Estimation and Test of a Simple Consumption-Based Asset Pricing Model

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This version: January 2013

Abstract

We derive and test a consumption-based intertemporal asset pricing model in which an asset earns a risk premium if it performs poorly when the expected future consumption growth deteriorates. The predictability in the consumption growth combined with the recursive preference delivers news about future consumption growth an additional risk factor, in addition to news about current consumption growth. We model the consumption growth dynamics using a vector autoregressive (VAR) structure with a set of instrumental variables commonly used for forecasting future economic growth. Our VAR estimation provides strong empirical support for future consumption growth predictability. The cross-sectional test shows that the model explains reasonably well the dispersion in average excess returns of not only 25 portfolios sorted on size and book-to-market, but also 25 portfolios sorted on size and long-term return reversal. Growth stocks and long-term winners underperform on average value stocks and long-term losers, respectively, because they hedge adverse changes in the future consumption growth opportunities.

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1 Introduction

Understanding the cross-sectional dispersions in asset returns is one of the central topics in finance. In rational asset pricing models, the dispersion in expected returns across different assets should be determined by a corresponding dispersion in the co-movement of the asset return with a set of common risk factors. A key insight of the consumption CAPM by Lucas (1978) and Breeden (1979) is that assets that covary negatively with contemporaneous aggregate consumption growth (and thus, covary positively with the marginal utility of consumption) should earn a lower risk premium, since they offer a hedge for bad states when consumption growth is lower. Despite its intuitive appeal, the empirical evidence finds little support for the standard consumption CAPM (Breeden, Gibbons, and Litzenberger, 1989).

This paper derives and tests a consumption-based intertemporal asset pricing model in which an asset earns a risk premium if it performs poorly when the expected future consumption growth deteriorates. We begin from the recursive utility function developed by Epstein and Zin (1989) and Weil (1989) in which a pricing kernel consists of the consumption growth and the return on the market portfolio. Using the restriction implied from the aggregate budget constraint, we then substitute out the return on market portfolio with the current and future consumption growths. The intuition behind this substitution is that an unexpected high current market return should link to either an increased level of consumption today or an improvement of future consumption due to precautionary savings for a long-term investor. As a consequence, we obtain a pricing kernel driven by two differently priced news components with respect to consumption growth: revisions in current consumption growth (as in the standard consumption CAPM), and revisions in expected future consumption growth. The latter is new and comes from allowing expectation of consumption growth to be time-varying.

We model the consumption growth dynamics using a vector autoregressive (VAR) structure with a set of instrumental variables commonly used for forecasting future economic growth. We use a VAR approach, since it has been commonly used for estimating news (unobservable) components of variables in the asset pricing literature (Campbell, 1996; Campbell and Voulteenaho, 2004; Petkova, 2006; Campbell, Giglio, Polk, and Turley, 2012). Empirically, we find that future consumption growth is strongly predicted by current economic conditions. In particular, the default spread and the relative T-bill rate strongly negatively predict future consumption growth, consistent with business-cycle-related interpretation: in economic recessions, when the default spread and the short-term interest rate are likely to be high, future consumption growth is expected to be low. This evidence is important, since if the consumption growth rate cannot be predicted, news about future consumption growth will have zero risk prices. Thus, the model collapses to the standard consumption CAPM. Put differently, the risk prices on the suggested risk factors are not free parameters, but are determined by the importance of the instrumental variables in forecasting future consumption growth.

We estimate and test our consumption-based intertemporal asset pricing model with 25 portfolios sorted on size and book-to-market and 25 portfolios sorted on size and long-term return reversal. The cross-sectional tests with generalized method of moments (GMM) show that the model explains a significant fraction of the dispersion in average excess returns of the two test assets, with explanatory ratios varying between 65% and 79%. In addition, revisions in expected future consumption growth is significantly priced, and seems to drive most of the explanatory power in explaining the cross-section of average returns, while revisions in current consumption growth seems to play a secondary role. Finally, the suggested model compares favorably with the CAPM, intertemporal CAPM, and standard consumption CAPM.

The two-factor consumption-based model does a good job in explaining the value premium anomaly. The model explains more than half of the realized value premium. For instance, the realized return on value-minus-growth portfolio for the smallest quintile is 2.64% per quarter and the expected return from the model is 2.05% per quarter, thus the model explains 78% of the realized value premium. According to our model, value stocks outperform on average growth stocks, because value stocks have more exposure to adverse changes in the future consumption growth opportunities. One possible explanation is that typically value firms - stocks with low prices relative to book value - have suffered a sequence of terrible shocks than growth firms. A recent study by Fama and French (2012) provide an evidence that high book-to-market signals persistent poor earnings and low book-to-market signals strong earnings.

The presented model also provides an explanation to the long-term return reversal anomaly. Majority of the realized return on a hedge portfolio that is buy long-term losers and short long-term winners can be explained by the model. Stocks with low long-term past returns (long-term losers) outperform on average stocks with high long-term past returns (long-term winners), because long-term losers perform poorly when the expected future consumption growth deteriorates. The plausible explanation is that firms with a consistent stock price decreases for several years are likely to experience a long sequence of negative cash flow shocks, whereas firms with a consistent stock price increases for several years are likely to experience a long sequence of positive cash flow shocks. As such, long-term losers should have higher risk exposure to news about the future prospects of consumption growth.

The explanatory power of the model holds under a battery of robustness checks: using alternative vector autoregression (VAR) specifications to estimate revisions in current and future consumption growths; testing the model simultaneously on value and long-term return reversal portfolios; including bonds in the test assets; estimating the model in expected return-beta form; and estimating the model with second-stage GMM.

Our work is related to recent literature on the long-run risk model of Bansal and Yaron (2004). Both our model and the long-run risk model study asset pricing implications of time-varying consumption growth rate combined with the recursive utility function of Epstein and Zin (1989). This paper, however, differs from the long-run risk model in some important ways. First, our model shares the view with the long-run risk model that future consumption growth is predictable. Our model, however, does not rely on the highly persistent component in the consumption growth. The persistent predictable component in the aggregate consumption growth is necessary for the long-run risk model to explain various asset markets phenomena. There has been a criticism on this assumption, however, by questioning whether or not the consumption data indeed has a highly persistent component (e.g., Beeler and Campbell, 2012). Second, the cross-sectional implications of the long-run risk model is that dispersion in expected returns across assets is determined by a corresponding dispersion in the cash flow (dividends) beta, i.e., the covariance between dividends and consumption growth. Bansal, Dittmar, and Lundblad (2005) and Bansal, Dittmar, and Kiku (2009) directly explore this implication. In contrast, we study the counterpart returns-based consumption beta, i.e., the covariance between returns and consumption growth.

Our work is complementary to research on the intertemporal CAPM of Merton (1973), in which the changes in the investment opportunity set (a hedging factor) affect asset returns (Campbell, 1996; Campbell and Voulteenaho, 2004; Brennan, Xia, and Wang, 2004; Petkova, 2006; Bali and Engle, 2010; Campbell, Giglio, Polk, and Turley, 2012). The consumption-based model is related to the intertemporal CAPM, since time variation in the investment opportunity set must all eventually affect consumption at some horizon because the aggregate budget constraint must hold. In contrast to the intertemporal CAPM that has equity financial-based sources of systematic risk, the ultimate source of systematic risk in our model is the consumption risk, a macroeconomic risk from outside the equity market.

