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Connecting Markets East & West

Long Vega Strategies

Tail risk hedging without the drag

Derivative Strategies
Quantitative Strategies

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Rates vega select

Using a signal and delta-thresholds to reduce total trades and outperform aggregate

Historical Performance

Strategy rules

- **Swaptions to choose from**: USD, EUR;
  Expiries 5y, 10y, 20y; **Tenors**: 2y, 5y, 10y, 20y, 30y.
- **Signal: Carry** (i.e., highest carry) – 6m z-score of 6m vol carry
  - going long two highest in USD and EUR
- **Trading-Frequency**: 1m , **Horizon**: 6m
- **Hedging:**
  - **Delta-hedging**: with 0.1 Delta Threshold, Weekly
  - **Annuity/Premium Hedging**: One time at trade start for USD, Weekly for EUR
- **Notional Scaling:** Scaled by vega and by strategy performance to date

Strategy Performance

	Since Inception	5Y	3Y	1Y
Average Return (p.a.)	6.66%	1.01%	3.21%	-5.54%
Volatility (p.a.)	10.65%	6.52%	6.48%	4.51%
Sharpe Ratio	**0.63**	**0.15**	**0.49**	**-1.23**
Max Drawdown	19.60%	11.93%	10.55%	6.78%
% of Positive Months	49%	41%	43%	31%
Skewness	2.08	0.88	1.14	0.41

Source: Nomura. Past performance is not a reliable indicator of future results.

Executive Summary

Tail risk hedging costs an arm and a leg – Rates vega select doesn't

- **Most crash insurance is**
  - **Too expensive**, bleeding away in between crises, with only small rallies during crisis events
- **Rates Vega Select**
  - Positive Carry – Buying swaptions has positive carry unlike options in Equities, FX, commodities
  - Benefits from macroeconomic shocks
  - Convexity of strategy is comparable to that of 50y bonds

- **Rates vega select has key benefits**
  - Can be delivered as a program of standard trades
  - Right tailed – Superior responsiveness – Buffering Economic shocks
  - Decent returns
  - Works well in overlays

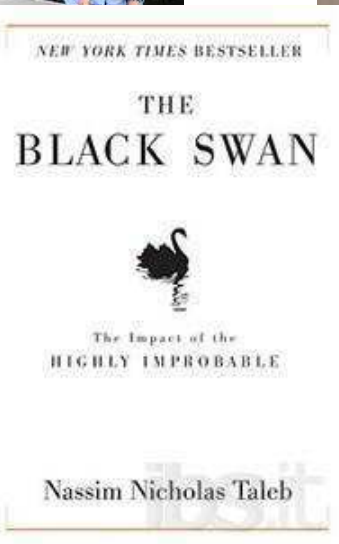
Source: Nomura

Tail-risk hedging

It’s more expensive than you can imagine

Tail risks = major problem

Uncertainty abounds

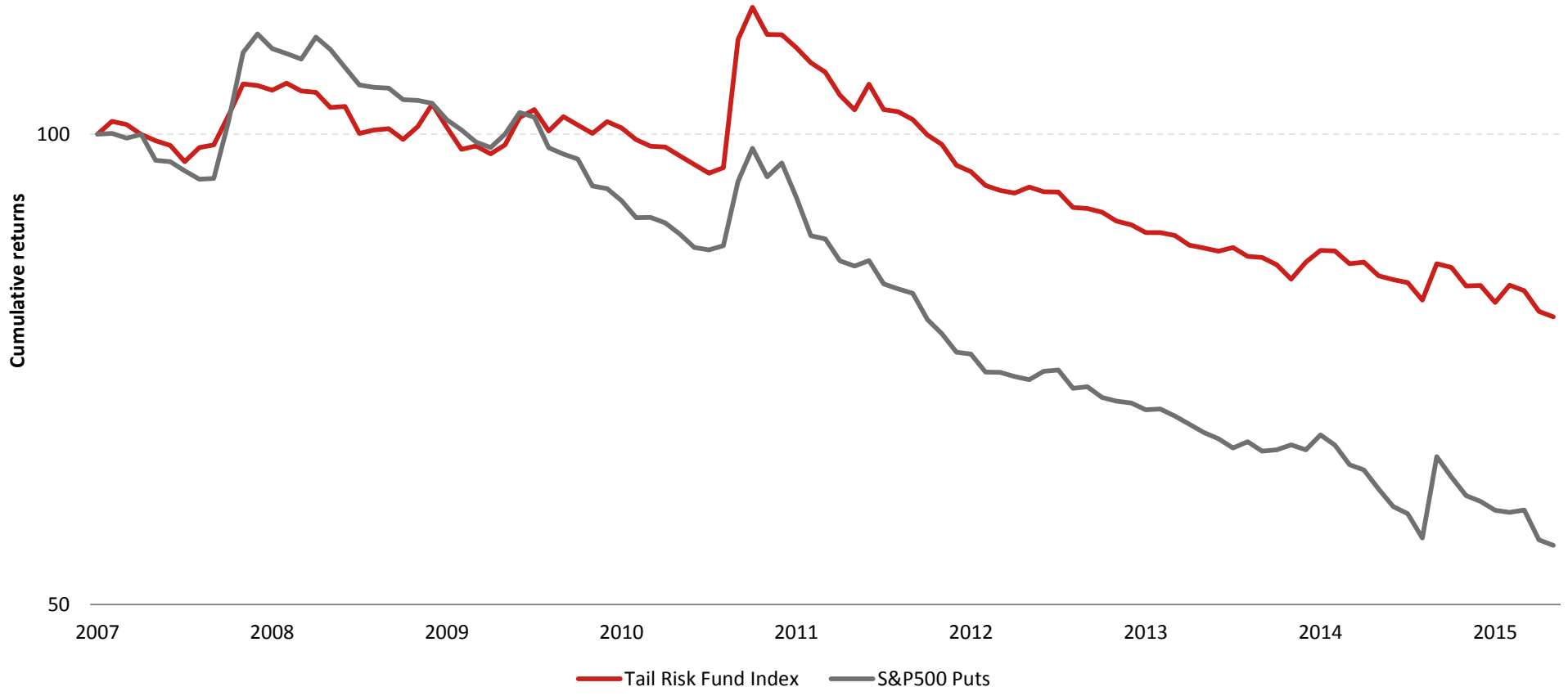


Source: Mother Jones, Guardian, Getty, Coliseum.Europa.eu, Random House

Tail risk funds are meant to hedge tail risk

Almost all bleed away premium, and the hedging performance suffers. Sad!

EurekaHedge CBOE Tail Risk Fund and Rolling low strike (1y SPX puts 95%), cumulative returns



Source: Nomura, Bloomberg, Tail Risk Fund Index = Eurekahedge Tail Risk Index (excess returns). Put Chart shows realised returns of buying and holding 1y 95% puts on the S&P 500.
Past performance is not a reliable indicator of future results.

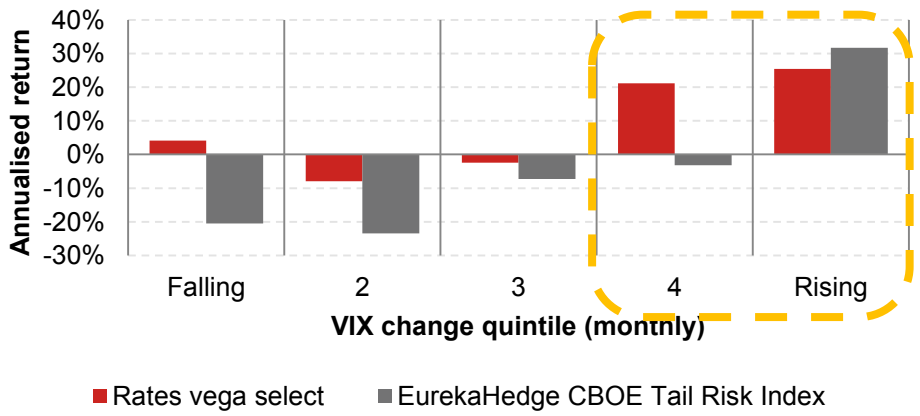
Rates vega select compares favorably to tail risk funds

Rates vega select outperforms tail risk funds at all times except during largest shocks, so why bother with them?

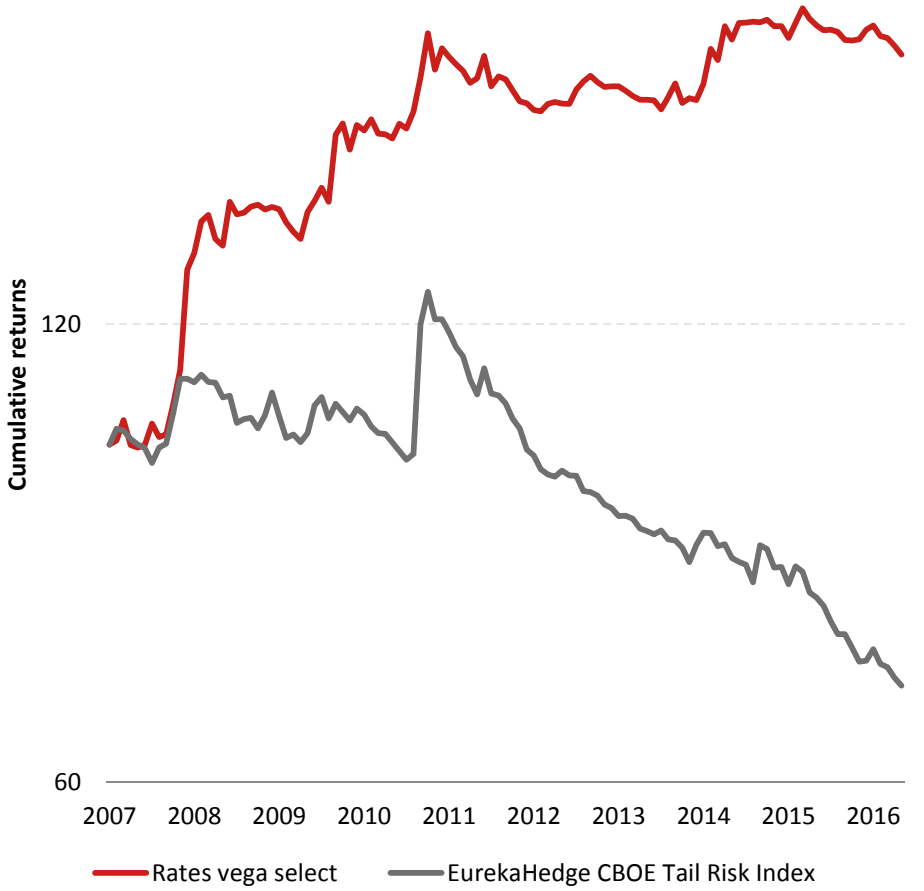
Much higher returns with slightly lower skewness*

	Rates vega select	EurekaHedge CBOE Tail Risk Index
Average return (p.a.)	6.82%	-3.44%
Volatility (p.a.)	10.00%	10.00%
Sharpe ratio	**0.68**	**-0.34**
Max draw dow n	11.13%	44.93%
Calmar ratio	**0.61**	**-0.08**
Skew ness	2.08	4.28

Performance (vol-scaled) bucketed by VIX quintiles



Rates vega select outperforms tail risk funds



** Returns from 2007-Present (matching EurekaHedge sample). Scaled to 10% vol.*
Source: Nomura, Bloomberg, Eurekahedge (EHFI453 Index). Past performance is not a reliable indicator of future results.

Using Rates vega select as an overlay

Adding vol protection as a hedge is a win-win

Sensitivity to macroeconomic shocks

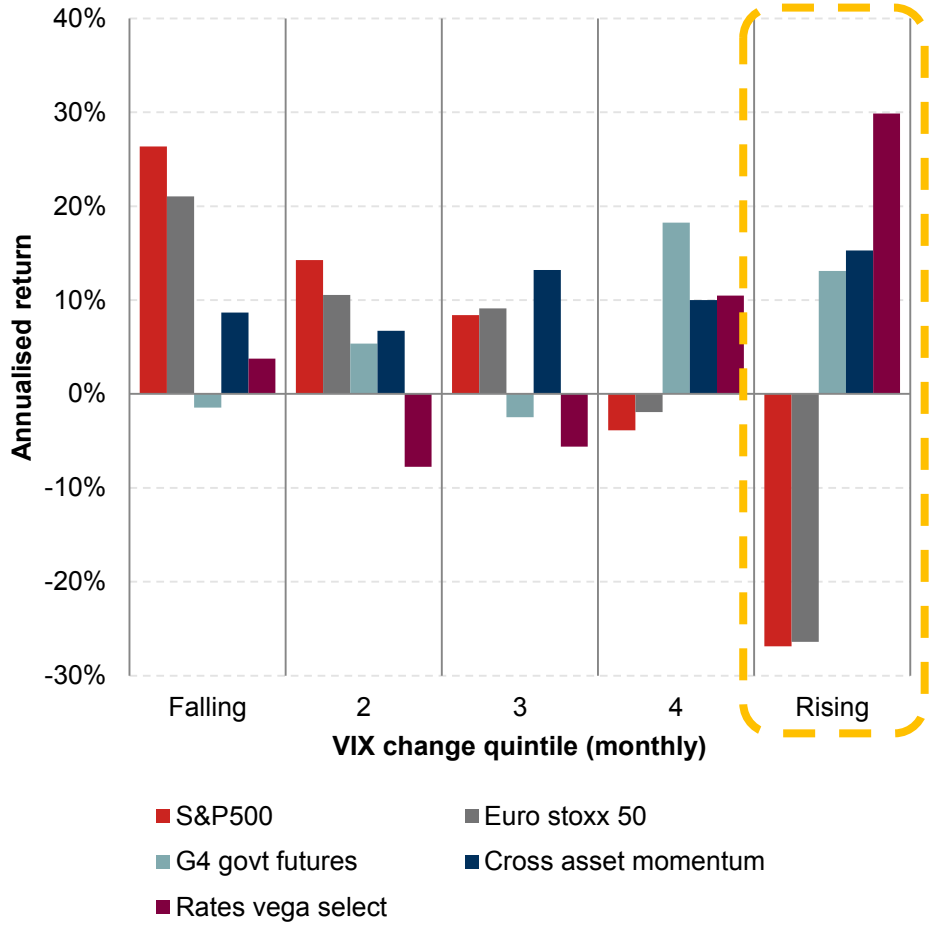
Rates vega select has greater sensitivity than other more common hedges, while offering diversification*

Vega offers diversification possibilities (monthly correlations)

	S&P500	Euro stoxx 50	G4 govt futures	Cross asset momentum	Rates vega select
S&P500	1.00	0.82	-0.25	-0.31	-0.50
Euro stoxx 50	0.82	1.00	-0.27	-0.23	-0.42
G4 govt futures	-0.25	-0.27	1.00	0.11	0.28
Cross asset momentum	-0.31	-0.23	0.11	1.00	0.40
Rates vega select	-0.50	-0.42	0.28	0.40	1.00

