Original Article

A dynamic analysis of higher-comoment risk premiums in hedge fund returns

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ABSTRACT Hedge funds display a strong non-linear payoff structure because of the use of highly dynamic trading strategies. This article examines the relevance of using higher-order comoment equity risk premiums implied in the United States and the emerging markets for capturing these return non-linearities. We provide evidence that the higher-order comoment equity risk premiums help in explaining the returns of the different hedge fund strategies from the *Hedge Fund Research* classification. We perform a dynamic analysis where moment risk exposures are examined separately in up and down markets. We show that hedge fund styles tend to vary their exposures to moment risks according to the market regimes.

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INTRODUCTION

The very first studies on hedge funds performed a mean-variance analysis of their returns: Hedge funds were only priced for their linear comovements (that is, covariance) with various market indexes (Agarwal and Naik, 2000). However, in the last 10 years, empirical works have demonstrated significant asymmetries and significant fat tails in the hedge fund return payoffs

(for example, Brooks and Kat, 2002; Ding and Shawky, 2007; Haglund, 2010). The non-linearities are translated into non-linear comovements of hedge funds with passive market indexes.

Such asymmetric payoffs have first been modelled through positions in derivatives on the US equity market (Agarwal and Naik, 2004). Very recently, some authors have exploited the contribution of the funds to

the skewness and the kurtosis risks embedded in the US market portfolio. For instance, Kat and Miffre (2005) and Agarwal *et al* (2010) have constructed coskewness and cokurtosis risk premiums for the US equity market and have tested the power of their self-computed moment-related factors on hedge fund returns.¹

This article contributes to the literature on multi-moment models by including the coskewness and the cokurtosis risk premiums embedded in the emerging stock markets. Although suggested in Agarwal *et al* (2010), higher-moments in other markets than the US markets have not yet been explored as possible explaining variables when pricing hedge funds. The study of Capocci and Hübner (2004) has, however, shown that hedge funds invest in the emerging bond markets. Therefore, the high levels of negative skewness and positive kurtosis exhibited by the emerging equity markets could also be interesting to investigate (Hwang and Satchell, 1999; Iqbal *et al*, 2010).

In addition, as hedge funds tend to shift investment strategies in response to changing market conditions (Kuenzi and Shi, 2007; Bollen and Whaley, 2009), we investigate the extent to which hedge funds are timing their exposure towards skewness and kurtosis risks in bull and bear markets.

The article is structured as follows. The next section presents the hedge fund data used for conducting our analysis and details the methodology used for constructing the coskewness and cokurtosis equity risk premiums. Subsequent section introduces the factor model approach with market-based factors, as well as innovative option- and distribution-based factors. The penultimate section discusses the results. The final section concludes.

DATA

Hedge fund data

We extract data on hedge funds from the *Hedge Fund Research, Inc.* database. We work separately on the following two time periods. First, we collect the monthly returns for 7533 individual hedge funds² from December 1997 to December 2007. This sample includes the technology bubble of the late 1990s, the severe market deflation of the early 2000s and the major market crises that tumbled on financial markets (Russian Crisis, LTCM collapse, Asian Crisis, Terrorist Attacks). Second, in order to highlight the effect of the financial crisis started in December 2007, we include data on 3310 funds from January 2008 to March 2009. This sample period is particularly interesting for studying skewness and kurtosis risks in time of economic turmoil.

We analyse the five hedge fund styles defined by the *Hedge Fund Research, Inc.* classification, that is, Equity Hedge (EH), Event Driven (ED), Macro (M), Relative Value (RV) and Funds of Hedge Funds (FF). Individual funds are sorted according to their investment style; each style portfolio is defined as the equally-weighted average return of all funds belonging to that category during the given month.³ We have to note that these portfolios provide a complete representation of each hedge fund style. The use of hedge fund indexes would not have provided such sample coverage.

