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Reviewed work(s):
Source: *The Journal of Finance*, Vol. 62, No. 4 (Aug., 2007), pp. 1623-1661
Published by: Wiley for the American Finance Association
Stable URL: http://www.jstor.org/stable/4622313
Accessed: 02/01/2013 14:55

THE JOURNAL OF FINANCE • VOL. LXII, NO. 4 • AUGUST 2007

Lazy Investors, Discretionary Consumption, and the Cross-Section of Stock Returns

RAVI JAGANNATHAN and YONG WANG*

ABSTRACT

When consumption betas of stocks are computed using year-over-year consumption growth based upon the fourth quarter, the consumption-based asset pricing model (CCAPM) explains the cross-section of stock returns as well as the Fama and French (1993) three-factor model. The CCAPM's performance deteriorates substantially when consumption growth is measured based upon other quarters. For the CCAPM to hold at any given point in time, investors must make their consumption and investment decisions simultaneously at that point in time. We suspect that this is more likely to happen during the fourth quarter, given investors' tax year ends in December.

THERE IS GENERAL AGREEMENT IN THE LITERATURE that the risk premium that investors require to invest in stocks varies across stocks of different types of firms in a systematic way. In particular, investors appear to be content to receive a lower return on average to invest in growth firms compared to value firms, and require a higher return to invest in smaller firms compared to larger firms. The question is, why? According to the standard consumption-based asset pricing model (CCAPM) developed by Rubinstein (1976), Lucas (1978), and Breeden (1979), investors will be content to accept a lower return on those assets that provide better insurance against consumption risk by paying more when macroeconomic events unfavorably affect consumption choices. In particular, according to the CCAPM, to a first order the risk premium on an asset is a scale multiple of its exposure to *consumption risk*, the covariance of the return on the asset with contemporaneous aggregate consumption growth. Hence, to the extent that the CCAPM holds, we should find that growth firms engage in activities that have less exposure to consumption risk compared to those of value firms, and similarly, smaller firms are exposed to higher consumption

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risk compared to larger firms. We show that, indeed, this is the case, provided we take certain empirical regularities into account when measuring the consumption risk exposure of stocks.

The empirical evidence finds little support for CCAPM. Hansen and Singleton (1982, 1983) reject the CCAPM model in their statistical tests. Mankiw and Shapiro (1986) compare the standard CAPM and the CCAPM specifications and find that the former performs better. Breeden, Gibbons, and Litzenberger (1989) show that the CCAPM performs about as well as the standard CAPM. Hansen and Jagannathan (1997) find that while the CCAPM performs about as well as the standard CAPM, the pricing errors for both models are rather large. The limited success of the standard CCAPM has led to the development of consumption-based asset pricing models that allow for a more general representation of investors' preferences for consumption at different points in time than assumed in the CCAPM, as in Epstein and Zin (1989), Sundaresan (1989), Constantinides (1990), Abel (1990), Heaton (1995), and Campbell and Cochrane (1999). Other authors have developed models that relax the assumption made in all consumption-based asset pricing models that investors can costlessly adjust consumption plans; see, for example, Grossman and Laroque (1990), Lynch (1996), and Gabaix and Laibson (2001).

Lettau and Ludvigson (2005) show that even in an economy in which the prices of financial assets are determined by one of the more general consumption-based asset pricing models, the CCAPM is a reasonably good approximation. It is therefore difficult to explain the empirical evidence against the standard CCAPM reported in the literature by appealing to the more general consumption-based asset pricing models alone.

Daniel and Marshall (1997) find that the correlation between equity returns and the growth rate in aggregate per capita consumption increases as the holding period over which returns are measured increases, consistent with consumption being measured with error and investors adjusting consumption plans only at periodic intervals because of transactions costs. Bansal and Yaron (2004), Bansal, Dittmar, and Lundblad (2005), and Hansen, Heaton, and Li (2005) find that when consumption risk is measured by the covariance between long-run cashflows from holding a security and long-run consumption growth in the economy, differences in consumption risk have the potential to explain expected return differentials across assets. Parker and Julliard (2005) find that the contemporaneous covariance between consumption growth and returns explains little of the cross-section of stock returns, that is, the data provide strong evidence against the standard CCAPM. However, the covariance between an asset's return during a quarter and cumulative consumption growth over the several following quarters, which they refer to as *ultimate consumption risk*, explains the cross-section of average returns on stocks surprisingly well. Malloy, Moskowitz, and Vissing-Jorgensen (2005) find that the ultimate consumption risk faced by the wealthiest of stock holders is able to explain both the cross-section of stock returns as well as the equity premium with a risk-aversion coefficient as low as 6.5. While these findings are consistent with the more general consumption-based asset pricing models, they are also consistent with investors making consumption and portfolio allocation decisions infrequently at discrete points in time.

Making consumption and investment decisions involves giving up a substantial amount of leisure time, that is, those decisions are associated with significant costs. Thus, investors are likely to review their decisions only at intervals determined by culture, institutional features of the economy, such as when profits and losses have to be realized for tax purposes, and the occurrence of important news events. Investors are also more likely to review their decisions during bad economic times. At those points in time when most investors revise their consumption and investment decisions *simultaneously,* the representative investor's intertemporal marginal rate of substitution for consumption is more likely to be equal across different financial assets. Hence, we should find stronger support for the standard CCAPM when consumption risk is measured by matching the growth rate in average per capita consumption in the economy from the end of the calendar year to any other time in the future, and also when consumption betas are estimated using returns on investments made during economic contractions. While investors may make both consumption and investment decisions during other time periods, these two types of decisions are less likely to be related to each other.

The empirical literature in finance and macroeconomics suggests that investors are more likely to make consumption and portfolio choice decisions at the end of each calendar year because of Christmas and the resolution of uncertainty about end-of-year bonuses and the tax consequences of capital gains and losses. Specifically, Miron and Beaulieu (1996) find that the seasonal behavior of GDP is dominated by fourth quarter increases and first quarter declines, consistent with Christmas demand being an important factor in seasonal fluctuations. Braun and Evans (1995) show that observed seasonal shifts in aggregate consumption are due to seasonal shifts in preferences, not technology. Piazzesi (2001) finds that, consistent with most individuals in the economy simultaneously adjusting their consumption at the end of the calendar year, current returns predict future aggregate consumption growth, especially for horizons that are multiples of four quarters. Geweke and Singleton (1981) find support in the data for the permanent income model of consumption at annual frequencies, and interpret this as consumers making annual consumption and investment plans for their disposable income. Ait-Sahalia, Parker, and Yogo (2004) point out that consumers have more discretion over their consumption of luxury goods than their consumption of essential goods, and the former covaries more strongly with stock returns.

Keim (1983) documents that smaller stocks earn most of their risk-adjusted return during the first week of January. Roll (1983) and Reinganum (1983) show that this may be due to investors selling stocks to realize losses for tax purposes at the end of the calendar year.

Lettau and Ludvigson (2001) find support for the conditional version of the CCAPM. Yogo (2006) finds that durable goods consumption, combined with nondurable goods consumption, is able to explain the cross-section of average returns on stocks. Conditional versions of the CCAPM and models with durable goods may help weight good economic and bad economic times differently, consistent with investors making decisions more frequently during relatively bad times.

Given the above findings, we match calendar year returns with growth rates in year-over-year fourth quarter consumption of nondurables and services in order to generate the most support from the data for the CCAPM. The use of calendar year returns avoids the need to explain various well-documented seasonal patterns in stock returns, such as the January effect, and the sell in May and go away effect (Bouman and Jacobsen (2002)). Working with a 1-year horizon also attenuates the errors that may arise due to ignoring the effect of habit formation on preferences. Although we suspect that fourth quarter consumption may be less subject to habit-like behavior induced by the need to commit consumption in advance,[1] and more subject to discretion because investors have more leisure time to review their consumption and portfolio choice decisions during the holiday season, we do not have any direct evidence to support this view.

With these modifications, we empirically demonstrate that a substantial part of the variation in the historical average returns across different firm types can be explained by differences in their historical exposure to consumption risk. The CCAPM performs almost as well as the Fama and French (1993) three-factor model in explaining the cross-section of average returns on the 25 book-to-market and size-sorted benchmark portfolios created by Fama and French (1993). We also find that there is more support for the CCAPM when consumption betas are estimated based upon return on investments made during contractions.

The remainder of the paper is organized as follows. Section I contains a review of related literature. Section II describes our econometric model, and Section III presents the empirical results. We conclude in Section IV.

I. Other Related Literature

In explaining the cross-sectional differences in average returns on financial assets, the literature has proposed several measures of risk. These risk measures can be grouped into two broad categories. Models that belong to the first category are commonly referred to as consumption-based asset pricing models. In these models systematic risk is represented by the sensitivity of an asset's return to changes in the intertemporal marginal rate of substitution (IMRS) of a representative investor. Models within this class differ from one another based on the specification for IMRS as a function of observable and latent variables.[2]

The primary appeal of consumption-based models comes from their simplicity and their ability to value not only primitive securities like stocks,

[1] See Chetty and Szeidl (2005), who show that consumption commitment will induce habit-like features in the indirect utility function.

[2] See Cochrane (2000) for an excellent review of this extensive literature.

but also derivative securities like stock options. Specifically, in the standard consumption-based model, that is, the CCAPM, the IMRS of the representative investor is a function of only the growth rate in aggregate per capita consumption. This model has the advantage that its validity can be evaluated using sample analogues of means, variances, and covariances of returns and per capita consumption growth rates without the need for specifying how these moments change over time in some systematic stochastic fashion. The disadvantage of this class of models is that they make use of macroeconomic factors that are measured with substantial error and at lower frequencies. Here, we examine the consumption-based CAPM when investors revise their consumption plans infrequently.

Models that belong to the second category are commonly referred to as portfolio return-based models. In these models systematic risk is represented by the sensitivity of an asset's return to returns on a small collection of benchmark factor portfolios. In the standard Sharpe–Lintner CAPM, the benchmark portfolio is the return on the aggregate wealth portfolio in the economy; in empirical studies of the CAPM, the return on a portfolio of all exchange-traded stocks is used as a proxy. Merton (1973) derives an intertemporal version of the CAPM (ICAPM) showing that the expected return on an asset is a linear function of its several factor betas, with the return on the market portfolio being one of the factors. Campbell (1993) identifies the other factors in Merton's ICAPM as those variables that help forecast the future return on the market portfolio of all assets in the economy. Ross (1976) shows that Merton's ICAPM-like model obtains even when markets are incomplete provided returns have a factor structure and the law of one price is satisfied. Connor (1984) provides sufficient conditions for Ross's results to obtain in equilibrium.

Portfolio return-based models have the advantage that they make use of factors that can be constructed from market prices of financial assets that are measured relatively more often and more accurately (if they are available). In the case of the CAPM and the ICAPM (which belong to this category), the difficulty is that the aggregate wealth portfolio of all assets in the economy is not observable, so a proxy must be used. The common practice is to use the return on all exchange-traded stocks as a proxy for the market portfolio. However, as Jagannathan and Wang (1996) point out, the stock market forms only a small part of an economy's total wealth. Indeed, human capital forms a much larger part, and because the return on human capital is not observed, it must be inferred from national income and product account numbers, which are subject to substantial measurement error. Note, however, that to apply a model in this category, we only have to find a method for identifying factor portfolios that capture pervasive economy-wide risk.

Chamberlain and Rothschild (1983) show that factors constructed through principal component analysis of returns on primitive assets can serve as valid factors. Connor and Korajczyk (1986) develop an efficient algorithm for constructing factors based on principal component analysis of returns on a large collection of assets. Fama and French (1993) construct factors by taking long and short positions in two asset classes that earn vastly different returns on average. Da (2004) shows that when firms' cashflows have a conditional one-factor structure, the Fama and French three-factor beta pricing model obtains, where the first factor is the return on a well-diversified portfolio of all assets and the other two factors are excess returns on well-diversified long-short portfolios. The Fama and French (1993) three-factor model has become the premier model within this class. We therefore use the Fama and French three-factor model as the benchmark for evaluating the performance of the CCAPM.

II. The Model

We assume that the economy is populated by a representative investor with time and state separable Von Neumann–Morgenstern utility function for lifetime consumption, that is, from the vantage point of time t, the investor's utility is given by

$$E\left[\left(\sum_{s=t}^{\infty} \delta^s u(c_s)\right) \middle| F_t\right], \tag{1}$$

where c_s denotes consumption expenditure over several types of goods during period s, $u(.)$ denotes a strictly concave period utility function, δ denotes the time discount factor, and F_t denotes the information set available to the representative agent at time t. We assume that the representative investor reviews her consumption policy and portfolio holdings at periodic intervals for exogenously given reasons.[3] In what follows we assume that such reviews take place once every k periods, and at the same time for every investor. In addition, such reviews can take place at other random points in time as determined by the occurrence of important news events. Below we also examine the case in which there are two investor types, whereby investors of the first type review consumption and investment decisions every period, whereas investors of the second type make decisions infrequently.

