Academic Research Monitor

Cross Asset Skewness and Risk Models

Equities

Global

Quantitative

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Profiting from commodity skewness

A portfolio of commodity futures with a low (or negative skewness) appears to outperform one containing futures with a more positive skewness. The first paper in this edition of the Academic Research Monitor shows that this strategy is different from more traditional commodity risk premia. Our reproduction finds the same result in both bonds and equities.

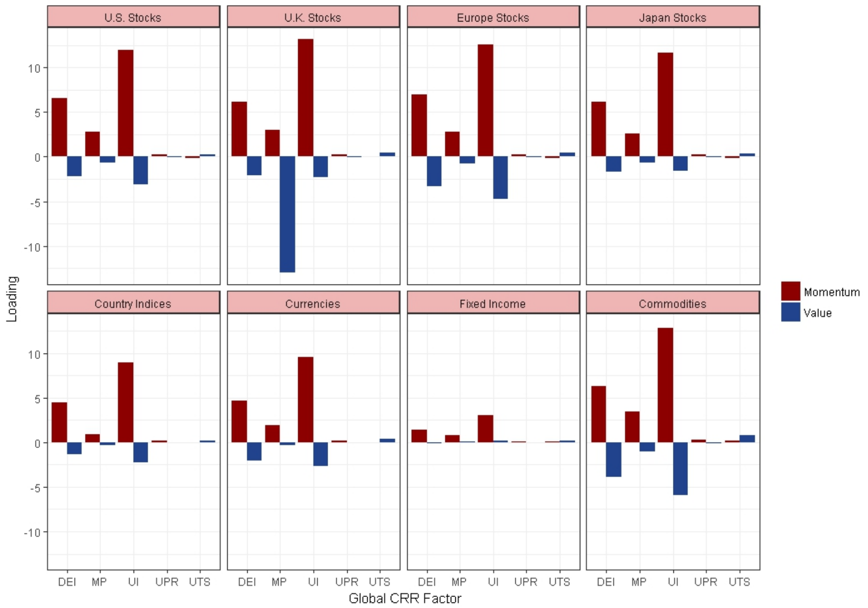
A global risk model to rival global CAPM

The task of building a unified risk model to explain factor-based returns across multiple asset classes and markets is an ongoing one. Several models exist in the literature, all of which have their limitations regarding the set of assets they perform well on. The second paper we review proposes a new global risk factor model which explains well the returns on value and momentum portfolios across countries and asset classes and outperforms global CAPM and other competing models on several metrics. Furthermore, it directly ties the returns to macroeconomic factors making it more intuitive and economically interpretable.

Commonalties in risk premia returns

Most papers which look at cross asset risk premia tend to treat them as individual factors. The third paper we review tries to find commonalities in the behaviour of various risk premia. For example the author finds that risk premia with undesirable characteristics (e.g. high volatility, negative co-skewness with equity returns) tend to perform better.

Figure 1: Value and Momentum exposures to Global risk factors



Source: "A Global Macroeconomic Risk Model for Value, Momentum, and Other Asset Classes" by Ilan Cooper, Andreea Mitrache, Richard Priestley. Used with permission.

Introduction

In this issue of our Academic Research Monitor, we consider three recent papers that touch on the topic of cross asset investing (Figure 2).

The first paper introduces a new return factor. The authors look at the skewness of commodity future returns and find those with negative skewness outperform those with positive skewness. We reproduce their analysis and find similar results in both equity and bond futures.

The second paper introduces a new asset pricing model which aims to map factor-based strategy returns to macroeconomic variables and deliver good performance (in the sense that it delivers statistically small pricing errors) both cross-asset and cross-market. It is shown that a model of global risk factors can better explain returns across multiple markets and asset groups for value and momentum strategies than competing models. In particular, the authors find that their model can explain both the negative correlation between value and momentum portfolios and the existence of a positive risk premia from combining the two factors. It turns out their results are robust to several tests and can be used on other asset classes as well.

The final paper is more of an overview paper which aims to analyse the common behaviours and sources of return across various risk premia.

Figure 2: Papers on Cross Asset Factor Investing

"The Skewness of Commodity Futures Returns" *Adrian Fernandez-Perez, Bart Frijns, Ana-Maria Fuertes, Joëlle Miffre*	*Journal of Banking and Finance*
"A Global Macroeconomic Risk Model for Value, Momentum, and Other Asset Classes" *Ilan Cooper, Andreea Mitrache, Richard Priestley*	*SSRN working paper, May 2017*
"Risk and Risk Premia: A Cross Asset Class Analysis" *Markus Ebner*	*SSRN working paper, May 2016*

Source: UBS.

"The Skewness of Commodity Futures Returns"

by Adrian Fernandez-Perez, Bart Frijns, Ana-Maria Fuertes, Joëlle Miffre

Negative skewness is associated with outperformance in commodity futures

In this paper the authors show that commodity futures with the strongest negative skewness tend to outperform those with the most positive skewness very convincingly, and that this alpha remains significant after taking into account the standard commodity pricing models. They find that the long short skewness factor has a larger premium than any of the risk factors thus far considered in the literature.

The authors' data is based on the front-end and second nearest futures contracts for 27 commodities across a wide variety of different sectors. Their sample period is Jan '87 to Nov '14.