The remainder of this paper proceeds as follows. Section 2 describes the development of a consumption-based intertemporal asset pricing model. Section 3 presents a method to estimate two news components in consumption growth, along with testing methodologies for the asset pricing model. Section 4 presents VAR estimates of the dynamic process for consumption growth, and the results on the cross-sectional asset pricing test. Section 5 report a set of robustness exercises in which we vary our basic VAR specifications for the dynamics of consumption growth, and consider alternative test portfolios. Finally, Section 6 sets forth a summary and conclusion.

2 Theoretical Background

Consider an agent who maximizes his Epstein and Zin (1989, 1991) objective function

$$U_t = \left[(1-\delta)C_t^{1-1/\psi} + \delta \left(E_t \left[U_{t+1}^{1-\gamma}\right]\right)^{1/\theta}\right]^{\frac{1}{1-1/\psi}}, \tag{1}$$

subject to the intertemporal budget constraint

$$W_{t+1} = R_{m,t+1}\left(W_t - C_t\right), \tag{2}$$

where C_t is consumption, W_t is total wealth, $R_{m,t+1}$ is the gross return on total wealth, ψ is the elasticity of intertemporal substitution, γ is the coefficient of relative risk aversion, δ is the time discount factor, and θ is defined as $\frac{(1-\gamma)}{\left(1-\frac{1}{\psi}\right)}$.

From equations (1) and (2), an Euler equation for asset i is obtained:

$$E_t\left[\delta^\theta \left(\frac{C_{t+1}}{C_t}\right)^{-\frac{\theta}{\psi}} \left(\frac{1}{R_{m,t+1}}\right)^{1-\theta} R_{i,t+1}\right] = 1. \tag{3}$$

Thus, the log stochastic discount factor or pricing kernel is equal to

$$m_{t+1} = \theta log\delta - \frac{\theta}{\psi}\Delta c_{t+1} - (1-\theta) r_{m,t+1}, \tag{4}$$

where $\Delta c_{t+1} \equiv log\left(\frac{C_{t+1}}{C_t}\right)$ and $r_{m,t+1} \equiv log\left(R_{m,t+1}\right)$ denote the log consumption growth and the log return on total wealth, respectively.[1] Subtracting $E_t\left(m_{t+1}\right)$ from both sides yields,

$$m_{t+1} - E_t(m_{t+1}) = -\frac{\theta}{\psi}\left[\Delta c_{t+1} - E_t\left(\Delta c_{t+1}\right)\right] - (1-\theta)\left[r_{m,t+1} - E_t\left(r_{m,t+1}\right)\right]. \tag{5}$$

Equation (5) means that shock to the pricing kernel is a linear combination of current unexpected consumption growth and current unexpected market return. Note that this

[1] From here on, lowercase letters denote the logs of uppercase letters.

specification stands on somewhat shaky ground. Since news about consumption growth affects market return, consumption and market wealth do not move independently (Cochrane, 2007).

In order to overcome this potential model misspecification, we can think of the stochastic discount factor in terms of only current and future consumption. Since the utility index is a function of the distribution of future consumption, the essence of the pricing kernel is that news about future consumption matters as well as current consumption in the pricing kernel.

Campbell (1993) linearizes the budget constraint and uses the Euler equation to derive a relation between expected consumption growth and expected market return. We adopt this relation and obtain an expression for unexpected market return as a function of innovations to current and future consumption growth. By doing so, an expression with only consumption growth appears in the pricing kernel.

Log-linearizing the budget constraint around the steady state, and assuming that the consumption-wealth ratio is stationary, in the sense that $lim_{j \to \infty} \rho^j \left(c_{t+j} - w_{t+j}\right)$, we get

$$r_{m,t+1} - E_t\left(r_{m,t+1}\right) = \left(E_{t+1} - E_t\right) \sum_{j=0}^{\infty} \rho^j \Delta c_{t+1+j} - \left(E_{t+1} - E_t\right) \rho^j r_{m,t+1+j}, \tag{6}$$

where ρ is defined as $1 - exp(c - w)$.

Campbell (1993) derives a linear relation between expected consumption growth and expected market return under the assumption that consumption and returns are conditionally homoskedastic and jointly log normal, such that

$$E_t\left(r_{m,t+1}\right) = \mu_m + \frac{1}{\psi} E_t\left(\Delta c_{t+1}\right), \tag{7}$$

where μ_m is a constant that includes the variance and covariance terms for innovation to consumption and market return. We substitute expected market return, $E_t\left(r_{m,t+1}\right)$, into equation (6) to obtain an expression with only consumption growth on the right-hand side:

$$r_{m,t+1} - E_t\left(r_{m,t+1}\right) = \Delta c_{t+1} - E_t\left(\Delta c_{t+1}\right) + \left(1 - \frac{1}{\psi}\right)\left(E_{t+1} - E_t\right)\sum_{j=1}^{\infty}\rho^j \Delta c_{t+1+j}. \quad (8)$$

Equation (8) states that, in the long-run, news about market returns is entirely determined by news about consumption growth.

Substituting equation (8) into (5), we derive the (log) stochastic discount factor:

$$m_{t+1} - E_t(m_{t+1}) = -\gamma\left[\Delta c_{t+1} - E_t\left(\Delta c_{t+1}\right)\right] - \left(\gamma - \frac{1}{\psi}\right)\left(E_{t+1} - E_t\right)\sum_{j=1}^{\infty}\rho^j \Delta c_{t+1+j}, \quad (9)$$

which makes use of the fact that $\left(\frac{\theta}{\psi} + 1 - \frac{1}{\psi}\right) = \gamma$, and $(1-\theta)\left(1 - \frac{1}{\psi}\right) = \gamma - \frac{1}{\psi}$. Fang (2004) and Hansen, Heaton, and Li (2008) also derive the pricing kernel in a manner similar to equation (9). Note that news about *future* consumption growth appears in the *current* stochastic discount factor. This is because a long-term investor cares about expected future consumption. Changes in expectation of future consumption affect the current marginal rate of substitution through intertemporal consumption-smoothing. As a special case, when $\theta = 1$, news about future consumption growth drops out from the log pricing kernel, because investors do not adjust current consumption through consumption-smoothing.

In equilibrium, expected return on any asset i should be determined by its covariance with the stochastic discount factor in the economy:

$$E\left(r_{i,t+1} - r_{f,t+1}\right) + \frac{\sigma_i^2}{2} = -Cov\left(r_{i,t+1}, m_{t+1}\right), \quad (10)$$

where $\frac{\sigma_i^2}{2}$ is a Jensen inequality adjustment arising from the lognormal model. Then, equation

(9) is substituted into equation (10), to obtain

$$E\left(r_{i,t+1} - r_{f,t+1}\right) + \frac{\sigma_i^2}{2} = \gamma Cov\left[r_{i,t+1}, \Delta c_{t+1} - E_t\left(\Delta c_{t+1}\right)\right] + \left(\gamma - \frac{1}{\psi}\right) Cov\left[r_{i,t+1}, \left(E_{t+1} - E_t\right)\sum_{j=1}^{\infty} \rho^j \Delta c_{t+1+j}\right]. \quad (11)$$

In addition to the current consumption growth shock, as in the standard Consumption CAPM of Breeden (1979), shocks to variables that predict future consumption growth represents a new risk factor. Note that the two different consumption growth shocks receive different prices of risk. Thus, assets should have differing exposures to the two shocks. In the special case where $\psi = \infty$, since there is a one-for-one relation between current and future consumption innovations, innovations in long-run consumption growth have the same price of risk as the current consumption innovation.