Note that whenever an investor reviews consumption and investment decisions, the first-order condition of the investor's utility maximization problem must hold. Consider an arbitrary point in time, t, at which the representative

[3] Lynch (1996) and Gabaix and Laibson (2001) examine economies in which investors make consumption–investment decisions at different but infrequent points in time. They show that in such economies aggregate consumption will be much smoother relative to consumption of any one investor. Marshall and Parekh (1999) examine an economy in which infrequent adjustment of consumption arises endogenously due to transactions costs. They show that the aggregation property fails; aggregate consumption does not resemble the optimal consumption path of a hypothetical representative agent with preferences belonging to the same class as the investors in the economy. In our economy all agents review their consumption–savings decisions infrequently, but at the same predetermined points in time. Hence, there is a representative investor in our example economy.

investor reviews her consumption–investment decisions. Such points will occur at times $t = 0, k, 2k, 3k, \ldots,$ that is, t is an integer multiple of the decision interval k. The investor will choose consumption and investment policies at $t, t = 0, k, 2k, 3k, \ldots,$ to maximize expected lifetime utility, giving rise to the following relation that must be satisfied by all financial assets:

$$E_t\left[R_{i,t+j}\left(\frac{\delta^j u'(c_{t+j})}{u'(c_t)}\right)\right] = 0, \quad t = 0, k, 2k, \ldots; \quad j = 1, 2, \ldots. \tag{2}$$

In equation (2) given above, $R_{i,t+j}$ denotes the excess return on an arbitrary asset i from date t to $t+j$, c_{t+j} denotes consumption flow during $t+j$, $u(.)$ denotes the utility function, $u'(.)$ denotes its first derivative, δ denotes the time discount factor, and $E_t[.]$ denotes the expectation operator based on information available to the investor at date t. For notational convenience define the stochastic discount factor (SDF) as $m_{t,t+j} \equiv \frac{\delta^j u'(c_{t+j})}{u'(c_t)}$. Substituting this into equation (2) gives

$$E_t[R_{i,t+j} m_{t,t+j}] = 0. \tag{3}$$

In our empirical study we work with expected returns that can be estimated using historical averages. Therefore we work with the unconditional version of equation (3), after rewriting it in the more common covariance form given by

$$E[R_{i,t+j}] = -\frac{\text{cov}[R_{i,t+j}, m_{t,t+j}]}{E[m_{t,t+j}]} = -\frac{\text{var}[m_{t,t+j}]}{E[m_{t,t+j}]}\frac{\text{cov}[R_{i,t+j}, m_{t,t+j}]}{\text{var}[m_{t,t+j}]} \equiv \lambda_m \beta_{im,j}, \tag{4}$$

where $\beta_{im,j}$, the sensitivity of excess return $R_{i,t+j}$ on asset i to changes in the SDF $m_{t,t+j}$, is in general negative, and the market price for SDF risk, λ_m, should be strictly negative. When the utility function exhibits constant relative risk aversion with coefficient of relative risk aversion γ, the SDF is given by

$$m_{t,t+j} = \delta^j \left(\frac{c_{t+j}}{c_t}\right)^{-\gamma} \equiv \delta^j g_{c,t+j}^{-\gamma}, \tag{5}$$

where $g_{c,t+j}$ is the j period growth in per capita consumption from t to $t+j$. Substituting the expression for $m_{t,t+j}$ given by equation (5) into equation (4) and simplifying gives

$$E[R_{i,t+j}] = \lambda_{c\gamma j} \beta_{ic\gamma,j}, \tag{6}$$

where

$$\beta_{ic\gamma,j} = \frac{\text{cov}\left(R_{i,t+j}, g_{c,t+j}^{-\gamma}\right)}{\text{var}\left(g_{c,t+j}^{-\gamma}\right)}$$

and $\lambda_{c\gamma j}$ is a strictly negative constant that represents the risk premium for bearing the risk in $g_{c,t+j}^{-\gamma}$. For most assets i, $\beta_{ic\gamma}$ is strictly negative.

Following Breeden et al. (1989) we consider the following linear version of equation (6), which is generally referred to as the consumption-based capital asset pricing model (CCAPM):[4]

$$E[R_{i,t+j}] = \lambda_{cj}\beta_{icj}, \tag{7}$$

where

$$\beta_{icj} = \frac{\text{cov}(R_{i,t+j}, g_{c,t+j})}{\text{var}(g_{c,t+j})}$$

and $\lambda_{cj} \simeq \gamma \frac{\text{var}(g_{c,t+j})}{1-\gamma E(g_{c,t+j}-1)}$ is the market price for consumption risk. Note that the consumption beta for most assets is strictly positive, and so is the market price of consumption risk.

We examine the specification in equation (7) using the two-stage cross-sectional regression (CSR) method of Black, Jensen, and Scholes (1972) and Fama and MacBeth (1973). Following Berk (1995) and Jagannathan and Wang (1998), we examine possible model misspecification by checking whether the coefficient for firm characteristics such as the book-to-market ratio and relative market capitalization are significant in the CSRs. We verify the robustness of our conclusions by estimating the CCAPM using Hansen's (1982) generalized method of moments (GMM). Further, following Breeden et al. (1989), we construct consumption mimicking portfolios (CMP) and examine the CCAPM specification using the multivariate test proposed by Gibbons, Ross, and Shanken (1989; henceforth GRS).

In general, the ratio of the first and second moments of the measurement error, $\varepsilon_{gc,t+j}$, to the corresponding moments of $g_{c,t+j}$ is decreasing in j. Hence, measurement errors in consumption will have less influence on the conclusions when the return horizon j is increased, provided that $E[R_{i,t+j}]$ and β_{icj} are known constants. When $E[R_{i,t+j}]$ and β_{icj} are not known, and have to be estimated using data, increasing the return horizon, j, decreases the precision of those estimates. Ideally, we would like to choose j so as to minimize the effect of measurement error as well as sampling error on our conclusions. Given we have insufficient information to assess how measurement error and sampling error depend on j, we decide to set the return horizon, j, equal to the review period, k. We assume that k is a calendar year, that is, investors review their consumption and investment decisions at the end of every calendar year. While these choices are somewhat arbitrary, measuring returns over the calendar year enables us to overcome the need to model and explain well-documented deterministic seasonal effects in stock returns. The use of quarterly consumption data introduces the temporal aggregation bias discussed in Grossman, Melino, and Shiller (1987) and Kandel and Stambaugh (1990). Breeden et al. (1989) provide sufficient conditions for the CCAPM to hold even with time aggregation bias. Under these assumptions, it can be shown that the covariance between aggregate consumption growth and asset returns computed using quarterly

[4] See Appendix A for details.

consumption data and annual returns will understate the true covariance by an eighth.

In deriving the CCAPM given by equation (7) we assume that all investors make their consumption and investment decisions at the same point in time. When there are several investor types, and each type rebalances at a different point in time, the CCAPM in equation (7) will hold only approximately. To see the issues that are involved, consider an arbitrary point in time t, when some investors review their consumption and portfolio holdings decisions simultaneously while others do not. Without loss of generality, denote those who review their decisions simultaneously as type 1 investors and the others as type 2 investors. In that case the CCAPM holds when consumption betas are measured using *aggregate consumption,* and returns correspond to investments made during those periods when all investors belong to the first type. We show in Appendix B that when consumption betas are measured using data for other periods, the CCAPM will hold only approximately. In general, the specification error is larger when there are more type 2 investors, who only review consumption and investment plans infrequently. We conjecture that a larger fraction of investors in the population are likely to review their consumption and investment plans in fourth quarter than in other quarters. Hence, we should expect to find more evidence for the CCAPM when consumption growth from fourth quarter of one year to that of the next is matched with excess returns for the corresponding period to compute consumption betas.

We also assume that a larger fraction of investors are likely to revise their consumption and investment decisions during economic contractions. If that were true, we should find stronger support for the CCAPM when consumption betas are measured using return on investments made during contractions, and corresponding aggregate consumption growth data. Let $E(R_i \mid \text{contraction}) = \beta_{i,\text{cont}}\pi_{\text{cont}}$ denote the expected excess return on asset i, given that the economy is in a contraction, where π_{cont} is the consumption risk premium in contractions, and $\beta_{i,\text{cont}}$ is the consumption beta of asset i in contractions, measured using consumption data for those investors who make consumption and investment decisions. Let $E(R_i \mid \exp) = \beta_{i,\exp}\pi_{\exp}$ denote the expected excess return on asset i given that the economy is in an expansionary phase, where $\beta_{i,\exp}$ denotes the consumption beta of asset i during expansions for those investors who make consumption and investment decisions, and $\pi_{\exp}$ denotes the consumption risk premium during expansions. Suppose $\beta_{i,\exp} = \psi\beta_{i,\text{cont}}$ for some time-invariant constant ψ. Then, $E(R_i) = \beta_{i,\text{cont}} \times [p_{\text{cont}}\pi_{\text{cont}} + (1 - p_{\text{cont}})\psi\pi_{\exp}] = \beta_{i,\text{cont}}\pi = \beta_{i,\exp}\pi/\psi$, where π is the weighted average consumption risk premium. Hence, the CCAPM will hold whether we use $\beta_{i,\text{cont}}$ or $\beta_{i,\exp}$ for asset i. However, we only observe aggregate consumption. Because a larger fraction of the population should be making consumption and investment decisions at the same time during economic contractions, the *contraction beta*, $\beta_{i,\text{cont}}$, should be measured more precisely than *expansion beta*, $\beta_{i,\exp}$, using aggregate consumption data, leading to a flatter relation between average return and expansion consumption beta, compared to the relation between average return and contraction consumption beta, in the cross-section.

III. Data and Empirical Analysis

We assume that time is measured in quarters. We use the annual and quarterly seasonally adjusted[5] aggregate nominal consumption expenditure on nondurables and services for the period 1954 to 2003 from National Income and Product Accounts (NIPA) Table 2.3.5, and the monthly nominal consumption expenditures from NIPA Table 2.8.5. We obtain population numbers from NIPA Tables 2.1 and 2.6 and price deflator series from NIPA Tables 2.3.4 and 2.8.4 to construct the time series of per capita real consumption figures. The returns on the 25 book-to-market and size-sorted portfolios, the risk-free return, and the values for the Fama and French (1993) three factors (market, SMB (small minus big), and HML (high minus low)) for the period 1954 to 2003 are taken from Kenneth French's web site. We construct the excess return series on the 25 portfolios from these data. To verify the robustness of our conclusions, we also examine the performance of the model specifications when time is measured in months.

In what follows we first discuss the results obtained using calendar year excess returns and the growth rate in per capita real consumption measured in the fourth quarter. Table I gives the summary statistics for the consumption data we use in the study. Note that the means and standard deviations of the four-quarter consumption growth rates do not depend much on which quarter of the year we start with. However, the max minus the min is larger for the fourth quarter compared to other quarters. Moreover, the share of a quarter's consumption as a percentage of that calendar year's consumption is much more variable in the fourth quarter when compared to other quarters, providing some support for our conjecture that fourth quarter consumption is less subject to rigidity due to prior commitments.

Panel A of Table II shows substantial variation in the average excess returns across the 25 portfolios. For example, small growth firms realize an average excess return of 6.19% per year whereas small value firms earn 17.19% per year over the risk-free rate. The value–growth effect is more pronounced among small firms and the size effect is more pronounced among value firms. Firms that earn a lower return on average tend to have smaller consumption betas. Small growth firms, which earn the lowest return on average, have a consumption beta of 3.46 whereas small value firms have a consumption beta of 5.94, that is, 1.72 times as large. Further, the estimated consumption betas are statistically significantly different from zero. Figure 1 provides a scatter plot of the mean excess returns of the 25 portfolios against their estimated consumption betas. We find a reasonably linear relation.

Table III provides the results for the CSR method. When the model is correctly specified the intercept term should be zero, that is, assets with consumption beta of zero should earn a risk premium of zero. Note that the intercept of CCAPM is 0.14% per year, which is not statistically significantly different from

[5] We use seasonally adjusted data since we are unable to obtain seasonally unadjusted data on the consumption deflator. The seasonal adjustment process can be viewed as another source of measurement error.

