Do Hedge Funds Hedge? New Evidence from Volatility Risk Premia Embedded in VIX Options

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Background

Figure 1: **A culture of secrecy.** Understanding complex hedge funds strategies has become crucial to explain hedge fund performance, managers' skills, and compensation scheme

Background

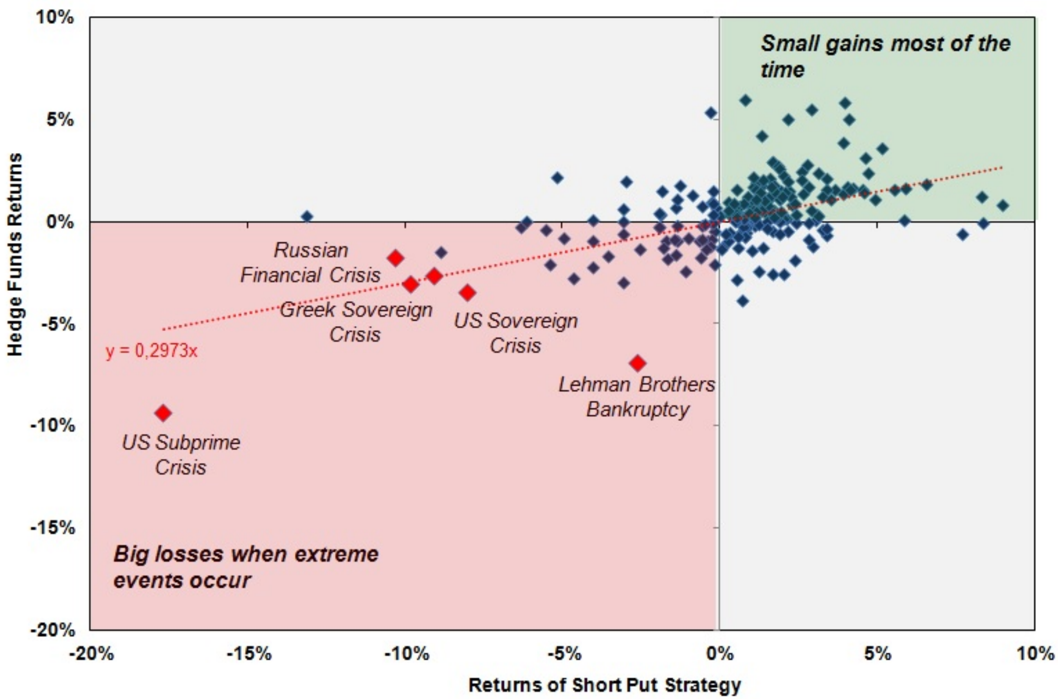

Figure 2: **Penny-by-penny gains before big losses.** This scatterplot exhibits monthly returns between Hedge Fund Global Index and **S&P 500 Put Write Index** over the period from January 1998 to June 2017

Background

Alpha or Beta?

" Hedge funds may have strategies that yield payoffs similar to those of a ***company selling earthquake insurance****; that is, most of the time the insurance company makes no payouts and has a nice profit, but from time to time* ***disaster strikes*** *and the insurance company makes large losses that may exceed its cumulative profits from good times. (...) Others have described hedge fund strategies as* ***picking up pennies in front of a steamroller****."*

" A hedge fund that implements a strategy akin to selling earthquake insurance and whose ***risk is not captured well*** *by commonly used risk factors will have a significant positive* ***alpha****—until the quake hits."*

R. Stulz, *Journal of Economic Perspectives*, **2007**

Background

Alpha or Beta?

" Exotic risks are also referred to as "advanced", ***"alternative", or "smart" beta*** *in the literature (e.g., Carhart et al. 2014). In our taxonomy, we separate premium-bearing risks into those that are generally available through liquid, low-cost, and transparent investment vehicles such as index mutual funds or ETFs* ***(traditional beta)*** *from those that can typically only be obtained through* ***hedge funds (exotic beta)****. "*

V. Agarwal, C. Green, and H. Ren, *Journal of Financial Economics*, **2017**

Our Paper

- HF are not just selling put options but this example is interesting
- The PNL of the strategy is (at least) impacted by two factors
  - When PRICE drops, Put Premium increases, PNL is NEGATIVE
  - When VOL spikes, Put Premium increases, PNL is NEGATIVE
- Under the standard Black-Scholes framework, the two factors are not treated in the same manner
  - (log)-PRICE Variations are stochastic (return **distribution**)
  - (log)-VOL is a **parameter** (potentially time-varying)
- How to take into account the stochastic nature of the VOL?

