Consumption and Expected Asset Returns: An Unobserved Component Approach

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Abstract

This paper proposes a state space approach to estimate the expected returns on household assets and expected growth rate of consumption in excess of labor income. We combine the state space approach with a present value model, which implies that the excess consumption-assets ratio can be expressed as a function of present discounted value of expected excess consumption growth and expected asset returns. Since expected returns and expected excess consumption growth are unobserved variables, we use an unobserved component approach to extract them from the observed history of realized returns and excess consumption growth. Our results suggest that both filtered returns and filtered excess consumption growth are significant and better predictors of realized returns and realized excess consumption growth. Our approach also provides us some insight into the behavior of excess consumption growth.

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1 Introduction

A considerable amount of research has been done on time variation of expected asset returns over the last two decades. Still there is no consensus on the predictability of asset returns. While many studies show that returns are not predictable, extensive research suggests that expected returns are time varying. It has been found that dividend-price ratio, dividend-earnings ratio, and earning-price ratio among others are some of the widely recognized predictors of stock returns. Recently, there has been an attempt to link the present value model of household consumption to aggregate stock returns. Prominent among these studies are those by Lettau and Ludvigson (2001) and Campbell and Mankiw (1989). A central idea behind these interlinkages is that the predictable fluctuations in asset returns may be reflected in current consumption decision of a household in a manner consistent with rational expectations.

Using a present-value model of consumption, Campbell and Mankiw (1989) showed that log of consumption-aggregate wealth ratio reflects information about expected returns on wealth and expected consumption growth. This model provides a framework to test whether consumption-wealth ratio is a good predictor of asset returns. The empirical implementation of this model, however, is limited by the unobservability of human capital component of aggregate wealth. To get around this problem of unobservability of human capital, Lettau and Ludvigson (2001) modified the present value relationship by using a set of approximating assumptions that link the unobservable total wealth series to observable series on assets and income. Their model implies that log of consumption, labor income and asset holdings share a common stochastic trend. Stationary deviations from the shared trend defined as $\Delta c$ is found to be a good predictor of future asset returns.

Whelan (2008) modified Lettau and Ludvigson (2001) model by taking into account the fact that the estimation of $\Delta c$ is based on the point estimate of cointegrating vector. Moreover, the relationship between $\Delta c$ and expected future values of returns and consumption growth is an approximation and the accuracy of this approximation depends on the stability over time of the ratio of observed asset to total wealth, which in turn might exhibit volatility. Whelan (2008) showed that the log ratio of excess consumption (consumption in excess of labor income) to wealth is related to expected discounted sum of future returns on household assets and future growth rates of excess consumption. This relationship eliminates the need to estimate any parameter
to construct the ratio of excess consumption to observable assets.\footnote{there is also a debate in the literature on the methodology involving estimation of cointegrating vector in Lettau and Ludvigson (2001) approach. See Hahn and Lee (2001) for details.}

In this paper, we combine the present-value model of consumption with the state space approach, that has recently been extensively applied in the present value model of dividend-price ratio in the stock returns literature\footnote{The present value approach used in our paper is closely related to literature on present value models. Rytchkov (2008), Binsbergen and Koijen (2010), Pastor and Stambaugh (2006), Brandt and Kang (2004) and Conrad and Kaul (1988) have also applied filtering techniques to predict stock returns and dividend growth rate. Rytchkov (2008) simultaneously and explicitly uses both dividends and returns in the filtering procedure. Binsbergen and Koijen (2010) follow the similar approach used in our paper to estimate the expected stock returns and apply it to predict stock returns. Brandt and Kang (2004) model conditional mean and volatility as unobservable variables following a latent VAR process and filter them out from the observed returns. Pastor and Stambaugh (2006) develop a methodology of uncovering unobservable expected returns from realized returns and imperfect exogenous predictors. Conrad and Kaul (1988) also apply the Kalman filter to extract expected returns, but only from the history of realized returns.}

The present value model of consumption in the present context implies that the excess consumption-assets ratio can be expressed as a function of present discounted value of expected excess consumption growth and expected asset returns. This model implies that an upward movement in excess consumption-assets ratio can occur either due to lower future expected excess consumption growth or/and due to higher than average expected asset returns. The usual approach of using finite lags of excess consumption-wealth ratio to predict aggregate stock returns is not optimal, as it does not use all the information efficiently. Instead of looking at the ad-hoc linear regressions, we employ a state space approach to estimate the expected returns and expected excess consumption growth. We treat expected returns and expected excess consumption growth as unobserved state variables that follow an exogenously specified time series. Kalman filter technique is then used to extract them from the observed history of realized returns and realized excess consumption. By construction, expected returns and expected excess consumption optimally use the whole history of observed returns and observed excess consumption. The present value approach we propose, in combination with the Kalman filter allows us, therefore, to expand the information set and form the best linear predictor making the forecast more precise. In particular, we follow Binsbergen and Koijen (2010) strategy and
model both expected returns and expected excess consumption growth as a first order AR process. AR(1) specification is quite parsimonious and has the minimum number of parameters sufficient to describe the time-varying expected returns and expected excess consumption growth rate. This low order autoregressive process admits an infinite order VAR representation. This has also been pointed out by Cochrane (2008), who shows that a structural state space model is able to capture individually small but possibly important moving average terms in the long run.

Lettau and Ludvigson (2001) and Whelan (2008) use consumption-wealth ratio and excess consumption-assets ratio respectively as a proxy for expected asset return. Excess consumption-assets ratio is only a noisy proxy for expected returns when the excess consumption-assets ratio also moves due to expected excess consumption growth rate variation\(^3\). In addition to using the information optimally, our framework also takes into account the fact that the excess consumption-assets ratio moves due to both expected return and expected excess consumption growth rate variation. The filtering procedure that we use assigns shocks to the excess consumption-assets ratio to either expected return and/or expected excess consumption growth rate shocks.

Our findings suggest that expected returns and expected excess consumption do a better job in explaining realized returns and realized excess consumption growth than excess consumption-assets ratio. We find that estimated expected returns explain 19 percent of the variation in realized asset returns and estimated excess consumption growth rate explains 9 percent of the variation in realized excess consumption growth. The corresponding R-squared values are 12 per cent for returns and 1.3 per cent when lagged excess consumption-wealth ratio is a predictor of realized asset returns and realized excess consumption growth.

