Table 2 shows the system estimation for the return to public equities and risk-free assets. The standard deviation of the transitory shocks are estimated to be 24.71 and 0.41 percentage points, respectively. Again, transitory shocks to public equities and risk-free assets, as well as head's wages, exhibit moving average coefficients similar to that for total returns. However, idiosyncratic risk to financial asset returns does not exhibit a significant correlation with either idiosyncratic innovation with head's wages. This suggests that the correlation between aggregate labor income risk and stock market returns documented by Campbell et al. (2001) may not translate to idiosyncratic risk on average.

Consider the interpretation of these findings. These estimates are the first empirical documentation of the covariance matrix of the idiosyncratic risks to wages and returns. The evidence supports the existence of idiosyncratic background risks from all asset classes not just primary homeownership (Grossman and Laroque, 1990; Brueckner, 1997; Fratantoni, 2001; Flavin and Yamashita, 2002; Cocco, 2005; Yao and Zhang, 2005) or private business assets (Heaton and Lucas, 2000) that may help explain the stockholding puzzle. The estimates suggest that, on average, households exposure to private businesses and primary housing in their asset portfolios on average result is a positive correlation between the permanent shock to head's wages and total assets returns. These idiosyncratic background risks as well as correlations are well known to influence the portfolio allocation of financial assets (Merton, 1971; Gollier and Pratt, 1996; Heaton and Lucas, 1996; Bertaut and Haliassos, 1997). Together, the evidence also shows the importance of household-level idiosyncratic risk, which is not reflected in aggregate indexes.

4.2 Capital Gains

This section repeats the baseline exercise but for the capital gains proportion of returns to inform whether the correlations and serial correlations in the returns arise due to capital gains or to flow

income. For the capital gains portion of returns, the asset value in the denominator of the returns remains the same, but the numerator only includes capital gains net investment and excludes flow income. Specifically, the annualized capital gains portion of returns, $rg_{j,it}$, is defined as

$$rg_{j,it} = \frac{\Delta a_{j,it} - i_{j,it}}{2a_{j,it-1}}, \quad (10)$$

where $a_{j,it}$ is the value of asset j of household i in time t , and $i_{j,it}$ is the household's i net investment within asset class j at time t . The returns from capital gains are converted to real returns and idiosyncratic returns are calculated the same as total returns, following equations 1 and 2. Households are included if there is no missing information on idiosyncratic returns from capital gains, and if these returns are subject to the same outlier restrictions as total returns. Equations (4) and (5) are estimated as systems that use the return on capital gains for each asset type and are summarized in Table 3.

Table 3. Capital Gains are Correlated with Wage Innovations

Return from Capital Gains	Total	Business	Prim. Hous.	Sec. Hous.	P. Equities
σ_u	22.73	31.84	24.16	24.51	20.23
(Temporary wage shock)	(6.54)	(13.68)	(6.68)	(10.40)	(8.15)
σ_v	18.87	31.55	20.21	28.55	18.58
(Permanent wage shock)	(7.07)	(17.55)	(6.82)	(13.98)	(9.17)
σ_{ur}	12.46	100.06	10.83	37.81	20.66
(Temporary return shock)	(3.88)	(43.20)	(2.43)	(12.79)	(8.03)
α^w	0.10	-	0.09	-	0.18
(Wage moving average)	(0.040)	-	(0.035)	-	(0.061)
α^r	-0.11	-	-0.14	-	-0.22
(Return moving average)	(0.046)	-	(0.036)	-	(0.110)
ρ_{vu^r}	0.06	0.23	0.07	-	-
(Corr. v wage u returns)	(0.031)	(0.086)	(0.026)	-	-
Observations	7,195	566	8,822	1,104	2,277
Persons	1,939	160	2,033	301	698
J-test p-value H_0 : Valid	0.737	0.480	0.345	0.420	0.260

Note: Estimates are from the system estimation that uses iterative GMM. Idiosyncratic rates of return are in percentage points; idiosyncratic wages are in percent change. Prim. and Sec. refer to primary and secondary housing (hous.), respectively. P. refers to public and corr. refers to correlation. Heteroskedastic and serial correlation robust standard errors are in parentheses.

Business profits and flow income from primary housing exacerbate variability in private business returns as the standard deviation for the transitory shock to capital gains is lower than that of the total returns to these assets. Importantly, the transitory capital gains innovations to private business and primary housing are correlated with permanent shocks to wages. This arises from

a positive correlation between the growth rate of the idiosyncratic appreciation in housing and private businesses with wages. Overall, the positive correlation of capital gains for these assets is reflected in the capital gains return to total household assets.

The estimates of the standard deviation for transitory shocks to the return from capital gains to public equities and secondary housing is larger than that of total returns to these assets. This suggests that the dividend proportion of the returns dampens the return volatility. Overall, this higher variability translates into higher variability in the capital gain returns to total household assets, which exhibits higher variability than the total return to household assets. The serial correlation of the returns and the heads' wage is consistent with the returns that include flow income, Table 2.

Returns excluding capital gains were examined, but not reported here for brevity. In this case, the return to total household assets failed to exhibit a correlation with wage innovations. Again, this suggests that the correlation arises primarily from capital gains. Only the return excluding capital to primary housing was correlated with the permanent wage innovation, with a coefficient value of 0.13. However, the primary housing return variation is significantly lower when capital gains are excluded. This again supports the role of primary housing capital gains in driving the return and wage correlation.

One of the advantages of the measures of returns in the PSID is that net investment is observed for the calculation of capital gains. We can quantify the importance by redoing the analysis of capital gains, Table 3, but removing net investment in the measure of capital gains from equation 10. In this case, the standard deviation of the transitory shock to returns increases to 103.6, 41.3, and 26.3 percentage points for private business, secondary housing, and public equities, respectively, and decreases to 11.9 and 10.6 for total and primary housing assets, respectively. Moreover, the correlation with the permanent shock to wages changes to 0.084, 0.19, and 0.056 for total, private business, and primary housing, respectively. Finally, the moving average coefficient is not longer significant for public equities. Hence, accounting for net investment in capital gains is important for estimates of the covariance matrix of idiosyncratic wage and return risk.

4.3 Ownership

In an examination of the returns to asset class j , the correlations of the returns to asset classes and to wages have been considered. Correlations have also been observed for private business assets and primary housing assets. In this section, we examine whether ownership of these assets implies that

these correlations also arise for returns to total household assets. Specifically, the return to total household assets for head of households that own or do not own specific asset classes is reported in Table 4.