Our Paper

- Generally, HF use derivatives to "hedge" some risks, and then are exposed to VOL (**distribution**)
- What is the impact of the stochastic nature of VOL (**distribution**) on:
  - Portfolio/Investment decisions ?
  - In turn, the cross-section of HF returns ?
- Already been investigated in Agarwal, Arisoy, Naik (JFE, 2017) paper **BUT**
  - They implicitly assume that the (log)-VOL is **normally distributed**
  - They build an investment strategy to get an exposure to the **VOL** of the (log)-VOL distribution
  - They use this factor in an asset pricing exercice
- Can we extend the study to higher-order moments (**SKEW, KURT)** of the (log)-VOL distribution ?

Our Paper

We solve several technical issues:

1. **The data issue:**
   - How to filter from VIX option market data some information about the **implied distribution** of VOL ?
   - How to filter from VIX spot returns a proxy for the **historical distribution** of VOL ?
2. **The investable factor issue:**
   - How to build an investable strategy exposed to **VOL** of VOL ?
   - How to build an investable strategy exposed to **SKEW** of VOL ?
   - How to build an investable strategy exposed to **KURT** of VOL ?

Main Findings

1 - HF are particularly VOL sensitive

HF are exposed to VOL risk, and the **3 VOL risk premia** are instrumental determinants of HF performance

2 - VOL sensitivity substantially arises from VOL of VOL

HF are particularly negatively exposed to **VOL of VOL**. This is especially true for **Relative Value** and **Equity Hedge** during crises when uncertainty is high

3 - HF are also exposed to higher-order moments of VOL

Relative Value and **Directional** are positively exposed to **SKEW of VOL**. **Global Macro** are positively exposed to **SKEW of VOL**. **Merger Arb** are positively exposed to **KURT of VOL** during crises

First Contribution - Evidence from HF Performance

- Volatility is instrumental in both **time-series** and **cross-section**
- Does **HF alpha** arise from volatility strategies ?
- Use of **multiple option-based** dynamic trading strategies

Existing literature

- Asness et al. (2001), Geman et al. (2003), Agarwal and Naik (2004), Stulz (2007), Patton (2009), Agarwal, Arisoy, and Naik (2015), Agarwal, Green, and Ren (2017)
- Extract VOL risks in HF from **nontradable** risk measures, or **standard** and **fragmentary** option-based strategies

Our contribution

- Extract VOL risks from **multiple** tradable **VOL risk premia**
- As **decomposed** into **VOL, SKEW and KURT of VOL** strategies
- Shows they are instrumental **determinants** in HF performance

Second Contribution - Evidence for Risk Premia Strats

- Most HF styles sell crash insurance, but VOL risk exposures across HF styles are **complex**
- Depend on **specific** trading strategies they use to "hedge" risk exposures

Existing literature

- Ait-Sahalia et al. (2001), Alireza (2005), Chang et al. (2013), Bondarenko (2014), Schneider et al. (2015), Al Wakil (2016)
- Evidences on **profitable** divergence trading strategies to monetize compensation for higher-order risks

Our contribution

- Evidences that **divergence swaps** are widely traded by HF
- Shows **VOL, SKEW, KURT of VOL** risk premia are mimicking portfolios for VOL risk premia harvested by HF

Multifactor Models

- HF returns exhibit **option-like payoffs** replicable by option-based factors
- Examples of option-based strategies: short puts (Agarwal and Naik, 2004), VIX lookback straddles (Agarwal, Arisoy, and Naik, 2015), OTM puts (Agarwal, Green, and Ren, 2017)
- We use the same approach with new factors related to the volatility distribution:

$$R_{it} = \underbrace{\alpha}_{\textbf{Hedge fund alpha}} + \underbrace{\sum_{j=1}^{m} \beta_{jt} F_{jt}}_{\substack{\textbf{Control variables:} \\ \text{Fung−Hsieh factors (2004)}}} + \underbrace{\sum_{k=1}^{n} \beta_{kt} F_{kt}}_{\substack{\textbf{VOL risk premia:} \\ \text{tradable, option−implied}}}$$

where R_{it} is returns of i-th HF strategy

Volatility Risk Premia

- Existing literature usually captures VOL risk from a **unique** exposure: doesn't reflect the full extent of volatility strategies [see e.g. Bondarenko (2004), Carr and Wu (2009), Bollerslev et al. (2009)]

VOL (of VOL) risk premium

- Widely traded to exploit pricing discrepancies between risk-neutral and realized volatilities (of volatility):

$$VoV_{t,t+\tau,T} \equiv E_t^P\left[\sigma_{t,t-\tau,T}\right] - E_t^Q\left[\sigma_{t,t+\tau}\right]$$

where VoV is the difference between ex-post realized volatility and ex-ante risk-neutral expectation of future volatility

