Cash-Flow News, Discount-Rate News and the Co-skewness Risk

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Abstract

The current paper considers an extension of the two-beta model of Campbell and Vuolteenaho (2004) to the higher-moment asset pricing model which includes co-skewness risk. We break down co-skewness risk into the co-skewness with the cash-flow news, co-skewness with the discount-rate news and the covariance with the product of the two — the co-variation risk. We find that stocks with high past returns have higher exposure to the co-variation risk in comparison to the stocks with low past returns. We also document positive and statistically significant market price of the co-variation risk, while no such evidence is found for the cash-flow and discount-rate co-skewness risk factors. The two-beta model of Campbell and Vuolteenaho, when it is augmented with the co-variation risk factor, explains about 73% of the variation of the size/book-to-market, size/momentum and industry-sorted portfolio excess returns. Finally, we compare and find the performance of the augmented two-beta model to be superior to empirical multifactor asset pricing models used in the prior literature.

JEL classification: G12, G14

Keywords: Asset pricing; Co-skewness risk; Cash-flow news; Discount-rate news; Momentum; Systematic risk.

A traditional view posits that the market value of equity is the present value of its future cash-flows (Gebhardt et al., 2001; Claus and Thomas, 2001; Easton, 2004). This suggests that the unanticipated changes in the value of equity market can be decomposed into the news about cash-flows and discount-rate (Campbell, 1991; Campbell and Ammer, 1993; Campbell and Vuolteenaho, 2004, Campbell *et al.*, 2010). This, in turn, implies that the overall systematic market risk of an asset can be decomposed into the systematic cash-flow and discount-rate risk components (Campbell and Vuolteenaho, 2004, Campbell *et al.*, 2010).

The central objective of this paper is to introduce an empirical extension of the Campbell and Vuolteenaho (2004) model to the higher-moment asset pricing model which includes co-skewness risk. We decompose the overall co-skewness risk into the co-skewness with the cash-flow news, co-skewness with the discount-rate news, and the covariation risk components. We examine the ability of the extended Campbell and Vuolteenaho (2004) model to price portfolios sorted by size, book-to-market and past performance (momentum) and compare its performance with the popular empirical multifactor models considered in prior literature.

Our paper is positioned at intersection of three strands of the asset pricing literature. A first strand of literature examines the importance of the unanticipated changes in cash-flows and discount-rate in explaining the dynamics of asset prices and cross-sectional differences in expected returns.. Campbell (1991) shows that unexpected stock returns must be associated with changes in expected dividends (cash-flow news) or expected future returns (discount-rate news). Employing a vector autoregressive method to break unexpected stock retruns unto these two components, he finds discount-rate news to account for most of stock return variation. Campbell and Ammer (1993) use similar method in decomposing stock and bond returns. They find stock returns to be mostly driven by news about future stock returns, while bond returns are driven largely by news about future inflation. Campbell and Vuolteenaho

(2004) introduce a methodology that allows disaggregating unexpected market return into the cash-flow and discount-rate news. Consequently, they show that the Capital Asset Pricing Model (CAPM) equity beta can be decomposed into the cash-flow and discount-rate betas. Campbell and Vuolteenaho find that it is the systematic cash-flow beta risk that is priced, while no such evidence is found for the systematic discount-rate beta risk. Campbell et al. (2010) show that cash-flows of growth stock are particularly sensitive to changes in the equity risk premium (market-wide discount rate news), while the cash-flows of value stocks are particularly sensitive to the market-wide shocks to cash-flows. Overall, these studies emphasize the importance of decomposing the overall changes in stock prices into those driven by shocks to cash-flows and those driven by changes in expected returns.

Campbell and Vuolteenaho (2004) focus on the cash-flow and discount-rate components of CAPM beta which measures systematic covariance risk. A second strand of literature investigates whether higher moments, in particular the co-skewness risk, are priced by the market as well. Kraus and Litzenberger (1976) provide a rational for the three-moment CAPM. In their model skewness matters since investors with the non-increasing aversion have a preference for positive skewness, and are averse to negative skewness. Co-skewness of the stock with the market, estimated as the covariance of stock return with the square of market return, measures the marginal contribution of the stock to the skewness of market portfolio. Harvey and Siddique (2000) find that some of the profitability of the momentum-based trading strategies can be explained by the co-skewness factor. Barone-Adesi et al., (2004) find that Fama-French (1993) factors lose their explanatory power when co-skewness factor is taken into account. In related papers Vanden (2006) and Smith (2007) find co-skewness. factor to be an important determinant of the equity risk premium. Martellini and Ziemann (2010) emphasize the importance of taking into account higher moments, co-skewness and co-kurtosis, for the optimal portfolio selection.

A third related strand of literature analyzes whether cross-sectional differences in exposure to marketwide correlation risk can account for cross-sectional differences in expected returns. Changes in marketwide variance are driven by shocks to both individual variances and correlations. If correlation risk is priced, then assets whose returns covary positively with correlation provide a hedge against unexpected correlation increases and earn negative excess returns relative to what is justified by their exposure to standard risk factors (Driessen, Maenhout, and Vilkov, 2009). Krishnan, Petkova and Ritchken (2009) document a significantly negative price of correlation risk for the cross-section of stock returns. Driessen, Maenhout, and Vilkov (2009) study whether exposure to marketwide correlation shocks affects expected option returns, using data on index and individual options. They find evidence of negative and statistically significant price of correlation risk, while no such evidence is found for the individual variance risk.

In this paper we extend the methodology of Campell and Vuolteenaho (2004) to the co-skewness risk. More specifically, we center our attention beyond the first and second moment price of risk — the market price of the third moment risk, namely the co-skewness of the stock with the market. While applying Campbell and Vuolteenaho (2004) decomposition to the square of the unexpected market return it is straightforward to show that changes in market return variation can be driven by a) shocks to cash-flow news variation b) shocks to discount-rate news variation, and c) shocks to co-variation between the two. Intuitively, co-skewness measures the ability of the asset to hedge changes in variation in market returns. Hence, we show that the overall measure of co-skewness risk can be decomposed into three components, which are the co-skewness with the cash-flow news, co-skewness with the discount-rate news and the covariance of stock return with the product of the two, the co-variation term. The first two terms measure the ability of the asset to hedge changes in variations in the cash-flow and discount-rate news, respectively, while the last term measures the ability of the asset to hedge co-variation between the cash-flow and discount-rate components of the unexpected market return.

We find that stocks with high past returns have higher exposure to the co-variation risk in comparison to the stocks with low past returns. Further, we document positive and statistically significant market price of the co-variation risk. The market prices of cash-flow and discount-rate co-skewness risk factors are both not statistically significant. The two-beta model of Campbell and Vuolteenaho (2004) augmented with the co-variation risk factor explains 73% of the variation of the size/book-to-market, size/momentum and industry-sorted portfolio excess returns. Furthermore, the null hypothesis of the augmented Campbelll and Vuolteenaho two-beta model correctly pricing excess returns on size/book-to-market and size/momentum sorted portfolios cannot be rejected at conventional significance levels.

We also compare the performance of the augmented two-beta model with the number of competing models. In particular, we find the explanatory power of Campbell and Vuolteenaho (2004) two-beta model augmented with the co-variation term to be comparable to the influential Fama-French (1993) three-factor and Carhart (1997) four-factor models. It is noteworthy that Fama-French (1993) size and value factors and Carhart (1997) momentum factor were constructed *ex post* to explain the size, book-to-market and momentum effects, while the factors of the augmented Campbell and Vuolteenaho model were constructed *ex ante*. Taking this aspect into account, we consider the performance of the augmented Campbell and Vuolteenaho (2004) model to be superior.

Our main contributions are as follows. First, we propose a natural extension of the two-beta model of Campbell and Vuolteenaho (2004) to the higher-moment asset pricing model which includes co-skewness risk. There is a growing body of evidence suggesting that co-skewness risk is an important determinant of the equity risk premium. Therefore, understanding the factors affecting the sign and the magnitude of the co-skewness risk shed further light on the determinants of the equity risk premium.

Second, our findings contribute to the informational market efficiency literature, in particular the debates regarding the origins of the momentum phenomenon, first documented by Jegadeesh and Titman (1993). Fama (1998), Barberis and Thaler (2003) and Jegadeesh and Titman (2005) suggest that momentum in stock returns is unlikely to be explained by risk and, instead, should be treated as the anomaly driven by behavioral explanations. Another strand of literature attempts to rationalize momentum by offering risk-related explanations (Bansal, Dittmar, and Lundblad, 2005; Sagi and Seasholes, 2007; Liu and Zhang, 2008). We find stocks with high past performance to have higher exposure to the co-variation risk compared to the stocks with low past returns. Futhermore, the two-beta model of Cambell and Vuolteenaho (2004), after being augmented with the co-variation factor, cannot be rejected when tested using the size/book-to-market and size/momentum sorted portfolios. Overall, our findings provide further support to the risk-based explanations of the momentum phenomenon.

