UBS

Trend-following, Risk-Parity and the influence of Correlations

Risk-Based and Factor Investing Conference

Imperial College Business School

Nick Baltas, PhD
Quantitative Analyst
Tel: +44 20 7568 3072
nick.baltas@ubs.com

November 2015

Introduction – Motivation

- Trend-following:
  - Long-short systematic strategy
  - Across multiple asset classes
  - Signals: buy rising assets, sell falling assets
  - Weighting scheme: inverse-volatility
- Poor performance during 2009-2013 (following double-digit returns in 2008)
  - The post-crisis period has been characterised by substantial asset co-movement
  - Inverse-volatility weights ignore pairwise correlations
  - Accounting for correlations would require the use of risk-parity
- Extend risk-parity to a long-short framework
  - Significant improvement in the performance of a trend-following strategy
  - Especially during periods of extreme correlation

Related Literature

- Trend-Following:
  - Covel (2009), Szakmary, Shen & Sharma (2010), Burnside, Eichenbaum & Rebelo (2011), Hurst, Ooi & Pedersen (2012, 2013), Moskowitz, Ooi & Pedersen (2012), Baltas & Kosowski (2013, 2014), Clare, Seaton, Smith & Thomas (2014), Hutchinson & O'Brien (2014)
  - UBS Research Notes:
    1. "*Trend-following meets Risk-Parity*", December 2, 2013

- Risk Parity & Low-Risk investing:
  - Maillard, Roncalli & Teiletche (2010), Bhansali (2011), Inker (2011), Lee (2011), Menchero & Davis (2011), Anderson, Bianchi & Goldberg (2012), Asness, Frazzini & Pedersen (2012), Bhansali, Davis, Rennison, Hsu & Li (2012), Clare, Seaton, Smith & Thomas (2012), Leote de Carvalho, Lu & Moulin (2012), Lohre, Neugebauer & Zimmer (2012), Steiner (2012), Bernandi, Leippold & Lohre (2013), Fisher, Maymin & Maymin (2013), Lohre, Opfer & Orszag (2013), Jurczenko, Michel & Teiletche (2015)
  - Ang, Hodrick, Xing & Zhang (2006, 2009), Baker, Bradley & Wurgler (2011), Frazzini & Pedersen (2014).
  - UBS Research Notes:
    1. "*Low-Risk Investing*", *September 23, 2011*
    2. "*Understanding Risk Parity*", February 7, 2013
    3. "*Risk Parity with Different Risk Measures*", July 10, 2013
    4. "*Risk-Parity versus Mean-Variance*", May 16, 2014
    5. "*Correlation, De-correlation and Risk-Parity*", 27 June 2014

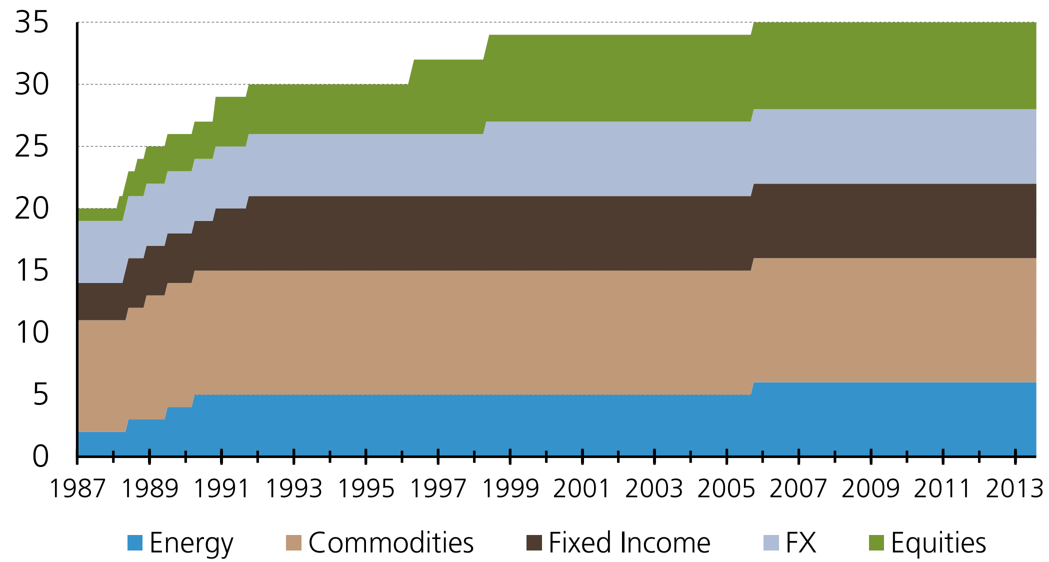
- Volatility Targeting:
  - Hallerbach (2012, 2014), Daniel & Moskowitz (2013), Barroso & Santa-Clara (2014).
  - UBS Research Notes:
    1. "*Understanding Volatility Targeting*", October 4, 2011
    2. "*Beyond Volatility Targeting*", June 18, 2012
    3. "*Extending Volatility Targeting*", September 2, 2013

Data Description

- Futures Data
  - Source: **Bloomberg** [see the Appendix A for details on the construction of continuous series]
  - Daily closing futures prices for 35 assets over the period January 1987 – December 2013:

- 6 Energy contracts:
  Brent Crude Oil, Gas Oil, Gasoline,
  Heating Oil #2, Light Crude Oil, Natural Gas
- 10 Commodity contracts:
  Metals: Cooper, Gold, Silver
  Meat: Live Cattle
  Grains: Corn, Soybeans, Wheat
  Softs: Coffee "C", Cotton #2, Sugar
- 7 Equity contracts:
  DAX, Eurostoxx 50, FTSE 100, KOSPI 200,
  NASDAQ Composite, Nikkei 225, S&P500.
- 6 Currency contracts:
  AUD, CAD, CHF, EUR, GBP, JPY.
- 6 Government Bond contracts:
  US T-Note 5Yr, US T-Note 10Yr, US T-Bond 30Yr,
  German Bobl (5Yr), German Bund (10Yr), JGB 10Yr.

