Commodity-based Consumption Tracking Portfolio and the Cross-section of Average Stock Returns

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Abstract

We find that the projection of consumption growth on commodity futures returns tracks the part of consumption that is priced in the cross-section of US stock returns. When consumption betas are estimated using the commodity-based consumption tracking portfolio, the Consumption CAPM (CCAPM) produces a significant risk premiums between 50bp and 1% per year depending on the empirical specification. In contrast, we fail to find significant risk premiums when the CCAPM is estimated using either non-traded consumption growth or stock- and bond-based consumption tracking portfolios. Our results are robust to using either portfolios or individual stocks in the asset pricing tests and to controlling for firm-level return predictors such as size, book-to-market, and past returns.

JEL classification: G12, G13

Keywords: Commodities, Consumption Risk, CCAPM, Tracking Portfolios

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1 Introduction

The standard consumption-based asset pricing model (CCAPM) developed by Rubinstein (1976), Lucas (1978), and Breeden (1979) is a natural choice for analyzing the cross-sectional differences in average returns on financial assets. The model builds on an idea that assets should carry higher risk premium if they pay off poorly in bad times as measured by consumption growth. Hence a simple relation between consumption growth and asset returns captures the implications of the multifactor intertemporal asset pricing models (Breeden (1979)). Despite being theoretically appealing, the empirical performance of the CCAPM has proven unsatisfactory (Campbell and Cochrane (2000)). To address this deficiency, the literature has proposed non-standard assumptions (e.g., infrequent decision making of Parker and Julliard (2005) or Jagannathan and Wang (2007)); more sophisticated preference structures (e.g., Campbell and Cochrane (1999), Bansal and Yaron (2004), Yogo (2006)); or hard to detect features of the consumption data (e.g., small but persistent component of the dividend process in the long run risk models as in Bansal and Yaron (2004)). But given that Lettau and Ludvigson (2005) show that the standard CCAPM should hold as a good approximation even if economies are driven by more sophisticated preference structures, the poor empirical performance of the CCAPM is still puzzling.

In this paper we offer a new measure of consumption risk that could potentially solve this puzzle. In particular, we replace the consumption growth in the CCAPM model with its tracking portfolios. Balduzzi and Robotti (2008) show that the risk premiums estimates are more reliable when noisy non-traded factors are replaced by their projections on the span of asset returns. What is novel here is that we construct the consumption tracking portfolios not from stocks and bonds, as is common in the literature, but from commodity futures contracts.

It is natural to think that commodities should contain price relevant consumption information, since certain commodities are directly related to aggregate consumption itself. For example, based on the data from the National Income and Product Accounts (NIPA) commodities constitute around 40% of the personal consumption expenditures (PCE) with energy commodities accounting for 4%, food commodities for 15%, and other commodities for 21%. Further, commodity futures are known to be good inflation hedges[1] and hence may be used for hedging real consumption risk. Finally, futures prices being forward looking are often viewed as informative about future economic activity, and are known to facilitate price discovery (e.g., Working (1948), Garbade and Silber (1983), and Hong and Yogo (2012)). Our goal in this paper is to construct a proxy that captures the part of consumption that is relevant for pricing and we posit that the commodity futures returns contain more price relevant consumption information than stocks and bonds.

We find that the fraction of variation in consumption growth captured by our commodity-based consumption tracking portfolios is similar to that of the more traditional stock-based tracking portfolios but higher than that of bond-based tracking portfolios. More importantly, betas with respect to the commodity-based consumption tracking portfolios (but not those related to the stock and bond-based tracking portfolios) are significantly priced in the cross section of stocks returns, with an average risk premium ranging between 50bp and 1% per year depending on the empirical specifications. Our results are robust to using either portfolios or individual stocks in the asset pricing tests and to controlling for firm-level return predictors such as size, book-to-market, and past returns.

Our paper is part of a growing literature that seeks to improve the performance of

[1]See e.g., Breeden (1980), Bodie (1983), Greer (2000), Erb and Harvey (2006),Gorton and Rouwenhorst (2006), Attié and Roache (2009), and Bekaert and Wang (2010).

the standard consumption-based asset pricing model. Early studies find little support for the CCAPM using non-traded consumption data. For example, Hansen and Singleton (1982) reject the model and Hansen and Jagannathan (1997) find large pricing errors. Breeden, Gibbons, and Litzenberger (1989) construct consumption mimicking portfolios from stocks and bonds but find that they do not change the poor performance of the CCAPM using monthly data. However, recent studies show more promises for the model. For example, Jagannathan and Wang (2007) show that the CCAPM performs better in annual data when consumption growth is measured over the fourth quarters. Savov (2011) proxies for consumption using data on municipal solid waste and finds that the garbage growth is priced in the cross-section of US and international portfolio returns. Da and Yun (2010) and Chen and Lu (2012) follow in his footsteps and find similar results when using electricity consumption and carbon dioxide emissions to proxy for consumption. This paper is in the same spirit, but we focus solely on traded portfolios when constructing our proxy for consumption risk.

The rest of the paper is organized as follows. In section 2 we introduce the standard beta representation of the CCAPM and discuss the construction of the consumption tracking portfolios. In Section 3 we describe our data. Section 4 shows the ability of our tracking portfolios to capture the dynamics of consumption data and reports the results of the asset pricing tests. Section 5 summarizes and concludes.

2 The Consumption-CAPM and consumption tracking portfolios

2.1 The Consumption-CAPM

Rubinstein (1976), Lucas (1978), and Breeden (1979) develop the Consumption-CAPM

(CCAPM) where the risk of a security is determined by its covariance with consumption growth. Assuming that the period utility function has a constant relative risk aversion γ, the pricing kernel for the standard CCAPM takes the following form:

$$m_t = \delta \left(\frac{C_t}{C_{t-1}} \right)^{-\gamma}, \tag{1}$$

where δ is the time discount factor, $\left(\frac{C_t}{C_{t-1}} \right)$ is the consumption growth from time $t-1$ to time t.

For the unconditional excess returns, $r_{i,t}$, the above defined stochastic discount factor yields

$$\begin{aligned} E\left[m_t r_{i,t}\right] &= 0 \\ \Leftrightarrow \quad E\left[r_{i,t}\right] &= -\frac{Cov\left[r_{i,t}, \Delta c_t^{-\gamma}\right]}{E\left[\Delta c_t^{-\gamma}\right]}, \end{aligned} \tag{2}$$

where $\Delta c_t = \left(\frac{C_t}{C_{t-1}} \right)$.

To derive a beta representation for this model we use a first order Taylor expansion of $\Delta c_t^{-\gamma}$ around its mean to avoid assuming a joint log-normality of returns and consumption growth

$$\begin{aligned} E\left[r_{i,t}\right] &= \lambda_c \beta_{ic} \\ \beta_{ic} &= \frac{Cov\left[r_{i,t}, \Delta c_t\right]}{Var\left[\Delta c_t\right]} \end{aligned} \tag{3}$$

where λ_c is the market price of consumption risk, $\lambda_c = -\gamma Var\left[\Delta c_t\right] / \overline{\Delta c_t}$.