Finally, our paper can be viewed as a contribution to the asset pricing literature in context of the ongoing discussion on the functional form of the pricing kernel. The well-documented inability of the linear one-factor CAPM of Sharpe and Linter (1964) to correctly price size, book-to-market and momentum-sorted portfolio returns led to introduction of the linear multifactor models (Fama and French, 1993; Carhart, 1997; Hahn and Lee, 2006), on the one hand, and the models with the non-linear pricing kernel, on the other (Bansal and Viswanathan, 1993; Bansal, Hsieh and Viswanathan, 1993; Dittmar, 2002; Vanden, 2006). We show that the linear two-factor model of Campbell and Vuolteenaho (2004), augmented with the non-linear product term of the cash-flow and discount-rate news, performs as well as the popular linear multifactor models, providing an additional argument in favor of the asset pricing models with non-linear pricing kernels.

The paper proceeds as follows. Section I defines the analytical framework. Section II presents the data and research design. Section III describes the empirical results for U.S. data over the period 1963 to 2010, while Section IV concludes.

I. Analytical Framework

Kraus and Litzenberger (1976) suggest that skewness matters since investors with the non-increasing aversion have a preference for positive skewness, and are averse to negative skewness. In their model the expected excess return on risky asset is given by

$$E[r_i] = \beta_i \mu_1 + \gamma_i \mu_2 \qquad (1)$$

where β_i is the beta of asset i, γ_i is the measure of the asset's coskewness risk, μ_1 is the price of beta risk, and μ_2 is the price of gamma risk. Asset beta and gamma, β_i and γ_i, are given in eq. (2) and (3), respectively

$$\beta_i = \frac{Cov(r_i, r_m)}{Var(r_m)} \qquad (2)$$

$$\gamma_i = \frac{Cov(r_i, r_m^2)}{Skew(r_m)} \qquad (3)$$

If investors care about covariance risk then μ_1 should be positive. Similarly, if investors care about co-skewness risk then μ_2 will be positive (negative) if the market returns are negatively (positively) skewed.

Campbel and Vuolteenaho (2004) and Campbell et al.(2010) show that the unexpected market return can be decomposed into the news about cash-flows, NCF, and discount-rate, NDR

$$r_m = NCF - NDR \qquad (4)$$

Based on this result they show that the CAPM beta, β_i, is the sum of the cash-flow beta, $\beta_{i,NCF}$, and discount-rate beta, $\beta_{i,NDR}$

$$\beta_{i,NCF} = \frac{Cov(r_i, NCF)}{Var(r_m)} \qquad (5)$$

$$\beta_{i,NDR} = \frac{Cov(r_i, -NDR)}{Var(r_m)} \qquad (6)$$

We extend their approach to the Kraus and Litzenberger (1976) model by applying the decomposition of the unexpected market return to the cash-flow and discount rate news to the co-skewness risk. It is straightforward to verify that the overall measure of the asset's measure of co-skewness risk, γ_i, is the sum of the following three components

$$\gamma_i = \gamma_{i,NCF} + \gamma_{i,NDR} + \lambda_i \qquad (7)$$

where

$$\gamma_{i,NCF} = \frac{Cov(r_i, NCF^2)}{Skew(r_m)} \qquad (8)$$

$$\gamma_{i,NDR} = \frac{Cov(r_i, NDR^2)}{Skew(r_m)} \qquad (9)$$

$$\lambda_i = \frac{-2 \times Cov(r_i, NCF \times NDR))}{Skew(r_m)} \qquad (10)$$

The overall gamma risk measures the ability of the asset to hedge variation in market return, as measured by r_m^2. The variation in market return is driven by a) variation in the cash-flow news, NCF^2, b) variation in the discount-rate news, NDR^2, and c) co-variation between the two, $-NCF \times NDR$. Therefore, the overall measure of gamma risk, γ_i, is the sum of the cash-flow gamma, $\gamma_{i,NCF}$ discount-rate gamma, $\gamma_{i,NDR,}$ and lambda, λ_i, which measures the ability of the asset to hedge co-variation between the two components.

II. Data and Research Design

A. Data and Sample Period

Unless otherwise indicated, all data were obtained from the Kenneth French data library and the Center for Research in Security Prices (CRSP). The sample period is July 1963-December 2010. All returns are measured on monthly basis.

B. The Portfolio Returns

Our basic test assets are the Fama-French 25 size/book-to-market sorted portfolios and 25 Fama-French portfolios, sorted by size and momentum. Size/book-to-market sorted portfolios have been used as the test assets in previous studies (Hodrick and Zhang, 2001; Campbell and Vuolteenaho, 2004; Hahn and Lee, 2006). We also add size/momentum sorted portfolios since momentum factor was shown as a particularly hard to price (Fama 1998; Jegadeesh and Titman, 2005). For each of these portfolios we estimate its monthly excess return as the difference between the gross monthly return and the yield on the 1-month Treasury Bill.

Summary statistics for the size/book-to-market and size/momentum sorted portfolios are reported in Table I, where in Panel A (B) we report the estimates for the size/book-to-market (size/momentum) sorted portfolios. For the size/book-to-market sorted portfolios the estimates are organized in a square matrix with small cap (large cap) stocks at the top (bottom) and low book-to-market (high book-to-market) at the left (right). Similarly, for the size/momentum sorted portfolios the estimates for the small cap (large cap) stocks are reported at the top (bottom), and the estimates for stocks with low (high) past returns appear at the left (right) of the Table.

For the size/book-to-market portfolios within a size quintile average returns increase as the book-to-market ratio increases. Also, within a book-to-market quintile average returns decline as the size increases, with the low book-to-market quintile being the only exception.

Standard deviations also seem to decline as the size increase. Overall, these observations are consistent with those reported by Hodrick and Zhang (2001).

For the size/momentum sorted portfolios within a size quintile there is a nearly monotonic increase in average returns as we move from the stocks with low past returns to the stocks with high past performance, consistent with the findings of Jegadeesh and Titman (1993). The difference between the extreme momentum-sorted portfolios is particularly pronounced for the small cap stocks, an observation consistent with the results reported by Hong, Lim and Stein (2000).

C. The Cash-Flow News, Discount-Rate News and Market Returns.

We estimate the unexpected market return, cash-flow and discount-rate news following Campbell and Vuolteenaho (2004) approach. First, a Vector Autoregression Model (VAR) with the state variables is estimated.[1] Next, the estimates of the VAR parameters and VAR residuals are used to decompose the unexpected market return into cash-flow and discount-rate components.

The summary statistics are reported in Table II, Panel A. The mean of the unexpected market return, r_{mkt}, is 0.01% and its standard deviation is 4.56%. The mean of the cash-flow component, NCF, is -0.06% and the mean of the discount-rate component, -NDR, is 0.05%. The standard deviation of the cash-flow component is 2.32%, much smaller than the standard deviation of the discount-rate component 4.36%, consistent with the results reported by Campbell and Vuolteenaho (2004).

In Table II, Panel B we report Ljung-Box (1978) statistics for the squares of the r_{mkt}, NCF, NDR, and the product of the two, -NCF$\times$NDR, series at different lags. Consistent with previous studies (e.g., Andersen et al., 2001), the squares of the unexpected market return

[1] For the choice and construction of state variables a reader is referred to Cambell and Vuolteenaho (2004) Data Appendix.

exhibit significant serial correlation even at high lags, as evident from the large values of Ljung-Box statistics and the corresponding *p*-values (smallest Q-statistic=7.25, *p*-value=0.01). Similar results hold for the squares of cash-flow (smallest Q-statistic=7.81, *p*-value=0.01) and discount-rate news series (smallest Q-statistic=4.21, *p*-value=0.04). On the other hand, we find no evidence of serial correlation for the -NCF×NDR series (largest Q-statistic=12.84, *p*-value=0.64). Taken together, these findings suggest that the main driver of market volatility clustering is clustering of the cash-flow and discount-rate news variations.

D. Decomposition of Beta and Gamma Risks for the Size/BM, Momentum, and Industry-sorted Portfolios

In this section we report the estimates of the cash-flow and discount rate betas and the estimates of the cash-flow gammas, discount-rate gammas and the lambdas for the size/book-to-market and size/momentum sorted portfolios and the results are reported in Table III, Table IV and Table V respectively. In each table we report the estimates for the size/BM-sorted portfolios (Panel A) and size/momentum–sorted portfolios (Panel B). The estimates of the Panel A are organized in a square matrix with small size (large size) stocks at the top (bottom) and high size/BM (low size/BM) at the left (right). In addition, for each size (size/BM) category we report the differences between the estimated coefficients for the extreme growth and value (small and large) portfolios. Similarly, for the Panel B the estimates for the small size (large size) stocks are reported at the top (bottom) and the estimates for the stocks with the low (high) past performance are reported at the left (right). The corresponding standard errors are reported in square brackets. For each category (size, book-to-market, past performance) we report the differences between the estimates for the extreme portfolios, with the corresponding *p*-values reported in parentheses.

We start by examining the estimates of the cash-flow and discount-rate betas. The results are reported in Tables III (cash-flow betas) and Table IV (discount-rate betas). Starting with the size/book-to-market-sorted portfolios the estimates of both cash-flow and discount-rate betas are consistent with those reported by Campbell and Vuolteenaho (2004) for the 1963-2001 sample period. More specifically, cash-flow betas are significantly larger for the value stocks compared to the growth stocks. Also, the discount-rate betas are significantly larger for the stocks in the small size category compared to the large size stocks.[2] Overall, our estimates support the results of Campbell and Vuolteenaho (2004), suggesting that news about cash-flows (discount-rate) has a more pronounced effect on the value (small size) stocks.