Multi-moment premiums

This article evaluates the significance of higher-order comoment risk premiums in the United States and the emerging equity markets. For constructing these factors, we collect the monthly returns and market values of the stocks

composing each market. Data on 11 377 stocks were collected from the US market. We moreover consider 2259 stocks from 26 emerging countries⁴ over the December 1997 – December 2007 period plus 2794 stocks from January 2008 to March 2009. We compute a value-weighted portfolio made of all equity assets for both markets, and use these as benchmarks for the covariance risk in these two markets.

We also consider two portfolios that display, respectively, a unitary coskewness and cokurtosis with the two market aggregates. For this purpose, we follow the methodology developed by Lambert and Hübner (2011) and perform a conditional triple sort of the stocks listed on the United States and the emerging markets on the basis of their higher-order comoments with the market aggregates. The premiums are then formed from the return spreads composing the 27 portfolios.

Table 1 displays some descriptive statistics about the covariance (USCOV and EMCOV), coskewness (USSK and EMSK) and cokurtosis (USKU and EMKU) risk factors in the United States and emerging stock markets.

From December 1997 to December 2007 (Panel A), the returns related to a unit exposure to cokurtosis risk in the emerging markets are superior to the levels of the same indicator in the US markets. The returns related to a unit exposure to coskewness risk in the emerging markets are, however, inferior to the levels of the same indicator in the US markets. As also evidenced by Iqbal *et al* (2010), the kurtosis effect looks stronger than the skewness effect in the emerging stock markets. Panel B redoes the analysis after including data on the recent financial crisis (that is, the period from January 2008 to March 2009). As expected, the historical

average return in both markets has been substantially decreased by the financial crisis. The coskewness premiums in both markets have also suffered from the crisis: the average returns of the premiums decrease, respectively, to -0.01 per cent and -0.03 per cent in the United States and emerging stock markets. Comparing the descriptive statistics over the cokurtosis premiums in both markets, we still observe a stronger cokurtosis effect in the emerging markets compared with the US markets.

FACTOR MODEL APPROACH

This section carries out regression-based analyses on the net-of-fees excess returns of the five hedge fund portfolios defined in hedge fund data section.

We consider four sets of explanatory variables. We first examine a set of asset-based⁵ and conditioning factors to capture the directional exposures in hedge fund styles. We make the assumption that hedge fund managers exploit available economic information in order to allocate their exposures towards the emerging and the US stock markets but also towards the risk captured by the size, the book-to-market and the momentum mimicking portfolios of Fama and French (1993) and Carhart (1997). Therefore, we condition the exposures to these risks onto the value taken by the United States risk-neutral volatility index or VIX (V), the US term spread (S), the US credit spread (C) and the US 3-month risk-free rate (R). We consider these four information variables (Z_j) to construct time-varying risk premiums or conditioning factors ($F'_{k,t}$) for the five market-based factors defined above ($F_{k,t}$)⁶

$$F'_{k,t} = (Z_{j,t-1} - \bar{Z}_j)F_{k,t} \quad (1)$$

Table 1: Summary statistics on comoment equity risk premiums in the United States and emerging markets

Type	Symbol	Mean (%)	Median (%)	Maximum (%)	Minimum (%)	SD (%)	Skewness	Kurtosis	J-B
<i>Panel A: December 1997–December 2007</i>									
<i>US stock market</i>									
Covariance	USCOV	0.53	0.85	8.14	−15.60	3.80	−0.8237	4.7363	28.88***
Coskewness	USSK	0.15	−0.08	5.17	−4.71	2.02	0.0036	2.5111	1.21***
Cokurtosis	USKU	0.31	0.35	12.88	−10.99	3.80	0.0665	5.0738	21.77***
<i>EM stock market</i>									
Covariance	EMCOV	1.69	2.24	17.84	−26.71	6.64	−0.8359	4.8911	32.12***
Coskewness	EMSK	0.02	0.26	13.50	−10.32	4.19	0.1274	3.7619	3.25
Cokurtosis	EMKU	0.54	0.29	13.13	−13.90	4.20	0.0535	4.0576	5.70*
<i>Panel B: December 1997–March 2009</i>									
<i>US stock market</i>									
Covariance	USCOV	0.07	0.77	8.76	−18.54	4.45	−1.0675	5.1909	53.03***
Coskewness	USSK	−0.01	−0.09	5.17	−8.21	2.26	−0.5289	3.7555	9.57***
Cokurtosis	USKU	0.30	0.35	13.41	−11.67	3.83	0.0702	4.9053	20.68***
<i>EM stock market</i>									
Covariance	EMCOV	0.97	1.70	17.40	−27.14	6.58	−0.7419	4.6223	27.39***
Coskewness	EMSK	−0.03	0.13	13.50	−10.32	4.13	0.1763	3.7664	4.03
Cokurtosis	EMKU	0.40	0.22	13.13	−13.90	4.26	0.0369	3.8143	3.79