This is the standard beta representation of the CCAPM. The intuition is that investors dislike securities that pay well in good times and poorly in bad times and will hence demand higher risk premiums for holding those assets. If we measure those bad and good states with consumption growth then the CCAPM predicts that assets with high covariances with consumption growth should earn high expected returns.

2.2 The consumption tracking portfolios

One challenge in estimating equation (3) is the poor quality of the consumption data. The common way of constructing Δc_t is to use data from NIPA tables which may be biased due to methodological issues like interpolating, forecasting, and the incidence of non-reporting. Also, theory implies that consumption risk is measured with respect to aggregate consumption growth between two points in time. In practice, however, we observe total expenditures on goods and services over a period of time. This creates a so called "summation (or time-aggregation) bias" (e.g., Breeden, Gibbons, and Litzenberger (1989)). One way to avoid this problem would be to use higher frequency consumption data, but these data are measured less precisely. Hence, the convention in the literature is to use lower frequency data - mostly at quarterly (e.g., Lettau and Ludvison (2001)) or annual frequencies (Jagannathan and Wang (2007)).

Instead, we replace non-traded consumption growth in equation (3) with traded tracking portfolio that captures the price relevant consumption information. Tracking portfolios have long been used in the asset-pricing literature. For example, Breeden, Gibbons, and Litzenberger (1989) and Jagannathan and Wang (2007) use simple unconditional tracking portfolios with fixed weights to mimic consumption growth and test the CCAPM. Lamont (2001) shows how to construct the portfolio that instead maximizes the conditional correlation between the span of asset returns and several economic factors such as production growth, consumption growth, labor income growth, and inflation. Vassalou (2003) uses Lamont's method to construct a mimicking portfolio that captures news related to future GDP growth. Ferson, Siegel, and Xu (2006) study similar portfolios as Lamont (2001) but they consider optimal time-varying portfolios weights in both unconditional and conditional setups. They find a potential improvement in the correlations above the fixed-weight portfolios of more than 20% but the results are sensitive to the estimation errors and errors in specifying the form of the data generating process. Alternatively, time-varying portfolio weights can be estimated using rolling window regressions as in Ferson and Harvey (1991) who use tracking portfolios to assess the level of return predictability captured by asset pricing models. In this paper, we use tracking portfolios with fixed weights, which we estimate unconditionally and conditionally.

In particular, we follow Huberman, Kandel, and Stambaugh (1987) and construct the fixed-weight portfolio that maximizes the unconditional correlation with the non-traded consumption growth by projecting consumption growth onto the span of base asset returns, augmented with a constant

$$\Delta c_t = \nu + \phi R_t + \varepsilon_t, \tag{4}$$

where Δc_t is the non-traded consumption growth, R_t is a vector of excess returns on the base assets.

Since the consumption tracking portfolios capture the risk that arises due to the changes in investment and consumption opportunities (Merton (1973), Breeden (1979)), we want to incorporate conditioning information into the estimation of the tracking portfolios. To this end we follow Lamont (2001) and extend equation (4) in the following way

$$\Delta c_t = \nu + \phi R_t + \varphi z_{t-1} + \varepsilon_t, \tag{5}$$

where z_{t-1} are predictive variables know one period before the returns are realized. The underlying assumption is that time-varying conditional means of base asset returns are linear functions of current information about the economic state that is captured with

z_{t-1}.

In both the unconditional and conditional cases we define the consumption tracking portfolio as $CTP_t = \phi R_t$.

3 Data

We use monthly data on consumption growth, asset returns, and predictive instruments from January 1984 to December 2007.

We obtain consumption and population data from the Bureau of Economic Analysis (BEA). We measure consumption growth as the percentage change in the seasonally adjusted, aggregate, real per capita consumption expenditures on nondurable goods and services from Section 2 of the National Income and Product Accounts (NIPA) tables.

We construct consumption tracking portfolios from three different sets of base assets: stocks, bonds, and commodity futures contracts. The stock-based consumption tracking portfolio (CTPs) uses as base assets the value-weighted CRSP index and the 17 value-weighted industry portfolios downloaded from Ken French's data library. The bond-based consumption tracking portfolio (CTPb) uses ten corporate bond portfolios (intermediate- and long-term returns for four investment grades and one junk grade) and two government bond portfolios (intermediate- and long-term). All bond data are retrieved from the WRDS.

To construct the commodity-based consumption tracking portfolio (CTPc), we use data on 84 futures contracts across 20 different commodities and up to five different maturities obtained from the Futures Industry Institute (FII) Data Center and RC Research. We sort those contracts into four sectors [2] (Energy, Meats, Metals, and Agriculture) and five maturities, which we then use to create 20 equally-weighted portfolios as base assets

[2]Similar classification was used in Hong and Yogo (2012).

for the consumption tracking portfolio.[3] Following common practice in the literature, we calculate futures returns using a rollover strategy with the nearest-to-maturity futures contracts. At the beginning of the month prior to the delivery month, we roll-over the position from the nearest-to-maturity contract to the contract with the next nearest delivery month. Prices of futures observed in the last month prior to and during the delivery month are excluded from the analysis to avoid irregular price behavior that is common due to investors rolling over their positions. Table 1 lists the 20 different underlying commodities, the delivery months for each contract, and the name of the exchange where each contract is traded. We also report the first observation for each commodity contract for all nearby series used. We choose 1984 as the starting point of our analysis because it ensures that we have at least ten commodity contracts and a minimum of two contracts in each sector.

Insert Table 1 around here

The descriptive statistics for the base assets are shown in Table 2. Panel A shows that the commodity portfolios exhibit substantial variation in average returns across sectors. For example, for the nearest maturity contracts, the average returns vary from a high of 1.35% for the Energy sector to a low -0.03% for the Agriculture sector. Energy and Metals have a downward-sloping term structure in average returns, while Meats and Agriculture have a hump-shape relation between average return and maturity. There is also considerable variation in volatility across sectors, with the Energy sector being almost twice as volatile as the other three sectors. The relation between volatility and maturity is fairly flat across sectors. Panel B of Table 2 shows that the average returns of the stock portfolios vary from a high of 1.09% for the CRSP index to a low of 33bps for the Durable industry and the volatility varies from a high of 7.50% for the Steel industry

[3] We get similar results when we use open-interest to weight the contracts within each sector.

to a low 3.93% for the Utility industry. Panel C of Table 2 shows more muted differences in average returns and volatility across bond portfolios. The average returns (volatility) vary from a high of 0.56% (2.55%) for long-term junk bonds to a low 20bps (0.86%) for intermediate-term government bonds.

Insert Table 2 around here

To capture conditioning information, we select seven instruments commonly used in the asset pricing literature.[4] Term spread (TERM) is the yield spread between ten- and one-year government bonds. Default spread (DEF) is the yield spread between Moody's Baa- and Aaa-ranked corporate bonds. Unexpected inflation (UI) is measured as the difference between the realized inflation and the one month t-bill rate (proxy for the market's short-term inflation expectation). Change in the short term-expected inflation (ESR) is measured as the change in the one month t-bill rate. Change in the long-term expected inflation (ELR) is measured as the change in ten-year government bond yield. We also include the CRSP value-weighted market index (MARKET) and the dividend yield on S&P 500 index (DY) as instruments.