Next, we examine the estimates of the cash-flow and discount-rate betas for the size/momentum sorted portfolios. The estimates of the cash-flow betas appear to be slightly lower for the stocks with high past returns compared to the stocks with poor past performance. The difference, however, is not significant for most of the categories, with the large size category being the only exception. The discount-rate betas, on the other hand, display a distinct U-shape, being largest for the stocks with poor and high past performance. This observation suggests that portfolios comprised of the stocks with poor or high past performance (that is, stocks that experienced in the past large absolute returns) are picking stocks with high sensitivity to the changes in discount-rate.

Next, we turn to the estimates of the co-skewness measures, namely lambdas, cash-flow gammas, and discount-rate gammas. The results are reported in Tables 5, 6, and 7, respectively. We start with the estimates of lambdas, reported in Table V. The estimated coefficients of lambda are positive for most of the portfolios. For the size/BM sorted portfolios we find no evidence of lambdas being different for the growth versus value stocks. On the other hand, the estimates of lambdas are declining at almost a monotonic rate, as we

[2] These results are also consistent with previous studies (Gertler and Gilchrist, 1994; Christiano, Eichenbaum and Evans, 1996; Perez-Quiros and Timmerman, 2000) who find small firms to be more sensitive to fluctuations in interest rates.

move from the small to large-size stocks. The difference is statistically significant at 10% for three out of five categories. Turning to the size/momentum sorted portfolios, the estimated lambdas are increasing as we move from the stocks with poor past performance to the stocks with high past returns. The difference is statistically significant at 5% level for all five categories.

The estimates of cash-flow gammas are positive and statistically significant for both size/BM and size/momentum sorted portfolios and so are the estimates of the discount-rate gammas, suggesting that regardless of their size/BM/past performance attributes stocks exhibit significant cash-flow and discount-rate negative coskewness[3]. We find some limited evidence of cash-flow gammas being larger for the value stocks. Also, the discount-rate gammas seem to be monotonously decreasing as we move from the small to the large-size stocks. Despite relatively large standard errors of the estimates the difference is also statistically significant at 10% significance level for three out of five categories.

III Empirical Results

A. Fama-MacBeth Cross-Sectional Estimation

In this section we estimate the prices of risk of each of the systematic risk measures, discussed in the previous section using Fama-MacBeth (1973) method. The prices of risk are estimated following Fama-MacBeth (1973) two-stage approach from the following cross-sectional regression

$$\bar{R}_i^e = g_0 + \sum_{k=1}^{K} g_k \hat{\theta}_{i,k} + \varepsilon_i \qquad (11)$$

where $\bar{R}_i^e$ is average excess portfolio return, $\hat{\theta}_{i,k}$ is the measure of systematic risk with respect to k-th risk factor and g_k is the price of the k-th factor risk. Our basic assets are 25

[3]Recall, that cash-flow gamma, discount rate gamma, and lambda are scaled by the skewness of market portfolio, which is negative.

Fama-French size/book-to-market sorted portfolios and 25 Fama-French size/momentum sorted portfolios. In addition, we include in our set of the test assets 12 Fama-French industry-sorted portfolios following Lewellen (1999) and Engle (2012). To incorporate a first-stage estimation uncertainty we produce standard errors with a bootstrap from 5000 simulated realizations, following Campbell and Vuolteenaho (2004). [4]

The results are reported in Table VIII, Panel A. Our first model is the CAPM of Sharpe and Lintner (1964), with a single explanatory variable, the estimated CAPM beta. Consistent with the results reported by prior studies (Fama and French, 1993; Campbell and Vuolteenaho, 2004; Hahn and Lee, 2006) traditional CAPM fails to explain the size, book-to-market and momentum premia on stock market. The estimate of premium for the CAPM beta is negative and not statistically significant (*t*-statistic=-1.10, *p*-value=0.27, two-tail), consistent with findings of Campbell and Vuolteenaho (2004) and Hahn and Lee (2006). Poor performance of traditional CAPM is also evident from the negative adjusted R^2 of -0.001%.

Next, we examine the performance of the two-beta model of Campbell and Vuolteenaho (2004), where the explanatory variables are the estimates of β_{NCF} and β_{NDR}. We find no substantial improvement in its performance compared to CAPM. The model has negative adjusted R^2 of -1.5%. The coefficients for both cash-flow and discount-rate betas are both not statistically significant (largest *t*-statistic=-0.51, *p*-value=0.70, two-tail). These findings are consistent with Campbell and Vuolteenaho (2004), who are skeptical regarding the ability of the two-beta model to correctly price momentum-sorted portfolios. We further examine this issue later in this section.

Next we examine the performance of the two-beta model augmented with the overall co-skewness measure, γ . This model, which we denote as "CV-gamma", can be viewed as the natural extension of the Campbell and Vuolteenaho two-beta model. We find that adding the

[4] Note that since the first-stage estimates of betas, gammas and deltas are not least-squares estimates, the correction proposed by Shanken (1992) is not applicable in this case.

γ as an additional explanatory variable to the cash-flow and discount-rate betas substantially improves its performance. The adjusted R^2 of the cross-sectional regression rises from -1.5% of the two-beta model to 51%. The estimated coefficient for γ is positive and statistically significant (*t*-statistic=2.40, *p*-value=0.016, two-tail), consistent with market participants being averse to negative skewness of the market portfolio. The co-skewness premium is economically significant as well (1.2% premium in monthly terms, or 14.4% in annual terms).

Next, we estimate the unrestricted five-factor model, with the two components of the CAPM beta, β_{NCF} and β_{NDR}, and three components of the co-skewness term, γ_{NCF}, γ_{NDR} and λ being included as the independent variables. The results are reported in the "CV-unrestricted" column. Allowing the components of the overall co-skewness to have different prices of risk leads to a substantial improvement of the explanatory power of the model, with the adjusted R^2 rising from 51% to 71%. The estimated price of λ risk is positive and statistically significant (*t*-statistic=2.11, *p*-value=0.035, two-tail), suggesting that investors consider stocks that negatively covary with the co-variation between the cash-flow and discount-rate shocks as more risky.[5] The estimate of λ premium is also economically significant (1.9% premium in monthly terms, or 22.8% premium in annual terms). The coefficients for both cash-flow and discount-rate gammas lack statistical significance (largest *t*-statistic=-0.41, *p*-value=0.68, two-tail).

Finally, we compare the explanatory power of the overall co-skewness risk to the one of its co-variation component by replacing the overall co-skewness measure, γ , by its co-variation component, λ. The estimates of this model are reported in the "CV-lambda" column. The price of lambda risk remains positive and statistically significant (*t*-statistic=2.21, *p*-value=0.025, two-tail), The model has the adjusted R^2 of 71.3%, providing a

[5] Recall that the estimates of all three components of co-skewness are scaled by the skewness of the market portfolio, which is negative.

substantial improvement over the CV-gamma model which uses the overall co-skeweness measure, γ, as a risk-factor. Comparing to the adjusted of 71% of the unrestricted five-factor model, our results suggest that it is the λ component of the overall co-skewness risk that is priced by the market, consistent with the results reported for the five-factor CV-unrestricted model.

As a supplemental analysis we compare the performance of the CV-lambda model with the influential Carhart (1997) four factor model, which includes size, value and momentum as the risk factors. The adjusted R^2 of the Carhart model (untabulated) is 74%. Compared to the adjusted R^2 of 71% of the CV-lambda model and taking into account that the Carhart (1997) model factors were constructed *ex post* to explain size, BM and momentum effects, we consider the performance of the CV-lambda model to be a success.

As a robustness test we repeat our analysis using 25 size/BM portfolios as test assets, to make our results comparable with the previous studies (Hodrick and Zhang, 2001; Campbell and Vuolteenaho, 2004; Hahn and Lee, 2006). The results are reported in Table VIII, Panel B.

A number of observations should be noted. First, CAPM continues to exhibit poor performance. The estimated price of risk is negative and marginally statistically significant (*t*-statistic=-1.77, *p*-value=0.08, two-tail) and the adjusted R^2 is 0.038. Second, in contrast to CAPM we find the performance of the two-beta model to improve substantially. The adjusted R^2 of the model is 0.29, compared to its negative adjusted R^2 of -0.015 reported in Table VIII, Panel A. The model yields positive and statistically significant price of risk for the cash-flow beta (*t*-statistic=2.08, *p*-value=0.04, two-tail). The estimated coefficient for the discount-rate beta remains not statistically significant (*t*-statistic=0.53, *p*-value=0.59, two-tail). The estimates of both cash-flow and discount rate beta risk premia are consistent with those reported by Campbell and Vuolteenaho (2004) for the 1963-2001 sample period. Overall, the results reported in Table VIII, panels A and B, are consistent with Campbell and Vuolteenaho

(2004) notion that, while being able to explain the size and book-to-market effects, the two-beta model fails to explain the momentum effect.

Third, we find that CV-lambda model continues to perform well. The price of λ risk continues to be positive and statistically significant (*t*-statistic=1.91, *p*-value=0.056, two-tail)[6] and the adjusted R^2 of the model is 73%. Comparing to the adjusted R^2 of 71% of the three-factor Fama-French (1993) model (untabulated), we find the performance of the CV-lambda model to be highly satisfactory.