Table 1 presents some summary statistics for the US and emerging markets (EM) comoment risk premiums over the following two time periods: Panel A covers the period from December 1997 to December 2007, while Panel B covers data from December 1997 up to March 2009. *, ** and *** stand for significant at 10, 5 and 1 per cent, respectively. *SD*=Standard Deviation, *J-B*=Jarque–Bera statistics.

We then examine the effects of introducing non-linear regressors into the market-based factor model. First, we consider the explanatory power of three optional factors published by the CBOE in pricing hedge fund returns.⁷ Second, we test the significance of the coskewness and cokurtosis risk premiums defined on the United States and on the emerging stock markets.

We try to explain hedge fund returns with the minimum set of variables encompassed by this

model. Namely, we search for the minimum set of variables that minimizes the Akaike Information Criterion of the regression model.

The exposures to the higher-order risk premiums might, however, change according to a modification of the individual's risk aversion. Indeed, the coskewness and the cokurtosis premiums reward the probability of an extreme loss event. Therefore, in upturn, the investors might accept such a risk, but in downturn they

might be willing to pay a premium to escape from risks alternative to the covariance. As a consequence, hedge funds could tend to vary the intensity of their higher-moment exposures.

We follow Pettengill *et al* (1995), Okunev and White (2003), and Hung *et al* (2004) and consider the exposures to the United States and the emerging markets coskewness and cokurtosis premiums asymmetrically in up and down markets.

RESULTS AND DISCUSSION

For each hedge fund portfolio, we select the subset of factor that best characterizes – along the Akaike Information Criterion – the fund return variation.

The model estimations over the December 1997–December 2007 period are displayed in Table 2.

The regression-based analyses demonstrate asymmetric exposures to coskewness and cokurtosis risks in both the United States and the emerging stock markets according to the conditions in these markets. Put differently, Table 2 shows that all hedge fund styles tend to time the riskiness of their investment strategies according to the favourable or unfavourable conditions in these markets. The analysis of non-directional risk exposures in hedge fund returns demonstrates the economic value of the US coskewness equity risk premium for the EH, RV and FF strategies. These hedge fund styles tend to be exposed to this downward risk in up market periods only. Kurtosis risks embedded in the emerging stock markets explain a significant part of the risks born by ED and M Funds in down market. In addition, the non-linear return structure of the M funds seems also to be related to the kurtosis risks embedded in the US stock market in downturn. This supports the evidence

that, whereas the coskewness risks are stronger in the US stock market, the cokurtosis risks mostly matter in the emerging stock markets (Hwang and Satchell, 1999; Iqbal *et al*, 2010).

To highlight the full blow of the financial crisis started in December 2007, Table 3 extends the sample period of Table 2 up to March 2009.

The goodness of fit of the regression-based analyses conducted in Table 3 is slightly inferior to the one displayed in Table 2. One explanation can be found in the large return instability that prevails in this period. We further examine whether the funds offer abnormal return over the extended period. Whereas the α estimates of all strategies but the FF were significant over the 1997–2007 period, the abnormal performance of the M and the RV funds get insignificant when considering the January 2008 – March 2009 period. The risk-adjusted return of the ED category is also substantially reduced in Table 3.

