Volatility targeting and volatility managing

David Jessop
Analyst
Tel: +44 20 7567 9882
David.Jessop@ubs.com

Claire Jones
Analyst
Tel: +44 20 7568 1873
Claire-c.Jones@ubs.com

Desi Ivanova
Analyst
Tel: +44 20 7568 1754
Desi-r.Ivanova@ubs.com

Josie Gerken
Analyst
Tel: +44 20 7568 3560
Josephine.Gerken@ubs.com

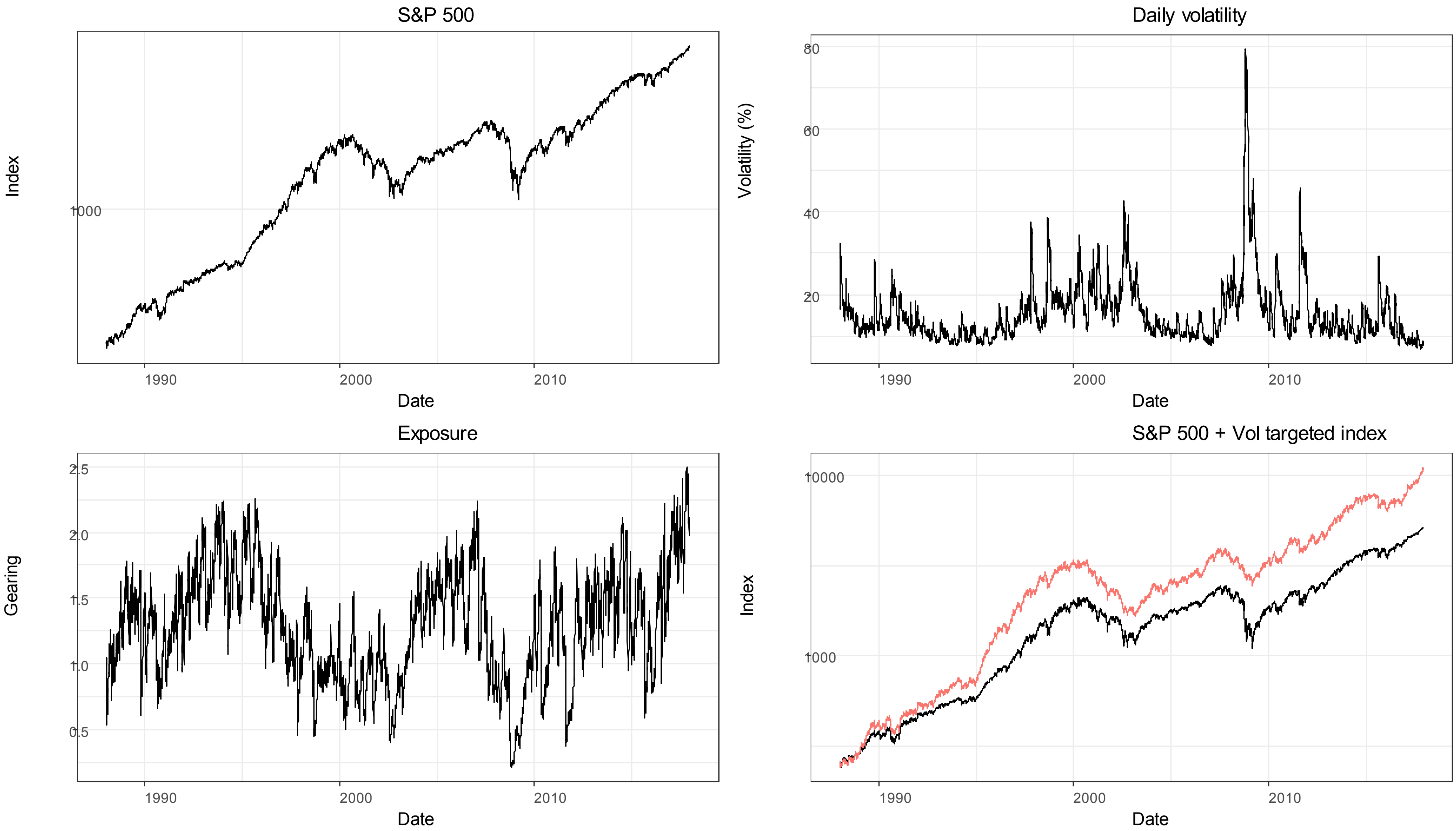
Section 1

Introduction

What is volatility targeting?

- The idea behind volatility targeting is simple – it is a dynamic allocation between cash and an asset / portfolio which aims to keep the overall volatility stable at a target level.
- Why would we want to do this?
  - Improve returns / Sharpe ratios
  - Reduce drawdowns
  - Reduce the cost of an option on the strategy

Simple example – the S&P 500



Source: UBS

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What is volatility targeting?

- More formally, we adjust the weight in the risky asset, w_t, using a conditional forecast of future volatility, $\hat{\sigma}_t$

$$w_t = \frac{c}{\hat{\sigma}_t}$$

  for some value of *c*, the target volatility for our strategy.

