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New Evidence from the Cross-Section of Stock Returns

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Abstract

This paper presents an empirical evaluation of recently proposed asset pricing models which extend the standard preference specification by a reference level of consumption. We motivate an alternative model that accounts for the return on human capital as a determinant of the reference level. Our analysis is based on a broad cross-section of test assets, which provides a level playing field for a comparison to established benchmark models. The reference level model extended by human capital does a good job in explaining size and value premia. Estimated on Fama and French's size and book-to-market sorted portfolios, it outperforms Lettau and Ludvigson's scaled CCAPM and delivers average pricing errors comparable to the Fama-French three-factor model.

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1 Introduction

Despite its theoretical appeal, the consumption-based asset pricing model (CCAPM) has achieved little empirical success in calibration exercises or formal econometric testing (See e.g. Hansen and Singleton 1982; Mehra and Prescott 1985; Cochrane 1996 or Lettau and Ludvigson 2001a). The empirical failure of the model has sparked a wave of research over the past 20 years aimed at improving the canonical CCAPM and making the model consistent with empirical facts.

This paper presents an empirical evaluation of recently proposed asset pricing models which extend investor preferences by a reference level of consumption. We also motivate an alternative model that accounts for the return on human capital as a determinant of the reference level. So far, the conditional implications of asset pricing models with a reference level have been tested using a market portfolio proxy and the Treasury-Bill as basic test assets. In our empirical investigation we use a broad cross-section of test assets, the 25 Fama-French portfolios sorted by size and book-to-market. This provides a level playing field for a comparison of reference level asset pricing models to well-established benchmark models like Lettau-Ludvigson's scaled CCAPM and the Fama-French three factor model.

Our paper contributes to the literature which tackles the empirical shortcomings of consumption-based asset pricing by modifying investor's preferences. Examples include the model proposed by Epstein and Zin (1989) who disentangle risk aversion and intertemporal substitution via a recursive utility specification and the literature on habit formation (e.g. Abel 1990; Constantinides 1990; Ferson and Constantinides 1991; Campbell and Cochrane 1999). The central idea of habit models is that consumers become accustomed to a certain standard of living and that their well-being depends on how much can be consumed relative to a reference level. The models considered in this paper are based on the notion of external habit formation. This implies that the reference level is not affected by the investor's decisions but depends on past aggregate consumption and can be interpreted as the benchmark level for the society as a whole. External habit formation expresses the idea that people wish to maintain their relative standing in society often referred to as "Catching up with the Joneses" behavior, as noted in Abel (1990).[1] When habit is a function not only of past but also of current consumption, this leads to the more general "Keeping up with the Joneses" specification as in Campbell and Cochrane (1999). An important implication of this model is the counter-cyclical variation of risk-aversion that depends on the state of the economy.

In this paper we focus on a class of consumption-based asset pricing models with a reference level introduced by Garcia et al. (2003).[2] In their framework, consumer preferences depend both on consumption relative to a reference level and the benchmark level itself. The reference level is modeled as a function of both past and current variables. Garcia et al. (2003) estimate their models using a reduced set of test assets: a market portfolio proxy and the Treasury-Bill rate. We extend their analysis by estimating and testing several asset pricing models with a reference level using the 25 Fama and French portfolios sorted according to size and book-to-market as test assets. Thereby, we test whether these models can account for the size and value premia in the cross-section of stock returns. The empirical performance of the reference level models is compared to classic and important recent asset pricing models like the Fama-French three factor model, which represents the natural benchmark when size and book-to-market sorted portfolios are used as test assets. Since Lettau and Ludvigson's (2001a) *cay*-scaled CCAPM does a particularly good job in pricing the 25 Fama-French portfolios and is also solely based on macroeconomic factors it serves as another important benchmark model. Our paper is rooted in the empirical literature on representative agent models which are estimated using aggregate consumption data as pioneered by Hansen and Singleton (1982). As pointed out by Cochrane (2006), earlier papers mainly

[1]Thus, asset pricing models with a reference level are also related to the strand of literature on social status and relative wealth as in the seminal paper by Bakshi and Chen (1996). For a recent paper investigating investors' portfolio allocation decisions when investors care about their social status, see e.g. Roussanov (2008).

[2]Alternative interesting approaches have been recently pursued in the literature. Chen and Ludvigson (2003) evaluate the Campbell and Cochrane (1999) model using a non-parametric specification of habit. Chen and Pakos (2006) motivate a linear factor model specification derived from the habit model by Campbell and Cochrane (1999). Yogo (2006a) proposes a consumption based model with a reference level in which a gains-loss utility function derived from behavioral and psychological considerations (loss aversion) is motivated.

looked at statistical rejections and only considered a few test assets. Recent contributions by Yogo (2006b) and Piazzesi et al. (2007) also focus on the economic significance of analyzing pricing errors (via root mean square error (RMSE) comparisons and pricing error plots) for a broader set of interesting portfolios. This paper is written in the same vein. It contributes to the literature by proposing an alternative specification that includes human capital as a determinant of the reference level. Classic papers have emphasized the role of human capital in asset pricing. Most prominently, Roll (1977) argues that a value-weighted stock market portfolio may not be an adequate proxy for the total wealth portfolio since the human capital component of aggregate wealth is neglected. Important contributions which take these implications into account for their empirical work include Jagannathan and Wang (1996), Lettau and Ludvigson (2001a). Recently, the work by Dittmar (2002) shows that integrating a measure of human capital into the stochastic discount factor is essential for pricing the cross-section of stock returns.

The main results of this paper can be summarized as follows. Asset pricing models which account for a reference level of consumption considerably improve the empirical performance of the standard CCAPM. It is essential, however, to account for human capital growth in the reference level specification. The reference level model extended by human capital delivers encouraging results from an economic perspective as well as in terms of explanatory power. The result that consumption close to or below the (estimated) reference level coincides with downturns in economic activity shows the link of the pricing kernel and the real economy. Estimated on the 25 Fama-French portfolios, the model extended by human capital outperforms Lettau and Ludvigson's scaled CCAPM and delivers average pricing errors comparable to the Fama-French three-factor model.

The remainder of the paper is organized as follows. Section 2 reviews the theoretical framework. Section 3 presents data, estimation results, and compares the empirical performance of asset pricing models with a reference level to benchmark linear factor models. Section 4 concludes.

2 Asset Pricing with a Reference Level of Consumption

In this section we review the theoretical framework of consumption-based asset pricing with a reference level introduced by Garcia et al. (2003). First, a few fundamental concepts are discussed. Then we turn to the modeling strategy of the reference level and propose a specification which accounts for human capital in the reference level.

2.1 Basic Concepts

Consumption-based asset pricing models with a reference level are best written in their stochastic discount factor representation. When the law of one price holds, there exists a stochastic discount factor (SDF) M_{t+1} that prices returns:

$$E[M_{t+1}R^i_{t+1}|\mathcal{F}_t] = 1. \tag{1}$$

R^i_{t+1} denotes the gross-return of asset i ($i = 1, \ldots, N$). $\mathcal{F}_t$ represents the investor's time t information set. The basic setting for asset pricing models with a reference level builds on classic consumption-based asset pricing, where Equation (1) results from the first order conditions of an intertemporal consumption allocation problem with time-separable utility. The stochastic discount factor can then be interpreted as the marginal rate of substitution, $M_{t+1} = \delta \frac{U'(C_{t+1})}{U'(C_t)}$, where δ denotes the subjective discount factor and $U(\cdot)$ is the period utility function. Assuming a power utility specification $U(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma}$ with γ as the relative risk aversion (RRA) parameter the SDF is then given by

$$M_{t+1} = \delta \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma}. \tag{2}$$

Asset pricing models with a reference level retain this basic framework but modify the period utility function. Garcia et al. (2003) advocate a specification where utility does not only depend on consumption C_t but also on consumption relative to a reference level X_t.

Their ratio specification is similar to Abel (1999). The reference level X_t also enters the utility function in its absolute level,

$$U(C_t/X_t, X_t) = \frac{\left(\frac{C_t}{X_t}\right)^{1-\gamma} X_t^{1-\psi}}{\text{sign}(1-\gamma)\text{sign}(1-\psi)}, \tag{3}$$

where $\text{sign}(z) = 1$ if $z \geq 0$ and $\text{sign}(z) = -1$ if $z < 0$, which ensures that utility is defined for all parameter values of interest. The parameter ψ controls the curvature of utility over the benchmark level. Several alternative specifications are nested as special cases. With $\psi = \gamma$, Equation (3) reduces to the power-utility CCAPM. With $\psi = 1$, the reference level itself does not enter the utility function directly and investor utility depends solely on consumption relative to her benchmark. The reference level is assumed to be related to aggregate consumption by identity in conditional expectations, i.e.

$$E_t(X_{t+\tau}) = E_t(C_{t+\tau}) \quad \forall\, \tau \geq 0. \tag{4}$$

The reference level is considered to be external by the investor. It is conceived as a societal standard which the investor views as a benchmark for her consumption decision. The SDF implied by Equation (3) then takes the following form:

$$M_{t+1} = \delta \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} \left(\frac{X_{t+1}}{X_t}\right)^{\gamma-\psi}. \tag{5}$$

To provide an empirically testable model, further assumptions regarding the evolution of the reference level X_t are necessary.