Following Campbell and Vuolteenaho (2004), we use simple expected returns, $E\left(R_{i,t+1} - R_{f,t+1}\right)$, on the left-hand side of equation (11), instead of log returns, $E\left(r_{i,t+1} - r_{f,t+1}\right) + \frac{\sigma_i^2}{2}$. Not only are both expectations the same in the lognormal model, but also by using simple returns, we can make our results directly comparable with previous empirical studies. This modification yields

$$E\left(R_{i,t+1} - R_{f,t+1}\right) = \gamma Cov\left[r_{i,t+1}, \Delta c_{t+1} - E_t\left(\Delta c_{t+1}\right)\right] + \left(\gamma - \frac{1}{\psi}\right) Cov\left[r_{i,t+1}, \left(E_{t+1} - E_t\right)\sum_{j=1}^{\infty} \rho^j \Delta c_{t+1+j}\right]. \quad (12)$$

Equation (12) represents the consumption-based two factor model set forth in this paper.

3 Data and Empirical Methodology

The consumption growth dynamics and the econometric framework used to estimate and evaluate an asset pricing model are set forth below.

3.1 Econometric Specification

We adopt the VAR approach of Campbell (1993,1996) to specify a process for the time-series dynamics of consumption growth. We let the (log) consumption growth rate be the first element of a state vector z_{t+1}. The other elements of z_{t+1} are state variables that are known to the market by the end of period $t+1$ and that are relevant in forecasting future consumption growth. We assume that vector z_{t+1} is generated by a first-order VAR model:[2]

$$z_{t+1} = a + \Gamma z_t + u_{t+1}. \tag{13}$$

In this framework, current and future consumption growth news are linear functions of the VAR shock (u_{t+1}):

$$N_C \equiv \Delta c_{t+1} - E_t\left(\Delta c_{t+1}\right) = e1' u_{t+1}, \tag{14}$$

$$\begin{aligned} N_{LR} &\equiv \left(E_{t+1} - E_t\right) \sum_{j=1}^{\infty} \delta^j \Delta c_{t+1+j} \\ &= e1' \rho\Gamma (I - \rho\Gamma)^{-1} u_{t+1} = \lambda' u_{t+1}. \end{aligned} \tag{15}$$

Here, $e1$ is a vector with the first element equal to 1 and all others equal to zero; Γ is the VAR coefficient matrix; and $\lambda' \equiv e1'\rho\Gamma(I - \rho\Gamma)^{-1}$ is a function that captures the long-run significance of each individual VAR shock to the expectation of consumption growth. We follow Campbell and Vuolteenaho (2004) and assume an annual consumption-wealth ratio of 5%, implying that $\rho = 0.95^{1/4}$ quarterly.[3]

In order to empirically implement the VAR approach, it is necessary to specify the identity of the state variables. We choose a set of state variables that are theoretically or empirically shown to be useful in forecasting future growth in the literature. Specifically, we opt for

[2] Any P order VAR with $P > 1$, can be stacked into first order VAR if the state vector is expanded by including lagged state variables, with Γ denoting the VAR companion matrix.

[3] We also allow discount rates to vary within the range of 0 to 10% ($\rho = 0.9^{1/4}$ to 1) and find no significant difference in results.

aggregate dividend yield (DIV), default spread (DEF), relative T-bill rate (RREL), and term spread (TERM), which are widely used for predicting business cycles (e.g., Chordia and Shivakumar, 2002).

Aggregate dividend yield, computed as the sum of dividends over the last one-year divided by the price level of the CRSP value-weighted portfolio, is helpful to predict future growth (Fama and French, 1988). In a simple discounted cash flow model, when dividend yield is high investors expect a high future discount rate or low future cash flow growth (Campbell and Shiller, 1988). To the extent that aggregate dividend and aggregate consumption in the economy are co-integrated, we can expect that dividend yield is useful in predicting future consumption growth (Bansal, Dittmar, and Kiku, 2009).

The default spread, measured as the difference between the the yield spread between Moody's BAA and AAA corporate bonds, is used to capture time variation in risk aversion in the economy (Keim and Stambaugh, 1986; Fama and French, 1989). When an economic downturn is expected, investors will tend to buy higher quality securities and to sell lower quality securities. This leads to higher prices and lower yields for the higher quality securities relative to lower quality ones. As a result, the default spread increases when economic recessions are expected.

The relative T-bill rate, calculated as the difference between the three-month Treasury bill rate and its moving average over the previous one-year, is shown to be related to economic conditions and to time-varying risk premium (Campbell,1991; Hodrick, 1992; Ang and Bekaert, 2007). In economic down-turns, the risk-free rate tends to decrease to stimulate investment for economic growth.

Finally, the term spread, measured as the difference between ten-year government bonds yields and three-month government bonds yields, contains important information about short-term fluctuations in the business cycle (Campbell, 1987; Fama and French, 1989). The values of the term spread are high during recessions and low during expansion. Thus, the term spread tends to be higher when future growth is expected to be low.

Data on bond yields are obtained from the FRED database, available from the St. Louis FED's website. Consumption is obtained from National Income and Product Accounts (NIPA), and we deflate it by the consumer price index (CPI) and total population in order to compute per capital real consumption. Table 1 provides descriptive statistics and contemporaneous correlations of the VAR state variables. The average (log) consumption growth over the sample period is 0.54% per quarter with a standard deviation of 0.57%. From the first-order autocorrelation coefficients (AR(1)), we see that both DIV and DEF are quite persistent: DIV has an AR(1) coefficient of 0.965, and DEF has an AR(1) coefficient of 0.865. In the correlation matrix, we see that consumption growth rate is positively correlated with RREL and TERM, and negatively correlated with DIV and DEF. Among the state variables, DIV and DEF are quite positively correlated, with a correlation coefficient of 44%, and RREL and TERM are highly negatively correlated, with a correlation coefficient of -53%.

3.2 Portfolios

We use two sets of equity portfolios to estimate and evaluate of the asset pricing models. The first group stands for 25 portfolios sorted on both size and book-to-market (SBM25). The second group contains 25 portfolios sorted on both size and long-term return reversal (SLTR25). SLTR25 are constructed from the intersection of five portfolios formed on size and five portfolios formed on past returns (13 to 60 months before the portfolio formation month). These portfolios are made by Fama and French (1996) to capture the reversal of long-term returns, one of the CAPM anomalies, documented by DeBondt and Thaler (1985): Stocks with low long-term past returns (long-term losers) tend to have higher future average returns, while stocks with high long-term past returns (long-term winners) tend to have lower future average returns. We consider the SLTR25 portfolios as an alternative set of test assets in response to the criticism of Lewellen, Nagel, and Shanken (2010) that most asset pricing tests rely exclusively on the SBM25 portfolios. We compound the monthly returns to compute the portfolio quarterly returns. We subtract the return on the three-month T-bill to calculate the portfolio excess returns. Finally, we use the CPI inflation rate to obtain the ex post real portfolio. All portfolio return data is obtained from Kenneth French's website. The return on the three-month T-bill rate and the seasonally adjusted CPI are obtained from the FRED database.

3.3 Econometric Methodology

We estimate our specification by a first-stage generalized method of moments (GMM) procedure (Hansen, 1982). The first-stage estimation uses equally weighted moments, conceptually equivalent to an ordinary least-squares (OLS) cross-sectional regression of average excess returns on factor covariances. This procedure enables one to evaluate whether our consumption-based model can explain the returns of a set of economically interesting portfolios (e.g., value premium or long-term return reversal effect).