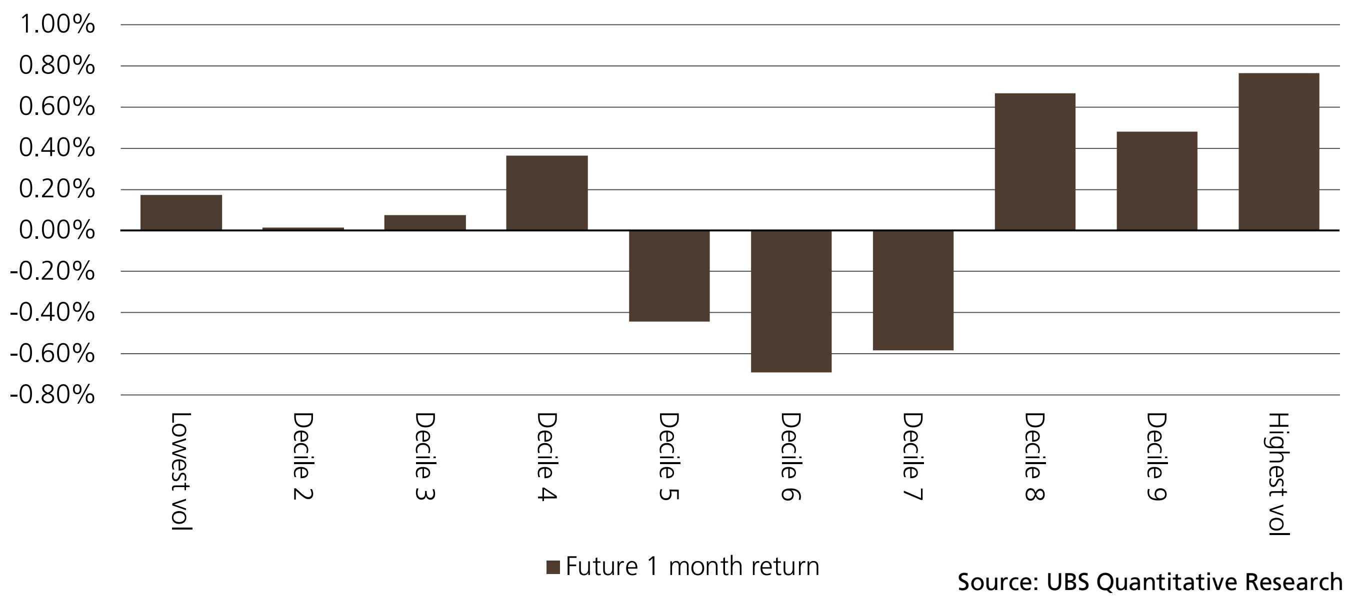
- In Moreira and Muir (2017) and our publication Beyond Volatility Targeting (18 June 2012) we extend this idea to a *volatility managed* portfolio where we introduce a second parameter, *k*:

$$w_t = \frac{c}{(\hat{\sigma}_t)^k}$$

- Here c doesn't have an obvious meaning but can be used to control the average leverage of the managed strategy, or chosen ex-post to give the unscaled and managed strategies the same ex-post volatility.

Why should volatility targeting help your Sharpe?

- How do you improve your Sharpe ratio? You either
  - Increase your exposure if you think future returns are going to be better, or
  - Decrease your exposure if you think future volatility is going to be high
- We know that volatility is persistent, so for all the factors you are doing the second of these; if your Sharpe ratio doesn't improve through volatility targeting this must mean that high volatility doesn't forecast lower returns for the risk asset. As an example, the chart shows the relationship between future returns and trailing volatility for our European P/B factor.



Source: UBS Quantitative Research

Section 2

Practical issues

Choices

- There are a number of choices to be made when designing a volatility targeting (or management) strategy. The first question, however, has to be what is our objective? Choices could include
  - A tight control on the out-of-sample volatility
  - Maximum Sharpe ratio or other performance measure (after costs)
  - Low maximum drawdown
- The design parameters include
  - Rebalancing frequency
  - Volatility forecasting methodology
  - Size of the no-trade range
- Obviously these choices interact – e.g. if you rebalance less frequently you might want a different volatility forecast.
- The choices are also influenced by the cost of trading along with more practical design features.

Volatility forecasting

- Volatility can not be directly observed, so we have to estimate it. Some options:
- Historical volatility
  - We use a simple historical volatility measure over differing periods. The only slight difference from normal is we impose a zero mean
- EWMA

$$h_{t+1} = (1-\lambda)r_t^2 + \lambda h_t$$

  - where h_t is the forecast of variance in the single period t
- GARCH & Restricted Least Squares
  - The basic GARCH (1, 1) model is $h_{t+1} = \alpha_0 + \alpha_1 r_t^2 + \beta h_t$
  - which can be rewritten as $H_{t,s} = \alpha_0' + \lambda \sum_{j=0}^{J} \beta^j r_{t-j}^2$
  - Ederington & Guan (2010) suggest a small variation to this where the beta is dependent on the forecast period, their restricted least squares (RLS) model:

$$H_{t,s} = \alpha_0' + \lambda \sum_{j=0}^{J} \beta_s^j r_{t-j}^2$$

Volatility forecasting

- Absolute Restricted Least Squares
  - This is a variant on the RLS model where we forecast the actual volatility rather than the variance:

$$\sqrt{H_{t,s}} = \alpha_0' + \lambda\sqrt{\pi/2}\sum_{j=0}^{J}\beta^j\left|r_{t-j}\right|$$

- Stochastic volatility
  - There are many stochastic volatility models. We use the basic one where

$$h_{t+1} = \alpha + \phi h_t + \eta_t$$

$$\log r_t = \exp(h_t / 2)\varepsilon_t$$

- Implied volatility
  - We do not include implied volatility in our tests as we do not have access to implieds for many of the indices in which we are interested