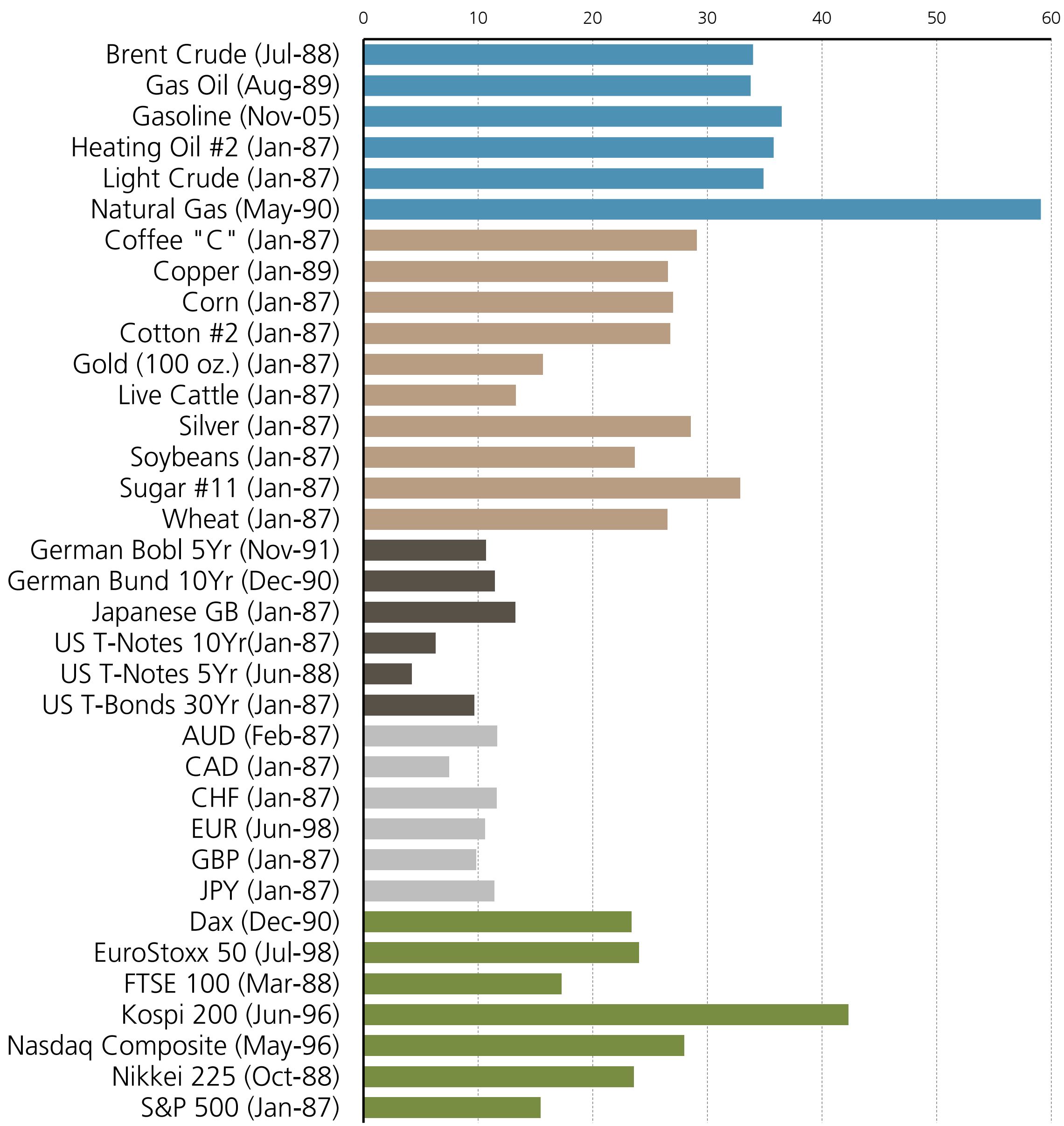
Number of available contracts



Source: Bloomberg

UBS

Unconditional Asset Volatilities



Source: UBS Quantitative Research

- Large cross-sectional dispersion of volatilities…
- Must be taken into account when constructing a cross-asset portfolio.

UBS

Trend-Following Strategies

- Trend-Following (TF) strategy:
  - Assume N_t available assets at the end of month t.
  - Look-back 12 months
  - Buy/sell signal = sign of past return.
  - Hold the portfolio for 1 month and rebalance:

$$r_{t,t+1}^{TF} = \sum_{i=1}^{N_t} \underbrace{sign\left(r_{t-12,t}^{i}\right) \cdot w_t^{i,Gross}}_{w_t^{i,Net}} \cdot r_{t,t+1}^{i}$$

where $\sum_{i=1}^{N_t} w_t^{i,Gross} = \sum_{i=1}^{N_t} \left|w_t^{i,Net}\right| = 100\%$ and $\sum_{i=1}^{N_t} w_t^{Net,i} \leq 100\%$.