Our results also indicate that expected returns are more persistent than expected excess consumption growth rate, which is consistent with what other researchers have found for stock returns in the finance literature. The decomposition of excess consumption to assets ratio based on the estimated return and consumption growth suggests that expected return accounts for 93 per cent of variation in the excess consumption-assets ratio. On the other hand, excess consumption growth accounts for 7 per cent of the variation in

\(^3\)Fama and French (1988) point out that the price-dividend ratio is only a noisy proxy for expected returns when the price-dividend ratio also moves due to expected dividend growth rate variation.
excess consumption-assets ratio. This is similar to the findings of Binsbergen and Koijen (2010), who find that most variation of the price-dividend ratio is related to expected return variation. Their findings suggest that expected returns account for 104 per cent of variation in price-dividend ratio, and expected dividend growth rate account for about 5 per cent of the variation.

As pointed out by Lettau and Ludvigson (2001), return on total household assets is highly correlated with the rate of return on the stock market. Therefore, we also examine whether the estimated expected return on assets from our approach has significant explanatory power for future movements in stock returns. We compare the predictive power of our measure of expected returns with the predictive power of \( cay \) and excess consumption-assets ratio. The results suggest that our measure improves upon the predictive power of the excess consumption-assets ratio and \( cay \). We find that 3 per cent of the variation in one quarter ahead movements in stock returns are explained by expected asset return, whereas excess consumption-assets ratio explains only 0.5 per cent of the variation. This suggests that decomposing the movements in excess consumption-assets ratio into expected asset growth and expected excess consumption growth led to a reduction in the noise of the predictive ability of excess consumption-assets ratio, and helped improve the predictive power. In terms of comparison with \( cay \), we find that \( cay \) explains 2.5 per cent of the variation in one quarter ahead stock returns, which is 0.5 per cent lower than our measure of expected returns.

We also compare the estimated expected asset returns and expected excess consumption growth from our approach with some usual measures of business cycles. Our results indicate significant correlation between business cycle indicators and our measure of expected return. Like dividend growth, it is harder to explain variations in realized excess consumption growth. It can be gauged from the fact that only 1.3 per cent of the variations in realized excess consumption growth is explained by the lagged excess consumption-assets ratio. However, the estimated expected excess consumption growth from our approach improves upon the predictive power of the excess consumption-assets ratio, as it explains 9 per cent of the variation in realized excess consumption growth. We also find that \( cay \) and money growth are significant predictors of expected excess consumption growth. This is similar to the findings of Lettau and Ludvigson (2005) who find that the cointegration residual \( cdy \) of consumption, dividends and labor income predicts U.S. stock dividend growth.

The plan of this paper is as follows: section 2 proposes an unobserved
component model to estimate a present value model of consumption. Section 3 describes the data. Section 4 provides the empirical methodology; section 5 explains the empirical results; and section 6 concludes.

2 Model Specification

2.1 Present Value Model

In this section we build on the present-value model of Whelan (2008) and combine it with the latent variable approach of Binsbergen and Koijen (2010). In doing so, we first briefly explain the evolution of present value models in consumption.

Campbell and Mankiw (1989) first applied the present value model to consumption and used the log consumption-aggregate wealth ratio to predict asset returns because it is a function of expected future returns on the market portfolio. They consider the following budget constraint of a consumer who invests his/her wealth in a single asset with a time varying risky return $R_t$:

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

where $W_t$ is aggregate wealth (human capital plus asset holdings) in period $t$. $C_t$ is consumption and $R_{t+1}$ is the net return on aggregate wealth.

Dividing across by $W_t$ and taking logs, equation (1) can be rearranged as:

$$\Delta w_{t+1} = r_{t+1} + \log(1 - \exp(c_t - w_t))$$

where $\log(1 - \exp(c_t - w_t))$ is a non-linear function of the log consumption-wealth ratio. Campbell and Mankiw (1989) show that the budget constraint in equation (2) can be approximated by taking a first-order Taylor approximation around $c_t - w_t$:

$$\Delta w_{t+1} \approx \kappa + r_{t+1} + \left(1 - \frac{1}{\rho}\right)(c_t - w_t)$$

where the parameter $\rho$ is equal to the average ratio of invested wealth, W-C, to total wealth, W. $\kappa$ is a constant and equals $\log \rho - \left(1 - \frac{1}{\rho}\right) \log(1 - \rho)$. The above equation can be iterated forward to get:\n
\footnote{See Campbell and Mankiw (1989)}
\[ c_t - w_t = \sum_{j=1}^{\infty} \rho^j (r_{t+j} - \Delta c_{t+j}) + \frac{\rho \kappa}{(1 - \rho)} \] 

Equation (4) is a log-linearized budget constraint. This equation holds ex-post but it should also hold ex-ante. Taking the mathematical expectation of equation conditional on time-\( t \) information yields the following expression for the consumption-wealth ratio:

\[ c_t - w_t = E_t \sum_{j=1}^{\infty} \rho^j (r_{t+j} - \Delta c_{t+j}) + \frac{\rho \kappa}{(1 - \rho)} \] 

The above equation states that a high log consumption-wealth ratio today must be associated either with high future rates of return on invested wealth, or with low future consumption growth.

Because aggregate lifetime wealth is not observable, equation (5) is not suitable for empirical estimation. Lettau and Ludvigson (2001) have operationalized the Campbell-Mankiw (1989) equation by using a set of approximating assumptions that link the unobservable total wealth series to observable series on assets and labor income. First, the nonstationary component of human wealth is assumed to be captured by aggregate labor income \( Y_t \). This implies that \( h_t = \kappa + y_t + z_t \), where \( z_t \) is a mean zero stationary random variable. Second, they approximate the log of aggregate wealth as:

\[ w_t = \omega a_t + (1 - \omega) h_t \] 

where \( \omega \) equals the average share of asset holdings in total wealth, \( A/W \). Lastly, log of returns is approximated by a weighted sum of the return on assets and the return on human capital:

\[ r_t = \omega r^a_t + (1 - \omega) r^h_t \] 

Substituting equation (7) into equation (5) (ignoring constant) yields the following:

\[ c_t - \omega a_t - (1 - \omega) y_t = E_t \sum_{j=1}^{\infty} \rho^j ([\omega r^a_{t+j} + (1 - \omega) r^h_{t+j}] - \Delta c_{t+j}) + (1 - \omega) z_t \] 

This improves upon the approach of Campbell and Mankiw (1989), as it does not include the unobserved variable \( h_t \). However, \( \omega \) is still unobserved.
Lettau and Ludvigson argue that $\omega$ can be superconsistently estimated using cointegration methods. They argue that there exists a cointegrating relationship between consumption, assets and labor income, and the OLS estimates of cointegrating parameters are superconsistent.

