Consumption-Income Sensitivity and Portfolio Choice

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Contrary to the predictions of traditional life-cycle models, household consumption is excessively sensitive to current income. Similarly, weak evidence of income hedging runs against standard portfolio theory. We link these two puzzles by modifying the theoretical framework of Viceira (2001) to study how consumption-income sensitivities generated by income in the utility function affect households' portfolio choices. Empirically, we find that consumption-income sensitivities affect asset allocation through the income hedging channel. In particular, we show that the interaction between consumption-income sensitivity and the correlation of income growth to stock market returns is an important explanatory variable for households' stock market holdings. (*JEL* D11, D12, D14, G11)

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Consumption and portfolio decisions are fundamentally interrelated because they are governed by the same preferences (e.g., Merton 1969; Samuelson 1969). However, the empirical literatures on consumption and

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portfolio choice have developed in relative isolation. Nevertheless, a common conclusion in both strands of literature is that standard economic models cannot fully explain household decisions.

Specifically, traditional life-cycle models predict that household consumption depends on lifetime income. Yet empirical evidence documents that households do not fully smooth consumption, because consumption is excessively sensitive to current income. In other words, the empirical correlation between consumption growth and current income growth is too high (Hall and Mishkin 1982; Courant et al. 1984; Shapiro and Slemrod 1995; Shea 1995; Parker 1999; Souleles 1999; Vissing-Jørgensen 2002b; Shapiro and Slemrod 2003; Agarwal et al. 2007; Johnson et al. 2009; Jappelli and Pistaferri 2010; Parker et al. 2013; Parker 2015). Further, canonical models of portfolio choice suggest that when making portfolio decisions, households should engage in income hedging using financial assets because income risk cannot be traded or insured (Viceira 2001; Campbell and Viceira 2002; Cocco et al. 2005; Gomes and Michaelides 2005).

According to this literature, the income hedging potential of financial assets is typically captured by the correlation between asset returns and income growth. When this correlation is negative, investors have an incentive to invest in risky assets to mitigate income fluctuations. In contrast, when this correlation is positive, investors have an incentive to reduce their asset holdings and even short-sell financial assets to hedge against income risk. Even though the income hedging mechanism is theoretically robust, existing empirical studies have not detected a strong income hedging motive in portfolio decisions (Heaton and Lucas 2000; Vissing-Jørgensen 2002b; Angerer and Lam 2009).

In this paper, we bridge the gap between the empirical consumption and portfolio literatures, and identify a novel connection between consumption smoothing and portfolio choice. Our key conjecture is that households who do not engage in perfect consumption smoothing, that is, exhibit excess sensitivity of consumption to current income, may have relatively weak underlying preferences for hedging income risk. Such households' consumption paths would optimally track their current income. Consequently, they would be willing to forgo opportunities to hedge income risk in the asset markets. This behavior would appear puzzling in canonical portfolio choice models that do not account for the excess sensitivity of consumption to current income.

We empirically validate our conjecture by showing that differences in the income sensitivity of consumption relate to household asset allocation decisions. We find that the interaction term between the consumption growth on income growth beta (i.e., our consumption-income sensitivity measure) and the correlation of income growth to stock market returns (i.e., the traditional income hedging measure) is an important explanatory variable for household stock market holdings. In particular, higher consumption-income sensitivity corresponds to weaker income hedging for a given correlation between income growth and stock returns.

We formally examine the effects of consumption-income sensitivities on portfolio decisions in a model in which individuals derive utility from consumption and income. In other words, we assume that consumption and income are considered a bundle of goods that jointly affect investor welfare. We call this model the consumption-income model. Our model is inspired by the recent behavioral literature in finance and economics.

One strand of this literature argues that signaling social status is an important determinant of consumption decisions. Specifically, Glazer and Konrad (1996) introduce a model where households derive utility from consumption and social status, which is primarily determined by current income. Thus, in their status model, current income directly affects household utility.

Including income as an argument in the utility function is also motivated by Akerlof (2007). He argues that household consumption is affected by consumption entitlements, with current income being the primary determinant of such entitlements.[1] Our consumption-income model is also consistent with findings that consumers view savings as a separate decision, and not as a simple residual action to consumption (e.g., Furnham and Argyle 1998). A utility function defined over consumption and income is also consistent with the debt aversion model of Prelec and Loewenstein (1998) and Thaler's (1985) transaction utility theory.

To derive optimal consumption and portfolio policies, we embed the consumption-income utility function in a portfolio choice problem with exogenous labor supply (e.g., Viceira 2001; Campbell and Viceira 2002). We solve the model analytically, and show that preferences over income affect consumption smoothing. Specifically, the consumption-income model generates positive consumption-income sensitivity when the elasticity of substitution between consumption and income is low. In contrast, the consumption-income model implies a negative consumption-income sensitivity when the elasticity of substitution between consumption and income is high.

More importantly, we show that preferences over income affect portfolio decisions. Specifically, the consumption-income model predicts that the income hedging motive is weakened when investors exhibit positive consumption-income sensitivity. In contrast, when investors exhibit negative consumption-income sensitivity, the income hedging motive is strengthened relative to canonical models in which investors do not exhibit preferences over income.

The rationale behind these predictions is the following. When consumption and income exhibit strong complementarities (positive

[1] For example see Keynes (1936), Weber (1958), Tversky and Kahneman (1981), Bourdieu (1984), Shefrin and Thaler 1988, and Guiso et al. (2006)

consumption-income sensitivity), investors derive utility from consumption tracking their income. Consequently, investors are not particularly concerned with income smoothing and do not value financial assets as instruments for mitigating income shocks. In contrast, when consumption and income exhibit strong substitutability (negative consumption-income sensitivity), investors are very concerned with income smoothing. Therefore, they assign great value to financial assets as vehicles for reducing income risk. Overall, the model confirms our intuition that consumption-income sensitivities affect the income hedging motive in portfolio decisions.

We empirically test the predictions of our consumption-income model with household data from the Panel Study of Income Dynamics (PSID). We begin our empirical analysis by first confirming that, on average, PSID households do not smooth consumption. Specifically, we estimate pooled panel regressions of consumption growth on income growth, conditioning on household demographic characteristics. Consistent with previous evidence, we find that consumption growth tracks current income growth. Our estimates suggest that a one-standard-deviation increase in current income growth is associated with about a 1.4% increase in consumption growth.

Next, we follow the predictions of our consumption-income model and examine how consumption-income sensitivities affect the portfolio decisions of PSID households. Specifically, our model predicts that consumption-income sensitivities affect portfolio choice through the income hedging motive. In other words, the model suggests that the optimal equity share should be affected by the interaction between the consumption-income sensitivity parameter and the correlation of household income growth with stock market returns (i.e., the income hedging motive). To compute this interaction term, we estimate household-level regressions of consumption growth on income growth and use the coefficient estimates on income growth to measure the consumption-income sensitivity for each household.

As implied by our model, we interact the consumption-income sensitivity estimates for each household with the respective correlations of income growth to stock market returns. According to our model, this interaction term should be positively related to the optimal equity share. We test this prediction by estimating Tobit and Heckman asset allocation regressions in which the consumption-income interaction term is the main explanatory variable.

Consistent with model predictions, we find that consumption-income sensitivities are an important determinant of the portfolio decisions of PSID households. Specifically, in our asset allocation regressions, the coefficient estimate on the consumption-income sensitivity interaction term is positive. Moreover, this effect is economically and statistically significant. For example, our estimates from the Tobit regressions suggest that a one-standard-deviation increase in the consumption-income sensitivity interaction term is related to a 2.6% increase in the equity share. This effect is much stronger (in absolute magnitude) than the impact of the traditional income hedging term: a one-standard-deviation increase in the correlation between income growth and stock market returns is related to a 1.3% decrease in the equity share.

We continue to find a strong consumption-income sensitivity effect in portfolio allocations even when we focus on market participants alone and estimate Heckman (1979) regressions. The Heckman estimates suggest that a one-standard-deviation increase in the consumption-income sensitivity interaction term leads to a 1.3% increase in the equity share. This effect is comparable to the impact of income growth volatility, which is also an important determinant of equity allocation: a one-standard-deviation increase in income growth volatility is associated with a 1.8% decrease in the equity share. In sum, we find that consumption-income sensitivity affects portfolio decisions through the income hedging motive.

We complement our baseline empirical analysis with a series of additional tests related to alternative explanations for our results. Our first concern is that income could be a proxy for the consumption of the household's reference group. In this case, consumption-income sensitivities would simply capture habit effects.[2] To this end, we examine whether the documented consumption-income effect on income hedging is related to external habit formation. Another potential issue is that consumption-income sensitivities might capture borrowing constraints (e.g., Runkle 1991). To address this concern, we test, both theoretically and empirically, whether the consumption-income effect on income hedging is driven by borrowing constraints at the household level.

The evidence from these tests suggests that neither habit formation nor borrowing constraints can explain the effect of consumption-income sensitivity on asset allocation decisions. Nevertheless, we acknowledge that our empirical measures for habit formation and borrowing constraints are inherently imperfect. Therefore, we cannot completely rule out these mechanisms as additional drivers of consumption-income sensitivities.

We also investigate whether the consumption-income sensitivity effect on income hedging captures peer effects, nonlinear effects of income or is a proxy for risk aversion. Since the PSID does not have a direct measure of risk aversion, we proxy for risk aversion using the volatility of household income growth (e.g., Ranish 2013). We find that the consumption-income sensitivity effect on portfolio choice is strong even in the presence of occupation-, industry-, and region-level fixed effects, quadratic income and wealth terms, and income growth volatility.

Overall, we document a series of novel findings that are important to the household finance literature, where the evidence for income hedging has been mixed and puzzling. On the one hand, Heaton and Lucas (2000) detect weak

[2] Examples of habit models include Campbell and Cochrane (1999), DeMarzo et al. (2004, 2008), Korniotis (2008), and Gomez et al. (2009).

evidence of income hedging in the investment decisions of entrepreneurs. Vissing-Jørgensen (2002b) finds no evidence that the correlation between income growth and market returns influences portfolio decisions. Further, Massa and Simonov (2006) show that income hedging motives do not influence the portfolio decisions of Swedish investors.

On the other hand, Bonaparte et al. (2014) document that Dutch and U.S. households consider the comovement between income growth and market returns when making portfolio decisions. Similarly, Betermier et al. (2017) show that preferences over value and growth stocks are motivated by hedging concerns regarding human capital risk. A common feature of these studies is examining portfolio decisions in isolation from consumption decisions. Instead, we examine both decisions jointly, and show that consumption-income sensitivities affect the income hedging motive in portfolio choice.

Our work is also related to the literature on the excess sensitivity of consumption to current income. A leading explanation of consumption-income sensitivity is borrowing constraints (Runkle 1991; Deaton 1992; Carroll 1994; Gourinchas and Parker 2002; Parker 2015). Borrowing restrictions are a reasonable explanation, especially for young individuals who have not accumulated a substantial stock of wealth. However, we find that consumption is excessively sensitive to current income even for the high-income households in our sample that are not likely to experience liquidity constraints.

1. The Consumption-Income Model

In this section we present the consumption-income model that allows for consumption-income sensitivities. The model is an extension of the dynamic portfolio choice model with fixed labor supply of Viceira (2001). We use this framework because we can obtain analytical solutions for optimal portfolio weights in discrete time, and clearly illustrate the impact of consumption-income sensitivities on portfolio decisions.

1.1 Utility from consumption and income

In our theoretical framework, we assume that investors derive utility from consumption and income. In other words, we assume that consumption and income are considered a bundle of goods that jointly affect investor welfare. Specifically, investors' utility function is a constant elasticity of substitution (CES) aggregator of consumption and income:

$$\frac{([\delta C_t^{\psi} + (1-\delta) Y_t^{\psi}]^{1/\psi})^{1-\rho}}{1-\rho}. \tag{1}$$

We use the CES specification because it is flexible and allows consumption and income to be either complements or substitutes. We call the above specification the "consumption-income model."

In Equation (1), C_t is consumption and Y_t is income. The constant δ ($\delta \in (0, 1]$) is the share of the respective goods (consumption and income) in the utility basket. The parameter ψ ($\psi \leq 1$) determines the elasticity of substitution between consumption and income, which is equal to $1/(1-\psi)$.[3] For ψ equal to 1, consumption and income are perfect substitutes, whereas as ψ tends to $-\infty$, consumption and income are perfect complements. The constant ρ ($\rho > 0$) in Equation (1) is a curvature parameter that, under the assumption of time-separable preferences, affects both the intertemporal elasticity of substitution (IES) and the risk aversion. For δ equal to 1 (no preferences over income), ρ becomes the traditional risk aversion parameter.

One of the motivations for our consumption-income model comes from the status preferences and conspicuous consumption literatures (e.g., Glazer and Konrad 1996; Charles et al. 2009; Roussanov 2010). Specifically, in the original work of Glazer and Konrad (1996) on status preferences, investors derive utility from consumption and social status, which is determined by income.[4]

Alternative motivations for preferences over income can also be found in the sociology and behavioral economics literatures. Specifically, Akerlof (2007) argues that household consumption is affected by consumption entitlements, with current income being the primary determinant of such entitlements. Our consumption-income model is consistent with findings that consumers view savings as a separate decision, and not as a simple residual action to consumption (e.g., Furnham and Argyle 1998). A utility function defined over consumption and income is also consistent with the debt aversion model of Prelec and Loewenstein (1998) and Thaler's (1985) transaction utility theory.

1.2 Life-cycle consumption-income model

To derive optimal consumption and portfolio policies, we embed the consumption-income utility of Equation (1) in the dynamic portfolio choice model of Viceira (2001) where investors have access to a risky and a risk-free asset. In the model, investors can either be employed or retired. When investors are employed, they receive a nontradeable endowment Y_t (labor income). In each period, investors remain employed with probability π_e and retire with probability $\pi_r = 1 - \pi_e$ ($\pi_e, \pi_r > 0$). Retirement is an absorbing state and is independent of income growth or asset returns. During retirement, investors receive a constant pension $\bar{Y}_r$, which we set equal to the last preretirement income payment.

3 For $\psi = 0$, the income-based utility function becomes $(C_t^{\delta} Y_t^{1-\delta})^{1-\rho}/(1-\rho)$.

4 We acknowledge that status preferences have been originally employed in a static, cross-sectional framework (e.g., Charles et al. 2009). This is consistent with the cross-sectional aspect of our main data set, the Panel Study of Income Dynamics.

To close the model, we follow Viceira (2001) and assume that income growth during employment Δy_t is an i.i.d. process with constant volatility and $N(0, 1)$ shocks $\epsilon_{\Delta y,t}$:

$$\Delta y_t = \mu_{\Delta y} + \sigma_{\Delta y}\epsilon_{\Delta y,t}. \tag{2}$$

Like in Viceira's model, we assume that markets are incomplete and that income risk is not spanned by financial assets. However, investors use financial assets to partially hedge income shocks. In the model, there are two assets, a risk-free and a risky asset. The log-return of the risk-free asset $r_{f,t}$ is constant, whereas the log-return of the risky asset $r_{m,t}$ is an i.i.d. process with constant volatility and $N(0, 1)$ shocks $\epsilon_{m,t}$:

$$r_{m,t} = \mu_m + \sigma_m\epsilon_{m,t}. \tag{3}$$

Finally, the correlation between income growth shocks ($\epsilon_{\Delta y,t}$) and asset return shocks ($\epsilon_{m,t}$) is $\rho_{\Delta y,m}$. Next, we derive the optimal consumption and portfolio rules during employment, which is the basis of our empirical analysis.