Finally, turning to the estimates of the CV-unrestricted model, the coefficients for the cash-flow and discount-rate gammas remain not statistically significant (largest *t*-statistic=-0.79, *p*-value=0.43, two-tail). Also, including these two risk measures results in no improvement in the adjusted R^2 of the model, similar to the results reported in Panel A of Table VIII.

Overall, a number of conclusions can be drawn from our analysis. First, we find the co-variation risk, λ, to be the only component of the co-skewness risk that is priced by the market. Second, we find the two-beta model of Campbell and Vuolteenaho (2004) augmented with the lambda factor being able to explain the cross-section of the size, BM and momentum sorted portfolios to the same extent as the influential Fama-French (1993) three-factor and Carhart (1997) four-factor models. Taking into consideration that the factors of both of these models were constructed ex post to explain the deviations from the standard CAPM model, we consider the performance of our model to be satisfactory.

B. GMM Estimation and Model Diagnostics

In this section we supplement the results, reported in Section 5, by evaluating the performance of the models discussed in the previous section in their stochastic discount

[6] Statistical significance slightly declines compared to Table VIII,Panel A, since in Panel B we have only 25 test portfolios.

factor representation using the GMM framework, following Hodrick and Zhang (2001) and Hahn and Lee (2006).

The law of one price implies the existence of a pricing kernel *m* such that $E_t(m_{t+1}r_{j,t+1}) = 0$, where $r_{j,t+1}$ is the excess return on portfolio *j* at time *t*+1. Similarly, for the gross return on a risk-free asset, $R_{f,t+1}$, *m* should satisfy $E_t(m_{t+1}R_{f,t+1}) = 1$.

We consider the following specification of the pricing kernel,

$$m_{t+1} = b_0 + b^{\perp} f_{t+1} \tag{12}$$

where f_{t+1} denotes a k-dimensional vector of risk factors. Campbell (1996) shows that eq. has an equivalent covariance representation

$$E(r_j) = \sum_{k=1}^{K} q_k cov(r_j, f_k) \tag{13}$$

where $q_k = -\frac{b_k}{E(m)}$ is the price of covariance with k-th risk factor.

We estimate the parameters and evaluate the performance of the asset pricing models using a GMM framework with the two alternative specifications of the weighting matrix, an optimal GMM weighting matrix (Hansen, 1982) and the diagonal variance weighting matrix (Campbell and Vuolteenaho, 2004). While the optimal GMM weighting matrix produces the most efficient estimates of the model parameters, it is model dependent and, thus, the evaluation diagnostics cannot be compared across the models (Hann and Lee, 2006). The diagonal variance weighting matrix is common across the models, which allows comparing the distance metrics of the models under consideration. Also, using the variance weighting matrix reduces the GMM estimation problems to the weighted least-squares problem and, thus, is intuitively appealing.

Our test assets are 25 size/BM sorted portfolios, 25 size/momentum sorted portfolios and a gross-return on the 1-month Treasury bill. The models tested are CAPM, Campbell and Vuolteenaho two-beta model, CV-gamma model, and CV-lambda model. The estimation results and the diagnostics statistics are reported in Table IX, Panels A (optimal GMM weighting matrix) and B (diagonal variance weighting matrix).

Starting with the results, reported in Panel A, we find that a standard single-factor CAPM (that is, f=r_{mkt}) fails to correctly price size/BM and size/momentum sorted portfolios (*J*-statistic=73.53, *p*-value=0.013). Turning to the two-beta model with f=[NCF,-NDR], we find no substantial improvement in the model performance. Similar to the standard single-factor CAPM a two-beta model fails to correctly price our test assets (*J*-statistic=72.39, *p*-value=0.013). Overall, these results are consistent with the low explanatory power of both CAPM and two-beta model reported in Table VIII, Panel A.

Next we examine the performance of the CV-gamma model, where we add a squared unexpected market return, r_{mkt}^2 to the cash-flow and discount-rate factors. This gives a three-factor model with f=[NCF,NDR, r_{mkt}^2]. Adding r_{mkt}^2 reduces the magnitude of the *J*-statistic which, however, still remains significant (*J*-statistic=69.37, *p*-value =0.02).

Finally, we examine the performance of the CV-lambda model, where we replace the squared market factor, r_{mkt}^2,by the covariation factor, NCF*(-NDR), which gives a three-factor model with f=[NCF,NDR, -NCF×NDR]. The model passes *J*-test (*J*-statistic=58.14, *p*-value=0.13).

As a robustness test and also in order to provide a comparison across the pricing performance of different models we conduct the same analysis with the diagonal variance weighting matrix. To evaluate the significance of the variance-weighted (VW) distance, we rely on a bootstrap analysis (Campbell and Vuolteenaho, 2004). More specifically, for each candidate pricing kernel we draw 5000 realizations of the test asset returns, constructed under the null hypothesis of that model pricing the test assets correctly, as shown in eq. (13), and for each realization we estimate the parameters of the model and the VW-distance. The *p*-value of the VW-distance diagnostic is estimated based on the empirical distribution of the VW-distance measure generated under the null hypothesis.

The results are reported in Table IX, Panel B. A single-factor CAPM fails to correctly price the returns on test assets (VW-distance=0.133, *p*-value<0.01) and so does the Campbell and Vuolteenaho two-beta model (VW-distance=0.126, *p*-value<0.01). Compared to these two models, a CV-lambda three-factor model provides a substantial improvement (VW-distance=0.052, *p*-value=0.14). Turning to CV-lambda model we find that replacing squared market return by the co-variation term leads to further improvement of model performance (VW-distance=0.034, *p*-value=0.35). To summarize, based on the results reported in Table IX, panels A and B, the null hypothesis of the CV-lambda model correctly pricing size, BM and momentum–sorted portfolios cannot be rejected based on both optimal GMM-and VW-distance metrics.

To gain some further insight we plot the pricing errors of each of the four models, namely CAPM, two-beta, CV-gamma and CV-lambda together with the popular three and four factor empirical models by Fama-French and Carhart. The results are depicted in Figure 1A and Figure 1B. For each asset pricing model we plot the estimated pricing errors (diamonds) and the two standard error bands (solid lines).

As expected, the pricing errors of the CAPM emphasize its failure to price both the size/BM and size/momentum sorted portfolios. In particular, the average returns on the growth (value) stocks are significantly lower (higher) than those predicted by CAPM. Similarly, the average returns on the stock with poor (good) past performance are significantly below (above) the CAPM estimates.

Compared to the traditional CAPM, the two-beta provides an improvement in terms of the magnitude of the pricing errors of the size/BM –sorted portfolios. However, for the size/momentum portfolios a mispricing pattern similar to the one of CAPM remains evident. A CV-gamma model offers a substantial improvement in performance compared to both CAPM and two-beta models. It correctly prices most of the size/BM sorted portfolios, with the small size/high BM portfolio being the only exception. It also reduces the magnitude of the pricing errors for the size/momentum sorted portfolios. However, for most of these portfolios the pricing errors of the extreme “winers” and “losers” are still statistically different from zero, indicating the failure of the CV-gamma model to price the momentum effect.

Turning to the CV-lambda model we find that it correctly prices most of the size/BM sorted portfolios with small/growth firms being the only exception[7]. In contrast to CV-gamma model, we also find that CV-lambda model prices correctly most of the momentum-sorted portfolios. The only exception is small winners portfolio which earns positive and statistically significant risk-adjusted returns. These deviations, however, do not appear to be anomalous enough to lead to the overall rejection of the model, as evident from the results reported in Table IX.

Finally, for the purpose of additional comparative analysis we also estimate and plot the pricing errors of the Fama-French (1993) three-factor and Carhart (1997) four-factor models. The Fama-French three-factor model is able to price most of the size/BM portfolios but fails to price momentum effect, an observation consistent with the results reported by Fama and French (1998). Carhart (1997) four-factor model performs reasonably well in pricing both size/BM and momentum effects, though statistically failing to price small/growth, small/loser and small/winner portfolios.

Overall, consistent with findings reported in Section 5, we find the performance of the CV-lambda model to be comparable with one of the Carhart (1997) four-factor model. Taking into account that a) CV-lambda model is a three-factor model, as opposed to the four-factor Carhart (1997) model and b) the factors of the CV-lambda model were constructed ex-ante,

[7] Previous studies (D’Avolio, 2002; Lamont and Thaller, 2003) suggest that pricing of small growth stocks is affected by short-sale constraints and, therefore, these stocks present a particular challenge to asset pricing models.

as opposed to the size, value and momentum factors of Carhart (1997) model, we find the performance of CV-lambda model to be more than satisfactory.

IV Conclusions

Campbell and Vuolteenaho (2004) introduce a methodology that allows disaggregating unexpected market return into the cash-flow and discount-rate news. Furthermore, they show that the Capital Asset Pricing Model (CAPM) equity beta can be broke down into the cash-flow and discount-rate betas. Their empirical evidence suggests that it is the systematic cash-flow risk that is priced, with no such evidence that the systematic discount-rate risk is priced. Our paper extends the two-beta model of Campbell and Vuolteenaho (2004) to the higher-moment asset pricing model which includes co-skewness risk. We investigate whether cash-flow and discount-rate news have different price of risk for higher moments as well.