Let $R^e_{t+1} = (R_{1,t+1} - R_{f,t+1}, \ldots, R_{N,t+1} - R_{f,t+1})'$ and $f_{t+1} = (N_{C,t+1}, N_{LR,t+1})$ be time $t+1$ observation of the vector of N excess returns on test assets, and the vector of K factors, respectively. The GMM system has $N + K$ moment conditions, where the first N sample moments correspond to the pricing errors for each of the N test portfolios:

$$\begin{bmatrix} R^e_{t+1} - R^e_{t+1}\left(f_{t+1} - \mu_f\right)' b \\ f_{t+1} - \mu_f \end{bmatrix} = 0, \tag{16}$$

where b denotes the factor prices of risk and μ_f denotes the means of factors. The last K moment conditions in the system above allow us to estimate the factor means, meaning that the estimated factor risk prices (b) take into account for the estimation error in the factor means, as in Cochrane (2005, Chapter 13), and Yogo (2006).

The over-identifying restrictions of the model can be tested by Hansen's (1982) J-test, and is given by

$$T\hat{\alpha}'\hat{S}_N^{-1}\hat{\alpha} \sim \chi^2(N-K), \tag{17}$$

where $\hat{\alpha}$ denotes the pricing errors associated with the N test assets, and $\hat{S}_N$ represents the block of the spectral density matrix associated with the N pricing errors. The degree of over-identification is $N-K$ (N moments and K parameters to estimate). The J-test tests the null hypothesis that the pricing errors are jointly zero across the N test assets. The test is conceptually similar to the GRS test (Gibbons, Ross, and Shanken, 1989), since the test statistic is a quadratic form in the vector of pricing errors (Cochrane, 2005).

In addition to the formal test statistic (17), we compute two simpler and more robust goodness-of-fit measures to evaluate the overall pricing ability of the model. The first measure is the cross-sectional OLS R^2:

$$R^2 = 1 - \frac{\sum_{i=1}^{N} \bar{\hat{\alpha}}_i^2}{\sum_{i=1}^{N} \bar{R}_i^2}, \tag{18}$$

where $\bar{R}_i = \frac{1}{T}\sum_{t=0}^{T-1}\left(R_{i,t+1}^e\right) - \frac{1}{N}\sum_{i=1}^{N}\left[\frac{1}{T}\sum_{t=0}^{T-1}\left(R_{i,t+1}^e\right)\right]$ represents the (cross-sectionally) demeaned average excess returns, and $\hat{\alpha}_i$ denotes the pricing errors, and $\bar{\hat{\alpha}}_i$ stands for the (cross-sectionally) demeaned pricing errors. The cross-sectional R^2 measures the proportion of the cross-sectional variance of average excess returns explained by the model.

The second measure is the mean absolute pricing error (MAE):

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|\hat{\alpha}_i| \tag{19}$$

4 Empirical Results

4.1 VAR Estimation

In order to identify two different news about consumption growth, it is necessary that the set of state variables have predictable power. It is important, therefore, to examine whether the chosen VAR state variables considered here, DIV, DEF, RREL, and TERM, are actually able to predict future consumption growth. Panel A of Table 2 reports the VAR estimation results. From the first row of Panel A of Table 3, we see that a set of state variables have some ability in predicting future consumption growth. Consumption growth, DEF, and RREL are statistically significant at the 5% level. The signs of the coefficients of these variables are consistent with business-cycle-related interpretation, as discussed in Section 3.1. For instance, in economic recessions, when the default spread (DEF) is high, future consumption growth is expected to be low. The adjusted R^2 of the consumption growth forecasting regression is 28%, indicating that the variables considered here jointly achieve the desired result of having predictable power. The remaining rows of Panel A of Table 2 show the dynamics of the VAR state variables. Each state variable is predicted not only by its own lag, but also by the other lagged state variable(s). For example, term spread is predicted by the lagged value of all other state variables, except dividend yield.

Table 3 summarizes the characteristics of the implied current and future shocks to consumption growth. The top panel reports the variances, covariances, standard deviations, and correlations of two consumption growth shocks. The standard deviation of news about future consumption growth is slightly larger than the standard deviation of news about current consumption growth. In addition, shock to future consumption growth is positively correlated with shock to current consumption growth, indicating that the prospects of long-run growth opportunities rise when consumption growth rises.

The bottom panel of Table 3 shows the correlations of innovations in the VAR state variables with two different consumption growth shocks. Innovations to the term spread are negatively correlated with current consumption growth shock while they are positively correlated with future consumption growth shock. This suggests that positive shocks to the steepness in the yield curve are associated with current bad economic conditions, but in the long-run they are associated with positive growth opportunities. Similarly, unexpected decreases in short-term interest rate are associated with current economic down turns, but they are also associated with a positive impact on revisions of future consumption growth. Table 3 also reports the coefficients that map innovations of state variables to news about current and future consumption growth. It is evident that innovations to default spread and consumption growth are the most important determinants of news about future consumption growth.

4.2 Estimation of Factor Risk Premia

The estimation and evaluation results for the CAPM, intertemporal CAPM, consumption CAPM, and suggested consumption-based intertemporal asset pricing model are reported in Table 4, in which the test assets are the 25 size/BM portfolios (Panel A) and the 25 portfolios sorted on size and long-term return reversal portfolios (Panel B). In the test of CAPM with the SBM25 portfolios, the estimated market risk price is 2.43 and is significant at the 1% level. The average pricing error is 0.61% per quarter, and the model is strongly rejected by the J-test statistic (p-value = 0.0%). In addition, the cross-sectional R^2 is negative (-17%), meaning that the CAPM performs worse than a model with only a constant factor.

The results for the intertemporal CAPM show that the model explains 48% of the cross-section variation in average excess returns, whereas the average pricing error is 43% per quarter. This fit represents a modest improvement relative to the CAPM. The two covariance risk prices, however, are both negative, inconsistent with theory prediction. The estimate for the risk price associated with the market excess return is -14.60 and significant (1% level), whereas the estimate for the risk price associated with news about future stock return is -27.72 and significant (1% level). The fit of the consumption CAPM is slightly worse than the intertemporal CAPM: the model yields an explanatory ratio of 27% and an average pricing error of 0.44% per quarter. The point estimate for the risk price of consumption (estimate of the relative risk aversion) is 92.98 and significant (1% level). This high estimate of relative risk aversion comes from the fact that the consumption growth is not enough volatile and correlated with stock returns.

For the suggested consumption-based intertemporal asset pricing model, the results show that adding news about future long-run consumption growth improves substantially the fit of the consumption CAPM in pricing the SBM25 portfolios, with an average pricing error (0.27%) that is almost half of the corresponding value for the C-CAPM, and the cross-sectional R^2 more than dobules to 79%. The risk price estimate for news about future consumption growth is positive and significant (1% level), whereas the risk price estimate for news about current consumption growth is negative and significant (1% level).

The results for the test with the SLTR25 portfolios (Panel B) show that the fit of the CAPM improves in relation to the test with the SBM25 portfolios, with now a positive cross-sectional coefficient of determination of 17%. The average pricing error is 0.46% per quarter, which is still economically large. The point estimate for market price of risk is close to the corresponding estimate in the test with the SBM25 portfolios. As in the case with SBM25 portfolios, the intertemporal CAPM outperforms the CAPM in pricing the SLTR25 portfolios, with the coefficient of determination of 36% and with the average pricing error of 39% per quarter. In addition, the estimates of risk prices for market excess return and news about future market return become positive and significant (1% level) in the test with SLTR25 portfolios.