1.3 Consumption and portfolio rules during employment

During employment, investors choose consumption and portfolio weights to maximize their lifetime utility by solving the following maximization problem:

$$V_t^e = \max_{C_t,a_t} \frac{[\delta C_t^{\psi} + (1-\delta)Y_t^{\psi}]^{\frac{1-\rho}{\psi}}}{1-\rho} + \beta \mathbf{E}_t[\pi_e V_{t+1}^e + \pi_r V_{t+1}^r], \quad \text{subject to}$$

$$W_{t+1} = (W_t - C_t + Y_t)[a_t(e^{r_{m,t+1}} - e^{r_{f,t+1}}) + e^{r_{f,t+1}}].$$

The constant β ($\beta \in (0,1)$) is the rate of time preference, W_t denotes wealth, and a_t is the portfolio weight on the risky asset. V_t^e is lifetime utility while employed and V_t^r is utility during retirement.

Proposition 1. During employment, the optimal portfolio rule in the consumption-income model is

$$a^e \approx \frac{\mu_m - r_f + 0.5\sigma_m^2}{\gamma(\pi_r + \pi_e\phi_1)\sigma_m^2} - (1-\phi_1-\theta)\frac{\pi_e\sigma_{\Delta y}\sigma_m}{(\pi_r+\pi_e\phi_1)\sigma_m^2}\rho_{\Delta y,m}, \tag{4}$$

optimal consumption (in logs) is approximately affine in wealth and income

$$c_t^e \approx \phi_0 + \phi_1 w_t^e + (1-\phi_1)y_t, \quad \text{with } 0 < \phi_1 < 1, \tag{5}$$

and the Euler equation for the risk-free rate conditional on two consecutive employment periods is

$$\mathbf{E}_t[\beta e^{-\gamma\Delta c^e_{t+1}+\gamma\theta\Delta y_{t+1}+r_{f,t+1}}] = 1. \tag{6}$$

Proof. See Appendix A ■

In relation to the traditional framework (e.g., Viceira 2001), the novel feature of the optimal decision rules in Equation (4) of Proposition 1 is the coefficient θ. This parameter is given by

$$\theta = -(1-\rho-\psi)\xi_2/[(1-\rho-\psi)\xi_1+\psi-1], \tag{7}$$

where ρ and ψ are preference parameters in the consumption-income utility, and ξ_1 and ξ_2 are log-linearization constants in the CES aggregator of Equation (1).[5] The parameter θ captures the excess consumption-income sensitivity. Specifically, θ depends on preferences over income through the linearization constant ξ_2, which is a function of the income weight $(1-\delta)$ in the consumption-income utility function. When δ in Equation (1) is 1, that is, when investors do not derive utility from income, ξ_2 and θ become zero, and consumption-income sensitivities vanish. In general, the sign of θ depends on the relative magnitude of $1-\psi$, which determines the elasticity of substitution between consumption and income in the consumption-income utility function.[6] For $1-\psi > \rho$, θ is positive (positive consumption-income sensitivity), whereas for $1-\psi < \rho$, θ is negative (negative consumption-income sensitivity).

The remaining important parameters in the optimal portfolio and consumption policies are γ, ϕ_0, and ϕ_1. The constant γ in Equations (4) and (6) is the effective risk aversion parameter. γ is equal to $-[(1-\rho-\psi)\xi_1+\psi-1]$, which is positive for $\rho > 0$, $\psi \leq 1$, and $\xi_1 \in (0,1)$. The parameter ϕ_0 in Equation (5) captures precautionary savings during employment. ϕ_0 is constant because we assume that asset returns and income growth are unpredictable processes with constant volatility.

The parameter ϕ_1 in the optimal equity share and the consumption function (Equations (4) and (5)) is the elasticity of consumption to wealth. Similarly, $1-\phi_1$ is the elasticity of consumption to income. ϕ_1 depends on the probability of employment π_e and the parameters κ_0, κ_1, and κ_2, which are log-linearization constants in the budget constraint.[7] The constant ϕ_1 is less than 1 for positive wealth, that is, $W_t + Y_t - C_t > 0$.

1.4 Portfolio choice and income hedging

According to the Euler equation in Proposition 1, consumption growth is sensitive to income growth, even if income growth is predictable.

[5] $\xi_1 = \frac{\delta e^{\psi\bar{c}}}{\delta e^{\psi\bar{c}}+(1-\delta)e^{\psi\bar{y}}}$, $\xi_2 = \frac{(1-\delta)e^{\psi\bar{y}}}{\delta e^{\psi\bar{c}}+(1-\delta)e^{\psi\bar{y}}}$. See Appendix A.

[6] The log-linearization constant ξ_2 is nonnegative, whereas the denominator $-[(1-\rho-\psi)\xi_1+\psi-1]$ in Equation (7) is positive for $\rho > 0$, $\psi \leq 1$, and $\xi_1 \in (0,1)$. Thus, the sign of θ depends on the sign of $1-\rho-\psi$.

[7] See Equation (A9) in Appendix A.

This prediction arises because in our consumption-income model, income affects the marginal utility of consumption. As we see from Equation (6), the parameter θ determines how strongly consumption growth tracks income growth.

The most important prediction of our model is that consumption-income sensitivities affect portfolio decisions. Specifically, the optimal equity share of the consumption-income model in Equation (4) is different to that of the traditional life-cycle model. In traditional life-cycle models with exogenous income, the optimal equity share is determined by a risk-return term $\left(\frac{\mu_m - r_f + 0.5\sigma_m^2}{\gamma(\pi_r + \pi_e\phi_1)\sigma_m^2}\right)$ like in Merton (1969) and Samuelson (1969) and by an income hedging term like in Viceira (2001). This traditional income hedging term is[8]

$$-(1-\phi_1)\frac{\pi_e\sigma_{\Delta y}\sigma_m}{(\pi_r+\phi_1\pi_e)\sigma_m^2}\rho_{\Delta y,m}. \tag{8}$$

Because the consumption-income elasticity $(1-\phi_1)$ is positive, the sign of the traditional hedging term depends on the correlation between income growth and the return of the risky asset, $\rho_{\Delta y,m}$. When $\rho_{\Delta y,m}$ is positive, investors have an incentive to disinvest from the risky asset because such investments will magnify their total risk exposure. However, when $\rho_{\Delta y,m}$ is negative, the risky asset has income hedging benefits and investors should allocate a significant portion of their savings to the risky asset.

In the consumption-income model, consumption is sensitive to current income; that is, the parameter θ in Proposition 1 is nonzero. Hence, the income hedging term in portfolio allocation is given by

$$-(1-\phi_1-\theta)\frac{\pi_e\sigma_{\Delta y}\sigma_m}{(\pi_r+\phi_1\pi_e)\sigma_m^2}\rho_{\Delta y,m}. \tag{9}$$

In this case, if an investor exhibits positive consumption-income sensitivity ($\theta > 0$), the term $1-\phi_1-\theta$ is smaller than the traditional hedging parameter $1-\phi_1$. The consumption-income model then predicts that investors with negative correlation $\rho_{\Delta y,m}$ who also exhibit positive consumption-income sensitivity should not fully hedge their income risk, and invest less in the risky asset.[9]

In contrast, if an investor exhibits negative consumption-income sensitivity ($\theta < 0$), the term $1-\phi_1-\theta$ is greater than the traditional hedging parameter $1-\phi_1$. The consumption-income model then predicts that investors with negative correlation $\rho_{\Delta y,m}$ who also exhibit negative consumption-income sensitivity should hedge their income risk more

8 To identify the traditional income hedging motive, we assume that investors do not have preferences over income; that is, the income share parameter $1-\delta$ in Equation (1) is zero. In this case, the linearization constant ξ_2 is zero, and the parameter θ in Equations (4), (6), and (7) also becomes zero.

9 Using simulations in Table 6, we show that the indirect effect of the consumption-income sensitivity parameter θ on portfolio choice through the wealth elasticity ϕ_1 is infinitesimal.

aggressively than in the traditional framework, and invest more in the risky asset.

The intuition for these predictions is the following. When the elasticity of substitution between consumption and income in the consumption-income utility function is relatively low (i.e., $1/(1-\psi) < 1/\rho$), the consumption-income sensitivity parameter θ is positive. In this case, investors derive utility from consumption tracking their income. Consequently, these investors are not particularly concerned with income smoothing, and do not value financial assets as instruments for mitigating income shocks.

In contrast, when consumption and income exhibit strong substitutability (i.e., $1/(1-\psi) > 1/\rho$), the consumption-income sensitivity parameter θ is negative. In this case, investors are concerned with income smoothing as an alternative to consumption smoothing, and assign great value to financial assets as vehicles for reducing income risk. Overall, the model confirms our intuition that consumption-income sensitivities affect the traditional income hedging motive in portfolio decisions.

2. Data and Summary Statistics

In this section, we describe the data and present summary statistics of the main variables used in our empirical analysis.

2.1 Panel Study of Income Dynamics

We use data from the Panel Study of Income Dynamics (PSID) because, to our knowledge, it is the only longitudinal survey that includes both consumption and portfolio decisions for a large sample of U.S. households. The long panel nature of the PSID allows us to estimate consumption growth regressions at the household level and obtain estimates for consumption-income sensitivities.[10]

In the first part of our empirical exercise, we estimate pooled regressions of consumption growth on income growth. For these regressions, we collect consumption and income data for all available annual waves between 1978 and 1997. Our measure of consumption is total food expenditures, the sum of expenditures on food consumed at and away from home, normalized by the number of household members. Like in many prior studies using the PSID, we treat food consumption as a proxy for total consumption (e.g., Zeldes 1989; Mankiw and Zeldes 1991; Runkle 1991; Lusardi 1996).

We also collect income and wealth data. Our income measure is total household nonfinancial income. Wealth is measured as the household's net worth. A large component of wealth is financial wealth which includes

[10] The long panel nature of the PSID has made it a frequent data source for studies of consumption and, more recently, asset allocation (e.g., Mankiw and Zeldes 1991; Shea 1995; Dynan 2000; Brunnermeier and Nagel 2008).

holdings in equities, IRAs, and bonds, as well as checking and savings accounts.[11] We define stock market participants as households that hold equity directly or indirectly through IRA holdings in stocks. We also collect various demographic variables such as gender, race, age, employment status, number of children, and education. Further, we use the U.S. stock market return index and the risk-free rate from Kenneth French's data library. Finally, we deflate all asset returns, income, and consumption using the consumer price index provided by the Bureau of Labor Statistics.

Following the literature (e.g., Runkle 1991; Vissing-Jørgensen 2002a; Angerer and Lam 2009), we impose various sample filters. We delete household-year observations in which annual consumption growth or income growth is higher than 400% or lower than -70%. We also delete observations with income less than \$100, and households with less than two years of observations.

We compute consumption growth and income growth to estimate the consumption-income effect. We also compute several moments of household income growth that are used in our portfolio choice regressions. Similar to Guiso et al. (1996) and Heaton and Lucas (2000), we define income risk as the standard deviation of income growth. To measure the traditional income hedging motive, we compute the correlation between household total non-financial income growth and excess stock market returns. We compute one correlation for each household using all available data for the household, which is consistent with Vissing-Jørgensen (2002b), Massa and Simonov (2006), and Bonaparte et al. (2014).

One issue with the PSID is that surveys were administered annually prior to 1997 and only biannually after 1997. Another issue is that the majority of observations regarding wealth, stock participation, and asset allocation are recorded in the post-1997 period. Prior to 1997, the PSID gathered information for wealth and stock ownership only in 1984, 1989, and 1994.

We exploit these two features of the data in our empirical methodology. Specifically, we estimate consumption-income sensitivities, income growth volatilities, and correlations between household income growth and excess stock market returns using the annual PSID waves from 1978 to 1997. In this way, we avoid combining annual and biannual observations into a single sample, which can be problematic. Further, we use the post-1997 sample to estimate our portfolio regressions. By separating the estimation period of the consumption-income sensitivities from the estimation of the portfolio choice regressions, we minimize any concerns related to potential look-ahead and generated regressor biases.

Finally, we follow Zeldes (1989) and Mankiw and Zeldes (1991) and interpret the PSID question on consumption as a measure of consumption

[11] Wealth information in the PSID is available only every 5 years between 1984 and 1999. Thereafter, it is available every 2 years.

Table 1
Summary statistics

A. Consumption growth, income growth, and the risk-free rate

	Moments (×100)				Correlations		
	$\Delta c_{i,t}$	$\Delta y_{i,t}$	$r_{f,t}$		$\Delta c_{i,t}$	$\Delta y_{i,t}$	$r_{f,t}$
Mean	1.226	2.251	2.974	$\Delta c_{i,t}$	1		
Median	−0.004	1.724	2.800	$\Delta y_{i,t}$	0.030***	1	
25th percentile	−23.239	−12.424	1.469	$r_{f,t}$	0.007**	0.018***	1
75th percentile	24.715	16.909	4.389				
SD	42.735	34.481	2.740				
N	62,904	62,904	62,904				

B. Income, consumption, retirement, age, and wealth

	Income ($)	Consumption ($)	Retired ind.	Age	Wealth ($)
Mean	28,735	1,115	0.099	43.197	71,762
Median	23,777	1,014	0.000	40	24,940
25th percentile	13,471	285	0	31	3,000
75th percentile	37,383	1,584	0	53	86,500
SD	25,304	989	0.299	15.017	119,092
N	62,904	62,904	62,904	62,904	3,133

This table shows summary statistics for key variables in this study. *SD* is the standard deviation. $\Delta c_{i,t}$ is consumption growth; $\Delta y_{i,t}$ is income growth; and $r_{f,t}$ is the annual log risk-free rate. Panel A shows pooled moments and correlation estimates for the entire sample. *** and ** indicate significance at the 1% and 5% confidence levels. Panel B shows summary statistics for consumption, income, retirement, age, and wealth. *Income* is total household nonfinancial income. *Consumption* is measured by food at home and food out normalized by the number of household members. *Retired ind.* is an indicator depending on whether the household head has retired. *Wealth* is household net worth. The sample period consists of the annual PSID waves (1978–1997).

during the first quarter of the survey year t.[12] Therefore, to match the timing of consumption with the timing of the risk-free rate in the consumption growth regressions, we measure the risk free rate between the first quarter of the survey year t ($Q1_t$) and the first quarter of the subsequent year $t+1$ ($Q1_{t+1}$). We then compute the $Q1_t$-to-$Q1_{t+1}$ risk-free rater, $r_{f,t+1}$, by compounding monthly risk-free rates like in Mankiw and Zeldes (1991).

2.2 Summary statistics

In Table 1, we present summary statistics for the annual PSID waves for the 1978 to 1997 period. The statistics in panel A of Table 1 show that consumption growth is about 1.2% on average, whereas income growth is 2.2% on average. Both income and consumption growth are volatile since their standard deviation is greater than 30%. Consistent with the previous literature, consumption and current income growth are also positively correlated; their correlation coefficient is 3%, and is statistically significant.

[12] This survey question is administered in the first quarter of the following year and refers to recent food consumption.

Moreover, as we report in panel B of Table 1, the average income is \$28,735 and the average wealth is \$71,762. There is also substantial cross-sectional variation in income and wealth. In particular, the 25th (75th) percentile of income is \$13,471 (\$37,383) and for wealth is \$3,000 (\$86,500). Finally, the average age in the full sample is 43, and only 10% of the households are retired. Next, we present the regression-based evidence of consumption-income sensitivity among households in the PSID.

3. Consumption-Income Sensitivity Evidence

In this section, we provide evidence that, contrary to the predictions of standard life-cycle models, household consumption growth in the PSID sample depends on current income growth.