In Kraus and Litzenberger's (1976) three-moment CAPM the skewness matters because investors with the non-increasing aversion have a preference for positive skewness while at the same time are averse to negative skewness. Co-skewness of the stock with the market, estimated as the covariance of stock return with the square of market return, measures the marginal contribution of the stock to the skewness of market portfolio.

First, we show that the overall co-skewness risk can be decomposed into the co-skewness with the cash-flow news (covariance of the stock return with the cash-flow news squared), co-skewness with the discount-rate news (covariance of the stock return with the discount-rate news squared) and the covariance with the product of the two, the co-variation risk. Next, we document positive and statistically significant market price of the co-variation risk, while we find no evidence of both the cash-flow and discount-rate co-skewness factors to be priced.

We also observe that the two-beta model of Campbell and Vuolteenaho, when it is augmented with the new co-variation risk factor, explains about 73% of the variation of the size/book-to-market, size/momentum and industry-sorted portfolio excess returns. In addition, we compare the performance of the two-beta model augmented with the co-variation risk factor with two popular model in empirical asset pricing literature: the three- (market, size and value) and the four-factor (market, size, value and momentum) models. We find that our model is superior to these ex-post asset pricing multifactor models.

Overall, our results emphasize the importance of accounting for the cash-flow news and the discount-rate news in context of the higher moment asset pricing models, as well as provide further support to the risk-based explanations of the momentum phenomenon.

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Table I

Descriptive Statistics-Test Portfolios

In this table we report selected descriptive statistics for the monthly returns on Fama-French 25 size/book-to-market and Fama-French 25 size/momentum portfolios for the sample period of July 1963-December 2010. Monthly means and standard deviations are reported in percentage points. The differences between the coefficients for the extreme growth and value, large and small, and high and low past performance portfolios are reported in the "Diff." columns.

Mean returns

Panel A: Size/BM sorted portfolios

	Growth	2	3	4	Value	Diff.
Small	0.22	0.78	0.83	0.99	1.12	0.90
2	0.42	0.69	0.91	0.91	1.01	0.59
3	0.43	0.73	0.76	0.85	1.05	0.62
4	0.54	0.53	0.68	0.82	0.81	0.27
Large	0.39	0.46	0.43	0.50	0.56	0.17
Diff.	0.17	-0.32	-0.40	-0.49	-0.56	

Panel B: Size/Momentum sorted portfolios

	Low	2	3	4	High	Diff.
Small	-0.02	0.65	0.88	1.03	1.39	1.41
2	0.09	0.61	0.78	0.98	1.19	1.10
3	0.23	0.53	0.66	0.74	1.19	0.96
4	0.13	0.53	0.58	0.75	1.03	0.90
Large	0.10	0.39	0.29	0.49	0.74	0.64
Diff.	0.12	-0.26	-0.59	-0.54	-0.65	

Standard deviations

Panel A: Size/BM sorted portfolios

	Growth	2	3	4	Value	Diff.
Small	8.14	7.00	6.09	5.75	6.21	-1.93
2	7.36	6.09	5.51	5.36	6.12	-1.24
3	6.78	5.55	5.06	4.95	5.57	-1.21
4	6.02	5.26	5.12	4.87	5.59	-0.43
Large	4.79	4.55	4.44	4.43	5.01	0.22
Diff.	-3.35	-2.45	-1.65	-1.32	-1.20	

Panel B: Size/Momentum sorted portfolios

	Low	2	3	4	High	Diff.
Small	8.12	5.98	5.52	5.57	6.89	-1.23
2	8.03	5.97	5.23	5.46	6.87	-1.16
3	7.51	5.59	5.12	5.04	6.40	-1.11
4	7.40	5.61	4.93	4.87	5.98	-1.42
Large	6.88	4.98	4.45	4.39	5.38	-1.50
Diff.	-1.24	-1.00	-1.07	-1.18	-1.51	

Table II
Descriptive Statistics-Market Return, Cash-Flow and Discount-Rate News

In Panel A of this table we report selected descriptive statistics for the unexpected market returns and the estimates of the cash-flow and discount-rate news for the sample period of July 1963-December 2010. The unexpected market returns , r_{mkt}, cash-flow (NCF) and discount-rate news (-NDR) were estimated following Campbell and Vuolteenaho (2004). Monthly means and standard deviations are reported in percentage points. In Panel B we report selected Ljung-Box (1978) test statistics and the corresponding p-values for the squares of the each of the variables and for the product of the cash-flow and discount-rate news.

Panel A: Descriptive statistics

	Mean	St.dev.	Skewness	Kurtosis
r_{mkt}	0.01	4.56	-0.69	5.48
NCF	-0.06	2.32	-0.43	5.79
-NDR	0.05	4.36	-0.47	4.91

Panel B: Portmanteu serial correlation tests

	Q-stat(lag=1)	Q-stat(lag=5)	Q-stat(lag=10)	Q-stat(lag=15)
r_{mkt}^2	7.25(0.01)	17.65(0.00)	24.48(0.01)	28.25(0.02)
NCF^2	7.81(0.01)	25.07(0.00)	35.96(0.00)	53.35(0.00)
NDR^2	4.21(0.04)	16.22(0.01)	34.29(0.00)	43.17(0.00)
-NCF×NDR	0.01 (0.93)	3.00(0.70)	7.22(0.71)	12.84(0.62)

Table III
Cash-Flow Betas of the Size/BM and Size/Momentum Sorted Portfolios

In this table we report the estimates of the cash-flow betas (β_{NCF}) of the portfolios sorted based on market capitalization (size), book-to-market (BM) and past performance (momentum) characteristics for the sample period July 1963-December 2010. Cash-flow beta are estimated as $\frac{cov(r_i,NCF)}{var(r_m)}$ where r_i is the return on portfolio, r_m is the unexpected excess market return, and NCF is the cash-flow news. The unexpected excess market return and cash-flow news were estimated following Campbell and Vuolteenaho (2004). The estimates for the size/BM (size/momentum) sorted portfolios are reported in Panel A (B). "Growth" denotes stocks with largest size/book-to-market, "value"-stocks with lowest size/book-to-market, "small"-stocks with lowest market capitalization, "large"-stocks with largest market capitalization. "Low" denotes stocks with lowest past returns, "high"-stocks with highest past returns. For each portfolio we report the estimated cash-flow beta and the corresponding GMM standard error (in squared brackets) adjusted for heteroskedasticity and serial correlation. The differences between the estimates of the extreme portfolios and the *p*-values of the corresponding *J*-statistics (in round brackets) are reported in the "Diff." columns.

Panel A: Size/BM sorted portfolios

	Growth		2		3		4		Value		Diff.	
Small	0.12	[0.05]	0.14	[0.05]	0.16	[0.04]	0.17	[0.04]	0.20	[0.03]	0.08	(0.013)
2	0.13	[0.04]	0.16	[0.03]	0.17	[0.03]	0.19	[0.03]	0.22	[0.04]	0.09	(0.001)
3	0.13	[0.04]	0.18	[0.03]	0.19	[0.03]	0.20	[0.03]	0.22	[0.03]	0.09	(0.003)
4	0.14	[0.03]	0.19	[0.03]	0.20	[0.02]	0.21	[0.02]	0.24	[0.03]	0.1	(0.001)
Large	0.14	[0.02]	0.18	[0.02]	0.18	[0.03]	0.21	[0.03]	0.21	[0.03]	0.07	(0.002)
Diff.	0.02	(0.691)	0.04	(0.428)	0.02	(0.679)	0.04	(0.355)	0.01	(0.785)		

Panel B: Size/Momentum sorted portfolios

	Low		2		3		4		High		Diff.	
Small	0.21	[0.04]	0.18	[0.03]	0.17	[0.03]	0.17	[0.03]	0.16	[0.04]	-0.05	(0.152)
2	0.21	[0.05]	0.18	[0.03]	0.18	[0.03]	0.18	[0.03]	0.16	[0.04]	-0.05	(0.214)
3	0.22	[0.04]	0.19	[0.03]	0.18	[0.02]	0.18	[0.03]	0.16	[0.04]	-0.05	(0.163)
4	0.23	[0.04]	0.22	[0.03]	0.19	[0.02]	0.19	[0.02]	0.17	[0.03]	-0.06	(0.146)
Large	0.25	[0.04]	0.18	[0.03]	0.17	[0.02]	0.17	[0.02]	0.17	[0.03]	-0.09	(0.019)
Diff.	0.04	(0.170)	0.00	(0.997)	0.00	(0.999)	0.00	(0.928)	0.01	(0.646)		

Table IV
Discount-Rate Betas of the Size/BM and Size/Momentum Portfolios

In this table we report the estimates of the discount-rate betas (β_{NDR}) of the portfolios sorted based on market capitalization (size), book-to-market (BM) and past performance (momentum) characteristics for the sample period July 1963-December 2010. Discount-rate beta is estimated as $\frac{cov(r_i,-NDR)}{var(r_m)}$ where r_i is the return on portfolio, r_m is the unexpected excess market return, and NDR is the discount-rate news. The unexpected excess market return and discount-rate news were estimated following Campbell and Vuolteenaho (2004). The estimates for the size/BM (size/momentum) sorted portfolios are reported in Panel A (B). “Growth” denotes stocks with largest size/book-to-market, “value”-stocks with lowest size/book-to-market, “small”-stocks with lowest market capitalization, “large”-stocks with largest market capitalization. “Low” denotes stocks with lowest past returns, “high”-stocks with highest past returns. For each portfolio we report the estimated discount-rate beta and the corresponding GMM standard error (in squared brackets) adjusted for heteroskedasticity and serial correlation. The differences between the estimates of the extreme portfolios and the *p*-values of the corresponding *J*-statistics (in round brackets) are reported in the “Diff.” columns.