	S&P500	Euro stoxx 50	G4 govt futures	Cross asset momentum	Rates vega select
Average return (p.a.)	3.88%	2.61%	6.36%	10.76%	6.26%
Volatility (p.a.)	10.00%	10.00%	10.00%	10.00%	10.00%
Sharpe ratio	**0.39**	**0.26**	**0.64**	**1.08**	**0.63**
Max drawdown	36.93%	33.96%	25.77%	13.18%	18.49%
Calmar ratio	**0.11**	**0.08**	**0.25**	**0.82**	**0.34**
Skewness	-0.78	-0.44	0.01	1.27	2.07

Vega select shows greater sensitivity to VIX spikes (daily)

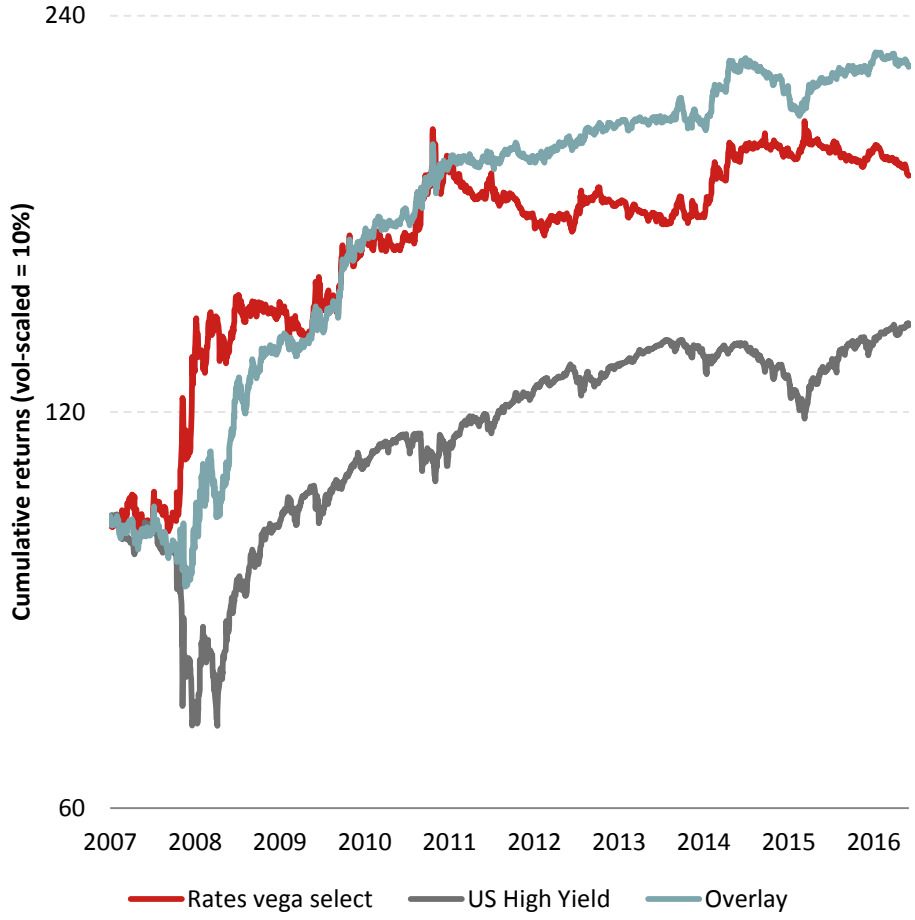


*Scaled to 10% vol. Daily calculations (except where noted) since inception – Feb 2005
Source: Nomura, Bloomberg. Past performance is not a reliable indicator of future results.

Rates vega select is excellent overlay to credit

US high yield bond overlay

Historical Cumulative Returns (US HY + Rates vega select)



Key points

- US High Yield ETF (JNK US Equity) is effectively long similar risk to equities
- Vega overlay (100%) mitigates some of the major macro risk which the HY index is subject to, downside, enhancing returns, significantly reducing drawdowns, resulting in positive skewness.

Performance (Since 2007*)

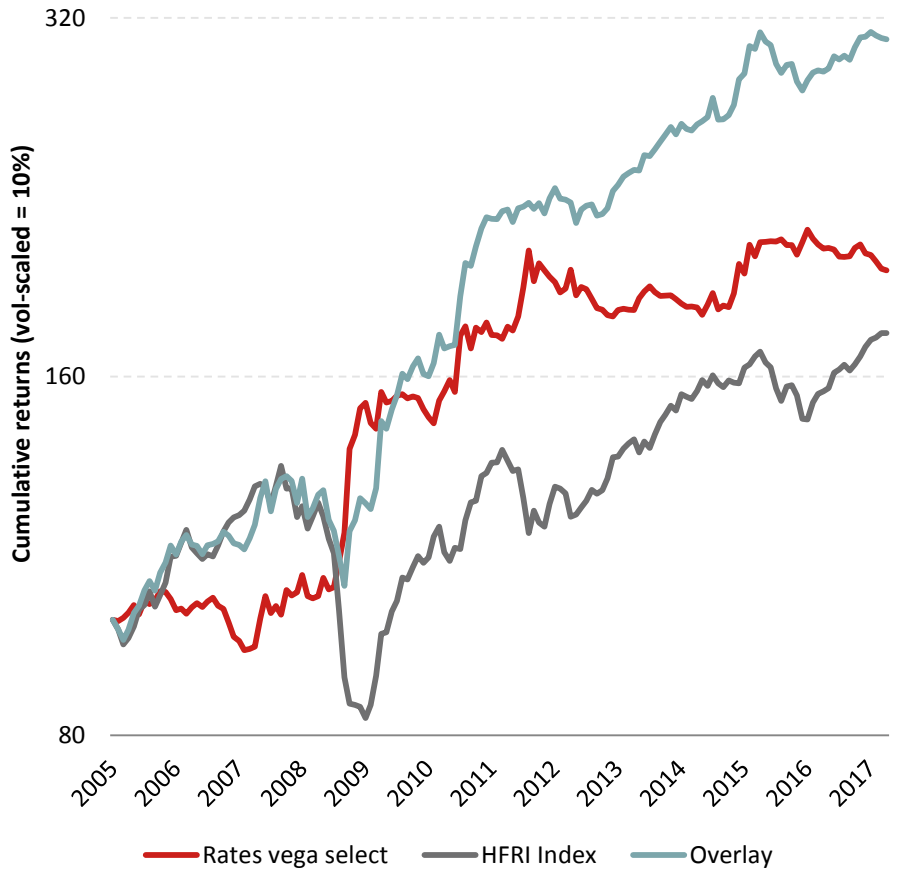
	Rates vega select	US High Yield	Overlay
Average return (p.a.)	6.81%	4.06%	8.85%
Volatility (p.a.)	10.00%	10.00%	10.00%
Sharpe ratio	**0.68**	**0.41**	**0.88**
Max drawdown	17.01%	30.95%	13.12%
Calmar ratio	**0.40**	**0.13**	**0.67**
Skewness	2.06	-0.46	1.37

** JNK US Equity only has performance data from 2007. Scaled to 10% vol.*
Source: Nomura, Bloomberg. Past performance is not a reliable indicator of future results.

Rates vega select is excellent overlay to hedge funds

Hedge fund overlay

Historical Cumulative Returns (HFRI Index + Rates vega select)



Key points

- HFRI index is sometimes long beta and sometimes long bonds.
- Vega overlay (100%) mitigates some of the HF downside, enhancing returns, and reducing the negative skewness.

Performance (Since Inception) – monthly returns*

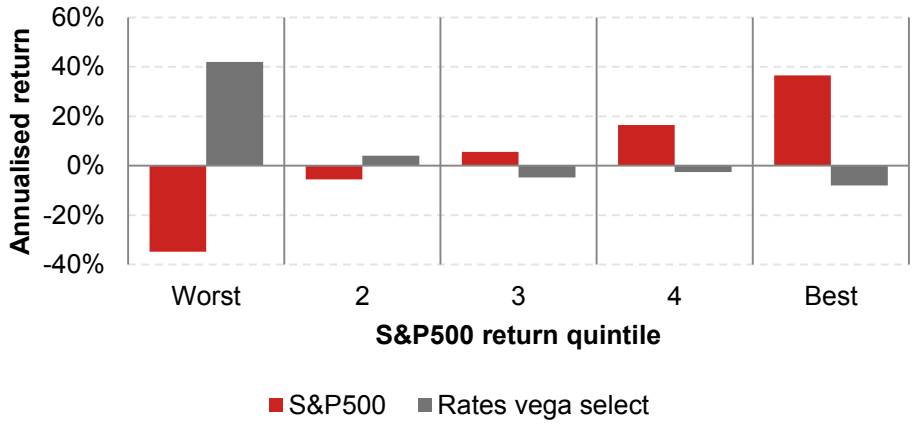
	Rates vega select	HFRI Index	Overlay
Average return (p.a.)	6.01%	5.04%	9.68%
Volatility (p.a.)	10.00%	10.00%	10.00%
Sharpe ratio	**0.60**	**0.50**	**0.97**
Max drawdown	11.95%	38.57%	19.12%
Calmar ratio	**0.50**	**0.13**	**0.51**
Skewness	2.08	-1.02	0.79

** Scaled to 10% vol. Monthly Returns since Inception (Feb 2005)*
Source: Nomura, Bloomberg. Past performance is not a reliable indicator of future results.

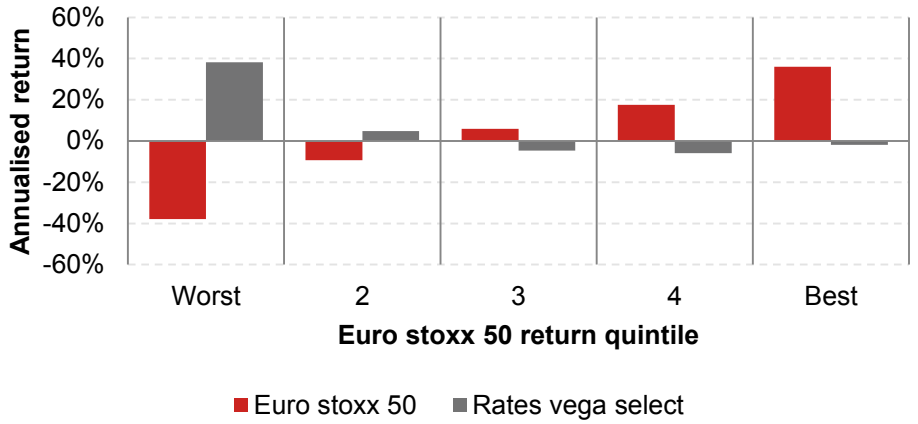
Hedging risky indices

Rates vega select* performs well when SPX, SX5E, MSCI World and HY underperform

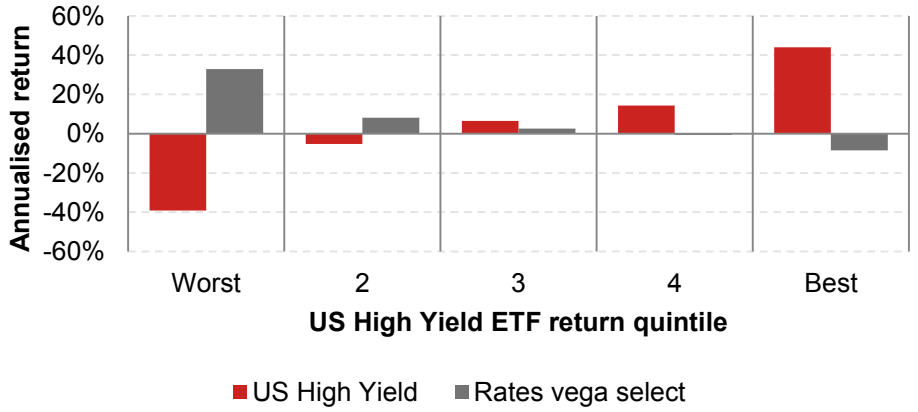
S&P 500



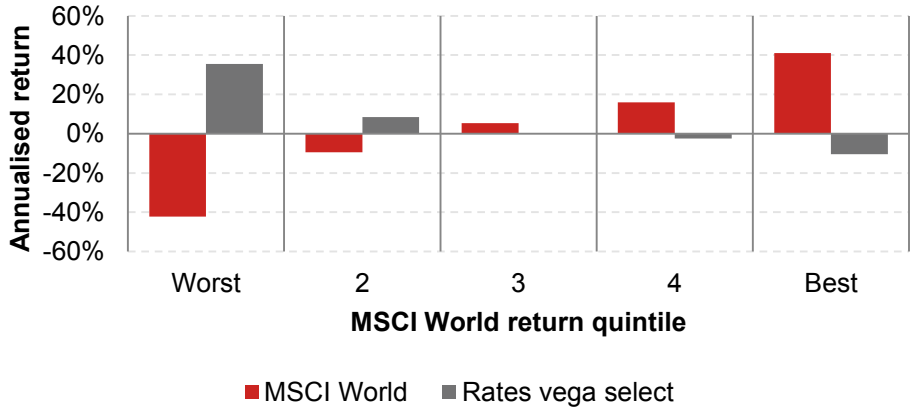
EuroStoxx 50



US High Yield (JNK US Equity)



MSCI World



** Scaled to 10% vol*
Source: Nomura, Bloomberg. Past performance is not a reliable indicator of future results.

Alternatives overlay: Rates vega select as MSCI World overlay

MSCI World overlay

Historical Cumulative Returns (MSCI World + Rates vega select)

Key points

- Rates Vega overlay helps mitigate the downside risk of equity market and delivers higher risk adjusted return. It improves the equity drawdowns and shifts the return distribution to positive skewness.