3.1 Pooled consumption growth regressions

Following existing studies of consumer behavior (e.g., Zeldes 1989; Vissing-Jørgensen 2002b), our estimation of consumption-income sensitivities is based on the Euler equation for the risk-free rate during two consecutive employment dates, which is described in Equation (6) of Proposition 1. To obtain the empirical regression, we assume rational expectations, and rewrite the Euler equation by replacing the conditional expectation $\mathbf{E}_t$ with a multiplicative error term $e^{\epsilon_{i,t+1}}$. Then we take logs and solve for consumption growth $\Delta c_{i,t+1}$. Finally, we augment the linearized Euler equation with additional control variables and obtain the following expression:

$$\Delta c_{i,t+1} = \frac{1}{\gamma} log\, \beta + \frac{1}{\gamma} r_{f,t+1} + \theta \Delta y_{i,t+1} + \boldsymbol{\alpha}_x{}' \boldsymbol{X}_{i,t+1} + \frac{1}{\gamma} \epsilon_{i,t+1}. \qquad (10)$$

Above, the term $1/\gamma$ is the inverse of the effective risk aversion parameter, and it is equal to the elasticity of intertemporal substitution (EIS). This parameter captures the effect of interest rates on consumption growth. The parameter θ is the consumption-income sensitivity. The vector $\mathbf{X}_{i,t+1}$ includes various control variables that capture cross-sectional heterogeneity in household consumption growth. These variables include age, age^2, and number of children and indicators for college education, gender, and employment status of the household head. Given the empirical evidence in Charles et al. (2009) on the relation between race and consumption, we also include race indicators (i.e., African-American, Asian, and Hispanic) in the regression of Equation (10).

We estimate Equation (10) with ordinary least squares (OLS). At the same time, we acknowledge that there are potential drawbacks with using OLS. To begin with, since total consumption is proxied by total food expenditures at and away from home, the above specification may suffer from biases due to measurement errors. Also, in the presence of heteroscedasticity, the OLS

Table 2
Consumption-income sensitivity regression estimates

	Full sample		Retirement		Age		Income	
			Nonret.	Ret.	1st tert.	3rd tert.	1st tert.	3rd tert.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$1/\gamma$	0.113	0.104	0.084	0.410	−0.011	0.020	0.049	0.114
	(1.86)	(1.73)	(1.34)	(1.95)	(0.10)	(0.19)	(0.34)	(1.40)
θ		0.039	0.045	−0.008	0.038	0.013	0.042	0.029
		(7.01)	(7.57)	(−0.55)	(3.87)	(1.45)	(4.38)	(3.03)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.002	0.003	0.004	0.001	0.004	0.001	0.002	0.003
N	62,904	62,904	56,641	6,263	20,548	19,540	18,312	23,595

This table shows pooled OLS regression results for the reduced-form consumption Euler equation:

$$\Delta c_{i,t} = \frac{1}{\gamma} log\, \beta + \frac{1}{\gamma} r_{f,t} + \theta \Delta y_{i,t} + \boldsymbol{\alpha}_x{}' \boldsymbol{X}_{i,t} + \frac{1}{\gamma} \epsilon_{i,t},$$

where $\Delta c_{i,t}$ is consumption growth, $r_{f,t}$ is the risk-free rate, and $\Delta y_{i,t}$ is income growth. The parameter $1/\gamma$ is the EIS, and the coefficient θ captures consumption-income sensitivities. The vector of control variables $\mathbf{X}_{i,t}$ includes age, demeaned-age-square, number of children, gender, race, unemployment indicator, and an indicator for college or graduate studies for household head. Income is total household nonfinancial income. *t*-statistics are shown in parentheses based on robust standard errors. The estimation period consists of the annual PSID waves (1978–1997).

estimates will be biased. Unfortunately, as Jappelli and Pistaferri (2010) conclude in their survey, there is no perfect methodology for estimating Euler equations of consumption growth since all available approaches have disadvantages. For example, instrumental variable estimators often suffer from the weak-instrument problem due to measurement errors in household-level data.

In the absence of one well-accepted methodology, we use OLS to estimate the log-linearized Euler equation because it offers some advantages for our study. First, since many existing studies use OLS, our results can be compared to most of the existing literature. Second, OLS estimation is simple and it can be applied to both pooled and household-level regressions. Third, we assume that the measurement error in consumption is multiplicative and independent of all the variables used in the estimation. In this case, Vissing-Jørgensen (2002a) shows that $1/\gamma$ (and thus θ) can be consistently estimated using the log-linearized Euler Equation (10).

3.2 Pooled OLS estimates

We present the estimates of the consumption growth regressions in Table 2. For the full sample case in Column 2, the estimate on income growth is 0.039. This estimate is statistically significant (*t*-statistic $=$ 7.01) even in the presence of additional control variables. The consumption-income sensitivity is also economically significant. A one-standard-deviation increase in income growth (0.35) leads to a 1.4% (0.039×0.35) increase in consumption growth.

We also find that consumption growth is weakly responsive to interest rate changes. Consistent with the results in Vissing-Jørgensen (2002a), the estimate of the EIS is positive and less than one (estimate = 0.104, t-statistic = 1.73). This estimate implies that a one-standard-deviation increase in the interest rate (0.028) leads to an increase in consumption growth of 0.29% (0.104×0.028).

In Table 2, we show that the significance of the consumption-income sensitivity is robust in various subsamples. First, the results in Columns 3 and 4 indicate that consumption-income sensitivity depends on the retirement status of the head-of-household. Consistent with our model, which predicts zero consumption-income sensitivity for retired individuals, consumption of retired households is less sensitive to income. Further, consumption-income sensitivity is decreasing in age-based subsamples. For example, the consumption-income sensitivity for the youngest households is 0.038 (t-statistic = 3.87), whereas for the oldest households this parameter is 0.013 (t-statistic = 1.45).

One potential explanation for consumption-income sensitivity is the presence of borrowing constraints. The inability to borrow might prohibit consumers from smoothing consumption, forcing consumption expenditures to track current income (e.g., Runkle 1991). To ensure that our estimates of consumption-income sensitivity do not reflect borrowing constraints, we estimate the consumption growth regressions on subgroups of households that should not face difficulty borrowing.

Drawing on Jappelli (1990), we examine households with the highest income (top tertile). The estimates in Column 8 of Table 2 show that consumption tracks current income even for the top income earners (estimate = 0.029; t-statistic = 3.03). This finding is consistent with prior evidence in the literature (e.g., Parker 2015). This result is also particularly important because our consumption-income sensitivity estimates are economically and statistically meaningful for top earners despite the fact that we are proxying total consumption with food consumption, which is not particulalry sensitive to income fluctuations.[13]

Overall, the evidence from the pooled consumption growth regressions indicates that consumption is sensitive to current income and that this sensitivity cannot be entirely explained by borrowing constraints. Moreover, the θ estimates in these pooled regressions confirm prior findings that consumption-income sensitivity is positive on average. According to our

[13] We acknowledge that the applied data filters might not completely eliminate the biases due to the measurement errors in the income and consumption processes of the wealthier households. Hence, the consumption-income sensitivity estimates for high-income households in Column 8 of Table 2 might be upward biased because, for these households, measurement errors in consumption and income might be correlated. Specifically, it is possible that top earners might underreport their income, whereas food consumption, which is the consumption measure in the PSID, might be a noisy proxy for the total consumption of these individuals.

consumption-income model, positive consumption-income sensitivity implies a relatively low elasticity of substitution between consumption and income.

4. Consumption-Income Sensitivity and Income Hedging

In this section, we examine the impact of consumption-income sensitivities on portfolio decisions. In particular, we disentangle the traditional income hedging component of risky asset demand from the component that is affected by consumption-income sensitivities. To do so, we decompose the optimal equity share from Equation (4) into three terms:

$$a_i^e = b_{i,0} - b_1 \rho_{\Delta y_i,m} + b_2(\theta_i \times \rho_{\Delta y_i,m}). \tag{11}$$

Above, $b_{i,0}$ captures the risk-return trade-off for each household, while the correlation $\rho_{\Delta y_i,m}$ captures the traditional income hedging motive. The interaction between the consumption-income sensitivity term θ_i and the correlation $\rho_{\Delta y_i,m}$ captures the consumption-income effect.

4.1 Consumption-income sensitivities at the household level

The main independent variable in Equation (11) is the household-level interaction term between the correlation $\rho_{\Delta y_i,m}$ and the consumption-income sensitivity θ_i. Therefore, before moving forward to the portfolio regressions, we estimate consumption-income sensitivities at the household-level. Specifically, for each household we estimate the following consumption growth regression

$$\Delta c_{i,t+1} = \frac{1}{\gamma_i} log\, \beta_i + \frac{1}{\gamma_i} r_{f,t+1} + \theta_i \Delta y_{i,t+1} + \frac{1}{\gamma_i} \epsilon_{i,t+1}, \tag{12}$$

and obtain estimates of θ_i. We only consider households that have at least 12 valid (i.e., nonmissing) consumption growth observations to ensure precision in our estimates of θ_i. Also, to mitigate the impact of outliers in the consumption growth data, we estimate the household-level regressions with the least absolute deviations (LADs) estimator. Finally, we exclude all observations with a retired household head. To our knowledge, we are the first to estimate consumption-income sensitivities at the household level and use them in portfolio choice regressions.

We report summary statistics for the θ_i estimates in Table 3. The average of the estimated θ_i coefficients is 0.05. This value is reasonable because it is similar to the full-sample sensitivity estimate from the pooled consumption growth regressions in Column 2 of Table 2. However, there is significant cross-sectional heterogeneity in the θ_i estimates since the standard deviation is large (st. deviation = 0.67).[14]

[14] One novel finding from the estimation of consumption-income sensitivities at the household level is that for some households these sensitivities are negative. We test the external validity of this finding using an experimental study detailed in Appendix C.

Table 3
Summary statistics for portfolio allocation

	Mean	Median	25th percentile	75th percentile	SD	N
Equity allocation	29.45	0.01	0	56.93	35.96	4,785
Participants' equity allocation	58.60	56.52	37.5	86.25	29.40	2,405
Participation indicator	0.50	1	0	1	0.50	4,785
Cons-inc sensitivity $\hat{\theta}_i$	0.05	0.04	–0.27	0.37	0.67	4,785
Correlation $\hat{\rho}_{\Delta y_i,m}$	−0.004	−0.007	–0.21	0.20	0.30	4,785
Interaction $\hat{\theta}_i \times \hat{\rho}_{\Delta y_i,m}$	−0.0003	−0.0002	–0.05	0.06	0.21	4,785
Participants' interaction $\hat{\theta}_i \times \hat{\rho}_{\Delta y_i,m}$	0.005	0.000	–0.04	0.06	0.20	2,405
Income growth volatility $\hat{\sigma}_{\Delta y_i}$	0.27	0.25	0.17	0.36	0.13	4,785
log income $y_{i,t}$	11.21	11.23	10.80	11.62	0.67	4,785
Wealth	0.21	0.12	0.04	0.29	0.23	4,785
Age	51.46	51	46	56	8.08	4,785
Number of children	0.65	0	0	1	0.99	4,785
Unemployment indicator	0.01	0	0	0	0.13	4,785
College or graduate school	0.34	0	0	1	0.47	4,785

This table shows summary statistics for the key variables in our portfolio regressions. *SD* is the standard deviation. *Equity allocation* is the fraction of wealth invested in the stock market ($\times 100$) and *Participants' equity allocation* is the fraction of wealth invested in the stock market conditional on having positive equity holdings. *Participation Indicator* is an indicator for stock market participation. The parameter $\hat{\theta}_i$ captures consumption-income sensitivity for household i, and is the LAD estimate of the expression in Equation (12) for households with more than 12 time-series observations in the annual PSID waves (1978–1997). $\hat{\rho}_{\Delta y_i,m}$ is the correlation coefficient between income growth for household i and the excess return on the stock market during the annual PSID waves. $\hat{\sigma}_{\Delta y_i}$ is income growth volatility during the annual PSID waves, and $y_{i,t}$ is total nonfinancial log-income for household i. *Wealth* is household net worth in millions of dollars. The sample period consists of the biannual PSID waves (1999–2007).

In Table 3, we also present summary statistics related to all the variables we use in the portfolio choice regressions. In this sample, which is based on the biannual PISD waves from 1999 to 2007, about 50% of respondents own stocks directly or indirectly through mutual funds and retirement accounts, and stockholders allocate 59% of their financial wealth to risky assets. Further, the average income is \$73,865, while the 25th and 75th percentiles are \$49,020 and \$111,301, respectively. Additionally, about one third of the sample is college educated, and the average age is 51.

According to the results in Table 3, the average correlation coefficient between income growth and market returns is almost zero. This finding is quite standard in the empirical portfolio choice literature (e.g., Lynch and Tan 2011). However, the 25th and 75th percentiles of this correlation estimate are -0.21 and 0.20, respectively, and the cross-sectional standard deviation is 0.30. Hence, a large number of households should exhibit significant income hedging demand that would affect their portfolio allocations. For these households, consumption-income sensitivity should matter in both a statistical and an economic sense.

4.2 Consumption-income sensitivity and household characteristics

To gain additional insight into the relation between household demographic characteristics and consumption-income sensitivities, we regress the consumption-income sensitivity estimates from Equation (12) on household characteristics. We report these regression results in Table 4. Among the

Table 4
Consumption-income sensitivity and household characteristics

	Dependent variable: $\hat{\theta}_i$							
	$\hat{\rho}_{\Delta y_i,m}$	$\hat{\sigma}_{\Delta y_i}$	y_i	Wealth	Age	Children	Unemployment	College
	0.002	−0.027	−0.008	0.162	−0.003	0.005	−0.099	−0.018
	(0.07)	(−0.35)	(−0.47)	(3.29)	(−2.01)	(0.45)	(−1.62)	(−0.86)
Race FEs					Yes			
N					4,785			

This table shows OLS regression results of consumption income sensitivities on household characteristics. The coefficient $\hat{\theta}_i$ captures consumption-income sensitivity for household i, and is estimated from Equation (12) for households with more than 12 time-series observations in the annual PSID waves (1978–1997). $\hat{\rho}_{\Delta y_i,m}$ is the correlation coefficient between income growth for household i and the excess return on the stock market during the annual PSID waves. $\hat{\sigma}_{\Delta y_i}$ is income growth volatility during the annual PSID waves. y_i is total household nonfinancial log-income and *Wealth* is household net worth in millions of dollars. *Race FEs* include indicators for African-Americans and Asians. t-statistics, which are shown in parentheses, are estimated using robust standard errors.

various demographic variables, only wealth and age are statistically related to the θ_i estimates. Specifically, the θ_i estimates are increasing with wealth and decreasing in age.

These results suggest that for wealthy young households consumption significantly tracks current income. According to the status-based interpretation of our model, these wealthy young households treat income and consumption as complements, and thus want their consumption to track their income. Similarly, according to the entitlement interpretation of our model (Akerlof 2007), these results imply that consumption entitlements are stronger among wealthy young households. The positive relation between wealth and consumption-income sensitivity is an additional piece of evidence that consumption-income sensitivities cannot be entirety attributed to borrowing constraints. This positive relation is also consistent with the wealthy hand-to-mouth effect documented by Kaplan et al. (2014) and Kaplan and Violante (2014).