Table I

Consumption Growth Summary

This table reports summary statistics of consumption growth. Consumption is measured by real per capita consumption expenditure on nondurables and services. For notational convenience, let Δc denote the growth rate in consumption, $(g_c - 1)$. Then, the consumption growth rate is given by $\Delta c_{t,t+j} = (\frac{C_{t+j}}{C_t} - 1) \times 100\%$. Panel A reports annual consumption growth rate. Q1-Q1 annual consumption growth is calculated using Quarter 1 consumption data. Q2-Q2, Q3-Q3, and Q4-Q4 annual consumption growth are calculated in a similar way. Annual-Annual consumption growth is calculated using annual consumption data. Dec-Dec consumption growth is calculated from December consumption data. Panel B reports quarterly consumption growth. Q3-Q4 is the fourth quarter consumption growth, calculated using Quarter 3 and Quarter 4 consumption data. Panel C gives the mean and standard deviation of quarterly consumption as a percentage of annual consumption for both nonseasonally adjusted and seasonally adjusted consumption. The sample period of quarterly and annual data is 1954–2003. The sample period of monthly data is 1960–2003. Panel A and Panel B are based on seasonally adjusted consumption. The unit of consumption growth rate is percentage points per year.

Panel A: Annual Consumption Growth (%)

	Q1-Q1	Q2-Q2	Q3-Q3	Q4-Q4	Annual-Annual	Dec-Dec
Mean	2.38	2.38	2.41	2.44	2.40	2.49
SD	1.38	1.31	1.29	1.38	1.21	1.43
Min	−0.36	−0.27	−0.49	−0.78	−0.07	−0.79
Max	5.72	5.40	4.83	5.70	4.52	5.17

Panel B: Quarterly Consumption Growth (%)

	Q4-Q1	Q1-Q2	Q2-Q3	Q3-Q4
Mean	3.36	3.60	3.64	3.80
SD	1.96	1.80	1.72	2.08
Min	−2.68	−3.52	−0.88	−1.12
Max	7.20	7.24	6.84	10.84

Panel C: Quarterly Consumption as Percentage of Annual Consumption (%)

		Q1	Q2	Q3	Q4
Not seasonally adjusted data	Mean	23.55	24.63	25.06	26.76
	SD	0.26	0.12	0.16	0.31
Seasonally adjusted data	Mean	24.77	24.93	25.07	25.23
	SD	0.13	0.07	0.06	0.14

zero after taking sampling errors into account. Consistent with our theoretical prediction, assets whose returns are not affected by fluctuations in the consumption growth rate factor do earn the risk-free rate.[6] The slope coefficient is significantly positive, consistent with the view that consumption risk carries a positive risk premium. There is some evidence that the model is misspecified;

[6] Daniel and Titman (2005) point out that spurious factor models can have high cross-sectional R^2. However, in the spurious factor models they examine using simulations, assets that have a zero beta earn substantially more than the risk-free return (see table 3 in their paper).

Table II

Annual Excess Returns and Consumption Betas

Panel A reports average annual excess returns on the 25 Fama–French portfolios from 1954 to 2003. Annual excess return is calculated from January to December in real terms. All returns are annual percentages. Panel B reports these portfolios' consumption betas estimated by the time-series regression:

$$R_{i,t} = \alpha_i + \beta_{i,c}\Delta c_t + \varepsilon_{i,t},$$

where $R_{i,t}$ is the excess return over the risk-free rate, and Δc_t is Q4-Q4 consumption growth calculated using fourth quarter consumption data. Panel C reports t-values associated with consumption betas.

	Low		Book-to-market		High
		Panel A: Average Annual Excess Returns (%)			
Small	6.19	12.47	12.24	15.75	17.19
	5.99	9.76	12.62	13.65	15.07
Size	6.93	10.14	10.43	13.23	13.94
	7.65	7.91	11.18	12.00	12.35
Big	7.08	7.19	8.52	8.75	9.50
		Panel B: Consumption Betas			
Small	3.46	5.51	4.26	4.75	5.94
	2.89	3.03	4.79	4.33	5.21
Size	2.88	4.10	4.35	4.79	5.71
	2.57	3.35	3.90	4.77	5.63
Big	3.39	2.34	2.83	4.07	4.41
		Panel C: t-values			
Small	0.93	1.71	1.59	1.83	2.08
	0.98	1.27	2.02	1.83	2.10
Size	1.15	1.93	2.17	2.07	2.39
	1.14	1.75	1.90	2.26	2.39
Big	1.71	1.32	1.67	2.15	2.00

when the log book-to-market ratio is introduced as an additional variable in the CSR, its slope coefficient is significantly different from zero. Note, however, that a similar phenomenon occurs with the Fama and French three-factor model as well. When the log size and log book-to-market ratio are added as additional explanatory variables in the Fama and French three-factor model, they depress the statistical significance of the slope coefficients for the three risk factors.[7] The point estimate of the intercept term for the Fama and French three-factor model is 10.43% per year, which is a rather large value for the expected return on a zero beta asset compared to the risk premium of 5.83% per year for the

[7] In contrast, Jagannathan, Kubota, and Takehara (1998) find that the book-to-market ratio is not significant when added as an additional variable in the Fama and French three-factor model.

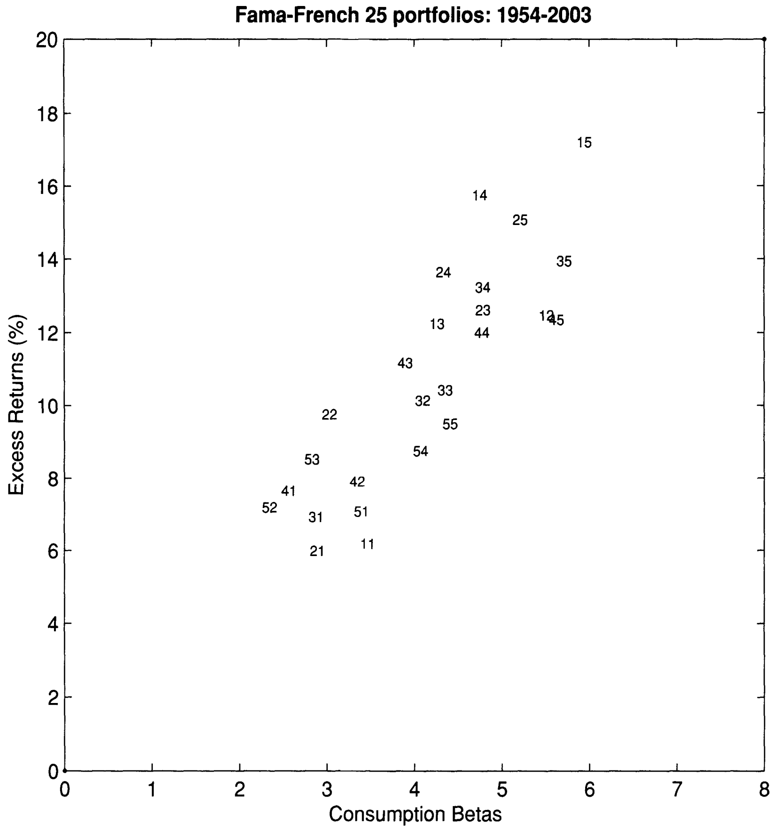

Figure 1. Annual excess returns and consumption betas. This figure plots the average annual excess returns on the 25 Fama–French portfolios and their consumption betas. Each two-digit number represents one portfolio. The first digit refers to the size quintile (1 smallest, 5 largest), and the second digit refers to the book-to-market quintile (1 lowest, 5 highest).

HML risk factor.[8] Figure 2 gives plots of the realized average excess returns against their theoretical values according to each of the three fitted models. Note that while the points are roughly evenly distributed around the 45-degree line for the CCAPM specification, there is a U-shaped pattern for the Fama and French three-factor model; assets with both high and low expected returns according to the model tend to earn more on average.

Fama and French (1993) examine the empirical support for their three-factor model using the seemingly unrelated regression method suggested by GRS (1989). To examine the empirical support for the CCAPM using the same method, we first construct the CMP that best approximates the consumption growth rate in a least squares sense. We regress demeaned consumption growth

[8] There is little variation in the stock market factor betas across the 25 portfolios, introducing near multicollinearity between the vector of ones and the vector of stock market betas. This is the reason for the large positive value for the intercept term in the CSRs.

Table III

Cross-Sectional Regression

This table reports the Fama–MacBeth (1973) cross-sectional regression estimation results for asset pricing model:

$$E[R_{i,t}] = \lambda_0 + \lambda'\beta.$$

Betas are estimated by the time-series regression of excess returns on the factors. Test portfolios are the 25 Fama–French portfolios' annual percentage return from 1954 to 2003. The estimation method is the Fama–MacBeth cross-sectional regression procedure. The first row reports the coefficient estimates ($\hat{\lambda}$). Fama–MacBeth t-statistics are reported in the second row, and Shanken-corrected t-statistics are in the third row. The last column gives the R^2 and adjusted R^2 just below it.

	Constant	Δc	R_m	SMB	HML	log(ME)	log(B/M)	R^2(adj R^2)
Estimate	0.14	2.56						0.73
t-value	0.05	3.89						0.71
Shanken-t	0.02	1.98						
Estimate	11.31		−0.56					0.00
t-value	2.05		−0.09					−0.04
Shanken-t	2.05		−0.08					
Estimate	10.43		−3.26	3.12	5.83			0.80
t-value	2.66		−0.70	1.62	3.11			0.77
Shanken-t	2.37		−0.57	1.03	2.12			
Estimate	11.75	1.58	−3.76	3.00	5.75			0.87
t-value	2.98	3.64	−0.81	1.56	3.07			0.84
Shanken-t	1.95	2.26	−0.50	0.83	1.71			
Estimate	16.20					−0.87	3.46	0.84
t-value	2.95					−1.43	3.00	0.83
Estimate	12.19	0.71				−0.71	2.66	0.86
t-value	2.41	1.62				−1.23	2.12	0.84
Estimate	22.22		−3.80	−0.67	0.96	−1.07	3.04	0.87
t-value	3.50		−0.88	−0.23	0.37	−1.51	2.87	0.84

on excess returns of the six Fama–French (1993) benchmark portfolios to estimate CMP weights. Note that the CMP obtained by regressing a constant on the excess return of the assets without an intercept term will be mean-variance efficient and hence price the excess returns of the assets used to construct the CMP without any error. That is the reason for demeaning consumption growth for use in constructing their mimicking portfolio. Since we only have 50 years of data, regressing demeaned consumption growth on all the 25 asset returns gives very imprecise estimates of the slope coefficients. We therefore reduce the number of assets from 25 to 6 by using the six book-to-market and size-sorted portfolios provided by Kenneth French in his web site when constructing CMP. We then regress the excess return of the 25 Fama and French stock portfolios on the excess return of the CMP that we construct. The results are given in Table IV. It can be verified that the average absolute value of the alphas is 1.91 for the CCAPM, and the corresponding figure for the Fama and French three-factor model is 1.22. The maximum absolute alpha for the CCAPM is

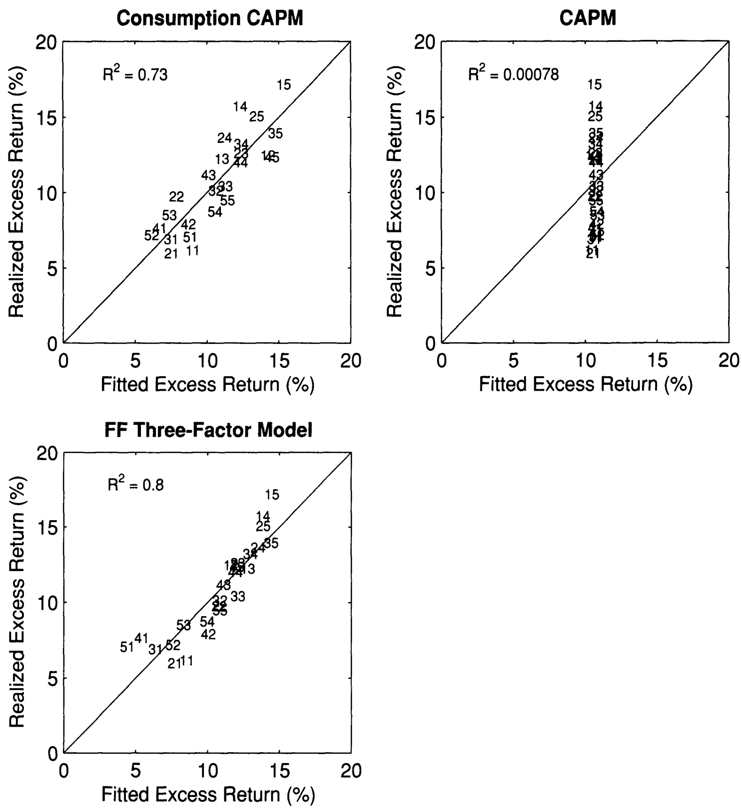

Figure 2. Realized and fitted excess returns. This figure compares realized annual excess returns and fitted annual excess returns of the 25 Fama–French portfolios during 1954–2003. Each two-digit number represents one portfolio. The first digit refers to the size quintile (1 smallest, 5 largest), and the second digit refers to the book-to-market quintile (1 lowest, 5 highest). Three models are compared: CCAPM, CAPM, and the Fama–French three-factor model. Models are estimated by the Fama–MacBeth cross-sectional regression procedure.

also larger: 5.27 for the CCAPM and 3.98 for the Fama and French three-factor model. However, the absolute value of the t statistic of the alphas for the Fama and French three-factor model is much larger. The GRS (1989) statistic for the CMP is 1.30 (p-value = 0.26); the corresponding statistic for the Fama and French three-factor model is 1.65 (p-value = 0.12).