For our asset-pricing tests, we use the independently-sorted five size, five book-to-market, five momentum, and five industry portfolios downloaded from Ken French's data library as test assets. Table 3 reports the descriptive statistics of the test asset portfolios. Panel A shows that these test portfolios produce substantial cross-sectional dispersion in average returns. For example, the momentum winner portfolio earn an average excess return of close to 1% per month, whereas the momentum loser portfolio earn only 10 bps per month. Large return differences are also observed across the book-to-market

[4]See, e.g., Fama and Schwert (1977), Ferson and Harvey (1991), Pesaran and Timmermann (1995), Kirby (1998), Erb and Harvey (2006), and Hong and Yogo (2012).

portfolios, from a high of 0.89% per month for the growth portfolio to a low of 0.60% per month for the value portfolio. Panel B reports the standard deviations of the test portfolios, which also show sizable variation. They vary from a high of 6.61% per month for the momentum loser portfolio to a low of 3.86% per month for the Manufacturing industry portfolio. Finally, Panel C reports the consumption betas of the test portfolios. The betas often go in the wrong direction in explaining the average return differences. For example, the value portfolio and the momentum winner portfolio earn higher returns but have lower consumption betas than the growth portfolio and the momentum loser portfolio, respectively. These results are consistent with the poor performance of the CCAPM reported in previous studies (Campbell and Cochrane (2000) and references therein).

Insert Table 3 around here

In addition to using test portfolios, we also use individual stocks from the CRSP universe (sharecodes 10 or 11, i.e., excluding ADRs, closed-end funds, and REITs) in our asset pricing tests. This is to ensure that our results are not affected by the potential concerns about the portfolio-based approach (see, e.g., Lewellen, Nagel, and Shanken (2010) and Ang, Liu, and Schwarz (2010)). To the best of our knowledge, our paper is the first to use individual stocks to test the CCAPM.

4 Results

We start out by discussing the ability of our tracking portfolios to capture the consumption growth dynamics. We then analyze the pricing implications of those consumption tracking portfolios for the cross-section of average returns.

4.1 How good are our tracking portfolios?

We estimate the consumption tracking portfolios by projecting consumption growth onto three different sets of base assets (stocks, bonds, and commodity futures returns), as given in equations (4) and (5). Table 4 reports the summary statistics of the consumption tracking portfolios. Panel A shows that the average returns of all three unconditional tracking portfolios are identical to the mean level of consumption growth, but the average returns of the conditional tracking portfolios are lower than the mean consumption growth. Both unconditional and conditional tracking portfolios are less volatile than raw consumption growth, with the monthly standard deviation ranging between 0.06 and 0.09% (compared with 0.29% for consumption). Consequently, the tracking portfolios capture less than a quarter of the variation of consumption growth. This is in line with consumption data being noisy and biased due to interpolating, incidence of non-reporting or data revisions as is commonly observed in the NIPA tables. Comparing across tracking portfolios, the stock-based and commodity-based tracking portfolios capture around 9% of the consumption growth variation unconditionally and 14% conditionally, whereas the bond-based consumption tracking portfolio captures 4% of the unconditional variation and 8% of the conditional variation. The p-values for the joint significance of all base assets reported in the last row of Panel A indicate that stocks and commodity futures are important in capturing consumption dynamics, while bonds are not (the individual coefficients on the base assets are reported in Panel C). Panel B of Table 4 reports the correlations between the consumption tracking portfolios and consumption growth. Consistent with the results from Panel A, both the stock-based and commodity-based tracking portfolios are more strongly correlated with consumption growth (correlations around 30%) than the bond-based tracking portfolios (correlation around 20%).

Insert Table 4 around here

To sum up, the evidence from Table 4 suggests that the stock-based and commodity-based tracking portfolios capture consumption dynamics to a similar degree, while the bond-based tracking portfolio does a poorer job. Next, we examine the pricing implications of these tracking portfolios.

4.2 Portfolio Results

We first study the ability of the CCAPM to explain the average returns of the 20 test portfolios (five size, five book-to-market, five momentum, and five industry portfolios). Panel A of Table 5 reports the average returns and the full-sample consumption betas, $\beta_{i,c}$, as well as the betas with respect to the unconditional consumption tracking portfolios, $\beta_{i,CTP}$, for the 20 test portfolios. The table shows that the CTPc betas line up fairly well with the average returns, whereas the other betas do not. For example, the CTPc beta increases monotonically from -0.238 for the momentum loser portfolio to 8.718 for the momentum winner portfolio. On the other hand, the consumption beta first decreases from 2.983 for the momentum loser portfolio to 1.155 for momentum quintile four and then increases to 2.240 for the momentum winner portfolio, exhibiting a U-shape pattern. Similarly, the CTPs beta decreases from 30.760 for the momentum loser portfolio to 15.000 for momentum quintile four and then increases to 24.701 for the momentum winner portfolio. Panel A also shows that the consumption betas and CTPc betas are of similar magnitude while the CTPs and CTPb betas are one order of magnitude larger.

Insert Table 5 around here

Panels B and C of Table 5 report the results of the portfolio-level asset pricing tests. Panel B reports the average coefficients and their associated t-statistics from monthly Fama and MacBeth (1973) cross-sectional regressions. In Panel C, we estimate the stochastic discount factor representation of the form

$$E[(1 - b'CTP_j)\, r_t] = 0, \tag{6}$$

and report the estimated coefficients, b, with their associated t-statistics, as well as the J-test for the overidentifying restrictions. We use fully iterated efficient GMM estimator of Hansen (1982) but our results are robust to using first-stage estimator or HJ-weighting matrix.

We start with the CCAPM estimated using the consumption growth itself. Consistent with numerous previous studies, we do not find much support for this model. Panel B shows that the average Fama-MacBeth regression coefficient on consumption beta is negative (-0.09%) and statistically insignificant (t-stat=-0.93), and the J-test in Panel C rejects the model with a p-value of 0.01.

The performance of the model is much improved when we replace the non-traded consumption growth with it's tracking portfolio constructed from commodity futures contracts. In Panel B, the average Fama-MacBeth coefficient on CTPc beta is positive and significant at 0.07% (t-stat=2.60) per month, which implies a risk premium of more than 80 bps per annum. In addition, the adjusted-R^2 increases sharply from 12% for the baseline case using consumption growth to 56%. In Panel C, the J-test fails to reject the hypothesis that the commodity-based consumption tracking portfolio prices the 20 test portfolios (p-value=0.57).

On the other hand, when we replace the consumption growth with either the stock-based or the bond-based consumption tracking portfolio, we see little improvement in the results. The average Fama-MacBeth coefficient in Panel B is -0.01% (t-stat=-0.98) for CTPs beta and -0.01% (t-stat=-1.16) for CTPb beta, and the J-test in Panel C rejects the model for both consumption tracking portfolio (p-values of 0.01 and 0.02, respectively). These results highlight the importance of base assets in constructing the consumption tracking portfolios and suggests that commodity futures contracts allow us to capture that part of consumption growth that is priced in the cross-section of average returns.