Their definition of skewness is the usual definition. They use daily returns over the previous 12 months and compute Pearson's moment coefficient of skewness:

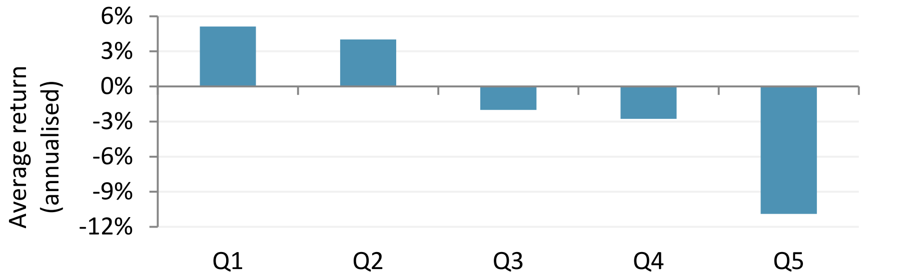
$$skewness_i = \frac{1}{T}\sum_t (r_{i,t} - \mu_i)^3/\sigma_i^3$$

where T is the number of daily returns over the previous year, μ_i is the average daily return to the asset i and σ_i^2 is the variance of the daily returns to the asset i.

Long short portfolio gained c. 8% per year

At each month end the authors divide their universe of 27 commodity futures into quintiles based on their skewness. They find that the sample period return to the assets decreases monotonically, with quintile 1 (negatively skewed assets) very strongly outperforming quintile 5 (positively skewed assets) with an annual return of +5% per annum vs -11% per annum. The long short portfolio, buying quintile 1 and selling quintile 5 would have gained around 8% per year. This is a highly significant difference.

Figure 3: Annualised return to skewness quintiles for commodity futures



Source: Data is an extract from Table IV, Panel A, Performance of skewness quintiles and long-short portfolios, in "The Skewness of Commodity Futures Returns" (2017), Chart by UBS

Traditional commodity risk models cannot explain excess return to low skewness

However, the different quintiles have very different exposures to, for example backwardation and contango, so the authors adjust for the standard commodity pricing factors: the market, term structure, momentum and hedging pressure[1]. This reduces the long short alpha from 8% to 6.6% per year, but it is still strongly significant. The authors also augment this basic pricing model with several further factors: liquidity, open interest, inflation, currency risk and volatility. This further

[1] The latter three of these are created as long-short portfolios. For term structure the signal is the average roll-yield (the daily in the logarithmic prices of the front-end and second-nearest contracts) over the previous 12 months; momentum is based on the past performance over the previous 12 months; and hedging pressure based on measurements of the open interest of hedgers and speculators.

reduces the alpha but it remains significant. It appears that the traditional commodity risk factors cannot explain the excess return to low skewness assets.

The outperformance can be explained by a behavioural bias. Investors, particularly retail investors, like "lottery type" payoffs with a small chance of making large profits. That means that stocks with positive skewness are desirable, so will tend to be bid up and become overpriced, depressing future returns. Alternatively, it may be that investors overweight the likelihood of rare events. This causes them to overvalue the expected return to an asset with positive skewness (and undervalue the expected return to an asset with negative skewness). This will again lead to stocks with positive skewness underperforming.

Our replication

Effect of skewness on futures for commodities, equity indexes and fixed income

We have tried to replicate the authors work and expand the analysis into equity index futures and fixed income futures. Our data includes 26 commodity futures (vs. 27 in the original paper), eight fixed income futures and 15 equity index futures. For commodities and fixed income, our data goes from Jan 1989 to Dec 2017. For equity indices, our data starts later, in Jan 1991, but also ends in Dec 2017.

For each asset, we compute the skewness of the daily returns over the preceding 258 week days. At each month end, we then divide the asset class into quintiles (for commodities) or thirds (for equity indexes) or halves (for fixed income futures). We equal weight the assets in each basket to create portfolios, which we rebalance monthly.

We replicate the paper's key result that negative skewness outperforms …

In each case, we do find that the low skewness portfolio is associated with strong out of sample performance.

In commodities, we found a monotonic decline in annualised return from quintile 1 (+5%) to quintile 5 (-4%). This return spread is smaller than that found by the authors, but corroborates their analysis. For the long short portfolio, buying the low skewness portfolio and selling the high skewness portfolio, we find an average monthly return of 0.7% with a t-stat of 2.39, which is significantly positive at a 5% level. This gives an annualised return of +6.9%.

Figure 4: Annualised return to each quintile of skewness in commodity futures

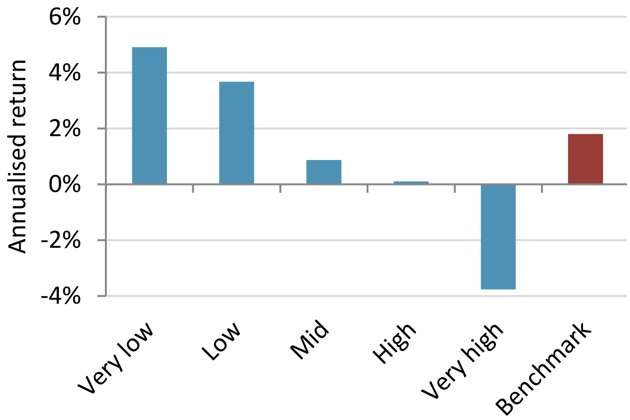


Figure 5: Statistics on performance of top and bottom quintiles of skewness

	Very low	Very high	Benchmark
Return	5%	-4%	2%
Risk	16%	17%	12%
Risk adjusted return	0.30	-0.22	0.15
Active Premium	3%	-6%	-
Tracking Error	12%	12%	-
Information Ratio	0.27	-0.46	-
Strategy return skewness	-0.13	0.20	-0.53

	Long short
Return	7%
Risk	20%
Risk adjusted return	0.35
Strategy return skewness	0.02

Source: UBS Quantitative Research. For illustrative purposes only.