Panel A: Size/BM sorted portfolios

	Growth		2		3		4		Value		Diff.	
Small	1.25	[0.08]	1.03	[0.06]	0.88	[0.05]	0.80	[0.04]	0.82	[0.04]	-0.43	(0.000)
2	1.22	[0.06]	0.96	[0.04]	0.84	[0.04]	0.78	[0.04]	0.84	[0.04]	-0.38	(0.000)
3	1.16	[0.06]	0.89	[0.03]	0.77	[0.04]	0.71	[0.04]	0.76	[0.05]	-0.40	(0.000)
4	1.05	[0.05]	0.86	[0.03]	0.79	[0.04]	0.72	[0.04]	0.76	[0.05]	-0.29	(0.002)
Large	0.83	[0.04]	0.74	[0.03]	0.68	[0.03]	0.60	[0.04]	0.64	[0.05]	-0.19	(0.004)
Diff.	-0.42	(0.000)	-0.29	(0.0003)	-0.20	(0.002)	-0.20	(0.005)	-0.18	(0.009)		

Panel B: Size/Momentum sorted portfolios

	Low		2		3		4		High		Diff.	
Small	1.08	[0.07]	0.83	[0.05]	0.77	[0.04]	0.79	[0.04]	1.00	[0.06]	-0.08	(0.428)
2	1.18	[0.08]	0.88	[0.05]	0.80	[0.04]	0.83	[0.04]	1.09	[0.07]	-0.09	(0.389)
3	1.08	[0.08]	0.85	[0.04]	0.79	[0.04]	0.79	[0.03]	1.03	[0.05]	-0.05	(0.593)
4	1.04	[0.09]	0.84	[0.05]	0.77	[0.04]	0.78	[0.03]	0.96	[0.05]	-0.08	(0.473)
Large	0.94	[0.07]	0.73	[0.05]	0.71	[0.03]	0.70	[0.03]	0.86	[0.05]	-0.08	(0.408)
Diff.	-0.14	(0.018)	-0.10	(0.082)	-0.06	(0.134)	-0.09	(0.043)	-0.14	(0.005)		

Table V
Lambdas of the Size/BM and Size/Momentum Portfolios

In this table we report the estimates of lambdas (λ) of the portfolios sorted based on market capitalization (size), book-to-market (BM) and past performance (momentum) characteristics for the sample period July 1963-December 2010. Delta is estimated as $\frac{-2*cov(r_i,NCF\times NDR)}{skew(r_m)}$ where r_i is the return on portfolio, r_m is the unexpected excess market return, NCF and NDR are the cash-flow and discount-rate news, respectively. The unexpected excess market return, cash-flow and discount-rate news were estimated following Campbell and Vuolteenaho (2004). The estimates for the size/BM (size/momentum) sorted portfolios are reported in Panel A (B). "Growth" denotes stocks with largest size/book-to-market, "value"-stocks with lowest size/book-to-market, "small"-stocks with lowest market capitalization, "large"-stocks with largest market capitalization. "Low" denotes stocks with lowest past returns, "high"-stocks with highest past returns. For each portfolio we report the estimated lambda and the corresponding GMM standard error (in squared brackets) adjusted for heteroskedasticity and serial correlation. The differences between the estimates of the extreme portfolios and the *p*-values of the corresponding *J*-statistics (in round brackets) are reported in the "Diff." columns.

Panel A: Size/BM sorted portfolios

	Growth		2		3		4		Value		Diff.	
Small	0.54	[0.34]	0.55	[0.31]	0.48	[0.24]	0.49	[0.24]	0.36	[0.20]	-0.18	(0.428)
2	0.45	[0.26]	0.38	[0.20]	0.32	[0.17]	0.28	[0.17]	0.35	[0.18]	-0.10	(0.437)
3	0.38	[0.23]	0.30	[0.17]	0.23	[0.16]	0.15	[0.17]	0.27	[0.16]	-0.11	(0.499)
4	0.28	[0.19]	0.24	[0.18]	0.17	[0.18]	0.10	[0.15]	0.10	[0.20]	-0.18	(0.232)
Large	0.17	[0.16]	0.12	[0.17]	0.08	[0.19]	0.02	[0.16]	0.02	[0.20]	-0.15	(0.311)
Diff.	-0.37	(0.133)	-0.43	(0.146)	-0.40	(0.073)	-0.47	(0.062)	-0.35	(0.098)		

Panel B: Size/Momentum sorted portfolios

	Low		2		3		4		High		Diff.	
Small	0.20	[0.21]	0.25	[0.17]	0.29	[0.17]	0.38	[0.18]	0.55	[0.26]	0.36	(0.027)
2	0.17	[0.22]	0.23	[0.18]	0.27	[0.18]	0.37	[0.18]	0.63	[0.34]	0.46	(0.043)
3	0.05	[0.22]	0.12	[0.18]	0.24	[0.16]	0.31	[0.18]	0.50	[0.23]	0.42	(0.031)
4	-0.05	[0.20]	0.07	[0.22]	0.15	[0.18]	0.17	[0.18]	0.43	[0.21]	0.48	(0.044)
Large	-0.03	[0.19]	-0.05	[0.18]	0.17	[0.14]	0.16	[0.14]	0.28	[0.16]	0.31	(0.095)
Diff.	-0.23	(0.170)	-0.30	(0.062)	-0.12	(0.183)	-0.22	(0.054)	-0.27	(0.043)		

Table VI
Cash-flows Gammas of the Size/BM and Size/Momentum Portfolios

In this table we report the estimates of cash-flow gammas (γ_{NCF}) of the portfolios sorted based on market capitalization (size), book-to-market (BM) and past performance (momentum) characteristics for the sample period July 1963-December 2010. Cash-flow gamma is estimated as $\frac{cov(r_i,NCF^2)}{skew(r_m)}$ where r_i is the return on portfolio, r_m is the unexpected excess market return, and NCF is the cash-flow news. The unexpected excess market return and cash-flow news were estimated following Campbell and Vuolteenaho (2004). The estimates for the size/BM (size/momentum) sorted portfolios are reported in Panel A (B). "Growth" denotes stocks with largest size/book-to-market, "value"-stocks with lowest size/book-to-market, "small"-stocks with lowest market capitalization, "large"-stocks with largest market capitalization. "Low" denotes stocks with lowest past returns, "high"-stocks with highest past returns. For each portfolio we report the estimated cash-flow gamma and the corresponding GMM standard error (in squared brackets) adjusted for heteroskedasticity and serial correlation. The differences between the estimates of the extreme portfolios and the *p*-values of the corresponding *J*-statistics (in round brackets) are reported in the "Diff." columns.

Panel A: Size/BM sorted portfolios

	Growth		2		3		4		Value		Diff.	
Small	0.17	[0.08]	0.15	[0.07]	0.15	[0.06]	0.15	[0.06]	0.18	[0.07]	0.01	(0.901)
2	0.17	[0.07]	0.16	[0.05]	0.16	[0.05]	0.18	[0.06]	0.20	[0.07]	0.03	(0.575)
3	0.17	[0.06]	0.17	[0.05]	0.15	[0.05]	0.16	[0.05]	0.16	[0.06]	-0.01	(0.815)
4	0.12	[0.05]	0.15	[0.05]	0.16	[0.05]	0.15	[0.05]	0.22	[0.08]	0.10	(0.056)
Large	0.10	[0.04]	0.14	[0.06]	0.16	[0.06]	0.16	[0.07]	0.19	[0.09]	0.09	(0.035)
Diff.	-0.07	(0.237)	-0.01	(0.917)	0.01	(0.873)	0.01	(0.884)	0.01	(0.879)		

Panel B: Size/Momentum sorted portfolios

	Low		2		3		4		High		Diff.	
Small	0.22	[0.08]	0.19	[0.06]	0.19	[0.06]	0.18	[0.05]	0.17	[0.06]	-0.05	(0.286)
2	0.22	[0.08]	0.18	[0.06]	0.18	[0.05]	0.17	[0.05]	0.12	[0.08]	-0.10	(0.164)
3	0.22	[0.09]	0.17	[0.06]	0.16	[0.05]	0.18	[0.05]	0.14	[0.06]	-0.08	(0.233)
4	0.21	[0.10]	0.18	[0.07]	0.15	[0.05]	0.15	[0.05]	0.14	[0.05]	-0.07	(0.324)
Large	0.18	[0.08]	0.13	[0.06]	0.13	[0.05]	0.11	[0.04]	0.13	[0.05]	-0.05	(0.389)
Diff.	-0.04	(0.325)	-0.06	(0.233)	-0.06	[0.068)	-0.07	(0.065)	-0.04	(0.339)		

Table VII
Discount-rate Gammas for the Size/BM and Size/Momentum Portfolios

In this table we report the estimates of discount-rate gammas (γ_{NDR}) for the portfolios sorted based on market capitalization (size), book-to-market (BM) and past performance (momentum) characteristics for the sample period July 1963-December 2010. Discount-rate gamma is estimated as $\frac{cov(r_i, NDR^2)}{skew(r_m)}$ where r_i is the return on portfolio, r_m is the unexpected excess market return, and NDR is the discount-rate news. The unexpected excess market return and discount-rate news were estimated following Campbell and Vuolteenaho (2004). The estimates for the size/BM (size/momentum) sorted portfolios are reported in Panel A (B). "Growth" denotes stocks with largest size/book-to-market, "value"-stocks with lowest size/book-to-market, "small"-stocks with lowest market capitalization, "large"-stocks with largest market capitalization. "Low" denotes stocks with lowest past returns, "high"-stocks with highest past returns. For each portfolio we report the estimated discount-rate gamma and the corresponding GMM standard error (in squared brackets) adjusted for heteroskedasticity and serial correlation. The differences between the estimates of the extreme portfolios and the *p*-values of the corresponding *J*-statistics (in round brackets) are reported in the "Diff." columns.