In the test with the SLTR25 portfolios, the fit of the consumption CAPM is comparable to the test with the SBM25 portfolios. The estimate for the relative risk aversion becomes nearly half (55.68) of the corresponding value in the test with the SBM25 portfolios, but is marginally significant (10% level). The consumption-based model with news about future long-run consumption growth as an additional factor outperforms the consumption CAPM by a good margin in pricing the SLTR25 portfolios as well, with an R^2 estimate of 73% and the average pricing error of 25% per quarter. The estimates of risk prices for two consumption risk factors are very stable across the test assets.

The results of the evaluation for the considered asset pricing models from Table 4 can be summarized in the following ways. First, the suggested consumption-based model is able to explain a significant fraction of the dispersion in average excess returns of the 25 size/BM portfolios and also the 25 portfolios sorted on size and long-term return reversal. Second, news about long-run future consumption growth is significantly priced, and seems to drive most of the explanatory power in explaining the cross-section of average returns, while news about current consumption growth seems to play a secondary role. Third, our specification compares favorably with the CAPM, intertemporal CAPM, and consumption CAPM.

4.3 Expected versus Realized Return

Although both R^2 and MAE represent the overall fit of the model, it would be interesting to examine how much of the observed magnitude of the value premium (the average value-minus-growth return) and the profit to long-term reversal strategy (the average long-term losers-minus-winners return) can be explained by our two-factor model. If our consumption-based model is sufficient to explain the value premium and the long-term reversal anomaly, then the difference between the realized return and the estimated expected return, i.e., pricing error, should be indistinguishable from zero.

Expected return is obtained from equation (12) with the estimated risk prices reported in Table 4. Panel A of Table 5 reports the results for the value premium within each size quintile. The first column $\left(\bar{R}_{VMG}\right)$ and second columns $(E[R]_{VMG})$ show realized and expected returns on the value-minus-growth portfolios, respectively. The third column (α_{VMG}) reports pricing errors, and the fourth column $(t\left(\alpha_{VMG}\right))$ reports the t-statistics corresponding the null hypothesis that the pricing error is zero. The fifth column $\left(E[R]_{VMG}/\bar{R}_{VMG}\right)$ shows the proportion of expected to realized value premium.

Panel A shows that the value premium is stronger in small firms (2.64% per quarter) than in big firms (0.43% per quarter), a stylized fact that poses a challenge to asset pricing models. The pricing errors, the difference between realized and expected returns on the value-minus-growth stocks, within each size quintile are all insignificant. For example, the largest pricing error occurs in medium size firms and is insignificant (t = 1.52). In addition, the pricing errors show no systematic pattern across size quintiles. In other words, they do not show monotonically decreasing patterns across size quintiles, which is the case when other asset pricing models (CAPM, intertemporal CAPM, and consumption CAPM) are used (not reported here). Most importantly, our consumption-based two-factor model explains more than half of the realized value premium. For instance, the realized return on value-minus-growth portfolio for the smallest quintile is 2.64% per quarter and the expected return from the model is 2.05% per quarter, thus the model explains 78% of the realized value premium.

Panel B reports realized returns, expected returns, and pricing errors for the long-term losers-minus-winners portfolios within each size quintile. Long-term losers earn higher average returns than long-term winners. The realized return on the losers-minus-winners is 2.01% per quarter in the smallest size quintile and 1.10% per quarter in the biggest size quintile. The proposed consumption-based model does a good job in explaining profits to the long-term reversal strategies. Predicted returns from the model are not significantly different from realized returns, as indicated by the fact that pricing errors for each size quintile are all insignificant. For instance, the model predicts the expected profits to the long-term reversal strategy to be 1.15% per quarter for small stocks, which is 57% of the realized profit, 2.01% per quarter. Further, the point estimates of pricing errors are negative for three long-short portfolios among five hedge portfolios.

Overall, the results in Table 5 show that the average return spreads between value and growth stocks (value premium) and between long-term losers and winners (long-term reversal profits) can be explained by the suggested consumption-based model. The average portion of the realized return spread accounted by the model is more than 50%, and pricing errors are statistically insignificant for all size quintile.

4.4 Factor Betas

In order to understand which factor drives the explanatory power of the suggested consumption-based model for the cross-section of stock returns, we examine whether there is a systematic pattern in the risk exposures (betas) on the two different consumption growth shocks. Put differently, we want to study which factor's betas can match the value premium (return difference between value and growth stocks) and the long-term return reversal effect (return difference between long-term losers and winners). Panel A of Table 6 reports the (quarterly) average excess returns for the SBM25 portfolios, and the betas for news about current and future consumption growth. The last column reports the difference in betas between value (BM5) and growth (BM1) quintiles (BM5-BM1) within each size quintile, while "Mean" stands for the average difference, BM5-BM1, across all size quintiles.

Reading across the rows of the table, average returns increase in book-to-market within each size quintile, confirming the well-known value premium in our sample. For the case of news about current consumption growth, the growth stocks have higher betas than value stocks, with an exception of fifth size quintile. The average difference, BM5-BM1, for the current consumption growth shock is -1.47. Furthermore, the betas with respect to current consumption growth exhibit an approximate u-shaped pattern: betas of current consumption risk decrease from the first to fourth BM quintile and increase from the fourth to the fifth BM quintile. These results indicate that current consumption growth risk seems not to be systematically related to the value premium and confirms why the standard consumption CAPM performs poorly in pricing the size/BM portfolios.

In contrast to the current consumption growth beta, the pattern of the long-run consumption growth beta matches closely to that of the returns. Value stocks always have greater loadings on the news about long-run consumption growth than growth stocks within each size quintile, and the relation is almost close to a monotonic one. In the case of long-run consumption growth shock, we have an average positive difference in factor loadings between value and growth stocks of 2.01. Overall, our results suggest that the value premium can be explained by a corresponding dispersion in betas associated with long-run consumption risk. In other words, news about future consumption growth is the key factor for the suggested model to explain the value premium anomaly.

Why do value stocks have more risk exposures than growth stocks? One possible explanation is that typically value firms - stocks with low prices relative to book value - have suffered a sequence of terrible shocks than growth firms. A recent study by Fama and French (2012) provide an evidence that high book-to-market signals persistent poor earnings and low book-to-market signals strong earnings. Thus, value firms should be more sensitive to news about the future prospects of consumption growth, a key relevant measure of macroeconomic conditions, than growth firms.

We redo the previous analysis for the long-term return reversal effect and report the (quarterly) average excess returns and the factor betas for the SLTR25 portfolios in Panel B of Table 6. We can see that the average returns increase from long-term winners (LTR5) to long-term losers (LTR1). The average return on long-term losers minus long-term winners, LTR1-LTR5, is 1.34% per quarter. As in the SBM25 portfolios, the current consumption risk betas show no meaningful dispersion across long-term return reversal portfolios within each size quintile. The average difference in betas, LTR1-LTR5, for the current consumption growth beta is close to zero, with a value of 0.06.

In the case of future consumption growth, the betas for long-term losers are significantly more positive than those for long-term winners, with an average difference of 1.66. As such, past losers are more sensitive to shocks to future consumption growth opportunities. These results show that the factor that allows the consumption-based model to explain the long-term return reversal anomaly is essentially news about future consumption growth factor. Put differently, the evidence on factor betas explains why the suggested consumption two-beta model can explain the long-term return reversal effect significantly better than the standard consumption CAPM can.

Why are long-term losers riskier than long-term winners? Firms with a consistent stock price decreases for several years are likely to experience a long sequence of negative cash flow shocks, whereas firms with a consistent stock price increases for several years are likely to experience a long sequence of positive cash flow shocks. As such, long-term losers should have higher risk exposure to news about the future prospects of consumption growth than long-term winners.