It is notable that the skewness of the strategy returns is not monotonic (although the very high skewness basket does exhibit higher skewness than the very low skewness basket). This suggests that skewness is not strongly persistent and past skewness is not a very reliable indicator of future skewness.

... but the strength of the authors' result may be due to their exact specification

As a robustness check, we tried re-running this analysis 26 times, each time excluding one of the futures from our universe. This did weaken the skewness effect. The long short monthly returns were still positive in every case, but for 13 out of the 26 cases, they were no longer significant at a 5% level.

This suggests that, while negative skewness does appear to be associated with outperformance in commodity futures, the strength of the result seen in the paper may have been due to their specific choice of universe.

Negative skewness also rewarded in equity index and fixed income futures universes

With the equity index and fixed income futures, we also saw that negatively skewed assets tended to outperform. In equity, we found the low skewness portfolio returned +8% vs +4% for the high skewness portfolio. In fixed income, those numbers were +3.3% vs +2.2%. For the long short portfolio, buying the low skewness portfolio and selling the high skewness portfolio, we find annualised returns of +2.3% for equities and +1.3% for fixed income and risk adjusted returns of 0.19 and 0.43 respectively.

Figure 6: Performance of skewness in equity index futures universe

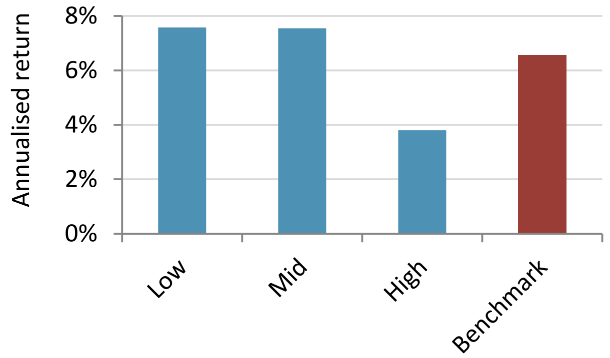


Figure 7: Performance of skewness in fixed income futures universe

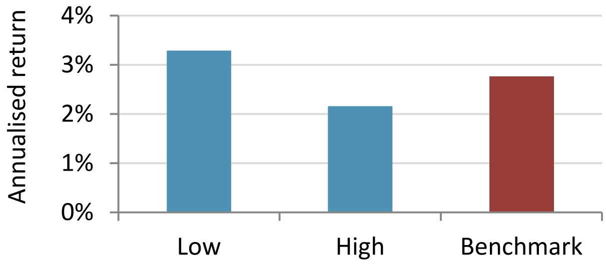


Figure 8: Summary statistics (equity indexes)

	Long short
Return	2.3%
Risk	11.8%
Risk adjusted return	0.19
Strategy return skewness	-0.23

Figure 9: Summary statistics (fixed income)

	Long short
Return	1.3%
Risk	3.0%
Risk adjusted return	0.43
Strategy return skewness	-0.08

Source: UBS Quantitative Research. For illustrative purposes only.

"A Global Macroeconomic Risk Model for Value, Momentum, and Other Asset Classes"

by Ilan Cooper, Andreea Mitrache, Richard Priestley

Numerous models exist for describing the returns to factor-based strategies across asset classes and countries. These differ, however, in the predictors included and typically focus on characteristic-based predictors which aim to summarise equity only portfolios. A unified model for explaining the returns to portfolios built on one or more asset classes across several markets, however, is yet to be established.

The majority of asset-pricing models focus on equities and are based on characteristics with little economic meaning …

The authors of this paper show that a factor structure which incorporates global macroeconomic risks is better at explaining anomalies present across multiple asset classes and countries when compared with the global CAPM and global three-factor model of Asness, Moskowitz, and Pedersen (2013) – henceforth, AMP3.

… a global macroeconomic risk model, however, can better explain returns across multiple asset classes and countries and offers improved interpretability.

In particular, Cooper et al. focus, predominantly, on describing value, momentum and value-momentum equal-weighted portfolio returns since these two factors are the most debated in the finance literature[2]. This is partly due to the fact that return premia to value and momentum strategies are negatively correlated yet have a positive return premia when combined in equal proportions; a finding which continues to puzzle both academics and practitioners. It turns out the global macroeconomic risk model (henceforth GMR) posited in this paper can demonstrate this empirical result and, since it directly maps the returns to macroeconomic variables, offers better economic interpretability.

In summary, evidence is presented to show that a global pricing model based on Ross's (1976) Arbitrage Pricing Theory using a global version of Chen, Roll and Ross's (1986) macroeconomic risk factors (CRR)[3] can explain return premia to value, momentum and combinations of these factors across multiple asset classes, countries and cross-sections of other asset classes.

GMR can replicate the negative correlation between value and momentum returns as well as the positive return premia associated with combining the two factors.

Three main findings emerge:

1. Positive return premia to value and momentum strategies across asset classes and countries can be explained by their loadings on global risk factors.

2. These different factor loadings also explain the negative correlation between value and momentum return premia.

3. GRM does a better job than global CAPM and AMP3 in terms of modelling the positive return premia to combinations of value and momentum strategies.

Motivation from existing literature.

Of course, the ultimate objective here is to construct an economically interpretable model which sufficiently explains the returns, in the sense that it produces low pricing errors, and performs well for all countries and asset types. Several attempts

[2] We have also written on these two factors extensively, see, for example our Academic Research Monitor from November 2017 and September 2016 on combining smart beta factors.