- Correspond to the payoff of a **volswap** on volatility

Volatility Risk Premia

Let $IV_{t,T}$ volatility smirk at time t for maturity T and moneyness ξ. Assume three-dimensional representation of IV:

$$IV_{t,T}(\xi) = \begin{cases} \gamma_{0,t,T} & \text{Black} - \text{Scholes}: \text{ flat smile} \\ \gamma_{0,t,T}\left[1 + \gamma_{1,t,T}\xi\right] & \text{Skewed IV smile} \\ \gamma_{0,t,T}\left[1 + \gamma_{1,t,T}\xi + \gamma_{2,t,T}\xi^2\right] & \text{Smirked IV smile} \end{cases}$$

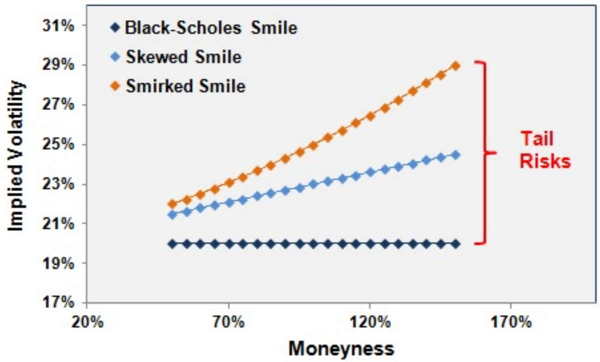

Figure 3: **Smile dynamics contains market price of risk.** VOL risks are embedded in level $\gamma_{0,t,T}$, slope $\gamma_{1,t,T}$, and curvature $\gamma_{2,t,T}$

Mimicking Portfolios

(Using Zhang-Xiang (2008) asymptotic approximations)

$$\gamma_{0,t,T} \approx \left[1 - \frac{1}{24}\left(RNKurt_{t,T} + 3\right)\right] RNVol_{t,T},$$

$$\gamma_{1,t,T} \approx \frac{1}{6} RNSkew_{t,T},$$

$$\gamma_{2,t,T} \approx \frac{1}{24}\left[RNKurt_{t,T} + 3\right]$$

Extending volswaps to **higher-order risks** gives:

$$\begin{cases} VoV_{t,T} = RDVol_t - RNVol_{t,T} & Volatility\ Factor \\ SoV_{t,T} = RDSkew_t - RNSkew_{t,T} & Skewness\ Factor \\ KoV_{t,T} = RDKurt_t - RNKurt_{t,T} & Kurtosis\ Factor \end{cases}$$

Volatility risk premia can be replicated by **distinct** delta-vega-neutral **portfolios** of European call and put options:

$$\Pi_{Kurt} = C\left(S_t, K_2\right) + \frac{\nu_{C_2}}{\nu_{P_2}} P\left(S_t, K_2\right) - C\left(S_t, K_3\right) - \frac{\nu_{C_3}}{\nu_{P_1}} P\left(S_t, K_1\right) - \left[\Delta_{C_3} + \frac{\nu_{C_3}}{\nu_{P_1}}\Delta_{P_1} - \Delta_{C_2} - \frac{\nu_{C_2}}{\nu_{P_2}}\Delta_{P_2}\right] S_t$$

Implementation

Risk-neutral estimators: $RNVol$, $RNSkew$, and $RNKurt$

- From market **VIX option prices**, provided by OptionMetrics
- **Model-free** approach of Bakshi, Kapadia, and Madan (2003)

Realized estimators: $RDVol$, $RDSkew$, and $RDKurt$

- From **high-frequency VIX spot prices**, provided by Bloomberg
- **Two-Scales Realized** measure of Ait-Sahalia, Mykland and Zhang (2005)
- **Bias-corrected** measure using subsampling and averaging to control for market microstructure noise

VOL risk premia: VoV, SoV, and KoV

- On a **daily** frequency, over **2008-2013**
- Risk premia are highly **ephemeral**: monthly calculations are inappropriate
- Constraint: length of **high-frequency** dataset

