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

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ABSTRACT

When consumption betas of stocks are computed using consumption growth from 4th quarter of one year to the next, the CCAPM explains the cross section of stock returns as well as the Fama and French (1993) three factor model. The CCAPM performance deteriorates substantially when consumption growth is measured over other quarters. For the CCAPM to hold at any given point in time, investors must be making their consumption and investment decisions simultaneously at that point in time. We suspect that it is more likely to happen during the fourth quarter given the ending of the tax year in December.

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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 for investing in growth firms when compared to value firms, and require a higher return for investing in smaller firms when 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 lower return on those assets that provide better insurance against consumption risk by paying more when macro economic 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 growth firms to be engaged in activities that have less exposure to consumption risk than value firms; and smaller firms to be exposed to higher consumption risk when compared to larger firms. We show that that is indeed the case provided we take certain empirical regularities into account when measuring the consumption risk exposure of stocks.

While the standard CCAPM has been widely examined in the empirical literature, the empirical evidence is mostly negative. Hansen and Singleton (1982, 1983) reject the CCAPM model in their statistical tests. Mankiew 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, on the one hand, lead to the development of other consumption based asset pricing models by allowing for 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). On the other hand, it has also lead to models that relax the assumption made in all consumption based asset pricing models that investors can costlessly adjust consumption plans, as in Grossman and Laroque (1990), Lynch (1996) and Gabaix and Laibson (2001).

Lettau and Ludvigson (2005) show that even in an economy where prices of financial assets are determined by one of the more general consumption based asset pricing models, the CCAPM can hold as a reasonably good approximation. It would therefore be 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, which is 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 (2004), and Hansen, Heaton and Li (2005) find that when consumption risk is measured by the covariance between longrun cashflows from holding a security and longrun consumption growth in the economy, differences in consumption risk have the potential to explain expected return differentials across assets. Parker and Juliard (2005) find that the contemporaneous covariance between consumption growth and returns explains little of the cross section of stock returns, i.e., there is strong evidence against the standard CCAPM in the data. However, the covariance between an asset's return during a quarter and cumulative consumption growth over several following quarters, which they denote as *ultimate consumption risk*, explains the cross section of average returns on stocks surprisingly well. Malloy, Moskowitz and Vissing-Jorgensen (2005) find that 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 leading to significant costs associated with making those decisions. 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. We should also find stronger support for the CCAPM when consumption betas are estimated using returns on investments made during economic contractions. While investors may make consumption decisions as well as investment decisions as often during other time periods, those 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 tax consequences of capital gains and losses. 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 shift 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 and not technology. Piazzesi (2001) finds that current returns predict future aggregate consumption growth especially for horizons that are multiples of 4 quarters. That is consistent with most individuals in the economy simultaneously adjusting their consumption at the end of the calendar year. Geweke and Singleton (1981) find more support in the data for the permanent income model of consumption at annual frequencies. They 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 essential goods, and consumption of 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 (2005) finds that durable goods consumption, combined with nondurables good 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.

We therefore match calendar year returns with growth rates in fourth quarter consumption of nondurables and services from one year to another, in order to generate the most support from the data for the CCAPM. The use of calendar year returns would avoids the need to explain various well documented within year seasonal patterns in stock returns, like the January effect, and the sell in May and go away effects. Working with a one 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 return on investments made during contractions are used for estimating consumption betas.

I. Other Related Literature

Several measures of risk have been proposed in the literature for explaining cross sectional differences in average returns on financial assets. They can be grouped into two broad categories. In models belonging to the first category, commonly referred to as consumption-based asset pricing models, systematic risk is represented by the sensitivity of the return on an asset to changes in the intertemporal marginal rates 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, but also derivative securities like stock options. The disadvantage is that the models in this class make use of macroeconomic factors that are measured with substantial errors and at lower

[1]See Chetty and Seidel (2004) 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.

frequencies. In the standard consumption-based model, i.e., 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. For reasons given earlier, we examine the consumption-based CAPM when investors revise their consumption plans infrequently.

Models in the second category are commonly referred to as portfolio-return-based models. In these models systematic risk is represented by the sensitivity of the return on an asset 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 its proxy. Merton (1973) derived an intertemporal version of the CAPM (ICAPM) showing that the expected return on an asset would be a linear function of its several factor betas, with the return on the market portfolio being one of the factors. Campbell (1993) identified 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) showed 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) provided sufficient conditions for Ross' results to obtain in equilibrium.

The models in the second category 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 only they are available). In the case of the CAPM and the ICAPM (belonging to this category), the shortcoming 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; but as Jagannathan and Wang (1996) point out, the stock market forms only a small part of the total wealth in the economy. Human capital forms a much larger part and the return on that part is not observed. The return on aggregate human capital has to be inferred from national income and product account numbers, and they are subject to substantial measurement errors. In contrast, to apply a model in this category, we only have to find a method for identifying *factor* portfolios that capture economy wide pervasive risk.

Chamberlain and Rothschild (1983) show that factors constructed through principal component analysis of returns on primitive assets would serve as valid factors. Connor and Korajczyk (1986) develop a fast 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 cash flows of firms 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 there is a representative investor in the economy with time and state separable Von Neumann – Morgenstern utility function for lifetime time consumption from the vantage point of time t given by:

$$E\left[\left(\sum_{s=t}^{\infty}\delta^{s}u(c_{s})\right)\ \mid F_{t}\right] \tag{1}$$

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 some exogenously given reasons[3]. In what follows we first 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 determined by the occurrence of important news events. Later we will examine the case where there are two investor types; 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 to the investor's utility maximization problem must hold. Consider an arbitrary point in time, t, where the representative investor reviews her consumption-investment decisions. Such points will occur at times $t = 0, k, 2k, 3k, ...$ i.e., t will be an integral multiple of the decision interval, k. The investor will choose consumption and investment policies at t, $t = 0, k, 2k, 3k, ...$to maximize expected life time utility. That gives rise to the following relation that must be satisfied by all financial assets:

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

In equation (2) given above, $R_{i,t+j}$ denotes the excess return on an arbitrary asset,

[3] Lynch (1996) and Gabaix and Laibson (2001) examine economies where 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 where 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.