In the final test, we include all three (commodity-, stock-, and bond-based) consumption tracking portfolios at the same time. The Fama-MacBeth coefficients in Panel B show that CTPc beta still carries a significant premium whereas CTPs and CTPc betas do not. The average coefficient on CTPc beta is 0.07% (t-stat=2.78), which is identical to the case when CTPc beta alone is included in the regressions. The coefficients on CTPs and CTPb betas are 0.00% and 0.01% (t-stats of -0.19 and 0.71, respectively). The J-test in Panel C also does not reject the model (p-value=0.41), but this is clearly driven by the commodity-based tracking portfolio.

Insert Figure 1 around here

The superior performance of the commodity-based consumption tracking portfolio can also be seen in Figure 1 where we plot the average returns of the test portfolios against the predicted values of each model. For the model with the commodity-based tracking portfolio and the model with all three tracking portfolios, the observations line up closely along the diagonal line, which is indicative of those models' ability to explain the average returns of the test portfolios. On the other hand, for the models with the consumption growth or the stock- or bond-based consumption tracking portfolios, there does not appear to be a clear relation between the average returns and predicted returns with some of the observations being fairly far from the diagonal, which confirms the poor performance of those models as shown in Table 5.

In Table 6, we repeat the analysis in Table 5 but replace the unconditional consumption tracking portfolios with the conditional tracking portfolios.[5] We find that our results are robust to using conditional consumption tracking portfolios. Specifically, the monthly Fama-MacBeth regressions in Panel B show that CTPc beta continues to carry a positive and significant risk premium (close to 1% per annum) while consumption, CTPs, and CTPc betas do not. The J-test in Panel C again easily rejects the models for the stock- and bond-based tracking portfolios but fails to reject for the commodity-based tracking portfolio.

Insert Table 6 around here

In sum, the portfolio level results in Tables 5 and 6 show that using traded consumption tracking portfolios instead of the non-traded consumption growth can significantly improve the ability of the CCAPM to explain the cross-section of average returns. More importantly, the base assets from which the tracking portfolios are constructed matter. We find that the consumption tracking portfolio that is based on commodity futures contracts captures the part of consumption that is relevant for pricing, but the same cannot be said about the stock- and bond-based consumption tracking portfolios.

4.3 Firm-level results

Lewellen, Nagel, and Shanken (2010) argue that portfolio-based asset pricing tests can be misleading as apparently strong explanatory power sometimes only provide weak support for a model. To ensure that our results are not affected by this critique, we now use individual stocks in the Fama-MacBeth regressions to test the explanatory power of

[5]In unreported results, we also replicate our results by incorporating time-varying portfolio weights in both the unconditional and conditional consumption tracking portfolios.

the commodity-based consumption tracking portfolio.[6] The firm-level regressions complement and provide further robustness checks to our portfolio-level regressions. They also allow us to include a greater number of controls for expected returns, which are often firm characteristics and can be measured precisely at the firm level.

One potential concern about the firm-level regressions is that the CTP betas for individual stocks are estimated with noise. Consequently, regressions of individual stock returns on measured betas suffer an error-in-variables problem, which will bias the coefficients on betas towards zero. To address this concern, we follow the literature and assign the betas of an industry/pre-ranking beta portfolio, which are measured more precisely, to each individual stock within that portfolio. Specifically, at the end of June of each year, we estimate the pre-ranking beta of each stock by regressing its returns over the previous 60 months (24 months minimum) on each consumption tracking portfolio. We then sort stocks into 48 Fama and French industries using the definitions downloaded from Ken French's website. We further sort stocks within each industry into two pre-ranking beta portfolios using the median breakpoint. Equally-weighted monthly returns on these industry/pre-ranking beta portfolios are calculated from July to June of next year. In the final step, we estimate the full-sample post-ranking beta of each portfolio and assign it to each stock within that portfolio. This procedure essentially shrinks individual stocks' betas to the averages of stocks from the same industry with similar pre-ranking betas to mitigate the errors-in-variables problem.

Insert Table 7 around here

Table 7 reports the average coefficients and their associated t-statistics from the firm-

[6]See also Ang, Liu, and Schwarz (2010) for the importance of performing tests at the firm level to limit loses of efficiency due to portfolio aggregation.

level Fama-MacBeth regressions. Panel A reports the results for betas with respect to the unconditional consumption tracking portfolios and Panel B reports those for the conditional tracking portfolios. The first model in Panel A shows that CTPc beta also carries a positive and significant premium in the cross-section of individual stock returns. The average coefficient on CTPc beta is 0.04% per month with a t-stat of 2.10, which amounts to a risk premium of 50 bps per annum. Models 2-4 show that CTPs and CTPb betas are not priced in the cross-section of individual stock returns (coefficients of 0.01% and 0.00% and t-stats of 0.62 and 0.06, respectively), and that controlling for these two betas leaves the coefficient and statistical significance of CTPc beta virtually unchanged (coefficient of 0.04% and t-stat of 2.26). The next four models include the firm characteristics of LnSize (the natural logarithm of market equity), LnB/M (the natural logarithm of book-to-market equity), Ret (-1:-1) (the previous month's return), Ret (-12:-2) (the cumulative return from month -12 to month -2), and Ret (-36:-13) (the cumulative return from month -36 to month -13) to control for the size, value, short-term reversal, medium-term momentum, and long-term reversal effects in average returns. They show that our results are robust to controlling for these average return predictors. In particular, the average coefficient on CTPc beta remains positive and significant (in fact, the statistical significance actually increases after controlling for the other return predictors) whereas the coefficients on CTPs and CTPb betas remain insignificant. Finally, Panel B of Table 7 show that our results are also robust to using the conditional consumption tracking portfolios to estimate the betas.

Taken together, the firm-level results in Table 7 confirm and reinforce our portfolio-level findings that consumption risk is priced in the cross-section of average returns if the risk is measured with respect to the commodity-based consumption tracking portfolio instead of the non-traded consumption factor. They also allow us to steer clear of the potential limitations to the portfolio-based approach.

4.4 Additional tests

In Table 8, we further analyze the performance of portfolios sorted based on CTP betas. At the end of June of each year, we sort individual stocks into quintile portfolios based on their full-sample post-ranking betas. Equal-weighted returns on these portfolios are calculated from July to June of next year. The table reports the average betas and returns of the quintile portfolios, the return spread between Quintiles 5 and 1, and the alphas from regressing the 5-1 return spreads on the Fama and French (1993) three-factor model and the Carhart (1997) four-factor model. Panel A reports the results when the betas are estimated using the unconditional consumption tracking portfolios. The panel shows a near monotonic positive relation between the average returns and betas for the CTPc beta-sorted portfolios, as the average return increases from 1.05% per month (t-stat=3.72) for the lowest beta quintile to 1.36% per month (t-stat=2.31). The average 5-1 quintile spread of 0.31% per month is highly significant (t-stat=2.31) and remains significant even after controlling for the common risk factors in the Fama-French/Carhart models (the Fama-French three-factor alpha is 0.27% with a t-stat of 2.54 and the Carhart four-factor alpha is 0.29% with a t-stat of 2.70). On the other hand, sorting on CTPs and CTPb betas fails to produce significant spreads in average returns. For example, the average 5-1 spread for quintiles sorted on CTPb betas is only 0.02% per month (t-stat=0.09), and the Fama-French and Carhart alphas are also insignificant. The results in Panel B for betas estimated using the conditional tracking portfolios are largely similar to the results in Panel A.