5 Conclusion

In this paper, we derive and test a consumption-based intertemporal asset pricing model in which an asset earns a risk premium if it performs poorly when the expected future consumption growth deteriorates. The predictability in the consumption growth combined with the recursive preference delivers revisions in expected future consumption growth an additional risk factor, in addition to revisions in current consumption growth. This paper contributes to the literature by empirically demonstrating that the consumption-based model can be dramatically improved if we consider implications of time-variation in expected future consumption growth for asset pricing.

We model the consumption growth dynamics using a vector autoregressive (VAR) structure with a set of instrumental variables commonly used for forecasting future economic growth. Empirically, we find that future consumption growth is strongly predicted by current economic conditions. This evidence is important, since if the consumption growth rate cannot be predicted, news about future consumption growth will have zero risk prices. Thus, the model collapses to the standard consumption CAPM.

We estimate and test our consumption-based intertemporal asset pricing model with 25 portfolios sorted on size and book-to-market and 25 portfolios sorted on size and long-term return reversal. The cross-sectional tests with generalized method of moments (GMM) show that the model explains a significant fraction of the dispersion in average excess returns of the two test assets, with explanatory ratios varying between 65% and 79%. In addition, revisions in expected future consumption growth is significantly priced, and seems to drive most of the explanatory power in explaining the cross-section of average returns, while revisions in current consumption growth seems to play a secondary role. Finally, the suggested model compares favorably with the CAPM, intertemporal CAPM, and standard consumption CAPM.

The suggested model can be extended by allowing the volatility of consumption growth to be time-varying. Following Campbell (1993, 1996), we maintain the assumption of constant consumption growth volatility. Given the evidence of time-variation in consumption growth volatility, it seems natural to study their asset pricing implications. With the heteroskedasticity assumption on consumption growth, revisions in expectation of future consumption growth volatility will appear as an additional risk factor. Extending the model along this dimension and examining the empirical performance of the extended model could be interesting.

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Table 1
Descriptive Statistics for VAR State Variables

The table reports the descriptive statistics of the VAR state variables used to predict to future consumption growth. Δc_t is the log consumption growth. DIV_t is the aggregate dividend yield, computed as the sum of dividends over the last one-year divided by the price level of the CRSP value-weighted portfolio. DEF_t is the default spread, measured as the difference between the the yield spread between Moody's BAA and AAA corporate bonds. $RREL_t$ is the relative T-bill rate, calculated as the difference between the three-month Treasury bill rate and its moving average over the previous one-year. $TERM_t$ is the term spread, measured as the difference between ten-year government bonds yields and three-month government bonds yields. The sample period is from 1963:Q3 to 2010:Q4.

Panel A

Variables	Mean	Std.	Min.	Max.	AR(1)
Δc_t	0.005	0.006	-0.018	0.021	0.480
DIV_t	0.030	0.011	0.011	0.055	0.965
DEF_t	0.010	0.005	0.003	0.034	0.865
$RREL_t$	0.000	0.009	-0.041	0.036	0.452
$TERM_t$	0.015	0.013	-0.027	0.044	0.806

Panel B

	Δc_t	DIV_t	DEF_t	$RREL_t$	$TERM_t$
Δc_t	1.00	-0.10	-0.36	0.20	0.02
DIV_t		1.00	0.44	0.04	-0.08
DEF_t			1.00	-0.33	0.28
$RREL_t$				1.00	-0.53
$TERM_t$					1.00

Table 2
VAR Parameter Estimates

Panel A shows the estimate results for a first-order VAR model where the state variables are a constant, the log consumption growth rate (Δc_t), dividend yield (DIV_t), default spread (DEF_t), relative T-bill rate ($RREL_t$), and term spread ($TERM_t$). Each set of five rows corresponds to a different dependent variable. The first six columns report coefficients and *t*-value of the six explanatory variables, and the remaining column shows R^2. Panel B shows the correlation matrix of the shocks with shock standard deviations on the diagonal. The sample period is from 1963:Q3 to 2010:Q4.

Panel A: VAR parameter estimates							
	Δc_t	DIV_t	DEF_t	$RREL_t$	$TERM_t$	Constant	R^2
Δc_{t+1}	0.47	0.04	-0.21	-0.15	0.05	0.33	0.28
	(6.85)	(1.00)	(-2.20)	(-2.96)	(1.39)	(2.52)	
DIV_{t+1}	-0.01	0.97	-0.03	0.04	-0.02	0.14	0.94
	(-0.37)	(45.68)	(-0.47)	(1.32)	(-0.81)	(1.85)	
DEF_{t+1}	-0.09	0.04	0.80	0.01	-0.01	0.14	0.76
	(-2.65)	(2.43)	(17.27)	(0.51)	(-0.48)	(2.27)	
$RREL_{t+1}$	0.26	0.01	-0.15	0.43	0.05	-0.11	0.23
	(2.36)	(0.18)	(-0.96)	(5.49)	(1.03)	(-0.53)	
$TERM_{t+1}$	-0.18	-0.06	0.37	0.14	0.82	0.17	0.67
	(-1.66)	(-1.04)	(2.45)	(1.85)	(16.00)	(0.82)	

Panel B: Corr/Std matrix of shocks					
	Δc_t	DIV_t	DEF_t	$RREL_t$	$TERM_t$
Δc_t	0.48	-0.12	-0.33	0.20	-0.10
DIV_t	-0.12	0.27	0.07	0.23	-0.08
DEF_t	-0.33	0.07	0.23	-0.27	0.11
$RREL_t$	0.20	0.23	-0.27	0.76	-0.77
$TERM_t$	-0.10	-0.08	0.11	-0.77	0.74

Table 3
Current and Long-run Consumption Growth Innovations

The table reports the properties of current consumption growth shock (CCS) and long-run consumption growth shock (LRCS) estimated from the VAR model of Table 2. The upper-left section of the table reports the covariance matrix of the two consumption growth shocks. The upper-right section reports the correlation matrix of the two shocks with standard deviations on the diagonal. The lower-left section reports the correlation of shocks to individual state variables with the consumption growth shocks. The lower-right section reports the column vectors that map the state variable shocks to consumption growth shocks. Δc_t is the log consumption growth. DIV_t is the aggregate dividend yield. DEF_t is the default spread. $RREL_t$ is the relative T-bill rate. $TERM_t$ is the term spread. The sample period is from 1963:Q3 to 2010:Q4.

News covariance	CCS	LRCS	News corr/std	CCS	LRCS
CCS	0.23	0.15	CCS	0.48	0.54
LRCS	0.15	0.34	LRCS	0.54	0.59

Shock correlations	CCS	LRCS	Functions	CCS	LRCS
Δc_t	1.00	0.54	Δc_t	1.00	0.71
DIV_t	-0.12	-0.21	DIV_t	0.00	0.05
DEF_t	-0.33	-0.35	DEF_t	0.00	-0.85
$RREL_t$	0.20	-0.59	$RREL_t$	0.00	-0.36
$TERM_t$	-0.10	0.69	$TERM_t$	0.00	0.34

Table 4

Estimation of Factor Risk Premia Using GMM

The table reports the estimation and evaluation results for the CAPM, Interteporal CAPM (ICAPM), Consumption CAPM (CCAPM), and Long-Run Consumption CAPM (LR-CCAPM). The testing portfolios are the 25 size/book-to-market portfolios (SBM25, Panel A) and the 25 size/long term return reversal portfolios (SLTR25, Panel B). The estimation procedure is first-stage GMM. CMS and LRMS are the risk prices associated with news about current and long-run future stock returns, respectively. CCS and LRCS are the risk prices associated with news about current and long-run consumption growth, respectively. Standard deviations are reported in parentheses. MAE refers to the mean absolute pricing error (in %), and R^2 is 1 minus the ratio of the cross-sectional variance of the pricing errors to the cross-sectional variance of realized average portfolio returns. The *p*-values for the *J*-test (test of over-identifying restrictions) are reported in parentheses. The sample period is from 1963:Q3 to 2010:Q4.

