The Returns on Human Capital: Good News on Wall Street is Bad News on Main Street

Very Preliminary

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Abstract

We use a standard single-agent model to do some simple consumption growth accounting. Consumption growth is driven by news about current and expected future returns on the market portfolio. The market portfolio includes financial and human wealth. We impute the residual of consumption growth innovations that cannot be attributed to either news about financial asset returns or future labor income growth to news about expected future returns on human wealth, and we back out the implied human wealth and market return process. Our consumption-implied market return is negatively correlated with the stock market return, but out consumption-consistent CAPM outperforms the standard CAPM in explaining the cross-sectional variation in stock returns.

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1 Introduction

We confront a single agent with the observed returns on US financial wealth and back out her implied consumption innovations. These consumption innovations are determined by news about current returns and by news about expected future returns on the market portfolio (Campbell (1993)). The effect of news about future returns on consumption only depends on the elasticity of intertemporal substitution (henceforth \( EIS \)).

If her portfolio -the market portfolio- only includes financial wealth, the agent’s consumption innovations are too volatile relative to US aggregate consumption innovations and the implied correlation of her consumption innovations with news about stock returns is much higher than that in US data, regardless of the \( EIS \).

The market return really consists of the return on financial assets and human wealth, but we cannot observe the returns on human wealth. In a first step, we do some basic consumption growth accounting: we impute that part of the consumption innovations that cannot be attributed to news about current or future financial returns, to the returns on human wealth. This approach enables us to back out a human wealth return process that matches the moments of aggregate consumption innovations in the data with those of our agent by construction. We find that (1) good news (for current returns) in financial markets is bad news in (for current returns) in labor markets, regardless of the \( EIS \), and (2) the implied total market return is negatively correlated with the returns on financial wealth, at least if the \( EIS \) is smaller than one.

The first stylized fact is not that surprising given that good news about future labor income growth tends to be bad news for the growth rate of payouts (dividends etc.) to securities holders.

In a second step, we actually estimate a process for the expected return on human wealth by minimizing the distance between the consumption innovation moments in the model and the data. These estimates corroborate our earlier findings.

Related Literature Lettau & Ludvigson (2001a) and Lettau & Ludvigson (2001b) find that the single agent’s budget constraint provides useful aggregate risk information: Lettau & Ludvigson (2001a) use a linearized version of the household budget constraint to show that the consumption-wealth ratio ought to predict stock returns, and it does. Lettau & Ludvigson (2001b) derive a scaled version of the Consumption CAPM from this budget constraint.

In the data the stock market wealth effect on consumption is small or non-existent. Of course, the market portfolio includes financial and human wealth. Looking at the data
through the lens of our (standard) model, we find that the effect a positive surprise in financial markets tends to be offset on average by bad news in labor markets, i.e. lower expected future labor income growth or higher future risk premia.

While Campbell’s work aimed to substitute consumption out of the asset pricing equations, we find we obtain better measures of market risk when the market return is forced to be consistent with the moments of aggregate consumption. The market return that we back out of aggregate consumption is consistent with household portfolio evidence. US household portfolios are biased towards US securities. We claim these securities provide US investors with a hedge against human capital risk. Baxter & Jermann (1997) reach the exact opposite conclusion. In their results, introducing labor income risk unambiguously worsens the international diversification puzzle, but they do not use the information embedded in aggregate consumption. In recent work, Julliard (2003) qualifies the Baxter-Jermann result.

There is also some evidence from the cross-section in favor of our approach. We use the budget constraint and the Euler equation to derive a consumption-consistent version of the CAPM. Our consumption-consistent CAPM (or CC-CAPM), which uses the market return process “implied” by actual US aggregate consumption innovations, actually does better in explaining the cross-section of asset returns than the standard CAPM return on the stock market, even though our consumption-consistent market return is negatively correlated with the return on financial assets.

Lewellen & Nagel (2004) argue the conditional CAPM betas do not vary the right way in order for a conditional version of the CAPM to explain the variation in returns. Our results shed some light on these findings. Bansal & Yaron (2004) attribute a key role to long-run consumption risk in explaining the time series and cross-section properties of the risk premia on stocks; they back out a consumption and dividend process that can match expected returns on financial wealth. We back out a (human wealth) return process that implies the right aggregate consumption behavior.

## 2 Environment

We adopt the environment of Campbell (1993). We consider a single agent decision problem. This agent ranks consumption streams \( \{C_t\} \) using the following utility index \( U_t \), which is defined recursively:

\[
U_t = \left( (1 - \beta)C_t^{(1-\gamma)/\theta} + \beta \left(E_tU_{t+1}^{1-\gamma}\right)^{1/\theta} \right)^{\theta/(1-\gamma)},
\]

(3)
where $\gamma$ is the coefficient of relative risk aversion and $\sigma$ is the intertemporal elasticity of substitution, henceforth $IES$. Finally, $\theta$ is defined as $\theta = \frac{1-\gamma}{1/(1/\sigma)}$. In the case of separable utility, the EIS equals the inverse of the coefficient of risk aversion and $\theta$ is one.

Distinguishing between the coefficient of risk aversion and the inverse of the $EIS$ will prove important later on. Our results only depend on the $EIS$, not on the coefficient of risk aversion.

Moreover, these preferences impute a concern for long run risk to our agent, and this plays potentially an important role in understanding risk premia (Bansal & Yaron (2004)).

**Trading Assets** All wealth, including human wealth, is tradable. We adopt Campbell’s notation: $W_t$ denotes the representative agent’s total wealth at the start of period $t$, and $R_{t+1}^m$ is the gross return on wealth invested from $t$ to $t+1$. This representative agent’s budget constraint is:

$$W_{t+1} = R_{t+1}^m (W_t - C_t) .$$

(1)

Our single agent takes the returns on the market $\{R_t^m\}$ as given, and decides how much to consume. Instead of imposing market clearing, forcing the agent to consume aggregate dividends and labor income, we simply let her choose the optimal aggregate consumption process, taking the market return process $\{R_t^m\}$ as given. No equilibrium or market clearing conditions are imposed.

### 3 The Joint Distribution of Consumption and Asset Returns

Innovations to consumption growth are driven by news about current financial and human wealth returns, and news about expected future financial or human wealth returns. The innovation to current human wealth returns can be stated as a function of expected future labor income growth and expected future returns on human wealth. We impute the residual component of aggregate consumption growth innovations not attributable to news about current or future financial returns and labor income growth, to news about future human wealth returns.
3.1 Substituting out Consumption

Campbell (1993) linearizes the budget constraint and uses the Euler equation to obtain an expression for consumption innovations as a function of innovations to current and future expected returns. First, Campbell linearizes the budget constraint around the mean log consumption/wealth ratio $c - w$. Lowercase letters denote logs. If the consumption-wealth ratio is stationary, in the sense that $\lim_{j \to \infty} \rho^j (c_{t+j} - w_{t+j}) = 0$, this approximation implies that:

$$c_{t+1} - E_t c_{t+1} = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j r^m_{t+1+j} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta c_{t+1+j}, \quad (2)$$

where $r^m = \log(1 + R^m)$ and $\rho$ is defined as $1 - e^{c - w}$. Innovations to consumption today reflect innovations to current and future expected returns, and innovations to future expected consumption growth. Campbell then assumes that consumption and returns are conditionally homoscedastic and jointly lognormal. Second, Campbell substitutes the consumption Euler equation:

$$E_t \Delta c_{t+1} = \mu_m + \sigma E_t r^m_{t+1}, \quad (3)$$

where $\mu_m$ is a constant that includes some variance and covariance terms for consumption and market innovations, back into the consumption innovation equation in (2), to obtain an expression with only returns on the right hand side:

$$c_{t+1} - E_t c_{t+1} = r^m_{t+1} - E_t r^m_{t+1} + (1 - \sigma)(E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r^m_{t+1+j}, \quad (4)$$

Innovations to the representative agent’s consumption are determined by (1) the unexpected part of this period’s market return and (2) the innovation to expected future market returns.

There is a one-for-one relation between current return and consumption innovations, regardless of the $EIS$, but the relation with between consumption innovations and innovations to expected future returns depends on the $EIS$. If the agent has log utility over deterministic consumption streams and $\sigma$ is one, the consumption innovations exactly equal the unanticipated return in this period. If $\sigma$ is larger than one, the representative agent lowers her consumption to take advantage of higher expected future returns, while, if $\sigma$ is smaller than one, the case we will focus on, she chooses to increase her consumption. \(^1\)

\(^1\)If each household’s Euler equation is satisfied, aggregation across heterogeneous households is straightforward as long as all of the households share the same $EIS$. Because of the linearity, aggregation reproduces exactly equation (4) for aggregate consumption innovations. However, if household wealth and the $EIS$ are positively correlated, then the aggregate $EIS$ that shows up in the aggregate consumption innovation.
Matching the moments of aggregate consumption  Campbell (1993) uses the consumption innovation equation in (4) to do asset pricing without aggregate consumption. But this relation between return and consumption innovations also puts tight restrictions on the joint distribution of aggregate consumption innovations and total wealth return innovations. Our aim is to reintroduce aggregate consumption. More specifically, we are interested in two moments of the consumption innovations: (1) the correlation of consumption innovations with return innovations, and, (2), the variance of consumption innovations. Matching these moments of the data is a major hurdle for this model, because in the data stock returns and consumption innovations have a low correlation, and because consumption innovations are much less volatile than return innovations.

Long-run restrictions  The household budget constraint also imposes a restriction on the long-run effect of news about market returns and consumption growth:

\[
(E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j r_{t+1+j} = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta c_{t+1+j},
\]

(5)

When we back out a process for human wealth returns that matches aggregate consumption innovations, we will check whether the news about the present discounted value of consumption growth in the data and the news about the discounted value of future market returns are consistent.

3.2 Matching the Moments with the Data

This section discusses the measurement of financial asset returns, the computation of all the innovations that feed into consumption innovations, and finally, the relevant moments of the data.

3.2.1 Measuring Financial Asset Returns

We use two measures of financial asset returns. The first measure is the return on the value-weighted CRSP stock market portfolio: \( R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t} \), where \( D_t \) is the quarterly dividend in period \( t \) and \( P_t \) is the ex-dividend price. To remove the seasonal component in dividends, we define the log dividend price ratio as

\[
dp_t^a = \log \left( \frac{.25D_t + .25D_{t-1} + .25D_{t-2} + .25D_{t-3}}{P_t} \right).
\]

expression exceeds the average EIS across households.
The full line in figure 1 shows the dividend-price ratio, \( \exp(dp_{it}) \). We follow the literature on repurchases (Fama & French (2001) and Grullon & Michaely (2002)), and adjust the dividend yield for repurchases of equity, to ensure its stationarity. The repurchase data are from Boudoukh, Michaely, Richardson, & Roberts (2004). This is the dotted line in figure 1. Consistent with the literature on repurchases (Fama & French (2001) and Grullon & Michaely (2002)), the dividend-price ratio adjusted for repurchases is similar to the unadjusted series until 1980, and consistently higher afterwards.

Our second measure takes a broader perspective by including corporate debt and private companies: we value a claim to US non-financial, non-farm corporations and we compute the total payouts to the owners of this claim. The value of US corporations is the market value of all financial liabilities plus the market value of equity less the market value of financial assets. The payout measure includes all corporate pay-outs to securities holders, both stock holders and bond holders (see appendix for details). This procedure is outlined in the appendix (section A).

The dashed line in figure 1 shows the pay-out to securities holders to market value of firms ratio (own computations). Over the last two decades, the dividend/yield for the firm-value measure has been much higher than the dividend/yield on stocks. This is consistent with the findings of Hall (2001). The firm value dividend/yield completely departs from the CRSP-based repurchase adjusted series after the stock market crash of 2001.
3.2.2 Computing the innovations

We follow Campbell (1996) and estimate a VAR with real financial asset returns \((r_t^a)\), real per capita labor income growth \((\Delta y_{t+1})\), and three predictors: the log dividend yield on financial assets \((dp_t^a)\), the relative T-bill return \((rtb_{t+1})\), and the yield spread \((ysp_{t+1})\). To be consistent with our exercises in the next section, we add the labor income share \(s_{t+1}\) and real per capita consumption growth on non-durables and services to the system \(\Delta c_{t+1}\). \(N = 7\) denotes the size of the state vector. We stack the \(N\) variables into a state vector \(z\).

The VAR describes a linear law of motion for the state:

\[
z_{t+1} = Az_t + \varepsilon_{t+1},
\]

with innovation covariance matrix \(E[\varepsilon\varepsilon'] = \Sigma\). The dimensions of \(\Sigma\) and \(A\) are \(N \times N\), the dimensions of \(\varepsilon\) and \(z\) are \(N \times T\). Finally, we also define \(e_k\) as the \(k\)th column of an identity matrix of the same dimension as \(A\).