2.2 Modeling the Reference Level

Garcia et al. (2003) distinguish between two possible modeling strategies. First, they assume that the investor only has information up to period t when forming her reference level for period $t+1$. It is assumed to be equal to the conditional expectation of the future consumption level, where the time t information set only includes past realizations of consumption levels, i.e. $X_{t+1} = E(C_{t+1}|C_t, C_{t-1}, \ldots)$. This is consistent with Equation (4) for horizon $\tau = 1$. Garcia et al. (2003) assume that the reference level reacts slowly to changes in consumption. Assuming adaptive expectations, a change in the reference level is a function of the error when forming the reference level in the previous period, $\Delta X_{t+1} = \rho(C_t - X_t)$. Allowing for a constant a and iterating forward on $X_{t+1} = a + \rho C_t + (1-\rho)X_t$, one obtains

$$X_{t+1} = \frac{a}{\rho} + \rho \sum_{i=0}^{\infty} (1-\rho)^i C_{t-i}. \tag{6}$$

In this specification, which we refer to as "pure habit formation" model, the reference level depends on past realizations of consumption with declining weights, similar to the case considered by Constantinides (1990).

In a second modeling strategy Garcia et al. (2003) assume that the investor can use some information available in $t+1$ when forming the reference level X_{t+1}. Specifically, they argue that the return on the wealth portfolio is an important variable that affects the reference level. In this respect the model by Garcia et al. (2003) bears a strong resemblance to the model by Bakshi and Chen (1996) in which the return on the wealth portfolio emerges as an important determinant of the stochastic discount factor.

As pointed out above, classic and recent literature suggests that the return on human capital should be taken into account, too. Roll's (1977) paper is the seminal point of reference, while Jagannathan and Wang (1996) re-emphasize that aggregate wealth also contains a human capital component. Lettau and Ludvigson (2001a) also estimate a "Scaled Human Capital CAPM" and Dittmar (2002) shows the importance of incorporating human capital into the pricing kernel. If "human capital matters", then it seems natural that the reference level is also determined by the return on human capital. When financial and non-financial wealth increases, the investor adjusts her benchmark to a higher level. The following equation for the log change of the reference level, Δx_{t+1}, takes these considerations into account:

$$\Delta x_{t+1} = a_0 + \sum_{i=1}^{n} a_i \Delta c_{t+1-i} + b r^m_{t+1} + c r^{hc}_{t+1}. \tag{7}$$

Δx_{t+1} denotes log consumption growth and r^m_{t+1} the log return on financial assets (market portfolio).[3] r^{hc}_{t+1} is the log return on human capital. We refer to the combination of Equation (7) and the SDF in Equation (5) as the "Human Capital-Extended (HCE) model".

Following Garcia et al. (2003), we assume that consumption growth equals the growth rate of the reference level plus noise. Hence, combining Equation (7) and Equation (4) at horizon $\tau = 1$, it follows that

$$\Delta c_{t+1} = a_0 + \sum_{i=1}^{n} a_i \Delta c_{t+1-i} + b r^m_{t+1} + c r^{hc}_{t+1} + \epsilon_{t+1}. \tag{8}$$

where ϵ_{t+1} is an orthogonal innovation. Reference level growth can then be written as

$$\frac{X_{t+1}}{X_t} = A \prod_{i=1}^{n} \left[\frac{C_{t+1-i}}{C_{t-i}} \right]^{a_i} \left(R^m_{t+1} \right)^b \left(R^{hc}_{t+1} \right)^c, \tag{9}$$

where $A = \exp(a_0)$. Inserting Equation (9) into Equation (5), the SDF of the HCE model is given by

$$M_{t+1} = \delta A^{\gamma-\psi} \left[\frac{C_{t+1}}{C_t} \right]^{-\gamma} \prod_{i=1}^{n} \left[\frac{C_{t+1-i}}{C_{t-i}} \right]^{a_i(\gamma-\psi)} \left(R^m_{t+1} \right)^{b(\gamma-\psi)} \left(R^{hc}_{t+1} \right)^{c(\gamma-\psi)}. \tag{10}$$

Defining $\delta^* = \delta A^{\gamma-\psi}$ and $\kappa = b(\gamma - \psi)$, Equation (10) can be then rewritten as

$$M_{t+1} = \delta^* \left[\frac{C_{t+1}}{C_t} \right]^{-\gamma} \prod_{i=1}^{n} \left[\frac{C_{t+1-i}}{C_{t-i}} \right]^{a_i(\gamma-\psi)} \left(R^m_{t+1} \right)^{\kappa} \left(R^{hc}_{t+1} \right)^{\frac{\kappa c}{b}}. \tag{11}$$

Garcia et al. (2003) show that the elasticity of intertemporal substitution implied by

[3] Throughout this paper we use lower case letters to denote natural logs of the respective variable.

Equation (11) is given by $\sigma = \frac{1+b(\gamma-\psi)}{\gamma} = \frac{1+\kappa}{\gamma}$.[4] Hence, testing whether κ equals zero means testing whether the elasticity of intertemporal substitution is the inverse of the coefficient of relative risk aversion as implied by the standard CCAPM with power-utility.

The SDF representation in Equation (11) is a general specification that nests various models proposed in the asset pricing literature as special cases. We will deal with these models in the following section.

3 Empirical Analysis and Results

3.1 A Level Playground

This subsection describes the data used in the empirical analysis. By focussing on tests assets and data which have been used in previous empirical studies, we intend to establish a level playing field on which the different models can show their relative merits and model performance can be compared. We use data from 1951:Q4-2005:Q1, the longest sample period for which observations of all variables are available. The main test assets are the 25 Fama and French portfolios sorted by size and book-to-market. We thereby assess whether reference level models can account for the size and value premia in the cross-section of stock returns. The repository of these data is Kenneth French's homepage.[5] We convert the monthly return series into quarterly frequency in order to match the sampling frequency of the macro variables. Nominal returns are converted into real returns by deflating the nominal returns by the price index for personal consumption expenditures (taken from the NIPA tables).

Kenneth French's homepage also serves as the source for other test asset portfolios sorted by size, book-to-market ratio, earnings-price ratio, cash flow-price ratio (ten portfolios, re-

[4]See Garcia et al. (2003) and Garcia et al. (2006) for further details. They also show that a separation between risk aversion and intertemporal substitution is only possible when the reference level not only depends on past but also on contemporaneous variables.

[5]`http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html`

spectively), as well as the Fama-French factors (SMB, HML). The return on the market portfolio is the value-weighted return on all stocks traded on NYSE, AMEX, and NASDAQ; the short term interest rate is the one-month Treasury-Bill from Ibbotson Associates (both series were also taken from Kenneth French's homepage).

The focus of the paper lies on cross-sectional tests of reference level models, but we also perform tests with conditioning variables. This is equivalent to testing how the models succeed in explaining the returns of so-called "managed portfolios" (see Cochrane, 1996). For the construction of managed portfolios we use two sets of instruments. The first set of instruments includes the dividend yield on the S&P500 obtained from Reuters-Ecowin, the term spread, and the default spread which are known as typical predictor of stock returns (see, for instance, Fama and French, 1989). The term spread is defined as the difference of 10-Year Treasury Bond and three-month T-Bill yields. The default spread is the yield difference between BAA rated corporate bonds and AAA rated corporate bonds. As the second set of instruments we use three variables capturing the common variation in a broad set of 15 conditioning variables.[6] The data necessary for the construction of these series are obtained from Amit Goyal's website. Information on the conditioning variable *cay* comes from Sydney Ludvigson's website. Lettau and Ludvigson (2001a; 2001b) compute the *cay* series as the residual from the cointegrating relationship between consumption, asset income and labor income.

Consumption and labor income (both real and per capita) are constructed from the US national accounts (NIPA tables). Consumption growth is constructed from seasonally adjusted non-durables and services consumption (NIPA table 2.3.5). Price indices for non-durables and services consumption (NIPA table 2.3.4) are used to deflate the series. The time series of labor income (NIPA table 2.1) is used to calculate the growth rate of labor income. Labor income is defined as wages and salaries plus transfer payments plus other labor income minus

[6]The 15 conditioning variables are the ones used by Goyal and Welch (2004) for studying the predictability of U.S. stock returns.

contributions to social insurance. The labor income series is deflated using the price index for personal consumption expenditures (NIPA table 2.3.4). Both real consumption and labor income are expressed in per capita terms using population numbers taken from NIPA table 2.1. In order to reduce potential measurement errors of the return on human capital, we calculate labor income growth as a two-period moving average following Jagannathan and Wang (1996). We employ the contemporaneous timing convention of Heaton and Lucas (2000) and Wang (2005).