Whelan (2008) argues that there are potential problems with the method suggested by Lettau and Ludvigson (2001). First, the relationship of interest in equation (8) is an approximation and the quality of approximation is not known. The accuracy of these approximations will depend on the stability over time of the ratio of observed assets to total wealth and there is a possibility that this ratio exhibits substantial variability. Second, $\omega$ cannot be observed and the claim that it can be superconsistently estimated depends on the stationarity of expected returns and expected consumption growth. However, it is possible that these series have mean breaks. In addition, the parameter $z_t$ is unobservable and there could be substantial variation due to this unobservable term.

Whelan (2008) suggests an alternative approach, where the household budget constraint can be described as follows:

$$A_{t+1} = R_{t+1}^a (A_t + Y_t - C_t)$$ (9)

where $A_t$ is total household assets, $R_{t+1}^a$ is the gross return on assets, $Y_t$ is labor income and $C_t$ is consumption. Dividing across by $A_t$ and taking logs we get:

$$\Delta a_{t+1} = r_{t+1}^a + \log \left(1 - \frac{C_t - Y_t}{A_t}\right)$$ (10)

Define, excess consumption as $X_t = C_t - Y_t$

Equation(10) can be rewritten as:

$$\Delta a_{t+1} = r_{t+1}^a + \log(1 - \exp(x_t - a_t))$$ (11)

The above equation is similar to equation (2). $\log(1 - \exp(x_t - a_t))$ is a non linear function. Taking a first order Taylor expansion around the mean $(\bar{x} - \bar{a})$, results in the following:

$$\log(1 - \exp(x_t - a_t)) \approx \log(1 - \exp(\bar{x} - \bar{a})) - \left(\frac{X}{A - X}\right)(x_t - a_t - \bar{x} + \bar{a})$$ (12)
The coefficient \(-\left(\frac{X}{A-X}\right)\) equals \(-\frac{\exp(\pi-\bar{\pi})}{1-\exp(\pi-\bar{\pi})}\). We can rewrite the coefficient \((\frac{\exp(\pi-\bar{\pi})}{1-\exp(\pi-\bar{\pi})})\) as \(1 - \frac{1}{\rho}\) where \(\rho \equiv 1 - \exp(\pi - \bar{\pi})\).

Equation (12) can be simplified to:

\[
\log(1 - \exp(x_t - a_t)) \approx \kappa + (1 - \rho^{-1})(x_t - a_t) \tag{13}
\]

where \(\kappa\) is a constant and equals \(\log(1 - \exp(\pi - \bar{\pi}))-(1 - \rho^{-1})(\pi - \bar{\pi})\).\(^5\)

Substituting back \(\kappa\), the approximation to the intertemporal budget constraint in equation (13) can be rewritten as:

\[
\Delta a_{t+1} = r^a_{t+1} + \kappa + (1 - \rho^{-1})(x_t - a_t) \tag{14}
\]

Also,

\[
\Delta a_{t+1} = \Delta x_{t+1} + (x_t - a_t) - (x_{t+1} - a_{t+1}). \tag{15}
\]

Equating the left hand sides of both the equations (14) and (15), we obtain a difference equation in the log of excess consumption-assets ratio.

\[
x_t - a_t \approx \rho(r^a_{t+1} + \kappa - \Delta x_{t+1}) + \rho(x_{t+1} - a_{t+1}) \tag{16}
\]

Solving forward via repeated substitution and imposing the condition that \(\lim_{j \to \infty} \rho^j (x_{t+j} - a_{t+j}) = 0\), we obtain

\[
x_t - a_t = \frac{\rho \kappa}{1 - \rho} + \sum_{j=1}^{\infty} \rho^j (r^a_{t+j} - \Delta x_{t+j}) \tag{17}
\]

The algebraic steps applied to the above equation are similar to the methodology applied in Campbell and Mankiw (1989) model.

The above equation can also be considered as a log linear equivalent of nonlinear present value budget constraint:

\[
\sum_{j=0}^{\infty} \frac{C_{t+j}}{\left(\prod_{k=0}^{j} R^a_{t+k}\right)} = A_t + \sum_{j=0}^{\infty} \frac{Y_{t+j}}{\left(\prod_{k=0}^{j} R^a_{t+k}\right)} \tag{18}
\]

\(^5\)In Whelan’s (2008) model, \(\kappa\) is dropped from the budget constraint.
Equation (17) holds \textit{ex post} and \textit{ex ante}. If one takes expectation at time \( t \) it yields the following expression for the excess consumption-assets ratio:

\[
x_t - a_t = \frac{\rho \kappa}{1 - \rho} + E_t \sum_{j=1}^{\infty} \rho^j (r^a_{t+j} - \Delta x_{t+j})
\]  
(19)

An upward surprise in excess consumption today must correspond to an unexpected return on assets today or to news that future returns will be higher or to a downward revision in expected excess future consumption growth.

The model is in spirit of models by Campbell and Mankiw (1989) and Lettau and Ludvigson (2001). A key advantage of this approach is that it does not require any assumptions about unobservable variables such as human capital variable. Also, it does not require estimation of unknown parameters to arrive at a forecasting variables.

We build upon this model to filter expected asset returns from the observed history of realized returns and excess consumption growth. We assume that expected returns and expected excess consumption growth are unobserved variables. This assumption is also justified by the finding that \( x_t - a_t \) is a noisy indicator for expected returns. We only observe realized returns and excess consumption growth. Since future returns and future excess consumption growth are unobserved, an unobserved component model is more suitable to model the present value model. We need to construct the most efficient estimates of unobservable expectations given available data that improves upon the predictive regressions.