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:

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

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

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

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

$$\begin{aligned} E[R_{i,t+j}] &= \lambda_{c\gamma j} \beta_{ic\gamma,j}, \\ \text{where, } \beta_{ic\gamma,j} &= \frac{Cov(R_{i,t+j}, g_{c,t+j}^{-\gamma})}{Var(g_{c,t+j}^{-\gamma})}, \end{aligned} \tag{6}$$

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

Following Breeden, Gibbons and Litzenberger (1989) we consider the following linear version of equation (6), generally referred to as the consumption capital asset pricing model (CCAPM)[4]:

$$\begin{aligned} E[R_{i,t+j}] &= \lambda_{cj}\beta_{icj}, \\ \text{where, } \beta_{icj} &= \frac{Cov(R_{i,t+j}, g_{c,t+j})}{Var(g_{c,t+j})}, \end{aligned} \tag{7}$$

and $\lambda_{cj} \simeq \gamma \frac{Var(g_{c,t+j})}{1-\gamma E(g_{c,t+j}-1)}$ is the market price for consumption risk; note that the consumption beta for most assets will be strictly positive, and so will 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 like book to market ratio and relative market capitalization are significant in the cross sectional regressions. We check the robustness of our conclusions by estimating the CCAPM using Hansens's (1982) Generalized Method of Moments (GMM). Further, following Breeden, Gibbons, and Litzenberger (1989), we construct consumption mimicking portfolios and examine the CCAPM specification using the multivariate test proposed by Gibbons, Ross and Shanken (1989).

In general, the ratio of the first and second moments of the measurement error, $\varepsilon_{gc,t+j}$, to the corresponding moments of $g_{c,t+j}$ will be 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, increas-

[4]See Appendix A for details.

ing 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 errors as well sampling errors on our conclusions. Given insufficient information to assess how measurement error and sampling error depend on j, we decided to set the return horizon, j, to equal the review period, k. We assume that k is a calendar year, i.e., 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 to 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 (1985) and Kandel and Stambaugh (1990). Breeden, Gibbons and Litzenberger (1989) provide sufficient conditions for the CCAPM to hold even with time aggregation bias. Under those assumptions, it can be shown that the covariance between aggregate consumption growth and asset returns computed using quarterly consumption data and annual returns will understate the true covariance by an eighth.

In deriving the CCAPM given by equation (7) we assumed 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 only hold approximately. To see the issues involved, consider an arbitrary point in time, t, when some investors review their consumption and portfolio holdings decisions simultaneously at that point in time while others don't. Without loss of generality, denote those who review their decisions that way as type 1 investors and the others as type 2 investors. In that case the CCAPM will hold when consumption betas are measured using *aggregate consumption,* and returns corresponding 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 only hold approximately. The specification error will in general be larger when there are more investors of type two 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 4th quarter than in other quarters. Hence, we should expect to find more evidence for the CCAPM when consumption growth from 4th quarter of one year to 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 returns on investments made during contractions, and corresponding aggregate consumption growth data. Let $E(R_i|contraction) = \beta_{i,cont}\pi_{cont}$ denotes the expected excess return on asset i, given that the economy is in a contraction. π_{cont} is the consumption risk premium in contractions. $\beta_{i,cont}$ is the consumption beta of asset i in contractions, measured using consumption data for those investors who make consumption and investment decisions. Let $E(R_i|\exp) = \beta_{i,\exp}\pi_{\exp}$, denotes the expected excess return on asset i given that the economy is in an expansionary phase. $\beta_{i,\exp}$ denotes the consumption beta of asset i during expansions for those investors who make consumption and investment decisions. $\pi_{\exp}$ denotes the consumption risk premium during expansions. Suppose $\beta_{i,\exp} = \psi\beta_{i,cont}$ for some time invariant constant ψ. Then, $E(R_i) = \beta_{i,cont} \times [p_{cont}\pi_{cont} + (1-p_{cont})\psi\pi_{\exp}] = \beta_{i,cont}\pi = \beta_{i,\exp}\pi/\psi$, where π is the weighted average consumption risk premium. Hence the CCAPM will hold whether we use $\beta_{i,cont}$ or $\beta_{i,\exp}$ for asset i. However, we only observe aggregate consumption. Because a larger fraction of the population will be making consumption and investment decisions at the same time during economic contractions, the *contraction beta*, $\beta_{i,cont}$, will be measured more precisely than *expansion beta*, $\beta_{i,\exp}$, using aggregate consumption data. That will lead 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 annual and quarterly seasonally adjusted[5] aggregate nominal consumption expenditure on nondurables and services for the period 1954-2003 from National Income and Product Accounts (NIPA) table 2.3.5, and monthly nominal consumption expenditures from NIPA table 2.8.5. We use population numbers taken from NIPA tables 2.1 and 2.6 and price deflator series taken from NIPA table 2.3.4 and 2.8.4 to construct the time series of per capita real consumption figures for use in our empirical work. The returns on the 25 size and book-to-market sorted portfolios, the risk free return, and the values for the three Fama and French (1993) factors for the period 1954-2003 are taken from Kenneth French's website. We construct the excess return series on the 25 portfolios from this data. To check the robustness of our conclusions, we also examine the performance of the model specifications when time is measured in months.

In what follows we will first discuss the results obtained using calendar year excess returns and 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 the standard deviation 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 Q4-Q4 when compared to other quarters. 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. That provides some support for our conjecture that Q4 consumption bundle is less subject to rigidity due to prior commitments.

Table II panel A shows substantial variation in the average excess returns across the 25 portfolios. For example, small growth firms had an average excess return of 6.19% per year whereas small value firms earned 17.19% per year over the riskless

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

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, i.e., 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 return on the 25 portfolios against their estimated consumption betas. We find a reasonable linear relation.

Table III provides the results for the cross sectional regression method. When the model is correctly specified the intercept term should be zero, i.e., assets with zero consumption beta should earn zero risk premium. Notice that the intercept of CCAPM is 0.14% per year, which is not statistically significantly different from 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; when log book to market ratio is introduced as an additional variable in the cross sectional regression, its slope coefficient is significantly different from zero. Notice however that a similar phenomenon occurs with the Fama and French three factor model as well. When log size and log book to market ratio are added as additional explanatory variables in the Fama and French three factor model, they take away 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 3 factor model is 10.43% per year, which is a rather large value for the expected return on a zero beta asset when compared to the risk premium of 5.83%

[6] Daniel and Titman (2005) point out that a spurious factor models can have high cross sectional R-Square. 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).