Table V gives the model misspecification measure, that is, the pricing error for the most mispriced portfolio, suggested by Hansen and Jagannathan (1997). That measure is smaller for the CCAPM than for the Fama and French three-factor model. On balance, it therefore appears that there is fairly strong empirical support for the consumption risk model.

A. Implied Coefficient of Relative Risk Aversion

Consider the slope coefficient, λ_1, in the CSR equation given by

$$R_{i,t+4} = \lambda_0 + \lambda_1 \beta_{ic4} + \varepsilon_{i,t+4}.$$

Table IV

Time-Series Regression and GRS Test

Panel A reports pricing errors (α) for the CCAPM, CAPM, and the Fama–French (1993) three-factor model. Pricing errors are estimated by the time-series regression

$$R_{i,t} = \alpha_i + \beta_i f_t + \varepsilon_{i,t},$$

where f_t = CMP (excess return of the consumption mimicking portfolio) for the CCAPM, $f_t = R_{m,t}$ (market excess return) for the CAPM, and $f_t = [R_{m,t}$, SMB, HML] for the Fama–French three-factor model (FF3). Test portfolios are the 25 Fama–French portfolios' annual percentage return from 1954 to 2003. Panel B reports Gibbons, Ross, and Shanken (1989) test statistics and p-values.

$$\text{GRS} = \frac{T-N-K}{N}[1 + E_T(f)'\hat{\Omega}^{-1}E_T(f)]^{-1}\hat{\alpha}'\hat{\Sigma}^{-1}\hat{\alpha} \sim F_{N,T-N-K}.$$

Panel A: Pricing Errors

CCAPM α					t-value				
−1.59	1.00	2.67	5.10	5.27	−0.27	0.21	0.69	1.42	1.33
−1.21	1.46	2.12	2.71	3.30	−0.26	0.42	0.67	0.90	1.05
0.05	1.25	1.03	2.20	2.04	0.01	0.43	0.40	0.75	0.69
2.01	0.57	1.79	1.58	0.16	0.57	0.21	0.67	0.60	0.06
−0.83	0.99	3.34	−0.98	−2.37	−0.30	0.39	1.29	−0.44	−0.98
CAPM$_\alpha$					t-value				
−5.14	1.84	3.84	7.65	8.08	−1.38	0.61	1.45	2.90	2.82
−3.99	1.51	4.58	5.87	6.79	−1.62	0.79	2.12	2.64	2.90
−2.23	2.45	3.36	5.33	6.31	−1.34	1.52	1.97	2.56	2.55
−0.55	0.90	3.68	4.65	3.98	−0.36	0.66	2.41	2.48	1.96
−0.46	0.40	2.22	1.85	1.88	−0.38	0.44	1.99	1.26	0.98
FF3 α					t-value				
−3.98	−0.83	0.36	2.81	2.23	−2.18	−0.72	0.38	2.76	2.49
−2.80	−0.71	1.09	0.42	0.70	−2.41	−0.71	0.96	0.42	0.74
−0.31	−0.13	−0.79	−0.06	−0.22	−0.39	−0.13	−0.82	−0.05	−0.19
2.19	−1.54	−0.17	0.03	−1.13	2.09	−1.28	−0.16	0.02	−0.82
1.93	−0.22	1.06	−1.70	−2.97	2.01	−0.24	0.96	−1.93	−2.50

Panel B: Gibbons, Ross, and Shanken Test

	CCAPM	CAPM	FF3
GRS	1.30	2.07	1.65
p-value	0.26	0.04	0.12

If the standard consumption-based asset pricing model holds, $\lambda_0 = 0$ and $\lambda_1 = \frac{\gamma \text{var}(g_{c,t+4})}{1-\gamma[E(g_{c,t+4})-1]}$, where γ denotes the coefficient of relative risk aversion. The estimated slope coefficient, $\hat{\lambda}_1 = 2.56$, therefore corresponds to an implied coefficient of relative risk aversion of about 31 when the model is correctly specified. The large estimate for the risk-aversion parameter of the

Table V

GMM Estimation

We estimate the stochastic discount factor representation of the CCAPM, CAPM, and Fama and French (1993) three-factor model given by

$$E[(1 - b'f)R_{i,t}] = 0,$$

where f denotes the per capita consumption growth rate in the case of the CCAPM, the excess return on the value-weighted portfolio of all NYSE, AMEX, and NASDAQ stocks in the case of the CAPM, and the vector of the three risk factors in the case of the Fama–French three-factor model. Asset returns are value-weighted annual returns on the 25 Fama–French portfolios. The sample period is 1954 to 2003. Following Hansen and Jagannathan (1997) the model is estimated by the generalized method of moments with the inverse of the second moments of asset excess returns as the weighting matrix. The coefficient estimates are reported in the first row. The second row reports t-statistics. The last two columns give the HJ distance and corresponding p-value.

	Δc	R_m	SMB	HML	HJ distance	p-value
Estimate	33.01				0.29	0.69
t-value	25.45					
Estimate		2.10			0.74	0.08
t-value		6.44				
Estimate		1.90	0.56	2.61	0.63	0.10
t-value		4.12	0.85	5.02		

representative investor on the one hand and the ability of the CCAPM to explain the cross-section of stock returns well on the other are consistent with the explanations given by Constantinides and Duffie (1996) and Heaton and Lucas (2000). These results are also consistent with the specification suggested by Campbell and Cochrane (1999). For example, suppose the utility function is given by Abel's external habit model, that is, the utility function is $u(C_t - X_t)$, where C_t denotes the date t consumption as before, and X_t represents the external habit level that the consumer uses as the reference point. In that case, as Campbell and Cochrane (1999) show, the SDF that assigns zero value to an excess return is given by

$$m_{t,t+k} = \left(\frac{S_{t+k}}{S_t}\frac{C_{t+k}}{C_t}\right)^{-\gamma}, \tag{8}$$

where $S_t = \frac{C_t - X_t}{C_t}$ denotes the surplus consumption ratio. We can approximate $m_{t,t+k}$ around $S_t = S_{t+k}$ and $C_t = C_{t+k}$ using Taylor series to get

$$m_{t,t+k} \simeq \left(1 - \gamma\left[\frac{S_{t+k} - S_t}{S_t} + \frac{C_{t+k} - C_t}{C_t}\right]\right) \tag{9}$$

$$= (1 - \gamma[(g_{s,t+k} - 1) + (g_{c,t+k} - 1)]), \tag{10}$$

where $g_{s,t+k}$ and $g_{c,t+k}$ are the growth in the surplus consumption ratio and consumption, respectively, from date t to date $t+k$. Substituting the above expression for $m_{t,t+k}$ into equation (3) and simplifying gives

$$E[R_{i,t+k}] = \lambda_c \beta_{ic} + \lambda_s \beta_{is}, \tag{11}$$

where

$$\beta_{ic} = \frac{\text{cov}(R_{i,t+k}, g_{c,t+k})}{\text{var}(g_{c,t+k})}; \quad \beta_{is} = \frac{\text{cov}(R_{i,t+k}, g_{s,t+k})}{\text{var}(g_{s,t+k})}, \tag{12}$$

and λ_s and λ_c are the risk premia for bearing the risk associated with the surplus consumption ratio growth and consumption growth, respectively. Note that S_t is a stationary random variable, whereas C_t is growing. This can be seen from the fact that $S_t = \frac{C_t - X_t}{C_t}$, and X_t is an average of past consumption realizations, the extreme case of which is $X_t = C_{t-1}$. Hence, $\frac{\text{var}(g_{s,t+k})}{\text{var}(g_{c,t+k})}$ becomes small as k becomes large. The rather large implied value for the coefficient of relative risk aversion indicates that setting k to four quarters may ignore some of the effect due to $\frac{S_{t+k} - S_t}{S_t}$. The high cross-sectional R^2, on the other hand, indicates that the effect due to possible omission of $\frac{S_{t+k} - S_t}{S_t}$ is likely to be the same across all the portfolios.

In deriving our consumption-based asset pricing model specification we assume that all investors revise their consumption decision at the same time. As Lynch (1996) and Gabaix and Laibson (2001) show, when investors review their consumption–investment plans infrequently, but at different points in time, aggregate consumption will exhibit substantially less variability than individual consumption. In that case, while the linear relation between expected return and consumption covariance will hold approximately, the implied risk-aversion coefficient will be much larger.

B. Alternative Empirical Specifications

We take the stand above that all investors review their consumption–investment decisions during the last quarter of the calendar year; while they may also review at other points in time, such reviews may not occur during the same period for all individuals. Given this view, we would expect to find the most support for the CCAPM when matching consumption growth from the fourth quarter of one calendar year to that of the next with asset returns for the corresponding period.[9] Table VI gives the results when we measure annual consumption growth starting from other than the fourth quarter in a year. Note that the consumption betas of small growth and small value firms are closer to each other when consumption growth is measured from the first, the second, or the third quarters. The cross-sectional R^2 drops substantially, to as low as 14% when consumption growth is measured from the second quarter of one year to that of the next year. The estimated intercepts are large and significantly different from zero. The second quarter is the farthest from the fourth. If the fraction of investors in the population who review their consumption and investment plans is an increasing function of how close they are to the fourth quarter in the

[9] See Appendix B for details.

Table VI

Consumption Betas Using Other Quarterly Data

Panel A reports the 25 Fama–French (1993) portfolios' annual returns and their consumption betas estimated by the time-series regression

$$R_{i,t} = \alpha_i + \beta_{i,c}\Delta c_t + \varepsilon_{i,t},$$

where Δc_t is annual consumption growth calculated using quarterly consumption data. Portfolio returns are annual excess returns on the 25 Fama–French portfolios from 1954 to 2003. For Q1-Q1 consumption growth, portfolio annual returns are calculated from April to the next March. For Q2-Q2 consumption growth, portfolio annual returns are calculated from July to the next June. For Q3-Q3 consumption growth, portfolio annual returns are calculated from October to the next September. All returns are annual percentages. Panel B reports Fama–MacBeth cross-sectional regression estimation results. Panel C reports the bootstrap simulation results for all consumption growth time series. We pick 50 of the consumption growth observation at random (with replacement) from the empirical demeaned consumption growth distribution, and use those 50 random realizations in the cross-sectional regression, GMM, and GRS tests. The simulation p-values are computed using 10,000 replications. The p-value for the CSR intercept denotes the probability of getting an intercept value that is smaller in absolute value than the intercept we obtained using actual consumption growth data. Other p-values denote the probability of getting estimates that are greater than the ones reported in the table that were obtained using realized consumption data.