We assume that expected returns and expected excess consumption growth are latent variables. We follow a parsimonious modeling strategy and model expected returns and expected excess consumption growth as AR(1) process. Similar approach has been applied in a series of papers such as Binsbergen and Kojien (2010) that estimate the expected stock returns and dividend growth by assuming an AR(1) process for the two variables. Fama and French (1988), Pastor and Stambaugh (2006) among others have argued that expected returns are likely to be persistent. Therefore, we model the two state variables as AR(1) process:

\[
r^e_{t+1} = \delta_0 + \delta_1 (r^e_t - \delta_0) + \epsilon^r_{t+1}
\]  
(20)

\[
\Delta x^e_{t+1} = \gamma_0 + \gamma_1 (\Delta x^e_t - \gamma_0) + \epsilon^{xe}_{t+1}
\]  
(21)
Where $r_t^e = E_t(r_{t+1})$ and $\Delta x_t^e = E_t(\Delta x_{t+1})$. The realized excess consumption growth is equal to expected excess consumption growth plus an idiosyncratic shock:

$$\Delta x_{t+1} = \Delta x_t^e + \epsilon_{t+1}^x$$

Plugging equations (20) and (21) into equation (19) and solving, we get:

$$x_t - a_t = \frac{\rho \kappa}{1 - \rho} + \frac{\rho (\delta_0 - \gamma_0)}{1 - \rho} + \frac{\rho \delta_1}{1 - \rho \delta_1} (r_t^e - \delta_0) - \frac{\rho \gamma_1}{1 - \rho \gamma_1} (\Delta x_t^e - \gamma_0) \quad (22)$$

let $A = \frac{\rho \kappa}{1 - \rho} + \frac{\rho (\delta_0 - \gamma_0)}{1 - \rho \delta_1}$, $B_1 = \frac{\rho \delta_1}{1 - \rho \delta_1}$, $B_2 = \frac{\rho \gamma_1}{1 - \rho \gamma_1}$.

Equation (22) can be rewritten as:

$$x_t - a_t = A + B_1 (r_t^e - \delta_0) - B_2 (\Delta x_t^e - \gamma_0) \quad (23)$$

The above equation implies that the log of excess consumption-assets ratio is linear in the expected excess consumption growth and expected returns. There are three shocks in the above model: shock to expected excess consumption growth ($\epsilon_{t+1}^e$), shock to expected returns ($\epsilon_{t+1}^r$), and shock to realized excess consumption growth ($\epsilon_{t+1}^x$). These shocks have a mean zero and have the following variance-covariance matrix:

$$\sum = \text{var} \begin{bmatrix} \epsilon_t^e & \epsilon_t^x & \epsilon_t^r \\ \epsilon_t^x & \sigma_{xx}^2 & \sigma_{xe} \\ \epsilon_t^r & \sigma_{rx} & \sigma_{rr} \end{bmatrix} = \begin{bmatrix} \sigma_{rr}^2 & \sigma_{rx} & \sigma_{rx} \\ \sigma_{rx} & \sigma_{xx}^2 & \sigma_{xr} \\ \sigma_{rx} & \sigma_{xr} & \sigma_{xx}^2 \end{bmatrix}$$

These shocks are independently and identically distributed over time. Further, in the maximum likelihood procedure we assume that the shocks are jointly normally distributed.

In this general correlation structure some of the parameters may be unidentified. Cochrane (2008) and Morley et al. (2003) suggest that we need to impose restrictions on covariance structure in the state space model to achieve identification. For our purpose, we assume that the covariance between shocks to expected returns and expected excess consumption is zero.

### 2.2 Variance Decomposition

We can decompose the variance of excess consumption-assets ratio using equation (23). The variance decomposition for the excess consumption-assets ratio is defined as:

$$\text{var}(x_t - a_t) = B_1^2 \text{var}(r_t^e) + B_2^2 \text{var}(\Delta x_t^e) + 2B_1B_2 \text{cov}(\Delta x_t^e, r_t^e)$$
The above formula implies that proportion of variation in excess consumption-assets ratio explained by expected returns equals $B_2^2 \var(r_e^t)$, and percentage of variation explained by excess consumption equals $B_2^2 \var(\Delta x_e^t)$. 

### 3 Data

The data in this paper includes excess consumption-assets ratio, return on assets and excess consumption. The quarterly data set used in this paper covers the period:1952 to 2006. Data on total household assets is based on the Federal Reserve Board’s Flow of Funds net worth series. We subtract the value of consumer durables from the net worth series because our measure of consumption includes outlays on durable goods.\(^6\) Our series for consumption is obtained from NIPA. Labor income is constructed using data from NIPA, and according to the procedure defined in Lettau and Ludvigson (2001). Labor income is wages and salaries plus transfer payments plus other labor income minus personal contributions for social insurance minus labor taxes. Labor taxes are defined by imputing a share of personal tax and non tax payments to labor income with the share calculated as the ratio of wage and salaries to the sum of wages and salaries, proprietors’ income and rental, dividend, and interest income.

All data on asset valuation, consumption, and labor income is in nominal terms. We deflate consumption, assets, and income series by the price index of total personal consumption expenditure to obtain real consumption, asset returns, and income.\(^7\)

Apart from estimating the time variation of expected returns and expected excess consumption, we also examine the role of different business cycle indicators and macroeconomic variables in explaining the movement of expected returns and excess consumption growth respectively. To examine the time variation in expected asset returns we look at variables that are considered to be proxies for business cycles. Some of the variables that we

\(^6\)Our measure of consumption is based on Whelan’s (2008) approach.

\(^7\)Whelan (2008) deflates the series of asset returns, consumption and labor income by the price index of personal consumption expenditure. Also see Palumbo, Rudd, and Whelan (2006).
consider are: yield-spread, rate of growth of money, 10-year US Treasury bill rate, NBER recession dummy, and \( cay \) (which is the cointegration residual between log consumption, log asset wealth, and log labor income is constructed in Lettau and Ludvigson (2001) and has been obtained from Martin Lettau’s website). Data on yield spread and rate of growth of money\(^9\) have been obtained from the Federal Reserve Bank of St. Louis’s Fred data set. We also add the NBER recession dummy which equals 1 for the particular year if the quarter belongs to the NBER recession period.

We also examine the relationship between expected excess consumption growth and macroeconomic indicators. We include three variables; \( cay \), non-farm payroll jobs growth, and rate of growth of money. Non-farm payroll jobs growth is also obtained from the Federal Reserve Bank of St. Louis’s Fred data set.