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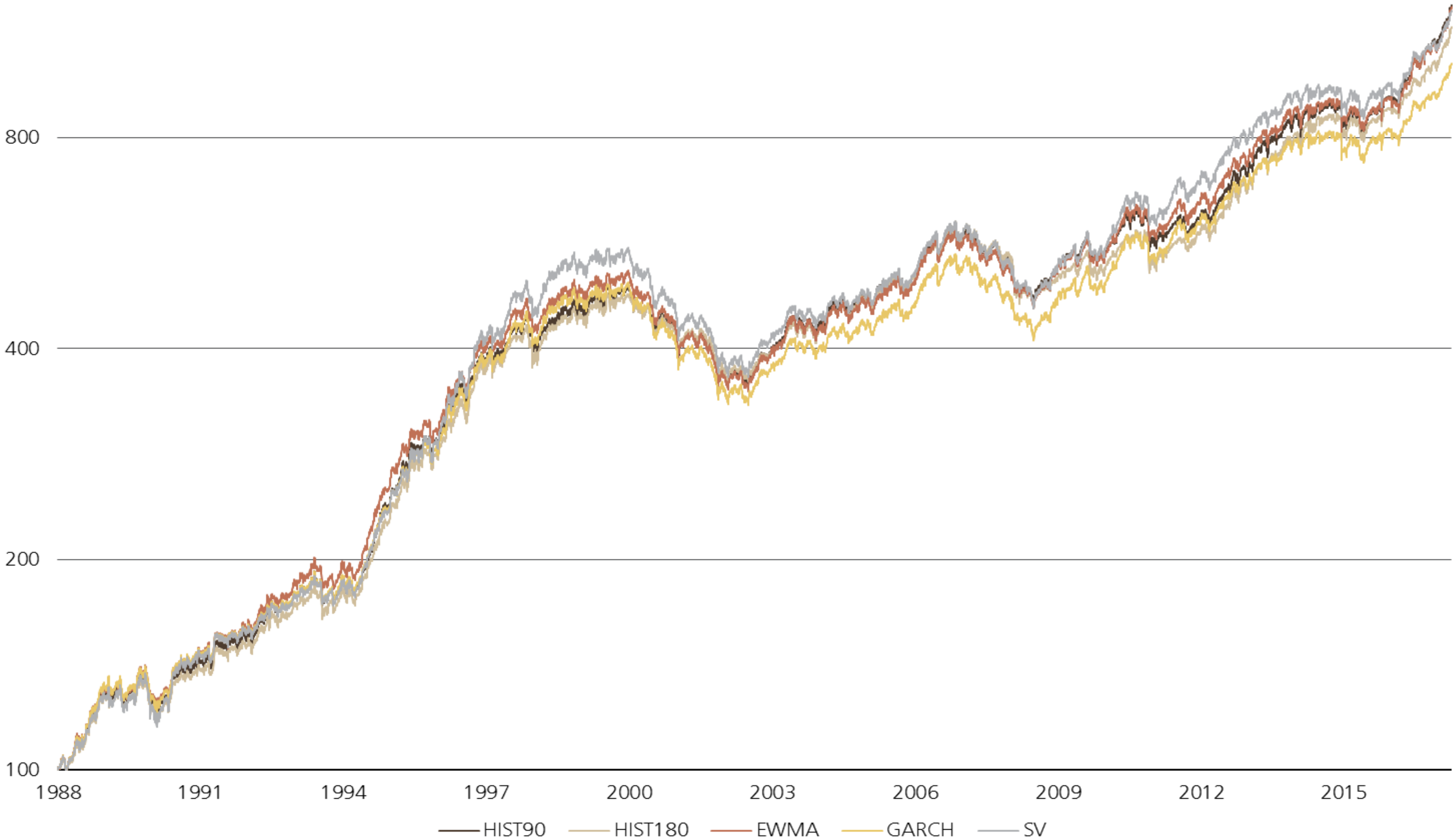
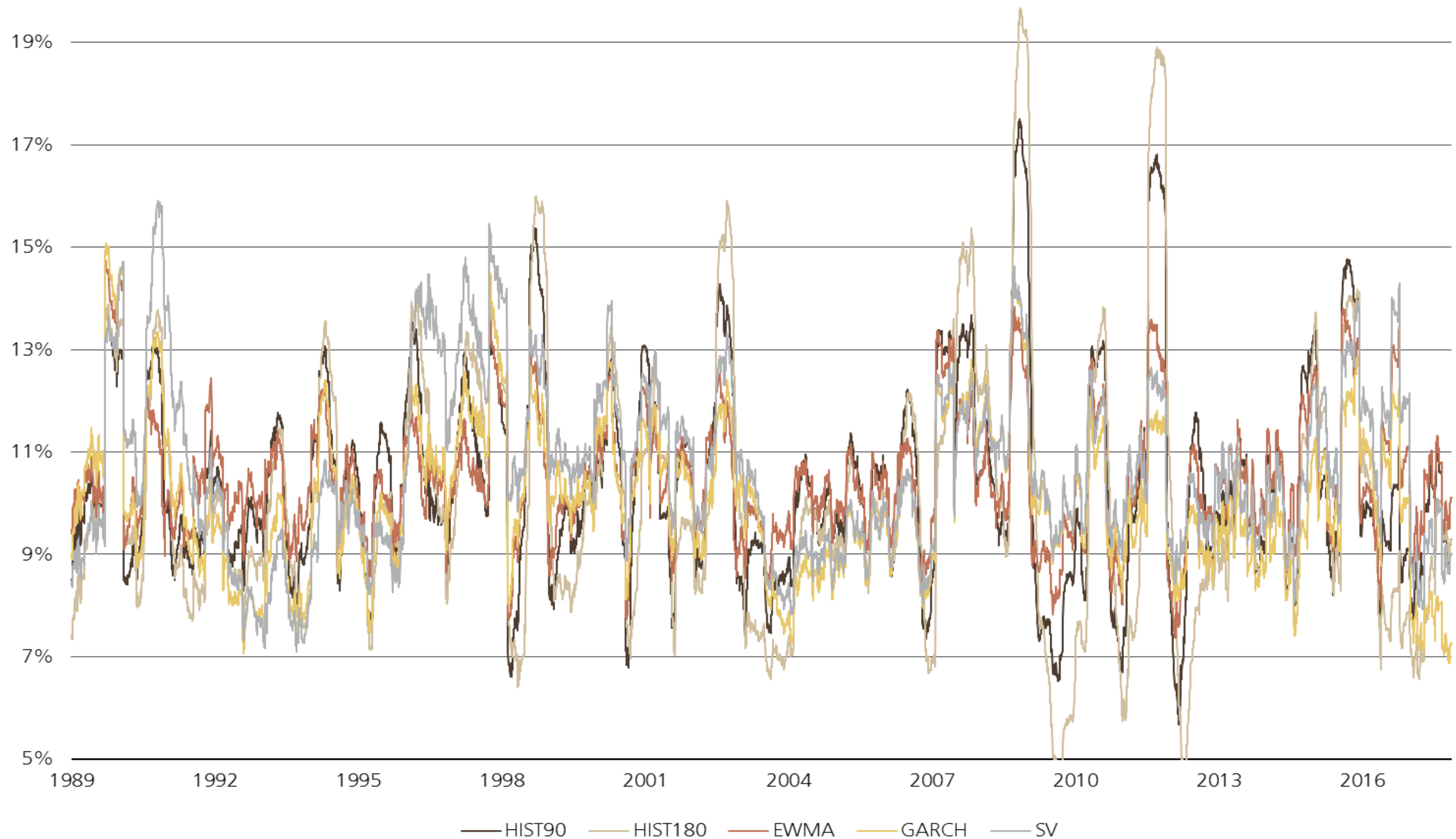
Performance



Source: UBS. Underlying index is S&P 500 from Sep 1988 to Dec 2017.