- Constant-Volatility Trend-Following ($CV{:}TF$) strategy:
  - Assuming a desirable target level of volatility σ_{TGT} (10% for our purposes):

$$r_{t,t+1}^{CV:TF} = \frac{\sigma_{TGT}}{\sigma_t^{TF}} \sum_{i=1}^{N_t} w_t^{i,Net} \cdot r_{t,t+1}^{i}$$

UBS

Trend-Following Strategies … picking the weights

- Volatility Parity Trend-Following ($VP\colon TF$) strategy:
  - Standard approach: inverse-volatility weighted portfolio, aka "volatility-parity":

$$w_t^{i,Gross,VP} = \frac{\left(\sigma_t^i\right)^{-1}}{\sum_{j=1}^{N_t}\left(\sigma_t^j\right)^{-1}}, \forall i$$

$$\Rightarrow \quad r_{t,t+1}^{VP:TF} = \frac{\sigma_{TGT}}{\sigma_t^{TF}} \sum_{i=1}^{N_t} sign\left(r_{t-12,t}^i\right) \cdot \frac{\left(\sigma_t^i\right)^{-1}}{\sum_{j=1}^{N_t}\left(\sigma_t^j\right)^{-1}} \cdot r_{t,t+1}^i$$

  - All assets enter the portfolio with the same volatility (hence "volatility-parity")
  - However, the portfolio construction ignores all pairwise correlations

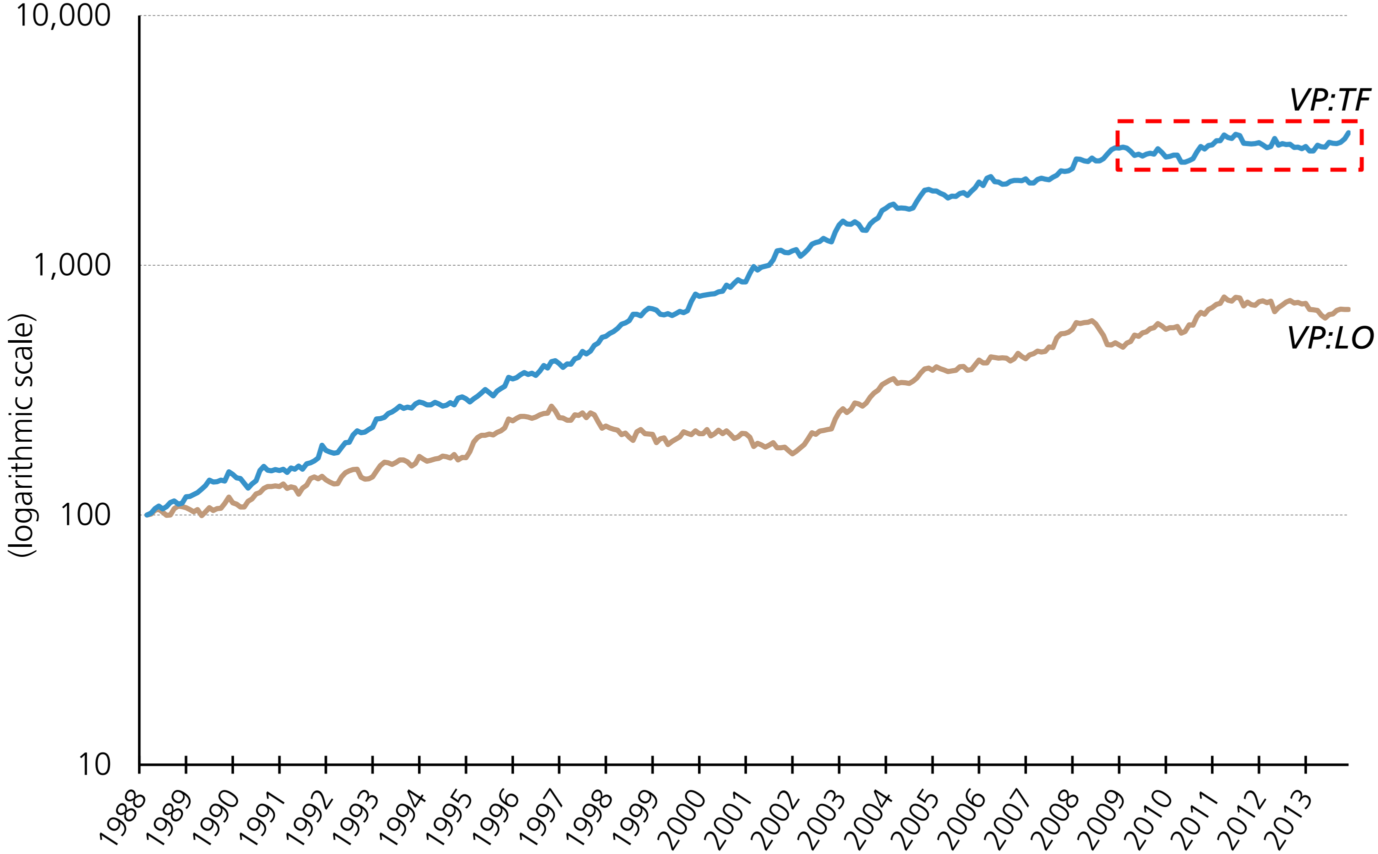
- Benchmark: Volatility Parity Long-Only ($VP\colon LO$) strategy:

$$r_{t,t+1}^{VP:LO} = \frac{\sigma_{TGT}}{\sigma_t^{LO}} \sum_{i=1}^{N_t} (+1) \cdot \frac{\left(\sigma_t^i\right)^{-1}}{\sum_{j=1}^{N_t}\left(\sigma_t^j\right)^{-1}} \cdot r_{t,t+1}^i$$