Panel A: Annual Excess Returns and Consumption Betas

Q1-Q1 Excess Returns (%)					Q1-Q1 Consumption Betas				
3.88	9.80	10.75	13.93	14.69	5.10	6.02	4.30	4.83	5.80
4.34	8.62	11.29	12.21	13.14	2.64	3.02	3.99	3.23	4.60
5.90	9.04	9.55	11.64	12.22	2.03	2.52	3.17	3.74	4.25
7.12	6.93	10.24	10.51	10.78	2.39	1.68	2.44	3.77	5.23
6.63	6.59	7.83	8.01	8.29	3.11	1.84	2.15	3.60	4.55
Q2-Q2 Excess Returns (%)					**Q2-Q2 Consumption Betas**				
4.61	10.95	11.54	14.83	15.67	5.31	4.81	4.28	4.38	5.14
5.58	9.55	12.08	12.78	13.90	2.03	2.46	3.23	2.64	3.60
6.85	10.06	10.32	12.23	12.82	1.93	1.70	2.83	2.51	2.95
7.66	7.91	10.94	11.16	11.38	1.90	0.60	1.24	2.81	3.10
7.18	7.00	8.44	8.60	8.79	3.03	0.15	0.89	1.88	2.73
Q3-Q3 Excess Returns (%)					**Q3-Q3 Consumption Betas**				
5.52	11.81	12.05	15.51	16.56	3.30	2.76	2.62	2.98	3.63
6.01	9.64	12.62	13.25	14.44	−0.02	0.54	1.84	1.11	2.52
7.35	10.64	10.45	13.03	13.33	0.01	0.34	1.41	0.66	2.80
8.51	8.26	11.37	11.99	11.81	0.19	0.11	0.10	1.95	2.09
7.64	7.47	8.67	8.75	9.10	1.41	−0.13	1.04	1.34	1.55

Panel B: Cross-Sectional Regression

	Constant	Q1-Q1	Q2-Q2	Q3-Q3	R^2(adj R^2)
Estimate	4.98	1.17			0.27
t-value	2.03	2.38			0.24
Estimate	7.52		0.87		0.18
t-value	3.08		1.67		0.14
Estimate	8.61			1.36	0.30
t-value	3.10			2.69	0.27

(*continued*)

Table VI—*Continued*

Panel C: Bootstrap Simulation p-values				
	Q1-Q1	Q2-Q2	Q3-Q3	Q4-Q4
CSR intercept	4.98	7.52	8.61	0.14
p-value	0.046	0.136	0.177	0.0003
CSR slope	1.17	0.87	1.36	2.56
p-value	0.196	0.254	0.137	0.023
CSR adj R^2	0.24	0.14	0.27	0.71
p-value	0.279	0.394	0.209	0.010
HJ-distance	0.31	0.33	0.31	0.29
p-value	0.815	0.620	0.682	0.886
CMP Sharpe ratio	0.45	−0.44	−0.64	0.70
p-value	0.135	0.977	0.998	0.012
GRS	2.76	1.96	1.92	1.30
p-value	0.892	0.859	0.966	0.981

calendar year, we should expect the pricing errors for the CCAPM to be smaller for returns on investments made during the third and first quarters relative to that for the second quarter.

Following Kan and Zhang (1999a, 1999b) and Shanken and Zhou (2007), we conduct a simulation exercise with a "useless consumption factor" and verify that the results we find can not happen if consumption growth rate is indeed just random noise. For that purpose we first randomly pick 50 demeaned consumption growth observations from the empirical distribution that we have (with replacement). Clearly, since these consumption growth numbers have been picked at random, they should not be able to explain the cross-section of stock returns. We then perform the cross-sectional regression, GMM, and GRS tests using the simulated consumption growth, and repeat the simulations 10,000 times. As can be seen from Table VI (Panel C), the probability of getting an intercept as close to zero as with the Q4-to-Q4 consumption growth in the CSR is almost zero. The probability of getting an adjusted R^2 greater than 0.71, or a Sharpe ratio for the CMP of 0.70 or higher that we get with Q4-to-Q4 consumption growth is about 1%. Clearly, the support for the Q4-to-Q4 consumption model we find would be difficult to obtain using a useless factor. Our simulations suggest that the CSR statistics and the CMP Sharpe ratio help discriminate a random useless factor from a useful economic factor. In contrast the GMM and GRS test statistics have low power.

Measurement error in consumption and the time aggregation bias have less influence on the conclusions when returns are measured over a longer holding period. However, the use of longer horizon returns reduces the number of observations available for estimating covariances, thereby increasing the associated estimation error. Using higher frequency consumption data minimizes the time aggregation bias, but also increases the measurement error in the

Table VII

CCAPM with Different Frequency Data

We use different frequency returns and consumption data to test the CCAPM. Panel A describes how consumption growth is calculated. For example, with monthly consumption data, annual consumption growth is measured using December consumption of one year and December consumption of the following year. Panel B reports cross-sectional regression estimation results for the CCAPM:

$$E[R_{i,t}] = \lambda_0 + \lambda_1 \beta_{i,c}.$$

Test portfolio returns are annualized excess returns on the 25 Fama–French (1993) portfolios from 1960 to 2003. (Monthly consumption data are available from 1959.)

Panel A: Consumption Growth

	Monthly Consumption Data	Quarterly Consumption Data	Annual Consumption Data
Monthly growth	Month-Month		
Quarterly growth	Dec–Mar, Mar–Jun Jun–Sep, Sep–Dec	Quarter-Quarter	
Annual growth	Dec-Dec	Q4-Q4	Annual-Annual

Panel B: Cross-Sectional Regression Results

	Monthly Consumption Data			Quarterly Consumption Data			Annual Consumption Data		
	λ_0	λ_1	R^2	λ_0	λ_1	R^2	λ_0	λ_1	R^2
Monthly return	7.70	0.02	0.00						
t-value	2.61	0.17	−0.04						
Quarterly return	8.34	0.03	0.00	4.52	0.33	0.22			
t-value	2.80	0.15	−0.04	1.83	1.59	0.18			
Annual return	−1.83	2.01	0.41	−1.19	2.68	0.69	10.12	1.32	0.21
t-value	−0.51	2.33	0.38	−0.37	3.49	0.68	3.70	1.61	0.18

consumption data.[10] We therefore examine the performance of the model when we match monthly and quarterly consumption data with monthly, quarterly, and annual return data. The results are given in Table VII. We find more support for the model when longer holding period returns are used. Performance worsens when we use monthly consumption data, indicating that the effect due to increased measurement error in the consumption data more than offsets the gain from any reduction in the time aggregation bias. When we use the monthly consumption data and measure the annual growth rate in consumption from December of one year to December of the following year, the cross-sectional R^2

[10] Mankiw and Shapiro (1986) use January and April monthly consumption data to calculate first quarter consumption growth. Breeden et al. (1989) use December and March monthly consumption data to calculate first quarter consumption growth. They both match the quarterly consumption growth rate with quarterly returns in order to compute the covariance between consumption growth rate and returns.

Table VIII
Fama–French 2×3 Portfolios

This table reports cross-sectional regression results of the CCAPM and Fama–French (1993) three-factor models on Fama–French 2 × 3 portfolios (small value, small neutral, small growth, big value, big neutral, big growth). Samples are 1954 to 2003 annual data. All returns are annual percentages.

	Constant	Δc	R_m	SMB	HML	R^2(adj R^2)
Estimate	−1.10	2.81				0.89
t-value	−0.33	3.86				0.86
Shanken-*t*	−0.16	1.84				
Estimate	9.07		−1.46	2.64	5.76	0.87
t-value	1.94		−0.27	1.39	3.11	0.68
Shanken-*t*	1.75		−0.23	0.88	2.12	

drops from 69% to 41% and the intercept term becomes larger in absolute value, though still not statistically different from zero.

To determine whether our conclusions depend critically on the use of seasonally adjusted data on expenditures of nondurables and services, we evaluate the model using nonseasonally adjusted consumption data. The price deflator for personal consumption expenditures is only available in the seasonally adjusted form, so we follow Ferson and Harvey (1992) and use nonseasonally adjusted CPI to deflate nominal consumption expenditures. The results (not reported) do not change in any significant way.

In order to examine the sensitivity of our conclusions to the particular consumption data series used, we estimate the model parameters using the data series used by Lettau and Ludvigson (2001) available from Martin Lettau's web site. We find that the parameter estimates (not reported) do not change much and the conclusions remain the same.

We also examine whether the favorable empirical evidence for the CCAPM that we find is driven by a few outlying observations. For that purpose we omit the four observations that correspond to the two largest and two smallest consumption growth numbers in our data. With this change, the adjusted cross-sectional R^2 drops from 71% to 58%. The slope coefficient for consumption beta changes from 2.56 (Shanken $t = 1.98$) to 2.16 (Shanken $t = 1.75$). Clearly, observations that correspond to large changes in consumption growth are important. However, they are not critical to our conclusion that the data support the CCAPM.

C. Other Portfolios

We also examine the robustness of our findings using the six book-to-market and size-sorted portfolios constructed by Fama and French. The asymptotic theory we rely on for statistical inference may be more justified in this smaller cross-section of assets. The results are given in Table VIII. The slope coefficient for consumption growth is 2.81, which is not much different from the 2.56 for

Table IX

Cross-Sectional Regression Results: Other Portfolios

Test portfolios are sorted on size, book-to-market, earning-to-price, and cashflow-to-price. Nineteen portfolios are constructed for each sorting variable: negative (not used for size and book-to-market), 30%, 40%, 30%, 5 quintiles, 10 deciles. Value-weighted annual returns are from December 31 to December 31. Consumption betas are estimated using Q4-Q4 consumption growth. Sample period is 1954–2003. All returns are annual percentages.

	CCAPM			Fama-French Three-Factor Model				
	Constant	Δc	R^2	Constant	R_m	SMB	HML	R^2
				18 Size Portfolios				
Estimate	−0.44	2.60	0.81	9.09	−1.01	3.36	−0.05	0.99
t-value	−0.09	1.68	0.80	0.78	−0.09	1.43	−0.01	0.99
Shanken-*t*	−0.04	0.85		0.75	−0.08	1.05	−0.01	
				18 B/M Portfolios				
Estimate	2.62	1.79	0.80	−0.58	8.53	0.27	4.62	0.95
t-value	0.97	2.94	0.79	−0.10	1.37	0.05	1.80	0.94
Shanken-*t*	0.63	1.87		−0.09	1.08	0.04	1.29	
				19 E/P Portfolios				
Estimate	1.94	2.09	0.53	−1.96	10.05	−0.02	6.44	0.96
t-value	0.93	3.85	0.50	−0.36	1.67	0.00	2.75	0.95
Shanken-*t*	0.55	2.22		−0.27	1.21	0.00	1.81	
				19 CF/P Portfolios				
Estimate	2.81	1.72	0.59	−1.33	9.41	1.64	6.09	0.90
t-value	1.19	3.46	0.56	−0.27	1.69	0.40	2.61	0.88
Shanken-*t*	0.79	2.22		−0.21	1.25	0.29	1.75	

the cross-section of 25 assets. The cross-sectional R^2's for the CCAPM and the Fama and French three-factor model specifications are again comparable.

Table IX gives the results for several other sets of assets, namely, 18 portfolios sorted on size, 18 portfolios sorted on book-to-market, 19 portfolios sorted on the earning-to-price ratio, and 19 portfolios sorted on the cashflow-to-price ratio, all taken from Kenneth French's web site. The consumption model performs almost as well as the Fama and French three-factor model for the portfolios sorted on size and book-to-market, but not for those sorted on the earning-to-price ratio and the cashflow-to-price ratio. However, the estimated slope coefficients for consumption growth in the CSRs are not much different across the different sets of assets.

Following Daniel and Titman (2005), we also evaluate the performance of the consumption-based model using returns on the 17 industry portfolios constructed by Fama and French. The average excess returns on the industry portfolios are closer together, and vary from a low of 6.07% to a high of 10.71%. The difference between the maximum and the minimum average excess returns is rather small, only 4.64%, when compared to the corresponding spread of 11% for the 25 book-to-market and size-sorted portfolios. There is substantial variation in consumption, market, SMB, and HML factor betas across the industries. Consumption betas vary from 0.15 to 0.60; market factor betas vary from 0.69 to 1.23; SMB factor betas vary from −0.37 to 0.72; and the HML factor betas vary from −0.34 to 0.73. There is substantial variation in the book-to-market characteristics as well. The average book-to-market ratios among the 17 industry portfolios vary from a low of 0.32 to a high of 1.11, for a difference of 0.79, which is comparable to the corresponding difference of 0.76 for the 25 book-to-market and size-sorted portfolios. There is less dispersion in the average size of firms across the industry portfolios, ranging from $154 million to $1,621 million. In contrast, the average firm size varies from a low of $22 million for the smallest size quintile to $7,980 million for the largest size quintile in the 25 book-to-market and size-sorted portfolios. The results for the time-series and CSR tests are reported in Table X. The average and the largest absolute value of the alphas are 1.98% and 5.28% per year, respectively, for the CCAPM using the CMP. The corresponding numbers for the Fama and French three-factor model are 2.23% and 6.24%. The alphas for the consumption-based model are smaller in magnitude than those for the Fama and French three-factor model. There is less evidence, in a statistical as well as economic sense, against the consumption-based model using excess returns on industry portfolios. Further, the slope coefficients corresponding to the book-to-market and size characteristics are not statistically significant in the CSRs.