We also explore the predictive ability of expected returns in explaining variation in stock returns and compare it with the predictive ability of consumption based predictors such as \( cay \) and \( x_t - a_t \). Data on stock returns has been obtained from the Standard & Poor’s (S&P) Composite Index for which quarterly earnings data are available.\(^10\)

### 4 Parameter Estimation

**State Space Representation**

The model has two latent variables: expected returns (\( r_t^e \)) and expected excess consumption growth (\( \Delta x_t^e \)). We define the demeaned state variables as:

\[
\Delta x_t^e = \gamma_0 + \Delta \tilde{x}_t^e
\]

\[
r_t^e = \delta_0 + \tilde{r}_t^e
\]

There are two transition equations associated with the demeaned latent variables:

\[
\tilde{r}_{t+1}^e = \delta_1 \tilde{r}_t^e + \epsilon_{t+1}^r
\]

\[
\Delta \tilde{x}_{t+1}^e = \gamma_1 \Delta \tilde{x}_t^e + \epsilon_{t+1}^x
\]

\(^8\)http://pages.stern.nyu.edu/mlettau/data/.

\(^9\)quarterly per cent change at an annualized rate.

\(^10\)S&P index data has been obtained from Robert Shiller’s website: http://www.econ.yale.edu/~shiller/data.htm
and two measurement equations are:

\[
\Delta x_{t+1} = \gamma_0 + \Delta \hat{x}_t + \epsilon_{t+1}
\]

\[
x_t - a_t = A + B_1(r^e_t - \delta_0) - B_2(\Delta x^e_t - \gamma_0)
\]

In the above measurement equations system, second equation does not contain any error term. Therefore, we can use the method employed by Binsbergen and Koijen (2010) and substitute out the latent variable \( r^e_t \). This makes the state space system smaller by reducing the number of transition equations. The final state space system has one transition equation and two measurement equations:

\[
\Delta \hat{x}^e_{t+1} = \gamma_1 \Delta \hat{x}^e_t + \epsilon^e_{t+1}
\]

Two measurement equations are:

\[
\Delta x_{t+1} = \gamma_0 + \Delta \hat{x}^e_t + \epsilon_{t+1}
\]

\[
x_{t+1} - a_{t+1} = (1 - \delta_1)A - B_2(\gamma_1 - \delta_1)\Delta \hat{x}^e_t + \delta_1(x_t - a_t) + B_1 \epsilon^e_{t+1} - B_2 \epsilon^e_{t+1}
\]

The measurement equation for excess consumption growth rate and the excess consumption-assets ratio implies the measurement equation for returns. We can estimate the above state space system using the maximum likelihood estimation via the Kalman filter. We estimate the following vector of parameters:

\[
\theta \equiv (\delta_0, \gamma_0, \delta_1, \gamma_1, \sigma_{xx}, \sigma_{x^e}, \sigma_{x}, \rho_{r^ex}, \rho_{x^ex})
\]

The details of the estimation procedure are described in the appendix.

5 Estimation Results

Table 1 reports the maximum likelihood estimates of the parameters of the present value model described in the equation (25)-(27). The estimated AR parameters for expected returns is highly persistent with a coefficient of 0.962. AR parameter for excess consumption growth is 0.678. The high persistence of expected returns is consistent with a variety of economic models in which the expected return varies overtime. Binsbergen and Koijen (2010) found that expected return on stock is persistent with a coefficient of 0.932. Our finding is also consistent with Fama and French (1988), Campbell and
Cochrane (1999), Pastor and Stambaugh (2006), and Rytchkov (2006). The unconditional mean for expected returns and expected excess consumption growth is 4.2% and 0.95% respectively. Correlation between expected returns and excess consumption growth provides us some interesting results. Correlation between the two variables is positive and equals 0.678. This implies that an upward rise in consumption today must correspond to news that future returns will be higher. This result conforms with the theoretical budget constraint derived by Campbell and Mankiw (1989), Lettau and Ludvigson (2001) and Whelan (2008). We find that expected excess consumption growth and realized excess consumption growth are negatively correlated with a correlation coefficient of -0.684. This implies that an upward revision in consumption today corresponds to a downward revision in expected future consumption growth.

Table 4 presents the variance decomposition results for excess consumption-assets ratio from the estimated state space model. Variation in $x_t - a_t$ is mostly explained by asset returns. The result show that expected returns explain 93% of the variation in the excess consumption-assets ratio. However, variation in expected excess consumption explains about 7% of the overall variation the ratio. The data also reflects the persistence of returns in excess consumption-asset ratio. For identification, we assume that correlation between expected return and expected excess consumption equals zero. We also assume that the covariance between shocks to expected return is correlated with shocks to realized excess consumption. Further, expected excess consumption and realized excess consumption are negatively correlated. Our results are not sensitive to the choice of restrictions on covariance structure.\textsuperscript{11}

As suggested by Lettau and Ludvigson (2001), most of the variation in total asset returns can be explained by stock market returns. Therefore, we try to analyze the ability of expected returns to forecast stock returns and compare it with the benchmark model of predictive regressions of stock returns on $x_t - a_t$ ratio and $cay$ respectively. The results are summarized in Table 10. We find that 3 per cent of the variation in the one quarter ahead movement in stock returns is explained by expected asset returns, whereas

\textsuperscript{11}We also estimate the model assuming non-zero correlation between expected returns and expected excess consumption growth. For identification, we assume zero correlation between expected returns and excess consumption growth. Our results remain same qualitatively. Most variation of the excess consumption-asset ratio is related to expected returns variation.
$x_t - a_t$ ratio explains only 0.5 per cent of the variation. $cay$ explains 2.5 per cent of the variation in one quarter ahead stock returns. The results suggest that our measure significantly improves upon the predictive power of $x_t - a_t$ ratio. This is not surprising since one of the objectives of our approach was to reduce the noise associated with $x_t - a_t$ as a proxy for expected returns. There is also a marginal improvement in the explanatory power as compared to $cay$.