Realised volatility



Source: UBS. Underlying index is S&P 500 from Sep 1988 to Dec 2017.

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Turnover

- As an example we consider the S&P 500, targeting 10% volatility. The turnover is annualised. This higher turnover will lead to higher rebalancing costs.

		Target 10%	Target 8-12%
Daily	EWMA	435%	113%
	HIST90	173%	51%
	HIST180	84%	24%
Weekly	EWMA	234%	108%
	HIST90	116%	52%
	HIST180	56%	24%

Source: UBS. Underlying index is S&P 500 from 31.12 1992 to Dec 2017.

Downside and other risk measures

- If the objective is not just to control the out-of-sample volatility of the strategy then one has to ask why one uses volatility as the control variable. Why not another version of risk?

$$w_t = \frac{c}{\widehat{risk}_t}$$

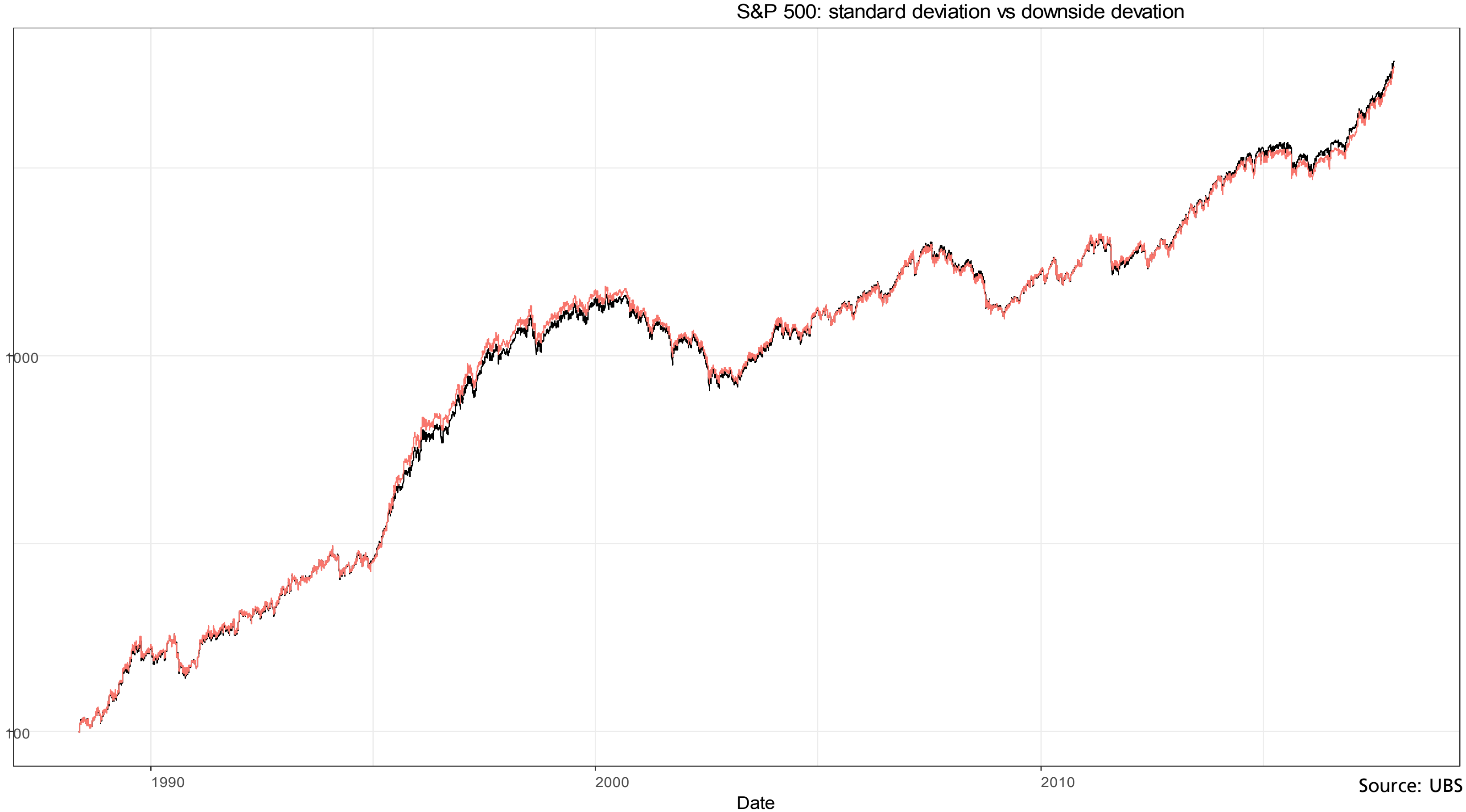
- So one runs a "risk managed" strategy rather than a "volatility managed" strategy.
- As an example we will consider downside deviation

$$DD = \sqrt{\frac{\sum_{i=1}^{n}(\min(r_i - m, 0))^2}{n}}$$

- where *m* is the Minimum Acceptable Return (or target return). We note there is some discussion as to whether one divides by *n* (the number of observations) or just the number of return which are less than *m*. For our examples we will take *m* = *0*.

Downside risk vs volatility: example

- For the S&P 500 it makes little difference if you use a simple standard deviation or downside deviation (assuming you adjust the value of *c*). Why? Because the returns are close to symmetric (skewness = -0.12).