Table 4. Idiosyncratic Risk is not just Entrepreneurs

Ownership Sample	Pr. Home	x Pr. Home	Business	x Business	Sec. Hous.	x Sec. Hous
σ_u	22.18	23.09	32.32	19.46	16.33	23.03
(Temporary wage shock)	(7.10)	(8.11)	(15.29)	(5.14)	(11.11)	(6.87)
σ_v	18.38	20.63	28.32	19.36	31.45	17.31
(Permanent wage shock)	(8.02)	(9.95)	(20.49)	(6.70)	(17.22)	(7.13)
σ_{ur}	9.98	2.24	13.90	8.68	12.96	8.40
(Temporary return shock)	(2.70)	(1.42)	(4.80)	(2.39)	(5.09)	(2.33)
α^w	0.10	-	-	-	-	0.10
(Wage moving average)	(0.048)	-	-	-	-	(0.042)
α^r	-0.16	-	-	-0.15	-	-0.15
(Return moving average)	(0.053)	-	-	(0.052)	-	(0.051)
ρ_{vu^r}	0.08	-	-	0.08	-	0.10
(Corr. v wage u returns)	(0.037)	-	-	(0.030)	-	(0.035)
Observations	4,674	1,339	416	5,821	687	5,873
Persons	1,281	395	147	1,595	216	1,587
J-test p-value H_0 : Valid	0.408	0.607	0.171	0.610	0.975	0.670

Note: Estimates are from system estimation using iterative GMM. Idiosyncratic rates of return are in percentage points, idiosyncratic head's wages are in percent change. Pr. Home and x Pr. Home refers to households that do and do not own primary housing assets, respectively, whereas x Business and x Sec. Hous. refers to households that own neither private businesses nor secondary (Sec.) housing assets, respectively. Heteroskedastic and serial correlation robust standard errors are in parentheses.

The negative moving average coefficient for idiosyncratic shocks to total assets returns is observed for owners of primary housing and those that do not own private businesses or secondary housing. These subsamples also exhibit correlation of the permanent innovation to the head's wage with the transitory innovation to total household assets. Notably, households that do not own primary housing experience much smaller standard deviations of the transitory idiosyncratic component of assets returns compared to households that own primary housing assets. Primary homeowners have close to four times the idiosyncratic variability in total assets returns compared to non-homeowners.

The higher risk to total assets returns not only arise from primary home ownership but also households that do not own homes are much less likely to own other risky assets such as private businesses. For example, the idiosyncratic risk to total household assets are also lower for households that do not own private businesses or secondary housing assets. Compared to the overall sample, these households have slightly less variability in idiosyncratic returns to total household assets

and this is consistent with the high risk in these asset classes. These households also continue to experience negative serial correlation of the transitory idiosyncratic return. Overall, the results reinforce the role of primary housing and business assets as sources of large idiosyncratic risk and the importance of primary home ownership for the negative serial correlation in the idiosyncratic returns to total assets.

4.4 Life-Cycle Factors

When modelling idiosyncratic assets returns risks, should the degree of risk depend on life-cycle factors such as age and wealth? To this end, age, education, and wealth subsamples are explored. While the estimated observable household characteristics in equations (1) and (3) account for how age and education affect the level of assets returns, the degree of the idiosyncratic risk and its correlation with the idiosyncratic wage risk, may still differ.

Table 5. Correlated Wage and Return Risk is Dependent on Age

Sample	Younger	Older	No College	College	Low Wealth	High Wealth
σ_u	20.15	23.95	22.77	21.89	21.59	22.76
(Temporary wage shock)	(6.01)	(8.32)	(7.01)	(7.46)	(6.38)	(7.90)
σ_v	15.89	20.67	15.90	19.25	16.75	20.09
(Permanent wage shock)	(7.24)	(9.52)	(8.41)	(8.03)	(7.67)	(9.08)
σ_{ur}	8.96	9.26	8.95	8.88	8.28	9.43
(Temporary return shock)	(2.40)	(2.98)	(3.04)	(2.57)	(2.75)	(2.76)
α^w	-	0.12	-	0.11	-	0.14
(Wage moving average)	-	(0.056)	-	(0.055)	-	(0.056)
α^r	-	-0.19	-0.16	-0.10	-0.16	-0.14
(Return moving average)	-	(0.076)	(0.084)	(0.051)	(0.071)	(0.061)
ρ_{uvr}	0.08	-0.09	-	-	-	-
(Corr. temporary shocks)	(0.030)	(0.052)	-	-	-	-
ρ_{vur}	-	0.17	0.13	-	0.13	-
(Corr. v wage u returns)	-	(0.084)	(0.061)	-	(0.048)	-
Observations	3,393	2,952	2,409	4,177	3,348	3,238
Persons	954	775	626	1,165	904	887
J-test p-value H_0 : Valid	0.377	0.548	0.117	0.923	0.650	0.815

Note: Estimates are from system estimation using iterative GMM. Idiosyncratic rates of return are in percentage points; idiosyncratic head's wages are in percent change. Wealth and age refers to above and below the median. Heteroskedastic and serial correlation robust standard errors are in parentheses.

Older and younger household subsamples are distinguished by their age relative to the median head-of-household age of 45, Table 5. Younger head of households have slightly lower variances of wages shocks compared to the baseline sample but a similar variance of the return shocks. There is also no evidence of serial correlation in either the wage or the return processes for younger

households in any model specification at any reasonable level of significance. Interestingly, younger households have a positive correlation between the transitory shock to wages and the returns to total assets, and this is significant at the 1 percent level. This arises from a positive correlation of the transitory wage and return shocks for public equities and housing assets of 0.07 and 0.08, respectively.

In contrast, older households experience a positive correlation coefficient, 0.17, between permanent innovations in wages and transitory innovations in returns, over twice as high as the total sample. Again, this arises from ownership in private business and primary housing ownership. Older households also experience a negative correlation coefficient, -0.09, between transitory innovations in wages and transitory innovations in returns. The negative correlation arises from other asset income and from public equities. The correlations of the transitory innovations of both the young and old sub-samples average out in the whole sample. Older households also drive the serial correlation in wages and return processes in the total sample.

Heads of households with high wealth, relative to the median, or by those with a college education maintain significant moving average coefficients of the transitory innovations in returns and wages. On average, older heads of households and those with college education are 3.2 and 2.3 time more wealthy than younger and non-college educated households, respectively. Thus, these households are more likely to hold primary housing and public equity, which exhibit the negative serial correlation in returns. College educated head of households do exhibit a positive correlation of the permanent wage shock with the transitory return shock to primary housing and private equity, but not for total assets. The transitory shock to public equities is not found to be correlated with either of the wage shocks, suggesting that the positive correlation of 0.52 between aggregate labor income risk and lagged excess stock returns for college educated attainment documented by Campbell et al. (2001) does not translate into idiosyncratic risk. Heads of households without college education and with low wealth exhibit the positive correlation of the permanent wage and transitory return innovations. This again arises from housing and private business assets, which represent over two-thirds of the asset portfolio for these households. As age is similar for those with and without college education, this suggests that the wage and return correlations are more related to age than to wealth and education.

4.5 Within-Household Insurance

Thus far, the analysis has considered the head of the household's wages. This section examines the sensitivity of the results to alternative measures of wages to consider within-household insurance. Specifically, to explore the role of a secondary income earner in a household, the head's and spouse's wage are compared separately and when both are included in the sample. The household wage, the combined wage of the head and spouse, is also considered, as is the wage of heads of households who are married and single.