Performance (Since Inception) *

	Rates vega select	MSCI World Excess Return	Overlay
Average return (p.a.)	6.26%	3.38%	8.22%
Volatility (p.a.)	10.00%	10.00%	10.00%
Sharpe ratio	0.63	0.34	0.82
Max drawdown	18.49%	41.66%	19.23%
Calmar ratio	0.34	0.08	0.43
Skewness	2.07	-0.87	1.19

**Scaled to 10% vol.*
Source: Nomura, Bloomberg. Past performance is not a reliable indicator of future results.

Drawdowns compared – MSCI World Excess Return and Rates vega select

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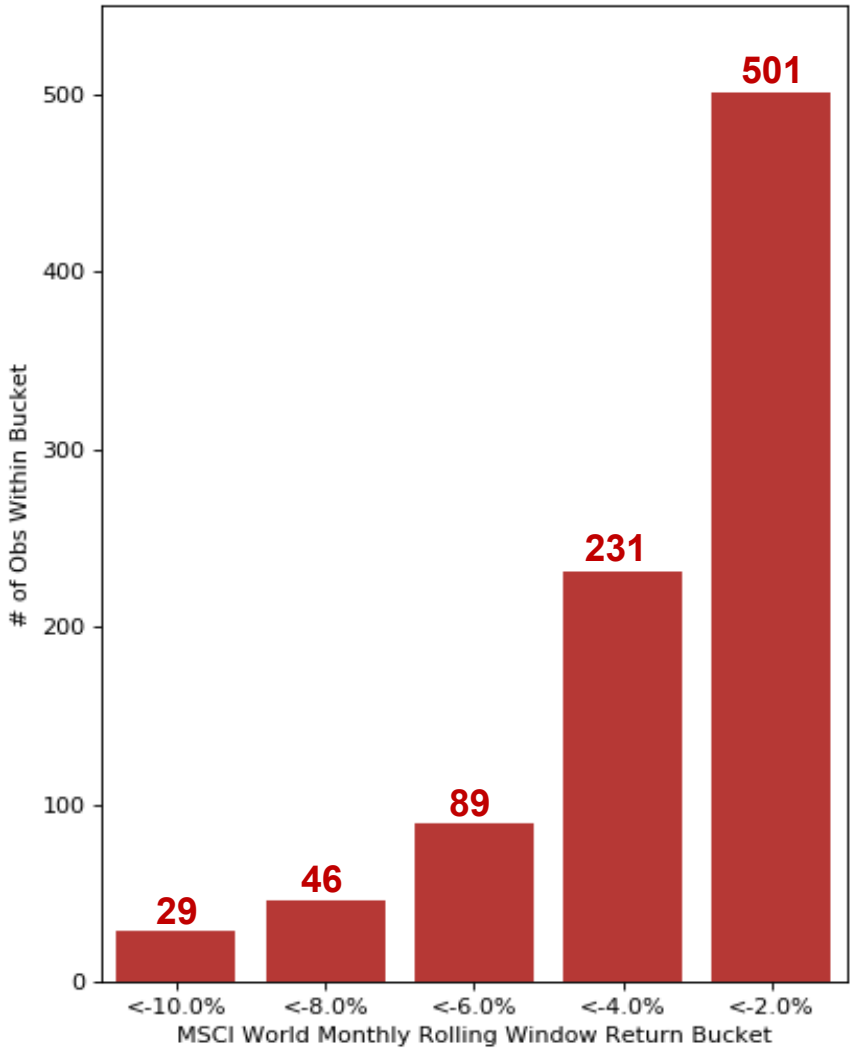
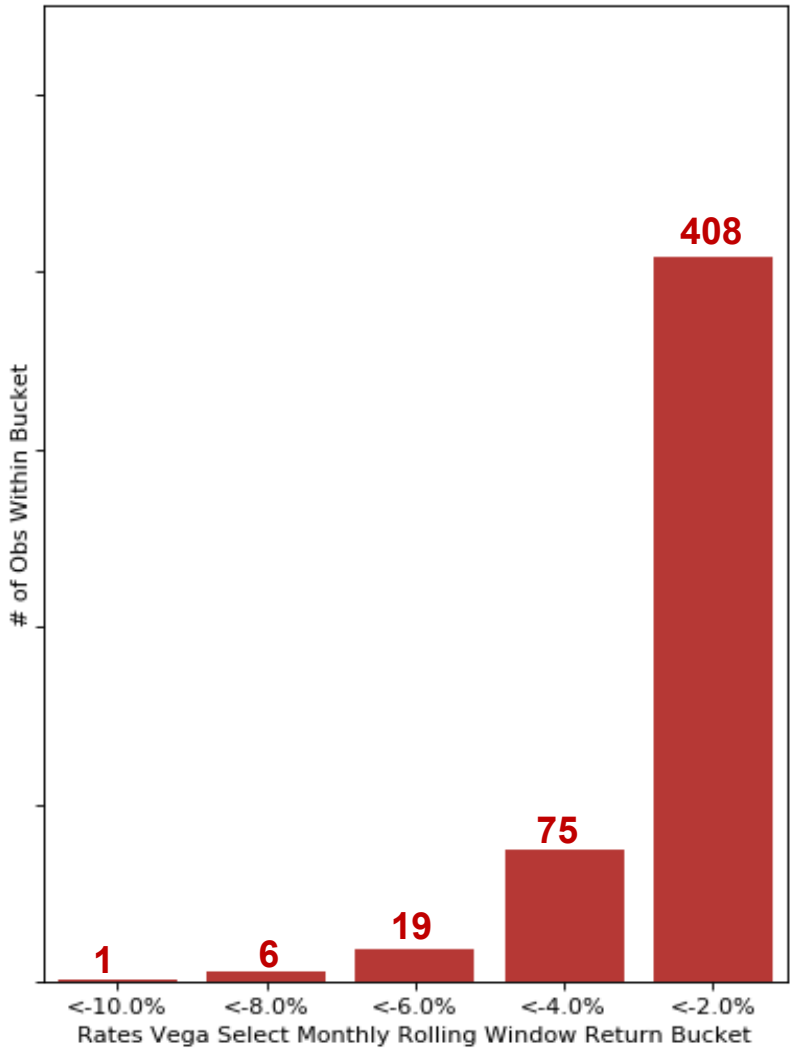
- **Scaled by volatility, Rates vega select has fewer drawdown than MSCI world for all the buckets**

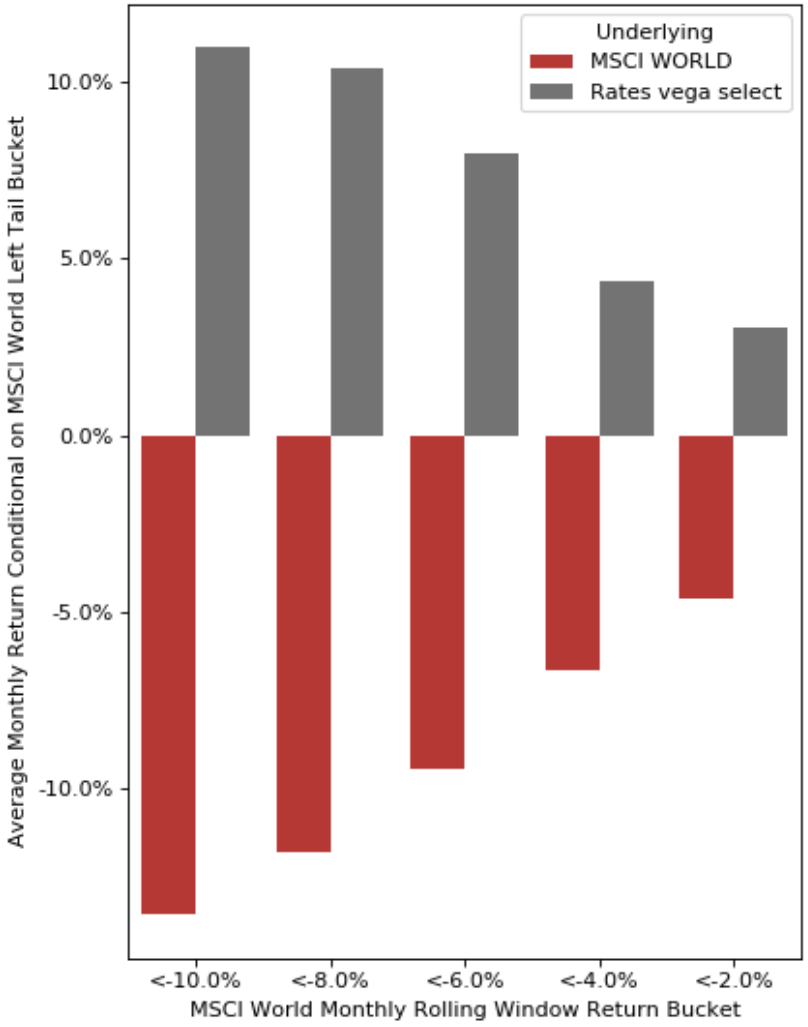


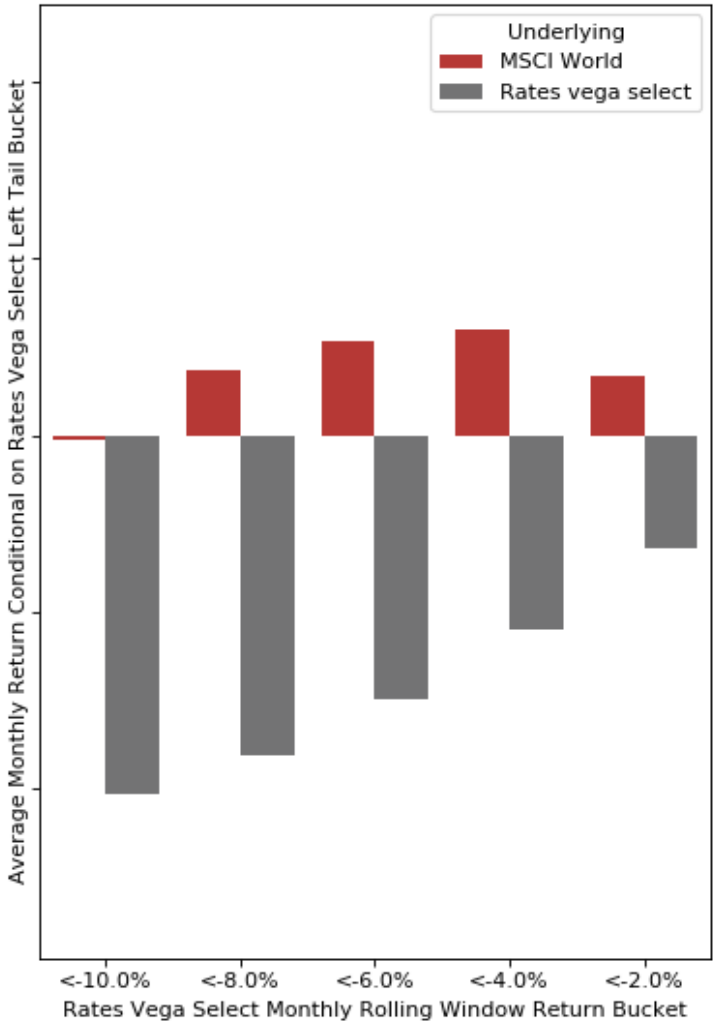


Both indices are scaled to 10% vol
Source: Nomura, Bloomberg. Date Range: 22 February 2005 to 05 May 2017 Past performance provides no guarantee of future results

Drawdowns combining MSCI World Excess Return and Rates vega select

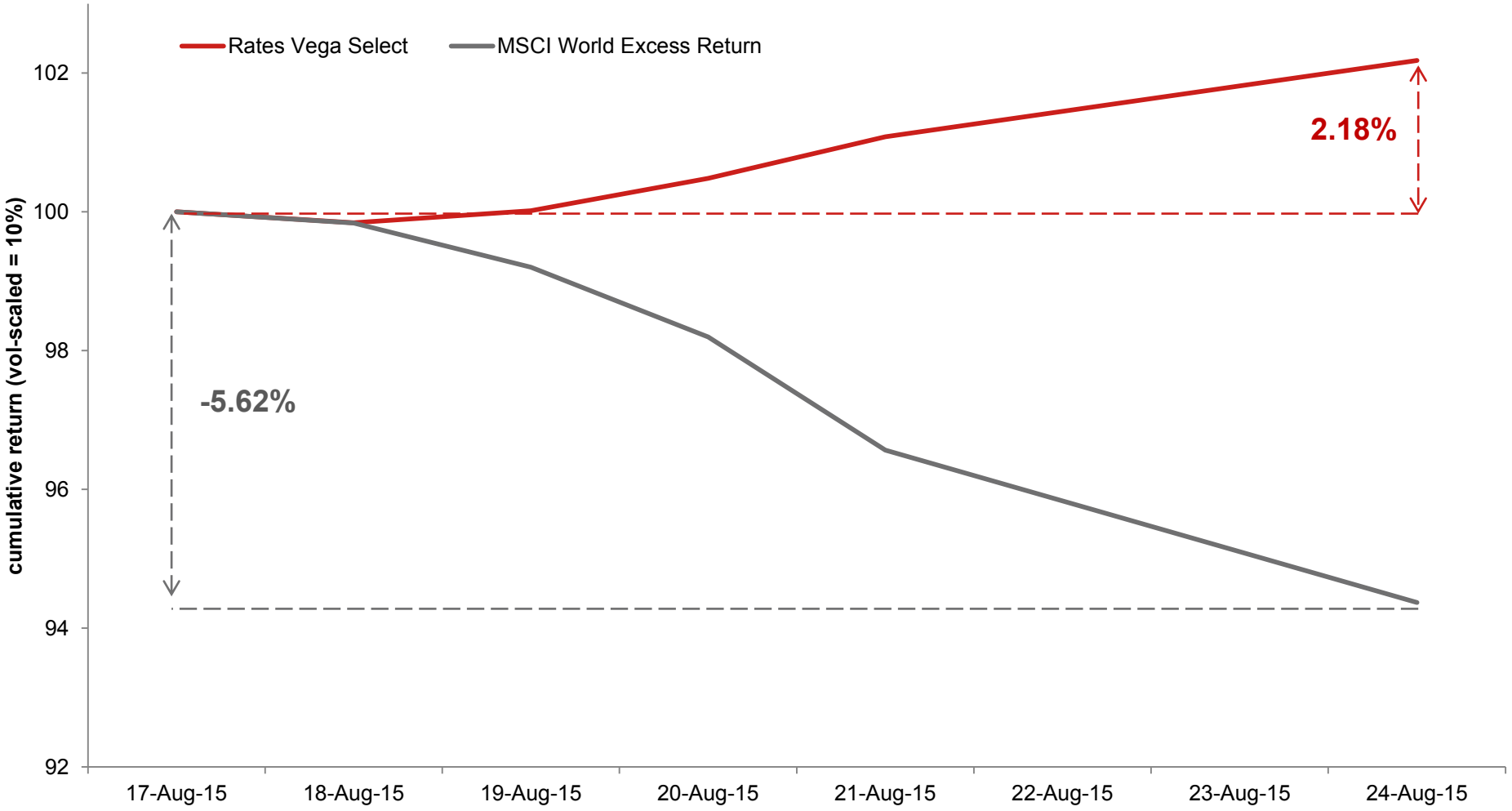
- **During MSCI World Index tail events, Rates vega select rallied correspondingly and consistently, providing downside protection to the shortfall**