Source: UBS

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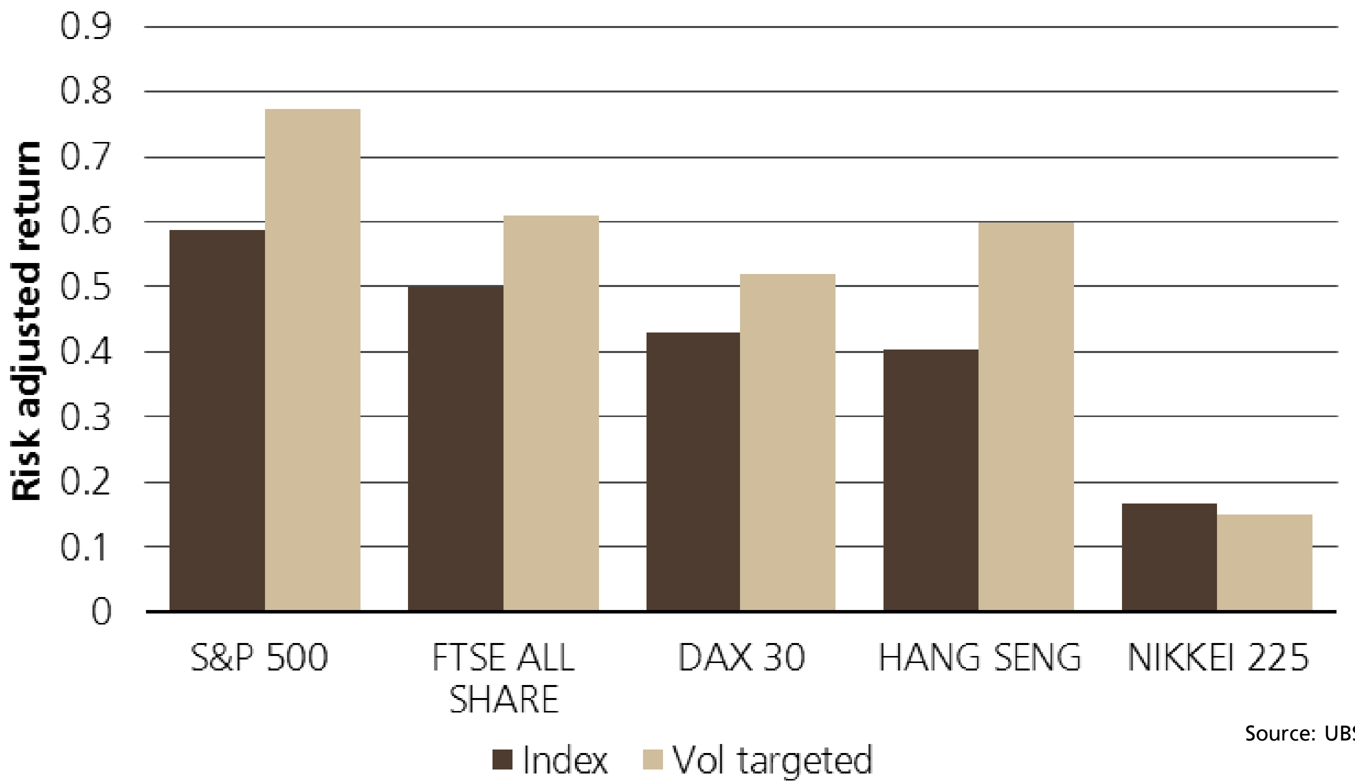
Downside risk vs volatility: an example (2)

- For momentum, which is more negatively skewed, it makes more of a difference.

Source: UBS

Where is volatility targeting valuable?

- Equity indices – a benefit everywhere except in Japan



Source: UBS

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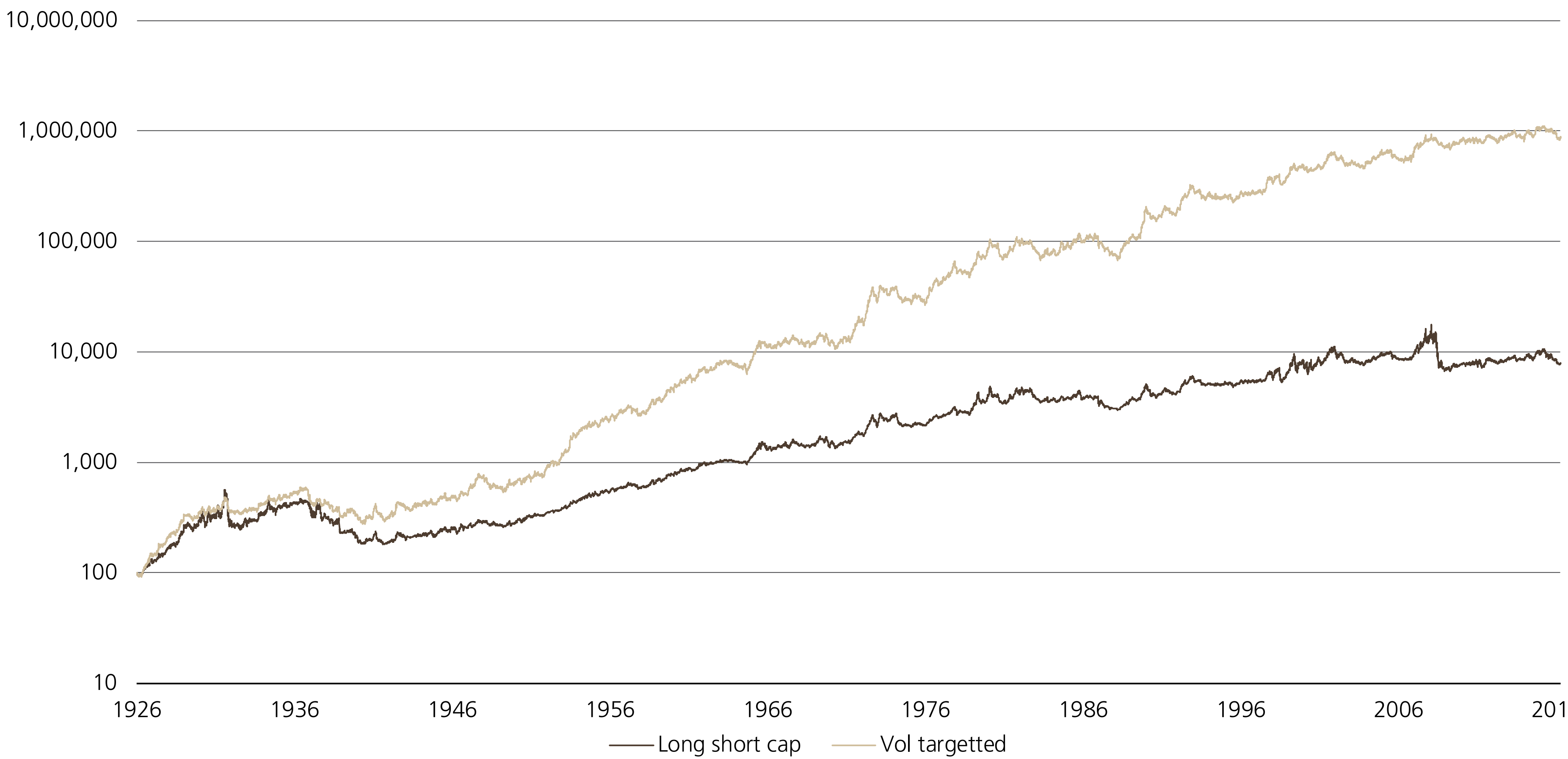
Volatility targeting momentum

- Volatility targeting momentum is very effective – the return / risk goes from 0.40 to 0.75.