Above, we compute consumption betas by matching consumption growth from the fourth quarter of one year to that of the next with the December-to-December return over the same year. However, there is no particularly compelling reason for matching the December-to-December return with the Q4-to-Q4 consumption growth. We should expect similar results if we were to match the October-to-October or November-to-November return with Q4-to-Q4 consumption growth while computing consumption betas. To examine the robustness of our conclusions we therefore use the average of October-to-October, November-to-November, and December-to-December returns. We find that the slope coefficient for consumption beta in the CSRs is 2.70 and the adjusted cross-sectional R^2 is 65%, not significantly different from the corresponding 2.56 and 71% for December-to-December returns.

D. Contraction Beta and Expansion Beta

We hypothesize above that when processing information and updating consumption and investment plans requires an investment of valuable time and effort, investors will find it optimal to review decisions infrequently. That is, we posit that the frequency with which decisions are reviewed should increase during economic contractions, when the relative value of leisure time required

Table X

Seventeen Industry Portfolios

This table reports time-series regression and cross-sectional regression results of the CCAPM (consumption mimicking portfolio) and the Fama–French three-factor model on 17 industry portfolios (food, minerals, oil, clothes, durables, chemicals, consumer goods, construction, steel, fabricated parts machinery, cars, transportation, utilities, retail, financial, others). Panel A gives pricing errors (α), t-value, and GRS test results. Panel B gives cross-sectional regression results. Samples are 1954–2003 annual data. All returns are annual percentages.

Panel A: Time-Series Regression and GRS Test

	CCAPM (CMP)		Fama–French Model	
	α	t-value	α	t-value
1	2.45	0.99	3.26	1.54
2	3.08	0.78	−0.96	−0.30
3	5.28	1.61	1.58	0.69
4	−3.42	−0.91	−4.08	−1.70
5	1.05	0.31	0.06	0.02
6	−0.79	−0.29	−0.98	−0.59
7	4.38	1.47	6.24	2.73
8	−0.38	−0.12	−1.18	−0.91
9	−2.83	−0.74	−4.59	−1.71
10	0.39	0.14	−0.98	−0.64
11	1.40	0.37	1.68	0.96
12	−4.51	−1.39	−4.79	−2.06
13	−1.13	−0.36	−2.70	−1.51
14	0.54	0.21	−1.59	−0.91
15	−1.83	−0.61	0.59	0.25
16	0.19	0.07	−1.25	−0.74
17	0.98	0.33	1.46	1.15
GRS	1.51		2.93	
p-value	0.15		0.00	

Panel B: Cross-Sectional Regression

	Constant	CMP	R_m	SMB	HML	log(ME)	log(B/M)	R^2
Estimate	6.90	3.61						0.09
t-value	2.83	0.54						0.06
Shanken-t	2.81	0.44						
Estimate	6.01		2.60	−1.24	−0.68			0.12
t-value	1.53		0.53	−0.48	−0.30			−0.08
Shanken-t	1.51		0.47	−0.37	−0.23			
Estimate	5.75					0.00	0.66	−0.33
t-value	1.83					1.06	0.26	−0.52

to analyze information and change plans is less expensive. If that were true, we should find stronger support for the CCAPM using contraction betas. To estimate contraction betas and expansion betas of the 25 stock portfolios, we use NBER dating of business cycle turning points to classify periods during which

Table XI

Consumption Beta in Contractions and Expansions

This table reports cross-sectional regression results of the CCAPM during different subperiods. First, we estimate the contraction consumption beta and the expansion consumption beta by the time-series regression

$$E_t[R_{i,t+4}] = \alpha_{i,\text{cont}} I_t + \alpha_{i,\text{exp}}(1 - I_t) + \beta_{i,\text{cont}} \Delta c_{t+4} I_t + \beta_{i,\text{exp}} \Delta c_{t+4}(1 - I_t),$$

where $I_t = 1$ if the economy is contracting according to the NBER Business Cycle Dating, otherwise $I_t = 0$; $\beta_{i,\text{cont}}$ is the contraction consumption beta and $\beta_{i,\text{exp}}$ is the expansion consumption beta. Then we run the cross-sectional regression

$$E[R_{i,t+4}] = \lambda_0 + \lambda' \beta_i.$$

$R_{i,t+4}$ are annual excess returns of the 25 Fama–French portfolios from quarter t to quarter $t+4$ for all quarters from 1954 to 2003. The total number of observations is 200, including 43 quarters of contractions and 157 quarters of expansions. Within the 43 recession quarters, there are 11 Q1s, 9 Q2s, 11 Q3s, and 12 Q4s.

	Intercept	Contraction	Expansion	R^2(adj R^2)
Estimate	0.86	0.98	0.23	0.65
t-value	0.50	6.11	0.67	0.62
Estimate	0.84	1.06		0.65
t-value	0.50	7.51		0.62
Estimate	6.10		1.40	0.33
t-value	4.71		4.78	0.26

the economy is contracting and periods during which the economy is expanding. Let the indicator variable I_t take the value of one when the economy is contracting during quarter t and zero when the economy is expanding during quarter t. Further, let $\beta_{i,cont}$ denote the contraction beta of an arbitrary asset i, $\beta_{i,\text{exp}}$ denote the corresponding expansion beta, and $R_{i,t+4}$ denote the excess return on asset i from quarter t to quarter $t+4$. We estimate the betas by estimating the following equation using ordinary least squares (OLS):

$$R_{i,t+4} = \alpha_{i,cont} I_t + \alpha_{i,\text{exp}}(1 - I_t) + \beta_{i,cont} \Delta c_{t+4} I_t + \beta_{i,\text{exp}} \Delta c_{t+4}(1 - I_t) + \varepsilon_{i,t+4}. \quad (13)$$

We then examine the extent to which contraction and expansion betas can explain cross-sectional variation in historical average returns across the 25 Fama and French portfolios using CSR. From Table XI it can be seen that contraction betas explain 62% of the cross-sectional variation in average returns whereas expansion betas explain only 26%, even though only 43 of the 200 quarters of data we use in our study correspond to economic contractions. This is consistent with our expectations.

Table XII

Cross Sectional Regression without an Intercept

This table reports Fama–MacBeth (1973) cross-sectional regression estimation results with restrictions:

$$E[R_{i,t}] = \lambda'\beta.$$

Betas are estimated by the time-series regression of excess returns on the factors. Test portfolios are the 25 Fama–French portfolios' annual return from 1954 to 2003. The estimation method is the Fama–MacBeth cross-sectional regression procedure. The first row reports the coefficient estimates ($\tilde{\lambda}$). Fama–MacBeth t-statistics are reported in the second row, and Shanken-corrected t-statistics are in the third row. The last column gives the R^2 and adjusted R^2 just below it.

	Δc	R_m	SMB	HML	log(ME)	log(B/M)	R^2(adj R^2)
Estimate	2.59						0.73
t-value	3.72						0.73
Shanken-t	1.88						
Estimate		9.71					−0.26
t-value		3.49					−0.26
Shanken-t		2.42					
Estimate		7.09	3.03	6.24			0.73
t-value		2.79	1.58	3.31			0.71
Shanken-t		1.79	0.95	2.13			
Estimate	1.67	7.78	2.92	6.21			0.79
t-value	3.84	3.06	1.52	3.30			0.76
Shanken-t	2.39	1.70	0.81	1.84			
Estimate					1.88	3.20	0.81
t-value					9.67	2.03	0.76
Estimate	2.75				0.01	0.29	0.74
t-value	3.09				0.03	0.18	0.72
Estimate		−1.13	7.27	3.04	1.29	2.39	0.77
t-value		−0.29	3.26	1.17	3.28	2.06	0.72

E. Further Comparison of CCAPM and the Fama and French Three-Factor Model

In order to compare the two models further, we also estimate each after imposing the restriction that the intercept term in the CSR equation, λ_0, is zero. The results are given in Table XII. The estimated value of the consumption risk premium for the restricted model is 2.59, which is not much different from the estimate of 2.56 obtained using the unrestricted model. The cross-sectional R^2 for the consumption risk model and the Fama and French three-factor model for the restricted model are the same, 73%. The estimated risk premiums for the HML and the SMB factors do not change much with the restriction that the intercept term in the CSR equation is zero. However, the estimated risk premium for the stock market factor changes substantially, increasing to 7.09% per year

Table XIII

Cross-Sectional Regression Pricing Errors

This table compares pricing errors of the 25 Fama–French (1993) portfolios generated by the CCAPM, the Fama–French three-factor model, and the nesting four-factor model (three Fama–French factors and consumption growth). When the model is estimated without restrictions, then pricing errors are calculated by $\hat{\alpha}_i = \overline{R_i} - \hat{\lambda}_0 - \hat{\lambda}'\hat{\beta}_i$; when the model is estimated with restrictions, then pricing errors are calculated by $\tilde{\alpha}_i = \overline{R_i} - \tilde{\lambda}'\hat{\beta}_i$. All numbers are annual percentages.

CCAPM: $\hat{\alpha}$					CCAPM: $\tilde{\alpha}$				
−2.82	−1.77	1.20	3.45	1.85	−2.78	−1.80	1.21	3.44	1.80
−1.55	1.87	0.23	2.41	1.59	−1.50	1.91	0.22	2.42	1.57
−0.58	−0.48	−0.85	0.85	−0.81	−0.53	−0.47	−0.85	0.83	−0.86
0.95	−0.79	1.07	−0.35	−2.18	1.01	−0.76	1.08	−0.37	−2.23
−1.74	1.06	1.14	−1.81	−1.93	−1.71	1.12	1.20	−1.80	−1.93
Three-Factor model: $\hat{\alpha}$					Three-Factor model: $\tilde{\alpha}$				
−2.36	0.87	−0.55	1.92	2.73	−3.30	−0.45	0.55	2.90	2.29
−1.74	−1.03	0.52	0.13	1.20	−2.18	−0.42	1.27	0.46	0.72
0.52	−0.71	−1.68	0.25	−0.49	0.33	0.11	−0.70	−0.01	−0.27
2.23	−2.14	0.08	0.06	0.32	2.85	−1.32	−0.03	0.11	−1.03
2.65	−0.40	0.20	−1.22	−1.37	2.54	0.13	1.34	−1.56	−2.88
Four-Factor model: $\hat{\alpha}$					Four-Factor model: $\tilde{\alpha}$				
−1.64	−0.01	−0.54	1.73	1.94	−2.77	−1.36	0.68	2.84	1.57
−0.82	0.48	−0.46	1.07	1.45	−1.43	0.95	0.50	1.31	0.88
0.58	−1.20	−2.06	0.60	−1.38	0.36	−0.22	−0.92	0.26	−1.02
1.66	−1.72	0.86	−0.37	−0.42	2.42	−0.86	0.64	−0.26	−1.82
0.73	0.71	0.36	−1.13	−0.44	0.86	1.15	1.60	−1.52	−2.24

from −3.26% per year. This is consistent with our earlier observation that the large intercept term in the CSRs may be due to the near multicollinearity induced by all the 25 stock market betas being nearly the same at 1.0.

Let $\alpha_i = E(R_i) - \lambda_0 - \lambda'\beta_i$ denote the model pricing error, that is, the difference between the expected return on asset i and the expected return assigned to it by the asset pricing model. Let $\hat{\lambda}_0$ and $\hat{\lambda}$ denote estimates obtained using the unrestricted models and $\tilde{\lambda}$ denote the estimates obtained with the restriction that $\lambda_0 = 0$. Define the corresponding estimated values for the alphas as $\hat{\alpha}_i \equiv E(R_i) - \hat{\lambda}_0 - \hat{\lambda}'\hat{\beta}_i$ and $\tilde{\alpha}_i \equiv E(R_i) - \tilde{\lambda}'\hat{\beta}_i$. Table XIII gives the pricing errors for the constrained and unconstrained models. For the CCAPM the average value of $|\hat{\alpha}_i|$ is 1.41% per year and the maximum value of $|\hat{\alpha}_i|$ is 3.45% per year. These values do not change when the intercept term in the CSR is restricted to zero. For the Fama and French three-factor model, the average value of $|\hat{\alpha}_i|$ is 1.09% per year, and the maximum value of $\hat{\alpha}_i$ is 2.73%, which is a substantial improvement over the CCAPM.