Implementation

	30 Days Maturity			60 Days Maturity			90 Days Maturity		
	VoV	**SoV**	**KoV**	**VoV**	**SoV**	**KoV**	**VoV**	**SoV**	**KoV**
Panel A: Levels of Option-Implied Risk Premia									
Nb. Observations	300	300	300	267	267	267	237	237	237
Mean	**-0,193**	**-0,718**	**-6,027**	**-0,411**	**-0,747**	**-5,818**	**-0,487**	**-0,652**	**-5,707**
Median	-0,242	-0,849	-2,680	-0,447	-0,774	-2,264	-0,515	-0,766	-1,852
Max	1,361	3,031	4,855	1,033	2,645	5,358	0,971	2,507	4,723
Min	-1,280	-4,555	-35,560	-1,205	-5,522	-33,474	-1,258	-4,382	-33,029
Standard Dev.	0,397	1,437	8,073	0,354	1,502	8,056	0,388	1,450	8,420
Skewness	0,736	0,047	-1,437	1,011	-0,157	-1,392	0,662	-0,038	-1,467
Kurtosis	4,017	2,457	4,322	5,091	2,673	4,273	3,559	2,541	4,435
LBQ Test	79,14*	0,01	0,12	40,11*	0,05	0,57	37,21*	0	0
ADF Test	-8,57**	-14**	-12,07**	-6,33**	-13,16**	-10,98**	-5,52**	-12,87**	-11,01**
Student Test	-8,41**	-8,66**	-12,93**	-18,94**	-8,13**	-11,8**	-19,35**	-6,92**	-10,44**
Panel B: First Differences of Option-Implied Risk Premia									
Nb. Observations	299	299	299	266	266	266	236	236	236
Mean	0,000	-0,004	0,025	-0,216	-0,100	0,006	-0,312	-0,013	0,308
Median	-0,016	-0,032	0,055	-0,224	-0,103	0,359	-0,330	-0,223	0,091
Max	1,166	5,826	30,593	1,432	5,615	28,863	1,400	4,908	36,231
Min	-1,443	-5,247	-35,141	-2,003	-6,249	-33,166	-1,966	-5,965	-33,478
Standard Dev.	0,393	2,029	11,543	0,523	2,013	11,314	0,519	1,915	11,922
Skewness	0,051	-0,017	-0,059	-0,030	-0,126	-0,211	0,058	-0,030	-0,062
Kurtosis	3,687	2,687	3,528	3,784	3,179	3,638	3,593	2,930	3,716
LBQ Test	49,88*	61,45*	96,49*	52,91*	0,77	0,58	42,15*	0,89	0,9
ADF Test	-26,52**	-28,05**	-32,7**	-9,03**	-17,1**	-15,53**	-7,95**	-16,3**	-16,26**
Student Test	0	-0,03	0,04	-6,75**	-0,81	0,01	-9,24**	-0,1	0,4

Table 1: **VOL risk premia embedded in VIX options**

Implementation

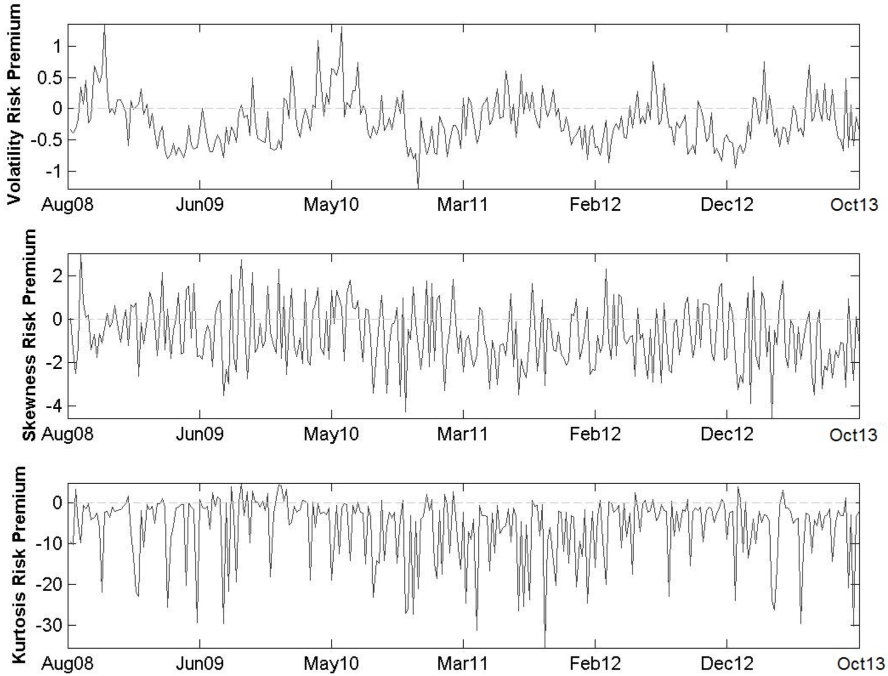

Figure 4: **VOL risk premia embedded in VIX options**

Data

Multiple datasets

- **HF indices**, on a **daily** frequency, from HFR: Global, Directional, Equity Hedge, Macro, Merger Arbitrage, and Relative Value
- **Fung-Hsieh** seven factors on a **daily** frequency, i.e. MKT-RF, SMB, term spread Δ, credit spread Δ, and trend-following factors
- **VOL risk premia**, priced on a **daily** frequency, over 2008-2013