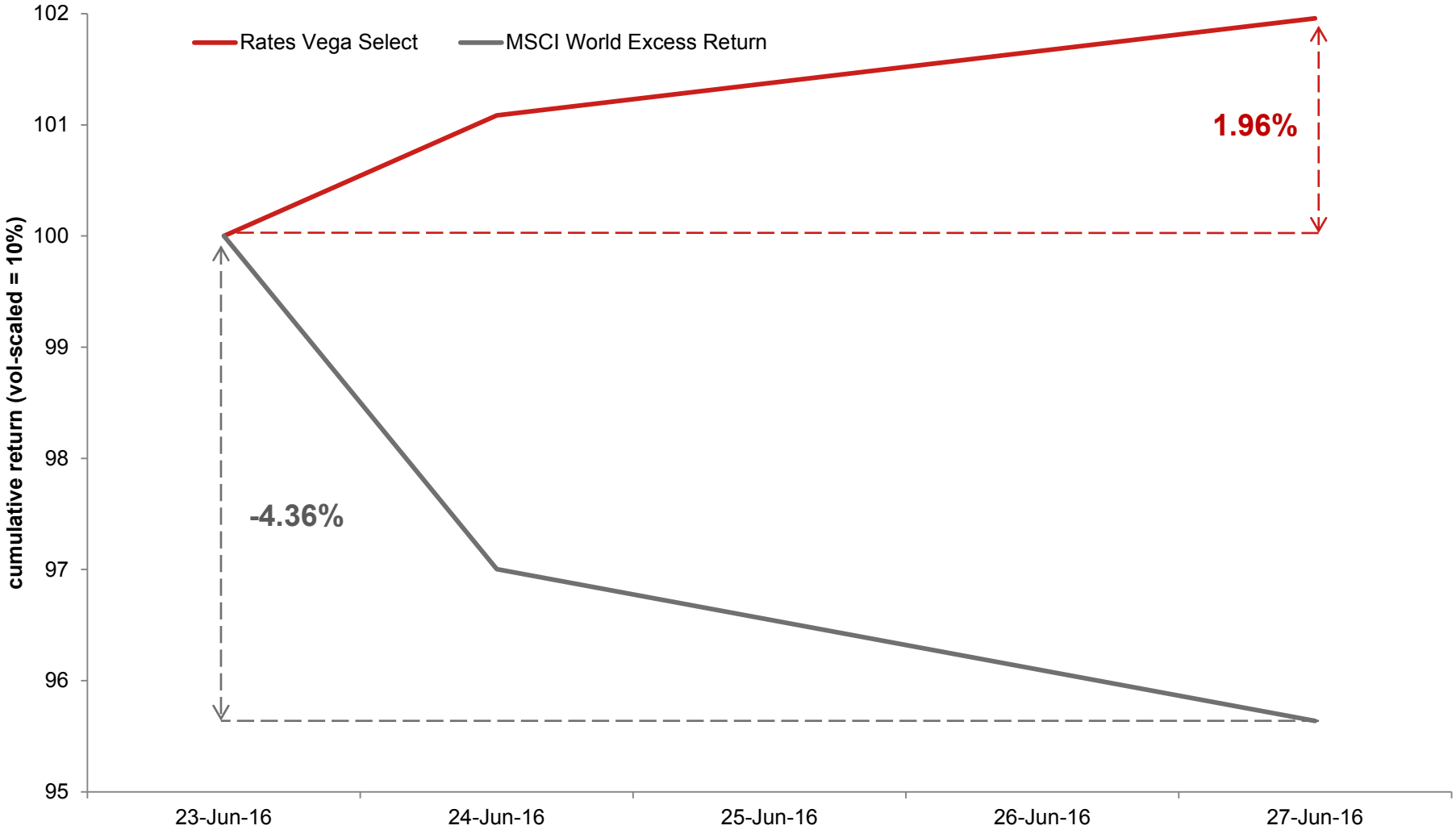
Both indices are scaled to 10% vol
Source: Nomura, Bloomberg. Date Range: 22 February 2005 to 05 May 2017 Past performance provides no guarantee of future results

Case Study – 2015 China Devaluation



Source: Nomura, Bloomberg. Date Range: 22 February 2005 to 19 April 2017 Past performance provides no guarantee of future results

Case Study – Brexit



Source: Nomura, Bloomberg. Date Range: 22 February 2005 to 19 April 2017 Past performance provides no guarantee of future results

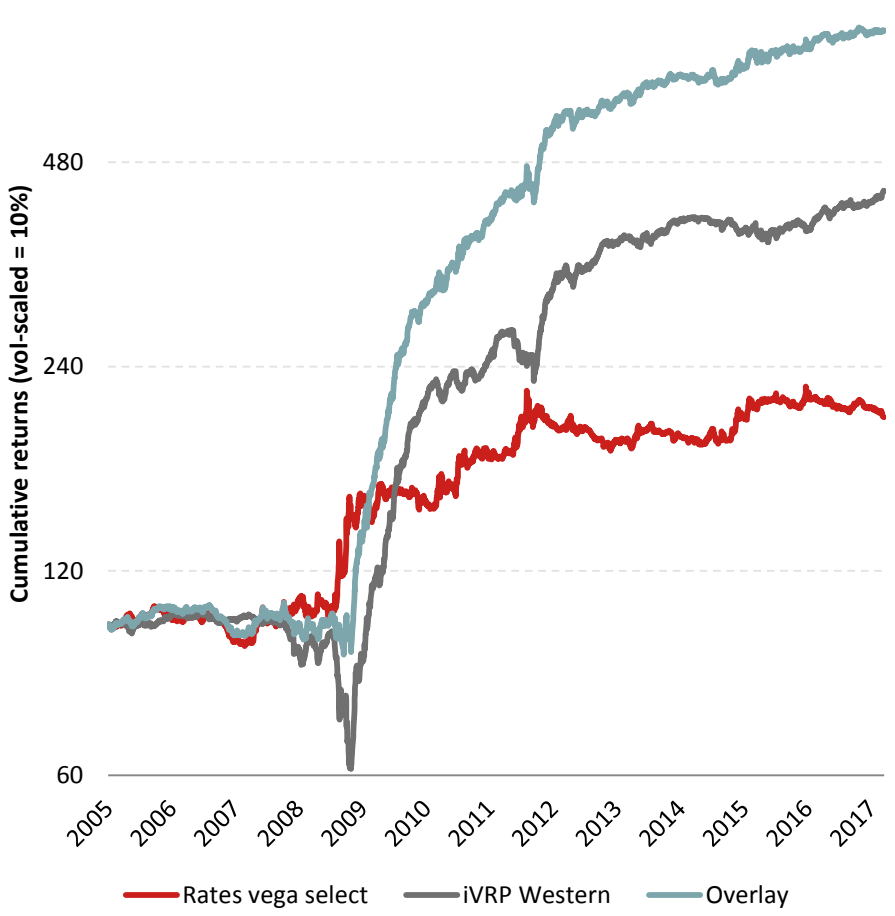
Overlay on vol selling strategies

Long vega works well with short gamma

Alternatives overlay: Rates Vega Select as an iVRP overlay

Rate short gamma index (iVRP*) overlay

Historical Cumulative Returns (iVRP Western + Rates vega select)



Key points

- Short gamma (interest rate Volatility Risk Premia) strategy produces steady stream of returns with large drawdowns from gamma exposure from systematic selling of short-dated swaptions.
- Vega overlay (100%) mitigates some of this downside, enhancing returns, and eliminating the negative skewness.

Performance (Since Inception) **

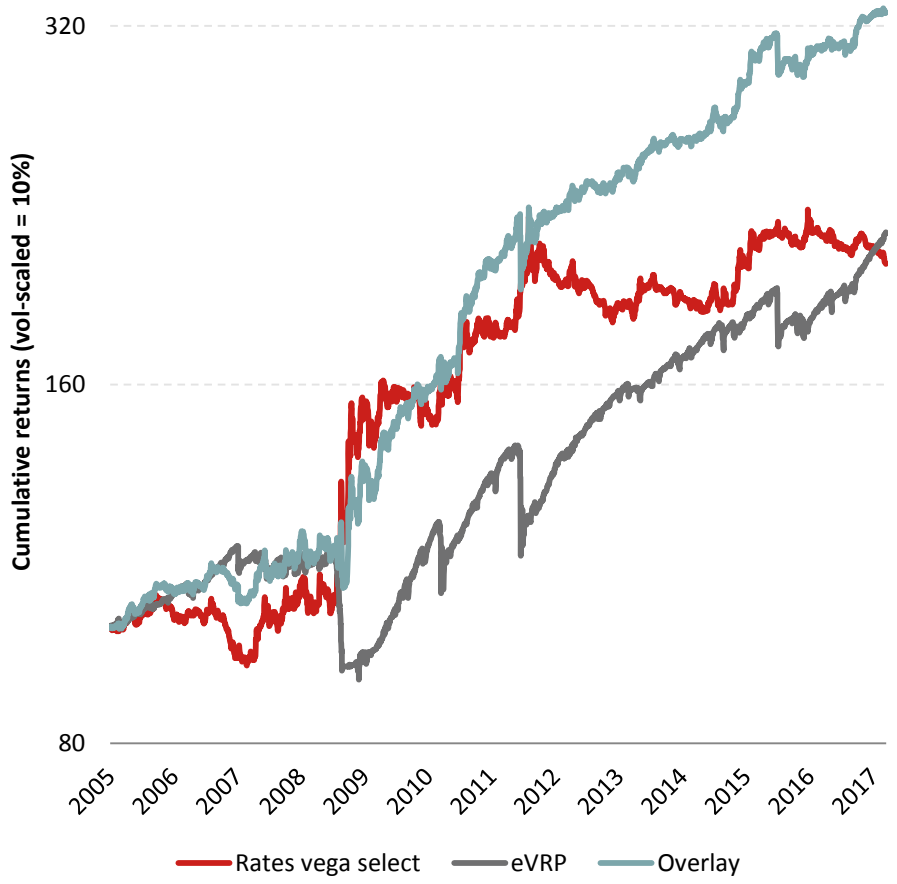
	Rates vega select	iVRP Western	Overlay
Average return (p.a.)	6.26%	12.55%	17.00%
Volatility (p.a.)	10.00%	10.00%	10.00%
Sharpe ratio	**0.63**	**1.25**	**1.70**
Max drawdown	18.49%	41.59%	16.15%
Calmar ratio	**0.34**	**0.30**	**1.05**
Skewness	2.07	0.94	1.94

** iVRP Index is subject to internal reviews and approvals prior to being available for investment by third parties. ** Scaled to 10% vol.*
Source: Nomura, Bloomberg. Past performance is not a reliable indicator of future results.

Alternatives overlay: Rate Vega Select as an eVRP overlay

Equity short variance swap overlay

Historical Cumulative Returns (eVRP + Rates vega select)



Key points

- eVRP (Equities Volatility or Variance Risk Premia) strategy produces a steady stream of returns with some sharper drawdowns typically coinciding with SPX drops.
- While it is not possible to anticipate these drawdowns, some downside can be mitigated.
- Vega overlay (100%) reduces some of this downside, enhancing returns, lowering the negative skewness.

Performance (Since Inception) *

	Rates vega select	eVRP	Overlay
Average return (p.a.)	6.26%	6.76%	10.24%
Volatility (p.a.)	10.00%	10.00%	10.00%
Sharpe ratio	**0.63**	**0.68**	**1.02**
Max drawdown	18.49%	22.81%	13.60%
Calmar ratio	**0.34**	**0.30**	**0.75**
Skewness	2.07	-3.25	1.56

** Scaled to 10% vol.*
Source: Nomura, Bloomberg. Past performance is not a reliable indicator of future results.

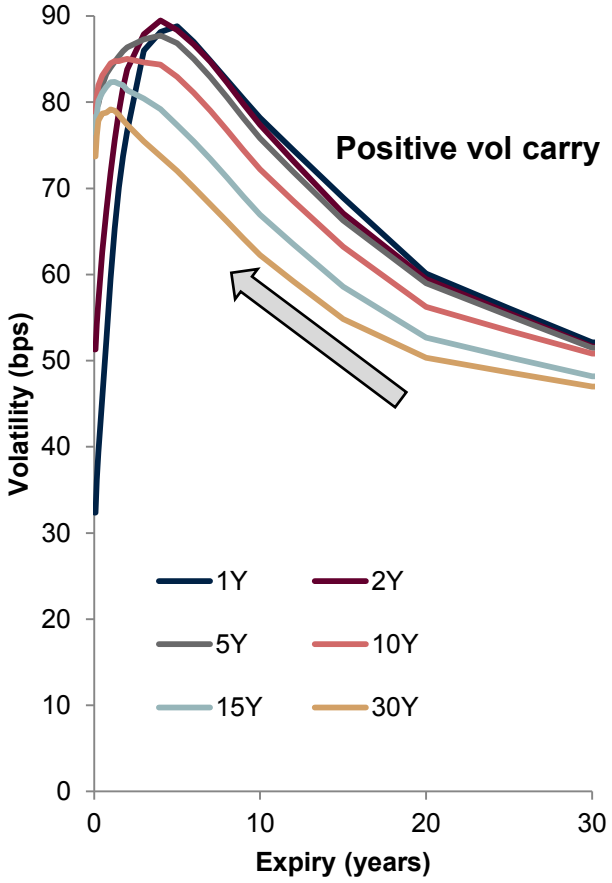
Rates vol: macro-risk protection with positive carry

Downward sloping vol surfaces give rates vega positive carry

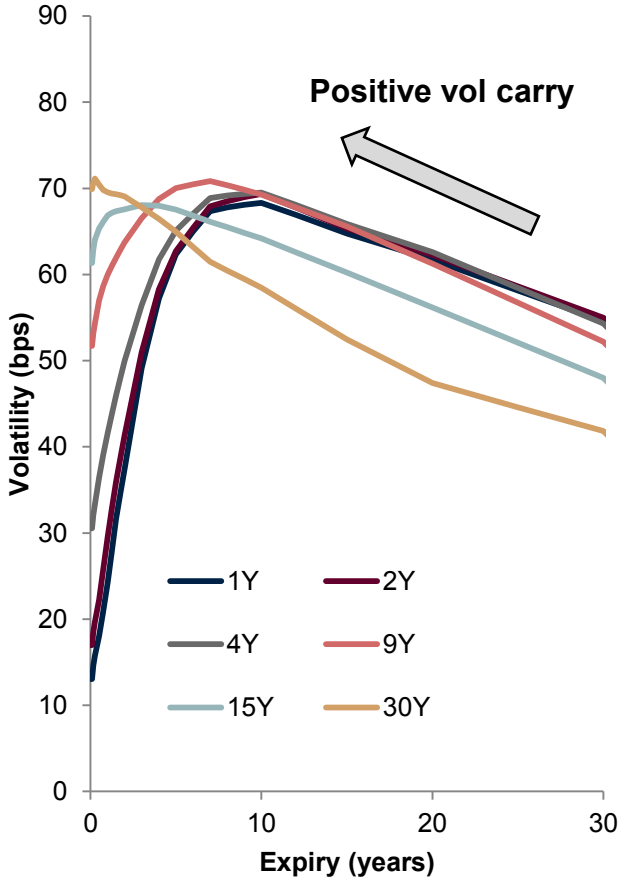
Long dated swaption vol is (mostly) downward sloping