Once the VAR has been estimated, we can extract the news components that drive the consumption growth innovations: we define innovations in current financial asset returns \(\{(a)_t\}\), innovations in current human wealth returns \(\{(y)_t\}\), news about current and future labor income growth \(\{(d^y)_t\}\), and news about future financial asset returns \(\{(h^a)_t\}\) and human capital returns \(\{(h^y)_t\}\):

\[
\begin{align*}
(a)_{t+1} &= r_t^a - E_t[r_{t+1}^a] = e'_1\varepsilon_{t+1} \\
(y)_{t+1} &= r_t^y - E_t[r_{t+1}^y] \\
(d^y)_{t+1} &= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} = e'_2(I - \rho A)^{-1}\varepsilon_{t+1} \\
(h^a)_{t+1} &= (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r_{t+1+j}^a = e'_1\rho A(I - \rho A)^{-1}\varepsilon_{t+1} \\
(h^y)_{t+1} &= (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r_{t+1+j}^y.
\end{align*}
\]

The moments of these innovations will be denoted using \(V_{i,j}\) and \(Corr_{i,j}\) notation for variances and correlations respectively. Finally, we can back out news about expected future

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\(^2\)In section B of the appendix, the first panel of table 11 reports the VAR-estimates using stock returns and the stock dividend yield, while the second panel re-estimates the VAR using returns and dividend yields on total firm value.
dividend growth from the news about asset returns:

\[(d^d)_{t+1} = (h^a)_{t+1} + (a)_{t+1}\]

**Stylized Facts** Table 1 summarizes the moments from the data using the firm value returns. This will be our benchmark. We report results for the full post-war sample (1947.II-2003.IV) obtained using a 1-lag VAR (column 1), at quarterly frequencies, and we also report results obtained using a 2-lag VAR (column 2). All variances are multiplied by 10,000. Five key stylized facts deserve mention.

- Firm value return innovations are about 15 times as volatile as consumption innovations. In annualized terms, the standard deviation of news about financial returns is 14 percent; the same number is 1.15 percent for consumption.

- News about future firm value returns is even more volatile: in annualized terms, the standard deviation is 20 percent.

- Consumption innovations and return innovations are only weakly correlated (0.15).

- Current return innovations are negatively correlated with news about future expected returns: there is strong (multivariate) mean reversion in returns on firm value.

- News about current labor income growth and current dividend growth are not correlated or negatively correlated.

- News about future dividend growth and news about future labor income growth are negatively correlated.

The first four facts are well-documented (at least for stock returns); the last two are not. These facts indicate that good news for securities holders may not necessarily be good news for workers. In addition, these stylized facts are robust. Including additional forecasting variables in the VAR does not affect these moments much.

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3 The signs and relative magnitudes correspond to the ones reported in Campbell (1996) for monthly and annual data.

4 Our measure of consumption is real per capita non-durables and services consumption. All results go through using total personal consumption. For total consumption \(V_c\) is .7 and \(Cov_{c,a}\) is 0.1.
Table 1: Moments from Data: Returns on Firm Value

The asset return is the return on firm value. The sample covers 1947.II-2003.IV. The second column reports results for a 2-lag VAR over the full sample. The subscript $a$ denotes innovations in current financial asset returns; $d_y$ denotes news in current and future labor income growth; $h_a$ denotes news in future financial market returns; $d_d$ denotes news in current and future financial dividend growth; and $c$ denotes innovations to non-durable and services consumption.

<table>
<thead>
<tr>
<th>Moments</th>
<th>1 Lag</th>
<th>2 Lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_a$</td>
<td>48.32</td>
<td>63.54</td>
</tr>
<tr>
<td>$V_{d_y}$</td>
<td>1.61</td>
<td>1.90</td>
</tr>
<tr>
<td>$V_{h_a}$</td>
<td>32.74</td>
<td>33.00</td>
</tr>
<tr>
<td>$\text{Cor}r_{a,h_a}$</td>
<td>-.478</td>
<td>-.625</td>
</tr>
<tr>
<td>$\text{Cor}r_{a,d_y}$</td>
<td>.337</td>
<td>.377</td>
</tr>
<tr>
<td>$\text{Cor}r_{d_y,h_a}$</td>
<td>-.526</td>
<td>-.665</td>
</tr>
<tr>
<td>$\text{Cor}r_{d_y,d_d}$</td>
<td>-.102</td>
<td>-.209</td>
</tr>
<tr>
<td>$\text{Cor}r_{y,d}$</td>
<td>-.092</td>
<td>-.08</td>
</tr>
<tr>
<td>$V_c$</td>
<td>.333</td>
<td>.325</td>
</tr>
<tr>
<td>$\text{Cor}r_{c,a}$</td>
<td>.168</td>
<td>.168</td>
</tr>
</tbody>
</table>

**Different Income Measures**

Our measure for labor income so far was (real, per capita) compensation of all employees. This excludes proprietor’s income, but includes wages and salaries to government employees. The first column of Table (2) lists the results if we only include the labor income of private company employees. We also use a measure of pay-outs to employees of non-financial corporate businesses. This measure is consistent with our measure of pay-outs to securities holders of non-financial corporate business. These results are reported in the second column of Table (2). All of the stylized facts seem to be mostly robust to using different labor income measures. The correlation between innovations to current financial returns and future labor income growth is even lower, while the correlation between news about future labor income growth and future financial returns is more negative. The other moments are virtually identical to before.

**Stock market Returns**

When we use stock market returns instead of the our measure of the return on a claim to US non-financial firms, we obtain very similar results, as reported in Table (3), but we find significantly more mean reversion in stock returns: $\text{Cor}r_{a,h_a}$ is around -.9; the same moment is about -.6 for the returns on firm value. The news about current stock market returns is slightly more volatile. In addition, the correlation between news about dividend and labor income growth (both current and future) is weakly positive for stock market returns, instead of weakly negative.
Table 2: Moments from Data: Different Income Measures

The asset return is the return on firm value. The moments for quarterly data are from own calculations for the 1947.II-2003.IV (column 2). The subscript $a$ denotes innovations in current financial asset returns; $d^y$ denotes news in current and future labor income growth; $h^a$ denotes news in future financial market returns; $d^d$ denotes news in current and future financial dividend growth; and $c$ denotes innovations to non-durable and services consumption.

<table>
<thead>
<tr>
<th>Moments</th>
<th>Non-Fin. Business</th>
<th>Proprietor’s Income</th>
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<tbody>
<tr>
<td>$V_a$</td>
<td>47.23</td>
<td>48.34</td>
</tr>
<tr>
<td>$V_{d^y}$</td>
<td>4.18</td>
<td>2.02</td>
</tr>
<tr>
<td>$V_{h^a}$</td>
<td>27.81</td>
<td>22.80</td>
</tr>
<tr>
<td>$\text{Corr}_{a,h^a}$</td>
<td>-.622</td>
<td>-.533</td>
</tr>
<tr>
<td>$\text{Corr}_{a,d^y}$</td>
<td>.334</td>
<td>.280</td>
</tr>
<tr>
<td>$\text{Corr}_{d^y, h^a}$</td>
<td>-.626</td>
<td>-.437</td>
</tr>
<tr>
<td>$\text{Corr}_{d^y, d^d}$</td>
<td>-.184</td>
<td>-.048</td>
</tr>
<tr>
<td>$\text{Corr}_{y, d}$</td>
<td>-.016</td>
<td>-.058</td>
</tr>
</tbody>
</table>

Table 3: Moments from Data: Stock Returns

The asset return is the return on the CRSP value-weighted stock index. The sample covers 1947.II-2003.IV. The second column reports results for a 2-lag VAR over the full sample. The subscript $a$ denotes innovations in current financial asset returns; $d^y$ denotes news in current and future labor income growth; $h^a$ denotes news in future financial market returns; $d^d$ denotes news in current and future financial dividend growth; and $c$ denotes innovations to non-durable and services consumption.

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<th>Moments</th>
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<th>2 Lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_a$</td>
<td>63.54</td>
<td>62.74</td>
</tr>
<tr>
<td>$V_{d^y}$</td>
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<tr>
<td>$V_{h^a}$</td>
<td>103.07</td>
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<td>.473</td>
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<td>-.336</td>
<td>-.208</td>
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<tr>
<td>$\text{Corr}_{d^y, d^d}$</td>
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<td>.286</td>
</tr>
<tr>
<td>$\text{Corr}_{y, d}$</td>
<td>.173</td>
<td>.114</td>
</tr>
<tr>
<td>$V_c$</td>
<td>.328</td>
<td>.320</td>
</tr>
<tr>
<td>$\text{Corr}_{c, a}$</td>
<td>.185</td>
<td>.175</td>
</tr>
</tbody>
</table>
3.3 The Market Return and Consumption Moments

We can back out the model-implied moments of the consumption innovation process from the expression for the consumption innovations in (4). We focus on two moments in particular: the variance of consumption innovations and their correlation with innovations to the current market return.

We use $V_c$ to denote the variance of consumption innovations $V_c = var(c_{t+1} - E_t c_{t+1})$, while the covariance with current return innovations is denoted $V_{c,m} = cov(c_{t+1} - E_t c_{t+1}, r_m^{t+1} - E_t r_m^{t+1})$. The covariance of current market return innovations with news about future returns is $V_{m,h} = cov(r_m^{t+1} - E_t r_m^{t+1}, (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r_m^{t+1+j})$. From equation (4), it follows that the variance of consumption innovations is given by:

$$V_c = V_m + (1 - \sigma)^2 V_h + 2(1 - \sigma) V_{m,h},$$

while the covariance of consumption with current return innovations is:

$$V_{c,m} = V_m + (1 - \sigma) V_{m,h}.$$

**Variance** In the log case ($\sigma = 1$), consumption responds one-for-one to current return innovations, and the variance of consumption innovations is the variance of news about current market returns. As the EIS decreases below 1, consumption absorbs part of the volatility of shocks to future asset returns $V_h$, but this effect on the variance of consumption innovations can be mitigated by the mean-reversion in the market return (negative covariance of shocks to current and future expected returns $V_{h,m}$). When the EIS is zero, the innovation to consumption simply equals the innovation to all expected returns, including the current one, and the variance of consumption innovations equals the total variance of current and future return innovations.

**Correlation** The correlation between consumption and return innovations is determined by the sum of the variance of returns and the covariance of current with future return innovations. If $\sigma$ is smaller than one, a negative covariance of current and future return innovations lowers the covariance of consumption with current return innovations: the agent adjusts her consumption by less in response to a positive surprise if the same news lowers her expectation about future asset returns. In the less than log case, mean reversion helps to match the variance and volatility of consumption.

Mean reversion in returns actually increases the volatility of consumption if the EIS exceeds one; in response to good news, the agent increases his consumption, but this effect
is reinforced because the agent anticipated lower returns in the future and decides to save less as a result!

There is little evidence for an *EIS* in excess of one. Browning, Hansen, & Heckman (2000) conduct an extensive survey of the consumption literature that estimates the *EIS* off household data; they conclude the consensus estimate is a little less than one, around .5 for food consumption. The estimates from macro data are much lower. Hall (1988) concludes the *EIS* is close to zero.

**Heterogeneity** Finally, Vissing-Jorgensen (2002) finds much higher *EIS* estimates of around .3-.4 for stockholders and .8-.9 for bondholders than for non-asset holders. As we pointed out, this raises the effective *EIS* that shows up in the aggregate consumption innovation equation, and worsens these puzzles as a result.

### 3.4 Financial Wealth Only

We start by abstracting from non-financial wealth, and we compare the model-implied consumption innovation behavior to aggregate US data. This is a natural starting point, because standard business cycle models imply that the returns on human and other assets are highly or even perfectly correlated (e.g. Baxter & Jermann (1997)).

In finance, it is standard practice to consider the stock market return $r_t$ a good measure for the market return $r_{mt}$ (Black (1987)).

We analyze the moments of the model-implied consumption innovations, simply by by feeding the actual innovations to financial asset returns and news about future returns into the linearized policy function of our single agent; our procedure delivers a time series for the model-implied consumption innovations.

**Matching Consumption Moments** In quarterly post-war data, the variance of consumption innovations $V_c$ is only .32, compared to 48 for return innovations, and the correlation with return innovations is around .15 (see Table 1). The mean reversion in returns helps to lower the implied volatility and correlation of consumption innovations, but not nearly enough. In the first panel of Figure (2), we plot the variance of the model-implied consumption innovations and in the second panel we plot their correlation with current stock market return innovations against the *EIS*.

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5 The capital and labor dividend streams are perfectly correlated in a Cobb-Douglas production economy in which the entire, random, capital stock process is fixed exogenously (i.e. no investment choice and no depreciation).
Even if $\sigma$ is zero - this value of the EIS maximizes the effect of the mean reversion on the volatility of consumption innovations - the model does not even come to close to matching the moments of the data. The standard deviation of consumption innovations is off by a factor of 7: at an annualized rate the model-implied standard deviation of news about current consumption is at least 9.5 percent, compared to about 1.5 percent in the data. As the EIS increases beyond the log case, the variance of consumption explodes.