Table 6. Married Households Exhibit Within-Household Wage-Return Correlation Insurance

Wage Sample	Head	Spouse	Individual	Household	Married	Single
σ_u	22.74	21.47	21.13	18.88	21.05	23.84
(Temporary wage shock)	(6.70)	(5.86)	(4.72)	(4.48)	(5.77)	(9.35)
σ_v	18.03	17.59	19.14	18.69	19.32	17.46
(Permanent wage shock)	(7.22)	(7.55)	(5.87)	(5.62)	(7.31)	(9.43)
σ_{ur}	8.96	8.65	9.10	8.99	8.97	8.43
(Temporary return shock)	(2.33)	(2.78)	(2.26)	(2.33)	(2.54)	(2.97)
α^w	0.10	-	-	-	-	0.14
(Wage moving average)	(0.042)	-	-	-	-	(0.074)
α^r	-0.14	-0.20	-0.19	-0.15	-0.19	-
(Return moving average)	(0.045)	(0.074)	(0.042)	(0.047)	(0.059)	-
ρ_{vur}	0.07	-	0.05	-	0.06	0.11
(Corr. v wage u returns)	(0.032)	-	(0.025)	-	(0.035)	(0.056)
Observations	6,586	3,609	10,244	7,082	5,328	5,285
Persons	1,791	1,017	2,824	1,903	1,791	490
J-test p-value H_0 : Valid	0.664	0.568	0.287	0.116	0.583	0.916

Note: Estimates are from system estimation using iterative GMM. Idiosyncratic rates of return to total household assets are in percentage points, idiosyncratic wages are in percent change. Heteroskedastic and serial correlation robust standard errors are in parentheses.

Table 6 reports the results for the alternative wage measures and for the return to total household assets. Relative to the baseline estimates of the heads' wages, the spouses wage exhibits a slightly lower standard deviations for the permanent and transitory wage shocks. Moreover, the spouses wages do not exhibit serial correlation or the positive correlation with the transitory innovation to returns. This is reflected in individual wages, as the correlation of permanent innovations in wages and transitory innovation in returns is lower than for heads of households. The total household wage fails to capture a correlation across innovations, which suggests that the spouses wage helps hedge this income correlation.

The last two columns of Table 6 report the system estimates when the sample is split between married and single heads of households. Single households are found to have lower permanent,

but higher transitory wage risk compared to married heads. Single households display a significant moving average coefficient for wages but not for returns, the opposite of married heads. As marriage, household wealth, and homeownership are highly correlated, the lack of serial correlation for single households is likely due to the lack of homeownership and portfolio diversification of the sample with single heads.

4.6 Robustness

This section summarizes the sensitivity of the results to the robustness checks on the baseline assumptions. This includes robustness for the treatment of outliers, the minimum number of consecutive observations, and assumptions regarding data construction. Generally, the main size of the standard deviations, the moving average, and the wage and return correlations are robust to most assumptions of the data treatment. The result that is the most sensitive to the data treatment is the significance of the moving average for wages.

Changes in the intensity to which outliers are dropped, such as at the 5 percent or 0.1 percent level, results in the standard deviation of the idiosyncratic shocks changing in the corresponding direction. The minimum asset value of \$500 follows Fagereng et al. (2020) and when the minimum value of the asset or labor income is increased, then the standard deviation of the idiosyncratic shocks declines accordingly. The result that is most sensitive to these assumptions is the correlation between wages and returns for private business assets. At a \$500 minimum value of business assets, the standard deviation in the returns to private business assets increases by 62%, and the correlation between the permanent shocks to wages and the transitory shocks to returns is only significant at the 10.6 percent level. The baseline minimum of \$5,000 provides a sample of private businesses with some physical capital while also preserving the sample size.

Given that the baseline sample consists of households with heads aged 20 to 70, a natural question is whether some risk or correlation is driven by heads who are either students or retired. However, when students, retirees, or both are dropped from the sample, there is a loss of only a few hundred observations and the results remain qualitatively unchanged. This arises since the baseline requires that a wage is observed. The results are also qualitatively robust to the inclusion of social security receipts and private transfers from family members outside the household.

Throughout the analysis, correlation is considered between the idiosyncratic shocks to wages and the shocks to the asset returns. It may be possible that the idiosyncratic returns on assets within an asset class are correlated with other asset class. However, only the idiosyncratic asset

returns for risk-free assets and public equity display a small pairwise correlation of 0.05 which is statistically significant at the 1 percent level. Thus, the correlations of idiosyncratic asset return risk across asset classes are not modelled in the analysis.

The baseline model in the analysis uses a moving average process for the transitory shocks to wages and returns. An autoregressive process for both wages and returns was considered. In such a model, the autoregressive parameter for the wage process is estimated to be unity with precision. This is not surprising, given that even when wages are log-differenced, there exists a positive moving average coefficient for the transitory wage innovations. The results confirm that some potential negative serial correlation exists in returns, but the models fails to reject the null of the valid over-identifying restrictions of the Hansen J-test (Hansen, 1982; Hall, 2005). While the results are available from the author, the observations are best modelled using the superior small sample properties of the moving average process.

The results are also robust to the choice of moment conditions. Throughout this paper, when the moving average processes are included, equations (4) and (5) are over-identified using eleven moment conditions that include all of the available variances, covariances, and first and second lagged covariances. The J-test for valid over-identifying restrictions rejects, at the 5 percent level, the return to total household assets for any model that excludes the moving average in returns. The results are robust to using the first and second leading covariances.

The asset values for private businesses and secondary housing are imputed prior to the 2012 wave. However, the qualitative findings are robust between the sample periods 1998–2012 and 2008–2018. The main difference is that in the later half of the sample, the moving average coefficient for wages is larger. The baseline results are also robust to estimated values of $\gamma_{j,b}$ and $\gamma_{j,s}$ which slightly lowers the mean-squared error between imputed and reported assets between 2012-2018. However, due to the small sample size, the estimates are generally not statistically significant at the 5 percent level. For example, for secondary housing investment $\gamma_{oh,b} = 0.76$, but this estimate has a standard error of 0.36. Alternative assumptions of $\gamma_{j,b}$ and $\gamma_{j,s}$ mainly influences the variability of the return to secondary housing and private business asset classes and do not affect the main results for the return to total household assets.

Finally, the results are robust to the method of calculation used for the idiosyncratic returns to assets, equation 1. This includes when portfolio shares are not accounted for in the total return to household assets. Thus, shifts in portfolio allocation do not introduce correlations between asset returns and wage shocks. The qualitative results for all the idiosyncratic returns are robust to

the cohort effects and to the alternative assumptions for the functional forms for age and regional controls.

5 Conclusion

This study developed new measures of household-level returns to total assets and by asset class that include capital gains net of investment and rental income. This has allowed for a joint estimation of return and wage risks to study the degree of idiosyncratic assets returns risk, their serial correlation, and their correlation with idiosyncratic wage risk. The empirical evidence can be used to discipline the structure and calibration of quantitative models of uninsured idiosyncratic income risk.

Sizeable idiosyncratic return risk is observed for total household returns and by asset class. This transitory idiosyncratic asset return risk exists concurrently with household-specific returns (Fagereng et al., 2020; Snudden, 2021). Quantitative models of uninsured idiosyncratic risks that seek to capture household-specific returns need to include both household-specific and transitory idiosyncratic components. This is analogous to models that allow for idiosyncratic innovations to labor income around a life-cycle earnings profile.