Long dated swaptions can make up for time value by positive vol roll

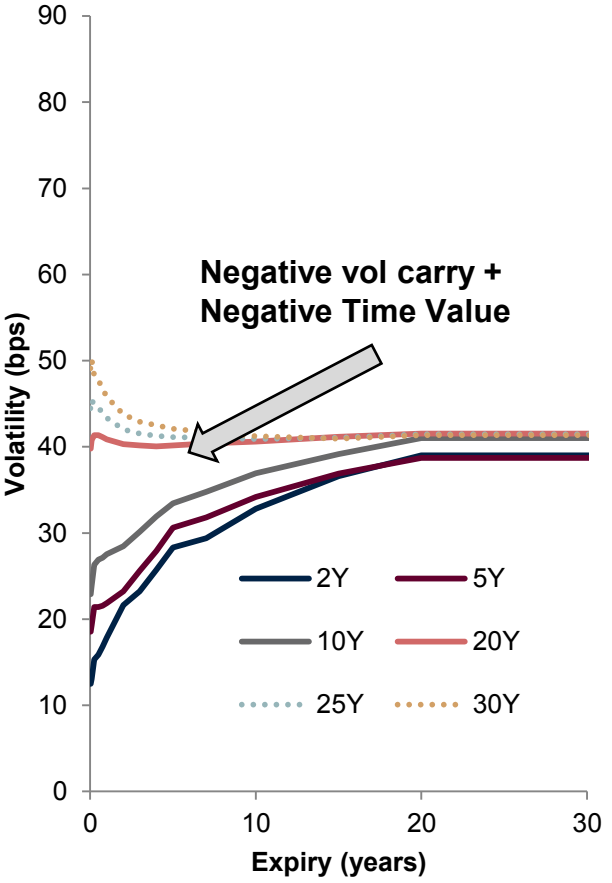
USD — positive vol carry



EUR – positive vol carry



JPY – uncertainty in the distant future

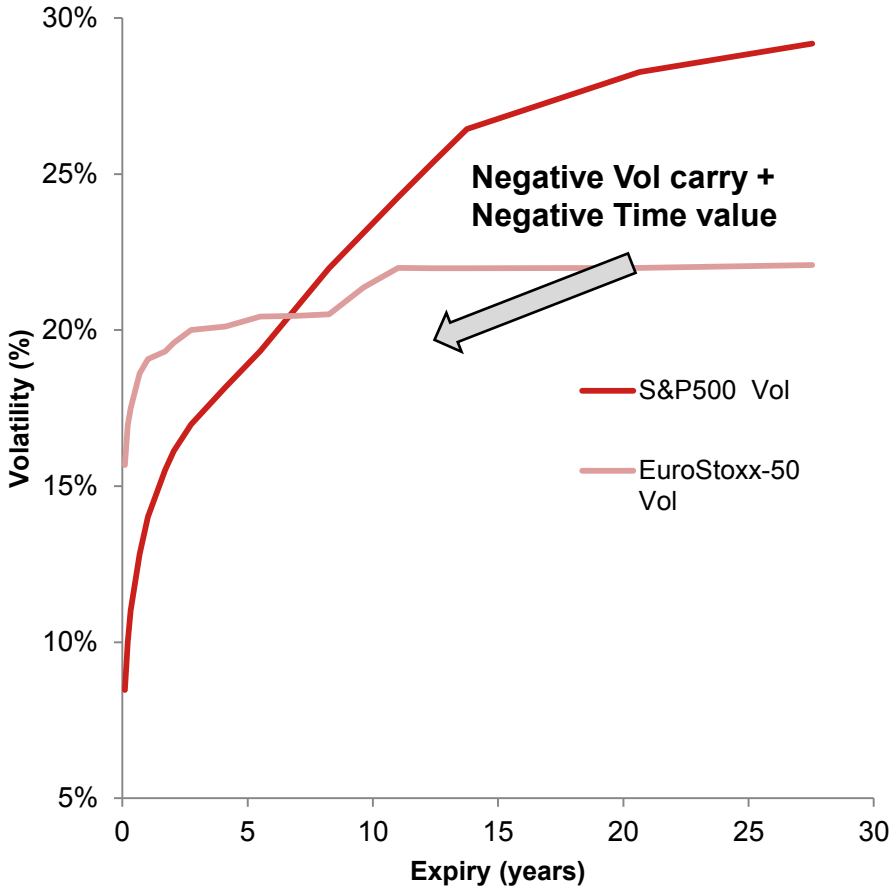


Source: Nomura, 21-Jan-2017, JPY 25y and 30y tails are highly illiquid

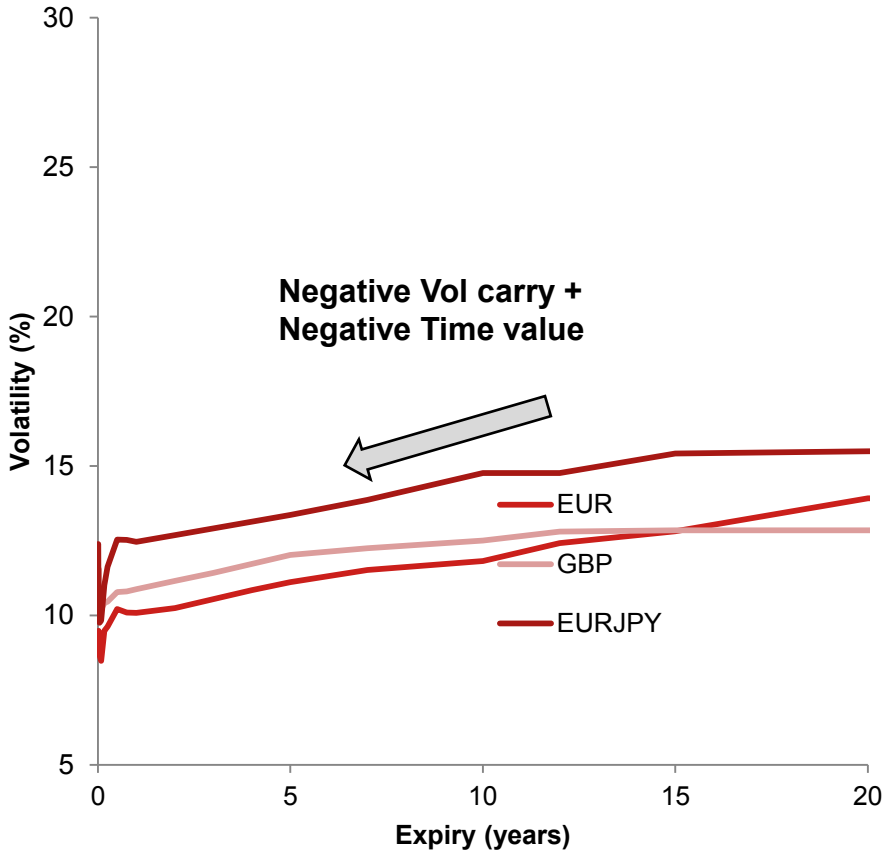
FX and Equities volatility

Pricing in a more uncertain future – long dated options lose on time value and on vol-roll

Equities vols - the world is more uncertain in the distant future



Most FX Vols are upward sloping



Source: Nomura, Bloomberg

Do other vol surfaces have downward slopes?

Select few asset-classes *pay* for buying protection (see Appendix)

Downward Vol Slopes

- **Long Dated Rate Forwards**
  ← only scalable strategy

- Long-dated WTI
- Natural Gas
- Power Futures
- Agricultural Futures
- VIX

- *Most everything in distress*

Upward Vol Slopes

- **Short Dated Rates Forwards**
- **JPY Rates**

- Money-market Futures
- Metals Futures
- Equities
- Foreign Exchange

Source: Duong-Kalev,, The Samuelson hypothesis in futures markets: An analysis using intraday data, J Bank Finance, Vol 32 (Apr 2008) and Back-Prokopczuk, Commodity Price Dynamics and Derivatives Valuation: A Review, SSRN, Aug 21, 2012

Long dated vol can carry flat to mildly positive

Delta-hedged carry = Vega Carry + Theta Carry + ε
= Total Carry – Delta Carry

USD carry (cts) 6M horizon – Long dated expiries get enough boost from vol roll to make up for loss in time value

USD (Straddle) Total Carry (6m horizon) as % of Notional (cts)

	1y	2y	5y	10y	20y	30y
1y	-12.60	-31.87	-85.80	-170.06	-285.60	-385.73
2y	-14.36	-27.62	-56.01	-101.64	-155.95	-199.53
5y	-5.76	-8.92	-22.49	-37.12	-53.94	-72.46
10y	0.22	0.89	2.06	3.11	3.65	3.72
15y	1.76	3.07	6.52	11.32	15.96	20.52
20y	2.56	3.42	7.04	12.50	14.71	18.49
30y	0.51	2.83	5.15	7.61	10.24	13.40

Vega Carry (cts)

	1y	2y	5y	10y	20y	30y
1y	-6.72	-8.14	-1.83	-4.43	-0.10	-4.53
2y	-4.99	-7.27	-1.71	0.64	14.57	27.35
5y	0.00	2.45	4.29	10.66	22.57	29.17
10y	2.23	4.83	11.05	19.79	31.81	41.19
15y	2.00	4.34	9.63	17.32	26.64	34.95
20y	1.91	3.26	7.62	13.97	17.62	22.25
30y	0.83	1.62	3.75	5.17	6.32	7.89

Delta-Hedged Carry (cts)

	1y	2y	5y	10y	20y	30y
1y	-18.18	-37.97	-92.04	-176.69	-293.14	-394.18
2y	-15.17	-29.66	-58.70	-105.72	-162.06	-207.08
5y	-5.86	-9.15	-23.15	-38.77	-55.94	-74.19
10y	0.20	0.86	1.70	3.02	5.33	6.20
15y	1.31	3.00	6.43	11.56	17.48	22.77
20y	1.81	3.07	7.15	13.12	16.24	20.42
30y	0.52	1.01	3.74	4.64	5.59	7.13

Theta (cts)

	1y	2y	5y	10y	20y	30y
1y	-11.47	-30.05	-91.14	-174.08	-296.20	-393.86
2y	-10.33	-22.68	-57.79	-107.85	-179.15	-237.81
5y	-5.94	-11.75	-27.79	-50.07	-79.55	-104.73
10y	-2.09	-4.09	-9.65	-17.31	-27.33	-36.12
15y	-0.70	-1.34	-3.20	-5.76	-9.17	-12.17
20y	-0.10	-0.19	-0.47	-0.84	-1.37	-1.84
30y	-0.31	-0.61	-0.01	-0.53	-0.73	-0.76

Source: Nomura

Key takeaways

Rates swaptions – Long event risk with positive carry

- Rates unlike FX and Equities, can have downward sloping vol curves
- JPY is different

- For long dated swaptions, positive vol-roll can outweigh time-value

- Long expiry rates swaptions:
  - **Positive carry**
  - **Long volatility, long event risk**

Source: Nomura

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Creating a vega strategy

Goals for the strategy

- Define **universe** of eligible swaptions
- **Buy** swaptions regularly
- **Hedge** curve exposure – choose reasonable and infrequent hedge to minimize transaction costs
- **Roll** regularly – longer holding horizons to minimize transaction costs
- Use **signal** to replicate and outperform

- **Measure** performance and reactiveness

Source: Nomura

The universe of long-dated vol trades

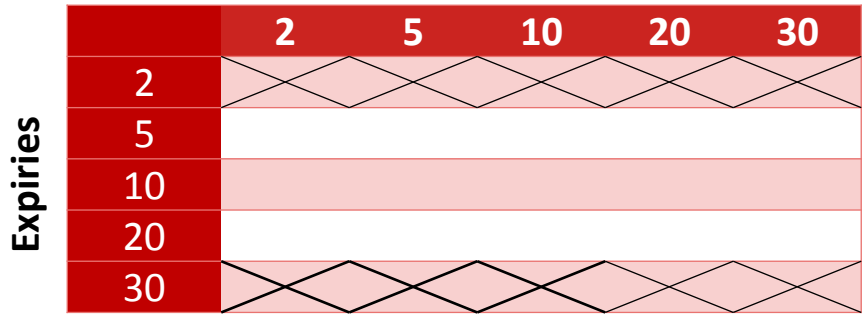
Focus on broad range of vols for program trading

Most liquid, most conventional

- Include
  - 5y, 10y, 20y expiries
  - 2y, 5y, 10y, 20y, 30y tenors
- We eliminate illiquid 30y expiries which have tiny trading volume
- We consider 2y expiries, arguably not in the *vega* part of the surface
- **Trade most commonly traded swaptions:**
  - **ATMs** at trade start (most liquid)
  - **Standard market convention** (USD: Swap-settle, Semi/Quarterly 3m LIBOR, EUR: Cash-settle Annual/Semi 6m EURIBOR)

Eliminate less useful vols

Vols for vega strategy (USD and EUR)



Source: Nomura

Performance of individual vol points

Vega scaled, weekly delta-hedged, annuity & forward premium hedged strategies

Rationale

- 5Y and upwards have decent returns since inception
- 2Y expiries are a significant drag and are dropped
- We can easily include all (liquid) vols with expiries greater than 5y
- We eliminate illiquid 30y expiries
- Total of 15 swaptions / currency or 30 swaptions in universe for Aggregate

- Note:
  - Hedge netting, diversification, and signals can improve on any single strategy
  - Details of hedging mechanism and signal given in appendix

Sharpe Ratios Since Inception (USD)

Currency Tenure Expiry	USD 2y	USD 5y	USD 10y	USD 20y	USD 30y
2y	0.15	0.09	-0.09	-0.09	-0.05
5y	0.20	0.18	0.24	0.30	0.30
10y	0.42	0.47	0.39	0.44	0.46
20y	0.30	0.33	0.38	0.40	0.39
30y	0.13	0.17	0.19	0.20	0.38

Sharpe Ratios Since Inception (EUR)

Currency Tenure Expiry	EUR 2y	EUR 5y	EUR 10y	EUR 20y	EUR 30y
2y	0.18	0.06	-0.14	-0.08	-0.05
5y	0.27	0.27	0.27	0.39	0.43
10y	0.34	0.39	0.42	0.52	0.57
20y	0.40	0.44	0.46	0.50	0.49
30y	0.31	0.33	0.34	0.32	0.28

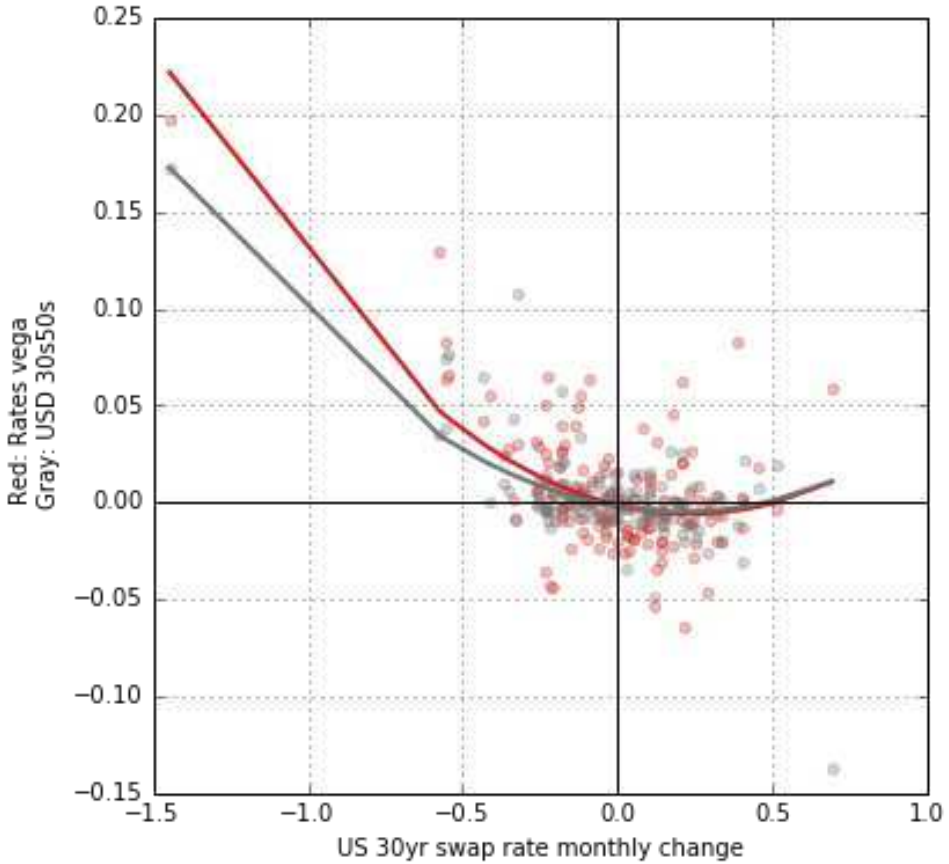
Source: Nomura. Past performance is not a reliable indicator of future results.