3.2 Empirical Setup

To compare the empirical performance of asset pricing models with a reference level, we round up the usual suspects. Along with the inevitable CAPM ($M_{t+1} = a + bR^m_{t+1}$), the power utility CCAPM ($M_{t+1} = \delta(\frac{C_{t+1}}{C_t})^{-\gamma}$) serves as the natural benchmark, but we also present results for empirically more successful models. These include Lettau-Ludvigson's scaled CCAPM ($M_{t+1} = a_0 + b_{cay}cay_t + b_{\Delta c}\Delta c_{t+1} + b_{\Delta c \cdot cay}\Delta c_{t+1}cay_t$) as well as the Fama-French three factor model ($M_{t+1} = a + b_m R^m_{t+1} + b_{SMB}SMB_{t+1} + b_{HML}HML_{t+1}$), which – estimated on its "home turf" (size and book-to-market sorted portfolios) – arguably represents the most challenging competitor. Given the proximity of the reference level framework to the literature on preferences where investors care about their social status, we also include the seminal model by Bakshi and Chen (1996) in our comparison.

In Section 3.3 we discuss results of cross-sectional tests. For GMM estimation we exploit the unconditional implications of the basic pricing equation (1). The aim is to investigate whether asset pricing models with a reference level of consumption are capable of explaining the well-known size and value premia in the US cross-section stock returns. We report both first stage and iterated GMM results. In order to guard against potential problems from time aggregation of consumption data, heteroskedasticity and autocorrelation consistent (HAC) standard errors are computed according to the Newey and West (1987) procedure with one lag (See Yogo 2006b). First-stage GMM, though less efficient, is preferable for model comparison since the average pricing errors for the test assets are identically weighted across all compared models. Estimation results for CCAPM and various reference level models are reported in Tables 1 through 3.[7]

As is common in the recent literature (see the literature review by Cochrane, 2006), we assess model performances by average pricing error comparisons and rank the models using root mean squared average pricing errors and Hansen-Jagannathan distance as performance criteria. Details on the computation of the Hansen-Jagannathan distance measure for non-linear SDF models are provided in the appendix. Figures 1 and 2 as well as Table 4 report the results.

In Section 3.4 conditional implications of reference level models are tested using managed portfolios. These estimation results based on two different sets of instruments are reported in Table 6. The sensitivity of the estimation results for the HC-extended reference level model to the choice of moment conditions is investigated in 3.5 using four other sets of test asset portfolios. In Section 3.6 we relate the relative position of consumption with respect to the reference level to the state of the business cycle and discuss the relationship between the reference level approach and other recently proposed macro-finance models.

3.3 Cross-Sectional Tests

CCAPM with Power-Utility

Asset pricing with a reference level is in part motivated by the empirical weakness of the power utility CCAPM. Hence, the model serves as the natural starting point for our comparisons. Estimation of the CCAPM yields familiar results (see Panel A of Table 1). The GMM estimate of the RRA parameter γ is large but rather imprecise, while the estimate of the subjective discount factor is greater than one; Hansen's (1982) J_T-test rejects the model. Hall and Horowitz (1996) and Altonji and Segal (1996) have pointed out that the J_T-test

[7] We refrain from reporting results for the linear factor models. Due to limitations of space, these are available upon request.

frequently over-rejects in small samples, which may be the case here, too. Indeed, all of the models considered in this paper are rejected, including the Fama-French three factor model. What is more troubling is the poor explanatory power of the model. Panel A in Figure 1 shows that the model completely fails to account for the cross-sectional return variation of the 25 Fama-French portfolios. Panel E in Figure 2 shows that same holds true for the CAPM. The failure of the CCAPM and the CAPM to explain size and value premia, which is a well-known result in the literature (See e.g. Lettau and Ludvigson 2001a), is replicated here.

– Insert Table 1 about here –

Pure Habit Formation

Section 2.2 already discussed the pure habit formation model of Garcia et al. (2003). An attempt to estimate the model is hampered by the problem that the calculation of the model's SDF requires information on habit growth (See Equation 5). These data are not directly observable. Garcia et al. (2003) suggest the following strategy to resolve this problem. Under the assumption that the reference level evolves according to the adaptive expectations hypothesis, it can be expressed as a function of past consumption levels with declining weights. Assuming that the reference level in $t+1$ is equal to the conditional expected consumption, we can write

$$C_{t+1} = \frac{a}{\rho} + \rho \sum_{i=0}^{\infty} (1-\rho)^i C_{t-i} + \epsilon_{t+1}, \tag{12}$$

where ϵ_{t+1} denotes an orthogonal innovation. A Koyck-transformation leads to the following MA(1) representation:

$$\Delta C_{t+1} = a - (1-\rho)\epsilon_t + \epsilon_{t+1}. \tag{13}$$

Garcia et al. (2003) propose a two-step estimation procedure which entails estimation of the MA(1) parameters a and ρ in the first step. Using the parameter estimates it is then possible to construct an estimated habit growth sequence $\{\hat{X}_{t+1}/\hat{X}_t\}$ which can then be used to estimate the SDF parameters by GMM.

Estimation results for the pure habit formation model estimated in this fashion are provided in Panel B of Table 1. These results are ambiguous from an economic point of view. The GMM estimates of the subjective time discount factor are both smaller than one – a sensible result from an economic perspective. The RRA-coefficient estimate points towards large risk aversion, but the standard errors are very large. Based on the first-stage GMM results, the hypotheses $\psi = \gamma$ and $\psi = 1$, respectively, cannot be rejected at conventional significance levels. The empirical performance for explaining the cross-section of stock returns is disappointing. Panel B in Figure 1 shows that the average pricing errors of the pure habit formation model are almost identical to those of CCAPM with power utility. The results reported in Table 4 confirm the poor performance of the pure habit formation model.

Bakshi-Chen Model

From a conceptual point of view, the consumption-based asset pricing models with a reference level of consumption studied in this paper bear a strong similarity to the literature on social status and relative wealth, as in the seminal "spirit of capitalism" model by Bakshi and Chen (1996). Thus, it is interesting to take a closer look at the performance of the Bakshi-Chen model to explain the cross-section of returns. In the model by Bakshi and Chen (1996) investors gain utility from accumulating wealth in order to maintain their relative standing in society. Our empirical implementation of the model uses their specification of preferences $u_t(C_t; S_t) = \frac{C_t^{1-\gamma}}{1-\gamma} S_t^{-\lambda}$ in which status is determined by total wealth, i.e. $S_t = W_t$ (Model 1 in Bakshi and Chen, 1996). The stochastic discount factor in this model is given as

$$M_{t+1} = \delta \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \left(R_{t+1}^w \right)^{-\lambda} \left(1 + \frac{\lambda}{\gamma - 1} \frac{C_{t+1}}{W_{t+1}} \right). \tag{14}$$

A feasible implementation of the model necessitates data on consumption growth, the return on total wealth R^w_{t+1} and the consumption-wealth ratio $\frac{C_t}{W_t}$. We follow Bakshi and Chen (1996) by using the market portfolio return R^m_{t+1} as the proxy for wealth growth, and compute the consumption-wealth ratio as $\frac{C_t}{W_t} = \frac{C_0}{W_0} \prod_{\tau=1}^{t} \frac{R_{c,\tau}}{R_{w,\tau}}$, where $R_{c,t+1} = \frac{C_{t+1}}{C_t}$ denotes consumption growth.[8]

Panel C of Table 1 contains estimation results for the Bakshi-Chen model. The table shows that the Bakshi-Chen model – similar to the previous models – has trouble in fitting the cross-section of returns with economically plausible parameter values. The estimated parameters (large RRA coefficient γ and negative λ) would imply that the investor does not strictly prefer higher social status, which would be at odds with the "spirit of capitalism hypothesis". However, as is usual in cross-sectional tests of consumption-based models, standard errors tend to be very large, thus ruling out sharp inference in that matter. The pricing error plots in Figure 1 show that the Bakshi-Chen model clearly improves upon the CCAPM with power-utility. Overall, however, the ability to explain the cross-section of returns is limited.

Epstein-Zin Model

Garcia et al. (2003) show that the class of asset pricing models with a reference level nests a specification of the SDF that is similar to the one that results from the assumption that investor's utility evolves recursively as in Epstein and Zin (1989). The SDF implied by the Epstein-Zin model results from Equation (11) by imposing $a_i = 0, \forall i$ and $c = 0$:

$$M_{t+1} = \delta^* \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \left(R^m_{t+1} \right)^{\kappa}, \tag{15}$$

where $\delta^* = \delta \exp[a_0(\gamma - \psi)]$ and $\kappa = b(\gamma - \psi)$. Conceiving the Epstein-Zin model as a special case of an asset pricing model with a reference level, one can write

[8] The initialization value $\frac{C_0}{W_0}$ for the (quarterly) consumption-wealth ratio is set to 0.0228, which corresponds to an annualized value of 9.12% as in Bakshi and Chen (1996).

$$\Delta c_{t+1} = a_0 + br^m_{t+1} + \epsilon_{t+1}, \tag{16}$$

where r^m_{t+1} denotes the log return on the market portfolio proxy. The orthogonality conditions $E_t[\epsilon_{t+1}] = 0$, $E_t[\epsilon_{t+1}r^m_{t+1}] = 0$ augment the asset pricing moment conditions $E(M_{t+1}R_{t+1} - 1) = 0$ such that all model parameters can be estimated by GMM in one step.