If we use stock returns instead of firm value returns, we can actually match the correlation because of the large mean-reversion in stock returns for very low EIS: $Corr_{a,h^a}$ is about -.9 for stocks, -.6 for the returns on firm value (see Table 3). However, we still cannot match the volatility of consumption innovations.

We will refer to these two facts, respectively, as the consumption volatility and the consumption correlation puzzle. These are both tied to the lack of a large, financial wealth effect on aggregate consumption. Before we introduce human wealth into the picture, we consider two other potential explanations for the lack of correlation and the volatility puzzle, because these could interfere with our consumption growth accounting exercise.
3.5 Other Explanations

First, we allow for heteroskedastic returns on financial assets, and we develop a way of testing whether this effect drives our results.

Second, we consider the effect of habit-style preferences. We rule out habits because reasonably specified cannot lower the correlation between consumption innovations and returns enough.

3.5.1 Heteroscedastic Market Returns

So far we have abstracted from time-variation in the joint distribution of consumption growth and returns. In particular, we worry about time-varying variances in consumption growth and the market return. Denote the conditional variance term by \( \mu_{m}^{n} \); this was previously assumed to be constant. In this case, a third source of consumption innovations arises (equation 38 in Campbell (1993)), which reflects the influence of changing risk on saving:

\[
c_{t+1} - E_{t}c_{t+1} = r_{t+1}^{m} - E_{t}r_{t+1}^{m} + (1 - \sigma)(E_{t+1} - E_{t}) \sum_{j=1}^{\infty} \rho^{j}r_{t+1+j}^{n} - (E_{t+1} - E_{t}) \sum_{j=1}^{\infty} \rho^{j} \mu_{t+1+j}^{n},
\]

where \( \mu_{t}^{n} = \sigma \log \beta + .5 \left( \frac{\theta}{\sigma} \right) \text{Var}[\Delta c_{t+1} - \sigma r_{t+1}^{m}] \). Campbell shows this last term drops out if either \( \gamma \) or \( \sigma \) are one. We call the last term news about future variances \( h^{\mu} \).

Assume we are in the plausible parameter range: \( \gamma > 1 \) and \( \sigma < 1 \). In this case, the last term can only resolve the correlation puzzle if \( V_{m,h^{\mu}} \) is strongly positive - good news in the stock market today increases the conditional volatility of future market returns persistently well into the future. This seems implausible, especially at annual frequencies. But we can test the heteroscedasticity hypothesis directly: if true, our consumption growth accounting residual should predict the future variance of stock market returns, and it does not. We will revisit this issue in section (5.6).

3.5.2 Habits

Finally, we consider the possibility that habits are responsible for the discrepancy between consumption innovation moments in the model and the data. If the log surplus consumption ratio \( spl_{t} \) follows an AR (1), then
\[ c_t - E_t c_{t+1} = r_{m,t+1} - E_t r_{m,t+1} + (1 - \sigma) (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r_{m,t+j+1} \]

\[ - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \mu_{m,t+j+1} + \frac{1}{\rho (1 - \rho)} \Delta s p l_{t+1} \]

Since we already dealt with variances term, let us focus on the habit term only. Clearly, the only way the habit can reduce the correlation between innovations to consumption and returns is if the change in the log consumption ratio is negatively correlated with news about market returns. But, conditionally, the change in the surplus consumption ratio is perfectly correlated with consumption growth! This habit mechanism cannot resolve the correlation puzzle, unless the surplus consumption ratio is not driven by consumption growth itself.

As it stands, the model simply cannot replicate the consumption moments. The next section brings human wealth into the model. In a first step, we keep the human wealth share constant; in a second step, we allow it to vary over time.

4 Adding Human Wealth

The market portfolio now includes a claim to the entire aggregate labor income stream. The total market return can be decomposed into the return on financial assets \( R^a \) and returns on human capital \( R^y \):

\[ R^{m}_{t+1} = (1 - \nu_t) R^a_{t+1} + \nu_t R^y_{t+1}, \tag{6} \]

where \( \nu_t \) is the ratio of human wealth to total wealth.

Consumption Innovations with Constant Human Wealth Share The innovation to the return on human capital equals the innovation to the expected present discounted value of labor income less the innovation the present discounted value of future returns. The Campbell (1991) decomposition gives:

\[ r^y_{t+1} - E_t [r^y_{t+1}] = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r^y_{t+1+j}. \tag{7} \]

A windfall in human wealth returns is driven by higher expected labor income (“dividend”) growth or by lower expected risk premia on human wealth. Campbell (1996) assumes that the human wealth share is constant: \( \nu_t = \bar{\nu} \). For now we maintain that assumption, but we
will relax it later on. The constant human wealth share equals the constant labor income share: \( \bar{\nu} = \bar{s} \).

The expression for news about the current returns on human wealth in equation (7) is substituted back into the expression for consumption innovations in (4) is:

\[
E_t c_{t+1} - E_t c_{t+1} = (1 - \bar{\nu})(r^a_{t+1} - E_t r^a_{t+1}) + \bar{\nu}(E_t c_{t+1} - E_{t+1}) \sum_{j=0}^\infty \rho^j \Delta y_{t+1+j} \\
+ (1 - \sigma)(1 - \bar{\nu})(E_t r^a_{t+1} - E_t) \sum_{j=1}^\infty \rho^j r^a_{t+1+j} - \sigma \bar{\nu}(E_t c_{t+1} - E_t) \sum_{j=1}^\infty \rho^j r^y_{t+1+j}.
\]

Consumption responds one-for-one to news about current asset returns, weighted with the capital income share, and to news about discounted current and future labor income growth, weighted with the labor income share, regardless of the EIS. As before, the response to news about future asset returns is governed by \(1 - \sigma\). But the response to news about future human wealth returns is governed by \(-\sigma\). This reflects the direct effect of future human wealth risk premia on consumption and the indirect effect on the current human wealth returns (see equation 7).\(^6\)

**Log Utility**  In the benchmark case of log utility, our agent is myopic: her consumption-wealth ratio is constant, and her consumption moves one-for-one with the weighted news about current asset returns and human capital returns:

\[
E_t c_{t+1} - E_t c_{t+1} = (1 - \bar{\nu})(r^a_{t+1} - E_t r^a_{t+1}) + \bar{\nu}(r^y_{t+1} - E_t r^y_{t+1}).
\]

News about future financial asset returns has no direct effect on consumption. In contrast, news in future human wealth returns has an indirect effect on consumption through the innovations in the current human wealth return. An increase in future risk premia decreases the agent’s consumption today, while an increase in expected future labor income growth increases it.

### 4.1 Matching Moments of Consumption

Using the consumption policy function, we can compute the model-implied correlation of consumption innovations with financial return innovations \( \text{Corr}_{c,a} \) and the implied variance

\(^6\)There is an asymmetry in how Campbell deals with the returns on financial assets and human capital: because the returns on human capital are not observable, he brings in the dividend part.
of consumption innovations $V_c$ as a function of observed moments $\text{Cor}r_{i,j}$ and $V_k$. Using the notation we defined earlier, we get:

$$(c)_t = (1 - \bar{\nu})(a)_t + \tilde{\nu}(d')_t + (1 - \sigma)(1 - \bar{\nu})(h^a)_t - \sigma\bar{\nu}(h^v)_t.$$ 

The expression for the variance of consumption innovations is long and tedious, so we relegate it to the appendix (equation 24 in section D). Similarly, we derive an expression for $V_{c,a}$, the covariance of consumption with asset return innovations (equation 25 in the appendix).

Log Utility To build intuition, we consider the simplest case of log utility. The variance of consumption innovations reduces to expression (26) and the correlation reduces to expression (26). The variance of consumption innovations increases the more volatile news about current asset returns, future labor income growth and future human wealth returns is.

A negative correlation between current asset returns and future labor income growth $\text{Cor}r_{a,dv}$ or a positive correlation with news about future risk premia on human wealth $\text{Cor}r_{a,hv}$, reduces the variance of consumption innovations, while a positive correlation between news about future labor income growth and news about future expected returns on human wealth $\text{Cor}r_{h,v,dv}$ also helps.

If good news in the stock market also pushes up future risk premia on human wealth and lowers expected future labor income growth, the innovation to the current human wealth returns will be negative, offsetting the effect of good news in the stock market on consumption.

To lower the correlation between current innovations to returns and consumption ($\text{Cor}r_{c,a}$), we need essentially the same pattern: (1) a negative correlation between current asset returns and future labor income growth $\text{Cor}r_{a,dv}$, and (2) a positive correlation between current asset returns and future expected risk premia on human wealth $\text{Cor}r_{a,hv}$.

In the data, we observe that news about current asset returns and future labor income growth is weakly positively correlated ($\text{Cor}r_{a,dv}$ is around .4 in table 1). This fact works against a low variance and a low correlation.

Less than Log Utility In the case in which the $EIS$ is smaller than one, changes in the investment opportunity set, through changes in future risk premia, also affect consumption behavior. Table 4 reports the effect of all the variances and covariances on the variance of consumption. $\text{Cor}r_{a,dv}$ and $\text{Cor}r_{h,v,dv}$ have the same effect as in the case of log utility, but now other “hedging” moments matter as well. A positive correlation between current
Table 4: Matching Consumption Moments when $\sigma < 1$

In the first panel, the entries show the sign of the effect of the variance/covariance of $(i, j)$ on the variance of consumption $V_c$. In the second panel, the entries show the sign of the effect of the variance/covariance of $(i, j)$ on the covariance of consumption $V_{c,a}$.

<table>
<thead>
<tr>
<th></th>
<th>$a$</th>
<th>$d^y$</th>
<th>$h^a$</th>
<th>$h^y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>$d^y$</td>
<td>+</td>
<td>+</td>
<td>−</td>
<td></td>
</tr>
<tr>
<td>$h^a$</td>
<td>+</td>
<td>−</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$h^y$</td>
<td></td>
<td>−</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>$a$</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>−</td>
</tr>
</tbody>
</table>

asset and future human wealth return innovations $Corr_{a,h^y}$ also pushes $V_c$ down. A negative $Corr_{a,h^y}$ also helps to lower the correlation between consumption and return innovations $Corr_{c,a}$.  

4.2 Expected Returns on Human Wealth

The returns on human capital are unobserved, at least for the econometrician. We proceed in three stages.

First, we entertain three different, reasonable specifications for the returns on human wealth that have been put forward in the literature. Each of these models has different implications for the cross-moments that determine the variance of consumption innovations and their correlation with asset return innovations. In a second step, we just impute the unexplained part of consumption growth innovations to news about future risk premia on human wealth. Finally, in a third step, we estimate a process for human wealth by minimizing the distance between model-implied moments and the moments in the data.

4.2.1 Three Benchmark Models

We start by considering three different models for human wealth returns. Each of these falls in the class of linear factor models.

1. **Campbell model**: Expected Return on Human Wealth equals Expected Return on Stocks: Campbell (1996) assumes that $E_t[r_{t+1}^a] = E_t[r_{t+1}^y]$, $\forall t$ and proceeds...
with the following expression for innovations in the human capital return:

\[ r_{t+1}^y - E_t r_{t+1}^y = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r_{t+1+j}^u. \]  

(8)

The Campbell model sets: \( V_{hy} = V_{h^*} \), \( Corr_{a,h^y} = Corr_{a,h^*} \), \( Corr_{d^y,h^y} = Corr_{d^y,h^*} \), \( Corr_{h^*,h^y} = 1 \). Aggregate consumption innovations in Campbell’s model are more volatile and more correlated with return innovations as a result. The news about future expected returns on human capital is as volatile as the news about financial returns, but it has the wrong effect. \( Corr_{a,h^y} \) has a negative effect on \( V_{c} \) and \( Corr_{c,a} \). But since this model sets it equal to \( Corr_{a,h^*} \), the mean reversion in the financial return data acts to increase the variance of consumption innovations and the correlation of financial return innovations and consumption innovations.

2. **Shiller model:** **Constant Expected Return on Human Wealth** : An alternative assumption is that the discount rate of labor income growth is constant. This implies that the second term in equation (7) is zero.

\[ r_{t+1}^y - E_t r_{t+1}^y = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} \]  

(9)

This is the specification formulated by Shiller (1993). We expect Shiller’s model to do better by assuming a constant discount rate for human capital, because this implies that \( V_{hy} = 0 = Corr_{a,h^y} = Corr_{d^y,h^y} = Corr_{a,h^*} \).