Insert Table 8 around here

Although the results up to this point are strongly indicative of the commodity-based tracking portfolio capturing the part consumption risk that is priced in the cross-section of average returns, one possible concern is that we may simply be capturing commodity risk premium that is not necessarily related to consumption risk. To address this concern, we repeat the portfolio- and firm-level tests in Tables 5 and 7 but instead of using the commodity-based consumption tracking portfolio we use an equal-weighted index of the commodity futures returns in our sample. The results are reported in Table 9. Panel A of Table 9 shows that beta with respect to the commodity index carries a negative but insignificant premium in the cross-section of test portfolio returns (coefficient of -0.22% and t-stat of -0.43) and the J-test easily rejects the model (p-value=0.01). Panel B of Table 9 shows that commodity index beta is also not priced in the cross-section of individual stock returns. The average coefficient on commodity index beta is 0.34% per month with a t-stat of 1.09 when it is the only regressor in the Fama-MacBeth regressions and 0.27% with a t-stat of 0.96 after controlling for other return predictors. Overall, the results in Table 9 clearly indicate that it is not the commodity contracts per se but the projection of consumption growth onto commodity contracts that is priced in average stock returns.

Insert Table 9 around here

In unreported results, we also construct the consumption tracking portfolios by excluding commodity contracts from one or more sectors from the set of base assets. We find that our results are weakened, sometimes significantly. This suggests that we need the full cross-section of commodity contracts to capture price relevant consumption information. In addition, we examine other specifications of the consumption-based model, such as habit preferences of Campbell and Cochrane (1999), the conditional CCAPM of

Jagannathan and Wang (1996) and Lettau and Ludvison (2001), and the long run risk specification of Parker and Julliard (2005). We find that the commodity-based consumption tracking portfolio is again priced in most of those alternative specifications with the exception of the long run risk model where the results are rather weak.

5 Conclusions

We argue in this paper that the basic idea behind the consumption CAPM (CCAPM) holds empirically, provided that the measure for consumption risk can separate price relevant information from noise. The common consumption risk proxy constructed from the consumption expenditure data may be noisy due to measurement issues such as benchmarking, interpolating, aggregation bias, or instances of non-reporting. One way to filter out this noise is to use consumption tracking portfolios instead of non-traded consumption growth. We argue that the choice of the base assets in constructing the consumption tracking portfolio matters and postulate that commodity futures returns carry more price-relevant consumption information than traditional base assets such as stocks and bonds. Empirically, we find that the CCAPM estimated using the commodity-based consumption tracking portfolio is able to explain the cross-section of average stock returns. Such is not the case for the CCAPM estimated using either non-traded consumption growth or stock- and bond-based consumption tracking portfolios. Our results highlight the importance of commodity futures contracts for understanding the tradeoff between risk and return in consumption-based asset pricing models.

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Table 1: **Futures contracts.**
The table reports the futures exchange, the delivery months, and the date of the first observation for the 20 futures contracts in our sample.

Futures contract		Exchange	Delivery months	Nearby series start dates				
				n=1	n=2	n=3	n=4	n=5
Energy								
Crude Oil	CL	NYMEX	All	198311	198311	198311	198311	198311
Heating Oil	HO	NYMEX	All	197911	197911	197911	197911	
Unleaded Gasoline	HR	NYMEX	All	198501	198501	198504	198504	
Meats								
Live cattle	LC	CME	2,4,6,8,10,12	196511	196511	196511	196602	197602
Feeder cattle	FC	CME	1,3,4,5,8,9,10,11	197112	197412	197412	197611	
Live hog	LH	CME	2,4,6,7,8,10,12	196603	196811	196811	196912	197009
Pork Bellies	PB	CME	2,3,5,7,8	196508	196508			
Metals								
Gold	GC	NYMEX	1,2,4,6,8,10,12	197501	197501	197501	197501	197501
Silver	SI	NYMEX	3,5,7,9,12	196409	196409	197501	197501	196701
Platinum	PL	NYMEX	1,4,7,10	196902				
Copper	HG	NYMEX	1,3,5,7,9,12	195908	195908	195908	196009	196301
Agriculture								
Wheat	W_	CBOT	3,5,7,9,12	195908	195908	195908	197608	
Corn	C_	CBOT	3,5,7,9,12	195908	195908	195908	197407	197710
Oats	O_	CBOT	3,5,7,9,12	195908				
Soybean	S_	CBOT	1,3,5,7,8,9,11	195908	195908	195908	195908	196810
Soybeans Oil	BO	CBOT	1,3,5,7,8,9,10,12	195908	195908	195908	196202	196208
Soybean meal	SM	CBOT	1,3,5,7,8,9,10,12	195908	195908	195908	196203	196208
Coffee	KC	ICE	3,5,7,9,12	197209	197309	197309	197505	198208
Sugar	SB	ICE	3,5,7,10	196309	196309	196309	196309	
Cotton	CT	ICE	3,5,7,10,12	195908	195908	195910	196002	197103

Table 2: **Descriptive statistics.**
The table reports the means and standard deviations for the returns on three different sets of base assets: stocks, bonds and commodity futures contracts. The sample period is from January 1984 until December 2007. Panel A gives the description of five nearby returns (r(1),...,r(5)) of four commodity futures sector portfolios. Panel B describes the 17 industry portfolio returns and the CRSP value-weighted index. Panel C gives the description of corporate and government bond returns.

Base Assets

Panel A: Commodities

	r(1)		r(2)		r(3)		r(4)		r(5)	
	mean	std	mean	std	mean	std	mean	std	mean	std
Energy	1.35%	9.18%	1.26%	8.57%	1.20%	8.08%	1.16%	7.67%	1.12%	7.62%
Meats	0.21%	4.72%	0.43%	4.14%	0.41%	2.89%	0.37%	2.56%	0.33%	2.69%
Metals	0.48%	4.51%	0.36%	4.56%	0.33%	4.46%	0.30%	4.39%	0.29%	4.36%
Agr	-0.02%	3.64%	0.05%	3.45%	0.05%	3.35%	0.08%	3.54%	0.03%	3.86%

Panel B: Stock returns

	mean	std		mean	std
Index	1.09%	5.12%	Steel	0.63%	7.50%
Food	0.94%	4.49%	FabPr	0.61%	5.22%
Mines	0.74%	7.31%	Machn	0.68%	7.20%
Oil	0.89%	5.03%	Cars	0.52%	6.19%
Clths	0.56%	5.93%	Trans	0.65%	5.06%
Durbl	0.33%	5.04%	Utils	0.68%	3.93%
Chems	0.73%	5.23%	Rtail	0.71%	5.36%
Cnsum	0.91%	4.68%	Finan	0.81%	5.01%
Cnstr	0.68%	5.69%	Other	0.58%	5.08%

Panel C: Bond returns

	Corporate Bond returns				Government Bond returns			
	Intermediate		Long Term		Intermediate		Short Term	
	mean	std	mean	std	mean	std	mean	std
AAA	0.26%	1.07%	0.41%	2.20%	0.20%	0.86%	0.31%	1.58%
AA	0.27%	1.10%	0.40%	2.19%				
A	0.27%	1.12%	0.40%	2.18%				
BAA	0.29%	1.20%	0.43%	2.12%				
Junk	0.34%	1.94%	0.56%	2.55%				

Table 3: **Test assets.**

The table reports the means, standard deviations and consumption betas for the returns on the test assets: five size, five book-to-market ratio, five momentum, and five industry portfolios. The sample period is from January 1984 until December 2007. The consumption betas are estimated using 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 asset, and Δc_t is the consumption growth.