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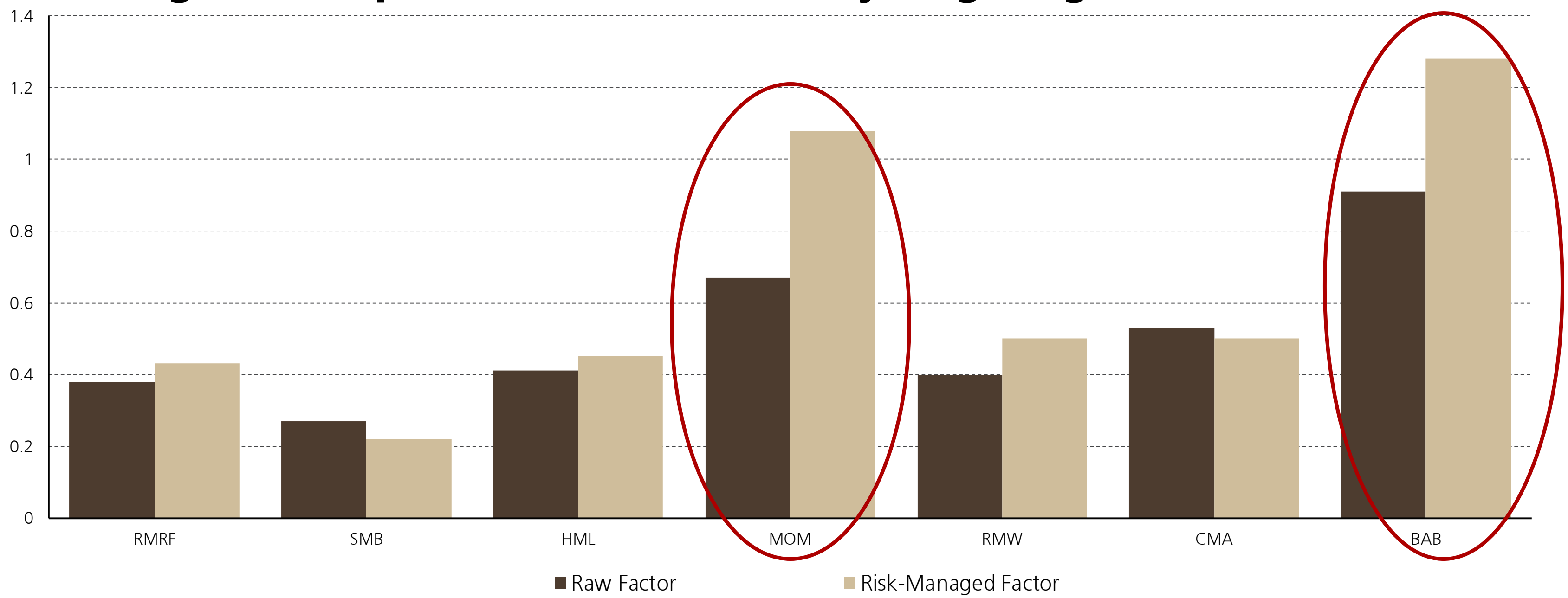
Source: UBS, Ken French Data Library (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html). The momentum portfolio is a long / short portfolio based on the large cap "6 portfolios based on size and momentum". The volatility targeted portfolio has its gearing changed monthly to achieve a volatility equal to that of the base portfolio over the whole sample. The average gearing for the portfolio is 1.48.

Other factors

- What about other factors? We wrote on this in our January 2017 [Academic Research Monitor]() where we summarised Barroso & Maio (2016) and Moreira & Muir (2016).
- Both papers look at a similar set of factors and report similar results. We note that the result for betting against beta extends to volatility as opposed to beta based portfolios.

Change in Sharpe ratio due to volatility-targeting



Source: "Managing the Risk of the 'Betting-Against-Beta' Anomaly: Does It Pay to Bet Against Beta?" by P. Barroso & P. Maio; the figure is constructed using data reported in Tables 1 and 3; reproduced with permission. The figure presents the Sharpe ratio of raw (buy and hold) long-short factors and of their risk-managed form using volatility-targeting. Sample period: January 1964 to December 2015.