3. **Jagannathan-Wang model:** **Constant Expected Return and No Predictability**:

In the final model the innovation to human wealth return equals the innovation to the labor income growth rate. This implies that:

\[ r_{t+1}^y - E_t r_{t+1}^y = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta y_{t+1+j} = \Delta y_{t+1} - E_t \Delta y_{t+1}. \]  

(10)

This is the specification adopted by Jagannathan & Wang (1996), henceforth JW. JW assume that (i) the discount rate is constant, implying that that the second term in equation (7) is zero, and they assume (ii) that labor income growth is unforecastable, so that the first term in equation (7) is \( \Delta y_{t+1} - E_t \Delta y_{t+1} \). As a result, the moments of
news in future human wealth returns in the JW model are:

\[ V_{hv} = V[(E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta y_{t+1+j}] \]

\[ Corr_{a,hv} = Corr[a, (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta y_{t+1+j}] \]

\[ Corr_{d'hv} = Corr[d'\alpha, (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta y_{t+1+j}] \]

\[ Corr_{h'a} = Corr[h'\alpha, (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta y_{t+1+j}] \].

Note that \((E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta y_{t+1+j} \neq d'y\) because of the summation index that starts at 1 instead of 0. This means \(V_{hv} \approx V_{dv}\), much less volatile than in Campbell’s model. Also \(Corr_{h'a} \approx Corr_{d'a} > 0\), a good assumption, because we know \(Corr_{h'a} > 0\) helps to lower the volatility and correlation of consumption innovations, when the IES is smaller than one.

**Linear Factor Model** These three models differ only in the \(N \times 1\) vector \(C\) in \(E_t[I_{t+1}] = C'z_t\). This vector \(C\) describes how the innovations to the expected returns on human wealth relate to the innovations to the state vector \(z\). In the Campbell model \(C' = e_1'A\), in the Shiller model \(C' = 0\), and in the Jagannathan-Wang model, \(C' = e_2'A\).

\(C\) implies a process for \(\{(h'y)\}_t\), the innovations to expected future returns on human wealth:

\[ (h'y)_t = C' \rho(I - \rho A)^{-1} \varepsilon_t, \] (11)

and a process for \(\{(y)\}_t\), the current innovation to the return on human wealth:

\[ (y)_t = (d'y)_t - (h'y)_t, \] (12)

\[ = e_2'(I - \rho A)^{-1} \varepsilon_t - C' \rho(I - \rho A)^{-1} \varepsilon_t \] (13)

From this equation, it is easy to verify that \(C'\) needs to be equal to \(e_2'A\) for \((y)_{t+1}\) to be equal to \(\Delta y_{t+1} - E_t \Delta y_{t+1} = e_2' \varepsilon_{t+1}\) in the JW case.

Having specified three different models for the expected returns on human wealth, we can now back out the moments of the implied aggregate consumption innovations.
Table 5: Moments for Consumption Growth and Human Capital Returns

This table uses firm value returns over the full sample (1947.II-2003.IV). In each panel, the first column represents the Campbell specification for human capital returns (equation 8). The second column represents the constant discounter model (equation 9), and the third column represents the autarkic model (equation 10). The last column gives the corresponding moments in the data, when available. \( a (y) \) denotes innovations in current asset (human capital) returns \( r_{t+1}^a - E_t r_{t+1}^a \). \( h^a \) is news in future asset returns \( (E_{t+1} - E_t ) \sum_{j=1}^\infty \rho_j r_{t+1+j}^a \). \( c \) denotes innovations in current consumption \( c_{t+1} - E_t c_{t+1} \). Computations are done for \( \bar{\nu} = .7000 \) and \( \sigma = .2789 \).

<table>
<thead>
<tr>
<th>Moments</th>
<th>Campbell</th>
<th>Shiller</th>
<th>JW</th>
<th>data</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{h^a} )</td>
<td>32.74</td>
<td>0</td>
<td>.54</td>
<td></td>
</tr>
<tr>
<td>( \text{Corr}_{a,h^a} )</td>
<td>-.478</td>
<td>0</td>
<td>.485</td>
<td></td>
</tr>
<tr>
<td>( \text{Corr}_{a,h^y} )</td>
<td>-.526</td>
<td>0</td>
<td>.752</td>
<td></td>
</tr>
<tr>
<td>( \text{Corr}_{h^a,h^y} )</td>
<td>1.000</td>
<td>0</td>
<td>-.306</td>
<td></td>
</tr>
<tr>
<td>( V_c )</td>
<td>6.05</td>
<td>4.29</td>
<td>3.94</td>
<td>.230</td>
</tr>
<tr>
<td>( \text{Corr}_{c,a} )</td>
<td>.946</td>
<td>.865</td>
<td>.868</td>
<td>.195</td>
</tr>
<tr>
<td>( \text{Corr}_{y,a} )</td>
<td>.488</td>
<td>.357</td>
<td>.081</td>
<td></td>
</tr>
<tr>
<td>( \text{Corr}_{y,h^a} )</td>
<td>-.986</td>
<td>-.526</td>
<td>-.511</td>
<td></td>
</tr>
<tr>
<td>( V_y )</td>
<td>42.00</td>
<td>1.61</td>
<td>.75</td>
<td></td>
</tr>
</tbody>
</table>

4.3 Results

Table 5 summarizes the moments of consumption innovations, and human capital return innovations for quarterly data, and for our benchmark calibration with constant labor income share \( \bar{\nu} = .7000 \), and EIS of \( \sigma = .2789 \). We use the returns on firm value. All three models display too much volatility in consumption innovations (by a factor of 30 for the Campbell model and a factor of 10 for the JW model), and a correlation with stock returns that is roughly 4 times too high.

The Campbell model does worse than the others because the high implied correlation between innovations in financial asset returns and human capital returns (1) imputes too much volatility to consumption. When we use stock returns instead of the returns on firm value, the predicted correlation of innovations in consumption decreases dramatically for the Shiller and JW models, because the financial returns display more mean reversion (see table 5 in the appendix, section B), but the volatility of consumption news is still off by an order of magnitude.

Robustness These results are robust to plausible changes in parameter values. Figure 3 plots the model-implied standard deviation of consumption innovations and the correlation of consumption innovations with innovations in financial market returns for different values of \( \sigma \) for the full sample; the labor share \( \bar{\nu} \) is .7. None of the models comes close to matching the variance and correlation, even for very low \( \sigma \). Table 6 demonstrates that an increase in the average labor income share to .85 brings the standard deviation of consumption in the
Table 6: Moments for Consumption Growth: Sensitivity Analysis

This panel uses the returns on firm value over the full sample (1947.II-2003.IV). The last column gives the corresponding moments in the data, when available. $V_c$ denotes the variance of model-implied innovations in consumption. $\text{Corr}_{c,a}$ is the model-implied correlation between innovations in consumption and innovations in current asset returns.

<table>
<thead>
<tr>
<th>Labor Share</th>
<th>EIS</th>
<th>Campbell</th>
<th>Shiller</th>
<th>JW</th>
<th>Campbell</th>
<th>Shiller</th>
<th>JW</th>
<th>$V_c$</th>
<th>$\text{Corr}_{c,a}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{\nu} = .70$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma = .27$</td>
<td>.605</td>
<td>4.29</td>
<td>3.94</td>
<td>0.95</td>
<td>0.87</td>
<td>0.87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma = .73$</td>
<td>19.96</td>
<td>5.27</td>
<td>4.24</td>
<td>0.80</td>
<td>0.94</td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma = 1.5$</td>
<td>73.65</td>
<td>9.64</td>
<td>7.23</td>
<td>0.66</td>
<td>0.90</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{\nu} = .85$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma = .27$</td>
<td>5.13</td>
<td>2.07</td>
<td>1.71</td>
<td>0.78</td>
<td>0.77</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma = .73$</td>
<td>21.45</td>
<td>2.58</td>
<td>1.64</td>
<td>0.65</td>
<td>0.81</td>
<td>0.84</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma = 1.5$</td>
<td>79.16</td>
<td>4.11</td>
<td>2.27</td>
<td>0.57</td>
<td>0.79</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: The EIS and Consumption Innovation Volatility and Correlation - Using Returns on Firm Value, Quarterly Data 1947-2003

The labor share $\nu$ is .70.

$JW$ model down to 2.7 times its value in the data; the correlation is still much too high. Figure (4) shows that a labor income share of close to 1 is needed to match both consumption moments.

So far we have been unable to bring the model’s moments closer to matching those in the data. In the next section, we treat the expected returns component of human wealth return innovations as a residual and we reverse-engineer a human wealth return process that can match the consumption data.
Figure 4: The Labor Share and Consumption Innovation Volatility and Correlation - Using Returns on Firm Value, Quarterly Data 1947-2003

The $EIS \sigma$ is .27.
4.4 Consumption Growth Accounting

This section reverses the logic we followed up until now: we impute the part of actual innovations in consumption that is not due to news about financial returns or labor income growth, to news about future human wealth returns. We fix a value of the EIS $\sigma$ and back out the innovations to future human capital returns that are implied by the observed aggregate consumption innovations. Of course, now we match all the moments of consumption by construction. The human wealth share is still constant. We find that positive news for current financial wealth returns is bad news for current human wealth returns. This finding is robust to changes in the EIS.

**Backing out a Human Wealth Return Process**

Innovations in current consumption growth can be recovered from the VAR residuals as follows:

$$(c)_{t} \equiv c_{t+1} - E_t[c_{t+1}] = e'_t \epsilon'_t. \quad (14)$$

Plugging these consumption innovations back in the household’s linear policy rule, we can back out the implied news in future human capital returns:

$$(h^y)_t \equiv \frac{1}{\sigma \bar{\nu}} [(1 - \bar{\nu})(a)_t + \bar{\nu}(d^y)_t + (1 - \sigma)(1 - \bar{\nu})(h^a)_t - (c)_t]. \quad (15)$$

Once we have constructed $(h^y)_t$, we form innovations in current human wealth returns $(y)_t = (d^y)_t - (h^y)_t$ and innovations in the current market return $(m)_t = (1 - \bar{\nu})(a)_t + \bar{\nu}(y)_t$.

**Current Human Wealth and Market Returns**

The first panel of table 7 reports the implied moments for the current innovations to human wealth $(y)_t$ and the market return $(m)_t$, implied by consumption data and the model. Regardless of the EIS and the labor income share, we find that innovations in current financial asset and human wealth returns are consistently negatively correlated: $\text{Corr}_{y,a} < 0$.

For the total market return, things are more complicated. In the less-than-log-case, good news in financial markets is bad news for the market return $\text{Corr}_{m,a} < 0$, and the market return is mean reverting. In the more-than-log-case, good news in financial markets is good news for the market as a whole $\text{Corr}_{m,a} > 0$, but the market returns display multivariate mean aversion.

In the benchmark case, $\bar{\nu} = .700$ and $\sigma = .279$, current human wealth returns $V_y$ are highly volatile, twice as volatile as the innovations to financial asset returns. As the EIS increases, the implied volatility decreases to less than 50 percent of the volatility of news
about current financial returns in the case of $\sigma = .73$.

**Future Risk Premia on Human Wealth** The second panel of Table 7 reports the moments for the innovations to expected future returns on human wealth, $(h^y)_t$, that we backed out of the model. Regardless of the $EIS$ and the labor income share, news about the implied risk premia on human and financial assets is negatively correlated: $Corr_{h^y,h^a} < 0$.

For our benchmark calibration $\bar{\nu} = .700$ and $\sigma = .279$, the implied volatility of shocks to expected future returns on human wealth $V_{h^y}$ is 104.3, its correlation with current asset return innovations $Corr_{a,h^y}$ is .9, its correlation with innovations to future labor income growth $Corr_{h^y,d^y}$ is .4, and its correlation with news in future returns is −.3.

**More than Log utility** As expected, the implied market returns is strongly mean-reverting for low $\sigma$, but there is strong mean-aversion in the more-than-log case (last column). The implied consumption wealth ratio is not stationary and this invalidates Campbell’s approximation method: a high wealth/consumption ratio predicts high market returns in the future, so there is no mean reversion in the consumption/wealth ratio. We have to rule out this case, just because our method is not valid.

**Robustness** Current innovations to financial asset and human wealth returns have to be negatively correlated, if we want to match the behavior of consumption in the data, and this is true for all the parameterizations we consider. A higher $EIS$ and a higher labor income share dramatically lower the required volatility of innovations to current and expected future human wealth returns. The same logic applies for the innovations to the market return. The implied mean reversion in the market return is also smaller when the $EIS$ is higher. Of the three benchmark models, only the $JW$ model actually generates the correct correlation pattern: $Corr_{a,h^y}$ is positive and $Corr_{h^y,h^a}$ is negative, but $(h^y)_t$ is not nearly volatile enough (.5 versus 104.3).
### Table 7: Implied Moments for Innovations to Human Capital and Market Returns

Panel A uses stock returns; Panel B uses the returns on firm value. We use the full sample (1947.II-2003.IV). $a(y)$ denotes innovations in current asset (human capital) returns $r_{t+1}^a - E_t(r_{t+1}^a) \ (r_{t+1}^y - E_t(r_{t+1}^y))$. $h^n$ is news in future asset returns $(E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r_{t+1+j}^n$. $c$ denotes innovations in current consumption $(c_{t+1} - E_t c_{t+1})$. Computations are done for $\nu \in \{.70, .85\}$ and $\sigma \in \{.2789, .75, 1.50\}$.