[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.

per year for the HML factor risk. Figure 2 gives plots of the realized average excess returns against what they should be according to each of the three fitted models. Notice that while the points are about 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 Gibbons, Ross and Shankern (1989). For examining the empirical support for the CCAPM using the same method, we first follow Breeden, Gibbons and Litzenberger (1989), and construct the portfolio of the 25 assets that best approximates the consumption growth rate in the least square sense. We then regressed the excess return of the 25 Fama and French stock portfolios on the excess return of the consumption mimicking portfolio that we constructed. The results are given in Table IV. It can be verified that the average absolute value of the alphas is 1.28 for the CCAPM, and the corresponding figure for the Fama and French three factor model is 1.22. However, the t statistic of the alphas for Fama and French three factor model are much larger. The maximum absolute alpha for the Fama and French three factor model is also larger: 2.86 for the CCAPM and 3.98 for the Fama and French three factor model. While the Fama and French model does better on average, for the most mispriced asset CCAPM does better. The GRS statistic for the consumption mimicking portfolio is 0.27 (p-value = 0.999); 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, 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 cross sectional regression equation given by:

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

If the standard consumption-based asset pricing model holds, the intercept, $\lambda_0 = 0$ and the slope coefficient, $\lambda_1 = \frac{\gamma Var(g_{c,t+4})}{1-\gamma[E(g_{c,t+4})-1]}$, where, γ denotes the coefficient of relative risk aversion. The estimated slope coefficient, $\widehat{\lambda}_1 = 2.56$, 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 representative investor on the one hand and the ability of the CCAPM to explain the cross section of stock returns well on the other hand, are consistent with the explanations given by Constantinides and Duffie (1996) and Heaton and Lucas (2000). It is 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, i.e., the utility function is, $u(C_t - X_t)$; C_t denotes the date t consumption as before, and X_t represents external habit level that the consumer uses as reference point. In that case, as Campbell and Cochrane (1999) show, the stochastic discount factor 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 $m_{t,t+k}$ given above around $S_t = S_{t+k}$ and $C_t = C_{t+k}$ using Taylor series to get:

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

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

where $g_{s,t+k}$ and $g_{c,t+k}$ are the growth in 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:

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

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

where λ_s and λ_c are the risk premia for bearing the risk associated with surplus consumption ratio growth and consumption growth respectively. S_t will be a stationary random variable, whereas C_t will be growing. This can be seen from the fact that $S_t = \frac{C_t - X_t}{C_t}$, and X_t will be some average of past consumptions, the extreme case of which will be, $X_t = C_{t-1}$. Hence $\frac{Var(g_{s,t+k})}{Var(g_{c,t+k})}$ will become small as k becomes large. The rather large implied value for the coefficient of relative risk aversion indicates that setting k to 4 quarters may ignore some of the effect due to $\frac{S_{t+k} - S_t}{S_t}$. The high cross sectional R-Square, 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 for all the portfolios.

In deriving our consumption based asset pricing model specification we assumed 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, but the implied risk aversion coefficient will be much larger.

B. *Alternative Empirical Specifications*

We took the stand that all investors review their consumption investment decisions during the last quarter of the calendar year. They may also review at other points in time, but such reviews may not occur during the same period for all individuals. Given this view, we would expect to find most support for the CCAPM when matching consumption growth from the fourth quarter of one calendar year to the next with asset returns for the corresponding period.[8] Table VI gives the results when we measure annual consumption growth starting from other than the 4th quarter in a year. Notice that the consumption betas of small growth and small value firms are closer to each other when consumption growth is measured from Q1-Q1, or Q2-Q2, or Q3-Q3. The cross sectional R-Squares drop substantially, to as low as 14% when consumption growth is measured from Q2 of one year to Q2 of the next year. The estimated intercepts are large and significantly different from zero. Quarter 2 is the farthest from quarter 4. 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 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.

Measurement errors in consumption and the time aggregation bias will 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 errors. Using higher frequency consumption data minimizes the time aggregation bias, but also increases the measurement errors in the consumption data[9]. 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. The 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

[8] See Appendix B for details.

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

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

To check whether our conclusions critically depend on the use of seasonally adjusted data on expenditures of nondurables and services, we evaluated the model using nonseasonally adjusted consumption data. The price deflator for personal consumption expenditures is only available in seasonally adjusted form, so we followed Ferson and Harvey (1992), and used 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 we used, we estimated the model parameters using the data series used by Lettau and Ludvigson (2001) available from Martin Lettau's website. We find that the parameter estimates (not reported) do not change much and the conclusions remain the same.

We also examined whether the favorable empirical evidence for the CCAPM we find is driven by a few outlying observations. For that purpose we omitted four of the observations, corresponding to the two largest and two smallest consumption growth numbers in our data. With this change, the adjusted cross sectional R-Square 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 corresponding 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 examined the robustness of our findings using the six size and book to market 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, not much different from the 2.56 for the cross section of 25 assets we examined earlier. The cross sectional R-squares for the CCAPM and the Fama and French three factor model specifications, again, are comparable.

Table IX gives the results for several other sets of assets: 18 portfolios sorted on size, 18 portfolios sorted on B/M, 19 portfolios sorted on E/P, and 19 portfolios sorted on CF/P, taken from Kenneth French's website. The consumption model performs almost as well as the Fama and French three factor model for the Size and B/M portfolios, but not for the E/P and CF/P sorted portfolios. However, the estimated slope coefficients for consumption growth in the cross sectional regressions are not much different across the different sets of assets.

Following Daniel and Titman (2005), we also evaluated 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/market and size sorted portfolios. There is substantial variation in consumption factor, market factor, and SMB factor, and HML factor betas across the industries. Consumption betas vary from a low of 1.20 to a high of 5.99; 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/market characteristics as well. The average book/market ratios among the 17 industry portfolios vary from a low of 0.32 to a high of 1.11, i.e., a difference of 0.79 which is comparable to the corresponding difference of 0.76 for the 25 book/market and size sorted portfolios. There is less dispersion in the average size of firms across the industry portfolios – ranging from \$154 million to \$1621 million. In contrast, the average firm size varies from a low of

\$22 million for the smallest size quintile to \$7980 million for the largest size quintile in the 25 size and book/market sorted portfolios. The results for the time series and cross sectional regression tests are reported in Table X. The average and the largest absolute value of the alphas are 1.16% and 2.9% per year respectively for the CCAPM using the consumption mimicking portfolio. 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 that 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/market and size characteristics are not statistically significant in the cross sectional regressions.

While computing consumption betas we matched consumption growth from the fourth quarter of one year to the next with return from the end of December of that year to the next. However, there is no particularly compelling reason for matching December to December return with Q4 to Q4 consumption growth. We should expect similar results if we were to match October to October or November to November return with Q4-Q4 consumption growth while computing consumption betas. To examine the robustness of our conclusions we therefore used the average of October-October, November-November and December-December returns. In that case the slope coefficient for consumption beta in the cross sectional regressions is 2.70 and the adjusted cross sectional R-Square is 65%, not significantly different from the corresponding 2.56 and 71% for December-December returns.