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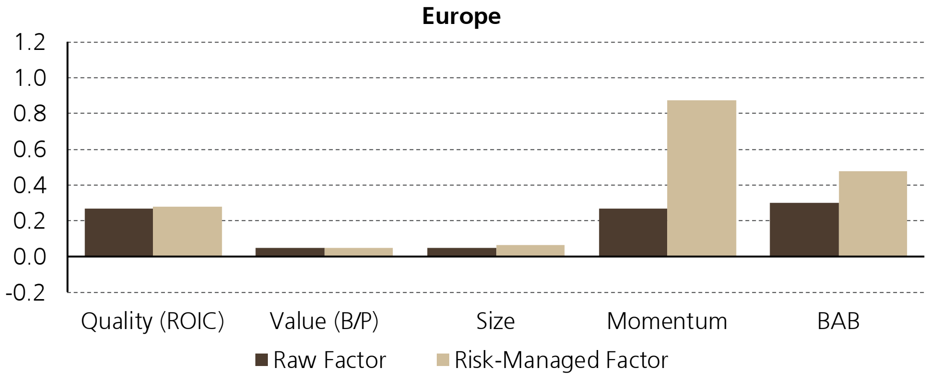
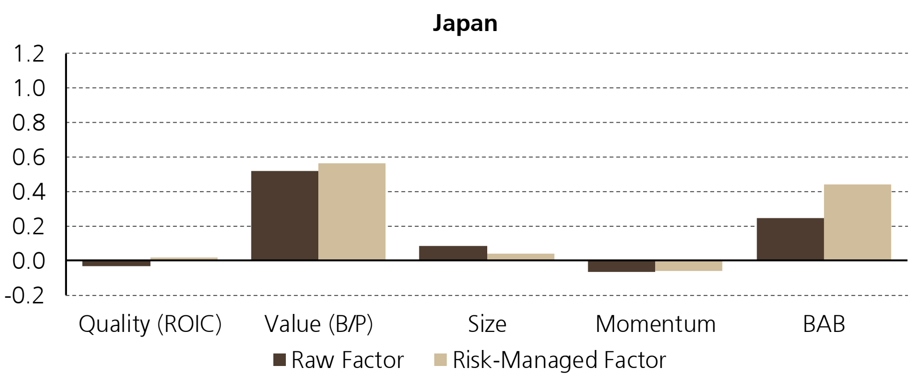
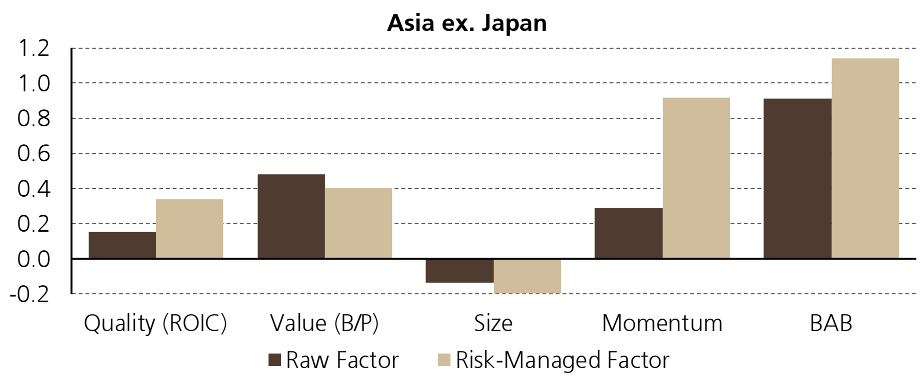
Other regions

- We reproduced these results for three other regions. The factors are constructed on a long-short basis as the spread return between the top and bottom thirds based on the factor The BAB factors are additionally adjusted so as to achieve an ex-ante zero beta
- As in the US, momentum and BAB factors are the strongest winners of volatility-targeting.







Source: UBS Quantitative Research. The figures presents the Sharpe ratio of raw (buy and hold) long-short factors and of their risk-managed form using volatility-targeting across three regions: Europe, Asia ex. Japan and Japan. The long-short factors are rebalanced on a monthly basis and represent the spread between top and bottom thirds of the universe. Sample period: March 1992 (March 1997 for BAB) to December 2016.

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Section 3

Volatility management

Volatility management

- Volatility management is an extension of volatility targeting

$$w_t = \frac{c}{(\hat{\sigma}_t)^k}$$

- The value of c becomes harder to define if k is not equal to 1. It can be picked to control the average (or expected) gearing, or (for research) to equate the ex-post volatility to some target.
- In *Beyond volatility targeting* we show that under the assumption that volatility can be modelled by a simple stochastic volatility model that the optimal value of *k* is generally close to but a little below 2.

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Volatility management (2)

- Moreira and Muir (2017) discuss the strategy where *k = 2.*
- Consider a mean variance investor deciding how much to invest in a risky portfolio. The optimal portfolio weight is proportional to the risk-return trade off

$$w_t{}^* \propto \frac{E_t(r_{t+1})}{\sigma_t{}^2}$$

- Given volatility is persistent they approximate this by the inverse of the conditional variance (i.e. *k = 2* in the above equation).
- They find that for all the Fama-French five factors except size, all four ZXB factors and betting against beta that the volatility managed portfolios have a positive and mainly significant alpha against the non-managed factor.

Volatility management: example

- The returns to a vol targeted or variance targeted S&P 500 are similar.
- The difference is the vol targeted strategy has a beta of 0.58 with an annualised alpha of 3.7%, whereas the variance targeted strategy has a beta of 0.41 and an alpha of 5.4%.

Source: UBS. S&P 500 volatility targeted to 10%, variance targeted to give same out of sample volatility. Rebalanced monthly using the realised volatility (variance) over the preceding calendar month.

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Section 4

Introducing our Interactive Volatility Targeting Tool

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Interactive Volatility Targeting Tool

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Global Research

Dec-17

Equities

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Interactive Volatility Targeting Tool

Change the inputs below		
Target volatility	9.0%	
No trade width	0.0%	
Trade frequency	D	
Costs	20	basis points
Max gearing	5	
Volatility power (k)	1	
Which Vol	EWMA	
Window Length	50	
EWMA Weight	0.96	
Implied half life	17	day(s)

David Jessop
Analyst
david.jessop@ubs.com
+44 20 7567 9882

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RETURNS (Geometric)	
Raw	4.61%
Vol targeted	7.94%
After costs	6.65%

RETURNS (Arithmetic)	
Raw	5.45%
Vol targeted	8.07%
After costs	6.87%

RISK ADJ RETURN (Arith)	
Raw	0.398
Vol targeted	0.872
After costs	0.742

VOLATILITY	
Raw	13.69%
Vol targeted	9.25%
After costs	9.25%

MAX DRAWDOWN	
Raw	-52.0%
Vol targeted	-22.0%
After costs	-22.3%

CALMAR RATIO	
Raw	0.089
Vol targeted	0.361
After costs	0.298

GEARING	
Average	1.157
Min	0.180
Max	3.031
Standard Dev	0.608

ANNUALISED TURNOVER	
	604%

Data assumed to be Daily

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Source: UBS

Inputs

Change the inputs below		
Target volatility	9.0%	
No trade width	0.0%	
Trade frequency	D	
Costs	20	basis points
Max gearing	5	
Volatility power (k)	1	
Which Vol	EWMA	
Window Length	50	
EWMA Weight	0.96	
Implied half life	17 day(s)	

Source: UBS

Target volatility: raised to power of k if needed

Trading frequency can be daily / weekly / monthly.

The gearing can be limited.