#### Panel I: Current Returns

<table>
<thead>
<tr>
<th>EIS</th>
<th>Labor Share</th>
<th>$V_y$</th>
<th>$\text{Corr}_{y,a}$</th>
<th>$\text{Corr}_{y,d}^d$</th>
<th>$\text{Corr}_{y,h}^h$</th>
<th>$V_m$</th>
<th>$\text{Corr}_{m,a}$</th>
<th>$\text{Corr}_{m,d}^d$</th>
<th>$\text{Corr}_{m,h}^h$</th>
<th>$\text{Corr}_{m,h}^h$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\nu = .70$</td>
<td>$\sigma = .27$</td>
<td>100.36</td>
<td>-0.82</td>
<td>-0.21</td>
<td>-0.03</td>
<td>-0.99</td>
<td>29.42</td>
<td>-0.68</td>
<td>-0.14</td>
<td>-0.22</td>
</tr>
<tr>
<td></td>
<td>$\sigma = .73$</td>
<td>14.49</td>
<td>-0.94</td>
<td>-0.21</td>
<td>0.26</td>
<td>-0.96</td>
<td>0.97</td>
<td>-0.43</td>
<td>0.14</td>
<td>-0.30</td>
</tr>
<tr>
<td></td>
<td>$\sigma = 1.5$</td>
<td>5.34</td>
<td>-0.93</td>
<td>-0.17</td>
<td>0.61</td>
<td>-0.90</td>
<td>0.71</td>
<td>0.69</td>
<td>0.50</td>
<td>-0.02</td>
</tr>
<tr>
<td>$\nu = .85$</td>
<td>$\sigma = .27$</td>
<td>24.40</td>
<td>-0.78</td>
<td>-0.44</td>
<td>0.12</td>
<td>-0.98</td>
<td>11.90</td>
<td>-0.65</td>
<td>-0.44</td>
<td>-0.00</td>
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<tr>
<td></td>
<td>$\sigma = .73$</td>
<td>2.96</td>
<td>-0.87</td>
<td>-0.21</td>
<td>0.25</td>
<td>-0.85</td>
<td>0.59</td>
<td>-0.29</td>
<td>0.05</td>
<td>-0.17</td>
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<td></td>
<td>$\sigma = 1.5$</td>
<td>1.03</td>
<td>-0.75</td>
<td>0.19</td>
<td>0.38</td>
<td>-0.53</td>
<td>0.49</td>
<td>0.57</td>
<td>0.74</td>
<td>-0.25</td>
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</tbody>
</table>

#### Panel II: Future Returns

<table>
<thead>
<tr>
<th>EIS</th>
<th>Labor Share</th>
<th>$V_{hy}$</th>
<th>$\text{Corr}_{kh,a}^h$</th>
<th>$\text{Corr}_{kh,d}^d$</th>
<th>$\text{Corr}_{kh,h}^h$</th>
<th>$V_{hm}$</th>
<th>$\text{Corr}_{km,a}^h$</th>
<th>$\text{Corr}_{km,d}^d$</th>
<th>$\text{Corr}_{km,h}^h$</th>
<th>$\text{Corr}_{km,h}^h$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\nu = .70$</td>
<td>$\sigma = .27$</td>
<td>107.26</td>
<td>0.84</td>
<td>0.32</td>
<td>-0.04</td>
<td>54.59</td>
<td>0.71</td>
<td>0.20</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\sigma = .73$</td>
<td>18.13</td>
<td>0.94</td>
<td>0.49</td>
<td>-0.39</td>
<td>7.82</td>
<td>0.71</td>
<td>0.20</td>
<td>0.20</td>
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</tr>
<tr>
<td></td>
<td>$\sigma = 1.5$</td>
<td>7.98</td>
<td>0.91</td>
<td>0.59</td>
<td>-0.73</td>
<td>1.89</td>
<td>0.71</td>
<td>0.20</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>$\nu = .85$</td>
<td>$\sigma = .27$</td>
<td>31.57</td>
<td>0.76</td>
<td>0.61</td>
<td>-0.22</td>
<td>21.73</td>
<td>0.69</td>
<td>0.53</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\sigma = .73$</td>
<td>5.51</td>
<td>0.82</td>
<td>0.70</td>
<td>-0.47</td>
<td>3.11</td>
<td>0.69</td>
<td>0.53</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\sigma = 1.5$</td>
<td>2.15</td>
<td>0.81</td>
<td>0.73</td>
<td>-0.72</td>
<td>0.75</td>
<td>0.69</td>
<td>0.53</td>
<td>-0.04</td>
<td></td>
</tr>
</tbody>
</table>
Incorporating Time-Varying Wealth Shares

So far we kept the share of human wealth in the market portfolio constant, but this may introduce approximation errors. These errors are small in Campbell’s model because the risk premia on the two assets are perfectly correlated, but, in general, these errors could be very large.

The return on the market is a weighted average of the return on financial assets and the return on human wealth:

\[ r_{m,t+1} = (1 - \nu_t) r_{a,t+1} + \nu_t r_{y,t+1} \]

with portfolio weight \( \nu_t \), the ratio of human wealth to total wealth, which depends on all the state variables in \( z : \nu_t(z_t) \). In this section, we extend all previous results to the economy with time-varying human wealth shares, and show that all results go through.

### 5.1 Computing the Human Wealth Share

First, we show that the price-dividend ratios on financial and human wealth are both linear in the state. We start with the human wealth part. The vector \( C \) relates the expected return on human wealth to the state vector. In Campbell’s model \( C' = e_1'A \), in Shiller’s model \( C' = 0 \), and in JW’s model, \( C' = e_2'A \). These different choices of \( C \) imply a different process for \((y)_t \) (as defined by equation 12) and a process for the (demeaned) dividend yield on human wealth:

\[
dp_t^y - E[dp_t^y] = E_t \sum_{j=1}^{\infty} \rho^j (r_{t+j}^y - \Delta y_{t+j}) = \rho(C' - e_2'A)(I - \rho A)^{-1}z_t = B'z_t
\]

In all three of the benchmark models we can write the (demeaned) log dividend yield as a linear function of the state \( z \) with loadings \( B \) (\( N \times 1 \)). The demeaned log dividend yield on financial assets is simply the third element in the VAR: \( dp_t - E[dp_t] = e_3'z_t \).

Now, the price-dividend ratio for the market is the wealth-consumption ratio; it is a weighted average of the price-dividend ratio for human wealth and for financial wealth:

\[
\frac{W}{C} = \frac{P^a}{D}D + \frac{P^y}{Y}Y
\]
where \( dp^y = -\log \left( \frac{P_Y}{Y} \right) \). The human wealth to total wealth ratio is given by:

\[
\nu_t = \frac{P_Y Y}{Y C} = \frac{e^{-dp^y_t} s_t}{e^{-dp^y_t s_t} + e^{-dp^y t - s_t} (1 - s_t)} = \frac{1}{1 + e^{dx_t}},
\]

which is a logistic function of \( x_t = dp^y_t - dp_t + \log \left( \frac{1 - s_t}{s_t} \right) \). We recall that \( s \) denotes the labor income share \( s_t = Y_t/C_t \) with mean \( \bar{s} \). When \( dp_t = dp^y_t \), the human wealth share equals the labor income share \( \nu_t = s_t \), but in general, \( \nu_t \) is a function of the difference in log dividend price ratios on human wealth and financial market wealth as well. In section E of the appendix, we derive a linear approximation of the demeaned human wealth share \( \tilde{\nu}_t \equiv \nu_t - \bar{\nu} = D'z_t \), with loadings \( D \) that are given by:

\[
D = e_6 - \bar{s}(1 - \bar{s})B + \bar{s}(1 - \bar{s})e_3.
\]

The linear expression for the wealth shares produces quadratic expression for news about future market returns.

5.2 Consumption Innovations

Allowing for time-varying wealth shares makes the algebra more involved, but the economics is very similar. Our agent now considers the effect of (future) changes in the portfolio share of each asset when she responds to news about returns.

The expression for consumption innovations with time-varying human wealth share is:

\[
(c)_{t+1} = (1 - \nu_t)(a)_{t+1} + \nu_t(d^y)_{t+1} - \nu_t(h^y)_{t+1} + (1 - \sigma)(E_t + 1 - E_t) \sum_{j=1}^{\infty} \rho^j (1 - \nu_{t+j}) r^a_{t+1+j} + (1 - \sigma)(E_t + 1 - E_t) \sum_{j=1}^{\infty} \rho^j \nu_{t+j} r^y_{t+1+j}.
\]

Define the news about weighted future financial asset returns and human wealth returns as:

\[
W^1_{t+1} = (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \tilde{\nu}_{t+j} r^a_{t+1+j}
\]
\[
W^2_{t+1} = (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \tilde{\nu}_{t+j} r^y_{t+1+j}.
\]
Using these definitions, the expression for consumption innovations reduces to:

\[ c_{t+1} - E_t c_{t+1} = (1 - \tilde{\nu} - \tilde{\nu}_t)(a)_{t+1} + (\tilde{\nu}_t + \tilde{\nu})(d^y)_{t+1} - (\tilde{\nu}_t + \sigma \tilde{\nu})(h^y)_{t+1} + (1 - \sigma)(1 - \tilde{\nu})(h^a)_{t+1} - \mathbf{1} - \sigma)(W^1_{t+1} - W^2_{t+1}). \]  

(20)

When the human wealth share is constant (\( \nu_t = \bar{\nu} \) or \( \tilde{\nu} = 0 \)), we recover equation (8). In the log case, variation in future human wealth shares has no bearing on consumption innovations today, but in any other case, our single agent responds to news about future returns weighted by the portfolio shares.

In Campbell's model, the conditional moments of future asset returns and human wealth returns are identical. As a result, \( (h^y)_t = (h^a)_t \), which also implies \( W^1_t - W^2_t = 0 \) for all \( t \). The latter can be shown by applying the law of iterated expectations. In Shiller's model, \( h^y = 0 \) and \( W^2_t = 0 \). In the JW model, \( W_2 = (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \tilde{\nu}_{t+j} \Delta y_{t+j} \). We compute the function \( W^1_t(z_t) \) and \( W^2_t(z_t) \), using value function iteration. With the portfolio weights \( \nu_t \) we can construct consumption innovations according to equation (20).

Define the news about weighted future asset returns as \( \tilde{W}^1_{t+1} = E_{t+1} \sum_{j=1}^{\infty} \rho^j \tilde{\nu}_{t+j} \Delta r_{t+j} \) and \( \tilde{W}^2_{t+1} = E_{t+1} \sum_{j=1}^{\infty} \rho^j \tilde{\nu}_{t+j} \Delta y_{t+j} \). In section E.1 of the appendix we exploit the recursive structure of \( \tilde{W}^1 \) (and \( \tilde{W}^2 \)) to show that \( \tilde{W}^1 \) can be stated as a quadratic function of the state:

\[ \tilde{W}^1_{t+1}(z_{t+1}) = z'_{t+1} P z_{t+1} + d, \]

where \( P \) solves the matrix Sylvester equation

\[ P_{j+1} = R + \rho A' P_j A. \]  

(21)

We solve this equation by iteration, starting from \( P_0 = 0 \), and \( R = \rho D e_1' A \). The constant \( d \) in the value function equals \( d = \frac{1}{1-\rho} tr(P \Sigma) \). This also implies that the news about future returns is a simple, quadratic function of the VAR innovations and the matrix \( P \):

\[ W_1(z_{t+1}) = (E_{t+1} - E_t) \tilde{W}^1_{t+1}(z_{t+1}) = \epsilon'_{t+1} P \epsilon_{t+1} - \sum_{i=1}^{N} \sum_{j=1}^{N} \Sigma_{ij} P_{ij}. \]

which turns out to be a simple quadratic function of the VAR shocks and the matrix \( P \). In the same manner we calculate \( W^2 \), replacing \( R \) in equation (29) by \( S = \rho D C' \).
5.3 Three Benchmark Models

Figure 5 plots the variation in the human wealth share over time, for different models alongside the labor income share. The Shiller and JW model imply quite some variation in the human wealth share, because the risk premia on human wealth and financial wealth are not correlated; e.g. in the 90’s, the human wealth share is very low, while it is much higher in the 80’s. In Campbell’s model, the human wealth shares follow the exact opposite pattern.

In Table 8, we report the model-implied moments (as in table 12, but allowing for time-varying human wealth shares). Rows 5 and 6 show that allowing for time-varying human wealth shares helps somewhat to reduce the volatility of consumption innovations and their correlation with stock return innovations, but overall, the models still don’t match the consumption data. While the results improve slightly, none of the three models comes close to matching the two moments of consumption we are interested in. The reason is that all three models imply a very high correlation between financial asset returns and the market return (line 11). Because financial market returns are so volatile, consumption ends up too volatile and too highly correlated with financial asset returns.