These findings can be used to inform the debate on optimal portfolio allocation and the causes and consequences of wealth inequality and mobility. The substantial idiosyncratic risks that exist within all asset classes suggests that background risks may arise from all asset classes. These background risks are found to be especially high for entrepreneurial assets (Heaton and Lucas, 2000), primary housing (Cocco, 2005; Flavin and Yamashita, 2002) and secondary housing assets (Brueckner, 1997; Yao and Zhang, 2005).

Permanent shocks to wages and transitory shocks to returns on total assets are correlated and arise from private business and primary housing assets. This idiosyncratic return and wage risk correlation is the first direct measure of a household-level covariance matrix for the determination of portfolio allocation. On average, households are unable to avoid a correlation between idiosyncratic wage and return risks in total household assets. Studies that have included idiosyncratic risks for both returns and wages (Cagetti and De Nardi, 2009; Benhabib et al., 2011, 2015) should include the correlation across these shocks.

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Online Appendices (not intended for publication)

A The New Measures of Returns

The redesigned Panel Study of Income and Dynamics (PSID) data is the main dataset for the calculation of household-level real rates of return. For the purpose of this paper, the main innovation of the PSID was the regular and detailed collection of asset income, wealth, and net investment. Households were surveyed every two years for the period 1999 to 2019. Rates of return are annualized and available for 2000 to 2020. The year 1998, or the initial household observation, is lost due to the calculation of the returns.

The PSID provides detailed socio-economic information on gender, age, marital status, education level, employment status, and geographic location. Data on labor and asset income are retrospective to the year prior, whereas wealth in assets and debt are reported at the time of the interview. Interviews are conducted early in the year (around March). The head of the household is defined as a person over age 15 with the most financial responsibility for the household.

A.1 Capital Gains Imputation

A difficulty previous studies incurred in calculating returns is that asset income is reported as a total for a year, whereas wealth is observed at a point in time. Wealth can be put into or removed from a particular asset category; for example, through the accumulation of capital gains in wealth. In the Scandinavian tax database used by Bach et al. (2020) and Fagereng et al. (2020), wealth is reported at the end of the year, income is reported for the year, and capital gains are reported when realized. However, in the PSID asset values, net investment and flow income that took place during the period between the two surveys are reported in every wave for the asset classes other than risk-free assets. Thus, unlike previous studies, capital gains can be observed for these assets in every period. All capital gains are annualized.

For each asset class, the wealth in the asset is defined as the value of the asset less the debt associated with the asset. The asset value and wealth are net of fees and commissions. For example, the wealth in the primary residence, $w_{ph,it}$ is defined as the reported value of the primary residence, $a_{ph,it}$, less the primary mortgage debt, $d_{ph,it}$: $w_{ph,it} = a_{ph,it} - d_{ph,it}$.

For the primary residence, capital gains are defined as the change in the reported value of the primary residence, $a_{ph,it} - a_{ph,it-1}$, between the two years if the house was not sold, or the

difference from the selling price, $a_{ph,it}^*$, on the last reported value if the primary residence was sold, $a_{ph,it}^* - a_{ph,it-1}$, less the value of renovations and upgrades, $i_{ph,it}$. Capital gains are measured between the waves and then annualized to match the asset income flows. Capital gains on primary housing, $yg_{ph,it}$ are

$$yg_{ph,it} = (\mathbb{1}_{\{sold=1\}}a_{ph,it}^* + \mathbb{1}_{\{sold=0\}}a_{ph,it} - a_{ph,it-1} - i_{ph,it})/2. \quad (11)$$

Capital gains to stocks, $yg_{s,it}$, private businesses, $yg_{b,it}$, and secondary housing wealth, $yg_{oh,it}$ are defined as the difference in net worth, $\Delta a_{j,it}$, less the net amount invested, $i_{j,it}$:

$$yg_{j,it} = (\Delta a_{j,it} - i_{j,it})/2, \quad (12)$$

for $j \in \{s, b, oh\}$.

Net investment is the amount of money put into an asset, less the amount of money taken out of that asset class. For example, for private businesses, a household's net investment is the difference between how much money the household put into the business and how much money the household got from selling all or part of the business. In the case of complete liquidation (say in the case of bankruptcy), the asset value $a_{j,it}$ would equal zero and the net investment would equal the amount received from the liquidation, $i_{j,it}$. Thus, returns are observed in the cases of total liquidation.

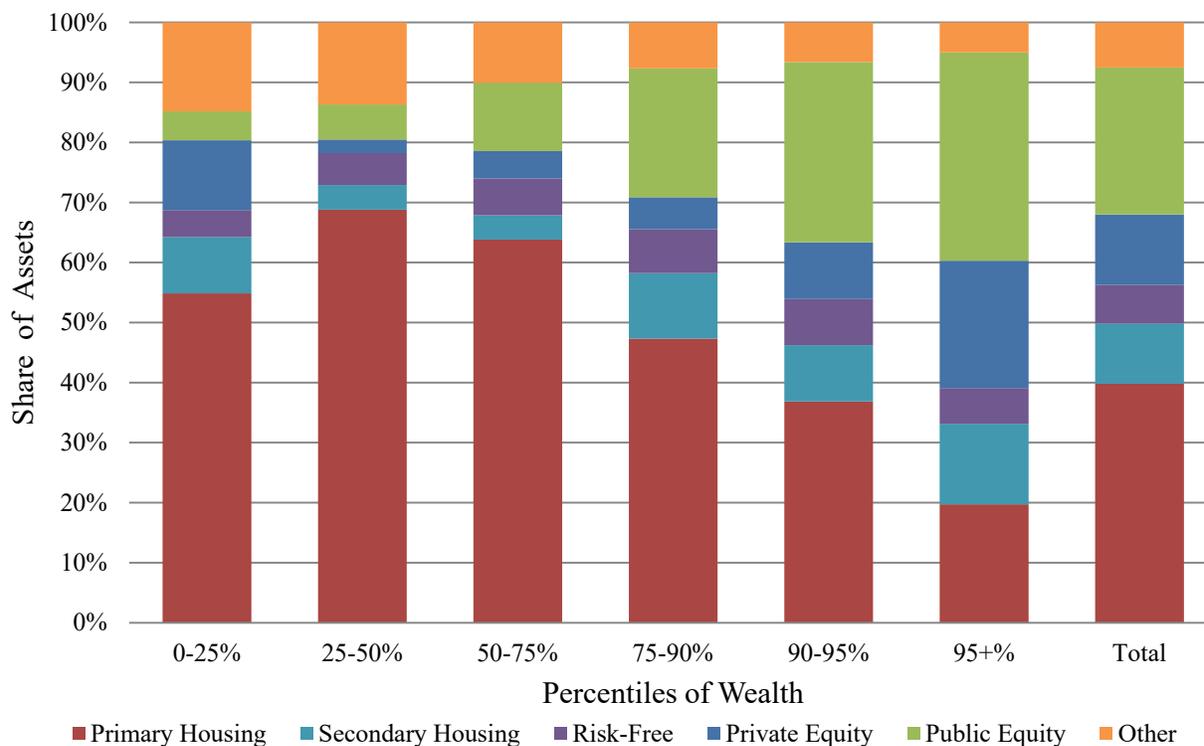
Asset values are available for every period for holdings of public equities and for primary residences. Asset values are available for private businesses and secondary housing, starting in the 2011 wave. Prior to 2011, net worth is reported for secondary housing and private business assets but not for asset values. Fortunately, however, net worth and net investment were reported. Thus, the asset values for secondary housing and private businesses can be imputed prior to 2011 by using simple accounting. The asset value $a_{j,it}$ can be imputed by using the change in net wealth $\Delta w_{j,it+1}$ and net investment $i_{j,it+1}$ as follows:

$$a_{j,it} = a_{j,it+1} - \Delta w_{j,it+1} - i_{j,it+1}, \quad (13)$$

for $j \in \{b, oh\}$. This inference implies that the wealth accumulation from principal payments is included in net investment. This is confirmed for 2012–2020, when asset values, net investment, and change in net worth are all observed. The imputed private business and secondary housing asset values are used in the calculation of returns for the survey waves prior to 2011.

A.2 Portfolio Composition

Figure 1. Asset Portfolio Composition



Note: For the years 2000-2020. “Public Equity” is the value of stocks held in publicly held corporations, mutual funds, or investment trusts and IRA’s. “Risk-free” assets include checking or savings accounts, money market funds, certificates of deposits, government savings bonds, or Treasury bills. “Other” includes all other assets not listed elsewhere such as a valuable collection for investment purposes, or rights in a trust or estate, the value of cars, trucks, motor homes, trailers, or boats. All values are in real 2010 USD.

Figure 1 reports the average asset portfolio composition across the wealth distribution for households in the PSID from 2000 to 2020. The asset portfolio composition held in every asset class depends on the level of wealth of the household. The reported categories of assets include primary and secondary housing assets, risk-free assets, private business equity, public equity and other assets. Immediately from the figure, we can see the importance of housing assets. Primary and secondary housing combined represent the majority of total household assets for households below the 90th percentile of wealth. On average, housing represents half of all assets held. Private business wealth represents about 35 percent of the asset portfolio for households above the 90th percentile of wealth. Considering that risk-free assets comprise only a small share of assets for all households along the wealth distribution, all households are likely subject to returns risk.

A.3 Asset Return and Wage Measures

The returns proposed in this study are pre-tax real returns to assets and wealth. In addition to returns to total household assets and wealth, returns are analysed for five asset categories: risk-free assets, primary and secondary housing, private businesses, and public equity. Observing and comparing returns to assets versus wealth allows one to parse the role of borrowing costs and leverage in the heterogeneity of returns to wealth. Merely focusing on the returns to assets ignores that leverage is a household's endogenous decision.

The return to primary housing include capital gains, the value of housing services, maintenance costs, and rental income. Let the dividend value from a residence in housing be denoted by DIV_{it} where

$$DIV_{it} = (rr + \delta)a_{ph,it-1} + ptax_{ph,it}, \quad (14)$$

and rr is the real interest rate, δ is the depreciation rate, and $ptax_{ph,it}$ is the value of property taxes. Following Flavin and Yamashita (2002), it is assumed that $rr = 0.05$. The cost of ownership is given by

$$COST_{it} = \delta a_{ph,it-1} - (1 - \tau_{it})ptax_{ph,it}, \quad (15)$$

where τ_{it} is the marginal income tax rate. It is assumed that the cost of maintenance and repairs from depreciation are equal for both landlords and homeowners, which implies that a house has a constant physical condition. Finally, households can rent out a fraction of their primary residence, RNT_{it} , and accrue rental income, $y_{ph,it}$, less reduced flow consumption and the additional cost of utilities, $utils_{ph,it}$:

$$RNT_{it} = y_{ph,it} - \kappa_{ph,i}(a_{ph,it-1}rr + utils_{ph,it}), \quad (16)$$

where $\kappa_{ph,i}$ is the share of the primary residence rented out. Rental income is reported for all housing assets. Rental income is attributed to the primary residence, $y_{ph,it}$, if the household does not own a secondary property, and to secondary income, $y_{oh,it}$, if the household owns a secondary property. Absent direct observations of the share of the primary residence rented out, it is assumed that $\kappa_{ph,i} = 0.5$ if rental income is accrued and $\kappa_{ph,i} = 0$ if no rental income is accrued.

For ease of exposition, let the net income from primary and secondary residences, the numerators of $r_{ph,it}^n$ and $r_{oh,it}^n$, excluding capital gains, be denoted by $yt_{ph,it}$ and $yt_{oh,it}$, respectively. The total

return to the primary residence is thus

$$\begin{aligned}
r_{ph,it}^n &= \frac{yg_{ph,it} + DIV_{it} - COST_{it} + RNT_{it}}{a_{ph,it-1}} \\
&= \frac{a_{ph,it-1}rr(1 - \kappa_{ph,it}) + y_{ph,it} + \tau_{it}ptax_{ph,it} - \kappa_{ph,it}utils_{ph,it} + yg_{ph,it}}{a_{ph,it-1}} \\
&= \frac{y_{ph,it}^t + yg_{ph,it}}{a_{ph,it-1}}.
\end{aligned} \tag{17}$$

The return to the primary housing asset differs from the one in Flavin and Yamashita (2002) in three ways. First, the tax rate is household and year specific and is calculated using the National Bureau of Economic Research tax simulator (Feenberg and Coutts, 1993). Second, capital gains are net of investment, which includes major improvements and upgrades. This data was not available for the sample covered by Flavin and Yamashita (2002). Third, rental income is acknowledged as a source of income. Failure to acknowledge rental income can understate the return to housing. These three differences are also true of the return to housing in Fagereng et al. (2020).⁵

The return to secondary housing is modelled to allow for the property to be owner-occupied, rented out full time, or rented out intermittently. Specifically, the asset return to secondary housing, $r_{oh,it}^n$, is given by

$$r_{oh,it}^n = \begin{cases} (a_{oh,it-1}rr + \tau_{it}ptax_{oh,it} + yg_{oh,it})/a_{oh,it-1}, & \text{if occupied} \\ (y_{oh,it} - a_{oh,it-1}\delta - ptax_{oh,it} + yg_{oh,it})/a_{oh,it-1}, & \text{if rented out} \end{cases} \tag{18}$$

where $ptax_{oh,it}$ are the property taxes on the secondary housing. It is assumed that the tenant pays for the cost of utilities. The PSID includes information on the repairs and maintenance of the primary residence, beginning in 2005. To incorporate this information, the average depreciation rate, δ , is set to 1.7 percent, the average value of the repairs and the depreciation costs for the years observed. For the baseline sample, 10.9 percent of homeowners own secondary properties, and 42.2 percent of secondary properties report rental income.

The PSID contains detailed information on mortgage rates for primary housing. A nominal mortgage interest rate is calculated as the debt-weighted average of the first and second mortgage. The calculation of the mortgage interest payments utilizes information on monthly mortgage payments, the current interest rate on the loan, the year the mortgage was obtained, and the years left

⁵Fagereng et al. (2020) impute housing values based on aggregate housing prices and use the average imputed house price between years in the denominator of the rate of return.

to pay it out, follow the TAXSIM recommendations for calculating mortgage deductibility.