[3] The original CRR factors in Chen, Roll and Ross (1986) include industrial production, expected and unexpected inflation, real interest rates, changes in expected inflation, risk premium and the term structure.

have been made in the extant literature to construct such a factor structure, a few of which were discussed in the paper and are summarised in Figure 10.

Figure 10: Extant literature on return factor models.

Academics	Model/Factors	Limitations
Asness, Moskowitz & Pedersen, (2013)	Global market index, global value and global momentum factors.	Does not tie the return premia to global macroeconomic risks.
Hou, Karolyi & Kho (2011)	Global and local factors relating to momentum and cash flow-to-price.	Limited to equities.
Karolyi & Wu (2014)	Global and local size, value and momentum factors.	Has relatively low pricing errors only when local factors are included.
Fama & French (2012)	Four regional firm characteristics; global version also exists.	Focused on equities only; global version does not explain international stock returns.
Lettau, Maggiori & Weber (2014)	A downside CAPM model	Does not explain the returns to momentum portfolios, corporate bonds and U.S. Treasuries.

Source: "A Global Macroeconomic Risk Model for Value, Momentum, and Other Asset Classes" by Ilan Cooper, Andreea Mitrache, Richard Priestley. Used with permission. The table summarise a number of existing asset pricing models and where they fail to adequately explain factor-based returns across multiple markets and asset classes.

Extant models have their limitations.

This study was therefore motivated by the limitations of existing models to replicate the empirical evidence regarding factor-based return premia across multiple countries and asset classes.

Empirical Analysis

Regarding the empirical analysis, 48 portfolios are constructed consisting of one or more of eight main markets and asset classes: U.S. stocks, U.K. stocks, continental Europe stocks, Japanese stocks, country equity index futures, currencies, government bonds and commodity futures. Data for these assets is sourced from the website of Tobias Moskowitz covering the time period January 1982 – June 2010[4].

Global macroeconomic risk factors

Global risk measures are simply GDP-weighted averages of the CRR factors for all countries in the sample where GDP weights are determined by GDP per capita values denominated in USD as reported by the OECD. The five global risk factors are then computed as follows:

- **Growth rate of Industrial Production (MP):**

$$MP_t \equiv \log IP_t - \log IP_{t-1},$$

where IP_t is the global index production in month t.

- **Unexpected Inflation (UI):**

$$UI_t \equiv I_t - \mathbb{E}[I_t|t-1],$$

where the inflation rate is given as a function of the seasonally-adjusted consumer price index at time t: $I_t = \log CPI_t - \log CPI_{t-1}$ and the expected inflation is given as $\mathbb{E}[I_t|t-1] = r_{f,t} - \mathbb{E}[RHO_t|t-1]$, where $r_{f,t}$ is the Treasury bill rate and $RHO_t \equiv r_{f,t} - I_t$ is the realised return on Treasury bills.

[4] Further details regarding the test assets can be found in Asness, Moskowitz and Pedersen (2013).

- **Change in Expected Inflation (DEI):**

$$DEI_t \equiv \mathbb{E}[I_{t+1}|t] - \mathbb{E}[I_t|t-1]$$

- **Global Term Premium (UTS):** the spread between the ten-year and one-year Treasury bonds for the US and the spread between the long-term interest rate and the money market for other countries.

- **Default Spread (UPR):** the spread between Moody's *Baa* and *Aaa* rated corporate bonds.

Data for the variables included in the global risk measures described above relating to the United States is sourced from the Federal Bank of St. Louis. For all other countries, data is taken from Datastream.

Mimicking portfolios

Since three of the global CRR factors are non-traded, the authors construct mimicking portfolios of traded assets (referred to in the paper as "base assets") following the approach described in Lehmann and Modest (1988). The base assets in this case are the six value and momentum portfolios in Asness, Moskowitz and Pedersen (2013), i.e. high, medium and low value and momentum factor portfolios. The methodology for building these mimicking portfolios is described in the following steps:

- Regress excess returns of the six value and momentum portfolios on the five CRR factors and produce a (6×5) matrix, B, of the slope coefficients;

- Construct the (6×6) covariance matrix, V, of error terms;

- Calculate the (5×6) matrix of mimicking portfolio weights as $\omega = (B'V^{-1}B)^{-1}B'V^{-1}$;

- Given the $(T \times 6)$ matrix of returns (where T is the sample length), the mimicking portfolios are given by $\omega R'$

Are stocks integrated with other asset classes?

GMR captures the degree of integration for stocks across markets and asset classes

In order to validate the use of a global macroeconomic model, it is necessary to determine that stocks are integrated with other asset classes. The authors apply two tests of market integration. The first takes a global model which can explain the cross section of global asset returns and checks whether it can also explain the cross section of local returns as in Buchak (2015)[5]. In this case, asset pricing integration is implied if the model passes the GRS test[6]. Secondly, the authors compare the performance of GMR with local versions of the macroeconomic model. Here, they form a global tangency portfolio[7] using the six value and momentum portfolios from Asness, Moskowitz and Pedersen (2013) and regress the 48 portfolio excess returns (5 value and momentum for 8 markets and regions) on the global tangency portfolio and local specifications of the macroeconomic model in order to analyse differences in pricing errors.

[5] Relating to the paper "Can a Global Model Explain the Local Cross Section of Equity Returns?", a working paper from the University of Chicago.

[6] The GRS statistic is the Gibbons, Ross and Shanken (1989) statistic which quantifies portfolio efficiency by testing whether the estimated intercepts from a multiple regression model are jointly zero.