Move from vol targeting to vol management

Spreadsheet only allows EWMA or simple volatility calculations

UBS

Inputs (2)

- Users can enter their own time series

	A	B	C	D	E	F	G
1	**Date**	**Index**					
2	03-Feb-92	100			This is where you input data. Please enter the dates in column A and the fund level (NOT RETURNS) in column B		
3	04-Feb-92	100.2059			Note - the dates are used to calculate the annualisation factor		
4	05-Feb-92	100.2878					
5	06-Feb-92	100.0372			Instructions		
6	07-Feb-92	100.1899			1) Press this button		Clear Data
7	10-Feb-92	100.2592					
8	11-Feb-92	100.5624					
9	12-Feb-92	100.6976			2) Copy your dates and index values into A2		
10	13-Feb-92	100.9347					
11	14-Feb-92	101.1335			3) Press this button		Calculate
12	17-Feb-92	101.6998					
13	18-Feb-92	101.7744					
14	19-Feb-92	101.821					
15	20-Feb-92	101.4631					
16	21-Feb-92	101.2948					
17	24-Feb-92	100.8462					
18	25-Feb-92	100.0929					
19	26-Feb-92	99.98195					
20	27-Feb-92	99.50716					

Source: UBS

Outputs (1): Summary statistics

- Sheet produces a number of summary statistics

RETURNS (Geometric)	
Raw	4.61%
Vol targeted	7.94%
After costs	6.65%

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ANNUALISED TURNOVER	
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	Raw	Vol targeted	After costs
Minimum	-849.1	-340.9	-341.2
Quartile 1	-29.0	-30.3	-30.7
Median	4.0	4.3	3.9
Arithmetic mean	2.2	3.2	2.7
Geometric mean			
Quartile 3	37.0	39.8	39.2
Maximum	751.4	362.9	362.1
Standard Deviation	86.3	58.3	58.3
Skewness	-0.66	-0.28	-0.28
Kurtosis	11.16	1.36	1.37

All results in basis points / day

Source: UBS

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Outputs (2): Graphs

- The returns of the raw, vol targeted / managed and vol targeted after costs are shown …

Source: UBS

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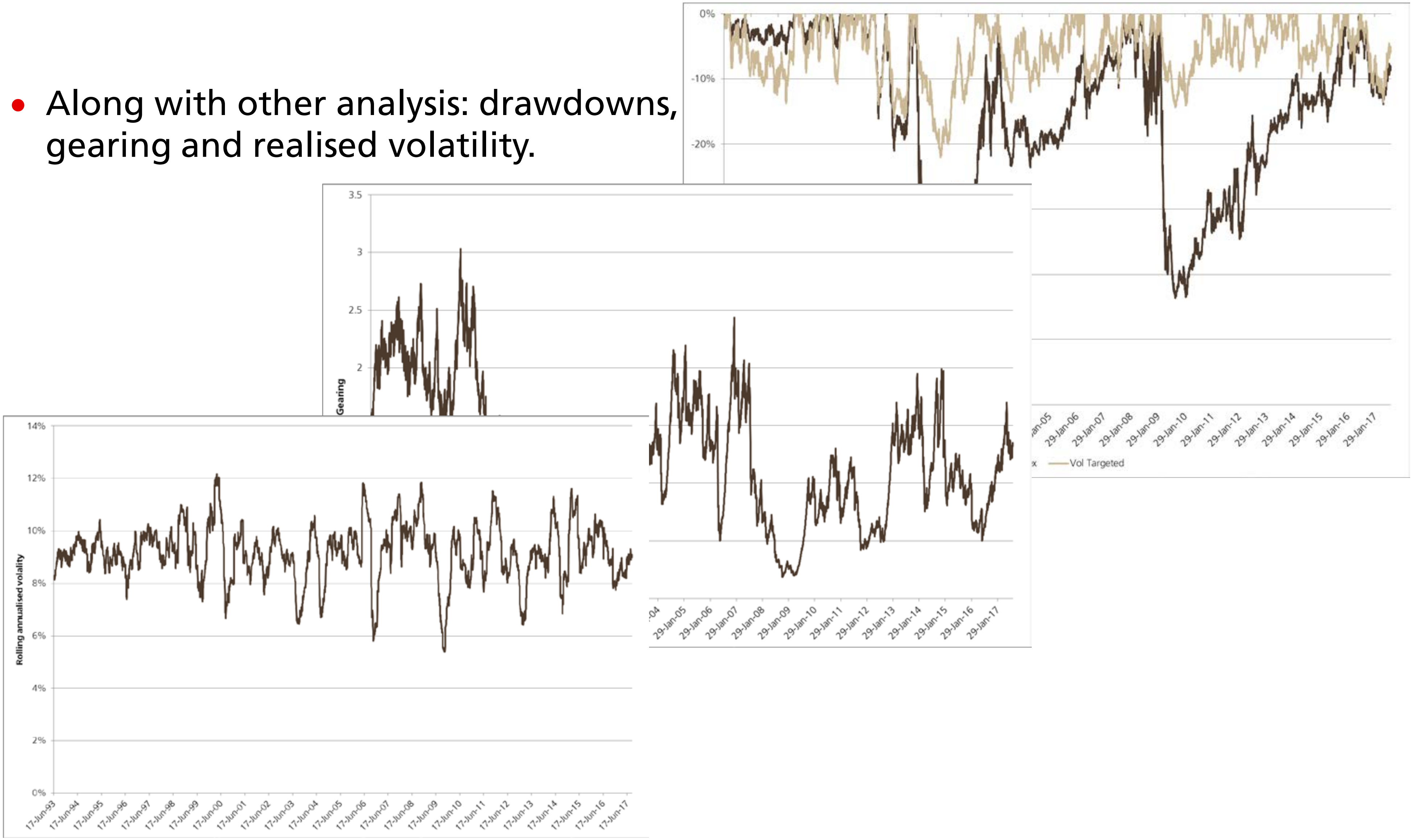
Outputs (3): More graphs

- Along with other analysis: drawdowns, gearing and realised volatility.



Source: UBS

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Buy	FSR is > 6% above the MRA.	45%	26%
Neutral	FSR is between -6% and 6% of the MRA.	39%	23%
Sell	FSR is > 6% below the MRA.	16%	11%
Short-Term Rating	**Definition**	**Coverage[3]**	**IB Services[4]**
Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 30 September 2017.
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Contact information

UBS Limited
5 Broadgate
London
EC2M 2QS

Tel: +44-207-567 8000

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