4.3 Empirical specification of portfolio regressions

Next, we test the asset allocation predictions of the consumption-income model using the following regression:

$$a^e_{i,t} = b_0 + \boldsymbol{b}_{0,z}{}'\mathbf{Z}_{i,t} - b_1\hat{\rho}_{\Delta y_i,m} + b_2(\hat{\theta}_i \times \hat{\rho}_{\Delta y_i,m}) + u_{i,t}. \quad (13)$$

The regression in Equation (13) is based on the optimal equity share from Equation (11). In Equation (13), we proxy $\rho_{\Delta y_i,m}$ and θ_i with their respective estimates $\hat{\rho}_{\Delta y_i,m}$ and $\hat{\theta}_i$ from the annual PSID waves (1978–1997). Also, the vector $\mathbf{Z}_{i,t}$ includes control variables found to be significant determinants of risk aversion and portfolio choice by the previous literature. The set of controls includes income, wealth, income growth risk (measured by the standard deviation of income growth from the annual PSID waves), age, age^2, number of children, an unemployment indicator, a college graduate indicator, an African-American indicator, and an Asian indicator. The variable u_i is the regression's error term. Finally, our consumption-income model predicts that the constants b_1 and b_2 in Equation (13) are positive. Therefore, in our empirical analysis we test whether the coefficient estimates on $\hat{\rho}_{\Delta y_i,m}$ and $\hat{\theta}_i \times \hat{\rho}_{\Delta y_i,m}$ are negative and positive, respectively.

To address any concerns regarding generated regressors bias, we exploit the structure of the PSID data set. Specifically, we use the annual PSID waves up to 1997 to estimate the correlations of income growth with market excess returns, the standard deviations of income growth, and the consumption-income sensitivities in Equation (12). Then we estimate the asset allocation regressions in Equation (13) with the biannual PSID waves from 1999 onward. In this way, we reduce the possibility that the estimation error in the regressors is correlated with the regression error $u_{i,t}$ in Equation (13).

In addition, we calculate standard errors for our asset allocation regressions using the block-bootstrap approach of Kunsch (1989). In particular, we conduct a cross-sectional bootstrap simulation in which we successively sample households with replacement. We perform 500 bootstrap replications and collect the bootstrap estimated parameters of all our explanatory variables. The bootstrapped standard errors are the standard errors according to the bootstrap distribution of the estimated coefficients in Equation (13).

4.4 Asset allocation: Tobit estimates

We present the results of our asset allocation regressions in Columns 1 to 3 of Table 5. In these regressions, the dependent variable is the percentage of financial wealth invested in stocks held directly or indirectly through retirement accounts. To begin, we estimate a Tobit regression and include the estimation results in Column 1 of Table 5.

The Tobit estimates provide evidence that consumption-income sensitivities affect the traditional income-hedging motive. Specifically, the estimated coefficient on the interaction term $\theta_i \times \rho_{\Delta y_i,m}$ is positive and statistically significant (estimate = 12.943; t-statistic = 2.97). This estimate implies a significant consumption-income effect on the asset allocation decision. Consider two households with the same positive correlation $\rho_{\Delta y_i,m}$, equal to 0.30. If their consumption-income sensitivity parameters differ by one standard deviation (0.67 from Table 3), then the first household will invest about 2.6% (12.943% $\times$ 0.30 $\times$ 0.67) more in risky assets.

In Column 2 of Table 5, we also show estimation results for the standardized variables to easily assess the quantitative importance of each variable.[15] Our standardized estimates in Table 5 suggest that a one-standard-deviation

[15] To obtain the standardized variables, we subtract the mean of each variable and divide by its standard deviation.

Table 5
Consumption-income sensitivity and portfolio allocation

	Tobit			Two-stage Heckman					
				Participation			Equity allocation		
	(1) Estimates	(2) Standardized	(3) Bias	(4) Estimates	(5) Standardized	(6) Bias	(7) Estimates	(8) Standardized	(9) Bias
Correlation $\hat{\rho}_{\Delta y_i,m}$	−4.216	−1.289	0.012	−0.014	−0.004	0.001	−3.246	−0.992	−0.062
	(−1.38)	(−1.44)	(0.00)	(−0.71)	(−0.73)	(0.02)	(−1.67)	(−1.59)	(−0.03)
Interaction $\hat{\theta}_i \times \hat{\rho}_{\Delta y_i,m}$	12.943	2.744	0.210	0.070	0.014	0.006	6.404	1.357	−0.068
	(2.97)	(2.83)	(0.04)	(2.24)	(2.33)	(0.06)	(2.35)	(2.18)	(−0.02)
Inc. growth volatility $\hat{\sigma}_{\Delta y_i}$	−28.876	−3.830	−0.269	−0.140	−0.018	−0.007	−14.278	−1.893	−0.129
	(−4.10)	(−4.07)	(−0.03)	(−2.82)	(−2.89)	(−0.04)	(−2.96)	(−3.00)	(−0.02)
log income $y_{i,t}$	12.534	8.464	−0.120	0.102	0.069	−0.000	−2.198	−1.484	−0.075
	(7.50)	(7.27)	(−0.07)	(8.19)	(8.03)	(−0.00)	(−1.94)	(−1.88)	(−0.06)
Wealth	69.545	16.682	0.177	0.685	0.164	0.021	15.618	3.746	−0.144
	(16.41)	(16.99)	(0.04)	(16.14)	(15.04)	(0.13)	(5.13)	(5.06)	(−0.04)
Age	−0.006	−0.049	0.027	−0.000	−0.007	0.000	0.058	0.473	0.020
	(−0.02)	(−0.02)	(0.10)	(−0.56)	(−0.55)	(0.04)	(0.30)	(0.31)	(0.10)
Age^2	−0.023	−0.047	−0.160	0.003	0.007	−0.002	−0.661	−1.355	−0.104
	(−0.03)	(−0.03)	(−0.17)	(0.61)	(0.60)	(−0.10)	(−0.97)	(−0.98)	(−0.15)
Num. of children	2.802	2.779	−0.029	0.015	0.015	0.000	1.149	1.139	−0.052
	(2.63)	(2.74)	(−0.02)	(2.11)	(2.18)	(0.01)	(1.61)	(1.59)	(−0.07)
Unemployment indicator	−4.380	−0.588	−0.032	−0.024	−0.003	0.000	1.279	0.171	0.089
	(−0.62)	(−0.62)	(−0.00)	(−0.51)	(−0.52)	(0.00)	(0.32)	(0.33)	(0.02)
College or grad. school	19.461	9.265	0.087	0.130	0.062	0.002	5.346	2.545	0.009
	(10.03)	(9.84)	(0.04)	(9.55)	(9.36)	(0.04)	(3.92)	(3.93)	(0.00)
Race FEs	Yes			Yes			Yes		
N	4,785			4,785			2,405		

This table shows Tobit and two-stage Heckman (1979) regressions for portfolio allocation based on the expression for optimal portfolio weights in Equation (13). In the Heckman selection regression, the dependent variable is an indicator function for stock market participation. In the Tobit and Heckman equity allocation regressions, the dependent variable is the percentage of total wealth allocated to risky assets. For the participation regression, we report estimates of the marginal effects. $\hat{\rho}_{\Delta y_i,m}$ is the correlation coefficient between income growth for household *i* and the excess return on the stock market during the annual PSID waves (1978–1997). The parameter $\hat{\theta}_i$ captures consumption-income sensitivity for household *i*, and is estimated from Equation (12) for households with more than 12 time-series observations in the annual PSID waves. $\hat{\sigma}_{\Delta y_i}$ is income growth volatility during the annual PSID waves, and $y_{i,t}$ is total nonfinancial log-income for household *i*. *Wealth* is household net worth in millions of dollars. *Race FEs* include indicators for African Americans and Asians. The *Standardized* column shows estimation results for standardized explanatory variables. *Bias* is the bootstrap estimate for the bias which is defined as the difference between the average estimate of the bootstrap distribution and the original estimate. *t*-statistics are shown in parentheses and are based on bootstrap standard errors. The estimation period consists of the biannual PSID waves (1999–2007).

increase in the consumption-income interaction term $\theta_i \times \rho_{\Delta y_i,m}$ leads to about a 2.7% increase in the allocation to stocks. This effect is economically important, and its magnitude is much stronger than the effect of traditional income hedging. Specifically, our estimates in Table 5 suggest that a one-standard-deviation increase in the income growth to market return correlation $\rho_{\Delta y_i,m}$ will lead to about a 1.3% decrease in the equity share. This negative effect is consistent with the traditional income-hedging motive.

Finally, the estimates on the other control variables in the Tobit regression are consistent with previous evidence (e.g., Campbell 2006). For example, we find that wealthy college graduates with high income invest the most in risky assets. Further, we find that households with low income growth volatility allocate more to risky assets, confirming the findings of Angerer and Lam (2009) and Betermier et al. (2012).

4.5 Asset allocation: Heckman estimates

The estimates from the Tobit regressions indicate that consumption-income sensitivities affect the traditional income hedging motive. However, the Tobit results are based on a sample that includes both stockholders and nonstockholders. To ensure that the Tobit results are not driven entirely by the participation decision, we estimate Heckman (1979) regressions that simultaneously consider the participation and asset allocation decisions.

Like in Vissing-Jørgensen (2002b), we estimate a system of two equations. The first is the participation equation estimated with data on both stockholders and nonstockholders. The first stage regression provides an estimate for the probability of participating, which is used in the second stage estimation of the equity share regression. The equity share regression is estimated using data for stockholders only. We present the results of the participation and asset allocation regressions in Columns 4 to 9 of Table 5.

The most interesting results from the Heckman system of equations are those related to the asset allocation decision. Consistent with our consumption-income model, the income hedging motive is affected by the consumption-income sensitivity. For instance, the estimated coefficient of the interaction term $\theta_i \times \rho_{\Delta y_i,m}$ in Column 7 of Table 5 is positive (6.404) and statistically significant (t-statistic $= 2.35$). This is the strongest evidence of the effect of consumption-income sensitivities on portfolio decisions because it is based solely on households that own risky assets.

The consumption-income effect is also economically significant. Consider two households with the same positive correlation $\rho_{\Delta y_i,m}$ of 0.30. If the consumption-income sensitivity of the first household is one-standard-deviation larger than that of the second, then the first household should allocate more of its wealth to risky assets. The Heckman estimation suggests that the first household will invest about 1.3% (6.404% $\times$ 0.30 $\times$ 0.67) more in risky assets.

This effect is comparable to the effect of income growth volatility on asset allocation. This result is notable since income growth volatility is one of the most important determinants of equity allocation (e.g., Vissing-Jørgensen 2002b; Campbell 2006). Specifically, our estimates in Column 8 of Table 5 suggest that a one-standard-deviation increase in income growth volatility leads to about a 1.9% decrease in the proportion of financial wealth allocated to risky assets.

4.6 Magnitude of estimation bias

One potential concern with our findings is the measurement error in the estimates of the consumption-income sensitivity θ_i and the correlation between income growth and stock market returns $\rho_{\Delta y_i,m}$. To address this concern, we directly examine the impact of measurement error in our regressors on the coefficient estimates of our asset allocation regressions. In particular, we provide estimates of the bias in the baseline results of Table 5. We compute the estimation bias of each coefficient using the bootstrap distribution. We define the estimation bias as the difference between the average estimate of the bootstrap distribution and the original estimate.

In Columns 3, 6, and 9 of Table 5, we report the estimation bias of each coefficient and its corresponding *t*-statistic. Although testing for consistency using finite samples can be problematic, the very small magnitude of the bootstrap bias suggests that the potential measurement error in θ_i should not affect the validity and significance of our baseline results.

4.7 Simulation evidence

To complement our baseline results, we simulate both our consumption-income and the traditional life-cycle models.[16] The goal of this simulation exercise is to show that consumption-income sensitivities impact portfolio decisions through the income hedging motive, as predicted by the optimal equity share in Equation (4). Specifically, we want to show that in our consumption-income model, portfolio decisions are affected by the interaction of consumption-income sensitivity θ with the correlation between stock returns and income growth $\rho_{\Delta y,m}$, which typically captures the income hedging potential of financial assets. Further, we want to show that the magnitude of the consumption-income sensitivity effect on income hedging documented by our empirical analysis is theoretically plausible under reasonable values for model parameters.[17] Appendix B provides a detailed description of the simulation methodology.

[16] By the traditional model, we mean the model with no income preferences where the parameter δ in the utility function of Equation (1) is 1. When δ is 1 in the consumption-income utility function, our model reduces to that of Viceira (2001).

[17] We thank Luis Viceira and Tarun Ramadorai for suggesting the simulation analysis to us.

To assess the impact of consumption-income sensitivity on the optimal equity share, we run two sets of simulations. First, we show that the asset allocation decisions of the consumption-income and traditional investor are almost identical when we shut down the income hedging motive. To this end, we set the correlation of income growth and stock market returns to zero ($\rho_{\Delta y,m} = 0$) in Equations (4), (8), and (9). We present the results of this simulation in panel B of Table 6.

According to these results, we find that the wealth elasticity of consumption ϕ_1 (Equations (4) and (5)) is 0.734 for the consumption-income model and 0.739 for the traditional model. The parameter ϕ_0 in the consumption function (Equation (5)) is –2.109 for the consumption-income investor and –2.185 for the traditional investor. Based on this evidence, we conclude that there are minimal differences in the optimal consumption choices between the two investors. We also find that the equity share for the consumption-income investor is 35.6%, whereas the equity share for the traditional investor is 35.5%. Overall, the first set of simulations shows that in the absence of the hedging motive, the consumption-income and traditional life-cycle investors make similar portfolio decisions.

In our second set of simulations, we turn on the income hedging motive. Specifically, we set the correlation between income growth and stock market returns to 0.3. This value is one-standard-deviation above the mean of the correlation reported in Table 3. We report the results of the second simulation in panel C of Table 6.

In the presence of income hedging ($\rho_{\Delta y,m} = 0.3$), the risky asset weight for the consumption-income investor (Equation (4)) is 22.2%. In contrast, the risky asset weight for the traditional life-cycle investor is 19.2%. This 3% difference is consistent with the empirical results from Table 5. Specifically, given a correlation of 0.3 between income growth and asset returns, a one-standard-deviation increase in consumption-income sensitivity increases risky portfolio holdings by 2.6%. These effects are economically significant when compared to the average equity share in this sample (29.5% in Table 3).

Importantly, the 3% difference is driven by attenuation of the income hedging motive due to the consumption-income effect. Specifically, the income hedging demand for the traditional investor (Equation (8)) is –18.3%, whereas the income hedging demand for the consumption-income investor (Equation (9)) is –15.4%. In the simulations, the income hedging motive for the consumption-income investor is attenuated because we assume that the consumption-income sensitivity parameter θ is positive, consistent with our empirical findings in Tables 2 and 3.[18]

[18] The equity share of the consumption-income investor might be different from that of the traditional investor due to differences in the steady-state wealth-income ratio, the steady-state consumption-income ratio, or the consumption function parameters ϕ_1 and ϕ_0. However, we find that such differences have minimal impact on the optimal asset allocation. Specifically, the difference in the equity shares of the consumption-income and traditional investors not attributed to income hedging is only 0.1% (= (22.2% – 19.2%) – (–15.4% + 18.3%)).