Panel A: Size/BM sorted portfolios

	Growth		2		3		4		Value		Diff.	
Small	0.83	[0.27]	0.68	[0.23]	0.63	[0.17]	0.57	[0.16]	0.82	[0.22]	-0.01	(0.836)
2	0.77	[0.21]	0.75	[0.17]	0.74	[0.17]	0.73	[0.19]	0.74	[0.17]	-0.03	(0.838)
3	0.72	[0.21]	0.72	[0.15]	0.71	[0.17]	0.67	[0.18]	0.71	[0.18]	-0.01	(0.934)
4	0.64	[0.18]	0.74	[0.18]	0.78	[0.24]	0.63	[0.21]	0.72	[0.20]	0.08	(0.559)
Large	0.51	[0.13]	0.62	[0.15]	0.59	[0.15]	0.53	[0.19]	0.72	[0.24]	0.21	(0.141)
Diff.	-0.32	(0.214)	-0.06	(0.814)	-0.04	(0.865)	-0.04	(0.852)	-0.10	(0.582)		

Panel B: Size/Momentum sorted portfolios

	Low		2		3		4		High		Diff.	
Small	0.93	[0.27]	0.81	[0.22]	0.78	[0.18]	0.78	[0.16]	0.79	[0.19]	-0.14	(0.473)
2	0.87	[0.27]	0.76	[0.21]	0.73	[0.16]	0.72	[0.14]	0.69	[0.25]	-0.18	(0.408)
3	0.68	[0.23]	0.73	[0.22]	0.70	[0.18]	0.73	[0.14]	0.72	[0.18]	0.04	(0.842)
4	0.70	[0.30]	0.72	[0.21]	0.68	[0.18]	0.70	[0.17]	0.72	[0.19]	0.02	(0.838)
Large	0.65	[0.29]	0.53	[0.22]	0.55	[0.13]	0.52	[0.12]	0.57	[0.12]	-0.08	(0.762)
Diff.	-0.28	(0.109)	-0.28	(0.098)	-0.23	(0.076)	-0.26	(0.047)	-0.22	(0.145)		

Table VIII
Asset Pricing Tests using Fama-MacBeth Regressions

Panel A: Size/BM, Size/Momentum and Industry Sorted Portfolios

In this table we report the estimated regression coefficients and the associated *t*-statistics from the Fama-MacBeth (1973) two-step regression approach for the sample period July 1963-December 2010. The dependent variable, $\bar{R}^e$, is the cross-section of the average monthly excess returns over the 1-month T Bill on the test assets. Test assets are Fama-French 25 size/book-to-market sorted portfolios, Fama-French 25 size/momentum sorted portfolios and Fama-French 12 industry portfolios. Each column reports estimated risk premia and corresponding t-statistics for the corresponding asset pricing model. For CAPM the independent variables are constant and the cross-section of estimated CAPM betas. For the two-beta model the independent variables are a constant, cross section of the estimated cash-flow (β_{NCF}) and discount-rate (β_{NDR}) betas. For CV-gamma model the independent variables are constant, cross section of the estimated cash-flow (β_{NCF}) and discount-rate (β_{NDR}) betas, and gammas (γ). For CV-lambda model the independent variables are constant, cross section of the estimated cash-flow (β_{NCF}) and discount-rate (β_{NDR}) betas and lambdas (λ). For CV-unrestricted model model the independent variables are constant, cross section of the estimated cash-flow (β_{NCF}) and discount-rate (β_{NDR}) betas, cross-section of the estimated cash-flow (γ_{NCF}) and discount-rate (γ_{NDR}) gammas, and lambdas (λ). All *t*-statistics are adjusted for the first-step estimation uncertainty using bootstrap methodology following Campbell and Vuolteenaho (2004).

Model	CAPM	Two-beta	CV-gamma	CV-lambda	CV-unrestricted
Const	0.0086	0.0093	0.0075	0.0069	0.0066
[t-stat]	[2.69]	[2.39]	[1.78]	[1.86]	[1.83]
β_{CAPM} premium	-0.0022				
[t-stat]	[1.10]				
β_{NCF} premium		-0.0069	-0.013	0.027	0.033
[t-stat]		[-0.47]	[-0.68]	[1.56]	[1.65]
β_{NDR} premium		-0.0020	-0.014	-0.012	-0.011
[t-stat]		[-0.51]	[-2.33]	[-1.83]	[-1.74]
γ premium			0.012		
[t-stat]			[2.40]		
γ_{NCF} premium					-0.012
[t-stat]					[-0.41]
γ_{NDR} premium					0.0012
[t-stat]					[0.18]
λ premium				0.019	0.019
[t-stat]				[2.21]	[2.11]
Adj. R^2	-0.0014	-0.015	0.514	0.713	0.708
R^2	0.015	0.018	0.538	0.727	0.732

Table VIII (continued)
Asset Pricing Tests using Fama-MacBeth Regressions

Panel B: Size/BM Sorted Portfolios

In this table we report the estimated regression coefficients and the associated *t*-statistics from the Fama-MacBeth (1973) two-step regression approach for the sample period July 1963-December 2010. The dependent variable, $\bar{R}^e$, is the cross-section of the average monthly excess returns over the 1-month T Bill on the test assets. Test assets are Fama-French 25 size/book-to-market sorted portfolios. Each column reports estimated risk premia and corresponding t-statistics for the corresponding asset pricing model. For CAPM the independent variables are constant and the cross-section of estimated CAPM betas. For the two-beta model the independent variables are a constant, cross section of the estimated cash-flow (β_{NCF}) and discount-rate (β_{NDR}) betas. For CV-gamma model the independent variables are constant, cross section of the estimated cash-flow (β_{NCF}) and discount-rate (β_{NDR}) betas, and gammas (γ). For CV-lambda model the independent variables are constant, cross section of the estimated cash-flow (β_{NCF}) and discount-rate (β_{NDR}) betas and lambdas (λ). For CV-unrestricted model model the independent variables are constant, cross section of the estimated cash-flow (β_{NCF}) and discount-rate (β_{NDR}) betas, cross-section of the estimated cash-flow (γ_{NCF}) and discount-rate (γ_{NDR}) gammas, and lambdas (λ). All *t*-statistics are adjusted for the first-step estimation uncertainty using bootstrap methodology following Campbell and Vuolteenaho (2004).

Model	CAPM	Two-beta	CV-gamma	CV-lambda	CV-unrestricted
Const	0.016	-0.0054	0.003	0.003	-0.001
[t-stat]	[3.48]	[-0.70]	[0.50]	[0.61]	[-0.18]
β_{MKT} premium	-0.0087				
[t-stat]	[-1.77]				
β_{NCF} premium		0.054	0.015	0.051	0.064
[t-stat]		[2.08]	[0.61]	[2.32]	[2.21]
β_{NDR} premium		0.003	-0.012	-0.0079	-0.0067
[t-stat]		[0.53]	[-1.71]	[-1.32]	[-0.93]
γ premium			0.011		
[t-stat]			[2.00]		
γ_{NCF} premium					-0.023
[t-stat]					[-0.79]
γ_{NDR} premium					0.003
[t-stat]					[0.45]
λ premium				0.015	0.015
[t-stat]				[1.91]	[1.88]
Adj. R^2	0.038	0.289	0.595	0.731	0.729
R^2	0.078	0.349	0.646	0.765	0.786

Table IX
Asset Pricing Tests using SDF Approach

Panel A: Optimal GMM weighting matrix

In this table we report the estimates of the stochastic discount factors. The test assets are 25 Fama-French size/book-to-market sorted portfolios, 25 Fama-French size/momentum sorted portfolios and the gross return on 1-month Treasury bill. The sample period is July 1963-December 2010. The parameters were estimated using GMM with Hansen (1982) optimal weighting matrix. Standard errors (in squared brackets) are adjusted for heteroskedasticy and serial correlation. Under the null hypothesis of pricing errors being jointly equal to zero (no over-identifying moment conditions) *J*-statistic is distributed χ^2_{N-k} where *N* is the number of test assets and *k* is the number of parameters of stochastic discount factor.