[7] The global tangency portfolio is the optimal portfolio in the risk-return sense after including the risk-free rate.

In summary, for both tests, it is determined that GMR is a "reasonable global model that captures integration in local markets and asset classes and that markets and asset classes are generally integrated globally."

How good is the GMR model?

The fundamental question now becomes: is GMR really a better model? One way to quantify whether this is the case is to compute pricing errors and factor loadings from regressing the returns of value and momentum portfolios on the global CRR factors (48 regressions):

$$r_{i,t} = \alpha_i + \beta_{i,MP} * MP_t + \beta_{i,UI} * UI_t + \beta_{i,DEI} * DEI_t + \beta_{i,UTS} * UTS_t \, \beta_{i,UI} * UTS_t + \varepsilon_{i,t}$$

Figure 11: Global macroeconomic exposure of value and momentum across markets and asset classes.

	Value			Momentum		
	Low	Medium	High	Low	Medium	High
U.S. Stocks	0.19	0.09	0.27	0.28	0.16	0.22
U.K. Stocks	-0.12	-0.08	-0.05	-0.18	0.02	-0.03
Europe Stocks	-0.04	0.11	0.15	-0.07	0.13	0.23
Japan Stocks	-0.45	-0.15	0.39	0.01	-0.09	-0.27
Country Indices	-0.53	-0.23	-0.17	**-0.49**	-0.28	-0.13
Currencies	-0.10	0.14	-0.15	-0.09	-0.20	-0.09
Fixed Income	0.24	0.16	0.15	**0.31**	0.21	0.12
Commodities	-0.05	-0.27	-0.28	-0.24	-0.18	-0.16

Source: "A Global Macroeconomic Risk Model for Value, Momentum, and Other Asset Classes" by Ilan Cooper, Andreea Mitrache, Richard Priestley. Used with permission. The table shows the alphas (pricing errors) from computing monthly regressions of portfolio excess returns on the five mimicking portfolios for the five global CRR factors. The sample covers the period January 1982 to June 2010. Bold values indicate statistical significance.

Pricing errors associated with GMR are small and mostly statistically insignificant

Alphas (pricing errors) resulting from the 48 regressions discussed above are reported in Figure 11. The first observation to note is that 29 of the alphas (over half) are negative. Secondly, only two (shown in bold) are statistically significant[8]. More importantly, the paper reports that, on the whole, pricing errors from the GMR model are small and less than those associated with single market portfolio models. This provides one support channel for GMR being adequate for modelling returns.

[8] The authors don't explicitly state it, but we assume statistical significance is associated with the 5% level.

Figure 12: Average and Dispersion of GMR Factor Loadings.

	Average β					Std. Dev β				
	MP	UI	DEI	UTS	UPR	MP	UI	DEI	UTS	UPR
All markets & asset classes	1.10	-2.12	-2.89	0.38	0.27	1.01	4.08	2.44	0.23	0.16
Equities across all markets	1.48	-3.02	-4.08	0.51	0.38	0.93	4.32	2.29	0.15	0.10
Country Indices	1.58	-1.02	-2.99	0.50	0.33	0.62	2.98	1.49	0.07	0.06
Currencies	0.21	-2.03	-1.63	0.14	0.11	0.64	3.29	1.65	0.14	0.06
Fixed Income	0.30	0.32	-0.10	0.04	0.06	0.34	1.61	0.69	0.07	0.04
Commodities	0.80	-2.13	-2.09	0.31	0.13	1.35	5.97	2.76	0.27	0.11

Source: "A Global Macroeconomic Risk Model for Value, Momentum, and Other Asset Classes" by Ilan Cooper, Andreea Mitrache, Richard Priestley. Used with permission. The table summarises the GMR factor loadings for all markets and asset classes. The first five columns show the average time series betas; the five columns on the far right report the standard deviation of time series betas.

When we consult Figure 12, we observe that cross-sectional differences in average betas are accompanied with large spreads in factor loadings. The key takeaway from Figure 12, therefore, is that this spread in factor loadings implies a spread in the expected returns associated with the various return premia, which is what is found empirically.

How does GMR compare with other asset pricing models?

GMR is compared with global CAPM and AMP3

Next, the performance of the GMR model is compared with that of the global CAPM and AMP3 according to several measures. Whilst the primary objective of the paper is not to conduct a horserace with competing risk models, a comparison of GMR with global CAPM and AMP based on numerous performance metrics serves to clarify that the GMR model is indeed a good description of the average returns.

In all but one case, a low value of these metrics indicates superior performance. The first of these is the GRS statistic (mentioned earlier). The second of these is the Hansen and Jagannathan (1977) distance (HJ), a function of pricing errors (alphas) scaled by the second moment matrix of test assets:

$$HJ = \sqrt{\alpha'\left(\mathbb{E}[rr]'^{-1}\right)\alpha}$$

The remaining metrics are functions of pricing errors and include the average absolute alpha ($A1 = A|\alpha_i|$), average absolute alpha divided by the average excess return on the global market index, $\overline{r_i}$, ($A2 = A|\alpha_i|/A|\,\overline{r_i}|$), the average squared alpha over the average squared value of $\overline{r_i}$, ($A3 = A\alpha_i^2/A\bar{r}_i^2$), the average of the estimates of the variances of sampling errors of the estimated alphas over the average squared alphas, ($A4 = As^2(\alpha_i)/A\alpha_i^2$) and the average value of the regression adjusted R^2 (A5).