Table 6
Simulations for the consumption-income model

A. Parameterization

	Asset dynamics			Income dynamics			Preferences				Initial conditions		
	μ_m	σ_m	r_f	$\mu_{\Delta y}$	$\sigma_{\Delta y}$	$\rho_{\Delta y,m}$	γ	θ	β	π_e	W_0	Y_0	ϕ_0^r
Consumption income	11%	19%	3%	2%	30%	$\{0, 0.3\}$	10	0.05	0.97	0.90	72,000	28,000	−2.3026
Life cycle	11%	19%	3%	2%	30%	$\{0, 0.3\}$	10	0	0.97	0.90	72,000	28,000	−2.3026

B. Simulation output for $\rho_{\Delta y,m} = 0$

	Portfolio weights		Wealth-income & consumption-income ratios		Consumption function	
	Hedging demand	a	$\mathbf{E}[w-y]$	$\mathbf{E}[c-y]$	ϕ_0	ϕ_1
Consumption income	0%	35.6%	3.013	0.104	−2.109	0.734
Life cycle	0%	35.5%	3.053	0.071	−2.185	0.739

C. Simulation output for $\rho_{\Delta y,m} = 0.3$

	Portfolio weights		Wealth-income & consumption-income ratios		Consumption function	
	Hedging demand	a	$\mathbf{E}[w-y]$	$\mathbf{E}[c-y]$	ϕ_0	ϕ_1
Consumption income	−15.4%	22.2%	2.820	−0.133	−2.078	0.689
Life cycle	−18.2%	19.2%	2.850	−0.203	−2.173	0.691

This table shows simulation results for the consumption-income and traditional life-cycle models at the annual frequency. The parameter μ_m is the expected return of the risky asset, σ_m is the corresponding volatility, and r_f is the risk-free rate. The constant $\mu_{\Delta y}$ is expected income growth, $\sigma_{\Delta y}$ is income growth volatility, and $\rho_{\Delta y,m}$ is the correlation between income growth and the excess return on the stock market. γ is the risk aversion coefficient, θ is the consumption-income sensitivity parameter, and π_e is the employment probability. W_0 and Y_0 are initial conditions for wealth and income. The constant ϕ_0^r is the precautionary savings motive during retirement from Appendix A. ϕ_0^r is the same across the traditional and consumption-income models because during retirement, income is assumed constant in both models. *Hedging demand* is the income hedging demand in portfolio allocation from Equations (8) and (9). a is the portfolio weight on the risky asset from Equation (4). $\mathbf{E}[w-y]$ is the simulated average log wealth/income ratio, and $\mathbf{E}[c-y]$ is the simulated average log consumption/income ratio. The constant ϕ_0 is the precautionary savings parameter during employment, and ϕ_1 is the wealth elasticity parameter in the consumption function of Equation (5).

Collectively, the simulation results confirm that the main mechanism through which the consumption-income effect manifests itself in portfolio decisions is the income hedging motive. The indirect effects of consumption-income preferences on the linearization constants and the steady-state wealth-income ratio are minimal.

5. Behavioral Theories for Preferences over Income

The previous empirical findings confirm our main hypothesis that consumption-income sensitivities affect portfolio decisions. We derived this core assumption from a model with income as an argument in the utility function. In this section, we discuss in more detail various theories that can justify having income in the utility function.

5.1 Micro-evidence for status preferences

One of our motivations including income in the utility function comes from the status preferences and conspicuous consumption literature (e.g., Glazer and Konrad 1996; Charles et al. 2009; Roussanov 2010). According to the status preferences framework, investors derive utility from consumption and social status, which is in turn determined by income (e.g., Glazer and Konrad 1996). For completeness, we provide some empirical micro-evidence that individuals care about their social status.

In particular, we conduct an online survey using Amazon's Mechanical Turk where we gauge individual attitudes toward social status and income as a determinant of social status. We also gather information on demographic variables including income, wealth, age, race, and education. In Appendix C, we provide all the details of the survey design and implementation. We present the summary statistics of the online survey respondents in Table A1 of Appendix C. These statistics show that our sample consists of relatively young individuals. On other dimensions, the descriptive statistics suggest that our sample is representative of U.S. households.

5.1.1 Income as a determinant of social status. In Table A2 of Appendix C, we present survey responses to various statements (statements S.1 to S.4) related to attitudes toward social status. We find that about 50% of the sample reports that they care about social status.[19] More importantly, we find that about 68% of the sample thinks that social status is determined by income and that people who make more money are well respected.[20] These

[19] We obtain this statistic by aggregating the "somewhat agree," "agree," and "strongly agree" responses to the statement S.1, which reads "I care about my social status."

[20] We obtain these statistics by aggregating the "somewhat agree," "agree," and "strongly agree" responses to the statement S.3, which reads "People who make more income are well respected."

findings indicate that individuals care about their social status and that income is an important determinant of status.

We also run a number of regressions to supplement the evidence from the summary statistics in Table A2. The goal of this regression analysis is to show that people who care about status perceive income as an important determinant of status. We present the regression results related to the survey in Table A3 of Appendix C. In these regressions, the dependent variable is an index of whether respondents draw utility from social status.[21] The main independent variable, "Income as status," is related to whether respondents agree that status is determined by income.[22]

According to the results in Table A3, we find that caring about social status and believing that income provides status are highly correlated. We also find that the income-as-status effect is distinct from any wealth-as-status effects. Specifically, in regression (3) of Table A3, we add the a control variable "Wealth as status" based on the respondents' opinion on whether wealthy individuals should be respected.[23] According to the results of this regression, the coefficient estimate of the "Income as status" variable remains statistically significant in the presence of the "Wealth as status" control variable, implying that the two effects are quite distinct.

Overall, our findings from the online survey suggest that individuals care about social status and that there is a strong link between income and status. These results corroborate our model assumptions and validate the utility function in Equation (1).

5.1.2 Negative consumption-income sensitivity. One novel finding from estimating consumption-income sensitivities at the household level in Section 4.1 is that for some households these sensitivities are negative. We test the external validity of this finding using the same experimental study we presented above. Specifically, we ask the respondents of our online survey how their spending patterns change when their income decreases.

We find that about 11% of the respondents say that when their income decreases, they increase their spending. Similarly, about 14% of the survey participants would rather not decrease their spending if their income rises. Further, about 21% of the respondents confirm that if their income is lower than expected, they spend more to feel better.[24] These responses suggest that for some households consumption growth and income growth may be negatively correlated. These households would exhibit negative

[21] The social status index is based on the responses to statements S.1 and S.2 in Table A2.

[22] This variable is constructed based on the responses to survey statement S.3 in Table A2.

[23] Statement S.4 in Table A2.

[24] The aforementioned statistics are based on the answers to statements S.5 to S.7 in Table A2. Specifically, we aggregate the percentage of respondents that "somewhat agree," "agree," and "strongly agree" with the various statements.

consumption-income sensitivities. From the perspective of our consumption-income model, this finding implies that for a number of households, the elasticity of substitution between consumption and income is relatively high.

5.2 Additional behavioral mechanisms

Besides status preferences and conspicuous consumption, there are additional behavioral mechanisms that may lead to investors deriving utility directly from income. Specifically, there is evidence that consumption decisions are affected by norms about what people think they are entitled to consume.[25] Based on this evidence, Akerlof (2007) proposes a theory whereby consumption is affected by entitlements and obligations, and suggests that current income is one of the major determinants of these entitlements.

Including income in the utility function is also consistent with evidence from behavioral economics that consumers view savings as a separate decision, and not as a residual action to consumption (e.g., Furnham and Argyle 1998). A utility function defined over consumption and income is also consistent with the debt aversion model of Prelec and Loewenstein (1998). Thaler (1985) proposes a transaction utility theory in which transactions involve both acquisition utility and transaction utility. Both papers stress that the process of buying a good has two dimensions: acquisition and transaction.

All of these theories imply that investor utility is defined over consumption and income. Therefore, it is challenging to empirically distinguish between the above mechanisms, both amongst themselves, and from a status preference model where status is determined by income. Nevertheless, with the exception of status preferences, the remaining behavioral models have one thing in common: they only imply positive consumption-income sensitivities. In contrast, a status preference model allows for both positive and negative consumption-income sensitivities, depending on the magnitude of the elasticity of substitution between consumption and status, which, in turn, is primarily determined by income.

In the PSID and in our online survey, we do find empirical evidence of negative consumption-income sensitivities for a number of households. This evidence favors the status preference model over the alternative behavioral theories of consumption-income sensitivities. However, this conclusion is not definitive, and additional tests are needed to identify the exact behavioral mechanism that leads to preferences over consumption and income.

6. Alternative Explanations for Consumption-Income Sensitivity

In addition to the behavioral theories described in the previous section, there are also a number of rational mechanisms that could result in

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[25] For example, see Tversky and Kahneman (1981), Bourdieu (1984), Shefrin and Thaler (1988), and Guiso et al. (2006).

consumption-income sensitivities without explicitly including income in the utility function. In this section, we examine whether the consumption-income effects on portfolio allocation can be attributed to any of these theories.

6.1 External habit formation and peer effects

One concern with our analysis is that consumption-income sensitivities could be attributed to habit formation. We examine this concern using the intuition of habit formation models.

In particular, following Abel (1990) and Gomez et al. (2009), we use a tractable habit model where utility is defined over the ratio of consumption to the external habit process:

$$U(C_{i,t};\bar{C}_{i,t-1}) = \frac{C_{i,t}^{1-\gamma_i}}{1-\gamma_i}\bar{C}_{i,t-1}^{\gamma_i\eta_i}. \tag{14}$$

Above, $\bar{C}_{i,t-1}$ is last period's consumption of the reference group, or the external habit for investor i, and η_i is the habit parameter. In untabulated results, we embed the utility function of Equation (14) in the Viceira (2001) model. We derive the Euler equations for the external habit formation model assuming that markets are incomplete, and find that the consumption growth of a habit-conscious consumer tracks the consumption growth of her reference group.[26] Based on this theoretical result, we estimate new consumption-income sensitivities from household regressions that control for external habit formation:

$$\Delta c_{i,t+1} = \frac{1}{\gamma_i} log\, \beta_i + \frac{1}{\gamma_i} r_{f,t+1} + \theta_i \Delta y_{i,t+1} + \eta_i \Delta \bar{c}_{i,t} + \frac{1}{\gamma_i}\epsilon_{i,t+1}, \tag{15}$$

where $\Delta\bar{c}_{i,t}$ is the growth rate of the habit process.

Estimating the habit level $\bar{C}_{i,t-1}$ is challenging, since the PSID does not include enough information to allow construction of peer groups for each household. Therefore, we follow the literature in assuming that the reference level of consumption for each household depends on its state of residence (e.g., Korniotis 2008). Specifically, we proxy for the external habit $\bar{C}_{i,t-1}$, using real state-level retail sales from Moody's Analytics. We then estimate

[26] We assume that markets are incomplete, because ample evidence indicates that income shocks cannot be completely hedged away (e.g., Cochrane 1991; Constantinides and Duffie 1996; Brav et al. 2002; Storesletten et al. 2004; Blundell et al. 2008; Guvenen et al. 2014). The market incompleteness assumption implies that consumption growth rates are different across households, and, thus, the consumption growth of the peer group of an investor is different from her own consumption growth. If markets were complete, individual consumption growth would be equal to the growth of the habit process. DeMarzo et al. (2004, 2008) introduce peer effects in a complete markets model by assuming that local investors compete for local resources. We do not follow their approach because we want the external habit formation model to be as close as possible to Viceira (2001), the latter being our benchmark framework.

Equation (15) for each household, and include the new estimates for the consumption-income sensitivity parameter in portfolio regressions.[27]

In the portfolio regressions of Table 7, we also include the estimate of the household habit parameter η_i as a control variable. If consumption-income sensitivities are a proxy for external habits, then controlling for habits should render the estimates of the consumption-income interaction term $\theta_i \times \rho_{\Delta y_i,m}$ insignificant in portfolio regressions. We report the results of our asset allocation regressions with the new consumption-income interaction term and the habit parameter in Table 7.

In Table 7, we also account for any residual external habit effects using peer effects. To control for peer effects, we add a series of fixed effects in our portfolio regressions. Specifically, assuming that investors belonging to the same occupation participate in similar peer groups, we add occupation fixed effects in the regressions of Table 7. In untabulated tests, we also consider household industry fixed effects and regional fixed effects based on households' geographical region. These results are very similar to the ones reported in Table 7 and are available from the authors on request.

The estimates in Table 7 indicate that the consumption-income effect on portfolio allocation remains significant even when controlling for external habit and peer effects. In fact, when we account for external habit, the effects of consumption-income sensitivities on income hedging are even more pronounced compared to our baseline results in Table 5. For example, the estimate of the interaction term $\theta_i \times \rho_{\Delta y_i,m}$ in the Heckman regression of Table 5 is 6.404. This estimate increases to 9.813 (t-statistic $= 3.62$) in Table 7 (Column 3). Further, the household habit parameter η_i has minimal effects on portfolio decisions (row 3). Based on these results, we conclude that accounting for external habit formation and peer effects does not attenuate the consumption-income sensitivity effect on portfolio choice.

6.2 Borrowing constraints

Another possible explanation for consumption-income sensitivity is borrowing constraints because households that cannot borrow will be frequently forced to set consumption equal to income (e.g., Jappelli 1990; Runkle 1991; Parker 2015). Thus, households with severe borrowing constraints will exhibit strong consumption-income sensitivity. In other words, borrowing constraints may inflate our household-level θ_i estimates.

[27] For our emprical tests, we follow Abel (1990) and assume that the habit process depends on the past consumption of the reference group (i.e., "catching-up with the Joneses" habit formation). For robustness, we repeat our empirical analysis using a habit process that is based on the current consumption of the reference group (i.e., "keeping up with the Joneses" habit formation) like in Gomez et al. (2009). In untabulated results, we find that the significance of the consumption-income sensitivities for asset allocation is robust to this alternative habit measure.

Table 7

Consumption-income sensitivity and portfolio allocation: Tobit and two-stage Heckman specifications controlling for alternative explanations

	Tobit	Two-stage Heckman	
		Participation	Equity allocation
	(1)	(2)	(3)
(1) Correlation $\hat{\rho}_{\Delta y_i,m}$	−3.542	−0.009	−2.641
	(−1.23)	(−0.48)	(−1.28)
(2) Interaction $\hat{\theta}_i \times \hat{\rho}_{\Delta y_i,m}$	19.817	0.125	9.813
	(5.35)	(4.14)	(3.62)
(3) Habit $\hat{\eta}_i$	−0.006	0.000	−0.049
	(−0.03)	(0.14)	(−0.30)
(4) Cons-inc sensitivity $\hat{\theta}_i$	0.548	0.002	0.718
	(0.46)	(0.27)	(0.93)
(5) Inc. growth volatility $\hat{\sigma}_{\Delta y_i}$	−31.294	−0.155	−21.087
	(−2.73)	(−1.88)	(−2.65)
(6) High inc. vol. indicator $\mathbf{1}\{\hat{\sigma}_{\Delta y_i} > median\}$	3.628	0.017	2.486
	(1.21)	(0.83)	(1.23)
(7) Interaction $\hat{\theta}_i \times \hat{\rho}_{\Delta y_i,m} \times \mathbf{1}\{\hat{\sigma}_{\Delta y_i} > median\}$	−23.066	−0.121	−14.143
	(−2.33)	(−1.90)	(−2.18)
(8) log income $y_{i,t}$	22.056	0.134	−4.416
	(5.92)	(5.27)	(−1.55)
(9) log income^2 $y_{i,t}^2$	−4.947	−0.023	0.579
	(−4.55)	(−2.50)	(0.71)
(10) Wealth	126.416	0.922	16.616
	(15.90)	(17.58)	(2.56)
(11) Wealth^2	−80.875	−0.501	−2.044
	(−9.02)	(−6.36)	(−0.31)
(12) Age	0.075	−0.000	0.160
	(0.29)	(−0.35)	(0.79)
(13) Age^2	−0.550	0.001	−1.043
	(−0.62)	(0.33)	(−1.44)
(14) Num. of children	2.919	0.016	1.350
	(2.68)	(2.26)	(1.84)
(15) Unemployment indicator	−4.169	−0.021	0.332
	(−0.62)	(−0.46)	(0.08)
(16) College or grad. school	14.077	0.098	4.658
	(6.94)	(6.60)	(3.29)
Household occupation FEs	Yes	Yes	Yes
Race FEs	Yes	Yes	Yes
N	4,785	4,785	2,405

This table shows Tobit and two-stage Heckman regressions estimates for portfolio allocation based on the expression for optimal portfolio weights in Equation (13). In the Heckman participation regression, the dependent variable is an indicator function for stock market participation. In the Tobit and equity allocation regressions, the dependent variable is the percentage of total wealth allocated to risky assets. For the participation regression, we report estimates of the marginal effects. $\hat{\rho}_{\Delta y_i,m}$ is the correlation coefficient between income growth for household i and the excess return on the stock market during the annual PSID waves (1978–1997). The parameter $\hat{\theta}_i$ captures consumption-income sensitivity for household i, and is estimated from Equation (15) for households with more than 12 time-series observations in the annual PSID waves. For the regression in Equation (15), we estimate consumption-income sensitivities controlling for external habit which is measured by retail sales at the state-level. The parameter $\hat{\eta}_i$ is the habit parameter. $\hat{\sigma}_{\Delta y_i}$ is income growth volatility during the annual PSID waves, and $y_{i,t}$ is total nonfinancial income for household i. *Wealth* is household net worth in millions of dollars. *Race FEs* include indicators for African Americans and Asians. *t*-statistics, which are shown in parentheses, are based on bootstrapped standard errors. The estimation period for consists of the biannual PSID waves (1999–2007).