5.1 Comparison with the benchmark model

Using the expected asset returns and expected excess consumption growth from our approach, we compute the R-squared values for asset returns and excess consumption growth rate and compare this with the benchmark model which uses the predictive OLS regressions.\textsuperscript{12}

\[
R_{\text{returns}}^2 = 1 - \frac{\text{var}(r_{t+1} - r_t^e)}{\text{var}(r_{t+1})}
\]

\[
R_{\Delta x}^2 = 1 - \frac{\text{var}(\Delta x_{t+1} - x_t^e)}{\text{var}(\Delta x_{t+1})}
\]

The R-squared value for expected returns is 19.44\% and for excess consumption growth it equals 9.17\%.\textsuperscript{13} Next, we compare the result of our model to a benchmark model\textsuperscript{14}.

\[
r_{t+1} = \alpha_1 + \beta_1(x_t - a_t) + \epsilon_{t+1}
\]

\[
\Delta x_{t+1} = \alpha_2 + \beta_2(x_t - a_t) + \epsilon_{t+1}^{\Delta x}
\]

The results are reported in Table 5. For the first regression, returns on excess consumption-assets ratio has a predictive coefficient of $\beta_1 = 0.054$ with an R-squared value of 11.6\%. The slope coefficient is positive and significant with a t-statistic of 5.30. The second regression of excess consumption

\textsuperscript{12}This is in spirit of Binsbergen and Koijen (2010).

\textsuperscript{13}See also Harvey (1989).

\textsuperscript{14}Whelan (2008) studies regressions of the form $\sum_{k=1}^{N} \rho^k (r_{t+k}^e - \Delta x_{t+k})$. In addition, he also examines separate forecasting regressions for $r_t$ and $\Delta x_t$. 

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growth has a predictive coefficient of $\beta_2 = -0.045$ with an R-squared of 1.3%. The slope coefficient is negative and significant with a t-statistics of -1.73. The result suggests that the state-space approach is a better predictor and improves upon the predictive regressions where only lags of excess consumption-assets ratio are used as predictors. It uses more information and aggregates this information in a parsimonious way. In addition to the lagged excess consumption-assets ratio, the state space approach uses the entire history of excess consumption growth rates and excess consumption-assets ratio to predict future returns and excess consumption growth rates.$^{15}$

$$r_t = \alpha^r + \sum_{j=0}^{\infty} \beta_{1j}^r (x_{t-j-1} - a_{t-j-1}) + \sum_{j=0}^{\infty} \beta_{2j}^r \Delta x_{t-j-1} + \epsilon_t^r$$

$$\Delta x_t = \alpha^x + \sum_{j=0}^{\infty} \beta_{1j}^x (x_{t-j-1} - a_{t-j-1}) + \sum_{j=0}^{\infty} \beta_{2j}^x \Delta x_{t-j-1} + \epsilon_t^x$$

Latent variable approach is more flexible than a simple OLS regression. The Kalman filter allows the data to form the best linear predictor, making the forecast more precise.

Figure 2 plots the realized return and expected return computed from the latent-variables approach. We also plot the forecast of returns from the predictive regression of realized returns on the lagged excess consumption-asset ratio. The two series reflect the difference between the forecasting power of two variables. Expected returns outperforms the excess consumption-asset ratio in explaining the variation in asset returns$^{16}$. In figure 3, we plot the realized excess consumption growth, filtered series of excess consumption growth as well as the fitted value from an OLS regression of realized excess consumption growth rate on the lagged excess consumption-assets ratio. The difference between the filtered series and fitted series is large. The filtered series explains greater variation of realized excess consumption growth than the fitted values from the predictive regression.

$^{15}$This is in spirit of Binsbergen and Koijen (2010).

$^{16}$Rychtikov (2008) and Binsbergen and Koijen (2010) also compare the filtered series of state variables with the forecasts based on conventional predictive regression.
5.2 Examining relationship between expected returns, excess consumption growth and macroeconomic indicators

To get more insight into the time variation of expected returns, we examine the role of variables that are considered to be proxies for business cycle. To examine the time variation of expected excess consumption growth we include variables that could be considered as measure of real economic activity. We include variables such as yield spread (YS), NBER recession dummy (NBER), rate of growth of money (DRM), cay, and 10 year US Treasury bill rate to explain movements in expected returns. To examine the impact of these variables in explaining time variation in expected asset returns, we estimate the following simple regression:

\[ r^e_t = c + \alpha r^e_{t-1} + \theta x_{t-1} + \epsilon_t \]

where \( \alpha \) is the predictive coefficient of lagged value of expected returns, \( r^e \) is the expected returns estimated from the latent-variables model, and \( x_t \) is a set of explanatory variables. If \( \theta \) is significant in the above regression then the lagged value of \( x_t \) contain useful information about future movements of returns that is not already present in its lagged value. The results are summarized in Table 6. Yield spread(YS), NBER, and rate of growth of money are significant if they are included as regressors in addition to the lagged returns. R-squared is approximately 0.92 for all the variables. cay and 10 year US Treasury bill rate are also significant predictors of expected returns but their significance disappears once we include the lagged value of expected returns. Table 7 reports the results of regressions without the inclusion of lagged value of expected returns. cay is a positive and significant predictor with a R-squared of 0.23. This implies that if returns are expected to decline in the future, investors who desire to smooth consumption paths will allow consumption to fall below its long term relationship with both assets and labor income in an attempt to insulate future consumption from lower returns, and vice versa. 10 year US Treasury bill rate is a negative and significant predictor.

The methodology proposed in this paper also provides some insight into the behavior of excess consumption growth. The predictive regression of excess consumption on \( x_t - a_t \) ratio lacks the power to predict future consumption. The adjusted \( R^2 \) statistic is 1.3%. In contrast, the \( R^2 \) value
computed within the state space model equals 9%. This improvement is due
to the fact that the filtering approach uses more information and aggregates
this information in a parsimonious way.

We also investigate relationship between macroeconomic indicators and
expected excess consumption growth. Table 8 and 9 report the results.
Lagged values of \( cay \) and rate of growth of money contain information about
the future movements of expected excess consumption. The predictive coeffi-
cient of these variables is significant, however, these variables explain little
variation in expected excess consumption. Once we include the lagged value
of \( \Delta x^e \), the significance of these explanatory variables disappears. Never-
theless, we can say that these variables help in explaining movements in
excess consumption growth. We find that lagged value of non-farm payroll
jobs growth (DEMP) also has significant additional information about future
movements in expected excess consumption that is not already contained in
its lagged value. The slope coefficient is significant and negative and the \( R^2 \)
correspond to the correlation coefficient of 0.15. The results as reported in
Table 8 suggest that there is a greater increase in income in comparison to
consumption as jobs growth increases.