Our approach

- Over 2008-2013, we regress 5 **daily HF indices** on Fung-Hsieh factors and the 3 volatility risk premia
- To understand HF performance on a **daily** frequency

First Result - HF are VOL sensitive

	Factor Beta Quantiles 1 [Low]	2	3 [High]	High - Low
Panel A: VOL of VOL Premia in the Cross-Section				
Average VOL of VOL Beta	**-0,216%** **[-18,35]**	-0,026% [-3,37]	**0,091%** **[11,47]**	0,307% [28,88]
Average Excess Return	0,0057 [0,16]	0,0051 [0,15]	-0,1113 [-2,4]	**-0,117*** [-2,38]**
Panel B: SKEW OF VOL Premia in the Cross-Section				
Average SKEW OF VOL Beta	**-0,019%** **[-6,49]**	0,035% [14,33]	**0,059%** **[18,28]**	0,078% [16,7]
Average Excess Return	0,001 [0,01]	-0,024 [-0,6]	0,008 [0,18]	0,008 [0,15]
Panel C: KURT OF VOL Premia in the Cross-Section				
Average KURT OF VOL Beta	**-0,003%** **[-9,1]**	0,005% [17,3]	**0,009%** **[21,91]**	0,012% [31,74]
Average Excess Return	0,0028 [0,07]	-0,0185 [-0,52]	-0,0832 [-1,79]	**-0,086*** [-1,86]**

Table 2: **Quantile portfolios sorted by VOL risk premia betas**

First Result - HF are VOL sensitive

After controlling for Fung-Hsieh factor loadings, we form **3 quantile portfolios** (high, medium, low beta) of cross-sectional HF index returns, **sorted** on loadings of each VOL premium:

- **HF that significantly load on VOL OF VOL (KURT OF VOL) premia substantially outperform low-beta funds by nearly 11.7% (8.6%) per year**
- **This finding sheds light to what extent HF alpha arises actually from volatility strategies**
- **Nevertheless, HF that significantly bear SKEW OF VOL premia were not compensated by excess returns**

Second Result - VOL sensitivity arises from VOL of VOL

Investment Style	Nb. Obs.	Intercept	MKT-RF	SMB	dTERM	dCREDIT	PTFSBD	PTFSFX	PTFSCOM	VoV	SoV	KoV	R-Square/ Adj. R-Square
Global	275	0,0000	0,088***							-0,0012***	0,0002**	0,0000	0,41
		[-0,19]	[11,48]							[-4,26]	[2,09]	[0,51]	0,41
		-0,0231	0,0872***	0,0064	-0,0052	-0,0114	0,0024	4,3693	-0,0001**	**-0,001*****	0,0001*	0,0000	0,43
		[-0,63]	[10,45]	[0,37]	[-0,4]	[-0,63]	[1,6]	[0,63]	[-2]	**[-3,4]**	[1,8]	[0,36]	0,41
Directionnal	275	0,0003	0,1979***							-0,0009*	0,0004***	0,0000	0,50
		[1,22]	[15,11]							[-1,85]	[3,34]	[1,5]	0,49
		-0,0407	0,1908***	-0,0623**	-0,0027	-0,0206	0,0027	1,2206	-0,0002**	-0,0007	0,0004***	0,0000	0,52
		[-0,66]	[13,52]	[-2,13]	[-0,12]	[-0,67]	[1,06]	[0,1]	[-2,24]	[-1,36]	[2,68]	[1,48]	0,50
Equity Hedge	275	-0,0001	0,1973***							-0,0013***	0,0001	0,0000	0,54
		[-0,22]	[15,54]							[-2,96]	[1,06]	[0,49]	0,53
		0,0096	0,1906***	0,0084	0,0153	0,0051	0,0044*	16,4733	-0,0001*	**-0,0013*****	0,0001	0,0000	0,55
		[0,16]	[13,88]	[0,29]	[0,71]	[0,17]	[1,79]	[1,43]	[-1,66]	**[-2,63]**	[0,52]	[0,57]	0,54
Macro	275	-0,0009***	-0,0321**							-0,0011**	-0,0004**	0,0000	0,05
		[-3,2]	[-2,23]							[-2,23]	[-2,5]	[-0,01]	0,03
		-0,0991	-0,0059	0,0866***	-0,0691***	-0,0495	0,0018	-17,9721	-0,0001	-0,0005	-0,0002	0,0000	0,18
		[-1,54]	[-0,4]	[2,83]	[-3]	[-1,54]	[0,69]	[-1,46]	[-1,27]	[-0,95]	[-1,35]	[-0,82]	0,15
Merger Arbitrage	275	0,0002	0,0979***							-0,0001	0,0001	0,0000	0,36
		[1,21]	[11,3]							[-0,47]	[0,62]	[0,88]	0,35
		0,1272***	0,0901***	-0,0272	0,0497***	0,0633***	-0,0001	-8,6250	0,0000	-0,0002	0,0000	0,0000	0,39
		[3,12]	[9,68]	[-1,41]	[3,42]	[3,11]	[-0,06]	[-1,11]	[-0,7]	[-0,53]	[0,5]	[0,98]	0,37
Relative Value	275	0,0004**	0,0424***							-0,0009**	0,0005***	0,0000	0,12
		[2,01]	[3,88]							[-2,4]	[4,14]	[0,06]	0,10
		0,0338	0,0314***	-0,0229	0,0267	0,0168	0,0021	2,7385	-0,0001	**-0,001****	0,0004***	0,0000	0,15
		[0,65]	[2,65]	[-0,93]	[1,44]	[0,65]	[1]	[0,28]	[-0,96]	**[-2,25]**	[3,47]	[0,27]	0,11