Figure 13: Summary Statistics of test values.

Model	GRS	HJ	A1	A2	A3	A4	A5
Global CAPM	3.99	0.82	0.25	0.57	0.33	0.50	0.39
AMP3	3.99	0.75	0.18	0.43	0.21	0.85	0.43
Global CRR	2.82	0.68	0.18	0.43	0.18	1.06	0.44

Source: "A Global Macroeconomic Risk Model for Value, Momentum, and Other Asset Classes" by Ilan Cooper, Andreea Mitrache, Richard Priestley. Used with permission. The table above shows average test values for various metrics aimed to quantify which asset pricing model performs the best.

For the first three measures of alpha, low values imply that the dispersion of unexplained returns is low relative to the dispersion of returns of the test assets. A high value for the fourth metric indicates that the dispersion of unexplained returns is due to sampling error rather than variation in true alphas. Finally, it is desired that the average adjusted R^2 from the regression (A5) is high.

Overall, Figure 13 shows that GMR is consistently better than global CAPM and mostly better than AMP. Further robustness checks are provided, including:

- Evaluating the ability of each model to price the factors in the other models;
- Checking whether a linear combination of the GMR factors is mean-variance efficient[9].
- Computing time series regressions of long-short value, momentum and value-momentum combination portfolio returns on the global CRR factors for all asset classes and markets.
- Evaluating the ability of the global CRR factors to explain the returns on a different set of assets[10].

Robustness checks confirm GMRs global pricing ability.

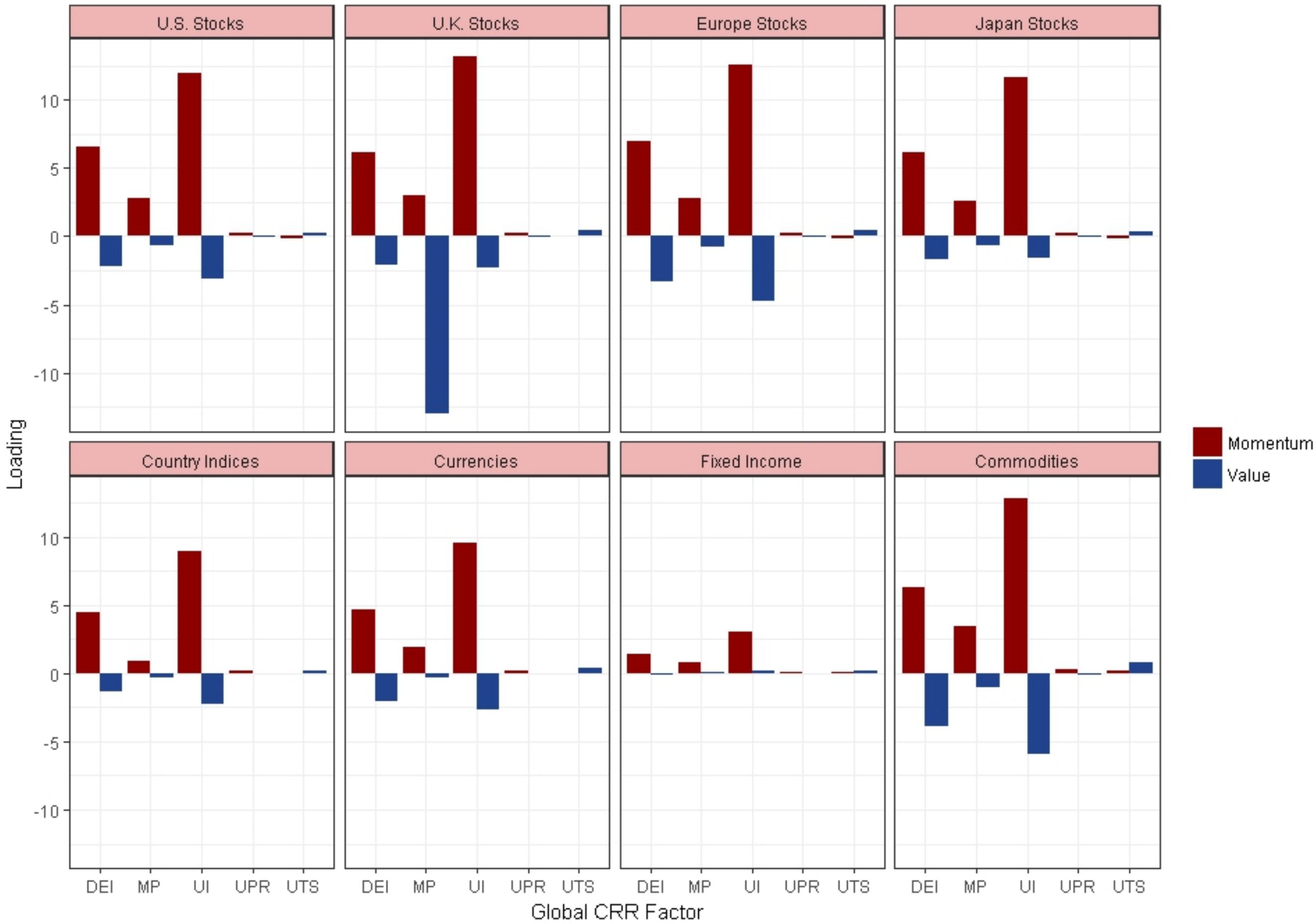
The verdict from carrying out the above aligns with the results already discussed above; GMR is a better model at describing average returns. Regarding the latter robustness check, it was found that the GMR model could, in most cases, explain the returns on a different set of base assets. For those cases where alphas were stastistically significant, these were substantially less than those associated with local CAPM and global CAPM alphas; for the case where all alphas were statistically significant, the model performed in line with CAPM and slightly better than global CAPM. On this same alternative set of base assets, it was shown that GMR performed better than CAPM and global CAPM according to the measures included in Figure 13. According to the authors, "we interpret this evidence as an out-of-sample robustness test". A final note on the robustness tests, Cooper et al. also form mimicking portfolios based on random noisy macroeconomic factors using the same procedure as before and compute the probability that noise-generated mimicking portfolios can replicate the pricing ability of the original mimicking portfolios. It turns out this probability is very small, implying it is unlikely that the pricing ability of GMR is good purely by chance.