6 Conclusion

In this paper we propose a latent-variables approach to estimate expected
asset returns and excess consumption growth. Acknowledging that expected
returns and excess consumption growth are unobservable, the Kalman filter
technique is used to extract them from the observed history of realized return
on assets and realized excess consumption growth. To apply the Kalman fil-
ter to the unobserved component model we assume that expected returns
and expected excess consumption growth follow a parsimonious autoregres-
sive progress. Since returns is the residual in accounting identity, we can
trace the time variation in returns once we estimate the expected excess
consumption. We combine this approach with a present value model, which
implies that the excess consumption-assets ratio can be expressed as a func-
tion of present discounted value of expected excess consumption growth and
expected asset returns. This is an attempt to link macroeconomic factors
to the predictability of asset return hypothesis. The present value model
also has some practical advantages over the earlier models by Campbell and
Mankiw (1989) and Lettau and Ludvigson (2001). This model does not rely
on untestable assumptions about unobserved variables or require estimation of unknown parameters to operationalize the forecasting equation.

The filtered series for returns and excess consumption turns out to be a good predictor for future returns and future excess consumption growth. Almost 9 per cent of the variation in excess consumption growth is explained by filtered series on excess consumption. The constructed predictor for asset returns can explain about 19 per cent of asset returns. In contrast, the predictive regression of excess consumption on excess consumption-assets ratio lacks the power to predict future consumption, with an R-squared of 1.3 per cent. The predictive regression of returns on excess consumption-asset ratio explains about 12 per cent of variation in asset returns. The variance decomposition of the excess consumption-assets ratio suggest that expected returns account for about 93 per cent variation in excess consumption-asset ratio and 7 per cent of the variation of the excess consumption-asset ratio is related to expected excess consumption growth variation.

The estimated expected returns also has significant explanatory power for future movements in stock returns. Our results suggest that filtered series for returns improve upon the predictive power of the excess consumption-assets ratio and cay. We also examine relationship between filtered returns, excess consumption growth, and macroeconomic indicators. Our result suggests that yield spread, rate of growth of money, and NBER recession dummy contain extra information about the future variation in expected returns that is not already present in its lagged value. The same approach also enables us to examine the predictability of excess consumption growth. Variables such as cay, non-farm payroll jobs growth, and rate of growth of money explain future movements in excess consumption growth.

References


Appendix: State Space Model

\[
\begin{bmatrix}
\Delta x_{t+1} \\
x_{t+1} - a_{t+1}
\end{bmatrix} =
\begin{bmatrix}
\gamma_0 \\
A(1 - \delta_1)
\end{bmatrix}
+ \begin{bmatrix}
0 & 0 & 0 \\
0 & \delta_1
\end{bmatrix}
\begin{bmatrix}
\Delta x_t \\
x_t - a_t
\end{bmatrix}
+
\begin{bmatrix}
1 & 1 & 0 & 0 \\
- B_2(\gamma_1 - \delta_1) & 0 & B_1 & - B_2
\end{bmatrix}
\begin{bmatrix}
\Delta \hat{x}^e_t \\
\epsilon_{t+1}^x \\
\epsilon_{t+1}^{xe} \\
\epsilon_{t+1}^{xe}
\end{bmatrix}
\]

Transition equation is represented as:

\[
\begin{bmatrix}
\Delta \hat{x}^e_t \\
\epsilon_{t+1}^x \\
\epsilon_{t+1}^{xe} \\
\epsilon_{t+1}^{xe}
\end{bmatrix} =
\begin{bmatrix}
\gamma_1 & 0 & 0 & 1 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0
\end{bmatrix}
\begin{bmatrix}
\Delta \hat{x}^e_{t-1} \\
\epsilon_{t}^x \\
\epsilon_{t}^{xe} \\
\epsilon_{t}^{xe}
\end{bmatrix}
+ \begin{bmatrix}
0 \\
\epsilon_{t+1}^x \\
\epsilon_{t+1}^{xe} \\
\epsilon_{t+1}^{xe}
\end{bmatrix}
\]

\[\sum = \text{var} \begin{bmatrix}
\epsilon_{t+1}^x \\
\epsilon_{t+1}^{xe} \\
\epsilon_{t+1}^{xe}
\end{bmatrix} =
\begin{bmatrix}
\sigma_x^2 & \sigma_{xe} & \sigma_{xe} \\
\sigma_{xe} & \sigma_x^2 & \sigma_{xe} \\
\sigma_{xe} & \sigma_{xe} & \sigma_x^2
\end{bmatrix}
\]
Table 1: **Maximum Likelihood Estimates of Hyperparameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_x$</td>
<td>0.0439</td>
<td>0.0032</td>
</tr>
<tr>
<td>$\sigma_{r\epsilon}$</td>
<td>0.0033</td>
<td>0.0008</td>
</tr>
<tr>
<td>$\sigma_{x\epsilon}$</td>
<td>0.0166</td>
<td>0.0046</td>
</tr>
<tr>
<td>$\delta_0$</td>
<td>0.0426</td>
<td>0.0051</td>
</tr>
<tr>
<td>$\delta_1$</td>
<td>0.9623</td>
<td>0.0158</td>
</tr>
<tr>
<td>$\gamma_0$</td>
<td>0.0095</td>
<td>0.0027</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>0.6788</td>
<td>0.0889</td>
</tr>
<tr>
<td>$\rho_{x\epsilon x}$</td>
<td>-0.6839</td>
<td>0.1661</td>
</tr>
<tr>
<td>$\rho_{r\epsilon x}$</td>
<td>0.6421</td>
<td>0.1505</td>
</tr>
</tbody>
</table>

Table 2: **Implied Present Value Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-3.422</td>
</tr>
<tr>
<td>$B_1$</td>
<td>13.013</td>
</tr>
<tr>
<td>$B_2$</td>
<td>1.899</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.965</td>
</tr>
</tbody>
</table>

Table 3: **R-squared values**

$R^2_{\text{Returns}}$ | 19.44 | $R^2_{\Delta x}$ | 9.17 |

Table 4: **Variance Decomposition of Excess Consumption-Asset Ratio**

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{var}(x_t - a_t)$</td>
<td>0.0237</td>
<td>1</td>
</tr>
<tr>
<td>$(B_1\sigma_{r\epsilon})^2$</td>
<td>0.0249</td>
<td>0.931</td>
</tr>
<tr>
<td>$(B_2\sigma_{x\epsilon})^2$</td>
<td>0.0018</td>
<td>0.069</td>
</tr>
</tbody>
</table>

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Table 5: **OLS predictive regressions**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>( r_t )</th>
<th>( \Delta x_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>0.229</td>
<td>-0.142</td>
</tr>
<tr>
<td></td>
<td>(5.302)</td>
<td>(-1.647)</td>
</tr>
<tr>
<td>( x_t - a_t )</td>
<td>0.054</td>
<td>-0.045</td>
</tr>
<tr>
<td></td>
<td>(4.299)</td>
<td>(-1.733)</td>
</tr>
<tr>
<td>Adj-R(^2)</td>
<td>0.116</td>
<td>0.013</td>
</tr>
</tbody>
</table>

The table collects regression results of log returns and log excess consumption growth on the lagged log excess consumption-asset ratio. The sample covers the period 1956 Q1-2006 Q3. t-statistics in parentheses are computed using the Newey-West standard errors.