Test assets							
Panel A: Average Excess Returns							
Small	0.63%	Low BM	0.60%	Losers	0.11%	Cnsmr	0.69%
2	0.66%	2	0.77%	2	0.59%	Manuf	0.78%
3	0.70%	3	0.71%	3	0.53%	HiTex	0.59%
4	0.76%	4	0.78%	4	0.76%	Hlth	0.81%
Big	0.67%	High BM	0.89%	Winners	0.97%	Other	0.68%
Panel B: Standard deviations							
Small	5.87%	Low BM	4.82%	Losers	6.61%	Cnsmr	4.42%
2	5.53%	2	4.44%	2	4.52%	Manuf	3.86%
3	5.07%	3	4.16%	3	4.03%	HiTex	6.25%
4	4.80%	4	3.87%	4	3.98%	Hlth	4.81%
Big	4.22%	High BM	4.28%	Winners	5.01%	Other	4.77%
Panel C: Consumption Betas							
Small	3.095	Low BM	2.355	Losers	2.983	Cnsmr	1.886
2	3.190	2	1.856	2	1.887	Manuf	1.622
3	3.107	3	1.691	3	1.413	HiTex	3.248
4	2.829	4	1.781	4	1.155	Hlth	0.457
Big	1.825	High BM	1.229	Winners	2.240	Other	2.187

Table 4: **Consumption tracking portfolios.**

The table reports the descriptive statistics for our consumption tracking portfolios. The sample period is from January 1984 until December 2007. We estimate each CTP by separate linear regression of consumption growth on each set of base assets: stocks, bonds, and commodity futures returns. We report the values for the tracking portfolios with fixed weights estimated in the unconditional (CTPc, CTPs, CTPb) and conditional (CTPc,c, CTPs,c, CTPb,c) setup. Panel A shows means and standard deviations for consumption growth and consumption tracking portfolios and below we report R^2s and p-values for the joint significance of the regression coefficients from the regressions used to create tracking portfolios. Panel B shows the correlation matrix for different tracking portfolios and Panel C gives the estimated weights of each base asset in the tracking portfolios.

Consumption Tracking Portfolios

Panel A: Descriptive statistics

	CG	CTPc	CTPs	CTPb	CTPc,c	CTPs,c	CTPb,c
mean	0.16%	0.16%	0.16%	0.16%	0.12%	0.11%	0.12%
std	0.29%	0.08%	0.09%	0.06%	0.08%	0.09%	0.06%
R2		8.88%	9.97%	3.8%	14.03%	13.06%	7.76%
p		*0.08*	*0.03*	*0.64*	*0.01*	*0.03*	*0.17*

Panel B: correlation matrix

	CG	CTPc	CTPs	CTPb		CG	CTPc,c	CTPs,c	CTPb,c
CG	1				CG	1			
CTPc	0.285	1			CTPc,c	0.278	1		
CTPs	0.316	0.128	1		CTPs,c	0.309	0.104	1	
CTPb	0.195	0.193	0.212	1	CTPb,c	0.188	0.201	0.146	1

Table 4 ctd.: **Consumption tracking portfolios ctd.**

Panel C: Coefficients on the base assets

	CTPc		CTPc,c			CTPs		CTPs,c			CTPb		CTPb,c	
	Coef.	SE	Coef.	SE		Coef.	SE	Coef.	SE		Coef.	SE	Coef.	SE
constant	0.001	0.000	0.002	0.001	constant	0.002	0.000	0.001	0.001	constant	0.002	0.000	0.001	0.001
Energy (r1)	0.042	0.025	0.033	0.024	Index	-0.005	0.007	-0.005	0.007	TB Short	-0.047	0.114	-0.060	0.116
Meats (r1)	-0.003	0.014	-0.004	0.014	Food	-0.007	0.003	-0.006	0.003	TB Int	-0.047	0.064	-0.067	0.066
Metals (r1)	0.007	0.007	0.006	0.007	Mines	0.003	0.005	0.002	0.005	AAA Int	-0.024	0.099	-0.008	0.099
Agr (r1)	0.045	0.030	0.052	0.030	Oil	0.003	0.007	0.001	0.007	AAA LT	0.106	0.057	0.122	0.057
Energy (r2)	-0.026	0.064	-0.021	0.063	Clths	-0.009	0.007	-0.009	0.007	AA Int	0.036	0.132	0.071	0.133
Meats (r2)	0.007	0.018	0.007	0.018	Durbl	0.003	0.007	0.006	0.007	AA LT	0.018	0.071	0.023	0.071
Metals (r2)	0.003	0.067	0.020	0.066	Chems	-0.009	0.006	-0.008	0.006	A Int	0.040	0.121	0.040	0.121
Agr (r2)	-0.116	0.047	-0.125	0.048	Cnsum	0.012	0.006	0.011	0.007	A LT	-0.083	0.078	-0.110	0.079
Energy (r3)	-0.136	0.090	-0.104	0.089	Cnstr	0.005	0.005	0.006	0.005	BAA Int	-0.026	0.075	-0.043	0.075
Meats (r3)	0.009	0.031	0.010	0.031	Steel	-0.004	0.008	-0.002	0.008	BAA LT	-0.011	0.057	-0.004	0.057
Metals (r3)	-0.009	0.164	-0.024	0.162	FabPr	-0.002	0.005	-0.001	0.005	Junk Int	0.018	0.021	0.013	0.021
Agr (r3)	0.078	0.031	0.082	0.031	Machn	-0.010	0.005	-0.011	0.005	Junk LT	0.000	0.016	0.002	0.017
Energy (r4)	0.148	0.057	0.115	0.056	Cars	0.004	0.007	0.003	0.007	TERM			0.000	0.000
Meats (r4)	-0.024	0.037	-0.019	0.037	Trans	0.000	0.006	0.001	0.006	DEF			-0.005	0.079
Metals (r4)	0.119	0.207	0.122	0.204	Utils	0.006	0.008	0.006	0.008	MARKET			0.000	0.000
Agr (r4)	-0.021	0.018	-0.020	0.017	Rtail	0.003	0.007	0.003	0.007	DY			0.000	0.000
Energy (r5)	-0.025	0.014	-0.022	0.014	Finan	0.004	0.009	0.006	0.009	UI			-0.154	0.097
Meats (r5)	0.010	0.017	0.004	0.017	Other	0.005	0.007	0.000	0.008	ESR			0.796	0.342
Metals (r5)	-0.123	0.118	-0.126	0.115	TERM			0.000	0.000	ELR			-0.226	0.714
Agr (r5)	0.015	0.010	0.013	0.010	DEF			-0.046	0.079					
TERM			0.000	0.000	MARKET			0.000	0.000					
DEF			0.095	0.043	DY			0.000	0.000					
MARKET			0.000	0.000	UI			-0.104	0.095					
DY			0.000	0.000	ESR			0.514	0.345					
UI			-0.060	0.082	ELR			-0.208	0.663					
ESR			0.543	0.322										
ELR			-0.081	0.628										