Panel A: SBM25				
Factor Price	CAPM	ICAPM	CCAPM	LR-CCAPM
CMS	2.43	-14.60		
	(0.93)	(3.38)		
LRMS		-27.72		
		(5.54)		
CCS			92.98	-208.99
			(29.39)	(57.72)
LRCS				243.14
				(49.54)
MAE (%)	0.61	0.43	0.44	0.27
R^2	-0.17	0.48	0.27	0.79
J-test	78.75	83.11	75.16	45.04
	(0.00)	(0.00)	(0.00)	(0.00)
Panel B: SLTR25				
Factor Price	CAPM	ICAPM	CCAPM	LR-CCAPM
CMS	2.19	8.87		
	(0.93)	(3.34)		
LRMS		10.58		
		(5.25)		
CCS			55.68	-202.67
			(33.56)	(60.64)
LRCS				222.87
				(45.31)
MAE (%)	0.46	0.39	0.42	0.25
R^2	0.17	0.36	0.35	0.73
J-test	62.93	62.24	57.80	49.88
	(0.00)	(0.00)	(0.00)	(0.00)

Table 5
Realized Returns versus Expected Returns

The table reports realized returns, expected returns, and pricing errors for long-short portfolioswithin each size quintile. The assets are the 25 size/book-to-market portfolios (SBM25, Panel A) and the 25 size/long term return reversal portfolios (SLTR25, Panel B). Column $\bar{R}_{VMG}$ ($\bar{R}_{LMW}$) reports realized return on the value-minus-growth (long-term losers-minus-winners) portfolios. Column $E[R]_{VMG}$ ($E[R]_{LMW}$) reports expected returns on the value-minus-growth (long-term losers-minus-winners) portfolios implied from the LR-CCAPM. Column α denotes pricing error, defined as the differences between realized and expected return. $t(\alpha)$ reports the *t*-statistics for α. The sample period is from 1963:Q3 to 2010:Q4.

Panel A: SBM25					
	$\bar{R}_{VMG}$	$E[R]_{VMG}$	α_{VMG}	$t(\alpha_{VMG})$	$E[R_{VMG}]/\bar{R}_{VMG}$
S1	2.64	2.05	0.59	1.06	78%
S2	1.69	1.72	-0.04	-0.05	102%
S3	1.81	0.77	1.04	1.52	42%
S4	0.80	1.50	-0.70	-0.98	187%
S5	0.43	0.68	-0.26	-0.32	161%
Panel B: SLTR25					
	$\bar{R}_{LMW}$	$E[R]_{LMW}$	α_{LMW}	$t(\alpha_{LMW})$	$E[R_{LMW}]/\bar{R}_{LMW}$
S1	2.01	1.15	0.85	1.01	57%
S2	1.49	1.54	-0.05	-0.06	103%
S3	1.05	0.44	0.61	0.68	42%
S4	1.06	1.32	-0.26	-0.27	125%
S5	1.10	0.60	0.50	0.53	55%

Table 6
Factor Betas

The table reports the average excess returns of test assets and the betas of the excess returns on the factors in the LR-CCAPM estimated by GMM. The testing portfolios are the 25 size/book-to-market portfolios (SBM25, Panel A) and the 25 size/long term return reversal portfolios (SLTR25, Panel B). The factors are news about current consumption growth (CCS) and long-run consumption growth (LRCS). BM1 (LTR1) denotes the lowest BM (LTR) quintile. The column labeled BM5-BM1 denotes the spread in beta estimates between the largest and lowest BM quintiles. The column labeled LTR1-LTR5 denotes the spread in beta estimates between the lowest and largest LTR quintiles. "Mean" is the respective average across size quintiles. The sample period is from 1963:Q3 to 2010:Q4.

Panel A: SBM25						
Average Excess Return (%)						
	BM1	BM2	BM3	BM4	BM5	BM5-BM1
S1	0.90	2.45	2.55	3.05	3.54	2.64
S2	1.36	2.12	2.77	2.76	3.05	1.69
S3	1.35	2.19	2.26	2.55	3.16	1.81
S4	1.65	1.57	1.97	2.43	2.45	0.80
S5	1.16	1.32	1.19	1.42	1.59	0.43
Mean						1.47
Betas on CCS						
	BM1	BM2	BM3	BM4	BM5	BM5-BM1
S1	7.22	5.57	3.54	3.17	3.93	-3.29
S2	4.29	2.99	2.21	1.68	2.28	-2.01
S3	3.38	2.41	1.93	1.39	1.77	-1.62
S4	3.09	2.62	1.72	0.45	2.10	-1.00
S5	1.66	0.69	1.76	0.92	2.20	0.54
Mean						-1.47
Betas on LRCS						
	BM1	BM2	BM3	BM4	BM5	BM5-BM1
S1	3.42	4.05	4.95	4.78	6.32	2.90
S2	2.81	4.01	4.46	5.18	5.39	2.58
S3	3.16	3.83	3.84	4.80	4.13	0.97
S4	2.66	2.84	4.05	4.81	5.05	2.39
S5	1.89	1.55	1.10	2.93	3.11	1.22
Mean						2.01

Table 6 (Continued)
Factor Betas

Panel B: SLTR25						
Average Excess Return (%)						
	LTR1	LTR2	LTR3	LTR4	LTR5	LTR1-LTR5
S1	3.43	2.66	2.94	2.46	1.43	2.01
S2	3.43	2.45	2.77	2.72	1.94	1.49
S3	2.98	2.63	2.34	2.27	1.93	1.05
S4	2.66	2.03	2.11	2.03	1.59	1.06
S5	2.09	1.69	1.45	1.24	0.99	1.10
Mean						1.34
Betas on CCS						
	LTR1	LTR2	LTR3	LTR4	LTR5	LTR1-LTR5
S1	5.44	2.90	2.23	2.23	4.15	1.29
S2	3.67	2.03	1.28	1.78	3.84	-0.18
S3	3.73	1.41	0.61	2.04	3.35	0.38
S4	2.34	0.91	0.55	1.32	3.54	-1.19
S5	2.36	1.06	0.92	0.66	2.36	0.00
Mean						0.06
Betas on LRCS						
	LTR1	LTR2	LTR3	LTR4	LTR5	LTR1-LTR5
S1	6.54	5.29	4.82	5.01	4.54	2.00
S2	6.21	4.92	4.11	4.50	3.67	2.54
S3	4.51	4.78	4.00	3.67	3.78	0.72
S4	4.93	3.99	3.94	3.46	2.85	2.08
S5	2.82	3.04	1.64	1.40	1.86	0.96
Mean						1.66

Table 7

Estimation of Factor Risk Premia: Alternative VAR Specifications

The table reports the estimation and evaluation results for the Long-Run Consumption CAPM, based on alternative VAR specifications. The first VAR specification follows Campbell (1996) (column labelled as C), in which (i) the dividend yield on the CRSP value-weighted index, (ii) the relative T-bill rate, and (iii) the yield spread between long- and short-term government bonds are state variables. The second VAR specification follows Campbell and Vuolteenaho (2004) (column labelled as CV), in which (i) the price-earnings ratio (measured as the ratio of the S&P 500 price index to a ten-year moving average of S&P 500 earnings), (ii) the yield spread between long-term and short-term bonds, and (iii) the value spread are state variables. The third VAR specification follows Campbell, Giglio, Polk, and Turley (2012) (column labelled as CGPT), in which (i) the price-earnings ratio, (ii) the term yield spread, (iii) the value spread, and (iv) the default spread are state variables. The testing portfolios are the 25 size/book-to-market portfolios (SBM25, Panel A) and the 25 size/long term return reversal portfolios (SLTR25, Panel B). The estimation procedure is first-stage GMM. CCS and LRCS are the risk prices associated with news about current and long-run consumption growth, respectively. Standard deviations are reported in parentheses. MAE refers to the mean absolute pricing error (in %), and R^2 is 1 minus the ratio of the cross-sectional variance of the pricing errors to the cross-sectional variance of realized average portfolio returns. The *p*-values for the *J*-test (test of over-identifying restrictions) are reported in parentheses. The sample period is from 1963:Q3 to 2010:Q4.