Table 6: **Regressions of expected returns on business cycle variables**

<table>
<thead>
<tr>
<th>Expected Returns</th>
<th>Model</th>
<th>C</th>
<th>Lag</th>
<th>YS</th>
<th>NBER</th>
<th>DRM</th>
<th>cay</th>
<th>GS10</th>
<th>R(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>0.002</td>
<td>0.94</td>
<td>0.0005</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.002</td>
<td>0.95</td>
<td>-0.001</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>3</td>
<td>0.001</td>
<td>0.96</td>
<td>0.0001</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.001</td>
<td>0.97</td>
<td>-0.016</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>5</td>
<td>0.0009</td>
<td>0.96</td>
<td>0.00</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table collects regression results of filtered expected returns on various business cycle proxies: yield spread (YS); NBER is NBER recession dummy; DRM is rate of growth of money; cay is a cointegrating residual between log consumption, log of assets, and log of labor income; GS10 is the 10 year US Treasury bill rate. C denotes constant. The P value are in parentheses. Newey-West HAC error are used in estimation. All these variables are based on quarterly sample which covers the period 1956Q1-2006 Q3.
Table 7: **Regressions of expected returns on business cycle variables (lag of expected returns not included in the equation)**

<table>
<thead>
<tr>
<th>Model</th>
<th>C</th>
<th>YS</th>
<th>NBER</th>
<th>DRM</th>
<th>cay</th>
<th>GS10</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.04</td>
<td>0.004</td>
<td>0.15</td>
<td>0.00</td>
<td>0.00</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.04</td>
<td>-0.008</td>
<td>0.08</td>
<td>0.00</td>
<td>0.02</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.04</td>
<td>0.0001</td>
<td>0.003</td>
<td>0.00</td>
<td>0.68</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.04</td>
<td>0.36</td>
<td>0.23</td>
<td>0.00</td>
<td>0.00</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.05</td>
<td>-0.001</td>
<td>0.10</td>
<td>0.00</td>
<td>0.00</td>
<td>0.10</td>
<td></td>
</tr>
</tbody>
</table>

The table collects regression results of filtered expected returns on various business cycle proxies with the exclusion of lag of expected returns: Yield Spread (YS), NBER, DRM, cay, and GS10. The P value are in parentheses. Newey-West HAC error are used in estimation. All these variables are based on quarterly sample which covers the period 1956Q1-2006Q3.

Table 8: **Regressions of expected excess consumption on macroeconomic variables**

<table>
<thead>
<tr>
<th>Model</th>
<th>C</th>
<th>lag</th>
<th>cay</th>
<th>DEMP</th>
<th>DRM</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.006(0.00)</td>
<td>0.33(0.00)</td>
<td>-0.05(0.47)</td>
<td>0.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.006(0.00)</td>
<td>0.47(0.00)</td>
<td>-0.0009(0.08)</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.006(0.00)</td>
<td>0.32(0.00)</td>
<td>-0.0003(0.36)</td>
<td>0.12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table collects the regression results of filtered expected excess consumption growth on three macroeconomic variables: cay, DRM, and DEMP. DEMP is non-farm payroll jobs growth. C denotes constant. The P values are in parentheses. Newey-West HAC error are used in estimation. All these variables are based on quarterly sample which covers the period 1956Q1-2006Q3.
Table 9: **Regressions of expected excess consumption on macroeconomic variables** (lag of expected excess consumption growth not included in the equation)

<table>
<thead>
<tr>
<th>Model</th>
<th>C</th>
<th>cay</th>
<th>DEMP</th>
<th>DRM</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.009(0.00)</td>
<td>-0.14(0.07)</td>
<td></td>
<td></td>
<td>0.026</td>
</tr>
<tr>
<td>2</td>
<td>0.010(0.00)</td>
<td>-0.0005(0.36)</td>
<td></td>
<td></td>
<td>0.008</td>
</tr>
<tr>
<td>3</td>
<td>0.008(0.00)</td>
<td>0.0005(0.04)</td>
<td></td>
<td></td>
<td>0.027</td>
</tr>
</tbody>
</table>

The table collects the regression results of filtered expected excess consumption growth on cay, DEMP and DRM. The regression does not include the lag of expected excess consumption. The P values are in parentheses. Newey-West HAC error are used in estimation. All these variables are based on quarterly sample which covers the period 1956Q1-2006Q3.

Table 10: **Regressions of returns on stocks on filtered expected returns, cay and excess consumption-assets ratio**

<table>
<thead>
<tr>
<th>Model</th>
<th>C</th>
<th>r^t_e</th>
<th>x - a</th>
<th>cay</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.016(0.001)</td>
<td>0.90(0.06)</td>
<td></td>
<td></td>
<td>0.031</td>
</tr>
<tr>
<td>2</td>
<td>0.115(0.345)</td>
<td>0.03(0.42)</td>
<td></td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>3</td>
<td>0.016(0.001)</td>
<td></td>
<td>0.62(0.02)</td>
<td></td>
<td>0.025</td>
</tr>
</tbody>
</table>

The table reports the regression result of stock returns on expected returns, x_t - a_t, and cay. The P values are in parentheses. Newey-west HAC error are used in estimation. All the variables are based on quarterly sample which covers the period 1956 Q1-2006 Q3.
Figure 1: The ratio of excess consumption to assets

Figure 2: Realized asset returns along with expected asset returns and the returns predicted by the excess consumption-assets ratio
Figure 3: Realized excess consumption along with expected excess consumption, and the excess consumption growth predicted by the excess consumption-assets ratio