5.4 Consumption Growth Accounting

This section redoes the consumption growth accounting exercise, but in a slightly more sophisticated way. We estimate the process for \( \{h^t\} \) that is consistent with the observed volatility of consumption innovations and with its correlation with innovations in financial asset returns.
Minimize Distance between Model and Data  We minimize the distance between the
same two moments of consumption innovations in the model and the data by optimizing over
the vector $C$. This vector relates the expected return on human wealth to the state vector
$E_t[r_{t+1}^y] = C'z_t$.

This procedure also delivers all the moments of the human wealth returns. We use a
non-linear least squares algorithm to find the vector $C$ that minimizes the distance between
the two model-implied and the two observed consumption moments. Of course, we cannot
rule out that the $C$ vector is not uniquely identified from these two (non-linear) moments. In
the next section, we estimate an over-identified system that includes asset pricing moments.
The results are essentially unchanged.

Figure 6 plots the model-implied human wealth share at the optimal parameter values,
alongside the observed labor income share. The human wealth share is much more volatile
than the labor income share.

Table 9 shows the moments for $h_y$ that replicate the two moments in consumption inno-

---

8 Implied by this specification is a process for $h_y^t \ (\text{equation } 11)$ and a process for the (demeaned) dividend yield on human wealth (equation 16). We still have that $\nu_t = D'z_t$, where $D = e_6 - s(1 - \bar{s})B + \bar{s}(1 - \bar{s})e_3$. We proceed as before to form $W_1$ and $W_2$, where we use $R = \rho D e'_t A$ and $S = \rho D C'$ and solve for $P$ and $Q$ from Sylvester equations like (29). For a given value of $C$, the algorithm computes the implied consumption innovations from equation (19), holding $\sigma$ fixed at its previous value of .2789. We form the volatility of model-implied consumption innovations, and their covariance with model-implied financial asset return innovations.

---

### Table 8: Moments for Consumption Growth and Human Capital Returns

<table>
<thead>
<tr>
<th>Moments</th>
<th>Campbell</th>
<th>Shiller</th>
<th>JW</th>
<th>data</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{hv}$</td>
<td>32.74</td>
<td>0</td>
<td>.54</td>
<td></td>
</tr>
<tr>
<td>$Corr_{a,hv}$</td>
<td>-.478</td>
<td>0</td>
<td>.485</td>
<td></td>
</tr>
<tr>
<td>$Corr_{y,hv}$</td>
<td>-.526</td>
<td>0</td>
<td>.752</td>
<td></td>
</tr>
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<td>$Corr_{a,hv}$</td>
<td>1.000</td>
<td>0</td>
<td>-.306</td>
<td></td>
</tr>
<tr>
<td>$V_c$</td>
<td>5.66</td>
<td>3.84</td>
<td>3.45</td>
<td>.333</td>
</tr>
<tr>
<td>$Corr_{c,a}$</td>
<td>.922</td>
<td>.848</td>
<td>.852</td>
<td>.168</td>
</tr>
<tr>
<td>$Corr_{y,a}$</td>
<td>.488</td>
<td>.337</td>
<td>.081</td>
<td></td>
</tr>
<tr>
<td>$Corr_{y,h}$</td>
<td>.986</td>
<td>-.526</td>
<td>-.511</td>
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<tr>
<td>$V_y$</td>
<td>42.00</td>
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<td>.75</td>
<td></td>
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<tr>
<td>$Corr_{m,a}$</td>
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<td>.917</td>
<td>.937</td>
<td></td>
</tr>
<tr>
<td>$Corr_{m,y}$</td>
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<td>.392</td>
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<tr>
<td>$Corr_{m,h}$</td>
<td>-.948</td>
<td>-.584</td>
<td>-.431</td>
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</table>

---

We proceed as before to form $W_1$ and $W_2$, where we use $R = \rho D e'_t A$ and $S = \rho D C'$ and solve for $P$ and $Q$ from Sylvester equations like (29). For a given value of $C$, the algorithm computes the implied consumption innovations from equation (19), holding $\sigma$ fixed at its previous value of .2789. We form the volatility of model-implied consumption innovations, and their covariance with model-implied financial asset return innovations.
Figure 6: Labor Income Share in Data and Human Wealth Share in Model Implied by Consumption Moments.
The return on financial assets is the return on firm value.

In the baseline case $\sigma$ is set to .27 (column 1). We match the standard deviation of consumption innovations and the correlation of consumption and stock return innovations (Rows 5 and 6). As expected, our $C$ estimates imply negatively correlated financial asset and human wealth returns, both for current innovations (-.87) and news about future expected returns (-.15) (Rows 4 and 7).

**Results**  Our main findings are robust to time-variation in the wealth shares. For each of the calibrations, we get a strong negative correlation between news about current (future) financial and human wealth returns. Figure 7 plots the innovations in current asset returns ($a_t$) and the innovations in current human wealth returns ($y_t$). The two are strongly negatively correlated (correlation = -.88). In addition, the market return is strongly positively correlated with the returns on human wealth, except in the more-than-log case.

In the baseline case, innovations to human wealth return innovations are more variable than financial asset returns: $V_y = 61$ (annualized standard deviation of 15 percent) versus $V_a = 65.40$, but as we increase $\sigma$, this number drops quickly to around 10 (annualized standard deviation of 6 percent). Allowing for time-varying human wealth shares makes the $h^y$ “residual” process implied by consumption data less volatile, and more strongly positively (negatively) correlated with $d^y$ ($h^a$), again, relative to the case with constant human wealth share. The volatility of news about future human capital returns is almost cut in half: $V_{h^y} = 69$ instead of 104.3 (annualized standard deviation of 20 percent).

The correlation between innovations in the market return and innovations in the human wealth returns is close to one in the baseline case, whereas the correlation with innovations in
Table 9: Moments for Consumption Growth and Human Capital Returns - Varying $\sigma$

The first column is for $\sigma = .2789$, the second column is for $.7368$, and the last column is for $\sigma = 1.5$. The sample is 1947.II-2004.III. Financial asset returns are firm value returns.

<table>
<thead>
<tr>
<th>Moments</th>
<th>$\sigma = .2789$</th>
<th>$\sigma = .7368$</th>
<th>$\sigma = 1.5$</th>
<th>data</th>
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</thead>
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<td>$V_{hv}$</td>
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<td>12.87</td>
<td>5.91</td>
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<td>.972</td>
<td>.914</td>
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<tr>
<td>$Corr_{d,v,hv}$</td>
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<td>.514</td>
<td>.604</td>
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<td>-.444</td>
<td>-.758</td>
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</tr>
<tr>
<td>$V_{c}$</td>
<td>.518</td>
<td>.333</td>
<td>.333</td>
<td>.333</td>
</tr>
<tr>
<td>$Corr_{c,a}$</td>
<td>.168</td>
<td>.168</td>
<td>.168</td>
<td>.168</td>
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<tr>
<td>$Corr_{y,a}$</td>
<td>-.879</td>
<td>-.977</td>
<td>-.922</td>
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<td>-.680</td>
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Figure 7: Innovations in Current Financial Asset and Human Wealth Returns Implied by Consumption Moments.
The return on financial assets is the return on firm value.
financial asset returns is around -7. The implied market returns are strongly mean-reverting, as shown by the correlation between \( m \) and \( h^m \) of -.98, except in the more than log case, but we can dismiss this case because of the non-stationarity of the consumption/wealth ratio. Using stock returns, we found very similar results.

Increasing the \( EIS \) to .7 lowers the implied volatility of human wealth returns to 6 percent on an annual basis and it reduces the correlation between the market and human wealth returns to .65.
Table 10: Moments for Consumption Growth and Human Capital Returns - Sensitivity to Income Measures

The left column includes proprietor’s income. The right column uses pay-outs to employees of non-financial corporate business. All results are for the full sample (1947.II-2003.IV). Computations are done for time-varying wealth share and $\sigma = .2789$. Financial asset returns are returns on total firm value.

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<td>×</td>
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<td>$Corr_{p,h^y}$</td>
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<td>×</td>
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<td>$Corr_{h^y,h^y}$</td>
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<td>-.720</td>
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<td>×</td>
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<td>$V_{c}$</td>
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<td>.340</td>
<td>.346</td>
<td>.346</td>
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<td>$Corr_{c,a}$</td>
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<td>.196</td>
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<td>$Corr_{y,a}$</td>
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<td>-.984</td>
<td>-.992</td>
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</table>

5.5 Robustness: Different Income Measures

Our measure for labor income so far was (real, per capita) compensation of employees. This excludes proprietor’s income, but includes wages and salaries to government employees. We investigate the robustness of our results to including proprietor’s income and to excluding government and non-financial employees’ wages.

Including Proprietor’s Income  When we include proprietor’s income to $y$, the average labor income share is 0.8394 (compared to 0.7317). The left column of table 10 shows the moments for $(h^y)_t$ that replicate the two moments in consumption innovations for the full sample. The financial asset returns are the returns on the total firm value. Rows 5 and 6 show that we match the consumption moments. We obtain strongly negatively correlated news in financial asset and human wealth returns (both current innovations, and future surprises). The main difference with our previous results is that innovations in current human wealth returns are about half as volatile as before: $V_y = 30$ versus 61.1 before; this is 50 percent less variable as financial asset return innovations: $V_a = 48.3$. The correlation between innovations in the market return and innovations in the human wealth return is .98, whereas the correlation with innovations in financial asset returns is -.78, evidence of strong mean reversion in the implied market return (-.984). These results are consistent with the effects of an increase in $\bar{\nu}$ to .85 discussed in section 4.
Using Pay-outs to Employees  We also use a measure of pay-outs to employees of non-financial corporate businesses. This measure is consistent with our measure of pay-outs to securities holders of non-financial corporate business. The labor income share is defined as the ratio of pay-outs to employees to the sum of pay-outs to employees and pay-outs to securities holders. The mean in the sample 1947.II-2004.III is 0.9162. The main difference with our first measure (see table ??) is that the variance of \( d^y \) increases from 1.61 to 4.18.9

The second column of table 10 shows the moments for \( h^y \) that replicate the two moments in consumption innovations. Rows 5 and 6 show that we indeed match the consumption moments. Rows 4 and 7 shows that the matching exercise implies strongly negatively correlated financial asset and human wealth returns. The difference with our previous results is that innovations in current human wealth returns must be less variable: \( V_y = 15.5 \) versus 47.2 for \( V_a \). Similar to what we found before, the correlation between innovations in the market return and innovations in the human wealth return is high (.99), whereas the correlation with innovations in financial asset returns is negative (-.65). The last line indicates the strong mean reversion in the implied market return (-.992).

5.6 Robustness: Time-Varying Variances

As pointed out in section 3.5.1, a theoretical possibility is that our consumption innovation residual measures up future return volatility rather than future human wealth returns. To rule out this explanation, we ask whether the residual \((h^y)_t\) that comes out of our model with time-varying human wealth shares predicts the future variance of stock returns. We find that it does not. From the VAR innovations we construct the conditional variance of financial asset returns:

\[
V^a_t \equiv V_t[r^a_{t+1}] = e_1'A z_t z_t'A e_1 + e_1' \Sigma e_1. \tag{22}
\]

We then regress \( \sum_{h=1}^H \rho^h V^a_{t+h} \) on \((h^y)_t\). We vary \( h \) from 1 to 20. In general, the regression coefficient is not statistically significant (we use Newey-West standard errors), and the \( R^2 \) of the regression is typically below 1%. The only exception is marginal statistical significance for long horizons \((h > 12)\) and \( R^2 \) of up to 2.7% when financial asset returns are stock returns and \( \sigma = .28 \). We conclude that there is very weak evidence that our residual proxies for conditional return volatility.

9For the full sample, \( V_a = 47.23, V_{dy} = 4.18, V_{ha} = 27.81, Corr_{a,ha} = -.622, Corr_{a,dy} = .334, \) and \( Corrd^y,h^a = -.626. \)
Figure 8: Innovations in Current and Future Market Returns and Innovations to Current and Future Cons. Growth.

The return on financial assets is the return on stocks. The sample is 1930-2003.

6 Long Run Restrictions

The budget constraint imposes an additional restriction: at each point in time, the revision of expected future consumption growth (which can back out from the estimated VAR) has to be identical to the revision of expected current and future market returns: $(m)_t + (h^m)_t = (d^c)_t$ (see 5), where the long-run response of consumption growth is:

$$(d^y)_{t+1} = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} = \epsilon'_t (I - \rho A)^{-1} \epsilon_{t+1}$$

In quarterly data, these two are only weakly positively correlated (.11) in our benchmark calibration and the market response is 2.5 times as volatile as the consumption growth response. However, if we use annual data over a longer sample (1930.I-2003.IV), this same correlation increases to .67, even though the market response is still 3.2 times as volatile as the consumption growth response. Figure 8 plots the innovations to current and future market returns against the innovations to current and future consumption growth, based on annual data.