To address borrowing constraints theoretically, in Appendix D, we consider the standard life-cycle model with constrained consumption policies. Specifically, we study a life-cycle problem in which consumption is forced to be equal to some fraction of income:

$$C_t = A_y Y_t,$$

where $A_y \in (0, 1]$ is a positive constant. We take this approach because with this constraint, we can solve the constrained problem analytically and explicitly demonstrate its differences from our model with income in the utility function. Life-cycle models with general borrowing constraints do not usually admit closed-form solutions (Zeldes 1989). Thus, studying the impact of borrowing constraints on consumption and portfolio decisions is a challenging task. Nevertheless, by using the above consumption constraint, we can obtain a clear picture of its impact on portfolio weights.

The analysis in Appendix D shows that introducing the constraint $C_t = A_y Y_t$ in the standard life-cycle model strengthens the income hedging term. This effect is similar to our consumption-income model only when the elasticity of substitution between consumption and income in the utility function of Equation (1) is high. That is, when the consumption-income sensitivity parameter θ in Equations (4), (6), and (9) is negative.

However, the most prevalent case of our consumption-income model is when the consumption-income sensitivity parameter θ is positive. In this case, our consumption-income model predicts that consumption-income sensitivities attenuate the income hedging motive. This result runs against the predictions of the constrained life-cycle model, where consumption constraints strengthen the income hedging motive.

We further investigate the effects of borrowing constraints on portfolio decisions in empirical tests. According to our consumption-income model, consumption-income sensitivities affect portfolio choice through the income hedging motive, that is, the interaction term with the correlation between income growth and stock returns. Therefore, we do not include the linear term θ_i in our baseline portfolio tests, because according to our model, the only relevant term for these regressions is the interaction $\theta_i \times \rho_{\Delta y,m}$.

For robustness, in Table 7, we include the consumption-income sensitivity estimate θ_i as a separate control variable. The rationale behind this test is the following. Consumption-income sensitivities might proxy for borrowing constraints because for constrained households, consumption and income move in lockstep, and, thus, their θ_i estimates should be positive and large. Consequently, if the linear term θ_i loads significantly in portfolio regressions, while the interaction term $\theta_i \times \rho_{\Delta y,m}$ does not, then our results are most likely driven by borrowing constraints. According to the results in Table 7, we find that the consumption-income sensitivity control variable θ_i is not significant (row 4), while the estimate of the consumption-income sensitivity interaction term $\theta_i \times \rho_{\Delta y_i,m}$ remains positive and statistically significant.

6.3 Risk aversion and endogenous labor income risk

A limitation of the PSID is that it does not provide a measure of risk aversion. Thus, it is possible that our consumption-income sensitivity estimates capture the latent effects of risk aversion. To account for risk aversion, we follow Ranish (2013), who shows that occupation choice is endogenous, with low risk aversion individuals self-selecting into risky occupations. Specifically, Ranish finds that the volatility of household labor income growth is positively correlated with financial risk taking and risk preferences. Thus, the volatility of labor income growth is a good proxy for risk aversion.

In our main specification in Table 5, we control for income growth volatility. Based on the findings in Ranish (2013), in Table 7, we additionally control for an indicator function that takes the value of 1 if household income growth volatility is above the median ($\mathbf{1}\{\sigma_{\Delta y_i} > median\}$). This is our proxy for low risk aversion households. We also control for the interaction between the high income volatility indicator and the consumption-income preference effect ($\theta_i \times \rho_{\Delta y_i,m} \times \mathbf{1}\{\sigma_{\Delta y_i} > median\}$). This interaction can help us examine whether risk aversion amplifies (or mitigates) the consumption-income sensitivity effect on optimal equity share.

According to the results in Table 7, the interaction term $\theta_i \times \rho_{\Delta y_i,m}$ remains statistically significant after controlling for the high income volatility indicator $\mathbf{1}\{\sigma_{\Delta y_i} > median\}$ and the triple interaction term $\theta_i \times \rho_{\Delta y_i,m} \times \mathbf{1}\{\sigma_{\Delta y_i} > median\}$. In contrast, the coefficient of the high income volatility indicator $\mathbf{1}\{\sigma_{\Delta y_i} > median\}$ is insignificant, and the sum of the estimated coefficients on $\theta_i \times \rho_{\Delta y_i,m}$ and $\theta_i \times \rho_{\Delta y_i,m} \times \mathbf{1}\{\sigma_{\Delta y_i} > median\}$ is low.

These results suggest that the consumption-income sensitivity effect on portfolio choice retains its statistical and economic significance after controlling for high income volatility, our empirical proxy for risk aversion. Nevertheless, our results also indicate that the consumption-income effect is stronger among the low income volatility (high risk aversion) households because the sum of the coefficients of $\theta_i \times \rho_{\Delta y_i,m} \times \mathbf{1}\{\sigma_{\Delta y_i} > median\}$ and $\theta_i \times \rho_{\Delta y_i,m}$ for the high income volatility (low risk aversion) households is quite low. We conclude that even though consumption-income sensitivity is distinct from risk aversion, both theoretically and empirically, high risk aversion amplifies the consumption-income effect on portfolio choice.

6.4 Nonlinear wealth and income effects

For parsimony, in our main regressions in Table 5, we only include linear wealth and income terms. Nevertheless, there might be some nonlinear effects related to income and wealth that are captured by the interaction term $\theta_i \times \rho_{\Delta y_i,m}$. Therefore, in the extended regressions in Table 7, we include quadratic wealth and income terms. Although these quadratic terms do carry statistically significant estimates (rows 9 and 11), the consumption-income sensitivity term $\theta_i \times \rho_{\Delta y_i,m}$ remains statistically significant.

Overall, the results in this section show that the consumption-income effect retains its explanatory power even when we include additional control variables that proxy for alternative rational explanations of consumption-income sensitivities. Specifically, the Tobit estimates in Table 7 imply that a one-standard-deviation increase in the consumption-income interaction term $\theta_i \times \rho_{\Delta y_i,m}$ results in a 4.7% (19.817% $\times$ 0.24) increase in risky asset allocation.[28] This value is stronger than the economic effect of 2.7% implied by our baseline Tobit regressions in Table 5.

We acknowledge that our empirical measures for habit formation, peer effects, borrowing constraints, and risk aversion are inherently imperfect. Therefore we cannot completely rule out these mechanisms as additional causes for consumption-income sensitivities. Nevertheless, the findings in Table 7 suggest that our main results on the importance of consumption-income sensitivities on portfolio choice cannot be entirely attributed to these alternative explanations.

7. Summary and Conclusions

Consumption and portfolio decisions are interrelated but seldom studied together. We take a first step toward jointly examining the observed consumption and portfolio decisions of a sample of U.S. households. Specifically, we document that consumption-income sensitivities affect the income hedging motive in portfolio decisions. We formalize our empirical findings in a life-cycle model in which income enters the utility function. We call this model the consumption-income model.

According to our consumption-income model, consumption and income are considered a bundle of goods that jointly affect investor welfare. We solve the model analytically and show that consumption-income sensitivities can either attenuate or strengthen the desire for income smoothing, depending on the elasticity of substitution between consumption and income. Specifically, consumption-income investors have a weak (strong) incentive to hedge income fluctuations using available financial assets when the elasticity of substitution between consumption and income is relatively low (high). Thus, according to our model, consumption-income sensitivities affect the income hedging motive in portfolio allocation decisions. We validate this prediction empirically using consumption and portfolio data from the PSID. Specifically, we find strong empirical support for the consumption-income sensitivity effect on portfolio allocation through the income hedging motive.

Appendix A. Proof of Proposition 1

In this section, we derive the optimal consumption and portfolio policies for the consumption-income investor. To derive these solutions, we perform a series of log-linearizations to the CES

[28] The cross-sectional standard deviation of the $\theta_i \times \rho_{\Delta y_i,m}$ estimates from the household regressions in Equation (15) is 0.24.

aggregator of the consumption-income utility function, the Euler equations, the budget constraint, and the expression for portfolio returns.

A.1 Optimal Decision Rules during Retirement

Assuming that retirement begins in period τ, the consumption-income investor solves the following maximization problem:

$$\max_{\{C_t\}_{t=\tau}^{\infty},\{\alpha_t\}_{t=\tau}^{\infty}} \mathbf{E}_\tau\left[\sum_{t=\tau}^{\infty}\beta^{t-\tau}\frac{[\delta C_t^{\psi}+(1-\delta)\bar{Y}_r^{\psi}]^{\frac{1-\rho}{\psi}}}{1-\rho}\right], \quad \text{subject to}$$

$$W_{t+1}=(W_t-C_t+\bar{Y}_r)R_{p,t+1}, \ \forall \ t\geq\tau.$$

Above, $R_{p,t+1}$ are portfolio returns given by $R_{p,t+1}=a_t(R_{m,t+1}-R_{f,t+1})+R_{f,t+1}$. The Euler equations for the portfolio p, the risky asset m, and the risk-free asset f are

$$\mathbf{E}_t\left[\beta\frac{[\delta C_{t+1}^{\psi}+(1-\delta)\bar{Y}_r^{\psi}]^{\frac{1-\rho}{\psi}-1}C_{t+1}^{\psi-1}}{[\delta C_t^{\psi}+(1-\delta)\bar{Y}_r^{\psi}]^{\frac{1-\rho}{\psi}-1}C_t^{\psi-1}}R_{i,t+1}\right]=1, \ \ i\in\{p,m,f\}.$$

First, we log-linearize the CES aggregator in the consumption-income utility function of Equation (1) as follows

$$\log[\delta e^{\psi c_t}+(1-\delta)e^{\psi y_t}]\approx\xi_0+\psi\xi_1 c_t+\psi\xi_2 y_t, \tag{A1}$$

with the linearization constants: $\xi_0=log[\delta e^{\psi\bar{c}}+(1-\delta)e^{\psi\bar{y}}]-\psi\xi_1\bar{c}-\psi\xi_2\bar{y}$, $\xi_1=\frac{\delta e^{\psi\bar{c}}}{\delta e^{\psi\bar{c}}+(1-\delta)e^{\psi\bar{y}}}$, and $\xi_2=\frac{(1-\delta)e^{\psi\bar{y}}}{\delta e^{\psi\bar{c}}+(1-\delta)e^{\psi\bar{y}}}$, $\xi_1,\xi_2\in(0,1)$. Using the log-linearized CES aggregator, we can rewrite the Euler equations as

$$\mathbf{E}_t\left[\beta\frac{e^{(\xi_0+\psi\xi_1 c_{t+1}+\psi\xi_2\bar{y}_r)\frac{1-\rho-\psi}{\psi}}e^{(\psi-1)c_{t+1}}}{e^{(\xi_0+\psi\xi_1 c_t+\psi\xi_2\bar{y}_r)\frac{1-\rho-\psi}{\psi}}e^{(\psi-1)c_t}}e^{r_{i,t+1}}\right]=1, \ \ i\in\{p,m,f\}.$$

Further, since we assume that $\bar{Y}_r$ is constant during retirment, the log-linearized Euler equations are given by[29]

$$log\,\beta-\gamma\mathbf{E}_t[\Delta c_{t+1}^r]+\mathbf{E}_t[r_{i,t+1}]+0.5Var_t[r_{i,t+1}-\gamma\Delta c_{t+1}^r]=0, \ \ i\in\{p,m,f\},$$

where $\gamma=-[(1-\rho-\psi)\xi_1+\psi-1]$ is the effective risk aversion coefficient. The parameter γ is positive since $\rho>0$, $\psi\leq 1$, and $\xi_1\in(0,1)$.

Next, we divide both sides of the budget constraint by $W_t+\bar{Y}_r$ to obtain the log-linearized version around $\bar{c}$ and $\bar{w}$

$$w_{t+1}-\tilde{\lambda}_0^r-\tilde{\lambda}_1^r w_t\approx\tilde{\kappa}_0^r-\tilde{\kappa}_1^r c_t+\tilde{\kappa}_2^r w_t+r_{p,t+1},$$

where $\tilde{\lambda}_0^r=log(e^{\bar{w}}+\bar{Y}_r)-\tilde{\lambda}_1^r\bar{w}$ and $\tilde{\lambda}_1^r=\frac{e^{\bar{w}}}{e^{\bar{w}}+\bar{Y}_r}$. Also, $\tilde{\kappa}_0^r=log(1-\frac{e^{\bar{c}}}{e^{\bar{w}}+\bar{Y}_r})+\tilde{\kappa}_1^r\bar{c}-\tilde{\kappa}_2^r\bar{w}$, $\tilde{\kappa}_1^r=\frac{1}{1-\frac{e^{\bar{c}}}{e^{\bar{w}}+\bar{Y}_r}}\frac{e^{\bar{c}}}{e^{\bar{w}}+\bar{Y}_r}$, and $\tilde{\kappa}_2^r=\frac{1}{1-\frac{e^{\bar{c}}}{e^{\bar{w}}+\bar{Y}_r}}\frac{e^{\bar{c}}}{(e^{\bar{w}}+\bar{Y}_r)^2}e^{\bar{w}}$. If we set $e^{\bar{w}}$ to be much larger than $\bar{Y}_r$, then $\tilde{\lambda}_1^r=\frac{e^{\bar{w}}}{e^{\bar{w}}+\bar{Y}_r}\approx 1$, $\tilde{\kappa}_1^r\approx\tilde{\kappa}_2^r$, and the log-linearized budget constraint simplifies to

$$w_{t+1}-w_t\approx\kappa_0^r-\kappa_1^r(c_t-w_t)+r_{p,t+1}, \tag{A2}$$

where $\kappa_0^r=log(1-\frac{e^{\bar{c}}}{e^{\bar{w}}+\bar{Y}_r})+\kappa_1^r(\bar{c}-\bar{w})+\log(e^{\bar{w}}+\bar{Y}_r)-\bar{w}$, and $\kappa_1^r=\frac{1}{1-\frac{e^{\bar{c}}}{e^{\bar{w}}+\bar{Y}_r}}\frac{e^{\bar{c}}}{e^{\bar{w}}+\bar{Y}_r}$.