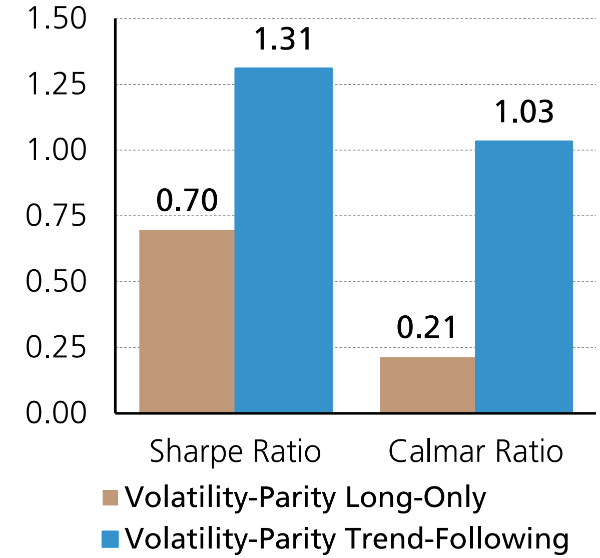
UBS

Cumulative Returns [Apr. 1988 – Dec.2013]

- Target volatility level $\sigma_{TGT} = 10\%$



Source: UBS Quantitative Research

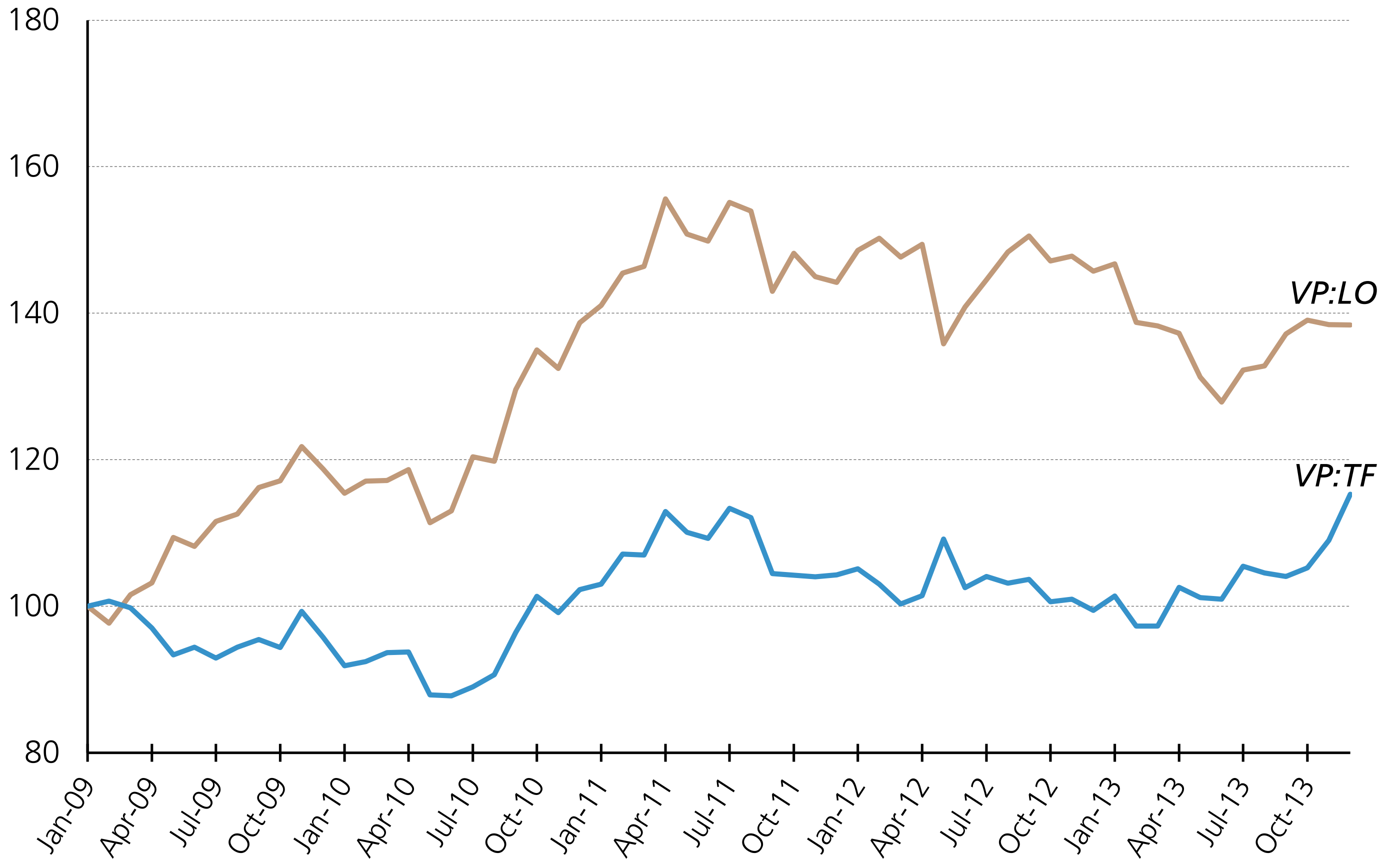


Source: UBS Quantitative Research

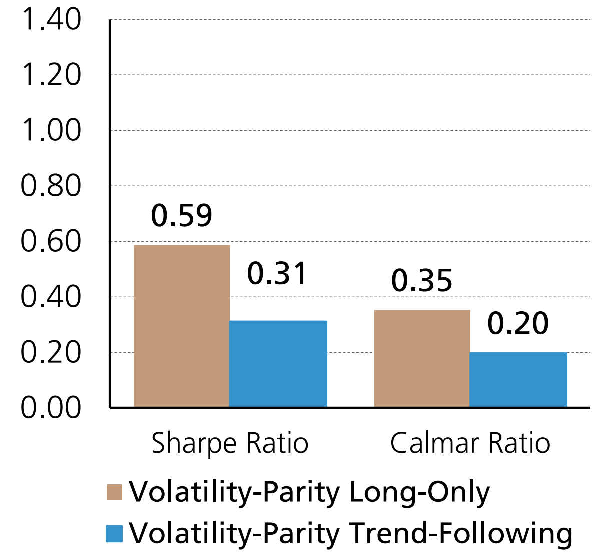
UBS

Cumulative Returns [Jan. 2009 – Dec.2013]