If an individual in the household actively participates in a private business, the PSID assigns half of business income to assets and half to labor. If an individual reports business income but does not actively participate in the business, the PSID assigns all of the business income to business asset income. If the household reports a loss in total business income, then the loss is attributed only to business asset income. The PSID does not distinguish between labor and asset income from farming, so it is assumed that farm owners actively contribute labor to farm activities and that farm income is, thus, split evenly between labor and asset income, as for the case of businesses. The flow profits from private businesses are denoted $y_{b,it}$. The nominal return to business assets is defined as the sum of income from businesses and farms plus capital gains:

$$r_{b,it}^n = \frac{y_{b,it} + yg_{b,it}}{a_{b,it-1}}. \quad (19)$$

The PSID does not report on net investment in risk-free assets. The value of the risk-free asset is thus calculated following Fagereng et al. (2020) by assuming that wealth is the average between the current and last period. The average value of assets in risk-free assets is thus $\bar{w}_{it} = (w_{f,it} + w_{f,it-1})/2$.

Interest income is reported by the household but is not allocated to a particular asset category. Interest income from bonds, $y_{c,it}$, is allocated between direct holdings and safe assets and is distinguished using the 3-month U.S. Treasury bill rate, $r_{tres,t}^n$. The interest income from bonds that are associated with risk-free assets is the smaller value of the Treasury bill rate times the value of the risk-free assets or the value reported from bond interest income. That is

$$y_{c,it} = \begin{cases} y_{c,it}, & \text{if } r_{tres,t}^n \bar{a}_{f,it} \leq y_{c,it} \\ r_{tres,t}^n \bar{a}_{f,it}, & \text{otherwise.} \end{cases} \quad (20)$$

The remainder of the reported interest income, $y_{q,it} = y_{c,it} - y_{f,it}$, is then allocated to IRAs and direct public equity holdings. The return to risk-free assets, $r_{f,it}^n$, is thus defined as

$$r_{f,it}^n = \frac{y_{f,it}}{a_{f,it}}. \quad (21)$$

Similarly, the nominal return to public equity, $r_{s,it}^n$, is the sum of dividends, $y_{s,it}$ interest income, $y_{q,it}$, and capital gains from stocks, $yg_{s,it}$, over the value of IRAs $\bar{w}_{ira,it}$ and direct holdings of public

equities, $w_{s,it-1}$:

$$r_{s,it}^n = \frac{y_{s,it} + y_{q,it} + yg_{s,it}}{\bar{w}_{ira,it} + w_{s,it-1}}. \quad (22)$$

It is assumed that households do not leverage wealth in public equities or risk-free assets and, thus, their returns to wealth and assets are equivalent. There are two main differences with the current measure of stocks, other than the country, in comparison to the datasets of Bach et al. (2020) and Fagereng et al. (2020). The first is that pension assets are included in the value of financial assets. The second is that capital gains are computed per period, in contrast to the imputed realized capital gains.

Total household asset income includes the returns to primary and secondary housing, $yt_{ph,it}$ and $yt_{oh,it}$, private business income, $y_{b,it}$, dividends, $y_{s,it}$, interest income, $y_{c,it}$, other asset income, $y_{o,it}$, and trusts, $y_{tr,it}$. Let income from total assets, excluding capital gains, be denoted by $y_{a,it}$

$$y_{a,it} = yt_{ph,it} + yt_{oh,it} + y_{b,it} + y_{s,it} + y_{c,it} + y_{o,it} + y_{tr,it}. \quad (23)$$

Similarly let total capital gains be denoted by, $yg_{a,it}$

$$yg_{a,it} = yg_{ph,it} + yg_{oh,it} + yg_{s,it} + yg_{b,it}. \quad (24)$$

The total nominal return to assets, $r_{a,it}^n$, includes flow income, excluding capital gains from all assets, plus the capital gains from primary and secondary housing, and public and private equity:

$$r_{a,it}^n = \frac{y_{a,it} + yg_{a,it}}{a_{b,it-1} + a_{ph,it-1} + a_{oh,it-1} + a_{s,it-1} + \bar{a}_{f,it} + \bar{a}_{ira,it} + \bar{w}_{o,it} + \bar{w}_{v,it}}. \quad (25)$$

The reported total assets of household i at time t includes the value of other assets the household holds, but it is not possible to separately calculate returns on these other assets. This includes wealth in all vehicles, $w_{v,it}$, (including boats and motor homes). The value of households' private annuities and employer-based pensions or IRAs, $a_{ira,it}$, are reported. Finally, all other assets, $w_{o,it}$, are reported including any other savings or assets, such as the cash value in a life insurance policy, a valuable collection for investment purposes, or rights in a trust or estate.

The returns to assets represents the pre-tax returns not including deductibility of interest payments. Thus, the measure is the exogenous returns to the assets if the household had fully paid off the assets. The total returns to assets is closely related to the measure reported by Fagereng et al. (2020), who use the value of the assets in the denominator but include primary housing

interest payments in the numerator. The measure of the return to assets in this paper also includes information on durable wealth and other valuables, such as collections that are reported by the household that would not traditionally be reported as assets income for tax purposes.

Finally, nominal returns to assets for all asset classes $j \in \{b, ph, oh, s, f\}$ and for total household returns $j = a$ are converted to real returns, using the annualized total consumer price index provided by the Federal Reserve (CPI):

$$r_{j,it} = \frac{1 + r_{j,it}^n}{1 + \pi_t} - 1.$$

B Proof of System Identification

We begin this appendix by showing how many moments are required to identify the models with and without moving averages. Within all possible model specifications, the following shock variances are included: σ_u^2 , σ_v^2 , $\sigma_{u_r}^2$. In the case of models without moving averages, only two additional potential parameters are tested for; these are ρ_u and ρ_{vu} . In this case, there are four admissible model-parameter combinations and the model can be linearly estimated. When allowing for moving averages, four potential parameters are tested for: α_r , α_w , ρ_u and ρ_{vu} . In this case, there are sixteen admissible model-parameter combinations and the model is estimated using a non-linear iterative generalized method of moments. The linear and non-linear cases are shown separately.