D. Contraction Beta and Expansion Beta

We hypothesized that when processing information, and when changing consumption and investment plans, requires investment of valuable time and effort, investors will find it optimal to review decisions infrequently. Therefore the frequency with which decisions are reviewed will increase during economic contractions when the relative value of leisure time required to analyze situations and change plans is less expensive. If that were true, as we had pointed out earlier, we should find stronger support for the CCAPM using contraction betas. To estimate contraction betas and expansion betas of the twenty five stock portfolios, we classify NBER dating of business cycle turning points to classify periods where the economy is contracting and periods during which the economy is in expanding. Let the indicator variable, I_t take the value of 1 when the economy is contracting during quarter t and 0 when the economy is in expanding during quarter t. Let $\beta_{i,cont}$ denote the contraction beta of an arbitrary asset, i, and $\beta_{i,\exp}$ denote the corresponding expansion beta. Let $R_{i,t+4}$ denote the excess return on asset i from quarter t to quarter $t+4$. We estimate the betas by estimating the following equation by OLS:

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

We then examine the extent to which contraction and expansion betas can explain cross sectional variation in historical average return across the 25 Fama and French portfolios using cross sectional regressions. 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 what we expected to find.

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

In order to compare the two models further, we also estimated them after imposing the restriction that the intercept term in the cross sectional regression 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, not much different from the estimate of 2.56 obtained using the unrestricted model. The cross sectional R-Squares 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 cross sectional regression equation is zero. However, the estimated risk premium for the stock market factor changes substantially; it increases to 9.71% per year from -3.26% per year, which is consistent with a flat relation between market factor beta and average return in the sample.

Let $\alpha_i = E(R_i) - \lambda_0 - \lambda' \beta_i$ denote the model pricing error, i.e., 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 cross sectional regressions is restricted to be 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%, a substantial improvement over the CCAPM.

When the intercept term is constrained to be zero, however, the maximum value of $\tilde{\alpha}_i$ for Fama and French three factor model increases to 3.30% per year, 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 alpha does not come down when the two models are combined, suggesting that both models may be capturing the same economy wide pervasive risks, to a large extent.

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:

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

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

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

where $\beta_{i,c}$ denotes the consumption beta, and $\beta_{i,m}$, $\beta_{i,SMB}$, and $\beta_{i,HML}$ denote the Fama and French three factor betas, $i = 1, 2, .., 25$. Let $a_{im} + b_{i,m}\beta_{i,c}$, $a_{iSMB} + b_{i,SMB}\beta_{i,c}$, and $a_{iHML} + b_{i,HML}\beta_{i,c}$ denote the three *fitted Fama and French factor betas* and e_{im}, e_{iSMB} , e_{iHML} the corresponding *residual Fama and French factor betas* of asset i. We run a cross sectional regression using fitted beta and residual beta. Table XIV gives the results. The R-Square in the cross sectional regression 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 thirteen plot below. Figure 4 plots the fitted average excess returns obtained using the two models against the realized average excess return for the twenty five test assets. Both models tend to underestimate large and small realized average excess returns. Figure 5 plots the location of the consumption mimicking portfolio and the three Fama and French factors in the sample mean-standard deviation space. Notice that the portfolio of the Fama and French three factors that have the same average excess return as the consumption mimicking portfolio has a substantially higher standard deviation of the excess return. Therefore we can not reject the hypothesis that the consumption mimicking portfolio is on the sample mean - variance efficient frontier generated by the excess return on the Fama and French 25 portfolios. The patterns we observe in these figures are consistent with the view that both the models are measuring the same pervasive risk in the twenty five assets, and 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 twenty five test assets. The minimum time series R-Square is 86% and the maximum is 97%. In contrast, the corresponding numbers for the consumption mimicking portfolio are 4% and 27%. 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, notice 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 time series variations in returns. The R-Squares in the time series regression of returns on the 25 portfolios on the HML factor vary from a low of 0.00% 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-Square coupled with the high cross sectional R-Square for the consumption mimicking portfolio is also consistent with the equity premium puzzle. The portfolio has a rather high Sharpe Ratio of 1.28.

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 variations in the excess returns on the 25 portfolios. In contrast, the corresponding numbers are 0% and 12% for the consumption mimicking portfolio (not reported in the tables). The low time series R-Squares we find are consistent with the view that a substantial part of the risk even in a large portfolio is not priced. It is also consistent with the view that there is some thing missing in the standard CCAPM, but for some reason whatever is missing 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 for explaining the cross section of asset returns. The fact that consumption betas 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. 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 in other test assets as well.

In deriving the econometric specifications for the CCAPM we assumed that investors are more likely to review their consumption-investment plans during the fourth quarter of every calendar year, and more likely when the economy is in contraction 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. Therefore the exceptional performance of the CCAPM using the Q4-Q4 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. While the model can explain the cross section of returns on stocks, it has difficulty explaining the equity premium. The implied market risk premium for bearing consumption risk is rather high. When book to market ratio is introduced as an additional variable in the cross sectional regressions, its slope coefficient is significantly different from zero, indicating that it would be possible to construct a set of interesting test assets that pose a challenge to the consumption based model by following Daniel and Titman (1997). That would help future research in identifying what is missing in consumption based models.

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, i.e., the risk that macro economic events may unfavorably affect consumption choices.

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Appendix A: Linear Consumption Factor Model

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

$$E_t\left[R_{i,t+j}\left(\frac{\delta^j u'(c_{t+j})}{u'(c_t)}\right)\right] = 0 \tag{17}$$

Take unconditional expectation, and rewrite the expectation of the product in terms of covariances,

$$E[R_{i,t+j}]E[\frac{\delta^j u'(c_{t+j})}{u'(c_t)}] = -Cov[\frac{\delta^j u'(c_{t+j})}{u'(c_t)}, R_{i,t+j}] \tag{18}$$

By the first order approximation, we have

$$\begin{aligned} \frac{u'(c_{t+j})}{u'(c_t)} &\approx \frac{u'(c_t) + u''(c_t)(c_{t+j} - c_t)}{u'(c_t)} \\ &= 1 - (-\frac{c_t u''(c_t)}{u'(c_t)})\frac{(c_{t+j} - c_t)}{c_t} \\ &= 1 - \gamma_t(g_{c,t+j} - 1) \end{aligned} \tag{19}$$

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. Plug (19) into (18) and reorganize, we get

$$E[R_{i,t+j}] = \frac{\gamma \cdot Var(g_{c,t+j})}{1 - \gamma E(g_{c,t+j} - 1)} \frac{Cov[g_{c,t+j}, R_{i,t+j}]}{Var(g_{c,t+j})} \tag{20}$$

Let

$$\lambda_{cj} = \frac{\gamma \cdot Var(g_{c,t+j})}{1 - \gamma E(g_{c,t+j} - 1)}, \beta_{icj} = \frac{Cov[g_{c,t+j}, R_{i,t+j}]}{Var(g_{c,t+j})}$$

We have

$$E[R_{i,t+j}] = \lambda_{cj}\beta_{icj}. \tag{21}$$

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 that way as *type 1* investors and the others as *type 2* investors. We get the following equation from the first order conditions for the lifetime expected utility maximization problem faced by type 1 investors at time t,

$$E\left[R_{i,t+j}(1-\gamma(g^{1}_{c,t+j}-1))\right]=0 \tag{22}$$

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 don't make consumption-investment decisions at time t, equation (22) will not hold. Therefore,

$$E\left[R_{i,t+j}\left(1-\gamma(g^{2}_{c,t+j}-1)\right)\right]=\epsilon_{it} \tag{23}$$

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 $t+j$, i.e., 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,

$$\begin{aligned} & E[R_{i,t+j}\left(1-\gamma(g^{A}_{c,t+j}-1)\right)] \\ = \; & E[R_{i,t+j}(1-\gamma w_t(g^{1}_{c,t+j}-1))]+E[\gamma(1-w_t)(g^{1}_{c,t+j}-g^{2}_{c,t+j})R_{i,t+j}] \\ = \; & \gamma(1-w_t)E[(g^{1}_{c,t+j}-g^{2}_{c,t+j})R_{i,t+j}] \end{aligned} \tag{24}$$

since $E[R_{i,t+j}(1-\gamma w_t(g^{1}_{c,t+j}-1))]=0$ from equation (22).