Rate vega select – properties

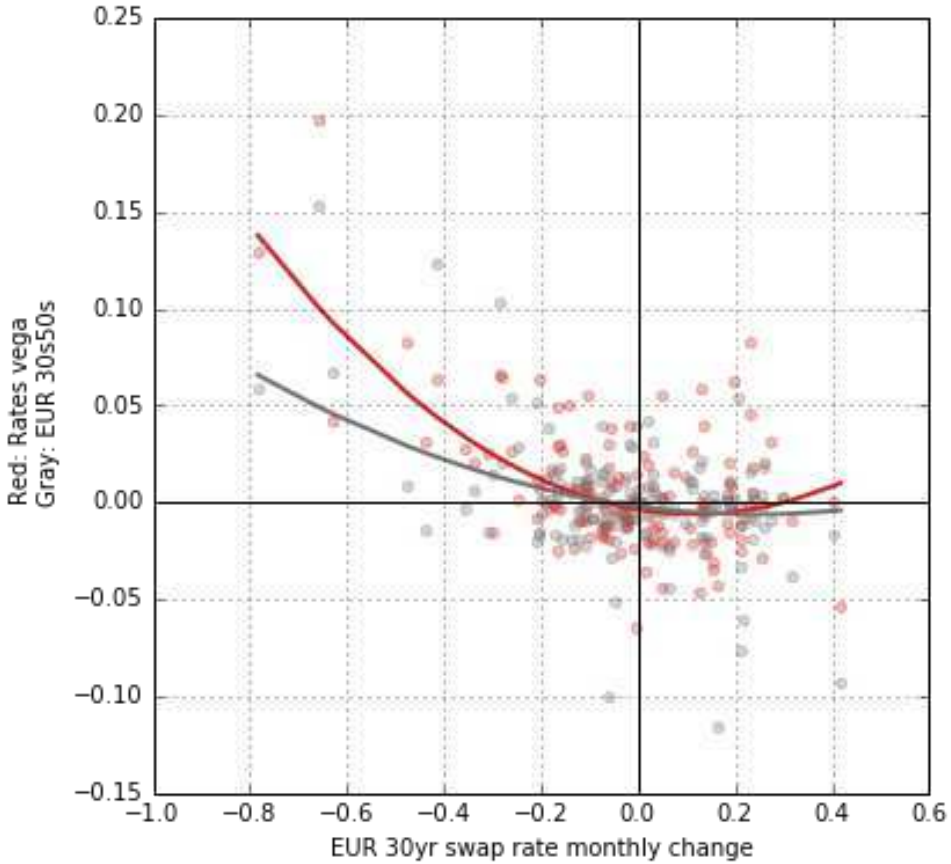
Rates vega select offers higher convexity than swaps

Comparing convexity of vega to the dv01-neutral 30s50s flattener

USD rates— Vega is more convex on average



EUR rates — Vega is more convex on average

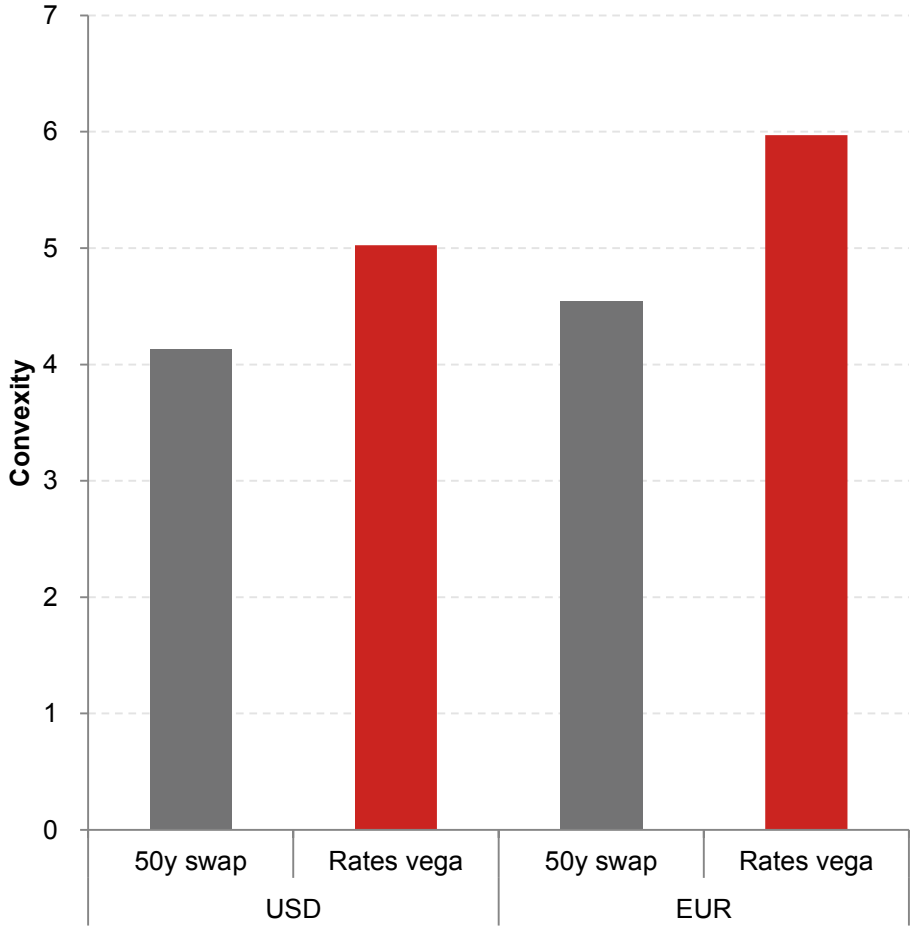


Source: Nomura. Past performance is not a reliable indicator of future results.

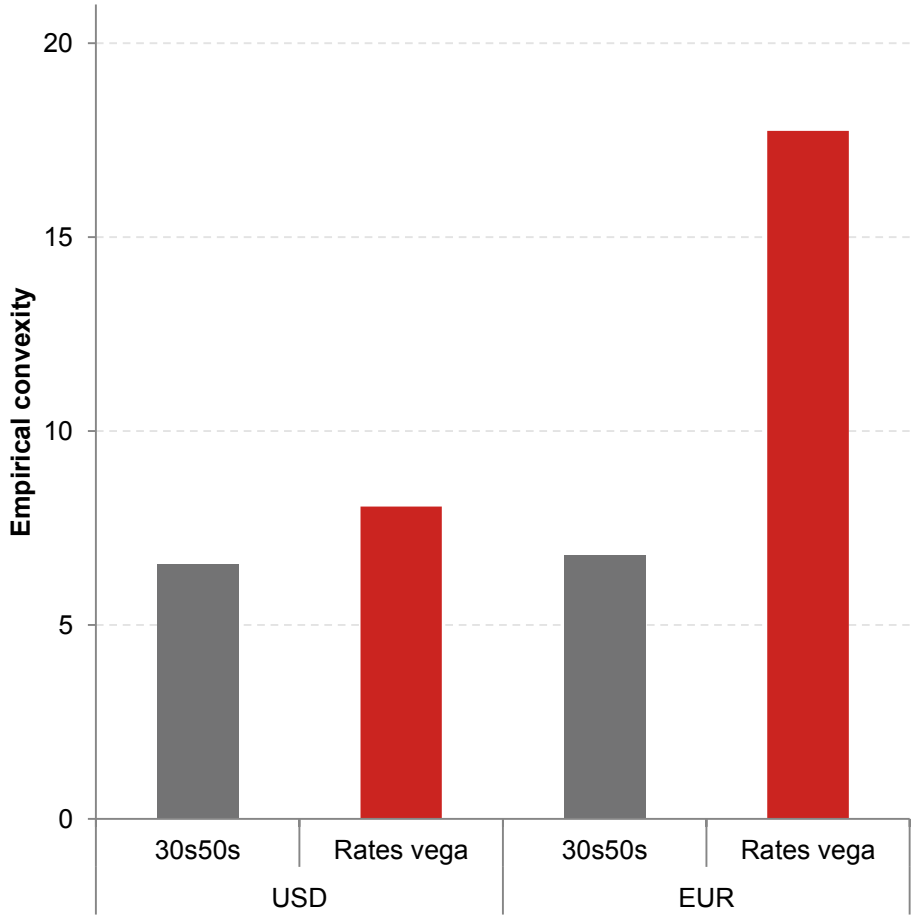
Rates vega select offers higher convexity than swaps

Comparing rates vega select convexity to the 50y

Convexity snapshot as of Jan 2017



Empirical (average) convexity since inception



Source: Nomura. Past performance is not a reliable indicator of future results.

Where does vega fit into “alternative styles”?

Rates vega select– tail-risk by design is clearly a momentum-styled strategy
More modest performance with higher responsiveness

Pairwise correlation Feb 2005 - May 2017 (Monthly returns)	S&P500	UST 10yr	G4 Rates Momentum	Commodity Momentum	EM FX Momentum	G3 Equity Momentum	Cross Asset Momentum	G4 Rates Carry	Commodity Relative Carry	CoLRS Select A Spread	G10 FX Carry	EM FX Carry	Global FX Carry	Western Fallen Angels	eVRP	Western iVRP	Rates vega select
S&P500	1.00	-0.26	-0.34	-0.27	-0.08	-0.13	-0.31	-0.02	-0.09	0.09	0.47	0.36	0.47	0.57	0.65	0.39	-0.50
UST 10yr	-0.26	1.00	0.61	0.01	-0.03	-0.12	0.17	0.44	0.08	-0.10	-0.19	-0.18	-0.23	-0.21	-0.19	-0.14	0.38
G4 Rates Momentum	-0.34	0.61	1.00	0.28	0.03	0.10	0.53	0.31	0.23	-0.09	-0.13	-0.12	-0.19	-0.26	-0.22	-0.19	0.51
Commodity Momentum	-0.27	0.01	0.28	1.00	0.25	0.40	0.75	-0.14	0.44	0.08	-0.15	-0.19	-0.18	-0.15	-0.24	-0.22	0.28
EM FX Momentum	-0.08	-0.03	0.03	0.25	1.00	0.12	0.60	-0.07	0.05	0.06	0.01	-0.01	0.03	0.06	0.01	-0.10	0.10
G3 Equity Momentum	-0.13	-0.12	0.10	0.40	0.12	1.00	0.63	-0.23	0.17	-0.02	0.03	0.06	0.04	0.02	-0.04	-0.18	0.15
Cross Asset Momentum	-0.31	0.17	0.53	0.75	0.60	0.63	1.00	-0.04	0.33	0.03	-0.09	-0.10	-0.11	-0.12	-0.18	-0.25	0.40
G4 Rates Carry	-0.02	0.44	0.31	-0.14	-0.07	-0.23	-0.04	1.00	-0.06	-0.11	0.04	-0.01	0.02	-0.06	-0.10	0.11	-0.07
Commodity Relative Carry	-0.09	0.08	0.23	0.44	0.05	0.17	0.33	-0.06	1.00	0.08	0.02	-0.13	-0.08	-0.07	-0.07	-0.15	0.20
CoLRS Select A Spread	0.09	-0.10	-0.09	0.08	0.06	-0.02	0.03	-0.11	0.08	1.00	0.00	0.07	0.07	-0.07	0.02	0.08	-0.06
G10 FX Carry	0.47	-0.19	-0.13	-0.15	0.01	0.03	-0.09	0.04	0.02	0.00	1.00	0.53	0.78	0.31	0.42	0.22	-0.23
EM FX Carry	0.36	-0.18	-0.12	-0.19	-0.01	0.06	-0.10	-0.01	-0.13	0.07	0.53	1.00	0.91	0.31	0.28	0.19	-0.22
Global FX Carry	0.47	-0.23	-0.19	-0.18	0.03	0.04	-0.11	0.02	-0.08	0.07	0.78	0.91	1.00	0.37	0.36	0.22	-0.29
Western Fallen Angels	0.57	-0.21	-0.26	-0.15	0.06	0.02	-0.12	-0.06	-0.07	-0.07	0.31	0.31	0.37	1.00	0.47	0.08	-0.39
eVRP	0.65	-0.19	-0.22	-0.24	0.01	-0.04	-0.18	-0.10	-0.07	0.02	0.42	0.28	0.36	0.47	1.00	0.43	-0.35
Western iVRP	0.39	-0.14	-0.19	-0.22	-0.10	-0.18	-0.25	0.11	-0.15	0.08	0.22	0.19	0.22	0.08	0.43	1.00	-0.40
Rates vega select	-0.50	0.38	0.51	0.28	0.10	0.15	0.40	-0.07	0.20	-0.06	-0.23	-0.22	-0.29	-0.39	-0.35	-0.40	1.00

Source: Nomura, Bloomberg. Past performance is not a reliable indicator of future results.