System Identification of Models Without Moving Averages

1. Suppose the dynamics of log-real wages and the returns on total wealth are given by the following equations:

$$\Delta \tilde{W}_{it} = v_{it} + \Delta u_{it} \tag{26}$$

$$\Delta \tilde{r}_{it} = \Delta u_{it}^r \tag{27}$$

2. The notation for asset class j in the rate of return is dropped for ease of exposition. There are seven moment conditions when the variance, covariances, and first lagged covariances are included. These moment conditions are as follows:

$$E[(\Delta \tilde{r}_{it})^2 - 2\sigma_{u_r}^2] = 0 \tag{28}$$

$$E[(\Delta \tilde{r}_{it})(\Delta \tilde{r}_{it-1}) + \sigma_{u_r}^2] = 0 \tag{29}$$

$$E[(\Delta \tilde{W}_{it})^2 - \sigma_v^2 - 2\sigma_u^2] = 0 \tag{30}$$

$$E[(\Delta\tilde{W}_{it})(\Delta\tilde{W}_{it-1}) + \sigma_u^2] = 0 \quad (31)$$

$$E[(\Delta\tilde{r}_{it})(\Delta\tilde{W}_{it}) - 2\rho_u\sigma_u\sigma_{u_r} - \rho_{vu}\sigma_v\sigma_{u_r}] = 0 \quad (32)$$

$$E[(\Delta\tilde{r}_{it-1})(\Delta\tilde{W}_{it}) + \rho_u\sigma_u\sigma_{u_r}] = 0 \quad (33)$$

$$E[(\Delta\tilde{r}_{it})(\Delta\tilde{W}_{it-1}) + \rho_u\sigma_u\sigma_{u_r} + \rho_{vu}\sigma_v\sigma_{u_r}] = 0 \quad (34)$$

3. *Proof of identification:* Suppose that the variances of the shocks are constant over time. The variances and means of the distribution of assets are allowed to vary over time and are observable. There are five parameters to be identified. These include shock variances σ_u^2 , σ_v^2 , $\sigma_{u_r}^2$, along with correlations ρ_u and ρ_{vu} . The following is a direct proof of the over-identification of those parameters by the above moment conditions.

The identification of σ_u^2 and $\sigma_{u_r}^2$ can be achieved by using $\text{Cov}(\Delta\tilde{W}_{it}, \Delta\tilde{W}_{it-1})$, and $\text{Cov}(\Delta\tilde{r}_{it}, \Delta\tilde{r}_{it-1})$, respectively:

$$\sigma_u^2 = -\text{Cov}(\Delta\tilde{W}_{it}, \Delta\tilde{W}_{it-1}), \quad (35)$$

$$\sigma_{u_r}^2 = -\text{Cov}(\Delta\tilde{r}_{it}, \Delta\tilde{r}_{it-1}). \quad (36)$$

This allows for the variance of the permanent shock to wages, σ_v^2 , to be identified using $\text{Var}(\Delta\tilde{W}_{it})$:

$$\sigma_v^2 = \text{Cov}(\Delta\tilde{W}_{it}, \Delta\tilde{W}_{it}) - 2\sigma_u^2. \quad (37)$$

Then the correlation of the shocks, ρ_u and ρ_{vu} , can be identified using the following covariances:

$$\rho_u = -\frac{\text{Cov}(\Delta\tilde{r}_{it-1}, \Delta\tilde{W}_{it})}{\sigma_u\sigma_{u_r}} = 0 \quad (38)$$

$$\rho_{vu} = \frac{\text{Cov}(\Delta\tilde{r}_{it}, \Delta\tilde{W}_{it}) - 2\rho_u\sigma_u\sigma_{u_r}}{\sigma_v\sigma_{u_r}} \quad (39)$$

Note that only five equations were needed for identification. QED.

System Identification of Models With Moving Averages

1. Now allow for moving average processes in wages and returns. The dynamics of log-real wages and the return on total wealth are given by the following equations:

$$\Delta\tilde{W}_{it} = v_{it} + \Delta u_{it} + \alpha_w \Delta u_{it-1}, \quad (40)$$

$$\Delta \tilde{r}_{it} = \Delta u_{it}^r + \alpha_r \Delta u_{it-1}^r. \quad (41)$$

2. There are eleven moment conditions of variances, covariances, and first and second lagged covariances. These moment conditions are as follows:

$$E[(\Delta \tilde{W}_{it})^2 - \sigma_v^2 - 2(\alpha_w^2 - \alpha_w + 1)\sigma_u^2] = 0 \quad (42)$$

$$E[(\Delta \tilde{W}_{it})(\Delta \tilde{W}_{it-1}) + (\alpha_w - 1)^2 \sigma_u^2] = 0 \quad (43)$$

$$E[(\Delta \tilde{W}_{it})(\Delta \tilde{W}_{it-2}) + \alpha_w \sigma_u^2] = 0 \quad (44)$$

$$E[(\Delta \tilde{r}_{it})^2 - 2(\alpha_r^2 - \alpha_r + 1)\sigma_{u_r}^2] = 0 \quad (45)$$

$$E[(\Delta \tilde{r}_{it})(\Delta \tilde{r}_{it-1}) + (\alpha_r - 1)^2 \sigma_{u_r}^2] = 0 \quad (46)$$

$$E[(\Delta \tilde{r}_{it})(\Delta \tilde{r}_{it-2}) + \alpha_r \sigma_{u_r}^2] = 0 \quad (47)$$

$$E[(\Delta \tilde{r}_{it})(\Delta \tilde{W}_{it}) - \rho_{vu} \sigma_v \sigma_{u_r} - (2\alpha_w \alpha_r - \alpha_r - \alpha_w + 2)\rho_u \sigma_u \sigma_{u_r}] = 0 \quad (48)$$

$$E[(\Delta \tilde{r}_{it})(\Delta \tilde{W}_{it-1}) - (2\alpha_r - \alpha_r \alpha_w - 1)\rho_u \sigma_u \sigma_{u_r} - (\alpha_r - 1)\rho_{vu} \sigma_v \sigma_{u_r}] = 0 \quad (49)$$

$$E[(\Delta \tilde{r}_{it})(\Delta \tilde{W}_{it-2}) + \alpha_r (\rho_u \sigma_u \sigma_{u_r} + \rho_{vu} \sigma_v \sigma_{u_r})] = 0 \quad (50)$$

$$E[(\Delta \tilde{r}_{it-1})(\Delta \tilde{W}_{it}) - (2\alpha_w - \alpha_r \alpha_w - 1)\rho_u \sigma_u \sigma_{u_r}] = 0 \quad (51)$$

$$E[(\Delta \tilde{r}_{it-2})(\Delta \tilde{W}_{it}) + \alpha_w \rho_u \sigma_u \sigma_{u_r}] = 0 \quad (52)$$

3. *Proof of identification:* Suppose that the variances of the shocks are constant over time. The variances and means of the distribution of assets are allowed to vary over time and are observable. There are seven parameters to be identified. These include shock variances σ_u^2 , σ_v^2 , $\sigma_{u_r}^2$, along with correlations ρ_u and ρ_{vu} , and moving averages α_w and α_r . The following is a direct proof of the over-identification of those parameters by the above moment conditions. The identification of the moving average and transitory shock variances can be achieved by using first and second auto-covariances:

$$\alpha_w = \frac{b - 2c - \sqrt{b}\sqrt{b + 4c}}{2}, \quad (53)$$

$$\sigma_u^2 = \frac{2c - b - \sqrt{b}\sqrt{b + 4c}}{2c}, \quad (54)$$

for $\text{Cov}(\Delta\tilde{W}_{it}, \Delta\tilde{W}_{it-2}) \neq 0$, where $b = \text{Cov}(\Delta\tilde{W}_{it}, \Delta\tilde{W}_{it-2})$ and $c = \text{Cov}(\Delta\tilde{W}_{it}, \Delta\tilde{W}_{it-2})$. The uniqueness follows from $\sigma_u^2 > 0$ and that the covariances are real numbers. The same moments for returns can be used to identify α_r and $\sigma_{u_r}^2$ for $\text{Cov}(\Delta\tilde{r}_{it}, \Delta\tilde{r}_{it-2}) \neq 0$. This allows for the variances of the permanent shocks σ_v^2 to wages to be identified using $\text{Var}(\Delta\tilde{W}_{it})$:

$$\sigma_v^2 = \text{Cov}(\Delta\tilde{W}_{it}, \Delta\tilde{W}_{it}) - 2b + 2c. \quad (55)$$