Does GMR model the negative correlation?

Finally, can GMR account for the negative correlation between value and momentum returns? The first thing to note is that the factor loadings from regressing value and momentum returns on the GMR factors have, on the whole, opposite signs. This is true across asset classes and markets (apart from Fixed Income) and is visualised in Figure 14. Furthermore, the fact that value-momentum combination returns do not have neutral loadings on GMR factors explains the combined negative correlation and positive risk premia phenomenon. In addition, the implied correlation from fitted value and momentum portfolios is negative[11].

[9] This is motivated by Cochrane (2005) which states that "a factor model is true if and only if a linear combination of the factors is mean-variance efficient."
[10] The authors consider the set of assets in Lettau, Maggiori and Weber (2014).
[11] A series of fitted values for both value and momentum are calculated by multiplying the returns on the mimicking portfolios for the CRR factors with the estimated loadings.

Figure 14: Global macroeconomic exposures of value and momentum portfolios.



Source: "A Global Macroeconomic Risk Model for Value, Momentum, and Other Asset Classes" by Ilan Cooper, Andreea Mitrache, Richard Priestley. Used with permission. The bar charts show factor loadings of the value and momentum portfolios of Asness, Moskowitz and Pedersen (013) on the global CRR factors.

Bringing everything together, the paper provides support for a unified risk model by identifying common variation in expected returns across asset classes and countries. For the purpose of describing returns to factor-based portfolios across various groups of assets, (in this case value, momentum and value-momentum combination portfolios), the model proposed competes favourably with existing asset-pricing models in the extant literature on two grounds; it doesn't suffer the same limitations and directly maps returns to macroeconomic variables thus also relating returns to the business cycle.

"Risk and Risk Premia: A Cross Asset Class Analysis"

by Markus Ebner

In this paper, the author aims to bring together the analysis of various risk premia "to uncover their common performance characteristics, underlying risk sources and return sensitivity to economic factors". He analyses 16 different risk premia across five asset classes (we detail the premia below) to achieve these ends.

What is a risk premium?

Risk premia investing, according to the author, is based on the idea that investors are compensated for taking risks. This is, as he points out, completely in line with the efficient market hypothesis – if you assume a risk you are, on average and over time, paid for doing so. This is in contrast to behavioural explanations or "anomalies" which might "dissolve if too many market participants try to benefit" from them.

The author then goes on to give a brief but comprehensive overview of the risk premia which have been documented in the academic literature. We summarise the premia the author uses in Figure 15 below. For details of the academic references and explanations for the existence of the premia, please see the paper.

Figure 15: Risk Premia considered in the paper

	Risk Premia				
Asset Class	Market	Momentum	Size	Value	Carry
Equity	x	x	x	x	
Govt Bonds	x	x			x
Credit	x				x
Real Estate	x				
Commodity	x	x			x
FX		x		x	x

Source: UBS Quantitative Research.

Data

All the non-market risk premia are built in a cross-sectional fashion (long the best assets, short the worst) rather than in a time series sense. They are calculated using data from Datastream and their start dates vary from Jan 1975 (equity momentum and value) to Dec 1992 (FX value).

For the FX factors the author uses 8 developed market currencies (all against the US dollar) and 10 emerging currencies and builds the factor portfolios out of these two subgroups, to "diminish the tendency towards emerging markets for FX value and carry strategies". Also, in contrast to our work on cross asset value (Harvesting Cross-Asset Value, 11 Dec 2014) this paper uses the ratio of the current exchange rate to purchasing power parity as its definition of FX value.

Although the author discusses "equity carry" (i.e. dividend yield) he doesn't include it in his set of risk premia.

Finally, to quote the author "the potential explanations for momentum effects are manifold".

The author starts by analysing the return statistics of each factor both from their respective start dates and from the common date of Dec 1992. In both cases there is one premia with a negative return (government bond momentum in the first case; equity value in the second) and the Sharpe ratios in both cases range from a small negative to 0.92, averaging around 0.35 in both cases. The majority of risk premia have negative skewness and all of them have positive excess kurtosis.

Do volatility, skewness and kurtosis affect returns?

The author then analyses (via a fixed effects panel regression using monthly data) whether risk premia returns are sensitive to their volatility, skewness and kurtosis. One would expect higher returns for risk premia with "unfavourable characteristics" (i.e. high volatility, negative skewness, high kurtosis). The results, reproduced in Figure 16 show the correct sign for all three factors individually but only the sensitivity to volatility is significant[12], and this remains the case when all three factors are included in one regression.