Table 5: **The CCAPM with unconditional CTP.**

The table reports in Panel A the average returns and the full-sample consumption betas, $\beta_{i,c}$, as well s the betas with respect to the unconditional consumption tracking portfolios, $\beta_{i,CTP}$, for the 20 test portfolios. CTPc stands for commodity-based consumption tracking portfolio, CTPs for the stock-based, and CTPb for the bond-based tracking portfolios. Panels B and C report the results of the portfolio-level asset pricing tests. Panel B reports the average coefficients and their associated t-statistics from monthly Fama and MacBeth (1973) cross-sectional regressions. In Panel C, we estimate the stochastic discount factor representation of the form

$$E[(1 - b'f)\, r_t] = 0$$

and report the estimated coefficients, b, with their associated t-statistics, as well as the J-test for the overidentifying restrictions.

Table 5 ctd.: **The CCAPM with unconditional CTP ctd.**

Panel A: Consumption betas

	Small	2	3	4	Big	Losers	2	3	4	Winners
$\overline{R}$	0.63%	0.66%	0.70%	0.76%	0.67%	0.11%	0.59%	0.53%	0.76%	0.97%
$\beta_{i,c}$	3.095	3.190	3.107	2.829	1.825	2.983	1.887	1.413	1.155	2.240
$\beta_{i,CTPc}$	4.997	5.176	5.339	6.168	4.366	-0.238	1.759	2.705	3.698	8.718
$\beta_{i,CTPs}$	28.642	29.701	27.749	26.729	19.500	30.760	18.444	15.655	15.000	24.701
$\beta_{i,CTPb}$	36.341	40.475	38.579	34.755	24.184	42.206	28.160	24.083	22.899	26.551

	Low BM	2	3	4	High BM	Cnsmr	Manuf	HiTex	Hlth	Other
$\overline{R}$	0.60%	0.77%	0.71%	0.78%	0.89%	0.69%	0.78%	0.59%	0.81%	0.68%
$\beta_{i,c}$	2.355	1.856	1.691	1.781	1.229	1.886	1.622	3.248	0.457	2.187
$\beta_{i,CTPc}$	4.500	4.271	4.180	4.869	6.290	3.869	2.767	5.387	4.365	5.974
$\beta_{i,CTPs}$	22.996	19.348	19.146	16.220	15.272	19.447	16.090	31.847	4.143	22.178
$\beta_{i,CTPb}$	26.866	31.130	29.717	29.985	30.810	31.197	24.065	29.184	20.148	32.931

	Panel B: Fama-MacBeth						Panel C: GMM				
	Int	CG	CTPc	CTPs	CTPb	R^2 / R^2_{adj}	CG	CTPc	CTPs	CTPb	J / p
Coef.	0.87%	-0.09%				16.53%	53.98				35.31
tt	*3.52*	*-0.93*				11.89%	*0.82*				*0.01*
Coef.	0.37%		0.07%			57.93%		893.42			17.28
t	*1.33*		*2.60*			55.59%		*3.15*			*0.57*
Coef.	0.91%			-0.01%		18.06%			57.30		37.17
t	*3.54*			*-0.98*		13.51%			*0.62*		*0.01*
Coef.	1.07%				-0.01%	19.35%				431.90	33.09
t	*3.28*				*-1.16*	14.87%				*2.02*	*0.02*
Coef.	0.63%		0.07%	0.00%	0.01%	84.67%		802.78	-67.87	221.07	17.66
t	*1.92*		*2.78*	*-0.19*	*0.71*	81.80%	*2.60*		*-0.57*	*0.83*	*0.41*

Table 6: **The CCAPM with conditional CTP.**
The table reports analogous to Table 5 summary of the estimation of the Consumption CAPM on a set of 20 portfolio returns as test assets, but using consumption tracking portfolios that are estimated conditionally. Panel A reports the consumption betas estimated in the time-series regressions. Panel B reports the results for the Fama and MacBeth (1973) cross-sectional regression and Panel C for the GMM estimation of Hansen (1982). See caption of Table for details.

Panel A: Consumption betas										
	Small	2	3	4	Big	Losers	2	3	4	Winners
$\overline{R}$	0.63%	0.66%	0.70%	0.76%	0.67%	0.11%	0.59%	0.53%	0.76%	0.97%
$\beta_{i,CTPc}$	4.093	4.708	5.184	6.070	4.428	4.361	4.427	4.302	4.790	6.411
$\beta_{i,CTPs}$	23.807	26.926	26.250	26.126	20.302	23.913	19.280	18.563	15.353	13.868
$\beta_{i,CTPb}$	24.902	29.922	28.932	25.960	16.793	18.784	23.642	22.522	23.758	22.707
	Low BM	2	3	4	High BM	Cnsmr	Manuf	HiTex	Hlth	Other
$\overline{R}$	0.60%	0.77%	0.71%	0.78%	0.89%	0.69%	0.78%	0.59%	0.81%	0.68%
$\beta_{i,CTPc}$	0.781	2.134	2.846	3.925	8.264	3.892	3.263	5.468	3.821	5.780
$\beta_{i,CTPs}$	28.314	17.826	15.595	15.349	24.950	18.768	16.655	32.804	4.869	21.335
$\beta_{i,CTPb}$	28.022	19.810	17.735	17.148	19.924	23.928	18.904	17.897	14.915	25.055

	Panel B: Fama-MacBeth						Panel C: GMM				
	Int	CTPc	CTPs	CTPb	R^2	R^2_{adj}	CTPc	CTPs	CTPb	J	p
Coef.	0.32%	0.08%			56.78%	54.38%	985.07			15.60	*0.68*
t	*1.15*	*2.77*					*3.20*				
Coef.	0.90%		-0.01%		15.46%	10.77%		92.96		36.19	*0.01*
t	*3.56*		*-0.95*					*0.97*			
Coef.	0.90%			-0.01%	5.89%	0.66%			432.26	31.69	*0.03*
t	*2.90*			*-0.75*					*2.07*		
Coef.	0.59%	0.09%	-0.01%	0.00%	85.06%	82.26%	892.60	-35.79	172.45	16.20	*0.51*
t	*1.84*	*3.01*	*-1.21*	*-0.07*			*2.68*	*-0.31*	*0.66*		

Table 7: **The firm-level CCAPM.**
The table reports the time-series average coefficients and their associated t-statistics from the monthly firm-level Fama-MacBeth regressions. The individual stocks' betas are shrinked to the averages of betas of the stocks from the same industry with similar pre-ranking betas. CTPc stands for commodity-based consumption tracking portfolio, CTPs for the stock-based, and CTPb for the bond-based tracking portfolios. LnSize is the natural logarithm of market equity, LnB/M is the natural logarithm of book-to-market equity, Ret(-1:-1) is the previous month's return, Ret(-12:-2) is the cumulative return from month -12 to month -2, and Ret(-36:-13) is the cumulative return from month -36 to month -13. Panel A reports the results for betas with respect to the unconditional consumption tracking portfolios and Panel B reports those for the conditional tracking portfolios.