- And then trend-following stopped working…



Source: UBS Quantitative Research

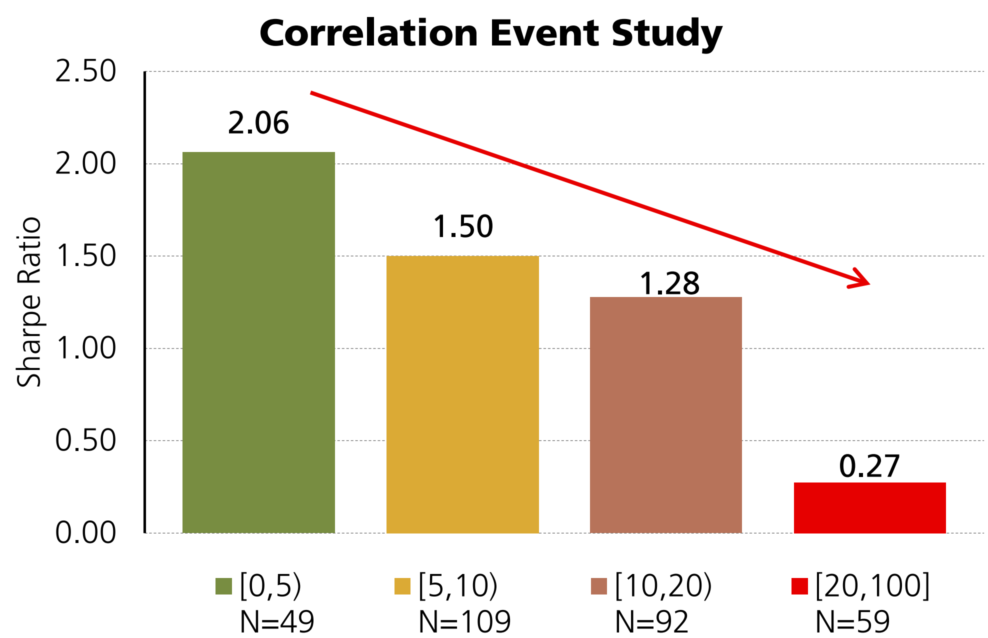


Source: UBS Quantitative Research

UBS

Correlation Event Study – Do correlations matter?

- Split months in correlation buckets and estimate Sharpe ratio per correlation regime