– Insert Table 2 about here –

Estimation results for the Epstein-Zin model are reported in Panel A in Table 2. As shown in the table, the economic plausibility of the estimates is limited. First-stage and iterated GMM estimates of the RRA coefficient γ are quite large but not different from zero at conventional levels of significance. The estimate of the subjective discount factor δ is smaller than one, but it is too small to be reasonable from an economic point of view. The restriction that $\sigma = 1/\gamma$, implied by the power utility consumption-based model, is rejected at the 10 percent significance level (iterated GMM). However, neither the hypothesis $\psi = \gamma$ nor $\psi = 1$ can be rejected. The empirical performance of the model as to explaining the cross-section of returns resembles that of the Bakshi-Chen model (see Panel A in Figure 2 and Table 4).

Garcia-Renault-Semenov Model

Let us now consider a model in which the growth rate of the reference level is a function of the current period market portfolio log return r^m_{t+1} and log consumption growth lagged by one period. This implies that:

$$\Delta c_{t+1} = a_0 + a_1 \Delta c_t + br^m_{t+1} + \epsilon_{t+1}. \tag{17}$$

The implied SDF is then given by:

$$M_{t+1} = \delta^* \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} \left(\frac{C_t}{C_{t-1}}\right)^{\frac{\kappa a_1}{b}} \left(R^m_{t+1}\right)^{\kappa}, \tag{18}$$

where R^m_{t+1} denotes the market portfolio gross return. We refer to this specification as the Garcia-Renault-Semenov (GRS) model. The estimation strategy is analogous to the Epstein-Zin model and includes the additional moment condition $E_t[\epsilon_{t+1}\Delta c_t] = 0$.

Estimation results for the GRS model are reported in Panel B of Table 2. In terms of economic plausibility the results are mixed. As for the other models considered so far, the first-stage estimate of the RRA coefficient is rather large and imprecise. The first-stage GMM estimate of the subjective discount factor δ is less than one but rather small in economic terms. The null hypotheses that investor preferences are of the power-utility form ($\psi = \gamma$) and that the elasticity of intertemporal substitution σ is equal to $1/\gamma$ are both rejected. However, this holds true only for first-stage and not for iterated GMM. The hypothesis that ψ equals one cannot be rejected at conventional levels of significance. Panel B in Figure 2 and Table 4 show that the empirical performance of the GRS model in terms of average pricing errors is improved compared to the other reference level models considered so far.

Human Capital-Extended Model

In the HC-extended model (HCE) the reference level evolves according to Equations (7) and (8). The SDF is given in Equation (11). As for the GRS model we set $n = 1$. We follow Jagannathan and Wang (1996) and Lettau and Ludvigson (2001a) and approximate the return on human capital r^{hc} by log labor income growth. GMM estimation proceeds as for the GRS model using $E_t[\epsilon_{t+1} r^{hc}_{t+1}] = 0$ as an additional moment condition. Estimation results are reported in Table 3. Panel C in Figure 2 depicts the HCE model's pricing error plot.

– Insert Table 3 about here –

As evinced by Figure 2 and Table 4, the HCE model accounts quite well for the cross-sectional variation of the returns of the 25 Fama-French portfolios. The HCE model outperforms Lettau and Ludvigson's scaled CCAPM in terms of average pricing errors (compare Panel C and D in Figure 2). The Hansen-Jagannathan metric is the lowest of all models. The HCE model produces average pricing errors close to those of the Fama-French three factor model (See Panel C and F in Figure 2), i.e. it accounts for the size and value premia just as well as the theoretically less appealing linear factor model. The first-stage GMM estimate of the subjective time discount factor is smaller than one and economically sensible for first-stage GMM. The estimation results actually do deliver evidence against the CCAPM with power utility. The hypothesis that the elasticity of intertemporal substitution is equal to the inverse of the RRA coefficient can be rejected at conventional levels of significance. The same holds true for the hypotheses $\psi = \gamma$ and $\psi = 1$, respectively. The troubling result that haunts consumption-based asset pricing models remains present, though: The RRA coefficient estimate is large and rather imprecise. Its magnitude and standard error as well as the estimate of the elasticity of intertemporal substitution are comparable to the results reported in Yogo (2006b).

– Insert Table 4 about here –

Pricing Errors for Individual Portfolios

Table 5 presents pricing errors for the individual size and book-to-market sorted portfolios as in Lettau and Ludvigson (2001a). The entries in the table – which also constitute the basis for the plots in Figures 1 and 2 – make it possible to investigate patterns of cross-sectional mispricing. In particular, table 5 offers an insight into how the different models succeed in explaining the size and value effects in the data.

– Insert Table 5 about here –

The table shows the well-known failure of the traditional CAPM and CCAPM to explain the return on stocks with high book-to-market ratios (see for instance Lettau and Ludvigson, 2001a and Fama and French, 1993). As evinced by the table, pricing errors for value stocks (in the $B5$ quintile) are very large and positive, i.e. average returns on these portfolios are too high to be consistent with the predictions of the traditional models. By contrast, the Fama-French three factor model and the Lettau-Ludvigson model successfully lower the pricing errors for these portfolios. The table further shows that extensions of the consumption-based model such as the models put forth by Bakshi and Chen (1996), Epstein and Zin (1989) and Garcia et al. (2003) are able to reduce the mispricing of value stocks to a certain extent. The human-capital extended reference level model, however, is quite successful in reducing the mispricing of value stocks in a way similar to the Lettau-Ludvigson and the Fama-French model.

– Insert Figure 1 about here –

– Insert Figure 2 about here –

3.4 Time-Series Tests: Managed Portfolios

While the main objective of this paper is to investigate the cross-sectional performance of consumption-based asset pricing models with a reference level, we also estimate the models drawing on conditional moment restrictions in order to gain a complete picture of their empirical performance. We form so-called "managed portfolios" (Cochrane, 1996) to test the conditional implications of asset pricing models with a reference level. Managed Portfolios result from multiplying the asset returns by instruments which are elements of the investor's information set $\mathcal{F}_t$.

There are not many theoretical guidelines with regard to the choice of instruments. Our empirical strategy is guided by three considerations. First, the instruments should approximate the information set $\mathcal{F}_t$ of the investor as comprehensively as possible, because otherwise important components of the conditioning set may be neglected (Hansen and Richard, 1987). Second, too many instrumental variables are undesirable since they would cause the number of moment conditions to rapidly increase and the finite-sample properties of the GMM estimator to deteriorate. Third, the instruments should be of relevance, i.e. have some predictive content for future returns and consumption growth in order to avoid statistical problems due to weak instruments (see for instance Yogo, 2004).

Hence, we use two sets of instruments for the tests with conditional moment restrictions. The first set includes variables familiar from the return predictability literature (e.g. Fama and French, 1989): the dividend yield on the S&P500, the term spread and the default spread. These variables do not suffer from the weak instruments problem since they are, to some extent, able to predict returns and consumption growth. The second set of instruments addresses the concern that individual variables are unlikely to be an adequate description of the entire information set $\mathcal{F}_t$ of the investor (see Hansen and Richard, 1987). In order to approximate the set of conditioning information as adequately as possible, we use summary measures of the common variation of a broad set of predictors. Hence, for our second set of instruments we use a broad set of 15 predictor variables – the same set as the one used in Goyal and Welch (2004) – and use the first three principal components as conditioning variables. We want to avoid an excessive number of moment conditions but want to keep most of the cross-sectional information. For this reason, we use a subset of ten portfolios ($S1B1$, $S1B5$, $S2B1$, $S1B5$ etc.) of the 25 Fama-French portfolios as in Lettau and Ludvigson (2001a).

The upper section of Table 6 contains the estimation results for the CCAPM with power utility, the pure habit formation model, and the Bakshi-Chen model. As in the case of the cross-sectional tests, parameter estimates for the CCAPM are not very reasonable from an economic point of view. The pure habit model yields more sensible results for the subjective time discount factor, but this only holds true for the first set of instruments. For both sets of instruments, more sensible estimates (in economic terms) are obtained for the Bakshi-Chen model.