29 For the derivation of the log-linearized Euler equation, see Viceira (2001, p. 457).

Finally, we log-linearize the expression for portfolio excess returns $\left(\frac{1+R_{p,t+1}}{1+R_{f,t+1}} = a_t\left(\frac{1+R_{m,t+1}}{1+R_{f,t+1}} - 1\right) + 1\right)$ according to the online appendix of Campbell and Viceira (2002) to obtain

$$r_{p,t+1} - r_{f,t+1} \approx a_t(r_{m,t+1} - r_{f,t+1}) + 0.5a_t(1 - a_t)\sigma_m^2.$$

To derive the optimal policy rules, we use the guess-and-verify method. Specifically, we guess that during retirement, the optimal consumption policy is

$$c_t^r = \phi_0^r + w_t^r, \tag{A3}$$

and that the optimal portfolio rule is constant across time, that is, $a_t^r = a^r$. Under these two guesses, we have that $\mathbf{E}_t[\Delta c_{t+1}^r] = \mathbf{E}_t[\Delta w_{t+1}^r]$. Using the log-linearized budget constraint in Equation (A2) and our guess for the optimal portfolio rule, we obtain

$$\mathbf{E}_t[\Delta c_{t+1}^r] = a^r(\mu_m - r_f) + r_f + 0.5a^r(1 - a^r)\sigma_m^2 + \kappa_0^r - \kappa_1^r\phi_0^r. \tag{A4}$$

On the other hand, the log-linearized Euler Equation for the portfolio implies that

$$\mathbf{E}_t[\Delta c_{t+1}^r] = \frac{1}{\gamma}\left(\log\beta + \mathbf{E}_t[r_{p,t+1}^r] + 0.5Var_t[r_{p,t+1}^r - \gamma\Delta c_{t+1}^r]\right).$$

Since $\Delta c_{t+1}^r = \Delta w_{t+1}^r$, we have that $Var_t[r_{p,t+1}^r - \gamma\Delta c_{t+1}^r] = Var_t[r_{p,t+1}^r - \gamma\Delta w_{t+1}^r]$. Using the log-linearized budget constraint in Equation (A2) and the guess that $a_t^r = a^r$, we can write this expression as $Var_t[r_{p,t+1}^r - \gamma\Delta w_{t+1}^r] = (1-\gamma)^2(a^r)^2\sigma_m^2$. Hence, the log-linearized Euler equation implies that expected consumption growth is

$$\mathbf{E}_t[\Delta c_{t+1}^r] = \frac{1}{\gamma}\left(\log\beta + a^r(\mu_m - r_f) + r_f + 0.5a^r(1 - a^r)\sigma_m^2 + 0.5(1-\gamma)^2(a^r)^2\sigma_m^2\right). \tag{A5}$$

Equalizing the two expressions in Equations (A4) and (A5), we obtain the solution for ϕ_0^r

$$\begin{aligned}\phi_0^r &= \frac{a^r(\mu_m - r_f) + r_f + 0.5a^r(1 - a^r)\sigma_m^2 + \kappa_0^r}{\kappa_1^r} \\ &\quad - \frac{1}{\kappa_1^r\gamma}\left[\log\beta + a^r(\mu_m - r_f) + r_f + 0.5a^r(1 - a^r)\sigma_m^2 + 0.5(1-\gamma)^2(a^r)^2\sigma_m^2\right].\end{aligned} \tag{A6}$$

To derive the optimal portfolio weight a^r, we subtract the log-linearized Euler equation for the risk-free asset from the log-linearized Euler equation for the risky asset to obtain $\mu_m - r_f + 0.5\sigma_m^2 = \gamma Cov_t(r_{m,t+1}, \Delta c_{t+1}^r)$. Using our guesses for optimal consumption $(c_t^r = \phi_0^r + w_t^r)$ and portfolio rules $(a_t^r = a^r)$, and the log-linearized budget constraint in Equation (A2), we obtain that

$$a^r = \frac{\mu_m - r_f + 0.5\sigma_m^2}{\gamma\sigma_m^2}. \tag{A7}$$

A.2 Optimal Decision Rules during Employment

To derive optimal portfolio and consumption rules during employment, we first log-linearize the preretirement budget constraint $W_{t+1} = (W_t - C_t + Y_t)R_{p,t+1}$. First, we divide both sides of the budget constraint by Y_{t+1}. Next, in the RHS of the budget constraint, we divide and multiply by Y_t. Thus, the log-linearized budget constraint around $\overline{W/Y} = e^{\overline{w-y}}$ and $\overline{C/Y} = e^{\overline{c-y}}$ becomes

$$w_{t+1} - y_{t+1} = \kappa_0 + \kappa_1(w_t - y_t) - \kappa_2(c_t - y_t) - \Delta y_{t+1} + r_{p,t+1}, \tag{A8}$$

with the linearization constants

$$\kappa_1 = \frac{\overline{W/Y}}{1 + \overline{W/Y} - \overline{C/Y}}, \quad \kappa_2 = \frac{\overline{C/Y}}{1 + \overline{W/Y} - \overline{C/Y}}, \tag{A9}$$

$$\kappa_0 = log[1 + \overline{W/Y} - \overline{C/Y}] - \kappa_1 \, log \, \overline{W/Y} + \kappa_2 \, log \, \overline{C/Y}.$$

Like in Viceira (2001), we assume that $1 + \overline{W/Y} - \overline{C/Y} > 0$, because we want $W_t - C_t + Y_t > 0$ along an optimal path.

During employment, the Euler equations for the three assets are

$$\pi_e \mathbf{E}_t \left[\beta \frac{[\delta C_{t+1}^{\psi} + (1-\delta) Y_{t+1}^{\psi}]^{\frac{1-\rho}{\psi}-1} \delta C_{t+1}^{\psi-1}}{[\delta C_t^{\psi} + (1-\delta) Y_t^{\psi}]^{\frac{1-\rho}{\psi}-1} \delta C_t^{\psi-1}} R_{i,t+1} \right] +$$

$$\pi_r \mathbf{E}_t \left[\beta \frac{[\delta C_{t+1}^{\psi} + (1-\delta) \bar{Y}_r^{\psi}]^{\frac{1-\rho}{\psi}-1} \delta C_{t+1}^{\psi-1}}{[\delta C_t^{\psi} + (1-\delta) Y_t^{\psi}]^{\frac{1-\rho}{\psi}-1} \delta C_t^{\psi-1}} R_{i,t+1} \right] = 1, \quad i \in \{p, m, f\}.$$

Because we assumed that pension income is equal to the last preretirement income payment ($\bar{Y}_r = Y_t$), the Euler equations for the three assets using the log-linearized CES aggregator from Equation (A1) read

$$\pi_e \mathbf{E}_t [\beta e^{-\gamma \Delta c_{t+1}^e + \gamma \theta \Delta y_{t+1} + r_{i,t+1}}] + \pi_r \mathbf{E}_t [\beta e^{-\gamma \Delta c_{t+1}^r + r_{i,t+1}}] = 1, \quad i \in \{p, m, f\}, \tag{A10}$$

where $\gamma = -[(1-\rho-\psi)\xi_1 + \psi - 1]$ and $\theta = -(1-\rho-\psi)\xi_2 / [(1-\rho-\psi)\xi_1 + \psi - 1]$. The parameter γ, which is the effective risk aversion coefficient, is positive since $\rho > 0$, $\psi \leq 1$, and $\xi_1 \in (0, 1)$. Further, the sign of the coefficient θ, the consumption-income sensitivity parameter, depends on the sign of the term $1 - \rho - \psi$ since $\xi_2 \in (0, 1)$ and $-[(1-\rho-\psi)\xi_1 + \psi - 1]$ is positive.

Based on Equation (A10) above, the second-order approximations of the Euler equations for the portfolio p, the risky asset m, and the risk-free asset f are

$$\pi_e \{ log \, \beta - \gamma \mathbf{E}_t [\Delta c_{t+1}^e] + \gamma \theta \mathbf{E}_t [\Delta y_{t+1}] + \mathbf{E}_t [r_{i,t+1}] + 0.5 Var_t [-\gamma \Delta c_{t+1}^e + \gamma \theta \Delta y_{t+1} + r_{i,t+1}] \} +$$
$$\pi_r \{ log \, \beta - \gamma \mathbf{E}_t [\Delta c_{t+1}^r] + \mathbf{E}_t [r_{i,t+1}] + 0.5 Var_t [-\gamma \Delta c_{t+1}^r + r_{i,t+1}] \} = 0, \quad i \in \{p, m, f\}.$$

Using the identity $\Delta c_{t+1}^s = (c_{t+1}^s - y_{t+1}) - (c_t^e - y_t) + \Delta y_{t+1}$ for $s \in \{e, r\}$, the log-linearized Euler equation for the portfolio p becomes

$$\begin{aligned} & log \, \beta - \gamma \sum_{s=e,r} \pi_s \mathbf{E}_t [c_{t+1}^s - y_{t+1}] + \gamma (c_t^e - y_t) - \gamma \mathbf{E}_t [\Delta y_{t+1}] + \gamma \theta \pi_e \mathbf{E}_t [\Delta y_{t+1}] + \mathbf{E}_t [r_{p,t+1}^e] \\ & + 0.5 \pi_e Var_t [-\gamma (c_{t+1}^e - y_{t+1}) + \gamma (c_t^e - y_t) - \gamma \Delta y_{t+1} + \gamma \theta \Delta y_{t+1} + r_{p,t+1}^e] \\ & + 0.5 \pi_r Var_t [-\gamma (c_{t+1}^r - y_{t+1}) + \gamma (c_t^e - y_t) - \gamma \Delta y_{t+1} + r_{p,t+1}^e] \\ & = 0. \end{aligned}$$

Next, following the guess-and-verify approach, we guess that portfolio weights are constant, that is, $a_t^e = a^e$, and that the log consumption-income ratio is linear in wealth and income, that is, $c_{t+1}^e - y_{t+1} = \phi_0 + \phi_1 (w_{t+1}^e - y_{t+1})$. We can also rewrite the optimal consumption policy during retirement as $c_{t+1}^r - y_{t+1} = \phi_0^r + \phi_1^r (w_{t+1}^e - y_{t+1})$, with $\phi_1^r = 1$. Plugging the above guesses into the portfolio Euler equation, we obtain

$$log \, \beta - \gamma [\pi_e (\phi_0 + \phi_1 \mathbf{E}_t [w_{t+1}^e - y_{t+1}]) + \pi_r (\phi_0^r + \mathbf{E}_t [w_{t+1}^e - y_{t+1}])] +$$
$$\gamma [\phi_0 + \phi_1 (w_t^e - y_t)] - \gamma \mathbf{E}_t [\Delta y_{t+1}] + \gamma \theta \pi_e \mathbf{E}_t [\Delta y_{t+1}] + \mathbf{E}_t [r_{p,t+1}^e] +$$
$$0.5 \pi_e Var_t [\gamma ([\phi_0 + \phi_1 (w_{t+1}^e - y_{t+1})] - [\phi_0 + \phi_1 (w_t^e - y_t)] + \Delta y_{t+1}) - \gamma \theta \Delta y_{t+1} - r_{p,t+1}^e] +$$
$$0.5 \pi_r Var_t [\gamma ([\phi_0^r + (w_{t+1}^e - y_{t+1})] - [\phi_0 + \phi_1 (w_t^e - y_t)] + \Delta y_{t+1}) - r_{p,t+1}^e] = 0.$$

Using the log-linearized budget constraint in Equation (A8), our guesses for the optimal consumption and portfolio policies, and our assumption that Δy_{t+1} is an i.i.d. process, the Euler equation becomes

$$\begin{aligned} &log\,\beta - \gamma[\pi_e(\phi_0 + \phi_1[\kappa_0 + \kappa_1(w_t^e - y_t) - \kappa_2(\phi_0 + \phi_1(w_t^e - y_t)) - \mu_{\Delta y} + a^e(\mu_m - r_f) + \\ &r_f + 0.5a^e(1-a^e)\sigma_m^2]) + \pi_r(\phi_0^r + \kappa_0 + \kappa_1(w_t^e - y_t) - \kappa_2(\phi_0 + \phi_1(w_t^e - y_t)) - \mu_{\Delta y} + \\ &a^e(\mu_m - r_f) + r_f + 0.5a^e(1-a^e)\sigma_m^2)] + \gamma[\phi_0 + \phi_1(w_t^e - y_t)] - \gamma\mu_{\Delta y} + \gamma\theta\pi_e\mu_{\Delta y} + \\ &a^e(\mu_m - r_f) + r_f + 0.5a^e(1-a^e)\sigma_m^2 + 0.5\pi_e Var_t[\gamma\phi_1(-\Delta y_{t+1} + r_{p,t+1}^e) + \gamma\Delta y_{t+1} \\ &-\gamma\theta\Delta y_{t+1} - r_{p,t+1}^e] + 0.5\pi_r Var_t[\gamma(-\Delta y_{t+1} + r_{p,t+1}^e) + \gamma\Delta y_{t+1} - r_{p,t+1}^e] = 0. \end{aligned} \tag{A11}$$

Collecting $w_t^e - y_t$ terms above, the following equation in ϕ_1 must hold:

$$-\gamma\pi_e\phi_1\kappa_1 + \gamma\pi_e\kappa_2(\phi_1)^2 - \gamma\pi_r\kappa_1 + \gamma\pi_r\kappa_2\phi_1 + \gamma\phi_1 = 0.$$

Both solutions for the quadratic equation above are real and have opposite signs because the constant term $(-\frac{\pi_r\kappa_1}{\pi_e\kappa_2})$ is negative. Since ϕ_1 has to be positive, we choose the largest root and conclude that

$$\phi_1 = \frac{(\pi_e\kappa_1 - \pi_r\kappa_2 - 1) + \sqrt{(1 + \pi_r\kappa_2 - \pi_e\kappa_1)^2 + 4\pi_e\kappa_2\pi_r\kappa_1}}{2\pi_e\kappa_2}. \tag{A12}$$

Finally, collecting constant terms from Equation (A11), ϕ_0 solves

$$\begin{aligned} &log\,\beta - \gamma\pi_e\phi_0 - \gamma\pi_e\phi_1\kappa_0 + \gamma\pi_e\phi_1\kappa_2\phi_0 - \gamma\pi_e\phi_1[-\mu_{\Delta y} + a^e(\mu_m - r_f) + r_f + 0.5a^e(1-a^e)\sigma_m^2] \\ &-\gamma\pi_r\phi_0^r - \gamma\pi_r\kappa_0 + \gamma\pi_r\kappa_2\phi_0 - \gamma\pi_r[-\mu_{\Delta y} + a^e(\mu_m - r_f) + r_f + 0.5a^e(1-a^e)\sigma_m^2] + \gamma\phi_0 - \gamma\mu_{\Delta y} \\ &+a^e(\mu_m - r_f) + r_f + 0.5a^e(1-a^e)\sigma_m^2 + 0.5\pi_e(1-\gamma\phi_1)^2(a^e)^2\sigma_m^2 + 0.5\pi_e\gamma^2(1-\phi_1-\theta)^2\sigma_{\Delta y}^2 \\ &+\gamma\theta\pi_e\mu_{\Delta y} - \pi_e(1-\gamma\phi_1)a^e\gamma(1-\phi_1-\theta)\rho_{\Delta y,m}\sigma_m\sigma_{\Delta y} + 0.5\pi_r(1-\gamma)^2(a^e)^2\sigma_m^2 = 0. \end{aligned} \tag{A13}$$

We prove that $\phi_1 < 1$ is by contradiction using Equation (A12) and the definition of κ_1 and κ_2 in Equation (A9). Suppose that $\phi_1 \geq 1$,

$$\begin{aligned} \phi_1 = \frac{(\pi_e\kappa_1 - \pi_r\kappa_2 - 1) + \sqrt{(1 + \pi_r\kappa_2 - \pi_e\kappa_1)^2 + 4\pi_e\kappa_2\pi_r\kappa_1}}{2\pi_e\kappa_2} \geq 1 \iff \\ \sqrt{(\pi_e\kappa_1 - \pi_r\kappa_2 - 1)^2 + 4\pi_e\kappa_2\pi_r\kappa_1} \geq 2\pi_e\kappa_2 + (1 + \pi_r\kappa_2 - \pi_e\kappa_1) \iff \\ (1 + \pi_r\kappa_2 - \pi_e\kappa_1)^2 + 4\pi_e\kappa_2\pi_r\kappa_1 \geq 4\pi_e^2\kappa_2^2 + (1 + \pi_r\kappa_2 - \pi_e\kappa_1)^2 + 4\pi_e\kappa_2(1 + \pi_r\kappa_2 - \pi_e\kappa_1) \iff \\ \pi_r\kappa_1 \geq \pi_e\kappa_2 + (1 + \pi_r\kappa_2 - \pi_e\kappa_1) \iff 0 \geq 1 + \kappa_2 - \kappa_1. \end{aligned}$$

The last inequality is false since the definition of κ_1 and κ_2 in Equation (A9) implies that 1 $+\kappa_2 - \kappa_1$ is positive for $W_t + Y_t - C_t > 0$.