Then the correlations of the shocks ρ_u and ρ_{vu} can be identified using the covariances, for example from

$$\rho_u = -\frac{\text{Cov}(\Delta\tilde{r}_{it-2}, \Delta\tilde{W}_{it})}{\alpha_w \sigma_u \sigma_{u_r}} \quad (56)$$

$$\rho_{vu} = -\frac{\text{Cov}(\Delta\tilde{r}_{it}, \Delta\tilde{W}_{it-2}) + \alpha_r \rho_u \sigma_u \sigma_{u_r}}{\alpha_r \sigma_v \sigma_{u_r}} \quad (57)$$

Note that only seven equations were needed for identification. QED.

C Idiosyncratic Returns: Estimation

Estimates of equations (1) and (2) are now described and presented in Table 7. The first column reports the estimates for the returns to total household assets. Portfolio shares are interacted with time fixed effects. Indicators are also included for each asset class if the asset had been sold since the last wave. The regression has an adjusted R^2 of 0.115. Generally, very few observable household characteristics display statistical significance. The presence of an advanced education degree increases the total rate of return on assets by a significant 0.83 percentage points. Coefficients on single heads, male heads, and African-American heads of households do not display statistical significance. Year fixed effects continue to remain significant (although not reported here) in explaining the returns to total household assets.

The second to fifth columns of Table 7 repeat the exercise for returns on assets within each asset class. The adjusted R^2 measures are quite low, with the highest value of 0.117 for the returns to primary housing assets. The indicator for whether that asset had been sold since the last wave may capture reporting bias, underestimated commissions and costs from selling, or address the timing of liquidation. The selling of private business and primary housing assets are found to be significantly

Table 7. Estimation of Idiosyncratic Returns

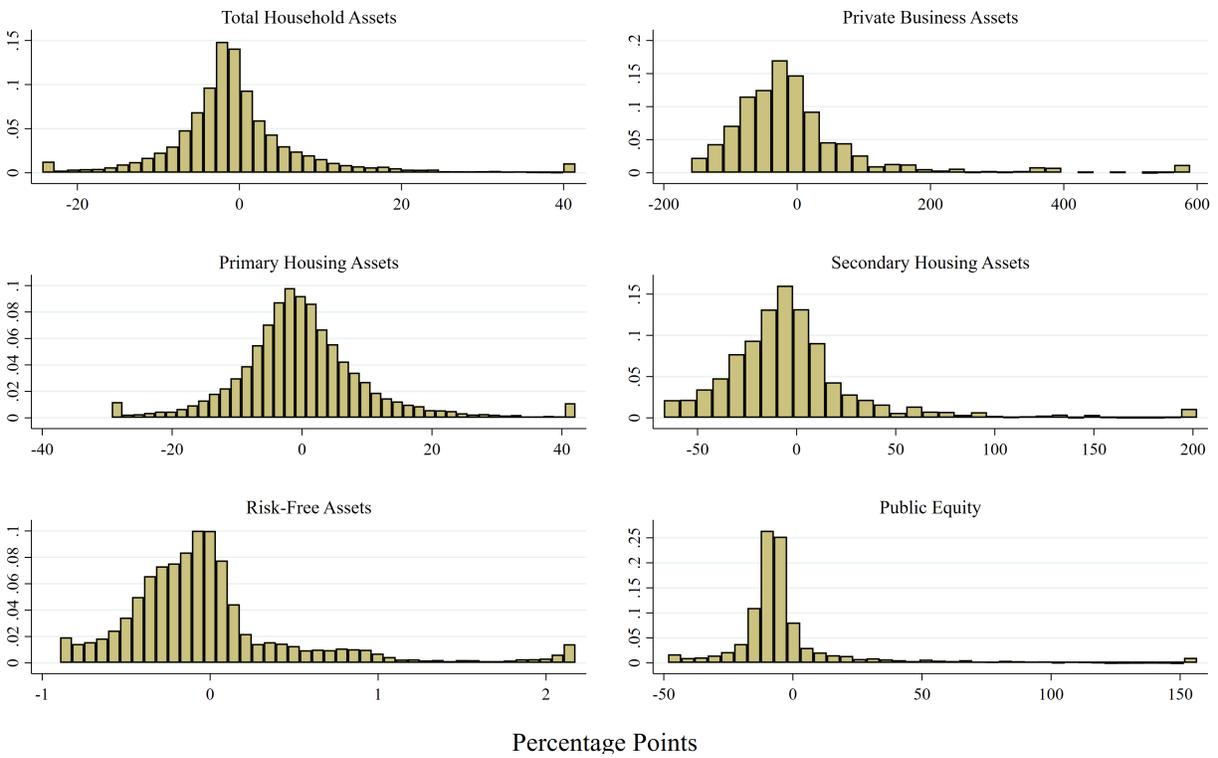
	Total Assets	Business	Prim. Housing	Sec. Housing	Public Equity
If sold	-	-38.14***	-6.69***	-3.74	6.60***
	-	(14.7)	(0.26)	(2.76)	(0.85)
Outside Dependents	0.55	-51.09	0.86	-20.55**	4.89
	(0.904)	(43.7)	(0.80)	(8.42)	(3.62)
Other Income	0.15	3.00	-0.34*	-3.50	-0.48
	(0.188)	(10.0)	(0.19)	(2.46)	(0.91)
Advanced Degree	0.83***	33.93	0.23	-19.72***	-0.45
	(0.255)	(51.5)	(0.41)	(7.02)	(2.37)
Single	-0.43	-2.31	0.06	7.90	2.11
	(0.445)	(29.5)	(0.65)	(11.67)	(2.88)
African-American	-0.04	1.10	0.69**	4.36	1.17
	(0.257)	(43.2)	(0.33)	(4.61)	(2.07)
Male	0.07	28.55	-0.60	-7.21	1.02
	(0.330)	(32.5)	(0.48)	(7.62)	(1.90)
N	32204	1904	36234	3579	15907
Adj. R ²	0.115	0.068	0.117	0.035	0.022

Note: Coefficient estimates from OLS regressions of demographic factors for each asset return in percentage points. All regressions also include control indicators for year, age, region, and indicators if assets were sold in that period. The return to total household assets interacts portfolio shares with year fixed effects. HAC-robust standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively.

associated with a decline in the return, whereas the selling of a public equity is associated with an increase in the return.

Figure 2 displays histograms of the estimates of the idiosyncratic returns on assets from equations 1, 2, and 3 as reported in Table 7.

Figure 2. Histograms of Idiosyncratic Returns



Bunched at the 1 and 99 percentile.