– Insert Table 6 about here –

The results for the Epstein-Zin, Garcia-Renault-Semenov and the HC-extended model are reported in the lower part of Table 6. The estimation based on conditional moments broadly confirms the results of the cross-sectional tests reported in section 3.3. The estimates of the subjective time preference parameter δ are economically sensible in case of the GRS and the HCE model. Compared to the cross-sectional tests, the estimates of the risk aversion parameter are somewhat smaller and economically more sensible. The encouraging results for the HCE model are largely confirmed. The subjective time discount factor estimate and the estimate of the elasticity of intertemporal substitution are economically sensible and quite precise. Just like above, the estimation of the HCE model delivers evidence against the power utility specification, which holds true for both sets of instruments.

3.5 HC-Extended Model: Results for Alternative Portfolios

In order to check the robustness of the results with respect to alternative choices of moment conditions, we estimate the HC-extended model on an alternative set of test assets. We use ten book-to-market portfolios, ten size portfolios, ten cash flow-price portfolios and ten earnings-price sorted portfolios. Evidence against the hypothesis that the elasticity of intertemporal substitution is equal to the inverse of the RRA parameter is found for the earnings-price sorted portfolios. For all portfolios (except cash-flow price sorted), the subjective discount factor estimate is smaller than one. As for the 25 Fama-French portfolios, evidence against the power utility specification is found for the book-to-market sorted portfolios and the earnings-price sorted portfolios. Overall, the tests drawing on these alternative moment conditions largely speak the same language as the previous tests with size and book-to-market sorted portfolios.

– Insert Table 7 about here –

3.6 Reference Level and the Business Cycle

Figure 3 shows the evolution of consumption in excess of the (estimated) reference level over time. The reference level series is the one implied by the HCE model estimated on the Fama-French portfolios. The grey shadings in the graph display the official recession periods published by the NBER. The figure shows that periods of consumption close to or below the reference level coincide with downturns in economic activity. Accordingly, allowing for a dependence of the utility specification on the state of the business cycle may indeed be the main driving force for the empirical success of the reference level approach in explaining the cross-section of returns.

These findings show the connection of the estimated stochastic discount factor to overall macroeconomic conditions. Interpreted in this way, our results are related to recent work most notably by Lustig and van Nieuwerburgh (2005), Yogo (2006b) and Piazzesi et al. (2007). In these models, the ratio of housing wealth to human capital wealth (collateral ratio), the relative importance of durables consumption versus nondurables (Yogo) and the share of housing consumption versus total consumption (Piazessi et al.), respectively, play a similar role as consumption relative to the reference level.

– Insert Figure 3 about here –

4 Conclusion

This paper presents an empirical evaluation of recently proposed asset pricing models which extend investor preferences by a reference level of consumption. It also motivates a specification that accounts for the return on human capital as a determinant of the reference level which we refer to as Human Capital-Extended (HCE) model. So far, the conditional implications of asset pricing models with a reference level have been tested using a market portfolio proxy and the Treasury-Bill as basic test assets. In our empirical investigation we use a broad cross-section of test assets, Fama and French's 25 portfolios sorted by size and book-to-market, which provides a level playing field for a comparison of reference level asset pricing models to successful benchmark models like Lettau-Ludvigson's scaled CCAPM and the Fama-French three factor model.

We find that asset pricing models that account for a reference level of consumption can considerably improve the empirical performance of consumption-based asset pricing models for the cross-section of stock returns. However, we find that it is crucial to allow for the return on human capital when modeling the reference level. The Human Capital-Extended model accounts for value and size effects in average returns just as well as the Fama-French three factor model. Estimated on the 25 Fama-French portfolios the HCE model outperforms Lettau and Ludvigson's scaled CCAPM in terms of average pricing errors. Consumption close to or below the reference level implied by the HCE model coincides with downturns in economic activity, which establishes the link between pricing kernel and the real economy. These overall encouraging results need to be taken with a grain of salt. All reference level models considered in this paper, including the HCE model, still require a high degree of risk-aversion. They do therefore not yet deliver a complete solution to the "equity premium puzzle" which motivated their introduction in the first place. Cochrane's (2006, p.24) conclusion that "maybe we have to accept high risk aversion, at least for reconciling aggregate consumption with market returns in this style of model" seems to extend to consumption-based asset pricing models with a reference level, as well.

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Appendix A: Details on Hansen-Jagannathan Distance

Jagannathan and Wang (1996), Hodrick and Zhang (2001) and Jagannathan and Wang (2006) use the Hansen-Jagannathan (HJ) distance as a convenient metric for model comparison purposes. The (sample) HJ distance (δ_T) is the square root of the minimum of a GMM objective function that uses the inverse of the sample second moment matrix of asset returns $G_T = [T^{-1} \sum_{t=1}^{T} R_t R_t']^{-1}$, where R_t is a $N \times 1$ vector of asset returns, as weighting matrix:

$$\delta_T = \left[\min_{\theta} g_T(\theta)' G_T g_T(\theta) \right]^{0.5}. \tag{A.1}$$

$g_T(\theta)$ denotes the vector of sample moment conditions implied by the asset pricing model. The HJ distance is suitable for model comparisons since the weighting matrix is not model dependent. Hansen and Jagannathan (1997) show that the distance between the set of true stochastic discount factors and the SDF proxy of the asset pricing model is minimized when the (sub)-optimal weighting matrix G_T is used for GMM estimation. Parker and Julliard (2005) extend these results and derive the distribution of the HJ-distance for non-linear pricing kernels. They show that under the null hypothesis (correct SDF) $T\delta_T^2$ is distributed as a weighted sum of $\chi^2(1)$ random variables. Following Jagannathan and Wang (1996) and Parker and Julliard (2005), we obtain the p-values reported in Table 4 via simulation.

As outlined in the main text, for GMM estimation of Epstein-Zin , Garcia-Renault-Semonov and Human Capital-Extended model we use k additional moment conditions that augment the moment conditions for the test assets. For these models, the GMM weighting matrix is given by

$$W_T = \begin{bmatrix} G_T & \mathbf{0} \\ \mathbf{0} & I_k \end{bmatrix}, \tag{A.2}$$

where $\mathbf{0}$ is a corresponding matrix of zeros. To ensure comparability between models, we compute the HJ-distance for Epstein-Zin , Garcia-Renault-Semonov and Human Capital-

Extended model using the first N moment conditions implied by the asset returns.

Table 1: CCAPM, Pure Habit and Bakshi-Chen Model: Estimation Results

Panel A: CCAPM with Power Utility

First-stage GMM			*Iterated GMM*		
Parameter	Estimate	t-Statistic	Parameter	Estimate	t-Statistic
δ	1.37	3.72	δ	1.05	4.36
γ	76.32	1.08	γ	15.03	0.34
J_T-Statistic	81.9	(0.00)	J_T-Statistic	83.6	(0.00)

Panel B: Pure Habit Model

First-stage GMM			*Iterated GMM*		
Parameter	Estimate	t-Statistic	Parameter	Estimate	t-Statistic
δ	0.99	1.12	δ	0.68	2.00
γ	75.27	1.24	γ	40.41	0.67
ψ	14.93	0.09	ψ	-44.57	-0.51
$\gamma - \psi$	60.33	0.41	$\gamma - \psi$	84.98	1.17
$1 - \psi$	-13.93	-0.09	$1 - \psi$	45.57	0.53
J_T-Statistic	86.6	(0.00)	J_T-Statistic	105.8	(0.00)

Panel C: Bakshi-Chen Model

First-stage GMM			*Iterated GMM*		
Parameter	Estimate	t-Statistic	Parameter	Estimate	t-Statistic
δ	1.35	4.65	δ	1.04	4.81
γ	91.71	1.65	γ	29.16	0.70
λ	-2.06	-1.27	λ	-2.40	-1.85
J_T-Statistic	84.3	(0.00)	J_T-Statistic	84.2	(0.00)

Note: The table reports estimation results for the CCAPM (Panel A), the Pure Habit Model (Panel B) and the Bakshi-Chen Model (Panel C). Both results of first-stage and iterated GMM are provided. Results in Panel A are based on (1) using the SDF specification in (2). For the Pure Habit Model in Panel B, an ARIMA(0,1,1)-model is estimated in order to obtain an estimate of habit as a function of past consumption levels. In the second step, we substitute habit growth in the stochastic discount factor by its estimate. The resulting moment conditions are estimated by GMM. J_T is the value of Hansen's (1982) test statistic of the overidentifying restrictions, the p-value is in parentheses. Standard errors of indirectly estimated parameters are calculated according to the Delta Method. Sample: 1951:Q4-2005:Q1.