	β_{CTPc}	β_{CTPs}	β_{CTPb}	LnSize	LnB/M	Ret(-1:-1)	Ret(-12:-2)	Ret(-36:-13)	R^2
Panel A: unconditional CTP									
Coef.	0.04%								0.14%
t	*2.10*								
Coef.		0.01%							1.22%
t		*0.62*							
Coef.			0.00%						0.47%
t			*0.06*						
Coef.	0.04%	0.01%	-0.01%						1.45%
t	*2.26*	*0.77*	*-1.27*						
Coef.	0.05%			-0.09%	0.19%	-4.49%	0.36%	-0.23%	3.03%
t	*2.87*			*-1.50*	*1.99*	*-8.61*	*2.10*	*-3.94*	
Coef.		0.01%		-0.09%	0.21%	-4.65%	0.37%	-0.21%	3.61%
t		*0.93*		*-1.48*	*2.59*	*-9.36*	*2.33*	*-3.83*	
Coef.			0.00%	-0.09%	0.18%	-4.60%	0.38%	-0.23%	3.29%
t			*-0.16*	*-1.56*	*1.84*	*-8.90*	*2.26*	*-4.08*	
Coef.	0.04%	0.01%	-0.01%	-0.09%	0.21%	-4.73%	0.37%	-0.20%	3.83%
t	*2.80*	*1.28*	*-1.85*	*-1.55*	*2.60*	*-9.55*	*2.30*	*-3.80*	
Panel B: conditional CTP									
Coef.	0.03%								0.07%
t	*2.06*								
Coef.		0.01%							1.11%
t		*0.68*							
Coef.			-0.01%						0.18%
t			*-1.19*						
Coef.	0.03%	0.01%	-0.02%						1.32%
t	*1.91*	*0.73*	*-1.62*						
Coef.	0.03%			-0.09%	0.19%	-4.47%	0.36%	-0.23%	3.00%
t	*2.38*			*-1.53*	*1.87*	*-8.56*	*2.12*	*-3.95*	
Coef.		0.01%		-0.09%	0.20%	-4.63%	0.36%	-0.21%	3.57%
t		*1.11*		*-1.53*	*2.46*	*-9.27*	*2.30*	*-3.82*	
Coef.			-0.02%	-0.10%	0.18%	-4.55%	0.37%	-0.23%	3.10%
t			*-1.42*	*-1.59*	*1.83*	*-8.72*	*2.14*	*-3.96*	
Coef.	0.03%	0.02%	-0.02%	-0.09%	0.21%	-4.70%	0.36%	-0.20%	3.75%
t	*2.06*	*1.24*	*-2.05*	*-1.56*	*2.58*	*-9.48*	*2.28*	*-3.73*	

Table 8: **Consumption betas.**

The table reports summary statistics for the quintile portfolios. At the end of June of each year, we sort individual stocks into quintile portfolios based on their full-sample post-ranking betas. Equal-weighted returns on these portfolios are calculated from July to June of next year. Below we report the average betas and returns of the quintile portfolios, the return spread between Quintile 5 and 1, and the alphas from regressing the 5-1 return spreads on the Fama and French (1993) three-factor model and the Carhart (1997) four-factor model. Panel A reports the results when the betas are estimated using the unconditional consumption tracking portfolios and Panel B reports those for the conditional tracking portfolios.

	Quintile 1	2	3	4	5	5-1	FF α	FFC α
				Panel A: unconditional CTP				
$\beta_{i,CTPc}$	0.5707	3.3481	4.4421	5.2895	7.7484	7.1778		
$\overline{R}$t	1.05%	1.25%	1.29%	1.38%	1.36%	0.31%	0.27%	0.29%
t	*3.72*	*3.46*	*4.46*	*3.87*	*3.80*	*2.31*	*2.54*	*2.70*
$\beta_{i,CTPs}$	11.4435	18.6578	23.0615	28.8710	39.6706	28.2271		
$\overline{R}$	1.15%	1.17%	1.29%	1.33%	1.38%	0.23%	0.05%	0.33%
t	*5.87*	*4.37*	*3.91*	*3.64*	*2.61*	*0.53*	*0.24*	*1.50*
$\beta_{i,CTPb}$	22.2446	31.1537	35.7272	39.0973	44.8979	22.6533		
$\overline{R}$t	1.23%	1.19%	1.35%	1.32%	1.25%	0.02%	-0.26%	-0.11%
t	*5.65*	*4.18*	*3.46*	*3.69*	*3.02*	*0.09*	*-1.41*	*-0.58*
				Panel B: conditional CTP				
$\beta_{i,CTPc}$	0.6669	3.0657	4.0581	5.1416	7.7549	7.0880		
$\overline{R}$	1.06%	1.33%	1.12%	1.42%	1.38%	0.32%	0.32%	0.36%
t	*3.76*	*3.42*	*3.83*	*3.94*	*4.24*	*2.30*	*2.35*	*2.63*
$\beta_{i,CTPs}$	8.1146	14.3214	18.1967	23.4923	33.6514	25.5369		
$\overline{R}$	1.18%	1.10%	1.33%	1.31%	1.40%	0.22%	0.03%	0.28%
t	*5.73*	*3.99*	*4.11*	*3.57*	*2.73*	*0.55*	*0.14*	*1.40*
$\beta_{i,CTPb}$	15.0789	21.1973	22.6928	25.2886	32.4048	17.3259		
$\overline{R}$	1.35%	1.28%	1.41%	1.25%	1.07%	-0.28%	-0.60%	-0.62%
t	*4.98*	*3.35*	*3.49*	*4.09*	*3.30*	*-1.44*	*-3.34*	*-3.34*

Table 9: **The CCAPM with commodity index.**
The table reports the estimates of the Consumption CAPM when using an equally weighted index of commodity futures returns instead of consumption tracking portfolio. Panel A reports the results for the Fama-MacBeth (1973) cross-sectional regression and the GMM estimation of Hansen (1982) for the 20 stock portfolios. Panel B reports the results for the firm-level regressions. We report coefficient estimates and the corresponding t-statistics, as well as the cross-sectional R^2s for the Fama-MacBeth regressions and the J-test for the overidentifying restrictions with the corresponding p-value for the GMM tests. See captions of Table 5 and 7 for details.

Panel A: Portfolio level results

	Fama-MacBeth			GMM		
	EW com	R2	R2-adj	EW com	J	p
Coef.	-0.22%	2.07%	-3.37%	1.45	36.86	*0.01*
t	*-0.43*			*0.39*		

Panel B: Firm-level regressions

	EW com	LnSize	LnB/M	Ret(-1:-1)	Ret(-12:-2)	Ret(-36:-13)	R^2
Coef.	0.34%						0.62%
t	*1.09*						
Coef.	0.27%	-0.09%	0.18%	-4.55%	0.35%	-0.22%	3.43%
t	*0.96*	*-1.57*	*1.86*	*-8.73*	*2.08*	*-3.89*	

Figure 1: **Realized versus Fitted Excess Returns.**