Conclusion

Rates vega select as cheap “insurance”

Buying insurance shouldn’t cost an arm and a leg— Vega gives you insurance with reasonable returns

- Tail Risk funds
  - Hedge inconsistently
  - Have large negative drag
  - Never truly pay back

- Rates vega select is one of the few strategies
  - Almost pure vol risk with positive carry
  - Right-tailed, performs well in *risk-off* markets
  - Pays for itself – reasonable returns the rest of the time
  - High convexity

Source: Nomura

Appendix: Costs and cashflows

Transaction costs and cashflows are internal to strategy

All backtests are net of the following transaction costs

- Strategy incurs the following charges:
  - Vol charge for each swaption upon entry
  - Vol charge for each swaption upon exit
  - Delta charge for each forward swap hedge
  - Delta charge for each annuity and forward premium hedge (net) using 2 spot swaps total per currency
  - Delta charge for each annuity and forward vol hedge unwind
  - Delta charge for each forward swap unwind
- Spot swaps' fixed/float payments accrue at OIS rate flat on both sides

	vega charge				
	2y	**5y**	**10y**	**20y**	**30y**
5y	0.5	0.5	0.5	0.5	0.5
10y	0.5	0.5	0.5	0.5	0.5
20y	0.5	0.5	0.5	0.5	0.6

delta charge is 0.5bp for all expiries/tenures

Source: Nomura

Appendix: Mechanics of the trade

Deriving a good strategy

Goals: Define universe

- **Vega Universe**
  - Define universe of *liquid* vega trades
  - Determine areas of significant performance (Sharpe, 'responsiveness', skewness, etc).
- **Aggregate Strategy**
  - Determine **Structural parameters:** Weighting, Holding horizon, Trade Frequency
  - Create **Hedging Strategy**
    - Appropriate Curve Risk Hedging (Annuity + Forward Premium)
    - Appropriate Black-Scholes Delta Hedging, exploring thresholds and target deltas
  - Create non-tradable Benchmark Aggregate Strategy
- **Signal-based trading**
  - **Carry selection**: use carry signal to select portfolio of 2 swaptions / currency / month
  - Weight and hedge the same way as benchmark aggregate
  - Determine performance relative to benchmark (Sharpe, responsiveness, skewness)
  - Create tradable Rates vega select

Source: Nomura

Where does positive carry come from?

After hedges, remaining terms are Time-Carry and Vol-Carry (and Gamma-carry which we ignore)+

$$SwaptionPV = BS \cdot Annuity$$

$$BS = BS(F, K, \sigma, t)$$

$$Annuity = Annuity(KCurve)$$

Expanding BS into hedge-able and other terms

$$dBS = \Delta_{\mathrm{BS}} dF + \theta dt + \nu d\sigma + \frac{1}{2}\Gamma d^2F + \cdots$$

Curve Risks are effectively hedge-able using combination of forward starting swaps and spot-starting swaps

What theoretically remains after we hedge

$$dSwaptionPV = A \cdot dBS + BS \cdot dA$$

$$dSwaptionPV = \underbrace{A \cdot \Delta_{\mathrm{BS}} dF + BS \cdot \frac{\partial A}{\partial (curve)} dt}_{Curve\ Risks/Hedged} + \underbrace{A \cdot \theta dt}_{Time\ Carry} + \underbrace{A \cdot \nu d\sigma}_{Vol\ Carry} + \underbrace{\frac{1}{2}\Gamma\sigma^2 dt}_{Gamma\ Carry}$$

Source: Nomura

Hedging curve risk of vega strategies

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Black-Scholes Delta hedge and an Annuity and Forward Premium Hedges

We consider a straddle with expiry T on a swap with maturity T_{mat} and swap rate $R(T)$. The payoff is

$$P = Annuity_{mat}(T) \cdot |R(T) - K|.$$

Evaluating this at time t, we get, using the *Black-Scholes* formula:

$$PV_{swaption}(t) = Annuity(t) \cdot PV_{BS}(t) \stackrel{\text{def}}{=} A(t) \cdot PV_{BS}(t)$$

If this swaption is forward settle, it has one extra cash-flow to give initial PV of 0 and lowers the initial curve dependence. We can also consider a running premium to lower overall curve dependence.

PV of the package is given by

$$PV_{package}(t) = PV_{swaption}(t) - FwdPrem(t) = A(t) \cdot PV_{BS}(t) - PV(t_0)DF(t,T)$$

Hedging curve risk , we get the following terms

$$\partial PV_{pkg}(t)\Big/_{\partial(Curve)} = \underbrace{A(t) \cdot \Delta_{BS}(t)}_{Black-Scholes\ Risk} + \underbrace{\partial A(t)\Big/_{\partial(Curve)} \cdot PV_{BS}(t)}_{Annuity\ Risk} - \underbrace{PV(t_0)\,\partial DF(t,T)\Big/_{\partial(Curve)}}_{Forward\ Premium\ Risk}$$

We manage Black-Scholes Delta quite actively using matched forwards.

Annuity / Forward Premium Risks are curve risks and we can hedge at trade start.

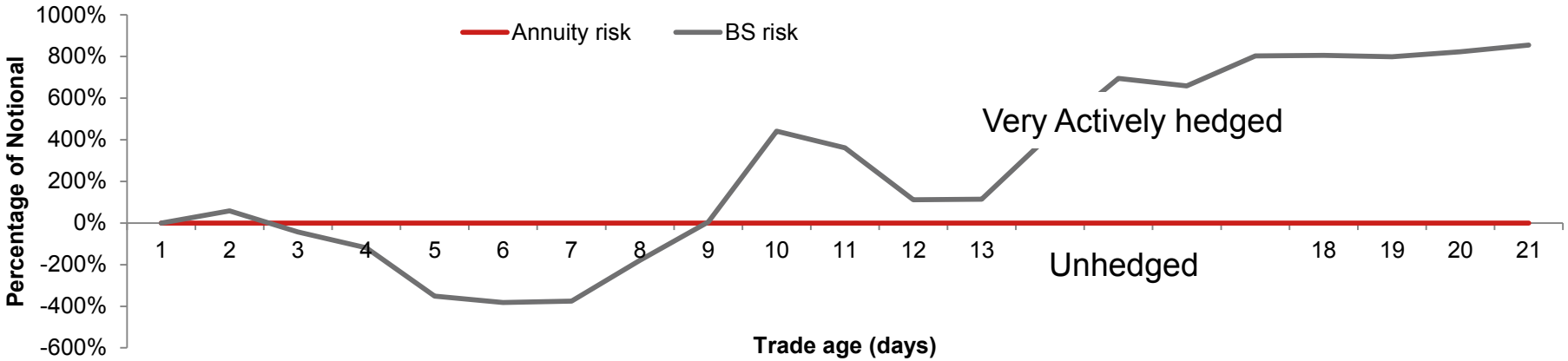
Leaves behind vega and time and gamma returns

Source: Nomura

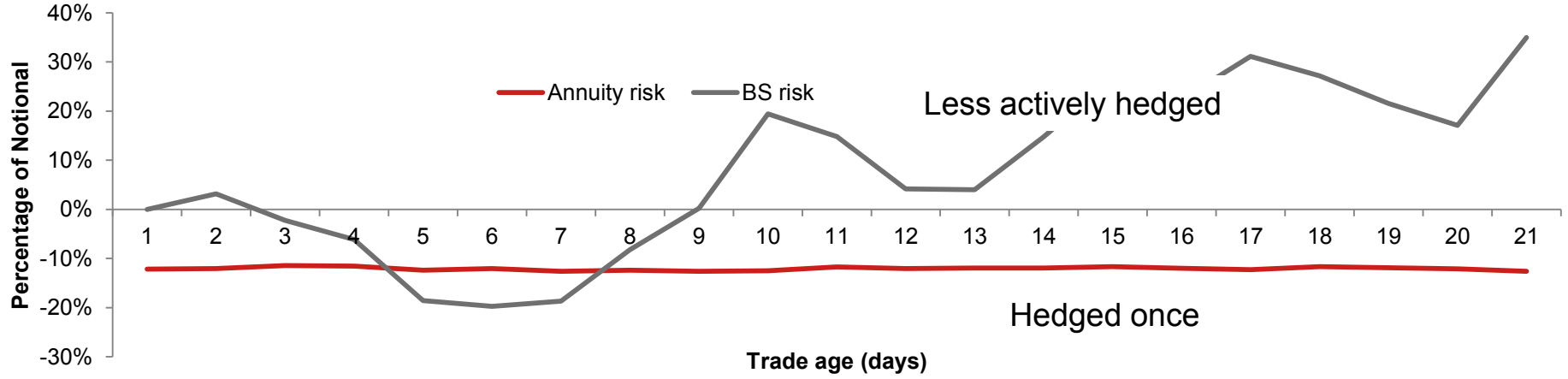
What curve exposures should we hedge?

Vega-trading is not like gamma-trading – we must hedge the annuity too. Initial curve delta is non-zero

Gamma Trading (iVRP) – USD 1m10y risk breakdown, November 2009 (initial premium 266ct)



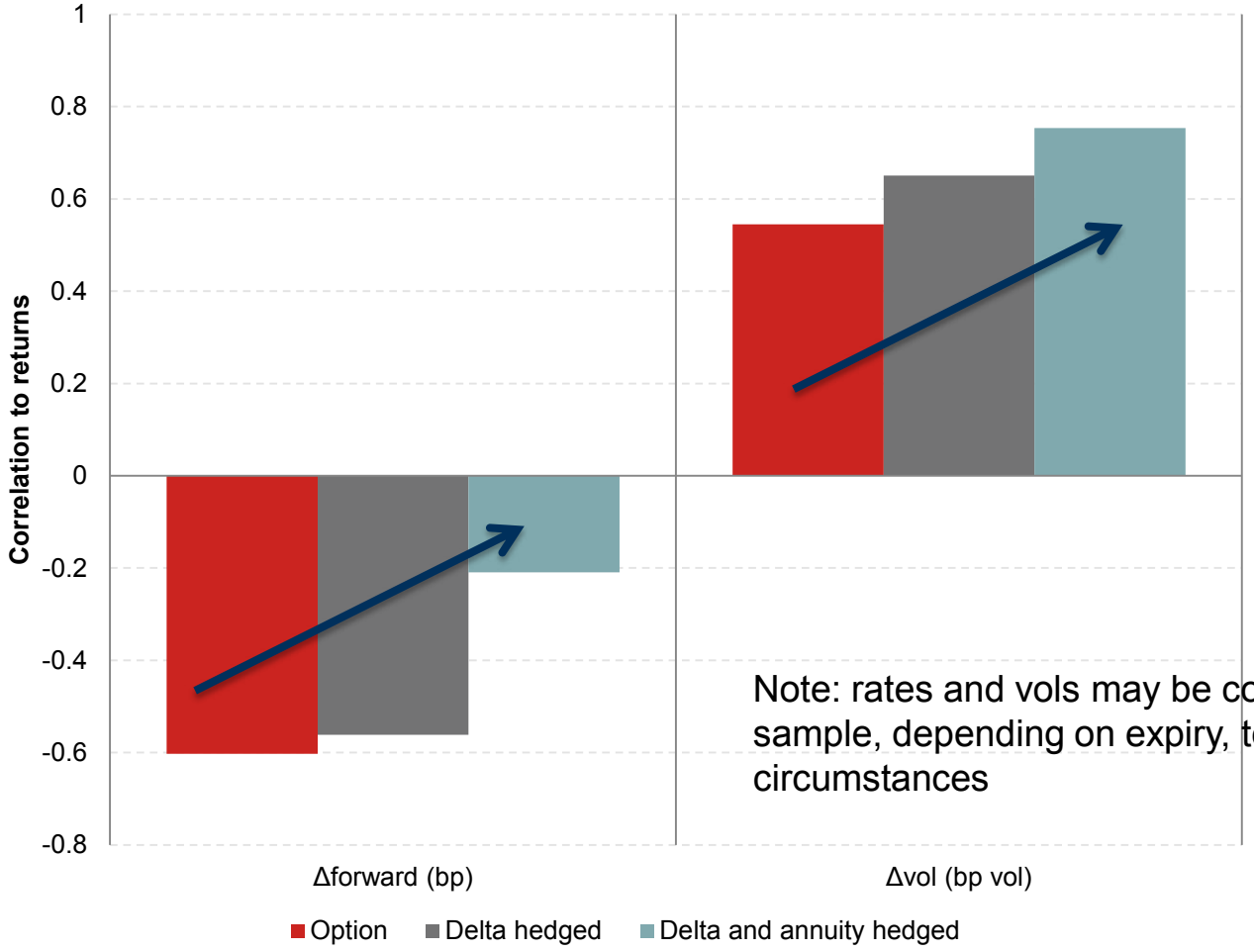
Vega Trading (Rates vega select) – USD 10y10y risk breakdown, November 2009 (initial premium 1252ct)



Source: Nomura

Fine-tuning sensitivities – lower curve and higher vol

USD 10y20y swaptions – Proper hedge decreases correlations to rates and increases correlations to volatilities



Note: rates and vols may be correlated in-sample, depending on expiry, tenor and market circumstances

Source: Nomura. Past performance is not a reliable indicator of future results.