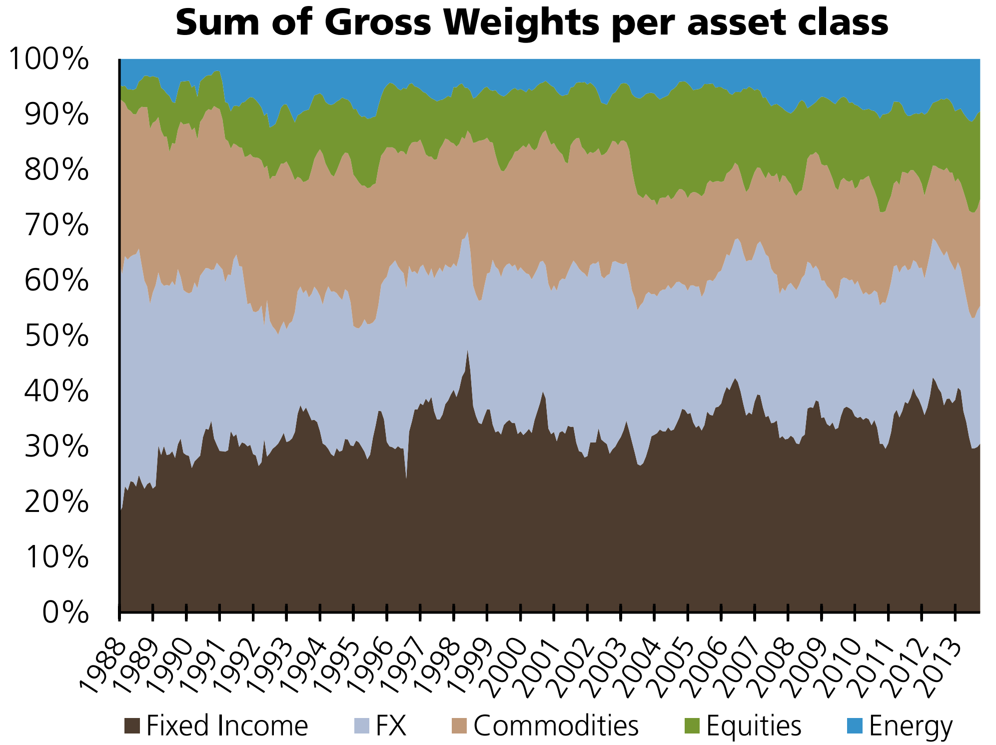


Source: UBS Quantitative Research

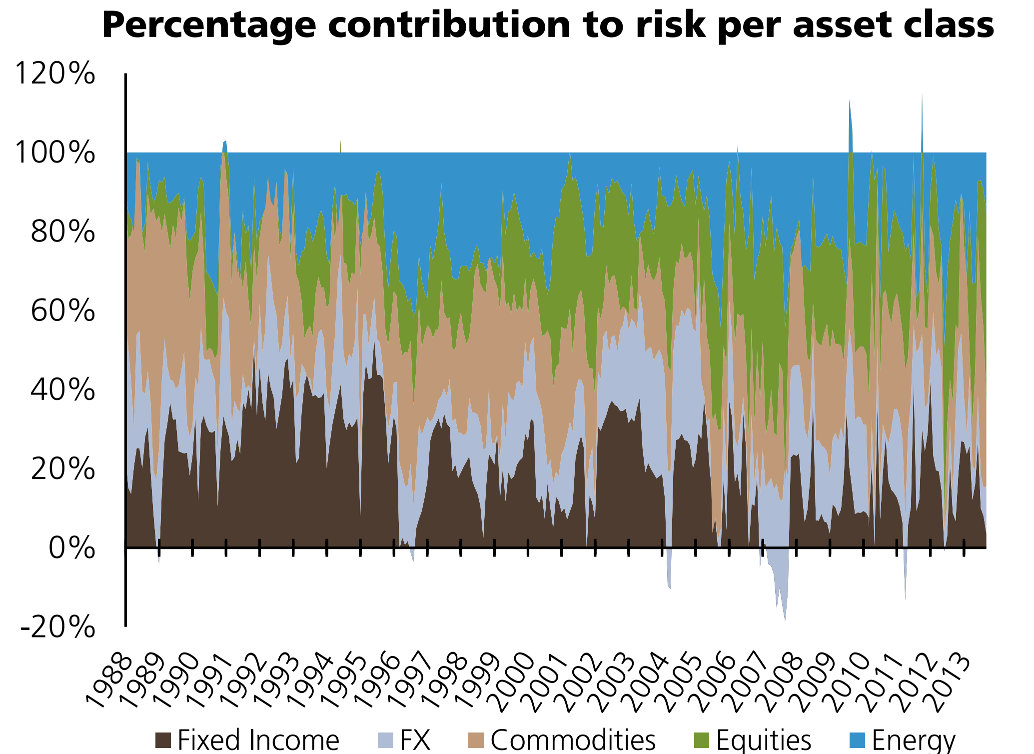
- Could this be due to the recent increases in correlations? "Risk On – Risk Off"…?
- *Volatility-Parity* ignores the effect of pairwise correlations, hence "*Naïve Risk Parity*"

Volatility Parity ignores the Pairwise Correlations

- Let's look into *gross weight allocation* and respective *risk allocation* per asset class