Table 3: **HF sensitivity to VOL of VOL over 2008-2013**

Second Result - VOL sensitivity arises from VOL of VOL

Investment Style	Nb. Obs.	Intercept	MKT-RF	SMB	dTERM	dCREDIT	PTFSBD	PTFSFX	PTFSCOM	VoV	SoV	KoV	R-Square/ Adj. R-Square
Global	71	0,0007	0,0939***							-0,003***	0,0004	0,0000	0,49
		[1,51]	[6,54]							[-3,41]	[1,65]	[0,59]	0,46
		0,0571	0,1044***	-0,0100	0,0136	0,0288	0,0116*	1,6329	-0,0002	**-0,0032*** **	0,0004	0,0000	0,53
		[0,74]	[5,3]	[-0,24]	[0,46]	[0,75]	[1,91]	[0,08]	[-1,58]	**[-3,01]**	[1,46]	[0,47]	0,46
Directionnal	71	0,0012	0,2318***							-0,0020	0,0011**	0,0000	0,60
		[1,53]	[9,49]							[-1,33]	[2,47]	[0,73]	0,58
		0,1378	0,207***	-0,0845	0,0725	0,0684	0,0146	-32,9534	-0,0004**	-0,0015	0,0009*	0,0000	0,66
		[1,08]	[6,35]	[-1,24]	[1,49]	[1,07]	[1,45]	[-0,97]	[-2,23]	[-0,84]	[1,91]	[0,4]	0,60
Equity Hedge	71	0,0010	0,207***							-0,0034**	0,0005	0,0000	0,62
		[1,4]	[9,47]							[-2,59]	[1,26]	[0,68]	0,60
		0,1467	0,2203***	-0,0033	0,0464	0,0741	0,0182*	5,4085	-0,0002	**-0,0039** **	0,0005	0,0000	0,66
		[1,26]	[7,4]	[-0,05]	[1,05]	[1,27]	[1,98]	[0,17]	[-1,26]	**[-2,46]**	[1,08]	[0,69]	0,60
Macro	71	-0,0005	-0,0637***							-0,0028**	-0,0011***	0,0001	0,24
		[-0,73]	[-3,12]							[-2,26]	[-3]	[1,1]	0,19
		-0,0696	-0,0372	-0,0290	-0,0646*	-0,0359	-0,0027	-40,9889	-0,0002	-0,0017	-0,0007*	0,0000	0,41
		[-0,69]	[-1,45]	[-0,54]	[-1,69]	[-0,72]	[-0,34]	[-1,53]	[-1,45]	[-1,22]	[-1,89]	[0,14]	0,32
Merger Arbitrage	71	0,0012**	0,1244***							-0,0009	-0,0002	0,0001**	0,57
		[2,64]	[8,39]							[-0,95]	[-0,66]	[2,3]	0,54
		0,2653***	0,1139***	-0,0527	0,0978***	0,1321***	0,0058	-19,6823	-0,0001	-0,0011	-0,0002	0,0001**	0,67
		[3,62]	[6,1]	[-1,35]	[3,52]	[3,62]	[1,01]	[-1,01]	[-0,78]	[-1,11]	[-0,81]	[2,28]	0,61
Relative Value	71	0,0012*	0,064***							-0,0033**	0,0011***	0,0000	0,23
		[1,68]	[2,8]							[-2,36]	[2,75]	[-0,11]	0,18
		0,0937	0,0662**	0,0199	0,0477	0,0481	0,0191**	31,5392	-0,0001	**-0,0042** **	0,0009**	0,0000	0,32
		[0,78]	[2,16]	[0,31]	[1,04]	[0,8]	[2,02]	[0,98]	[-0,82]	**[-2,52]**	[2,02]	[0,32]	0,21