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

$$\begin{aligned} & Cov[(1-\gamma(g^A_{c,t+j}-1), R_{i,t+j}] + E[1-\gamma(g^A_{c,t+j}-1)]E[R_{i,t+j}] \\ = & \gamma(1-w_t)E[(g^1_{c,t+j}-g^2_{c,t+j})R_{i,t+j}] \end{aligned} \quad (25)$$

By rearranging the terms, we get,

$$E[R_{i,t+j}] = \frac{\gamma(1-w_t)E[(g^1_{c,t+j}-g^2_{c,t+j})R_{i,t+j}]}{1-\gamma E[g^A_{c,t+j}-1]} + \frac{\gamma Cov[(g^A_{c,t+j}-1), R_{i,t+j}]}{1-\gamma E[g^A_{c,t+j}-1]} \quad (26)$$

Subtracting equation (23) from (22) gives:

$$E[(g^1_{c,t+j}-g^2_{c,t+j})R_{i,t+j}] = \epsilon_{it} \quad (27)$$

By combining the above equation with equation (26) we get:

$$E[R_{i,t+j}] = \varepsilon_{it} + \lambda_t \beta^A_{ic} \quad (28)$$

where

$$\varepsilon_{it} = \frac{(1-w_t)\gamma}{1-\gamma E[g^A_{c,t+j}-1]}\epsilon_{it} \quad (29)$$

$$\lambda_t = \frac{\gamma Var[g^A_{c,t+j}]}{1-\gamma E[g^A_{c,t+j}-1]} \quad (30)$$

$$\beta^A_{ic} = \frac{Cov[g^A_{c,t+j}, R_{i,t+j}]}{Var[g^A_{c,t+j}]} \quad (31)$$

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

$$E[R_{i,t+j}] = \lambda_t \beta^A_{ic} \quad (32)$$

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

$$E[R_{i,t+j}] = \overline{\varepsilon_t} + \lambda_t \beta_{ic}^A + (\varepsilon_{it} - \overline{\varepsilon_t}) \tag{33}$$

where $\overline{\varepsilon_t}$ is 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 Q4 of one year to the next is matched with excess returns for the corresponding period to compute consumption betas.

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 the 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 the quarterly consumption growth. Q3-Q4 is the 4th 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
std	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
std	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	mean	23.55	24.63	25.06	26.76
Adjusted	std	0.26	0.12	0.16	0.31
Seasonally	mean	24.77	24.93	25.07	25.23
Adjusted	std	0.13	0.07	0.06	0.14

Table II
Annual Excess Returns and Consumption Betas

Panel A reports average annual excess returns on Fama-French 25 portfolios from 1954-2003. 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 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 4th quarter consumption data. Panel C reports t-values associated with consumption betas.

Panel A: Average Annual Excess Returns (%)

	Low	book-to-market			High
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

	Low	book-to-market			High
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

	Low	book-to-market			High
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

Table III
Cross Sectional Regression

This table reports Fama-MacBeth 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 Fama-French 25 portfolios, annual percentage return from 1954-2003. The estimation method is the Fama-MacBeth cross-sectional regression procedure. The first row reports the coefficient estimates ($\widehat{\lambda}$). 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.

	const	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

Table IV
Time Series Regression and GRS Test

Panel A reports pricing errors (α) for the CCAPM, the CAPM, and the Fama French three factor model. Pricing errors are estimated by 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, $f_t = [R_{m,t}, SMB, HML]$ for the Fama French three factor model. Test portfolios are Fama-French 25 portfolios, annual percentage return from 1954-2003. Panel B reports Gibbons, Ross and Shanken (1989) test statistics and p-values.

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

Panel A: Pricing Errors

CCAPM									
alpha					t-value				
-2.49	-2.61	-0.66	0.34	-0.87	-0.30	-0.38	-0.12	0.06	-0.15
-1.66	0.07	-1.34	-0.06	-0.77	-0.25	0.01	-0.27	-0.01	-0.15
-1.15	-1.49	-1.76	-1.02	-2.18	-0.21	-0.34	-0.43	-0.22	-0.45
-0.26	-1.41	-0.62	-1.64	-2.86	-0.05	-0.35	-0.15	-0.38	-0.59
-1.91	-0.13	-0.24	-2.17	-2.34	-0.45	-0.03	-0.07	-0.55	-0.50
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									
alpha					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	FF 3 Factor
GRS	0.27	2.07	1.65
p-value	0.999	0.04	0.12

Table V
GMM Estimation

We estimate the stochastic discount factor representation of the CCAPM, the CAPM, and the Fama and French 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 Fama and French three factor model.

Asset returns are value-weighted annual returns on Fama-French 25 portfolios. The sample period is 1954 – 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 weighting matrix. The coefficient estimates are reported in the first row. The second row reports t-statistics. The last two columns give the J-statistic and corresponding p-value.

CCAPM

	Δc	$HJ - dist$	p-value.
estimate	33.01	0.29	0.69
t-value	(25.45)		

CAPM

	R_m	$HJ - dist$	p-value.
estimate	2.10	0.74	0.08
t-value	(6.44)		

Fama-French 3 Factor Model

	R_m	SMB	HML	$HJ - dist$	p-value.
estimate	1.90	0.56	2.61	0.63	0.10
t-value	(4.12)	(0.85)	(5.02)		

Table VI
Consumption Betas Using Other Quarterly Data

Panel A reports Fama French 25 portfolios' annual returns and their consumption betas estimated by 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 Fama-French 25 portfolios from 1954-2003. For Q1-Q1 consumption growth, portfolio annual returns are calculated from April to next March. For Q2-Q2 consumption growth, portfolio annual returns are calculated from July to next June. For Q3-Q3 consumption growth, portfolio annual returns are calculated from October to next September. All returns are annual percentages. Panel B reports Fama-MacBeth cross sectional regression estimation results for CCAPM.