Table 2: Epstein-Zin and Garcia-Renault-Semenov Model: Estimation Results

Panel A: Epstein-Zin Model						**Panel B: Garcia-Renault-Semenov Model**					
First-Stage GMM			*Iterated GMM*			*First-stage GMM*			*Iterated GMM*		
Parameter	Est.	t-Stat.	Parameter	Est.	t-Stat.	Parameter	Est.	t-Stat.	Parameter	Est.	t-Stat.
δ^*	1.35	4.58	δ^*	1.01	4.58	δ^*	0.42	1.40	δ^*	0.68	2.58
γ	90.63	1.61	γ	24.37	0.56	γ	215.76	2.90	γ	61.77	1.11
κ	1.95	1.21	κ	2.38	1.82	κ	8.33	2.33	κ	2.72	1.42
a_0	0.005	14.78	a_0	0.005	15.42	a_0	0.024	0.96	a_0	0.010	7.09
						a_1	0.611	2.22	a_1	0.336	5.68
b	0.009	2.91	b	0.006	1.93	b	0.024	5.75	b	0.010	3.76
$\gamma - \psi$	210.84	1.24	$\gamma - \psi$	413.74	1.53	$\gamma - \psi$	347.47	2.18	$\gamma - \psi$	282.12	1.47
ψ	-120.21	-0.63	ψ	-389.38	-1.40	ψ	-131.71	-0.81	ψ	-220.35	-1.35
$1 - \psi$	121.21	0.63	$1 - \psi$	390.38	1.41	$1 - \psi$	132.71	0.82	$1 - \psi$	221.35	1.36
δ	0.45	1.01	δ	0.11	0.67	δ	0.25	1.00	δ	0.27	1.02
σ	0.03	1.41	σ	0.14	0.80	σ	0.04	2.41	σ	0.06	1.96
J_T-Stat.	84.1	(0.00)	J_T-Stat.	83.3	(0.00)	J_T-Stat.	88.0	(0.00)	J_T-Stat.	78.8	(0.00)

Note: Estimation is based on unconditional moment conditions using the 25 Fama-French portfolios sorted by size and book-to-market. Panel A reports estimation results for the Epstein-Zin Model, where the specification of the SDF is given in Equation (15). The moment conditions are estimated jointly with the linear Equation (16). Panel B contains results for the Garcia-Renault-Semenov model where the SDF is specified as in Equation (18). The moment conditions for the test asset returns are estimated jointly with the moment conditions implied by the linear Equation (17). J_T is the value of Hansen's (1982) test statistic of the overidentifying restrictions, the p-value is in parentheses. The sample period is 1951:Q4-2005:Q1. Standard errors of indirectly estimated parameters are calculated by the Delta Method.

Table 3: Human Capital-Extended Model: Estimation Results

First-stage GMM			*Iterated GMM*		
Parameter	Estimate	t-Statistic	Parameter	Estimate	t-Statistic
δ^*	0.56	1.27	δ^*	0.33	2.42
γ	282.18	2.64	γ	180.11	3.13
κ	3.76	1.02	κ	3.88	2.46
a_0	-0.001	-0.20	a_0	0.003	5.97
a_1	0.336	0.65	a_1	0.093	1.45
b	0.017	3.04	b	0.008	3.02
c	0.747	0.92	c	0.360	6.05
$\gamma - \psi$	216.54	1.22	$\gamma - \psi$	517.41	4.76
ψ	65.64	0.32	ψ	-337.30	-3.54
$1 - \psi$	-64.64	-0.31	$1 - \psi$	338.30	3.55
δ	0.68	0.97	δ	0.08	1.52
σ	0.02	1.22	σ	0.03	3.13
J_T-Statistic	56.3	(0.00)	J_T-Statistic	50.2	(0.00)

Note: Estimation is based on unconditional moment conditions using the 25 Fama-French portfolios sorted by size and book-to-market. The specification of the SDF is given in Equation (11), where n is set to one. The moment conditions for the test asset returns are estimated jointly with the moment conditions implied by the linear Equation (8), also setting $n = 1$. J_T is the value of Hansen's (1982) test statistic of the overidentifying restrictions, the p-value is in parentheses. The sample period is 1951:Q4-2005:Q1. Standard errors of indirectly estimated parameters are calculated by the Delta Method.

Table 4: Summary of Model Comparison Statistics

Model	RMSE	HJ-dist.	p-val.	$J_H J$	p-val.
Fama-French	0.325	0.52	0.00	67.11	0.00
Human Capital Extended	0.330	0.44	0.43	36.55	0.27
Lettau-Ludvigson	0.402	0.57	0.00	89.59	0.00
Garcia-Renault-Semenov	0.553	0.56	0.00	81.11	0.00
Bakshi-Chen	0.588	0.57	0.00	84.72	0.00
Epstein-Zin	0.596	0.57	0.00	84.22	0.00
Pure Habit Model	0.633	0.59	0.00	92.37	0.00
Power Utility CCAPM	0.637	0.59	0.00	83.79	0.00
CAPM	0.639	0.58	0.00	82.34	0.00

Note: The table contains a summary of model performance evaluation. The test assets are 25 size and book-to-market sorted portfolios. RMSE is the root mean square average pricing error based on first-stage GMM, HJ-dist. denotes to the Hansen-Jagannathan distance , J_{HJ} is the J_T-statistic when using the HJ weighting matrix. Details on HJ-GMM estimation are provided in appendix 4. The p-value for the model test based on the HJ-distance is determined by simulation (10,000 replications, see appendix). The sample period is 1951:Q4-2005:Q1.

Table 5: Euler Equation Errors

	A: Nonlinear Models						B: Linear Factor Models			
Portfolio	CCAPM	Habit	BC	EZ	GRS	HC-Extended	Linearized CCAPM	Scaled CCAPM	CAPM	Fama-French
$S1B1$	-1.5903	-1.6510	-1.0466	-1.0339	-0.4568	0.0247	-1.7231	-1.0018	-0.9017	-0.9102
$S1B2$	-0.1360	-0.2378	0.1127	0.1278	-0.0053	-0.0922	-0.3641	0.0267	0.4571	0.0707
$S1B3$	0.2242	0.1738	0.2467	0.2658	-0.1205	0.0743	0.1763	-0.1947	0.3480	-0.2983
$S1B4$	0.8884	0.8749	0.7986	0.8262	0.5543	0.4324	0.8356	0.4350	0.9836	0.2435
$S1B5$	1.1665	1.1198	1.1733	1.1978	0.9641	0.4824	1.0256	0.5760	1.3927	0.4359
$S2B1$	-0.9599	-1.0360	-0.4032	-0.4223	-0.1419	-0.3075	-1.0000	-0.1028	-0.5776	-0.1512
$S2B2$	-0.0859	-0.0878	0.1258	0.1276	0.1793	-0.0829	-0.1167	-0.3190	-0.0016	-0.1400
$S2B3$	0.4211	0.4701	0.4019	0.4241	0.3324	0.1102	0.3950	0.3003	0.4407	0.1533
$S2B4$	0.6712	0.6357	0.6200	0.6291	0.6045	0.3937	0.6643	0.3356	0.5900	0.1214
$S2B5$	0.8578	0.8319	0.8248	0.8203	0.6602	0.4583	0.7545	0.2761	0.9797	0.3341
$S3B1$	-0.6227	-0.6292	-0.1838	-0.2016	-0.2493	-0.3449	-0.6458	0.4810	-0.4109	0.2867
$S3B2$	0.1145	0.1050	0.2064	0.2027	0.3828	0.2227	0.1413	0.2314	0.0392	0.1428
$S3B3$	0.0760	0.1478	-0.0153	0.0015	0.0189	-0.2929	0.0900	-0.2747	-0.0740	-0.2273
$S3B4$	0.5163	0.5375	0.4045	0.4197	0.4875	0.3833	0.5180	0.3326	0.3188	0.0360
$S3B5$	0.6578	0.5594	0.5182	0.5096	0.3805	-0.0098	0.6207	0.2000	0.6243	0.0462
$S4B1$	-0.4180	-0.4212	-0.1167	-0.1425	-0.0201	0.1227	-0.3531	0.6104	-0.3627	0.6167
$S4B2$	-0.3953	-0.4049	-0.3903	-0.3942	-0.2670	0.0191	-0.3230	-0.1137	-0.5651	-0.2547
$S4B3$	0.3542	0.3595	0.2603	0.2743	0.4801	0.3310	0.4223	0.1408	0.0606	0.1766
$S4B4$	0.3600	0.3857	0.2180	0.2186	0.4083	0.3134	0.3934	0.2078	0.1206	0.0836
$S4B5$	0.2605	0.3037	0.1687	0.1371	0.2212	-0.4234	0.2007	-0.1527	0.3135	0.0705
$S5B1$	-0.7864	-0.7124	-0.8824	-0.8822	-1.0033	-0.1264	-0.6705	-0.0472	-0.8856	0.3869
$S5B2$	-0.4979	-0.4557	-0.7320	-0.7494	-0.7156	-0.0790	-0.2865	-0.4006	-0.8560	-0.0966
$S5B3$	-0.3854	-0.2468	-0.8253	-0.8165	-1.0822	-0.4575	-0.2258	-0.3000	-0.7926	-0.2902
$S5B4$	-0.3366	-0.2909	-0.7088	-0.7371	-0.9203	-0.7806	-0.2134	-0.5328	-0.7899	-0.5321
$S5B5$	-0.4527	-0.4282	-0.8583	-0.8874	-0.7639	-0.3972	-0.4089	-0.7522	-0.5488	-0.3296

Note: The table contains pricing errors for the different portfolios implied by the different asset pricing models. Size quintiles are referred to as S (1=small, 5=big) and book-to-market quintiles are denoted as B (1=low, 5=high). $S1B1$, for instance, is the portfolio with the smallest stocks in terms of market capitalization and the lowest book-to-market ratio. The sample period is 1951:Q4-2005:Q1.