The US coskewness equity risk premium comes out as a significant common factor across all hedge fund styles. The five portfolios indeed present significant negative exposures to the US skewness risk during the economic turmoil of 2008–2009. Intuitively, hedge fund managers could be able to hedge their downward risks, especially during market downturn. Billio *et al* (forthcoming) analyse the market risk exposures of several hedge fund style indexes over different market regimes during the 1994–2009 period. Their results also suggest that the exposures to the US equity market are small or even negative in economic turmoil compared with the levels in more tranquil periods. In addition, comparing Table 3 with Table 2, all hedge fund styles but the M strategy reduce their exposures to the US market risks during financial distress. On the one hand, EH funds and the RV funds reduce their

Table 2: Higher-moment option pricing models (December 1997 – December 2007)

	HFR classification				FF
	EH	ED	M	RV	
Assets					
USCOV	0.4634***	0.3158***	—	—	0.1502***
EMCOV	0.0954***	—	0.2877***	0.0524***	0.1070***
SMB	0.1691***	0.1604***	—	0.0759***	0.1044***
HML	0.0734***	0.1124***	0.0677**	0.0665***	0.0841***
UMD	—	−0.0323***	0.0762***	—	0.0569***
WEX	0.1151	—	0.2029**	0.2153***	0.2100***
EMB	—	—	0.0976***	—	—
WGBI	—	—	—	0.6037***	—
USGOV	—	—	—	—	—
CBY	4.8955***	—	—	3.0523***	2.8106***
Instruments					
ZCUSCOV	—	—	—	—	—
ZRUSCOV	—	2.6572***	—	—	—
ZSUSCOV	—	—	−14.5141***	−19.7734***	−9.4580***
ZVUSCOV	—	—	—	—	—
ZCEMCOV	—	—	—	—	8.1374**
ZREMCOV	3.0120***	—	—	—	—
ZSEMCOV	—	—	—	6.0792**	—
ZVEMCOV	—	—	—	—	—
ZCSMB	6.2990*	—	13.7786***	—	—
ZRSMB	—	—	—	—	—
ZSSMB	—	—	—	—	5.7577**
ZVSMB	—	—	—	—	—
ZCHML	—	—	—	—	—

ZRHML	—	—	—	—	—	—
ZSHML	8.0092***	—	—	—	—	—
ZVHML	—	—	—	—	—	—
ZCUMD	—	—	—	7.0167**	—	8.1565***
ZRUMD	0.6247	—	1.2825**	—	—	—
ZSUMD	—	—	—	—	—	—
ZVUMD	—	—	—	—	—	—
<i>Options</i>						
Short Put	—	—	—	—	—	−0.2610***
B&W(ATM)	—	—	—	—	—	—
B&W(OTM)	−0.2683**	—	—	—	—	—
<i>Moments</i>						
USSK _{down}	—	—	—	—	—	—
USKU _{down}	—	—	−0.0806*	—	—	—
EMSK _{down}	—	—	—	—	—	—
EMKU _{down}	—	−0.0398*	−0.0624*	—	—	—
USSK _{up}	−0.1090**	—	—	−0.0662*	—	−0.1368***
USKU _{up}	—	—	—	—	—	—
EMSK _{up}	—	—	—	—	—	—
EMKU _{up}	—	—	—	—	—	—
α (%)	−2.10***	0.5093***	0.2017*	−1.0402*	−1.3094	—
AIC	−7.03	−6.96	−6.29	−7.25	−7.28	—
Adjusted R^2 (%)	91.61	76.87	85.22	56.61	81.83	—

Table 2 presents the outputs (β loadings, α , adjusted R^2 and Akaike Information Criterion or AIC) of a higher-order moment option pricing model with market- (with instruments), option-based factors and with asymmetric exposures to US and emerging markets coskewness and cokurtosis risk premiums. *, ** and *** stand for significant at 10, 5 and 1 per cent, respectively.