When the intercept term is constrained to zero, however, the maximum value of $\tilde{\alpha}_i$ for the Fama and French three-factor model increases to 3.30% per year, which is not much different from the corresponding value for the CCAPM model. While the Fama and French model does better on average, for the most mispriced asset both models are about equally good or bad. The average value of

Table XIV

Fitted Beta and Residual Beta

We regress Fama and French (1993) three-factor betas on an intercept and the consumption beta separately, using the following regression equations:

$$\beta_{i,m} = a_{im} + b_{i,m}\beta_{i,c} + e_{im}$$

$$\beta_{i,\text{SMB}} = a_{i\text{SMB}} + b_{i,\text{SMB}}\beta_{i,c} + e_{i\text{SMB}}$$

$$\beta_{i,\text{HML}} = a_{i\text{HML}} + b_{i,\text{HML}}\beta_{i,c} + e_{i\text{HML}},$$

where $\beta_{i,c}$ denotes the consumption beta, and $\beta_{i,m}$, $\beta_{i,\text{SMB}}$, and $\beta_{i,\text{HML}}$ denote the Fama and French three-factor betas, $i = 1, 2, \ldots, 25$. Let $a_{im} + b_{i,m}\beta_{i,c}$, $a_{i\text{SMB}} + b_{i,\text{SMB}}\beta_{i,c}$, and $a_{i\text{HML}} + b_{i,\text{HML}}\beta_{i,c}$ denote the three *fitted Fama and French factor betas* and e_{im}, $e_{i\text{SMB}}$, and $e_{i\text{HML}}$ the corresponding *residual Fama and French factor betas* of asset i. We run cross-sectional regressions using the fitted betas and the residual betas. The results are reported in this table.

	Intercept	R_m	SMB	HML	$R^2(\text{adj}\,R^2)$
		Fitted Beta			
Estimate	5.01	5.52	5.04	9.35	0.57
t-value	1.73	2.24	0.95	2.91	0.51
		Residual Beta			
Estimate	10.71	−9.93	1.57	2.33	0.14
t-value	3.59	−1.96	0.80	1.14	0.02

alpha does not decline when the two models are combined, suggesting that to a large extent both models may be capturing the same pervasive economy-wide risks.

These results suggest that the Fama and French three factors may be proxying for consumption risk. As an additional diagnostic, we examine the extent to which the Fama and French three-factor betas that are not well approximated by the consumption beta can explain the cross-section of stock returns. For that purpose, we approximate each of the 25 sets of Fama and French three-factor betas by consumption beta using the following regression equations:

$$\beta_{i,m} = a_{im} + b_{i,m}\beta_{i,c} + e_{im} \tag{14}$$

$$\beta_{i,\text{SMB}} = a_{i\text{SMB}} + b_{i,\text{SMB}}\beta_{i,c} + e_{i\text{SMB}} \tag{15}$$

$$\beta_{i,\text{HML}} = a_{i\text{HML}} + b_{i,\text{HML}}\beta_{i,c} + e_{i\text{HML}}, \tag{16}$$

where $\beta_{i,c}$ denotes the consumption beta, $\beta_{i,m}$, $\beta_{i,\text{SMB}}$, and $\beta_{i,\text{HML}}$ denote the Fama and French three-factor betas, and $i = 1, 2, \ldots, 25$. Let $a_{im} + b_{i,m}\beta_{i,c}$, $a_{i\text{SMB}} + b_{i,\text{SMB}}\beta_{i,c}$, and $a_{i\text{HML}} + b_{i,\text{HML}}\beta_{i,c}$ denote the three *fitted Fama and French factor betas* and e_{im}, $e_{i\text{SMB}}$, and $e_{i\text{HML}}$ denote the corresponding *residual Fama and French factor betas* of asset i. We run CSRs using the fitted and

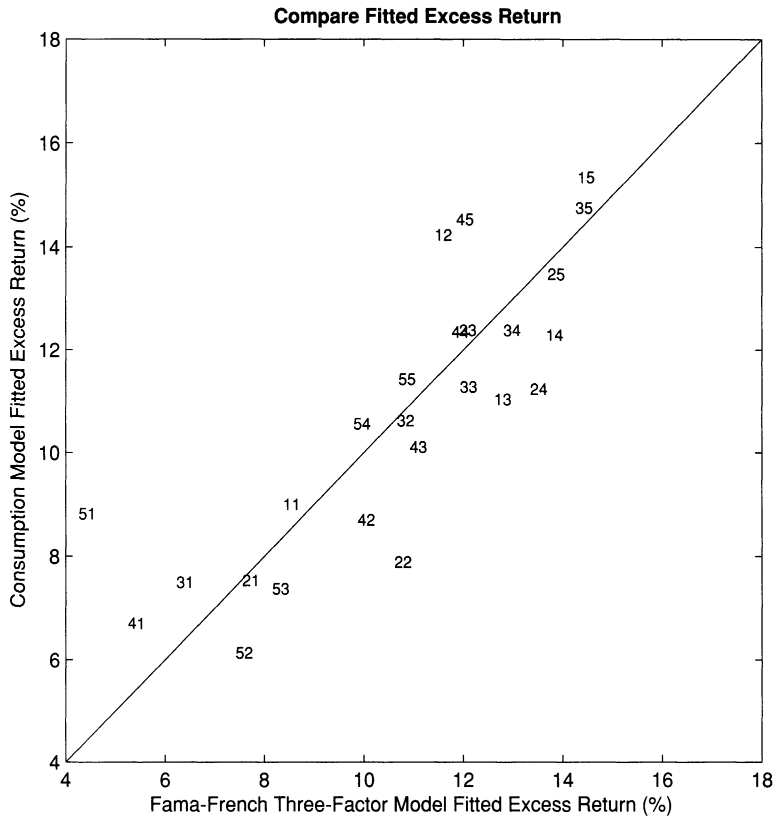

Figure 3. Fitted returns in CCAPM versus fitted returns in Fama and French three-factor model. This figure plots the expected excess return of the 25 Fama–French portfolios according to the Fama and French three-factor model on the horizontal axis, and the expected excess return according to the CCAPM on the vertical axis.

residual betas. Table XIV gives the results. The R^2 in the CSR of the excess return on the 25 assets on the fitted betas is 57%. However, it is only 14% when we use the corresponding residual betas. Clearly, that part of the three Fama and French betas not in the span of the consumption beta and a constant is not very helpful in explaining the cross-section of stock returns.

Figure 3 gives a plot of the fitted average excess returns in the CCAPM model against the fitted average excess returns in the Fama and French three-factor model. Twelve of the points plot above the 45-degree line and 13 plot below. Figure 4 plots the fitted average excess returns obtained using the two models against the realized average excess return for the 25 test assets. Both models tend to underestimate large and small realized average excess returns. Figure 5 plots the location of the CMP and the three Fama and French factors in the sample mean-standard deviation space. Note that the portfolio of the three Fama and French factors that has the same average excess return as the CMP has a higher standard deviation on the excess return. Therefore, we cannot reject the hypothesis that the CMP is on the sample mean–variance efficient

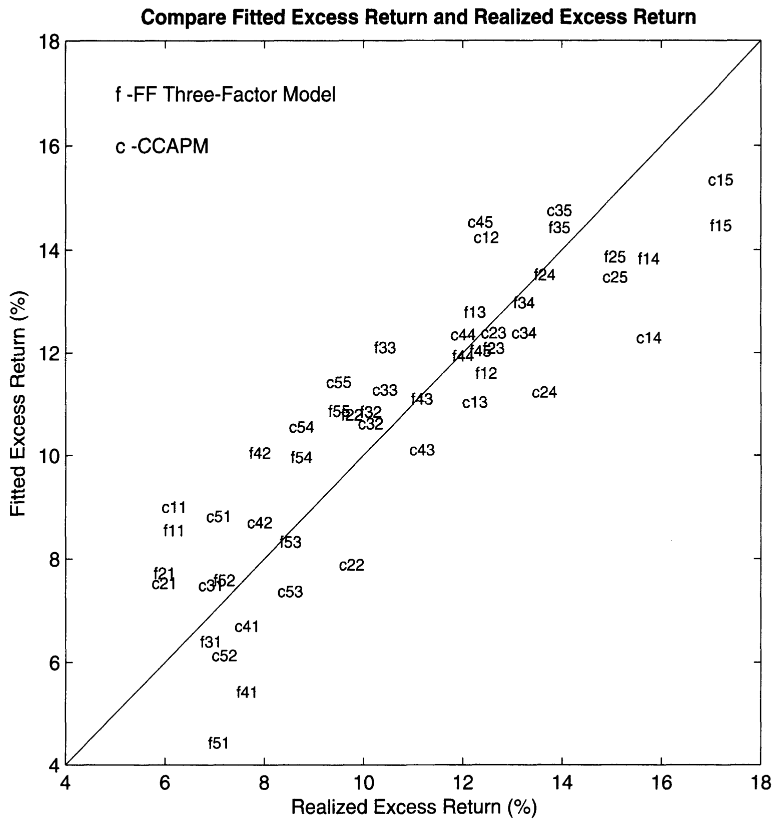

Figure 4. Fitted average excess return versus realized average excess return: CCAPM and Fama and French three-factor model. This figure plots the realized average excess return of the 25 Fama–French portfolios on the horizontal axis and both the Fama and French three-factor model fitted returns and the CCAPM model fitted returns on the vertical axis.

frontier generated by the three Fama and French factors. The patterns in these figures are consistent with the view that both the models measure the same pervasive risk in the 25 assets, that is, whatever is missing in one model may be missing in the other as well.

While the two models perform about equally well in explaining the cross-section of returns, they perform very differently when it comes to explaining time-series variations in returns. As can be seen from Table XV, the three Fama and French risk factors together are able to explain a large fraction of the time-series variation in returns on the 25 test assets. The minimum time-series R^2 is 86% and the maximum is 97%. In contrast, the corresponding numbers for the CMP are 10% and 60%. The ability of the consumption CAPM to explain a large part of the cross-sectional variation in average returns may come as a surprise at first glance. However, note that in the Fama and French three-factor model too the factor that explains most of the cross-sectional variation in average returns contributes little toward explaining the time-series variation in returns. The R^2 in the time-series regression of returns on the 25 portfolios

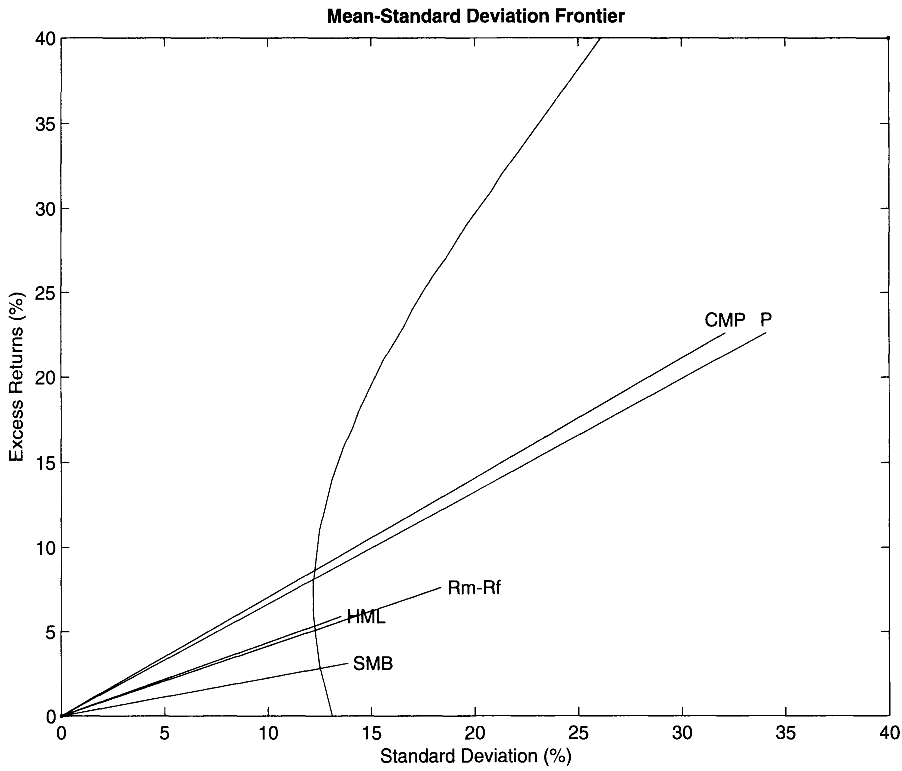

Figure 5. Mean-standard deviation space. The hyperbola is the mean standard deviation frontier of the 25 Fama–French portfolio excess returns. CMP is the consumption mimicking portfolio, and Rm-Rf, SMB, and HML are the three Fama–French factors. P is the portfolio of Rm-Rf, SMB, and HML that has the largest Sharpe ratio.

on the HML factor varies from a low of 0% to a high of only 17%. In contrast, the HML factor alone explains 53% of the cross-sectional variation in average returns on the 25 portfolios. The low time-series R^2 coupled with the high cross-sectional R^2 for the CMP is also consistent with the equity premium puzzle. The CMP has a high Sharpe ratio of 0.70.