Source: UBS Quantitative Research



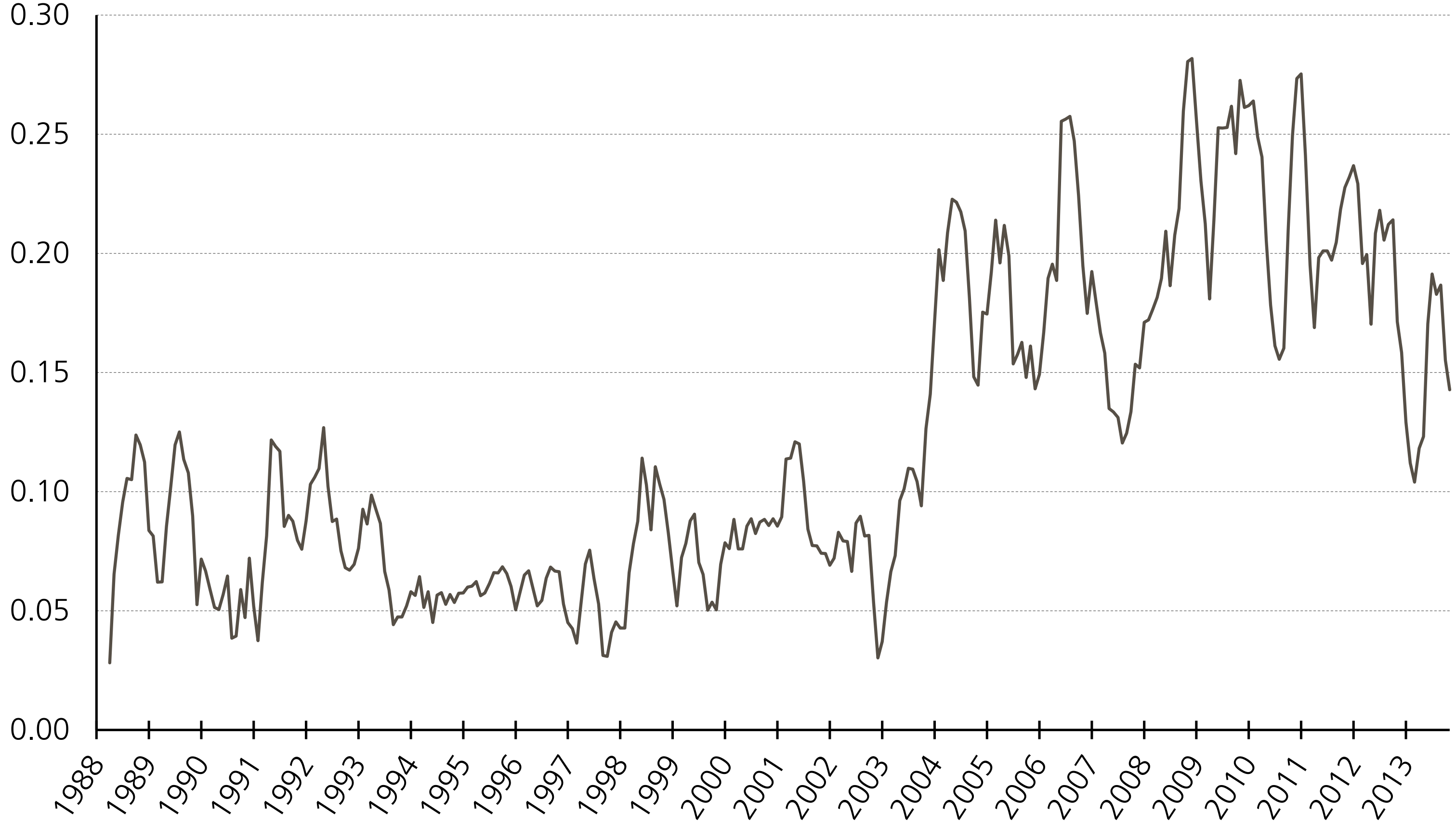
Source: UBS Quantitative Research

- There in No Equal Contribution to Risk
- …clearly due to asset pairwise correlations not being equal

UBS

Volatility Parity ignores the Pairwise Correlations

- We next plot 90-day rolling estimates of average pairwise correlation over time.