Table 4: **HF sensitivity to VOL of VOL over crisis periods**

Second Result - VOL sensitivity arises from VOL of VOL

At **HF investment style** level, after controlling for Fung-Hsieh factors, we estimate time-series OLS regressions:

- **A one-standard deviation increase in VOL of VOL premia is associated with a substantial decline in aggregate HF returns of 25.2% annually**
- **Relative Value and Equity Hedge are the most negatively exposed strategies to VOL of VOL, particularly during crises when volatility swap returns are the highest**

- Relative Value are usually considered as the last insurer against tail risks, executing risk transfer from financial institutions
- Whereas Equity Hedge usually overlay hedge long positions; the 2 payoff return profiles equal to buying a call hedged by **selling realized volatility**

Third Result - HF exposed to higher-order moments

Investment Style	Nb. Obs.	Intercept	MKT-RF	SMB	dTERM	dCREDIT	PTFSBD	PTFSFX	PTFSCOM	VoV	SoV	KoV	R-Square/ Adj. R-Square
Global	275	0,0000	0,088***							-0,0012***	0,0002**	0,0000	0,41
		[-0,19]	[11,48]							[-4,26]	[2,09]	[0,51]	0,41
		-0,0231	0,0872***	0,0064	-0,0052	-0,0114	0,0024	4,3693	-0,0001**	-0,001***	0,0001*	0,0000	0,43
		[-0,63]	[10,45]	[0,37]	[-0,4]	[-0,63]	[1,6]	[0,63]	[-2]	[-3,4]	[1,8]	[0,36]	0,41
Directionnal	275	0,0003	0,1979***							-0,0009*	0,0004***	0,0000	0,50
		[1,22]	[15,11]							[-1,85]	[3,34]	[1,5]	0,49
		-0,0407	0,1908***	-0,0623**	-0,0027	-0,0206	0,0027	1,2206	-0,0002**	-0,0007	**0,0004*** **	0,0000	0,52
		[-0,66]	[13,52]	[-2,13]	[-0,12]	[-0,67]	[1,06]	[0,1]	[-2,24]	[-1,36]	**[2,68]**	[1,48]	0,50
Equity Hedge	275	-0,0001	0,1973***							-0,0013***	0,0001	0,0000	0,54
		[-0,22]	[15,54]							[-2,96]	[1,06]	[0,49]	0,53
		0,0096	0,1906***	0,0084	0,0153	0,0051	0,0044*	16,4733	-0,0001*	-0,0013***	0,0001	0,0000	0,55
		[0,16]	[13,88]	[0,29]	[0,71]	[0,17]	[1,79]	[1,43]	[-1,66]	[-2,63]	[0,52]	[0,57]	0,54
Macro	275	-0,0009***	-0,0321**							-0,0011**	-0,0004**	0,0000	0,05
		[-3,2]	[-2,23]							[-2,23]	[-2,5]	[-0,01]	0,03
		-0,0991	-0,0059	0,0866***	-0,0691***	-0,0495	0,0018	-17,9721	-0,0001	-0,0005	**-0,0002**	0,0000	0,18
		[-1,54]	[-0,4]	[2,83]	[-3]	[-1,54]	[0,69]	[-1,46]	[-1,27]	[-0,95]	**[-1,35]**	[-0,82]	0,15
Merger Arbitrage	275	0,0002	0,0979***							-0,0001	0,0001	0,0000	0,36
		[1,21]	[11,3]							[-0,47]	[0,62]	[0,88]	0,35
		0,1272***	0,0901***	-0,0272	0,0497***	0,0633***	-0,0001	-8,6250	0,0000	-0,0002	0,0000	0,0000	0,39
		[3,12]	[9,68]	[-1,41]	[3,42]	[3,11]	[-0,06]	[-1,11]	[-0,7]	[-0,53]	[0,5]	[0,98]	0,37
Relative Value	275	0,0004**	0,0424***							-0,0009**	0,0005***	0,0000	0,12
		[2,01]	[3,88]							[-2,4]	[4,14]	[0,06]	0,10
		0,0338	0,0314***	-0,0229	0,0267	0,0168	0,0021	2,7385	-0,0001	**-0,001*** **	**0,0004*** **	0,0000	0,15
		[0,65]	[2,65]	[-0,93]	[1,44]	[0,65]	[1]	[0,28]	[-0,96]	**[-2,25]**	**[3,47]**	[0,27]	0,11