7 The CC-CAPM

The last section examines the cross-sectional asset pricing implications of our framework. Growth firms are a good hedge against total US market risk. (to be completed)
8 Conclusion

(to be completed)

References


Lettau, Martin, & Syndey Ludvigson, 2001b, Resurrecting the (c)capm: A cross-sectional test when risk premia are time-varying, *The Journal of Political Economy* 109, 1238–1287.


A Data Appendix: Returns on Firm Value

This computation is based on (Hall 2001). The data to construct our measure of returns on firm value were obtained from the Federal Flow of Funds. The data are for non-farm, non-financial business. We extracted the stock data from ltabs.zip. The Coded Tables provide more information about the codes used in the Flow of Funds accounts. A complete description is available in the Guide to the Flow of Funds Accounts. We calculated the value of all securities as the sum of financial liabilities (144190005), the market value of equity (1031640030) less financial assets (144090005), adjusted for the difference between market and book for bonds. The subcategories unidentified miscellaneous assets (113193005) and liabilities (103193005) were omitted from all of the calculations. These are residual values that do not correspond to any financial assets or liabilities. We correct for changes in the market value of outstanding bonds by applying the index of corporate bonds to the level of outstanding corporate bonds at the end of the previous year. The Dow Jones Corporate Bond Index is available from Global Financial Data. We measured the flow of pay-outs as the flow of dividends (10612005) plus the interest paid on debt (net interest series from NIPA, see Gross Product of non-financial, corporate business.) less the increase in the volume of financial liabilities (10419005), which includes issues of equity (103164003).

B Tables

C Notation

$$V_a = V[r_{t+1}^a - E_t[r_{t+1}^a]]$$

$$V_{dq} = V[(E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}]$$

$$V_h^a = V[(E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r_{t+1+j}^a]$$

$$Corr_{a,h} = Corr[r_{t+1}^a - E_t[r_{t+1}^a], (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta y_{t+1+j}]$$

$$Corr_{a,dq} = Corr[r_{t+1}^a - E_t[r_{t+1}^a], (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}]$$

$$Corr_{h^a,dq} = Corr[(E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}, (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r_{t+1+j}^a]$$

News to future expected returns on human wealth, \((h^y)_t\), is an unobservable to the

---

\(^{10}\)Federal Reserve Board of Governors, downloadable at www.federalreserve.gov/releases/z1/current/data.htm.
Table 11: VAR Estimation - Using Returns on Value-weighted Stock Market Index

This table reports the results from the VAR estimation for the sample 1947.II-2003.IV. The asset return is the return on firm value. The rows describe the time $t$ variables and the columns the time $t-1$ variables. Newey-West HAC standard errors are in parentheses. The VAR contains 7 elements.

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<th>Stock Returns</th>
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<th>$\Delta y_{t-1}$</th>
<th>$dp_{t-1}^s$</th>
<th>$r_{t-1}^{bt}$</th>
<th>$ysp_{t-1}$</th>
<th>$s_{t-1}$</th>
<th>$\Delta c_{t-1}$</th>
<th>R²</th>
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<th>$r_{t-1}^{bt}$</th>
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<td>(0.1239)</td>
<td>20.49</td>
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</table>
Table 12: Moments for Consumption Growth and Human Capital Returns

This table uses stock returns over the full sample (1947.II-2003.IV). In each panel, the first column represents the Campbell specification for human capital returns (equation 8). The second column represents the constant discounter model (equation 9), and the third column represents the autarkic model (equation 10). The last column gives the corresponding moments in the data, when available.

\( \text{innovations in current asset (human capital) returns} \)
\( r_{t+1} - E_t r_{t+1} = r_y^{t+1} - E_t r_y^{t+1} \). \( k^v \) is news in future asset returns \( (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho_j r_y^{t+1+j} \). \( c \) denotes innovations in current consumption \( (c_{t+1} - E_t c_{t+1}) \). Computations are done for \( \bar{\nu} = .7000 \) and \( \sigma = .2789 \).

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<td>0</td>
<td>.644</td>
<td></td>
</tr>
<tr>
<td>Corr_{h^v,d^v}</td>
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<td>0</td>
<td>.735</td>
<td></td>
</tr>
<tr>
<td>Corr_{h^v,h^v}</td>
<td>1.000</td>
<td>0</td>
<td>-.453</td>
<td></td>
</tr>
<tr>
<td>( V_c )</td>
<td>7.61</td>
<td>2.49</td>
<td>2.10</td>
<td>.225</td>
</tr>
<tr>
<td>Corr_{c,a}</td>
<td>.955</td>
<td>.518</td>
<td>.465</td>
<td>.213</td>
</tr>
<tr>
<td>( V_y )</td>
<td>113.84</td>
<td>1.65</td>
<td>.76</td>
<td></td>
</tr>
<tr>
<td>Corr_{y,a}</td>
<td>.994</td>
<td>.518</td>
<td>.465</td>
<td>.213</td>
</tr>
<tr>
<td>Corr_{y,h^a}</td>
<td>-.994</td>
<td>-.336</td>
<td>-.032</td>
<td></td>
</tr>
</tbody>
</table>

The following moments of \( (h^v)_t \) will play a crucial role in the exercise:

\[ V_{h^v} = V[(E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho_j r_y^{t+1+j}] \]

\[ \text{Corr}_{a,h^v} = \text{Corr}[r_{t+1} - E_t r_{t+1}; (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho_j r_y^{t+1+j}] \]

\[ \text{Corr}_{d^v,h^v} = \text{Corr}[(E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho_j \Delta y_{t+1+j}; (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho_j r_y^{t+1+j}] \]

\[ \text{Corr}_{h^v,h^v} = \text{Corr}[(E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho_j r_{t+1+j}; (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho_j r_y^{t+1+j}] \]

D Moments of Consumption Innovations with Constant Wealth Shares

We denote the innovations to current consumption growth using \( (c)_t \). Using the symbols defined in the text, we get:

\[ (c)_t = (1 - \bar{\nu})(a)_t + \bar{\nu}(d^v)_t + (1 - \sigma)(1 - \bar{\nu})(h^a)_t - \sigma \bar{\nu}(h^v)_t. \]
### Table 13: Implied Moments for Innovations to Human Capital and Market Returns

<table>
<thead>
<tr>
<th>Panel A: Stock Returns</th>
<th>Panel B: Firms Value</th>
<th>( \sigma_{\nu} ) for Stock Returns θ</th>
<th>( \sigma_{\nu} ) for Firms Value θ</th>
<th>Labor Share V ( \nu ) ( \sigma ) Corr</th>
<th>V ( \nu ) ( \sigma ) Corr</th>
<th>( \nu ) ( \sigma ) Corr</th>
<th>( \nu ) ( \sigma ) Corr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>1970</td>
<td>1.5</td>
<td>1.5</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
</tr>
<tr>
<td>1971</td>
<td>1971</td>
<td>1.5</td>
<td>1.5</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
</tr>
<tr>
<td>1972</td>
<td>1972</td>
<td>1.5</td>
<td>1.5</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
</tr>
<tr>
<td>1973</td>
<td>1973</td>
<td>1.5</td>
<td>1.5</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
</tr>
<tr>
<td>1974</td>
<td>1974</td>
<td>1.5</td>
<td>1.5</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
</tr>
<tr>
<td>1975</td>
<td>1975</td>
<td>1.5</td>
<td>1.5</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
</tr>
<tr>
<td>1976</td>
<td>1976</td>
<td>1.5</td>
<td>1.5</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
</tr>
<tr>
<td>1977</td>
<td>1977</td>
<td>1.5</td>
<td>1.5</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
<td>0.74</td>
</tr>
</tbody>
</table>

**Notes:**
- Computations are done for \( q \) ∈ \{0.1, 0.5, 0.8, 1.0\} and \( v \) ∈ \{0.1, 0.5, 0.8, 1.0\}.
- \( \nu \) and \( v \) denote innovations in current consumption (human capital) and current consumption (asset returns) respectively.
- \( \gamma \) is the rate of the asset returns (capital stock).
- Implied moments are in annual rate of return.
Table 14: Moments for Consumption Growth and Human Capital Returns
The first panel is the Campbell sample (1952.I-1990.IV), the second panel is the full sample (1947.II-2003.IV). In each panel, the first column represents the Campbell specification for human capital returns (equation 8). The second column represents the constant discounter model (equation 9), and the third column represents the autarkic model (equation 10). The last column gives the corresponding moments in the data, when available. (a), (y), and (m) stand for innovations in current asset, human capital and total market returns. (h^a), (h^y) and 9h^m stand for news in future financial asset returns, future human wealth returns and future market returns. Computations are done for time-varying, human wealth share ν and σ = .2789.

<table>
<thead>
<tr>
<th>Moments</th>
<th>Campbell</th>
<th>Shiller</th>
<th>JW data</th>
<th>Campbell</th>
<th>Shiller</th>
<th>JW data</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_h^y</td>
<td>.9280</td>
<td>.0</td>
<td>2.17</td>
<td>.10307</td>
<td>0</td>
<td>.79</td>
</tr>
<tr>
<td>Corr_a_h^y</td>
<td>-.919</td>
<td>-.0</td>
<td>.406</td>
<td>-.918</td>
<td>0</td>
<td>.644</td>
</tr>
<tr>
<td>Corr_y_h^y</td>
<td>-.177</td>
<td>0</td>
<td>.886</td>
<td>-.336</td>
<td>0</td>
<td>.735</td>
</tr>
<tr>
<td>Corr_h^a_h^y</td>
<td>1.000</td>
<td>0</td>
<td>-.150</td>
<td>1.000</td>
<td>0</td>
<td>-.453</td>
</tr>
<tr>
<td>V_c</td>
<td>8.35</td>
<td>3.50</td>
<td>2.56</td>
<td>.279</td>
<td>8.00</td>
<td>2.77</td>
</tr>
<tr>
<td>Corr_c_a</td>
<td>.947</td>
<td>.503</td>
<td>.507</td>
<td>.199</td>
<td>.955</td>
<td>.511</td>
</tr>
<tr>
<td>Corr_y_a</td>
<td>.951</td>
<td>.448</td>
<td>.963</td>
<td>.934</td>
<td>.491</td>
<td>.065</td>
</tr>
<tr>
<td>Corr_y_h^a</td>
<td>-.990</td>
<td>-.177</td>
<td>-.047</td>
<td>-.994</td>
<td>-.336</td>
<td>-.032</td>
</tr>
<tr>
<td>V_y</td>
<td>99.74</td>
<td>2.05</td>
<td>.48</td>
<td>113.48</td>
<td>1.65</td>
<td>.76</td>
</tr>
<tr>
<td>Corr_m_a</td>
<td>.971</td>
<td>.925</td>
<td>.958</td>
<td>.961</td>
<td>.939</td>
<td>.937</td>
</tr>
<tr>
<td>Corr_m_y</td>
<td>.997</td>
<td>.742</td>
<td>.305</td>
<td>.996</td>
<td>.736</td>
<td>.353</td>
</tr>
<tr>
<td>Corr_m_h^m</td>
<td>-.982</td>
<td>-.744</td>
<td>-.698</td>
<td>-.987</td>
<td>-.810</td>
<td>-.748</td>
</tr>
</tbody>
</table>

Table 15: Moments for Consumption Growth and Human Capital Returns
The first panel is the Campbell sample (1952.I-1990.IV), the second panel is the full sample (1947.II-2003.IV). In each panel, the first column represents the model implied moments. The last column gives the corresponding moments in the data, when available. (a)_{t+1} are innovations in current asset (human capital) returns r^a_{t+1} - E_t r^a_{t+1} (r^y_{t+1} - E_t r^y_{t+1}). (a)_{t+1} is similarly defined. (h^a_{t+1}) represents news in future asset returns (E_{t+1} - E_t) \sum_{j=1}^\infty \rho^j r^a_{t+1+j}. (c)_{t+1} represents the innovation to current consumption (c_{t+1} - E_t c_{t+1}). Computations are done for time-varying wealth share and σ = .2789. Financial asset returns are returns on the CRSP value-weighted stock market index.