Returning to optimal portfolio weights, we subtract the log-linearized Euler equation for the risk-free asset from the log-linearized Euler equation for the risky asset to get

$$\mu_m - r_f + 0.5\sigma_m^2 = \gamma[\pi_e Cov_t(r_{m,t+1}, \Delta c_{t+1}^e) + \pi_r Cov_t(r_{m,t+1}, \Delta c_{t+1}^r)] - \gamma\theta\pi_e Cov_t(r_{m,t+1}, \Delta y_{t+1}).$$

Using the identity $c^s_{t+1} - c^e_t = (c^s_{t+1} - y_{t+1}) - (c^e_t - y_t) + \Delta y_{t+1}$ for $s \in \{r, e\}$, our guesses for optimal consumption and portfolio policies, that is, $c^e_t - y_t = \phi_0 + \phi_1(w^e_t - y_t)$, $c^r_t - y_t = \phi^r_0 + w^r_t - y_t$ and $a^e_t = a^e$, and the linearized budget constraint in Equation (A8), we find that

$$a^e = \frac{\mu_m - r_f + 0.5\sigma^2_m}{\gamma(\pi_r + \pi_e\phi_1)\sigma^2_m} - (1 - \phi_1 - \theta)\frac{\pi_e\sigma_{\Delta y}\sigma_m}{(\pi_r + \pi_e\phi_1)\sigma^2_m}\rho_{\Delta y,m}.$$

Appendix B Simulating the Consumption-Income Model

For the simulation analysis in this section, we focus on optimal decisions rules during employment. Specifically, we simulate income and stock market returns for 50 years, according to Equations (2) and (3), respectively. We then calculate the optimal equity share from Equation (4), and simulate wealth dynamics based on the linearized budget constraint from Equation (A8) in Appendix A. After simulating wealth and income, we obtain the consumption process based on the consumption function from Equation (5). The output of the simulation exercise consists of the average wealth-income and consumption-income ratios that determine the budget constraint linearization constants in Equation (A9) of Appendix A, as well as the consumption function parameters ϕ_1 and ϕ_0 in Equations (4) and (5).

To run the simulation, we use parameter values that are either common in the literature or implied by our estimation results in the PSID data set. In panel A of Table 6, we report the values of the calibrated parameters used in the simulation. Specifically, the parameters for income growth, stock market returns, and the risk-free rate are based on the corresponding annual moments from the PSID sample in Table 1. The initial conditions for wealth and income are based on the PSID sample averages from Table 1 as well. The preferences parameters γ and θ are based on the estimates from Table 2 (specification (2)) and Table 3, respectively. Following the literature, we set the discount factor β to 0.99. Finally, we assume that during retirement investors consume 10% of their wealth every year.[30]

Appendix C MTurk Survey on Status Preferences and Income

In this section, we discuss the design and implementation of the MTurk survey, which provides microevidence on the plausibility of the consumption-income utility function.

We design a survey to primarily examine individuals' perceptions of social status and income as a source of status. We therefore construct a series of questions to elicit the participant's perception of the relationship between welfare, social status, and income. For instance, we ask respondents to rate their level of agreement, on a seven point scale, with statements such as "I care about what people of think of me" and "I think social status is determined by one's income." We also gather information related to how individuals change their spending in response to income changes. Finally, we collect information related to demographic characteristics.

To implement the survey, we utilize Amazon's Mechanical Turk (MTurk) website (Buhrmester et al. 2011; Paolacci et al. 2010). The MTurk platform enables Requesters to post tasks which a large pool of Workers can access and perform online. The Workers provide personal details to Amazon, including their address of residence and social security number for tax purposes, and are compensated for completing tasks. While Workers on MTurk are compensated less than in-person laboratory study participants, the quality of answers is not lower than in-person laboratory studies (Casler et al. 2013). To further address potential concerns that Workers may not adequately perform the task, we restrict participation to individuals who were positively rated by at least 90% of their previous Requesters.

[30] This assumption implies that the parameter ϕ^r_0 in Equation (A6) of Appendix A is equal to –2.302.

Table A1
Descriptive statistics of survey participants

	Mean	Median	25%	75%
Age (yrs)	31.55	31.00	26.00	40.00
	(10.45)			
Income ($)	60,727	51,000	30,000	78,000
	(42,610)			
Financial wealth ($)	47,257	17,000	4,000	63,000
	(65,862)			
Female (%)	51.07			
Home ownership (%)				
Rent	44.97			
Own	39.95			
Live with family	15.08			
Race (%)				
African American	17.27			
American Indian or Alaskan	0.61			
Asian	3.92			
Latino	15.85			
White	60.66			
Other	1.70			
Education (%)				
Less than HS	0.40			
HS graduate	8.45			
Some college	27.21			
2-yr degree	12.58			
4-yr degree	36.55			
Professional degree	2.99			
Master's degree	10.47			
Doctoral degree	1.33			
Employment status (%)				
Employed	68.70			
Unemployed	4.08			
Self-employed	11.52			
Student	6.55			
Other	9.14			
No. obs.	2,534			

The table presents descriptive statistics of the survey participants. *Financial wealth* reflects the participant's savings in bank accounts and investment accounts. Standard deviations are displayed in parentheses.

We recruit a sample of 2,534 individuals living in the United States to complete the survey. The survey lasted approximately fifteen minutes and participants were compensated $1.50, a competitive pay rate given the duration of the task. As we see in Table A1, the average age of our sample participants is 31 years, and their average income and average wealth are about $60,000 and $47,000, respectively. Also, about 50% of the sample is female; 60% is white; and 17% is African American.

We summarize participants' responses to the statements related to social status, income as status, and spending in Table A2. Specifically, we code participants' responses to the survey statements on a seven-point scale from –3 (strongly disagree) to 3 (strongly agree). To capture each participant's social status preferences, we construct a *Social Status Index* as the equally weighted average of the subject's responses to statements S.1 and S.2. To measure each participant's perception of the relationship between income and social status, we construct the variable *Income as Status*, which depends on the subjects' responses to statement S.3.

Table A2
MTurk survey response rates

	S.1	S.2	S.3	S.4	S.5	S.6	S.7
Strongly disagree	6.98	6.86	3.51	33.67	39.20	23.56	28.45
Disagree	13.07	9.85	5.92	32.83	33.05	30.90	33.05
Somewhat disagree	14.97	11.26	7.92	12.87	10.65	15.61	14.87
Neutral	16.35	13.97	14.19	6.53	6.28	8.66	8.72
Somewhat agree	29.42	30.35	34.27	8.66	6.73	12.52	9.53
Agree	15.03	21.34	24.85	4.31	3.12	6.28	4.09
Strongly agree	4.18	6.37	9.24	1.13	0.97	2.48	1.29

This table shows the responses of 2,534 participants to an online survey. In the survey, the respondents were asked to state their agreement on a scale from -3 to 3, where -3 is “strongly disagree” and 3 is “strongly agree”, to the following statements:
1. I care about my social status.
2. I care about what people think of me.
3. People who make more money are more well respected.
4. People who are wealthy should be respected.
5. When my income decreases, I spend money to make myself feel better.
6. When my income is lower than expected, I increase my spending to feel better.
7. If my income decreases, I would rather not reduce my spending.
Table A1 describes the surveys demographic information. The survey was conducted on Amazon’s Mechanical Turk in June of 2016.

Table A3
Social status and income

	(1)	(2)	(3)
Income as status	0.273	0.274	0.205
	(14.95)	(14.93)	(10.75)
Wealth as status			0.241
			(11.84)
Age		−0.073	−0.065
		(−6.32)	(−5.78)
Race		−0.009	−0.015
		(−0.72)	(−1.24)
Education		0.065	0.072
		(3.85)	(4.45)
Employment status		0.021	0.022
		(1.29)	(1.39)
log income		0.032	0.035
		(0.87)	(1.01)
log financial wealth		0.074	0.046
		(4.27)	(2.66)
Homeownership status		−0.004	−0.002
		(−0.12)	(−0.07)
Female		−0.020	−0.007
		(−0.44)	(−0.15)
N	2,534	2,473	2,473
Adj. R-sq.	0.087	0.118	0.168

This table shows OLS regression results based on data gathered through the MTurk survey described in Appendix C. Specifically, the dependent variable in these regressions is each participant’s score on a *Social status index*, which is the equally weighted average of the responses to statements S.1 and S.2 of the survey (see Table A2). The independent variables include *Income as Status*, which is the participant’s response to statement S.3. The *Wealth as status* variable measures respondents’ agreement with statement S.4 of the survey. The rest of the dependent variables are demographic variables whose corresponding summary statistics are presented in Table A1. t-statistics are shown in parentheses and standard errors have been clustered at the participant’s zip code of residence-level. $Adj.R-sq.$ is the adjusted R-square.

Appendix D Life-Cycle Consumption Model with Consumption Constraints

In this section, we study the differences between the income hedging motive in our consumption-income framework, where income enters directly in the utility function, and the income hedging motive in a standard life-cycle model with consumption constraints. To this end, we study a life-cycle consumption problem in which consumption is forced to be equal to some fraction of income: $C_t = A_y Y_t$, where $A_y \in (0, 1]$ is a positive constant.

As pointed out by Zeldes (1989), life-cycle consumption problems with general borrowing constraints do not usually admit closed-form solutions because the Lagrange multipliers associated with the constraints are unknown functions of the state variables. Thus, studying the impact of borrowing constraints on consumption and portfolio decisions is a challenging task. Nevertheless, by focusing on the extreme constraint $C_t = A_y Y_t$, we are able to derive explicit solutions for optimal portfolio weights and examine how these weights are affected when consumption constraints are binding.

We first assume that consumption and portfolio policies during retirement are unconstrained and given by Equations (A3) and (A7). This assumption is motivated by the fact that we cannot study the effects of constrained consumption policies on income hedging during retirement because of our assumption that income during retirement is constant.

During employment, investors in the constrained life-cycle model choose consumption and portfolio weights to maximize their lifetime utility by solving the following maximization problem:

$$V_t^e = \max_{C_t, a_t} \frac{C_t^{1-\gamma}}{1-\gamma} + \beta \mathbf{E}_t[\pi_e V_{t+1}^e + \pi_r V_{t+1}^r], \text{ subject to}$$

$$W_{t+1} = (W_t - C_t + Y_t)[a_t(e^{r_{m,t+1}} - e^{r_{f,t+1}}) + e^{r_{f,t+1}}], \quad C_t = A_y Y_t.$$

Following the arguments in Appendix A, the log-linearized Euler equation for the risky and risk-free assets in the constrained life-cycle problem are given by

$$\pi_e\{log\,\beta - \gamma \mathbf{E}_t[\Delta c_{t+1}^e] + \mathbf{E}_t[r_{i,t+1}] + 0.5 Var_t[-\gamma \Delta c_{t+1}^e + r_{i,t+1}]\} +$$
$$\pi_r\{log\,\beta - \gamma \mathbf{E}_t[\Delta c_{t+1}^r] + \mathbf{E}_t[r_{i,t+1}] + 0.5 Var_t[-\gamma \Delta c_{t+1}^r + r_{i,t+1}]\} = 0, \;\; i \in \{m, f\}.$$

Subtracting the log-linearized Euler equation for the risk-free asset from the log-linearized Euler equation for the risky asset, we obtain

$$\mu_m - r_f + 0.5\sigma_m^2 = \gamma[\pi_e Cov_t(r_{m,t+1}, \Delta c_{t+1}^e) + \pi_r Cov_t(r_{m,t+1}, \Delta c_{t+1}^r)].$$

Next, to derive the optimal portfolio weight for the risky asset, we exploit the following three relations. First, we focus on consumption polices that are always constrained and thus, during employment, consumption growth is equal to income growth, $\Delta c_{t+1}^e = \Delta y_{t+1}$. Second, we use the identity $c_{t+1}^r - c_t^e = (c_{t+1}^r - y_{t+1}) - (c_t^e - y_t) + \Delta y_{t+1}$ for consumption in the first retirement period. Third, from Equation (A3), we know that during retirement, optimal consumption is given by $c_{t+1}^r = \phi_0^r + w_{t+1}^r$. Based on these three relations and the log-linearized budget constraint from Equation (A8), the log-linearized Euler equation becomes

$$\mu_m - r_f + 0.5\sigma_m^2 = \gamma[\pi_e Cov_t(r_{m,t+1}, \Delta y_{t+1}) + \pi_r Cov_t(r_{m,t+1}, (a_{cons}^e r_{m,t+1} - \Delta y_{t+1}) + \Delta y_{t+1})].$$

Solving for the constrained optimal portfolio weight a_{cons}^e, we obtain

$$a_{cons}^e = \frac{\mu_m - r_f + 0.5\sigma_m^2}{\gamma \pi_r \sigma_m^2} - \frac{\pi_e \sigma_{\Delta y} \sigma_m}{\pi_r \sigma_m^2} \rho_{\Delta y, m}. \tag{A14}$$

The income hedging term of the constrained life-cycle problem in Equation (A14) is $-\frac{\pi_e \sigma_{\Delta y} \sigma_m}{\pi_r \sigma_m^2} \rho_{\Delta y, m}$. In contrast, the income hedging term of the unconstrained life-cycle model in

Equation (8) is $-(1-\phi_1)\dfrac{\pi_e\sigma_{\Delta y}\sigma_m}{(\pi_r+\phi_1\pi_e)\sigma_m^2}\rho_{\Delta y,m}$. Comparing these two terms, we conclude that the constraint $C_t = A_y Y_t$ strengthens the income hedging term since the parameters ϕ_1 and π_e are positive and less than 1.

The previous analysis shows that the effects of borrowing constraints on income hedging in the standard life-cycle model are similar to those in our consumption-income framework only when the elasticity of substitution between consumption and income in the consumption-income utility function of Equation (1) is relatively high (i.e., $1/(1-\psi) > 1/\rho$). That is, when the consumption-income sensitivity parameter θ in Equations (4), (6), and (9) is negative, the effects of our consumption-income model on income hedging are similar to those of the constrained life-cycle model. In this case, both models predict that the income hedging motive strengthens relative to the standard life-cycle model.

However, the most prevalent and intuitive case of our consumption-income model is the one where the elasticity of substitution between consumption and income in the consumption-income utility function is relatively low (i.e., $1/(1-\psi) < 1/\rho$), and the consumption-income sensitivity parameter θ in Equations (4), (6), and (9) is positive. In this case, our consumption-income model predicts that consumption-income sensitivities attenuate the income hedging motive. This result runs against the predictions of the constrained life-cycle model, where consumption constraints strengthen the income hedging motive.

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