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

Panel A: Annual Excess Returns and Consumption Betas

Excess Returns (%)					Consumption Betas				
				Q1-Q1					
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					
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					
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

	const	Δc	R^2(adj-R^2)
		Q1-Q1	
estimate	5.10	1.18	0.27
t-value	(2.00)	(2.39)	0.24
		Q2-Q2	
estimate	7.70	0.88	0.18
t-value	(3.05)	(1.68)	0.14
		Q3-Q3	
estimate	8.64	1.38	0.30
t-value	(2.98)	(2.71)	0.27

Table VII
CCAPM with Different Frequency Data

We use different frequency returns data and consumption data to test the CCAPM. Panel A describes how the 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 Fama-French 25 portfolios from 1960-2003. (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	7.70	0.02	0.00						
Return	(2.61)	(0.17)	-0.04						
Quarterly	8.34	0.03	0.00	4.52	0.33	0.22			
Return	(2.80)	(0.15)	-0.04	(1.83)	(1.59)	0.18			
Annual	-1.83	2.01	0.41	-1.19	2.68	0.69	10.12	1.32	0.21
Return	(-0.51)	(2.33)	0.38	(-0.37)	(3.49)	0.68	(3.70)	(1.61)	0.18

Table VIII
Fama-French 2×3 Portfolios

This table reports cross sectional regression results of the CCAPM and Fama-French three factor models on Fama-French 2×3 portfolios (Small Value, Small Neutral, Small Growth, Big Value, Big Neutral, Big Growth). Samples are 1954-2003 annual data. All returns are annual percentages.

	$const$	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)	

Table IX
Cross Sectional Regression Results: Other Portfolios

Test portfolios are sorted on size, book-to-market, earning/price, and cashflow/price. 19 portfolios are constructed for each sorting variable: Negative (not used for size and B/M), 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 3 Factor Model				
	const	Δc	$R^2(\overline{R^2})$	const	R_m	SMB	HML	$R^2(\overline{R^2})$
				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)	

Table X
17 Industry Portfolios

This table reports time series regression and cross sectional regression results of the CCAPM (consumption mimicking portfolio) and the Fama-French 3 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		FF 3 Factor Model	
	α	t-value	α	t-value
1	1.59	0.60	3.26	1.54
2	1.71	0.41	-0.96	-0.30
3	-0.89	-0.32	1.58	0.69
4	0.01	0.00	-4.08	-1.70
5	-1.31	-0.36	0.06	0.02
6	-1.31	-0.47	-0.98	-0.59
7	2.54	0.84	6.24	2.73
8	-1.16	-0.35	-1.18	-0.91
9	-2.54	-0.58	-4.59	-1.71
10	0.28	0.10	-0.98	-0.64
11	-1.23	-0.31	1.68	0.96
12	-2.90	-0.74	-4.79	-2.06
13	-1.44	-0.42	-2.70	-1.51
14	0.24	0.09	-1.59	-0.91
15	-0.06	-0.02	0.59	0.25
16	0.08	0.03	-1.25	-0.74
17	-0.47	-0.16	1.46	1.15
	GRS	p-value	GRS	p-value
	0.19	1.00	2.93	0.00

Panel B: Cross Sectional Regression

	const	CMP	R_m	SMB	HML	log(ME)	log(B/M)	R^2(adj-R^2)
estimate	4.50	7.80						0.25
t-value	(1.68)	(1.15)						0.20
shanken-t	(1.59)	(0.99)						
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

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 time series regression:

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

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

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

$R_{i,t+4}$ are annual excess returns of Fama-French 25 portfolios from quarter t to quarter $t+4$ for all quarters from 1954-2003. 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

Table XII
Cross Sectional Regression without an Intercept

This table reports Fama-MacBeth 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 Fama-French 25 portfolios, annual return from 1954-2003. The estimation method is the Fama-MacBeth cross-sectional regression procedure. The first row reports the coefficient estimates ($\widetilde{\lambda}$). 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

Table XIII
Cross Sectional Regression Pricing Errors

This table compares pricing errors of Fama-French 25 portfolios generated by the CCAPM, the Fama-French three factor model, and the nesting four factor model (FF 3 factor $+\Delta c$). When the model is estimated without restrictions, then pricing errors are calculated by $\widehat{\alpha}_i = \overline{R_i} - \widehat{\lambda}_0 - \widehat{\lambda}' \widehat{\beta}_i$; when the model is estimated with restrictions, then pricing errors are calculated by $\widetilde{\alpha}_i = \overline{R_i} - \widetilde{\lambda}' \widehat{\beta}_i$. All numbers are annual percentages.

CCAPM: $\widehat{\alpha}$

-2.82	-1.77	1.20	3.45	1.85
-1.55	1.87	0.23	2.41	1.59
-0.58	-0.48	-0.85	0.85	-0.81
0.95	-0.79	1.07	-0.35	-2.18
-1.74	1.06	1.14	-1.81	-1.93

CCAPM: $\widetilde{\alpha}$

-2.78	-1.80	1.21	3.44	1.80
-1.50	1.91	0.22	2.42	1.57
-0.53	-0.47	-0.85	0.83	-0.86
1.01	-0.76	1.08	-0.37	-2.23
-1.71	1.12	1.20	-1.80	-1.93

3 Factor model: $\widehat{\alpha}$

-2.36	0.87	-0.55	1.92	2.73
-1.74	-1.03	0.52	0.13	1.20
0.52	-0.71	-1.68	0.25	-0.49
2.23	-2.14	0.08	0.06	0.32
2.65	-0.40	0.20	-1.22	-1.37

3 Factor model: $\widetilde{\alpha}$

-3.30	-0.45	0.55	2.90	2.29
-2.18	-0.42	1.27	0.46	0.72
0.33	0.11	-0.70	-0.01	-0.27
2.85	-1.32	-0.03	0.11	-1.03
2.54	0.13	1.34	-1.56	-2.88

4 Factor model: $\widehat{\alpha}$

-1.64	-0.01	-0.54	1.73	1.94
-0.82	0.48	-0.46	1.07	1.45
0.58	-1.20	-2.06	0.60	-1.38
1.66	-1.72	0.86	-0.37	-0.42
0.73	0.71	0.36	-1.13	-0.44

4 Factor model: $\widetilde{\alpha}$

-2.77	-1.36	0.68	2.84	1.57
-1.43	0.95	0.50	1.31	0.88
0.36	-0.22	-0.92	0.26	-1.02
2.42	-0.86	0.64	-0.26	-1.82
0.86	1.15	1.60	-1.52	-2.24