<table>
<thead>
<tr>
<th>Moments</th>
<th>model data</th>
<th>model data</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_h^y</td>
<td>.4530</td>
<td>.3638</td>
</tr>
<tr>
<td>Corr_a_h^y</td>
<td>.542</td>
<td>.504</td>
</tr>
<tr>
<td>Corr_y_h^y</td>
<td>.931</td>
<td>.874</td>
</tr>
<tr>
<td>Corr_h^a_h^y</td>
<td>-.200</td>
<td>-.200</td>
</tr>
<tr>
<td>V_c</td>
<td>.643</td>
<td>.279</td>
</tr>
<tr>
<td>Corr_c_a</td>
<td>.199</td>
<td>.199</td>
</tr>
<tr>
<td>Corr_y_a</td>
<td>-.554</td>
<td>-.487</td>
</tr>
<tr>
<td>Corr_y_h^a</td>
<td>.213</td>
<td>.168</td>
</tr>
<tr>
<td>V_y</td>
<td>27.97</td>
<td>24.50</td>
</tr>
<tr>
<td>Corr_m_a</td>
<td>11.39</td>
<td>11.10</td>
</tr>
<tr>
<td>Corr_m_y</td>
<td>-.063</td>
<td>.067</td>
</tr>
<tr>
<td>Corr_m_h^m</td>
<td>-.850</td>
<td>.825</td>
</tr>
</tbody>
</table>

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The variance of consumption innovations is readily found as:

\[ V_c = (1 - \bar{\nu})^2 V_a + \bar{\nu}^2 V_{ds} + (1 - \sigma)^2 (1 - \bar{\nu})^2 V_{h^s} + \sigma^2 \bar{\nu}^2 V_{h^v} + 2(1 - \bar{\nu}) \nu Corr_{a, dv} \sqrt{V_a} \sqrt{V_{ds}} + 2(1 - \sigma)(1 - \bar{\nu})^2 Corr_{a, h^s} \sqrt{V_a} \sqrt{V_{h^s}} - 2\sigma(1 - \bar{\nu}) \nu Corr_{a, h^v} \sqrt{V_a} \sqrt{V_{h^v}} - 2\sigma^2 Corr_{h^v, dv} \sqrt{V_{ds}} \sqrt{V_{h^v}} - 2\sigma(1 - \sigma)(1 - \bar{\nu}) \nu Corr_{h^v, h^s} \sqrt{V_{h^v}}. \]  

(24)

Similarly, we derive an expression for \( V_{c,a} \), the covariance of consumption with asset return innovations:

\[ V_{c,a} = (1 - \bar{\nu})V_a + \bar{\nu} Corr_{a, dv} \sqrt{V_a} \sqrt{V_{ds}} + (1 - \sigma)(1 - \bar{\nu}) Corr_{a, h^s} \sqrt{V_a} \sqrt{V_{h^s}} - \sigma \nu Corr_{a, h^v} \sqrt{V_a} \sqrt{V_{h^v}}. \]  

(25)

Note that \( Corr_{a, h^v} > 0 \), \( Corr_{dv, h^s} > 0 \), and \( Corr_{h^v, h^s} > 0 \) keep the variance of consumption innovations and the covariance of consumption innovations with financial asset return innovations low. Likewise, a low variance of news in future human capital returns \( (V_{h^v}) \) keeps consumption volatility low.

**Log Utility**  The variance of consumption innovations reduces to:

\[ V_c = (1 - \bar{\nu})^2 V_a + \bar{\nu}^2 V_{ds} + (1 - \sigma)^2 (1 - \bar{\nu})^2 V_{h^s} + \sigma^2 \bar{\nu}^2 V_{h^v} + 2(1 - \bar{\nu}) \nu Corr_{a, dv} \sqrt{V_a} \sqrt{V_{ds}} + 2(1 - \sigma)(1 - \bar{\nu})^2 Corr_{a, h^s} \sqrt{V_a} \sqrt{V_{h^s}}. \]

while the covariance is given by:

\[ V_{c,a} = (1 - \bar{\nu})V_a + \bar{\nu} \left( Corr_{a, dv} \sqrt{V_a} \sqrt{V_{ds}} - Corr_{a, h^s} \sqrt{V_a} \sqrt{V_{h^s}} \right). \]

**More moments** Another moment of interest is the correlation between the innovations in human wealth returns \( (y) \) and either innovations in financial asset returns \( (a) \) or news in future financial asset returns \( (h^o) \). Now go back to equation (7) and take the covariance with current financial asset return innovations:

\[ V_{a, y} = Corr_{a, dv} \sqrt{V_a} \sqrt{V_{ds}} - Corr_{a, h^s} \sqrt{V_a} \sqrt{V_{h^s}} \]

Likewise, take the covariance with news to future stock market returns:

\[ V_{h^o, y} = Corr_{dv, h^o} \sqrt{V_{ds}} \sqrt{V_{h^o}} - Corr_{h^o, h^s} \sqrt{V_{h^o}} \sqrt{V_{h^s}} \]

Finally, note that the variance of human capital return innovations is

\[ V_y = V_{ds} + V_{h^o} - 2V_{dv, h^o} \]

**E  Time-Varying Wealth Share**

Because \( dp_t^h \) is a function of the entire state space, so is \( \nu_t \). \( \nu_{t+1} \) is not a linear, but a logistic function of the state. We use a linear specification:

\[ \tilde{\nu}_t \equiv \nu_t - \bar{\nu} = D^t z_t \]
and we pin down $D$ ($N \times 1$) using a first order Taylor approximation. Let $s_t$ be the labor income share with mean $\bar{s}$ and $w_t = dp_t^y - dp_t$ with mean zero.\footnote{The mean of $w_t$ must be zero to be able to use the same linearization constant $\rho$ for human wealth and financial wealth.} We can linearize the logistic function for the human wealth share $\nu_t$ from equation (18) using a first order Taylor approximation around $(s_t = \bar{s}, w_t = 0)$. We obtain:

$$
\nu_t(s_t, w_t) \approx \nu_t(\bar{s}, 0) + \frac{\partial \nu_t}{\partial s_t}|_{s_t=\bar{s},w_t=0}(s_t-\bar{s}) + \frac{\partial \nu_t}{\partial w_t}|_{s_t=\bar{s},w_t=0}(w_t),
$$

$$
\approx \bar{s} + (s_t - \bar{s}) - (\bar{s}(1 - \bar{s}))w_t,
$$

$$
\approx s_t - \bar{s}(1 - \bar{s})dp_t^y + \bar{s}(1 - \bar{s})dp_t
$$

(26)

The average human wealth share is the average labor income share: $\bar{\nu} = \bar{s}$. If $dp_t$ is the third element of the VAR, $dp_t = c_3'z_t$, and $s_t - \bar{s}$ the sixth, and if $dp_t^y = B'z_t$, then we can solve for $D$ from equation (26) and $\nu_t = D'z_t$:

$$
D = \epsilon_6 - \bar{s}(1 - \bar{s})B + \bar{s}(1 - \bar{s})c_3.
$$

(27)

### E.1 Riccati equation

With the portfolio weights $\nu_t$ we can construct consumption innovations according to equation (20). The difficulty is to calculate the terms $W_1$ and $W_2$. We use value function iteration to pin down $W_1$ and $W_2$. Let

$$
\bar{W}_1(z_{t+1}) = E_{t+1} \sum_{j=1}^{\infty} \rho^j \nu_{t+j} r_{t+1+j}^a
$$

$$
\bar{W}_1(z_{t+1}) = \bar{\nu}_{t+1} E_{t+1} \rho_e |_{\rho_e = 2} + E_{t+1} \sum_{j=2}^{\infty} \bar{\nu}_{t+j} \rho^j E_{t+j} r_{t+1+j}^a
$$

$$
\bar{W}_1(z_{t+1}) = \nu_{t+1} \rho_e c_1' A z_{t+1} + \rho E_{t+1} \sum_{j=2}^{\infty} \nu_{t+j} \rho^{j-1} E_{t+j} r_{t+1+j}^a
$$

$$
= \nu_{t+1} D \rho_e c_1' A z_{t+1} + \rho E_{t+1} \bar{W}_1(z_{t+2})
$$

(28)

We can compute a solution to this recursive equation by iterating on it. We posit a quadratic objective function:

$$
\bar{W}_1(z_{t+1}) = z_{t+1}' P z_{t+1} + d
$$

where $P$ solves a matrix Riccati equation, whose fixed point is found by iterating on:

$$
P_{t+1} = R + \rho A' P_t A,
$$

starting from $P_0 = 0$, and $R = \rho Dc_1' A$. The constant $d$ in the value function equals

$$
d = \frac{\rho}{1 - \rho} tr(P \Sigma)
$$

We are interested in:

$$
W_1(z_{t+1}) = (E_{t+1} - E_t) \bar{W}_1(z_{t+1}) = (E_{t+1} - E_t)[z_{t+1}' P z_{t+1} + d] = \varepsilon_{t+1}' P \varepsilon_{t+1} - E_t [\varepsilon_{t+1}' P \varepsilon_{t+1}] = \varepsilon_{t+1}' P \varepsilon_{t+1} - \sum_{i=1}^{N} \sum_{j=1}^{N} \Sigma_{ij} P_{ij}
$$

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which turns out to be a simple quadratic function of the VAR shocks and the matrix $P$.

In the same manner we calculate $W_2$, replacing $R$ in equation (29) by $S = \rho DC'$. $C$ takes on different values for the three canonical models.

### E.2 Market Return

We can now compute innovations to the total market return ($m$):

$$(m)_{t+1} \equiv r^m_{t+1} - E_t[r^m_{t+1}]$$

$$= (\tilde{\nu}_t + \tilde{\nu}) (r^g_{t+1} - E_t[r^g_{t+1}]) + (1 - \tilde{\nu}_t - \tilde{\nu}) (r^a_{t+1} - E_t[r^a_{t+1}])$$

$$= (\tilde{\nu}_t + \tilde{\nu}) ICY R_{t+1} + (1 - \tilde{\nu}_t - \tilde{\nu}) ICAR_{t+1}$$

$$\equiv [(\tilde{\nu}_t + \tilde{\nu}) (e'_2 - \rho C')(I - \rho A)^{-1} + (1 - \tilde{\nu}_t - \tilde{\nu}) e'_1] \varepsilon_{t+1}$$

and also news in future market returns ($h^m$):

$$(h^m)_{t+1} \equiv (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r^m_{t+1+j}$$

$$= (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j [(\tilde{\nu}_{t+j} + \tilde{\nu}) r^g_{t+1+j} + (1 - \tilde{\nu}_{t+j} - \tilde{\nu}) r^a_{t+1+j}]$$

$$= \tilde{\nu} N F Y R_{t+1} + W_{2,t+1} + (1 - \tilde{\nu}) N F A R_{t+1} - W_{1,t+1}$$

$$= \rho [\tilde{\nu} C' + (1 - \tilde{\nu}) e'_1 A] (I - \rho A)^{-1} \varepsilon_{t+1} - (e'_1 (P - Q) \varepsilon_{t+1} - q$$

where the constant $q = \sum_{i=1}^{N} \sum_{j=1}^{N} \Sigma_{ij} (P_{ij} - Q_{ij})$.

From the innovations, we back out realized human wealth returns and market returns:

$$r^g_{t+1} = (y)_{t+1} + C' z_t$$

$$r^m_{t+1} = (m)_{t+1} + (\tilde{\nu}_t + \tilde{\nu}) C' z_t + (1 - \tilde{\nu}_t - \tilde{\nu}) e'_1 A z_t$$

### F Asset Pricing

Using the definition of $(m)_t$ in equation (30),

$$V_{im} = \sum_{k=1}^{N} [(\tilde{\nu}_t + \tilde{\nu}) (e'_2 - \rho C')(I - \rho A)^{-1} + (1 - \tilde{\nu}_t - \tilde{\nu}) e'_1] V_{ik} \quad (30)$$

Likewise, we can define $V_{ih}$ as a linear combination of $V_{ik}$ terms. Recalling the definition of $(h^m)_t$ in equation (30), we note that it contains both linear and quadratic terms in $\varepsilon$. The covariance of return innovations in asset $i$ with the quadratic terms involves third moments of normally distributed variables. They are all zero. The expression for $V_{ih}$ becomes:

$$V_{ih} = \sum_{k=1}^{N} \left[ \rho [\tilde{\nu} C' + (1 - \tilde{\nu}) e'_1 A] (I - \rho A)^{-1} \right] V_{ik} \quad (31)$$

### G Remark on Time-Varying Moments

In its simplest form, the (Campbell 1996) model does not allow for time-varying return moments. To introduce time-variation in returns, one would have to augment the standard
Epstein-Zin model model with an aggregate consumption or dividend process that has
time-varying volatility, as in (Bansal & Yaron 2004). Alternatively, one can think of the
aforementioned model as describing the consumption process of an individual consumer (as
opposed to the representative agent). This insight leads us to also compute the variance
of consumption innovations and their correlation with innovations in current asset returns
in a model without predictability. When asset returns and labor income growth are i.i.d.,
consumption innovations are:

\[(c)_t \equiv c_t + 1 - E_t (c)_{t+1} = (1 - \nu) (a)_{t+1} + \nu (\Delta y_{t+1} - E_t \Delta y_{t+1})\]

In the full sample for $\nu = 0.7$ and using stock market returns, the implied variance of
(10,000 times) of consumption innovations is 6.62, similar to the numbers in table 12.
The implied correlation with current asset return innovations is also similar, and equal to
0.961.