Table 6: Nonlinear Consumption-Based Asset Pricing Models: Estimation Results with Managed Portfolios

Panel A: Instrument Set 1									Panel B: Instrument Set 2								
A.I. CCAPM			*A.II. Pure Habit*			*A.III. Bakshi-Chen*			*B.I.CCAPM*			*B.II. Pure Habit*			*B.III. Bakshi-Chen*		
	Est.	t-Stat.		Est.	t-Stat.		Est.	t-Stat.		Est.	t-Stat.		Est.	t-Stat.		Est.	t-Stat.
δ	1.08	32.55	δ	1.05	20.48	δ	0.98	105.74	δ	1.06	32.22	δ	0.92	12.86	δ	1.01	175.77
γ	20.66	3.71	γ	28.56	4.38	γ	-0.57	-0.35	γ	17.24	3.05	γ	26.95	2.93	γ	2.78	3.53
			ψ	14.53	1.64	λ	0.65	5.52				ψ	-8.11	-0.60	λ	1.05	21.97
			$\gamma-\psi$	14.03	2.09							$\gamma-\psi$	35.06	2.74			
			$1-\psi$	-13.53	-1.53							$1-\psi$	9.11	0.67			
J_T	94.0	(0.00)	J_T	88.6	(0.00)	J_T	98.5	(0.00)	J_T	116.2	(0.00)	J_T	111.8	(0.00)	J_T	112.3	(0.00)

A.IV. Epstein-Zin			*A.V. GRS*			*A.VI. HC-Extended*			*B.IV. Epstein-Zin*			*B.V. GRS*			*B.VI. HC-Extended*		
	Est.	t-Stat.		Est.	t-Stat.		Est.	t-Stat.		Est.	t-Stat.		Est.	t-Stat.		Est.	t-Stat.
δ^*	1.00	179.63	δ^*	1.07	14.49	δ^*	1.09	22.62	δ^*	1.01	204.13	δ^*	1.05	13.54	δ^*	0.98	9.22
γ	0.79	0.78	γ	43.76	3.23	γ	41.25	4.20	γ	1.76	1.86	γ	37.95	2.66	γ	163.86	5.51
κ	-0.82	-13.85	κ	0.58	1.18	κ	0.21	1.79	κ	-1.04	-27.47	κ	0.50	0.95	κ	2.09	2.55
a_0	0.005	17.09	a_0	0.008	8.74	a_0	0.003	7.92	a_0	0.005	17.00	a_0	0.011	6.62	a_0	0.003	6.98
a_1			a_1	0.283	4.80	a_1	0.016	0.26	a_1			a_1	0.403	6.91	a_1	0.070	1.16
b	0.006	2.21	b	0.008	3.47	b	0.005	2.29	b	0.008	3.29	b	0.011	4.53	b	0.008	3.36
c			c			c	0.365	6.93	c			c			c	0.361	6.91
$\gamma-\psi$	-143.32	-2.20	$\gamma-\psi$	73.61	1.24	$\gamma-\psi$	40.73	3.10	$\gamma-\psi$	-126.51	-3.17	$\gamma-\psi$	45.81	0.99	$\gamma-\psi$	260.03	4.76
ψ	144.11	2.21	ψ	-29.85	-0.60	ψ	0.52	0.05	ψ	128.27	3.21	ψ	-7.86	-0.22	ψ	-96.17	-2.49
$1-\psi$	-143.11	-2.20	$1-\psi$	30.85	0.62	$1-\psi$	0.48	0.05	$1-\psi$	-127.27	-3.19	$1-\psi$	8.86	0.25	$1-\psi$	97.17	2.52
δ	2.11	2.93	δ	0.80	3.46	δ	0.96	17.85	δ	1.92	4.89	δ	0.92	5.08	δ	0.46	3.98
σ	0.23	0.17	σ	0.04	4.23	σ	0.03	11.39	σ	-0.02	-0.07	σ	0.04	3.85	σ	0.02	4.56
J_T	95.0	(0.00)	J_T	83.1	(0.00)	J_T	83.9	(0.00)	J_T	112.0	(0.00)	J_T	110.5	(0.00)	J_T	96.8	(0.00)

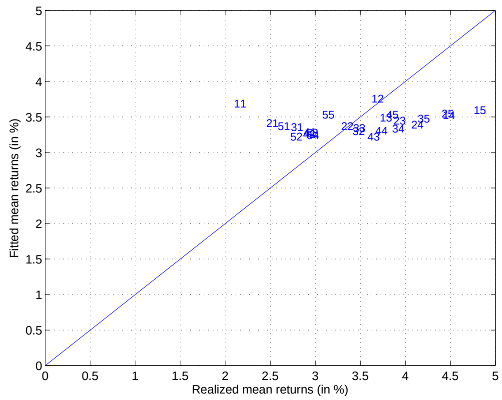
Note: Estimation is by iterated GMM using test asset returns scaled by instruments z_t. Two sets of instruments are used: the first set contains a constant, the dividend yield the term spread, and the default spread while the second set contains a constant and the first three principal components capturing the common variation in a broad set of 15 conditioning variables. The test assets are a subset of ten portfolios of the 25 Fama-French portfolios sorted by size and book-to-market. The sample period is 1951:Q4-2005:Q1. Standard errors of indirectly estimated parameters are calculated by the Delta Method.

Table 7: Human Capital Extended Model: Estimation Results for Other Portfolios

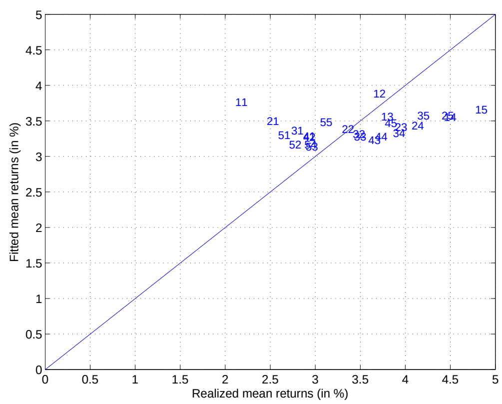
	FF10BM		*FF10ME*		*FF10CP*		*FF10EP*	
	Estimate	t-Statistic	Estimate	t-Statistic	Estimate	t-Statistic	Estimate	t-Statistic
δ^*	1.13	4.26	0.94	2.25	1.17	3.82	0.86	3.07
γ	141.91	2.64	137.62	1.33	70.76	1.10	285.14	3.04
κ	1.74	1.48	1.77	0.99	0.46	0.36	3.98	2.06
a_0	0.003	6.10	0.003	5.90	0.003	5.72	0.003	6.05
a_1	0.084	1.22	0.085	1.20	0.119	1.72	0.100	1.45
b	0.010	3.40	0.008	2.58	0.008	2.91	0.010	3.45
c	0.348	5.67	0.360	5.81	0.341	5.61	0.333	5.45
$\gamma - \psi$	178.99	1.73	237.28	1.08	55.92	0.36	405.15	2.89
ψ	-37.08	-0.47	-99.66	-0.69	14.84	0.13	-120.01	-1.55
$1 - \psi$	38.08	0.49	100.66	0.69	-13.84	-0.12	121.01	1.57
δ	0.69	2.15	0.48	1.00	1.01	1.63	0.28	1.48
σ	0.02	3.04	0.02	2.44	0.02	1.47	0.02	3.72
J_T-Statistic	3.8	(80.54)	6.6	(46.74)	18.0	(1.12)	9.3	(23.42)

Note: Results are based on iterated GMM using as test assets 10 book-to-market (FF10BM), 10 size (FF10ME), 10 cash flow-price (FF10CP) and 10 earnings-price (FF10EP) sorted portfolios. The specification of the SDF is given in Equation (11), where n is set to one. The moment conditions for the test asset returns are estimated jointly with the moment conditions implied by the linear Equation (8), also setting $n = 1$. The sample period is 1951:Q4-2005:Q1. Standard errors of indirectly estimated parameters were calculated by the Delta Method.