Table XIV
Fitted Beta and Residual Beta

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

$$\begin{aligned}\beta_{i,m} &= a_{im} + b_{i,m}\beta_{i,c} + e_{im} \\ \beta_{i,SMB} &= a_{iSMB} + b_{i,SMB}\beta_{i,c} + e_{iSMB} \\ \beta_{i,HML} &= a_{iHML} + b_{i,HML}\beta_{i,c} + e_{iHML}\end{aligned}$$

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

Fitted beta

	intercept	Rm	SMB	HML	R^2(adj-R^2)
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

	intercept	Rm	SMB	HML	R^2(adj-R^2)
estimate	10.71	-9.93	1.57	2.33	0.14
t-value	(3.59)	(-1.96)	(0.80)	(1.14)	0.02

Table XV
Time Series Regression vs. Cross Sectional Regression

Panel A reports time series regression R-Squares for the CCAPM (Consumption Mimicking Portfolio), the Fama 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-squares

CCAPM					3 Factor Model				
0.04	0.14	0.15	0.22	0.25	0.91	0.96	0.96	0.95	0.97
0.04	0.11	0.21	0.21	0.25	0.94	0.94	0.92	0.94	0.95
0.07	0.19	0.22	0.23	0.27	0.96	0.93	0.92	0.93	0.92
0.08	0.15	0.20	0.25	0.25	0.92	0.86	0.91	0.87	0.89
0.13	0.11	0.17	0.20	0.18	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	-0.83	46.23				0.92
t-value	(-0.26)	(4.16)				0.91
Shanken-*t*	(-0.16)	(2.54)				
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)			

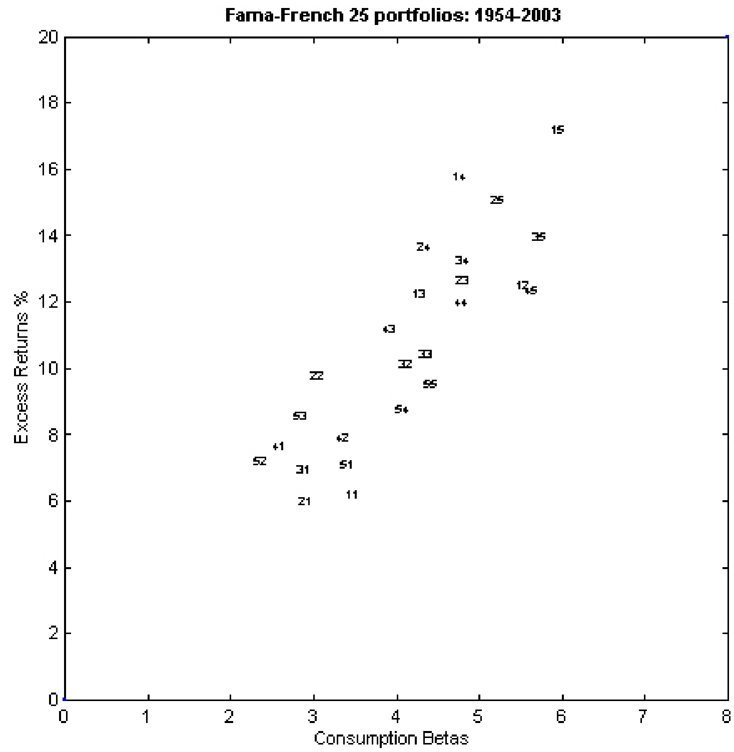

Figure 1. Annual Excess Returns and Consumption Betas. Plot figure of average annual excess returns on Fama-French 25 portfolios and their consumption betas. Each two digit number represents one portfolio. The first digit refers to the size quintile (1 smallest, 5 largest), and the second digit refers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

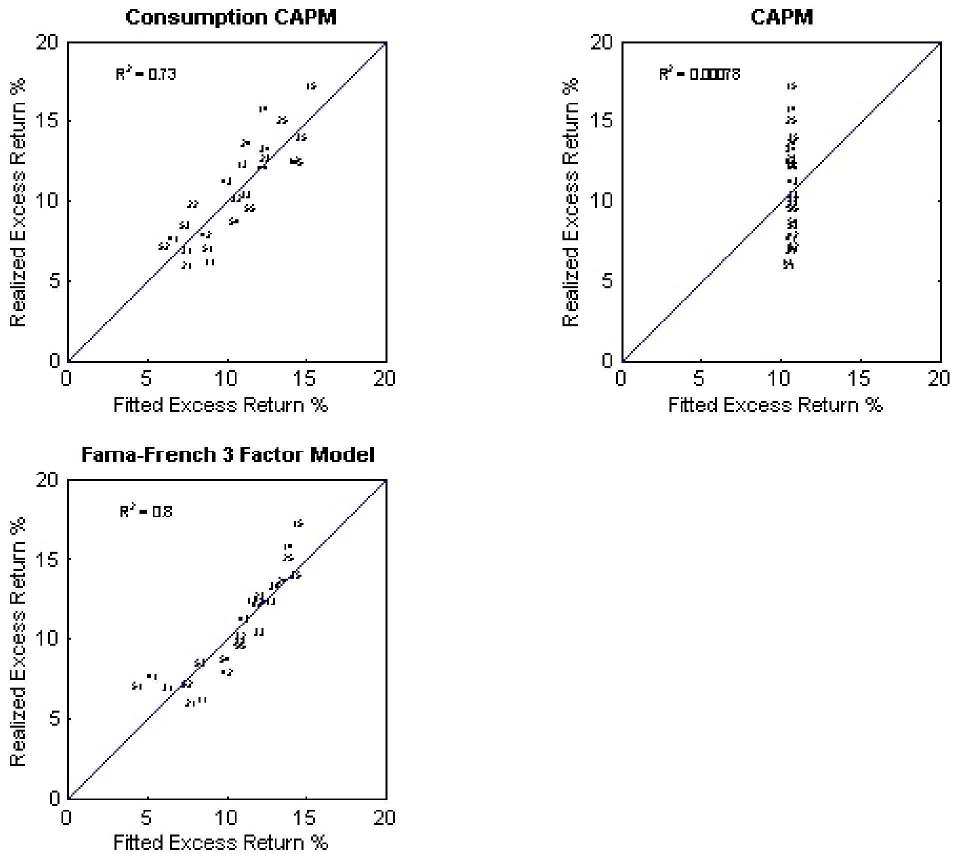

Figure 2. Realized and Fitted Excess Returns. This figure compares realized annual excess returns and fitted annual excess returns of Fama-French 25 portfolios, 1954-2003. Each two digit number represents one portfolio. The first digit refers to the size quintile (1 smallest, 5 largest), and the second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