When returns are measured in excess of the stock market index portfolio, the HML factor explains anywhere from 0% to 65% of the time-series variation in the excess returns on the 25 portfolios. In contrast, the corresponding numbers are 0% and 27% for the CMP (not reported in the tables). The low time-series R^2's we find are consistent with the view that a substantial part of the risk is not priced, even in a large portfolio, and also consistent with the view that something is missing in the standard CCAPM, but for some reason the missing factor is not important for the particular set of assets we examine in this study. For example, suppose the representative agent's preference belongs to the Epstein and Zin (1989) class. In that case we will need another factor, the excess return on the *true* market index portfolio, in addition to the consumption factor to explain the cross-section of asset returns. The fact that consumption betas

Table XV

Time-Series Regression vs. Cross-Sectional Regression

Panel A reports time-series regression R^2 for the CCAPM (consumption mimicking portfolio), the Fama and French three-factor model, the HML factor alone, and the CAPM. Panel B reports the cross-sectional regression results for these models.

Panel A: Time-Series Regression R^2's

		CCAPM					Three-Factor Model		
0.10	0.27	0.27	0.35	0.36	0.91	0.96	0.96	0.95	0.97
0.13	0.26	0.40	0.45	0.46	0.94	0.94	0.92	0.94	0.95
0.16	0.37	0.45	0.47	0.50	0.96	0.93	0.92	0.93	0.92
0.14	0.31	0.43	0.49	0.53	0.92	0.86	0.91	0.87	0.89
0.33	0.27	0.20	0.54	0.60	0.92	0.91	0.85	0.93	0.90
		HML					CAPM		
0.08	0.00	0.00	0.02	0.03	0.56	0.63	0.58	0.56	0.58
0.09	0.00	0.01	0.07	0.08	0.69	0.72	0.66	0.63	0.63
0.12	0.00	0.05	0.08	0.12	0.81	0.76	0.70	0.66	0.57
0.17	0.01	0.04	0.07	0.07	0.80	0.79	0.77	0.68	0.70
0.11	0.00	0.00	0.07	0.11	0.84	0.88	0.81	0.75	0.68

Panel B: Cross-Sectional Regression

	Intercept	CMP	R_m	SMB	HML	R^2(adj R^2)
Estimate	−0.40	26.86				0.65
t-value	−0.12	3.66				0.64
Shanken-*t*	−0.09	2.53				
Estimate	10.43		−3.26	3.12	5.83	0.80
t-value	2.66		−0.70	1.62	3.11	0.77
Shanken-*t*	2.37		−0.57	1.03	2.12	
Estimate	10.24				5.23	0.53
t-value	3.41				2.70	0.51
Shanken-*t*	3.14				1.90	
Estimate	11.31		−0.56			0.00
t-value	2.05		−0.09			−0.04
Shanken-*t*	2.05		−0.08			

alone are able to explain the cross-section of stock returns implies that consumption betas and market betas are highly correlated for our 25 test assets, and in addition, the average value of the true market index factor betas (after the market index factor is made orthogonal to the consumption factor) is close to zero.

IV. Conclusion

In this paper we examine the ability of the CCAPM to explain the cross-section of average returns on the 25 benchmark equity portfolios constructed by Fama and French (1993). We find surprisingly strong support for the model. The

CCAPM performs almost as well as the widely used Fama and French (1993) three-factor model. Most of the variation in average returns can be explained by corresponding variation in exposure to the consumption risk factor. The model performs well for other test assets as well.

In deriving the econometric specifications for the CCAPM we assume that investors are more likely to review their consumption–investment plans during the fourth quarter of every calendar year, and when the economy is in contraction rather than when it is in expansion. We find more support for this assumption than for the standard assumption that investors review their consumption–investment plans at every instant in time. However, we do not provide any direct evidence in support of this assumption. Thus, the exceptional performance of the CCAPM using the fourth quarter consumption measure remains a mystery to be solved by future research.

While the consumption-based model is able to explain the cross-section of average return on stocks surprisingly well, we also find evidence indicating that the model specifications used in our empirical study miss some important aspects of reality. First, the implied market risk premium for bearing consumption risk is rather high. Second, following Jagannathan and Wang (1998), when the book-to-market ratio is introduced as an additional variable in the CSRs, its slope coefficient is significantly different from zero, indicating model misspecification. This suggests that it would be possible to construct a set of interesting test assets that pose a challenge to the consumption-based model by following the methods in Daniel and Titman (1997). Differential taxation of dividends and capital gains could explain some of the cross-sectional variation in historical average returns across stocks not explained by the consumption model, especially along the value–growth dimension, since a larger part of the historical average return for a typical value stock is in the form of dividends.

While the CCAPM explains the cross-section of stock returns almost as well as the Fama and French three-factor model, it is not a substitute for the latter. Since our specification requires the use of annual data, very long time series of data are required for estimating consumption betas accurately, which limits the CCAPM's applicability. In contrast, betas with respect to factors that are returns on traded assets can be estimated accurately using relatively short time series of high-frequency data. However, the limitation of models that use such factors is that it is difficult to interpret what risk they are representing, and why they are systematic and not diversifiable. Our findings support the view that the three risk factors identified by Fama and French (1993) represent consumption risk, that is, the risk that macroeconomic events may unfavorably affect consumption choices.

Appendix A: Linear Consumption Factor Model

The Euler equation holds for any asset i and any time interval $[t, t+j]$:

$$E_t\left[R_{i,t+j}\left(\frac{\delta^j u'(c_{t+j})}{u'(c_t)}\right)\right] = 0. \quad \text{(A1)}$$

Taking the unconditional expectation and rewriting the expectation of the product in terms of covariances, we obtain

$$E[R_{i,t+j}]E\left[\frac{\delta^j u'(c_{t+j})}{u'(c_t)}\right] = -\text{cov}\left[\frac{\delta^j u'(c_{t+j})}{u'(c_t)}, R_{i,t+j}\right]. \tag{A2}$$

By a first-order approximation, we then have

$$\begin{aligned}\frac{u'(c_{t+j})}{u'(c_t)} &\approx \frac{u'(c_t) + u''(c_t)(c_{t+j} - c_t)}{u'(c_t)} \\ &= 1 - \left(-\frac{c_t u''(c_t)}{u'(c_t)}\right)\frac{(c_{t+j} - c_t)}{c_t} \\ &= 1 - \gamma_t(g_{c,t+j} - 1),\end{aligned} \tag{A3}$$

where $\gamma_t = -\frac{c_t u''(c_t)}{u'(c_t)}$ is the relative risk-aversion coefficient, which is assumed to be a constant γ, and $g_{c,t+j} = \frac{c_{t+j}}{c_t}$ indicates consumption growth. Substituting (A3) into (A2) and reorganizing, we get

$$E[R_{i,t+j}] = \frac{\gamma \text{var}(g_{c,t+j})}{1 - \gamma E(g_{c,t+j} - 1)} \frac{\text{cov}[g_{c,t+j}, R_{i,t+j}]}{\text{var}(g_{c,t+j})}. \tag{A4}$$

Let

$$\lambda_{cj} = \frac{\gamma \cdot \text{var}(g_{c,t+j})}{1 - \gamma E(g_{c,t+j} - 1)}, \quad \beta_{icj} = \frac{\text{cov}[g_{c,t+j}, R_{i,t+j}]}{\text{var}(g_{c,t+j})}.$$

We then have

$$E[R_{i,t+j}] = \lambda_{cj}\beta_{icj}. \tag{A5}$$

Appendix B: A Model with Infrequent Adjustment of Consumption and Investment Plans

Consider an arbitrary point in time, t. We assume that some investors review their consumption and portfolio holdings decisions simultaneously at that point in time while others do not. Without loss of generality, denote those who review their decisions simultaneously as type 1 investors and the others as type 2 investors. The first-order conditions for the lifetime expected utility maximization problem faced by type 1 investors at time t give

$$E\left[R_{i,t+j}\left(1 - \gamma\left(g^1_{c,t+j} - 1\right)\right)\right] = 0, \tag{B1}$$

where $g^1_{c,t+j}$ indicates the type 1 investor's consumption growth from t to $t+j$, $R_{i,t+j}$ is the excess return of asset i from t to $t+j$, and $E[.]$ denotes the unconditional expectation operator.

For type 2 investors who do not make consumption–investment decisions at time t, equation (B1) does not hold. Therefore,

$$E\left[R_{i,t+j}\left(1-\gamma\left(g^{2}_{c,t+j}-1\right)\right)\right]=\epsilon_{it}. \tag{B2}$$

Let w_t denote the fraction of the investors who are of type 1, and $g^{A}_{c,t+j}$ denote the aggregate consumption growth from t to $t+j$, that is, to a first-order approximation, $g^{A}_{c,t+j}=w_t g^{1}_{c,t+j}+(1-w_t)g^{2}_{c,t+j}$. Then,

$$\begin{aligned}
&E\left[R_{i,t+j}\left(1-\gamma\left(g^{A}_{c,t+j}-1\right)\right)\right]\\
&\quad=E\left[R_{i,t+j}\left(1-\gamma\left(g^{1}_{c,t+j}-1\right)\right)\right]+E\left[\gamma(1-w_t)\left(g^{1}_{c,t+j}-g^{2}_{c,t+j}\right)R_{i,t+j}\right]\\
&\quad=\gamma(1-w_t)E\left[\left(g^{1}_{c,t+j}-g^{2}_{c,t+j}\right)R_{i,t+j}\right],
\end{aligned} \tag{B3}$$

since $E[R_{i,t+j}(1-\gamma(g^{1}_{c,t+j}-1))]=0$ from equation (B1).

Rewriting the left side of the above equation and equating it to the right side gives

$$\begin{aligned}
&\operatorname{cov}\left[\left(1-\gamma\left(g^{A}_{c,t+j}-1\right),R_{i,t+j}\right]+E\left[1-\gamma\left(g^{A}_{c,t+j}-1\right)\right]E[R_{i,t+j}]\\
&\quad=\gamma(1-w_t)E\left[\left(g^{1}_{c,t+j}-g^{2}_{c,t+j}\right)R_{i,t+j}\right].
\end{aligned} \tag{B4}$$

By rearranging terms, we get

$$E[R_{i,t+j}]=\frac{\gamma(1-w_t)E\left[\left(g^{1}_{c,t+j}-g^{2}_{c,t+j}\right)R_{i,t+j}\right]}{1-\gamma E\left[g^{A}_{c,t+j}-1\right]}+\frac{\gamma\operatorname{cov}\left[\left(g^{A}_{c,t+j}-1\right),R_{i,t+j}\right]}{1-\gamma E\left[g^{A}_{c,t+j}-1\right]}. \tag{B5}$$

Subtracting equation (B2) from (B1) gives

$$E\left[\left(g^{1}_{c,t+j}-g^{2}_{c,t+j}\right)R_{i,t+j}\right]=\epsilon_{it}. \tag{B6}$$

By combining the above equation with equation (B5) we get

$$E[R_{i,t+j}]=\varepsilon_{it}+\lambda_t\beta^{A}_{ic}, \tag{B7}$$

where

$$\varepsilon_{it}=\frac{(1-w_t)\gamma}{1-\gamma E\left[g^{A}_{c,t+j}-1\right]}\epsilon_{it} \tag{B8}$$

$$\lambda_t=\frac{\gamma\operatorname{var}\left[g^{A}_{c,t+j}\right]}{1-\gamma E\left[g^{A}_{c,t+j}-1\right]} \tag{B9}$$

$$\beta^{A}_{ic}=\frac{\operatorname{cov}\left[g^{A}_{c,t+j},R_{i,t+j}\right]}{\operatorname{var}\left[g^{A}_{c,t+j}\right]}. \tag{B10}$$

If all investors are type 1 investors at time t, that is, if all investors make consumption and investment decisions at time t, then $w_t = 1$. In that case the following CCAPM holds for aggregation consumption:

$$E[R_{i,t+j}] = \lambda_t \beta_{ic}^{A}. \quad \text{(B11)}$$

Suppose some investors do not adjust their consumption at time t, that is, $0 < w_t < 1$. We have

$$E[R_{i,t+j}] = \overline{\varepsilon_t} + \lambda_t \beta_{ic}^{A} + (\varepsilon_{it} - \overline{\varepsilon_t}), \quad \text{(B12)}$$

where $\overline{\varepsilon_t}$ is the average ε_{it} across i. Hence, the CCAPM will only hold approximately. Note that the deviation from the CCAPM, ε_{it}, will in general be larger in magnitude when w_t is smaller. We conjecture that w_{Q1}, w_{Q2}, and w_{Q3} will be strictly smaller than w_{Q4}. If that were true, we should find more evidence for the CCAPM when consumption growth from the fourth quarter of one year to that of the next is matched with excess returns for the corresponding period to compute consumption betas.

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