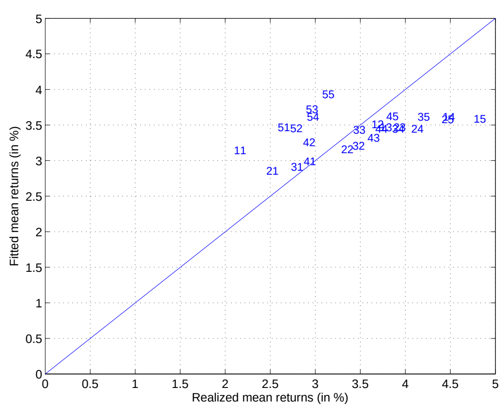
Figure 1: CCAPM with Power Utility, Pure Habit and Bakshi-Chen model: Fitted vs. Actual Mean Returns (in % per Quarter)



(a) Panel A: CCAPM



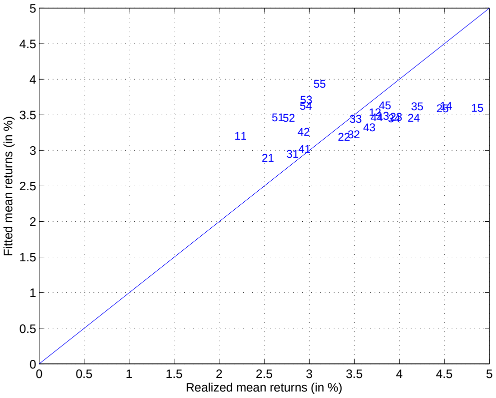
(b) Panel B: Pure Habit Model



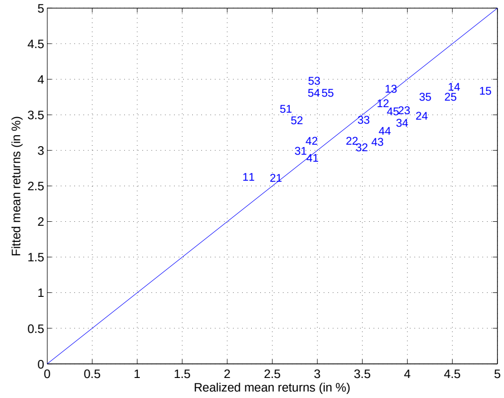
(c) Panel C: Bakshi-Chen Model

Note: The graphs are based on first-stage GMM estimates using the 25 Fama-French portfolios as test assets. Realized mean returns are given on the horizontal axis, and the returns predicted by the model are provided on the vertical axis. The first digit represents the size quintiles (1=small, 5=big) whereas the second digit refers to the book-to-market quintiles (1=low, 5=high). The sample period is 1951:Q4-2005:Q1. The three graphs show results for the nonlinear consumption-based model with power utility, the pure habit model and the Bakshi-Chen model.

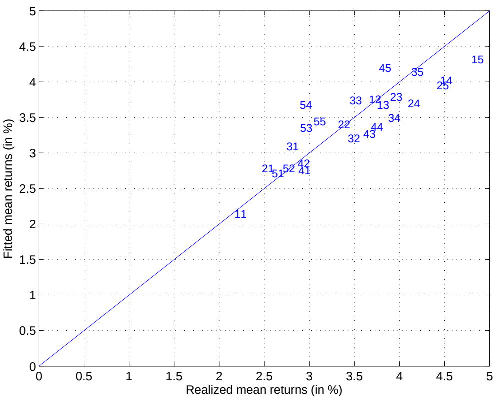
Figure 2: Consumption-Based Asset Pricing Models and Benchmark Linear Factor Models: Fitted vs. Actual Mean Returns (in % per Quarter)



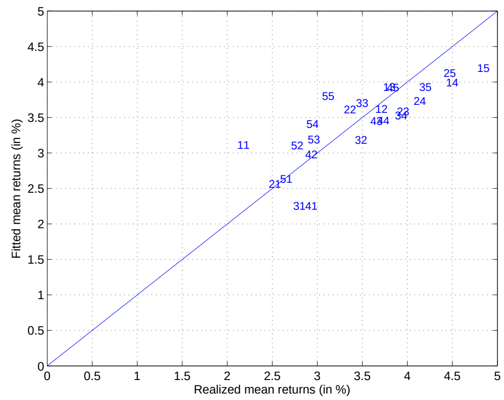
(a) Panel A: Epstein-Zin



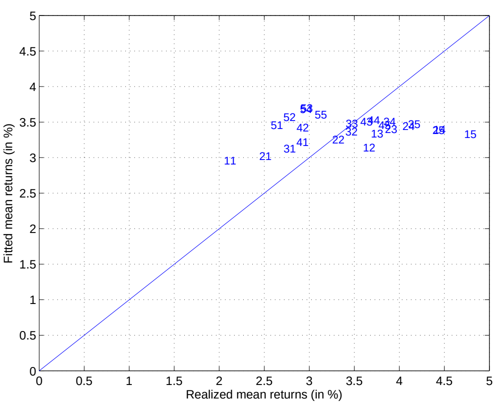
(b) Panel B: Garcia-Renault-Semenov



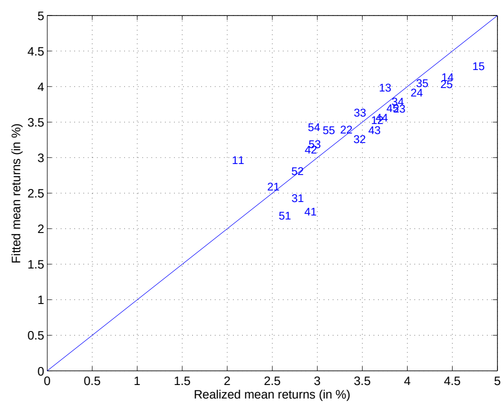
(c) Panel C: HC-Extended Model



(d) Panel D: Scaled CCAPM



(e) Panel E: CAPM



(f) Panel F: Fama-French Model

Note: The graphs are based on first-stage GMM estimates using the 25 Fama-French portfolios as test assets. Realized mean returns are given on the horizontal axis, and the returns predicted by the model are provided on the vertical axis. The first digit represents the size quintiles (1=small, 5=big) whereas the second digit refers to the book-to-market quintiles (1=low, 5=high). The sample period is 1951:Q4-2005:Q1. The upper two graphs show results for the Epstein-Zin Model and the Garcia-Renault-Semenov model. Below we display pricing error plots for the Human Capital-Extended Model and the scaled CCAPM by Lettau and Ludvigson (2001a). Pricing error plots for the CAPM and the Fama-French model are shown at the bottom.

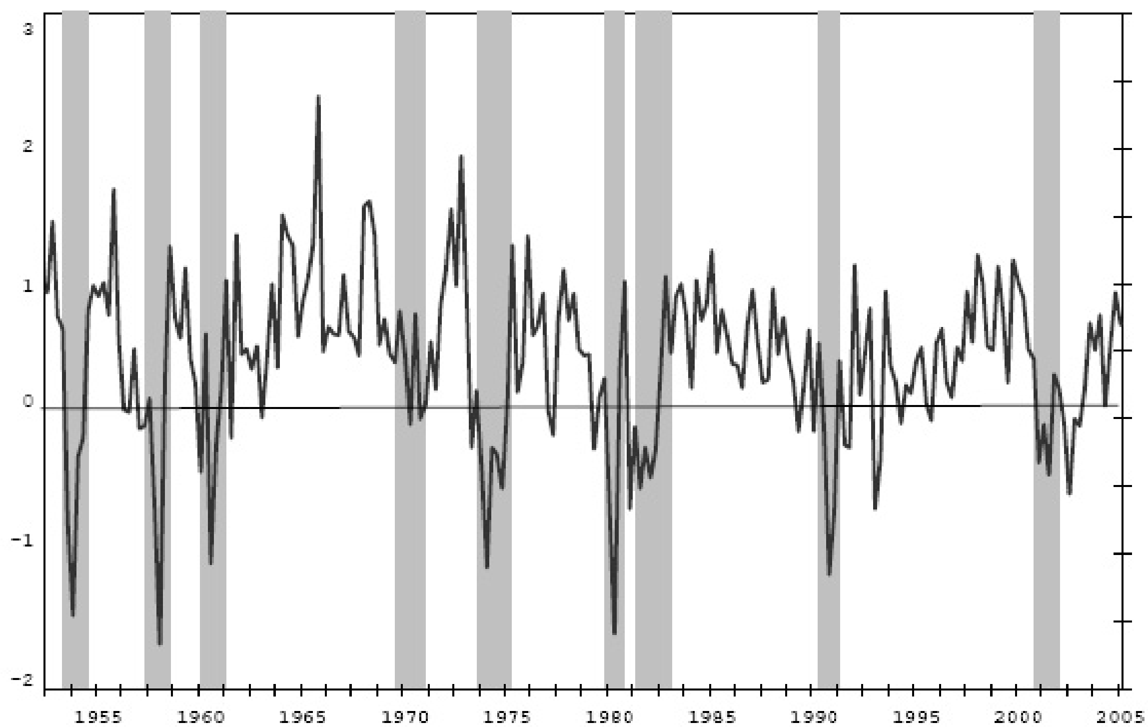


Figure 3: Consumption in Excess of the Reference Level

Note: The graph depicts the evolution of consumption in excess of the reference level (in %) over time. Grey-shaded are recession periods as identified by the NBER. The graph is based on the estimation results for the human capital augmented model in table 3. The sample period is 1951:Q4-2005:Q1.

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