Panel A: SBM25			
Factor Price	C	CV	CGPT
CCS	-229.57	-286.69	-282.61
	(125.68)	(153.82)	(160.44)
LRCS	322.49	282.26	275.40
	(116.31)	(119.21)	(113.57)
MAE (%)	0.30	0.33	0.30
R^2	0.77	0.69	0.74
J-test	44.51	26.22	26.88
	(0.00)	(0.29)	(0.26)
Panel B: SLTR25			
Factor Price	C	CV	CGPT
CCS	-142.06	-209.16	-211.83
	(81.03)	(110.45)	(114.81)
LRCS	256.77	232.99	230.00
	(94.93)	(86.09)	(84.63)
MAE (%)	0.28	0.28	0.27
R^2	0.65	0.65	0.67
J-test	51.48	48.30	51.39
	(0.00)	(0.00)	(0.00)

Table 8
Estimation of Factor Risk Premia: Alternative Portfolios

The table reports the estimation and evaluation results for the Long-Run Consumption CAPM using an alternative set of test portfolios. The first test assets consist of 10 size portfolios, 10 book-to-market portfolios, and 10 long term return reversal portfolios (S10+BM10+LTR10, Panel A). The second test assets consist of 25 size/book-to-market portfolios and 7 bond portfolios (SBM25+Bond7, Panel B). The estimation procedure is first-stage GMM. CCS and LRCS are the risk prices associated with news about current and long-run consumption growth, respectively. Standard deviations are reported in parentheses. MAE refers to the mean absolute pricing error (in %), and R^2 is 1 minus the ratio of the cross-sectional variance of the pricing errors to the cross- sectional variance of realized average portfolio returns. The *p*-values for the *J*-test (test of over-identifying restrictions) are reported in parentheses. The sample period is from 1963:Q3 to 2010:Q4.

Panel A: S10+BM10+LTR10				
Factor Price	CAPM	ICAPM	CCAPM	LR-CCAPM
CMS	2.34	7.97		
	(0.94)	(5.52)		
LRMS		9.56		
		(9.10)		
CCS			146.79	-166.63
			(54.99)	(51.51)
LRCS				224.70
				(47.60)
MAE (%)	0.30	0.29	0.29	0.19
R^2	0.25	0.37	0.38	0.71
J-test	24.39	24.73	26.21	25.06
	(0.71)	(0.64)	(0.61)	(0.62)
Panel B: SBM25+Bond7				
Factor Price	CAPM	ICAPM	CCAPM	LR-CCAPM
CMS	2.32	-7.37		
	(0.84)	(2.59)		
LRMS		-15.40		
		(3.89)		
CCS			110.20	-145.51
			(33.62)	(111.94)
LRCS				216.70
				(88.25)
MAE (%)	0.52	0.41	0.43	0.26
R^2	0.52	0.74	0.66	0.88
J-test	99.33	102.82	110.58	63.74
	(0.00)	(0.00)	(0.00)	(0.00)

Table 9
Estimation of Factor Risk Premia: Expected Return-Beta Representation

The table reports the estimation and evaluation results for the CAPM, Interteporal CAPM (ICAPM), Consumption CAPM (CCAPM), and Long-Run Consumption CAPM (LR-CCAPM). The testing portfolios are the 25 size/book-to-market portfolios (SBM25, Panel A) and the 25 size/long term return reversal portfolios (SLTR25, Panel B). The estimation procedure is the time-series/cross-sectional regressions approach. CMS and LRMS are the beta risk premia associated with news about current and long-run future stock returns, respectively. CCS and LRCS are the beta risk premia associated with news about current and long-run consumption growth, respectively. Standard deviations are reported in parentheses. MAE refers to the mean absolute pricing error (in %), and R^2 is 1 minus the ratio of the cross-sectional variance of the pricing errors to the cross-sectional variance of realized average portfolio returns. The *p*-values for the *J*-test (test of over-identifying restrictions) are reported in parentheses. The sample period is from 1963:Q3 to 2010:Q4.

Panel A: SBM25				
Risk Premium	CAPM	ICAPM	CCAPM	LR-CCAPM
CMS	1.85	-6.82		
	(0.68)	(5.20)		
LRMS		-6.98		
		(4.06)		
CCS			0.38	-0.46
			(0.14)	(0.20)
LRCS				0.89
				(0.19)
MAE (%)	0.66	0.67	0.61	0.27
R^2	-0.34	-0.25	-0.34	0.76
Panel B: SLTR25				
Risk Premium	CAPM	ICAPM	CCAPM	LR-CCAPM
CMS	2.03	7.00		
	(0.68)	(4.60)		
LRMS		3.97		
		(3.48)		
CCS			0.43	-0.45
			(0.14)	(0.15)
LRCS				0.88
				(0.18)
MAE (%)	0.48	0.45	0.55	0.25
R^2	0.09	0.13	-0.06	0.69

Table 10
Estimation of Factor Risk Premia: Second Stage GMM

The table reports the estimation and evaluation results for the CAPM, Interteporal CAPM (ICAPM), Consumption CAPM (CCAPM), and Long-Run Consumption CAPM (LR-CCAPM). The testing portfolios are the 25 size/book-to-market portfolios (SBM25, Panel A) and the 25 size/long term return reversal portfolios (SLTR25, Panel B). The estimation procedure is second-stage (optimal) GMM. CMS and LRMS are the risk prices associated with news about current and long-run future stock returns, respectively. CCS and LRCS are the risk prices associated with news about current and long-run consumption growth, respectively. Standard deviations are reported in parentheses. MAE refers to the mean absolute pricing error (in %), and R^2 is 1 minus the ratio of the cross-sectional variance of the pricing errors to the cross-sectional variance of realized average portfolio returns. The *p*-values for the *J*-test (test of over-identifying restrictions) are reported in parentheses. The sample period is from 1963:Q3 to 2010:Q4.

Panel A: SBM25				
Factor Price	CAPM	ICAPM	CCAPM	LR-CCAPM
CMS	2.43	-14.60		
	(0.93)	(3.38)		
LRMS		-27.72		
		(5.54)		
CCS			92.98	-208.99
			(29.39)	(57.72)
LRCS				243.14
				(49.54)
Panel B: SLTR25				
Factor Price	CAPM	ICAPM	CCAPM	LR-CCAPM
CMS	2.19	8.87		
	(0.93)	(3.34)		
LRMS		10.58		
		(5.25)		
CCS			55.68	-202.67
			(33.56)	(60.64)
LRCS				222.87
				(45.31)