Table 3: Higher-moment option pricing models (December 1997 – March 2009)

	HFR classification				FF
	EH	ED	M	RV	
Assets					
USCOV	0.4523***	0.2439***	—	—	0.1107**
EMCOV	0.1375***	0.0734***	0.3151***	—	0.1221***
SMB	0.1355***	0.1076***	—	0.0620***	0.0528***
HML	0.0543**	0.0834***	0.0826**	—	—
UMD	0.0297**	—	0.0663***	—	0.0428***
WEX	—	—	—	0.3409***	0.2697***
EMB	—	—	0.1258***	0.0395*	—
WGBI	−0.4934**	—	—	—	—
USGOV	—	—	—	—	—
CBY	3.9410***	—	—	2.7465**	3.0366***
Instruments					
ZCUSCOV	—	−2.2448**	—	—	−3.2724***
ZRUSCOV	—	—	—	—	—
ZSUSCOV	—	—	—	−6.8452**	—
ZVUSCOV	—	—	—	—	—
ZCEMCOV	—	—	—	—	2.3661***
ZREMCOV	3.0898***	2.0499***	—	1.6090**	—
ZSEMCOV	—	—	−4.1559***	—	—
ZVEMCOV	—	—	—	—	—
ZCSMB	6.8467*	—	—	—	—
ZRSMB	—	—	—	—	—
ZSSMB	—	—	—	6.9794**	—
ZVSMB	—	—	—	—	—
ZCHML	—	—	—	—	—

ZRHML	—	—	—	—	—	—
ZSHML	—	—	6.2270**	—	—	—
ZVHML	—	—	—	—	—	—
ZCUMD	—	—	—	—	—	3.5946*
ZRUMD	1.3697**	—	1.6774***	—	—	—
ZSUMD	—	—	—	—	—	—
ZVUMD	—	—	—	—	—	—
<i>Options</i>						
Short Put	—	—	—0.7573***	—	—	—
B&W(ATM)	—	—	—	—	—	—
B&W(OTM)	−0.2776**	—	0.4618**	—	—	−0.3127**
<i>Moments</i>						
USSK _{down}	−0.1962***	−0.1178***	−0.1714**	−0.1170**	−0.1344***	—
USKU _{down}	—	—	—	—	—	—
EMSK _{down}	—	—	—	—	—	—
EMKU _{down}	—	—	−0.0568	—	—	—
USSK _{up}	−0.1043*	—	—	−0.1064***	—	—
USKU _{up}	—	—	—	—	—	—
EMSK _{up}	—	—	—	—	—	—
EMKU _{up}	—	—	—	—	—	—
α (%)	−1.8667***	0.2894***	0.1596	−1.0225	−1.52**	—
AIC	−6.63	−6.57	−6.12	−6.60	−6.86	—
Adjusted R^2 (%)	89.29	74.93	81.57	67.50	80.67	—

Table 3 presents the outputs (β loadings, α , adjusted R^2 and Akaike Information Criterion or AIC) of a higher-order moment option pricing model with market- (with instruments), option-based factors and with asymmetric exposures to US and emerging markets coskewness and cokurtosis risk premiums. *, ** and *** stand for significant at 10, 5 and 1 per cent, respectively.

exposures towards the US Corporate Bond Yield index compared with the same risk estimates over the 1997–2007 period. On the other hand, the ED and the FF styles also present reduced exposures to the US covariance risk premium, as well as to empirical sources of risk from the US equity market like the outperformance of small stocks over big stocks, of value over growth firms and of persistent winner over loser stocks.