CAPM

	Const	r_m
b	0.995	-2.949
S.E.	[0.0043]	[0.848]
J-statistic (*p*-value)	73.53 (0.01)	

Two-beta

	Const	*NCF*	*-NDR*
b	0.987	-13.21	-0.813
S.E.	[0.0071]	[2.828]	[1.028]
J-statistic (*p*-value)	72.39 (0.01)		

CV-gamma

	Const	*NCF*	*-NDR*	r_m^2
b	0.617	-9.858	6.299	182.98
S.E.	[0.074]	[3.503]	[1.537]	[46.54]
J-statistic (*p*-value)	69.37 (0.02)			

CV-lambda

	Const	*NCF*	*-NDR*	*NCF*(-NDR)*
b	1.072	-19.54	2.755	415.38
S.E.	[0.031]	[4.908]	[1.476]	[154.25]
J-statistic (*p*-value)	58.14 (0.13)			

Table IX (continued)
Asset Pricing Tests using SDF Approach

Panel B: Variance weighting matrix

In this table we report the estimates of the stochastic discount factors. The test assets are 25 Fama-French size/book-to-market sorted portfolios, 25 Fama-French size/momentum sorted portfolios and the gross return on 1-month Treasury bill. The sample period is July 1963-December 2010. The parameters were estimated using GMM with Campbell and Vuolteenaho (2004) diagonal variance weighting (VW) matrix. Standard errors (in squared brackets) are adjusted for heteroskedasticy and serial correlation. Distribution of the VW-distance measure under the null of pricing errors being jointly equal to zero (no over-identifying moment restrictions) and the corresponding *p*-values were estimated using bootstrap method with 5000 replications.

CAPM	Const	r_m
b	0.995	-3.132
S.E.	[0.006]	[1.009]
VW-distance (*p*-value)	0.133 (0.000)	

Two-beta	Const	*NCF*	*-NDR*
b	0.991	-9.833	-1.675
S.E.	[0.009]	[3.559]	[1.237]
VW-distance (*p*-value)	0.126 (0.000)		

CV-gamma	Const	*NCF*	*-NDR*	r_m^2
b	0.591	-4.964	5.149	192.53
S.E.	[0.081]	[4.659]	[2.026]	[48.46]
VW-distance (*p*-value)	0.052 (0.14)			

CV-lambda	Const	*NCF*	*-NDR*	*NCF*(-NDR)*
b	1.093	-24.67	4.378	626.27
S.E.	[0.039]	[5.332]	[1.881]	[159.59]
VW-distance (*p*-value)	0.034 (0.35)			

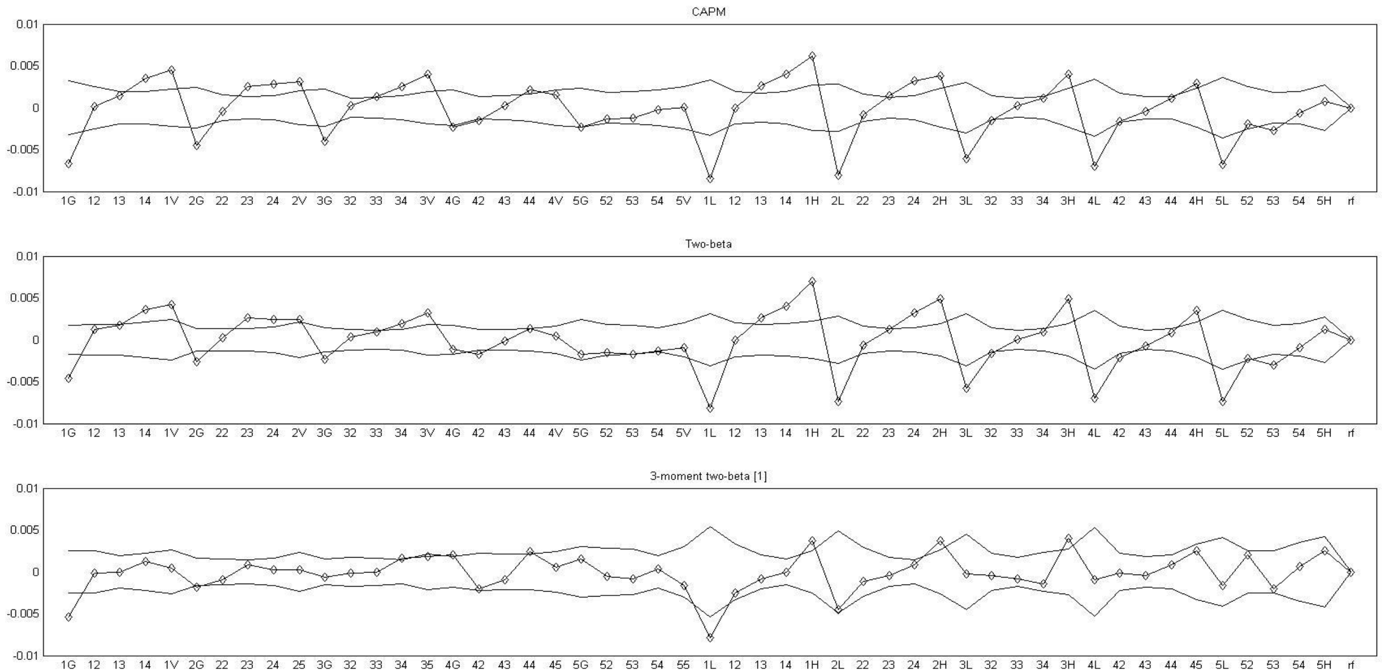

Figure 1A. Pricing errors of CAPM, two-beta CAPM and CV-gamma models

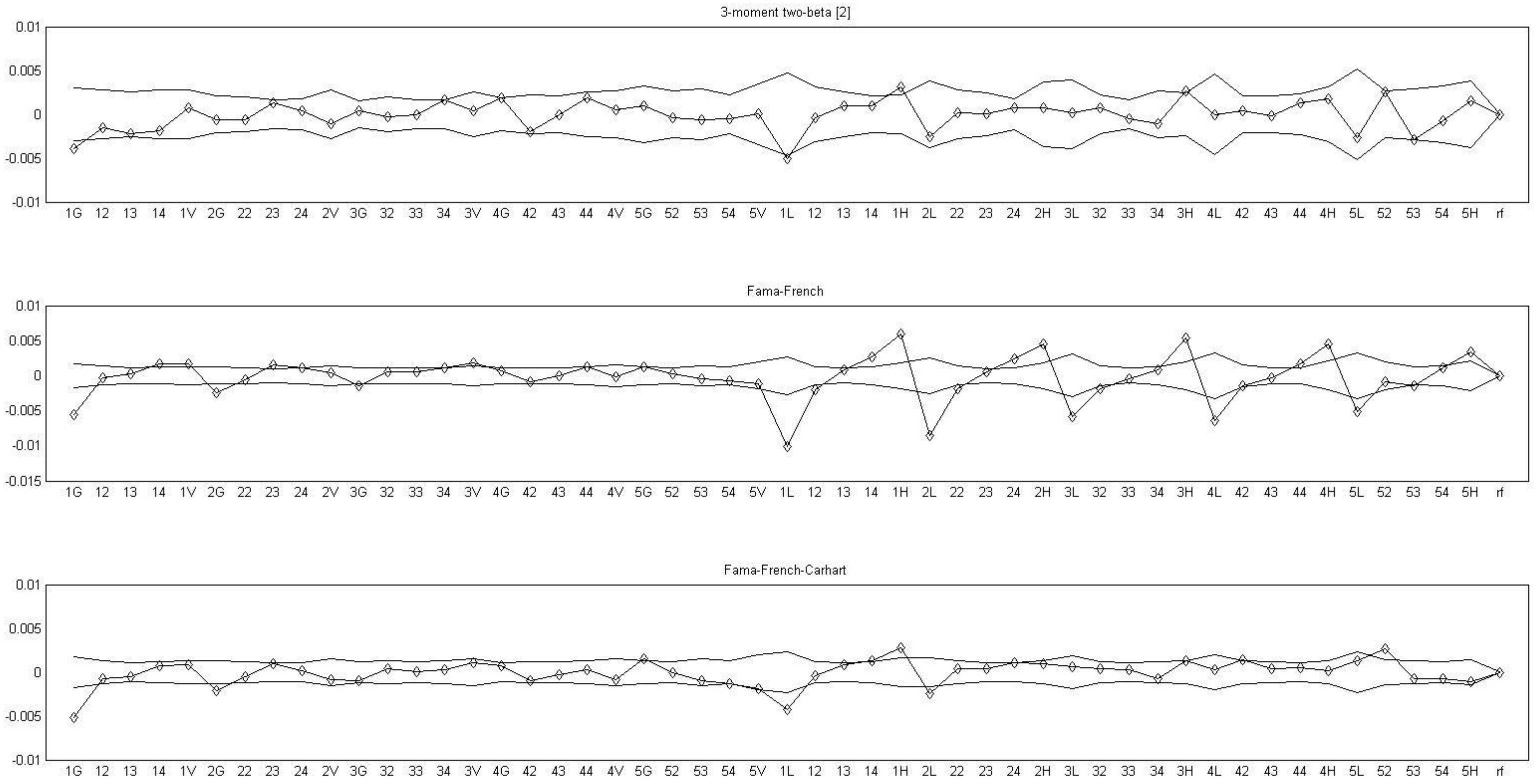

Figure 1B. Pricing errors of CV-lambda, Fama-French and Fama-French-Carhart models