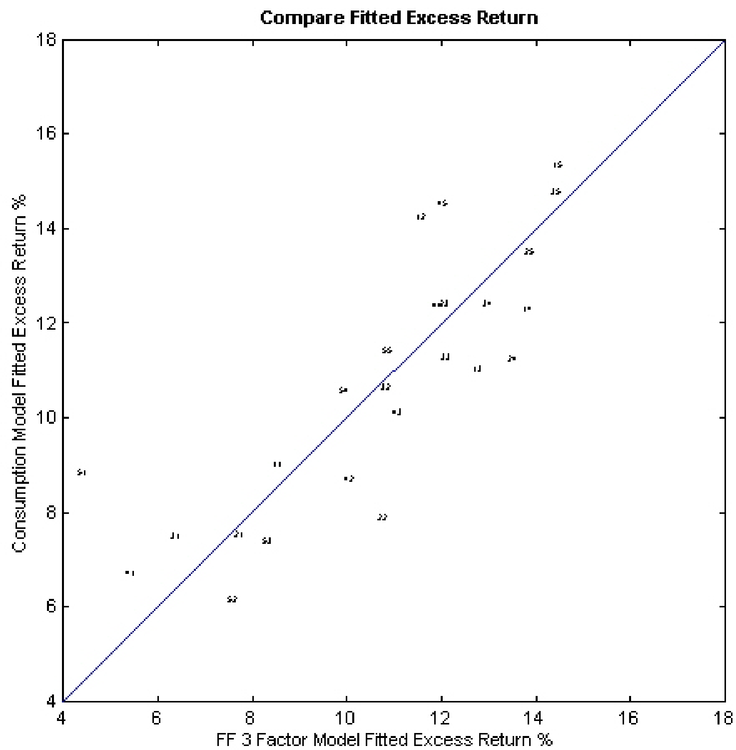

Figure 3. Fitted Returns in CCAPM Vs. Fitted Returns in Fama and French Three Factor Model. This figure plots the expected excess return of Fama-French 25 portfolios according to the Fama-French 3 factor model on the horizontal axis, and the expected excess return according to the CCAPM on the vertical axis.

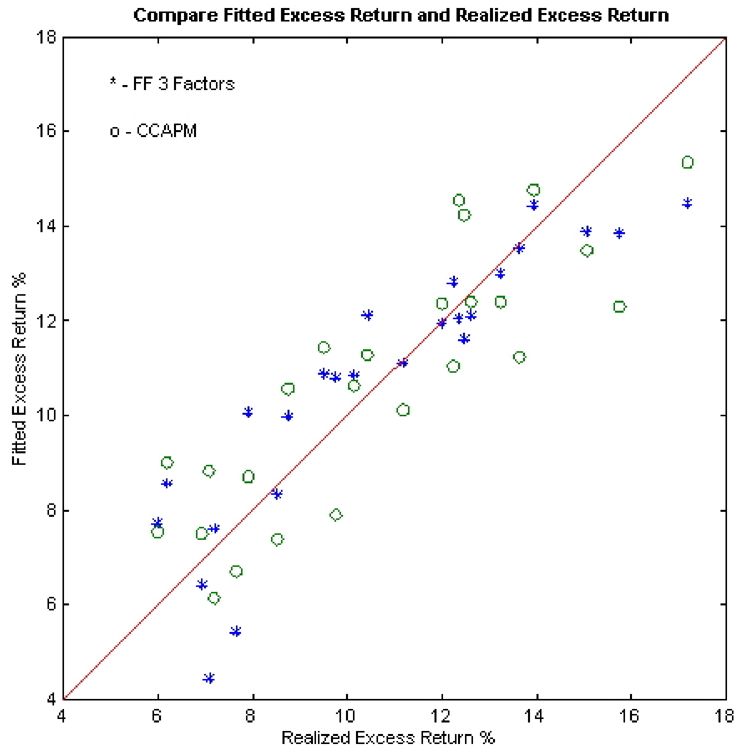

Figure 4. Fitted Average Excess Return vs Realized Average Excess Return: CCAPM and Fama and French Three Factor Model. This figure plots the realized average excess return of Fama-French 25 portfolios on the horizontal axis and the Fama French three factor model fitted returns and the CCAPM model fitted returns on the vertical axis.

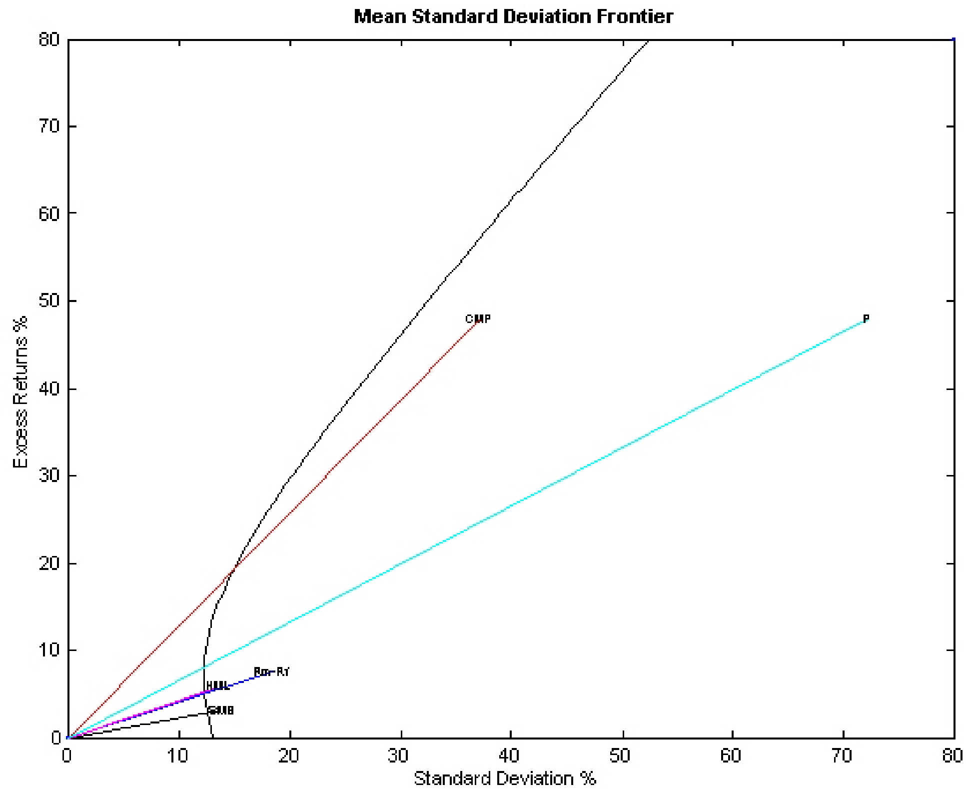

Figure 5. Mean-Standard Deviation Space. The hyperbola is the mean standard deviation frontier of Fama French 25 portfolio excess returns. CMP is the consumption mimicking potfolio, and Rm-Rf, SMB and HML are Fama and French three factors. P is the portfolio of Rm-Rf, SMB and HML that has the largest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