Table 5: **HF sensitivity to SKEW/KURT of VOL over 2008-2013**

Third Result - HF exposed to higher-order moments

Investment Style	Nb. Obs.	Intercept	MKT-RF	SMB	dTERM	dCREDIT	PTFSBD	PTFSFX	PTFSCOM	VoV	SoV	KoV	R-Square/ Adj. R-Square
Global	71	0,0007	0,0939***							-0,003***	0,0004	0,0000	0,49
		[1,51]	[6,54]							[-3,41]	[1,65]	[0,59]	0,46
		0,0571	0,1044***	-0,0100	0,0136	0,0288	0,0116*	1,6329	-0,0002	-0,0032***	0,0004	0,0000	0,53
		[0,74]	[5,3]	[-0,24]	[0,46]	[0,75]	[1,91]	[0,08]	[-1,58]	[-3,01]	[1,46]	[0,47]	0,46
Directionnal	71	0,0012	0,2318***							-0,0020	0,0011**	0,0000	0,60
		[1,53]	[9,49]							[-1,33]	[2,47]	[0,73]	0,58
		0,1378	0,207***	-0,0845	0,0725	0,0684	0,0146	-32,9534	-0,0004**	-0,0015	**0,0009***	0,0000	0,66
		[1,08]	[6,35]	[-1,24]	[1,49]	[1,07]	[1,45]	[-0,97]	[-2,23]	[-0,84]	**[1,91]**	[0,4]	0,60
Equity Hedge	71	0,0010	0,207***							-0,0034**	0,0005	0,0000	0,62
		[1,4]	[9,47]							[-2,59]	[1,26]	[0,68]	0,60
		0,1467	0,2203***	-0,0033	0,0464	0,0741	0,0182*	5,4085	-0,0002	-0,0039**	0,0005	0,0000	0,66
		[1,26]	[7,4]	[-0,05]	[1,05]	[1,27]	[1,98]	[0,17]	[-1,26]	[-2,46]	[1,08]	[0,69]	0,60
Macro	71	-0,0005	-0,0637***							-0,0028**	-0,0011***	0,0001	0,24
		[-0,73]	[-3,12]							[-2,26]	[-3]	[1,1]	0,19
		-0,0696	-0,0372	-0,0290	-0,0646*	-0,0359	-0,0027	-40,9889	-0,0002	-0,0017	**-0,0007***	0,0000	0,41
		[-0,69]	[-1,45]	[-0,54]	[-1,69]	[-0,72]	[-0,34]	[-1,53]	[-1,45]	[-1,22]	**[-1,89]**	[0,14]	0,32
Merger Arbitrage	71	0,0012**	0,1244***							-0,0009	-0,0002	0,0001**	0,57
		[2,64]	[8,39]							[-0,95]	[-0,66]	[2,3]	0,54
		0,2653***	0,1139***	-0,0527	0,0978***	0,1321***	0,0058	-19,6823	-0,0001	-0,0011	-0,0002	**0,0001****	0,67
		[3,62]	[6,1]	[-1,35]	[3,52]	[3,62]	[1,01]	[-1,01]	[-0,78]	[-1,11]	[-0,81]	**[2,28]**	0,61
Relative Value	71	0,0012*	0,064***							-0,0033**	0,0011***	0,0000	0,23
		[1,68]	[2,8]							[-2,36]	[2,75]	[-0,11]	0,18
		0,0937	0,0662**	0,0199	0,0477	0,0481	0,0191**	31,5392	-0,0001	**-0,0042****	**0,0009****	0,0000	0,32
		[0,78]	[2,16]	[0,31]	[1,04]	[0,8]	[2,02]	[0,98]	[-0,82]	**[-2,52]**	**[2,02]**	[0,32]	0,21

Table 6: **HF sensitivity to SKEW/KURT of VOL over crisis periods**

Third Result - HF exposed to higher-order moments

At **HF investment style** level, after controlling for Fung-Hsieh factors, we estimate time-series OLS regressions:

- **Relative Value and Directional are the most positively exposed to SKEW of VOL, since they are usually skewness-buyers strategies.**
- **Relative Value are not completely insurance-sellers strategies, since they partially hedge VOL of VOL exposure by buying SKEW of VOL.**
- **Whereas Global Macro are usually negatively exposed to SKEW of VOL**

Relative Value and Directional profit from VOL of VOL: Relative Value is long gamma, and trend-followers aim to buying max lookback straddles. It equals to **buying realized skewness**. Alternatively, Global Macro takes contrarian bets on tail risks, i.e. **selling realized SKEW** during crises: convergence trades based on long term macro-trends

Conclusion

- Provides a new evidence for **volatility risk** in HF performance
- Showing it is an instrumental determinant in both **time-series** and **cross-section**
- To what extent **HF alpha** actually arises from volatility exposure
- Decompose HF volatility risk from **multiple** and **tradable** option-based strategies
- Decomposed into **volatility, skewness, and kurtosis** risk premia
- Indeed, divergent swaps are now **widely** used by HF managers
- Most HF styles **sell** volatility
- But VOL risk exposures across HF are widely **distinguishable**, depending on specific strategies

Thank you