Figure 16: Distribution Characteristics

lag 1	lag 2	lag 3	Volatility	Skewness	Kurtosis
-0.0380**	0.0366**	0.0413**	0.0823**		
(0.0165)	(0.0164)	(0.0166)	(0. 0344)		
-0.0351**	0.0394**	0.0440***		-0.003	
(0.0166)	(0.0166)	(0.0167)		(0.0019)	
-0.0371**	0.0372**	0.0418**			0.0005
(0.0165)	(0.0165)	(0.0166)			(0.0003)
0.0036**	0.0381**	0.0428**	0.0782*	-0.0021	-0.0001
(0.0165)	(0.0166)	(0.0167)	(0.0427)	(0.0024)	(0.0005)

Source: Risk and Risk Premia: A Cross Asset Class Analysis by Markus Ebner. Used with permission. This table provides coefficients and standard errors (in parentheses) from fixed-effect panel regression of the risk premia's monthly returns with lagged returns of 1-3 months and volatility, skewness and) kurtosis. The calculation is done on a monthly basis with increasing sample size. The sample period for the panel estimation is from Dec. 1995 to Dec. 2014. Significance levels: ***=1%, **=5%, *=10%.

Co-moments against equities are important

The next analysis undertaken in the paper considers co-moments of the risk premia with US equities, US government bonds and a global market portfolio. This extends the above analysis to a portfolio context – an asset would be an attractive addition to an existing portfolio if it has a negative correlation, or reduced the kurtosis (i.e. the asset had a negative co-kurtosis with the portfolio) or increased the skewness (positive co-skewness). For example, for an investor holding the S&P 500, US government bonds are attractive because they have a negative co-kurtosis (-3.73), a negative correlation (-0.17) and a positive co-skewness. Hence a portfolio of US equities and US bonds looks more attractive on all three risk measures.

For a US equity investor, US government bonds are the only asset class that increases the portfolio's skewness, whereas for a holder of US government bonds then credit, commodity and FX momentum, both value premia and commodity carry all help. Many of the risk premia have negative correlations with all three market portfolios.

Given this argument, as with the discussion above in the review of "The Skewness of Commodity Futures Returns", one would expect the demand for a risk premia with high co-skewness to be higher and hence the future returns to this premia to

[12] Note – one has to include various lagged returns in order to account for the documented autocorrelation effects for various risk premia. The author finds a negative sensitivity at lag 1 and a positive one at lags 2 and 3.

be lower. The same argument can be made for low co-kurtosis and low correlation (or beta). For the global market and the S&P 500 the author finds these conclusions to be the case – "attractive" risk premia have lower expected returns. For the US bond market the author finds the opposite effect for beta and co-kurtosis. He postulates that "this may be caused by the fact that US bonds are already a good diversifier to the global market portfolio".

Moving on from considering the risk premia by themselves, the author then analyses the effects of macroeconomic regimes on the returns of the premia. The economic measures used by the author have been used elsewhere in the literature and are documented in Figure 17.

Figure 17: Macro variables

Factor	Definition
Recessions	NBER classification
Industrial Production	Monthly change in US IP
Inflation	Monthly change in US CPI
Volatility	Volatility of daily returns over one month
Funding Liquidity	TED Spread
Market Liquidity	Pastor and Stambaugh (2003) liquidity factor

Source: Risk and Risk Premia: A Cross Asset Class Analysis by Markus Ebner. Used with permission

Most of the risk premia have a higher return during normal times than in recessions, but only for US equities is the difference significant. Interestingly government bonds, size (small – large), FX value and commodity carry have higher returns during the recessionary periods in the data set. A summary of the author's results is shown in Figure 18, where we show the sign of the difference in returns, highlighting those differences which are significant.

Figure 18: Summary of relationship between risk premia and economic regimes

	Expansion - Recession	High - Low Industrial Production	High - Low Inflation	High - Low Funding Liquidity	High - Low Market Liquidity	High - Low Volatility
MKT.Eq	+	+	-	+	+	-
MKT.Gov	-	-	-	-	-	+
MKT.Credit	+	-	-	+	+	+
MKT.REITs	+	+	-	+	+	-
MKT.Comm	+	-	-	+	+	-
MOM.Eq	+	+	-	+	-	-
MOM.Gov	+	+	+	+	+	+
MOM.Comm	+	-	+	-	-	-
MOM.FX	+	+	+	+	+	-
Size.Eq	-	-	+	+	+	-
Value.Eq	+	-	+	+	+	+
Value.FX	-	-	-	-	+	-
Carry.Gov	+	-	-	+	-	-
Carry.Credit	+	+	-	+	+	-
Carry.Comm	-	+	+	-	-	+
Carry.FX	+	+	-	+	+	-

Source: UBS (summary), Risk and Risk Premia: A Cross Asset Class Analysis by Markus Ebner (underlying data). Used with permission.

Industrial production, funding liquidity and inflation affect risk premia returns in general

Given these results the author then runs another series of panel regressions on each macroeconomic factor separately and finds that the expected returns of risk premia are superior during periods of strong increases in industrial production, periods of high funding liquidity and low increases in inflation[13] but the results for market liquidity and volatility are insignificant. Running a multivariate regression on the three individually significant factors gives a significant coefficient only to the

[13] Using a lagged version of inflation and industrial production to take into account data availability.

change in industrial production (which the author suggests might be due to the correlation between the variables).

The final analysis in the paper looks at whether the individual betas of the risk premia to the macroeconomic variables explain any of the returns (i.e. if one risk premia has a low beta to industrial production and another has a high beta, does this explain the difference in their returns?) Risk premia with high sensitivities to market volatility and funding liquidity tend to have higher expected returns.

This paper shows that there are interesting commonalities between all the risk premia studied in terms of their macroeconomic sensitivities and overall behaviour.

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