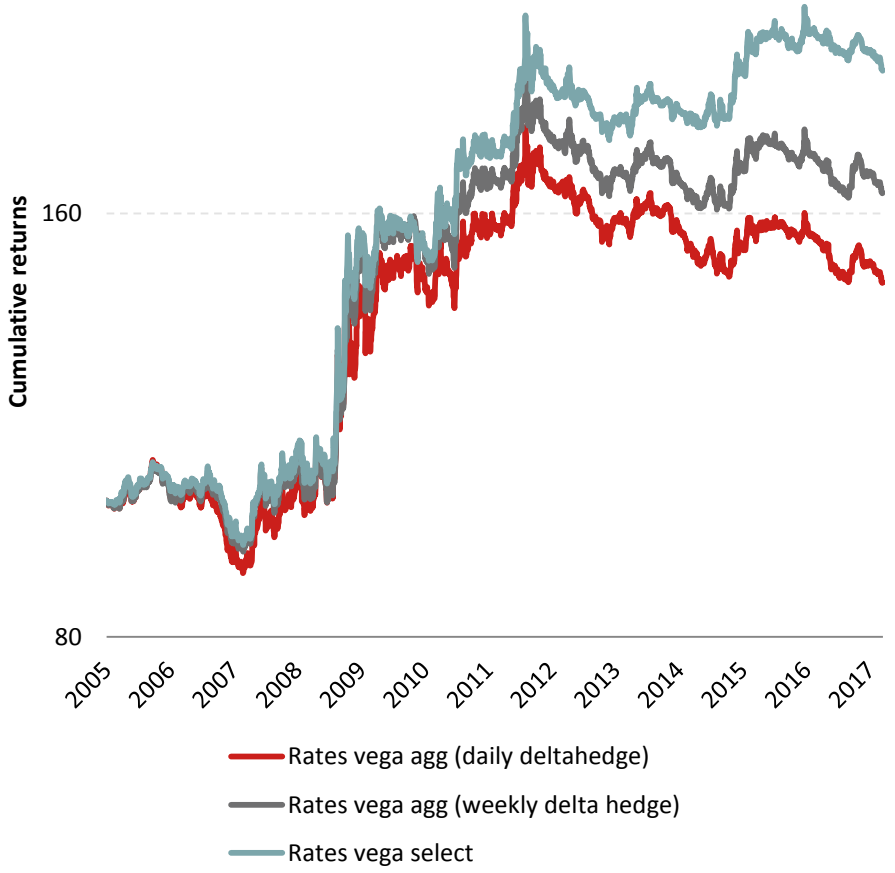
Hedging strategy + signal improves performance

Weekly hedging + carry-based signal
Less transaction costs, less hassle, better performance

Performance improvements *

	Rates vega agg (daily delta hedge)	Rates vega agg (weekly delta hedge)	Rates vega select
Average return (p.a.)	3.42%	4.62%	6.26%
Volatility (p.a.)	10.00%	10.00%	10.00%
Sharpe ratio	**0.34**	**0.46**	**0.63**
Max drawdown	22.51%	21.19%	18.49%
Calmar ratio	**0.15**	**0.22**	**0.34**
Skewness	0.96	1.42	2.07
Backtest info			
Hedging frequency	1d	1w	1w
Delta threshold	0	0.1	0.1
Delta target	0	0.1	0.1
Indicator			6m vol carry
Signal			6m z-score

Hedging strategy (weekly Δ target) + Signal Performance



** Scaled to 10% vol.*
Source: Nomura. Past performance is not a reliable indicator of future results.

Rates vega select: hedging and signal

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Goal: Exceed aggregate performance with fewer swaptions

- **Rates vega select: Monthly Trade Frequency**
  - **Carry signal** - rank trades by 6-month z-score of 6-month vol carry
  - **Pick two highest carry trades per currency**
  - Notional is Vega-weighted, compounded by overall strategy performance
  - **Hold for 6m and unwind** (2 x 2 x 6 = 24 swaptions)
  - **Hedges divided into two buckets:**
    - **Weekly Black-Scholes hedge:** Delta hedge Black-Scholes risk from trade start to trade unwind
      - Using appropriate matched (dated) forward for each swaption
      - **Weekly hedge frequency**
      - **Delta threshold and Delta target** – hedge only if swaption |Delta|>0.1
    - **Non-Black-Scholes Hedge:**
      - **USD**
        - **One time hedge:** determine Annuity/Forward Premium (initial curve risk) at trade start
        - Hedge with spot swaps for life of trade (6M), accrue cash at OIS rate
      - **EUR**
        - Hedge with matched forward swaps at trade start, as well as the same timing as Black-Scholes hedge
      - **Netting** of transactions for cost savings

Source: Nomura

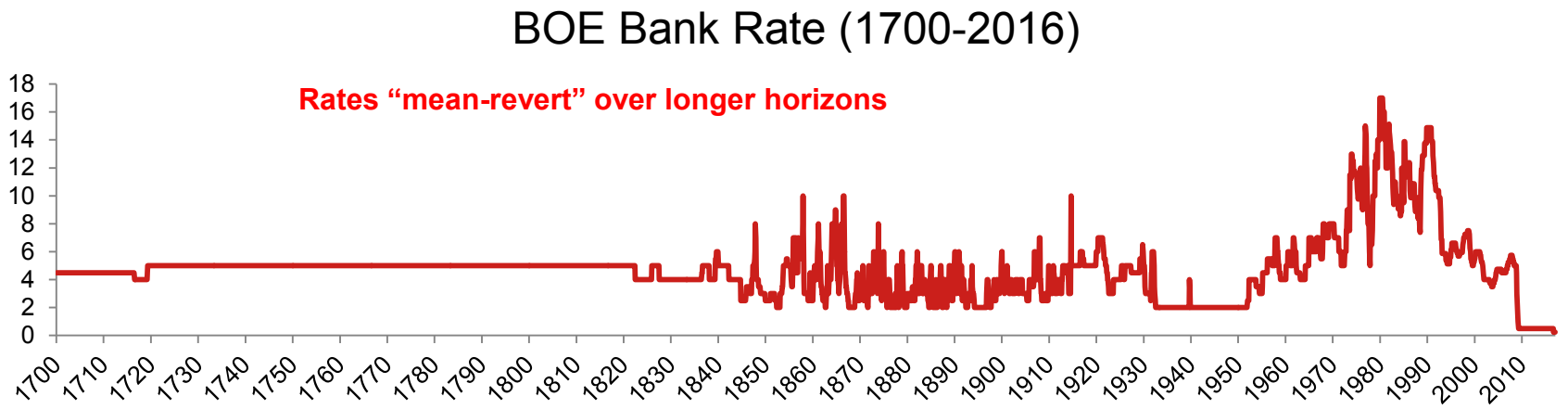
Appendix: What drives vol slopes?

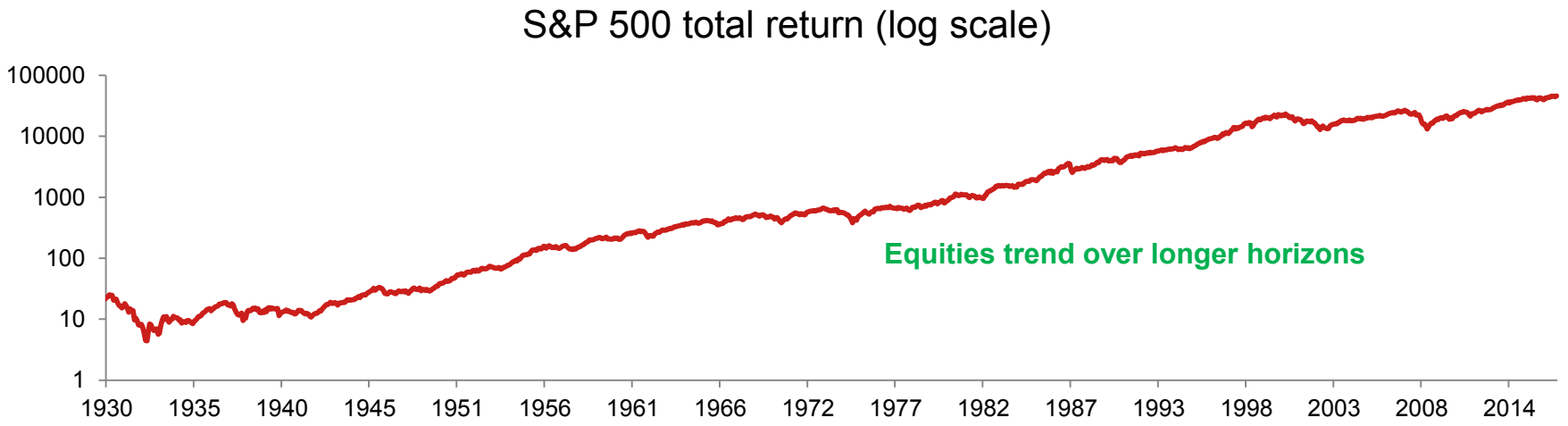
More fundamental than exotic flow!

Rates mean-revert over long horizons, Equities & FX do not

The view from the P-measure – rates, unlike equities and fx, mean revert….

…..but we care more about risk-neutral measure



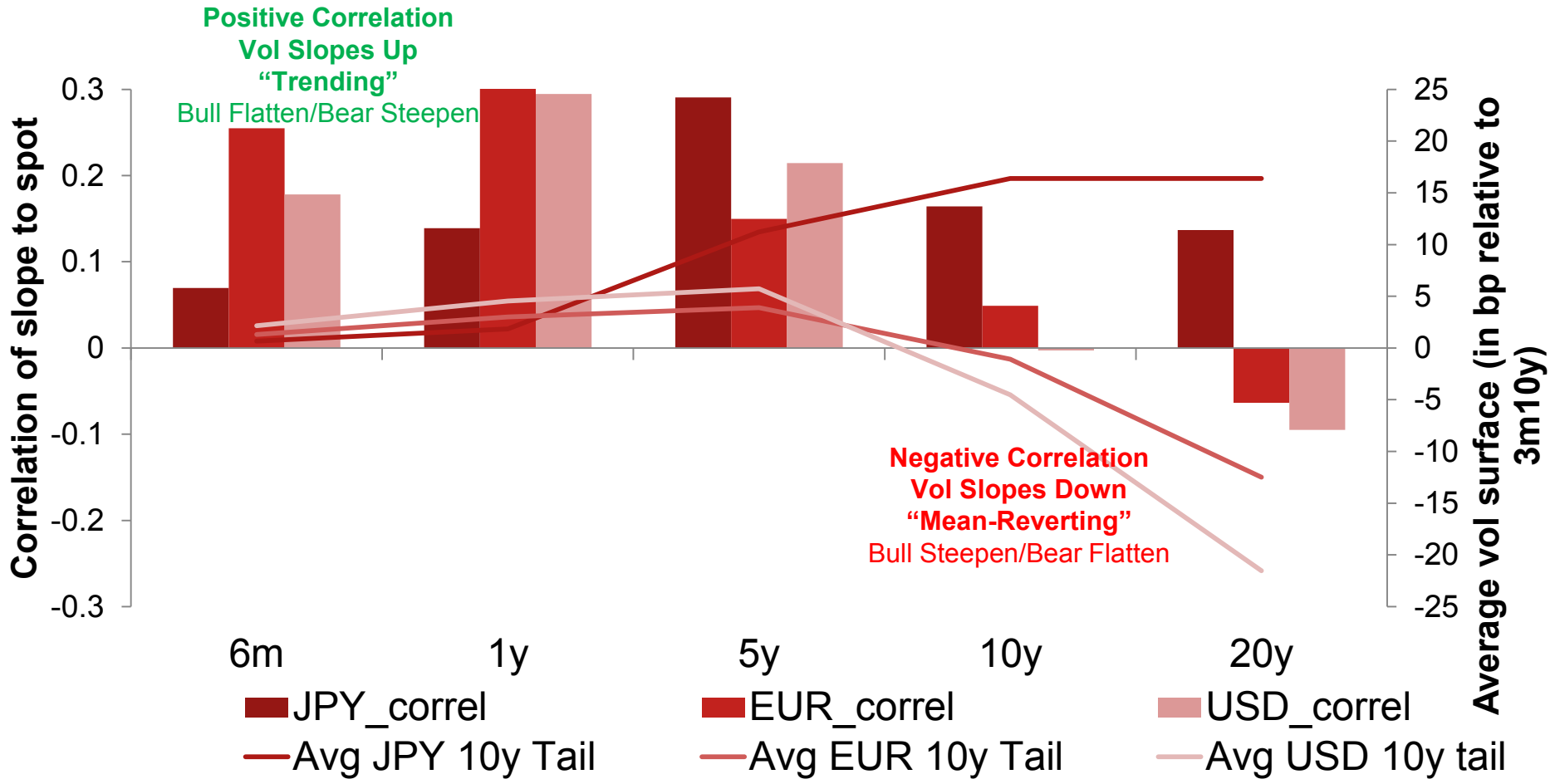


Source: Bank of England, Moneyweek, Bloomberg

Rates mean-revert in the Q-measure too

Downward sloping vol surfaces – the market's take on mean-reversion – in Q-measure
Slope and Levels negatively correlated → downward sloping vols

EUR, USD and JPY Forward slope vs Spot (10y) correlations and 10y tails



Source: Nomura, Bloomberg

Commodity vol – downward vs upward sloping

Select few asset-classes *pay* for buying protection

Downward Sloping Vol

Negative correlation between changes in spot and calendar spreads, i.e.,

Corr[ΔSpot , ΔF(T) —ΔSpot] < 0

i.e., curve 'more contango' when spot is high and 'more backwardated' when spot is low**.** This is known as the **'Samuelson Hypothesis'**

- Long-dated WTI (past 5 years)
- NatGas (past 5 years)
- Power Futures
- Agricultural Futures
- VIX

Upward Sloping Vol

Positive correlation between changes in spot and calendar spreads, i.e.,

Corr[ΔSpot , ΔF(T) —ΔSpot] >= 0

i.e., curve is unch or 'more backwardated' when spot is high and unch or 'more contango' when spot is low

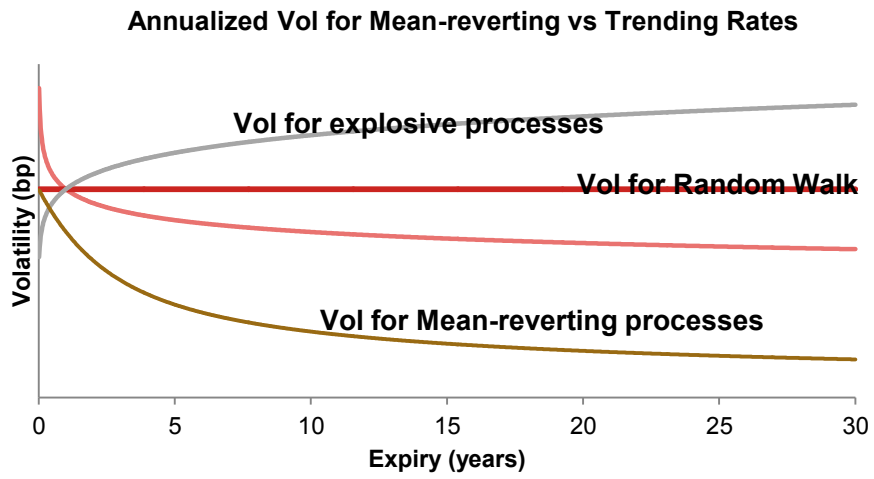
- Energy (1995-2000)
- Metals Futures
- Financial Futures (i.e., short dated rates futures, short-dated bond futures)

Source: Duong-Kalev, The Samuelson hypothesis in futures markets: An analysis using intraday data, J Bank Finance, Vol 32 (Apr 2008)
And Back-Prokopczuk, Commodity Price Dynamics and Derivatives Valuation: A Review, SSRN, Aug 21, 2012

Why do negative correlations lead to mean-reversion?

- **Correlation** ρ(ΔSpot, Δ (Forward(Long)-Forward(Short)) < 0
  - "Bear Flattening"/"Bull Steepening"
  - When spot is high, Forwards $= E_Q[Spot]$slope lower
  - When spot is low, Forwards $= E_Q[Spot]$slopes higher
  - Effectively this is the same as mean reversion (only in the risk-neutral measure)

- **Variance and volatility**
  - **For a random walk, k-day variance ≈ k×1-day variance.**
  - Implied volatility is already annualized
  - So if volatility is flat ⇒ Random walk
  - If volatility is upward sloping ⇒ Explosive process
  - If volatility is downward sloping ⇒Mean-reverting process



Source: Nomura

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