Table 2 demonstrates the relevance of both the US coskewness and the emerging markets cokurtosis premiums in explaining the hedge fund return variability. In the period from December 1997 up to March 2009, the significant exposures to the emerging markets cokurtosis premium – which was significant in explaining the returns for the M and the ED funds – are subsumed by significant exposures to the US coskewness risk across all funds. The highest downward risks are indeed to be found in the US markets at this time period. However, although not significant, the cokurtosis premium estimated from the emerging markets still contributes to improve the Akaike Information Criterion of the multifactor model conducted on M funds. In addition, both the JP Morgan Emerging Market Bond Index and the emerging market aggregate are significant in explaining the M funds return variation. In other words, the emerging markets still play a role in explaining the risk profile of this hedge fund style. Finally, similar to Table 2, skewness remains the most important risk in the US equity market.

CONCLUDING REMARKS

Hedge funds display a strong non-linear payoff structure because of the use of highly dynamic

trading strategies. This study outlines the importance of the coskewness risk premium embedded in the US stock markets and of the emerging markets cokurtosis risk premium for evaluating the hedge fund non-linear return structure. Our performance attribution model is evaluated for the five hedge fund styles of the *Hedge Fund Research, Inc.* classification.

On the one hand, the coskewness premium appears to be relevant for evaluating the returns of EH, RV and FF, whereas the relevance of the cokurtosis risk premium embedded in the emerging stock markets is emphasized in the ED and M styles. On the other hand, it appears that exposures to higher-moment risks vary from up to down market regimes. Our analysis even suggests that hedge fund managers were able to hedge their market exposures and their downward risks during the recent subprime crisis.

To conclude, this analysis shows that substantial improvement can be achieved by considering the covariance, the coskewness and the cokurtosis in another market than the US stock market. The main challenge for future research is the investigation of higher-order comoments in other markets actively traded by alternative investment funds.

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NOTES

1. The study of Lambert and Hübner (2011) proposes an improvement of the former methodologies used in constructing moment-related factors.
2. In order to limit any reporting biases, we have removed from the database all the funds that reported results for less than 12 consecutive months or that do not report in US dollars (1511 out of 7533 funds were excluded because of these restrictions).
3. All observations with a monthly return superior to 100 per cent or equal to 0 around the date of observation (lead and lag of 1 month), indicating possible reporting errors, were excluded from the final data set.
4. We download data about the constituents of the BMI S&P Emerging Index covering 26 emerging economies: Argentina, Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Indonesia, Israel, Jordan, Korea, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Russia, South Africa, Taiwan, Thailand, Turkey and Venezuela. We control for exchange rate risk by converting all prices to a common currency, namely the US dollar.
5. The JP Morgan US Government Bond Index (USGOV), the Citigroup World Government Bond Index excluding US (WGBI), the JP Morgan Emerging Market Bond Index (EMB), the US Corporate Bond Yield-middle rate (CBY), the US and Emerging stock markets aggregates (USCOV and EMCOV), the MSCI World Index excluding US (WEX), the Fama and French size (SMB) and value (HML) factors, and finally the Carhart momentum factor (UMD).
6. We refer to the conditioning factor $F'_{k,t}$ by the letter 'Z' followed by the symbol standing for the information variable (that is, V, S, C or R) and the name of the explanatory factor. For instance, ZCUSCOV stands for the USCOV factor conditional on the levels of the US default spread.
7. We consider three option-like strategies published by the Chicago Board Options Exchange (CBOE). The first option-like factor corresponds to the payoffs of a strategy that sells a sequence of 1-month at-the-money (ATM) S&P 500 index puts, and invests cash in 1-month and 3-month Treasury bill rates. The second option-like factor corresponds to a covered call strategy, that is, an investment strategy where an investor buys a stock or a basket of stocks, and also writes ATM call options on the stock (buy and write – *B&W* – strategy). Both strategies enhance portfolio performance in a mean-variance framework. Indeed, when introduced into a portfolio, they reduce the portfolio volatility because of their low level of linear correlation with traditional assets. It comes, however, at the cost of decreasing skewness and of increasing kurtosis of the portfolio. Finally, we consider the same buy and write call strategy using 2 per cent out-of-the-money (OTM) calls. All these factors are proxies for dynamic strategies often implemented by hedge fund managers.

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