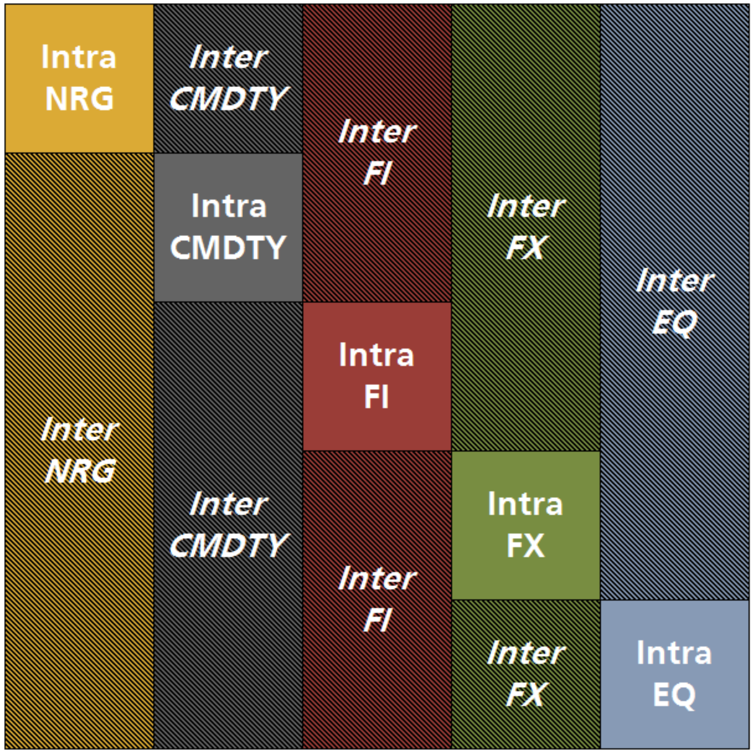


Source: UBS Quantitative Research

UBS

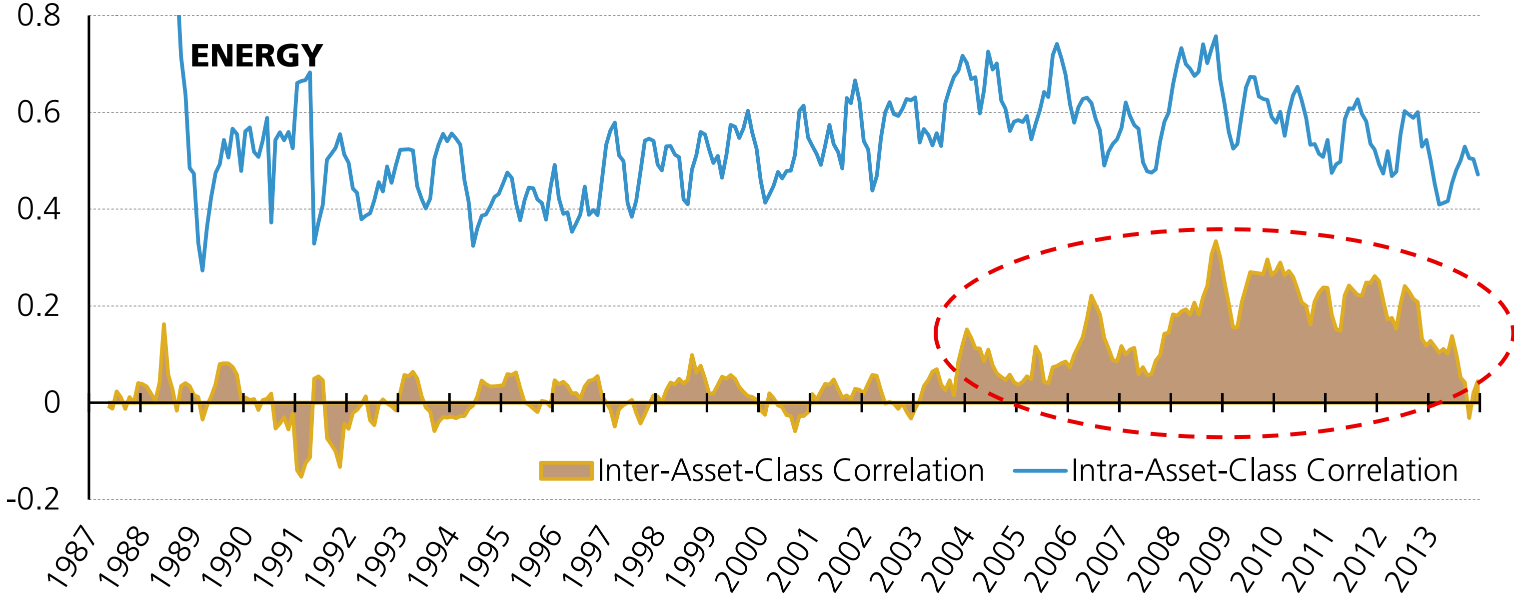
Volatility Parity ignores the Pairwise Correlations

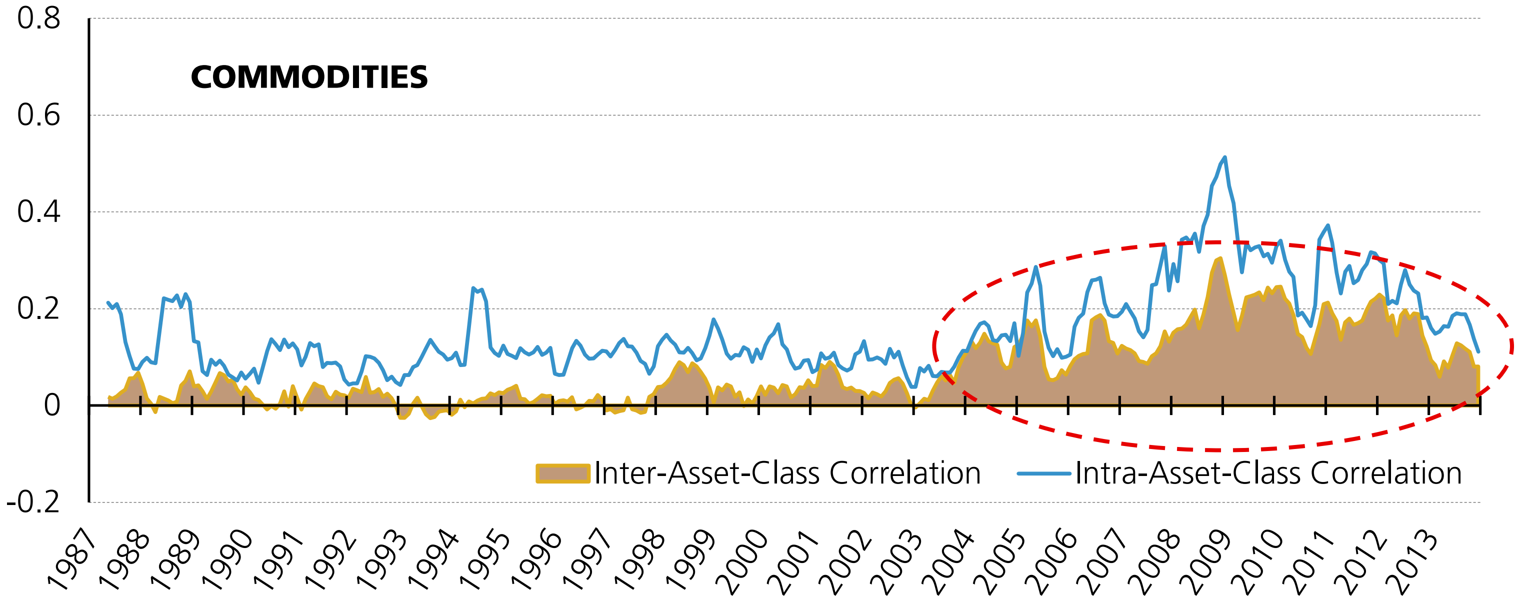
- We next plot 90-day rolling estimates of intra and inter asset-class correlations over time.



Source: UBS Quantitative Research

Intra and Inter Asset-Class Correlations

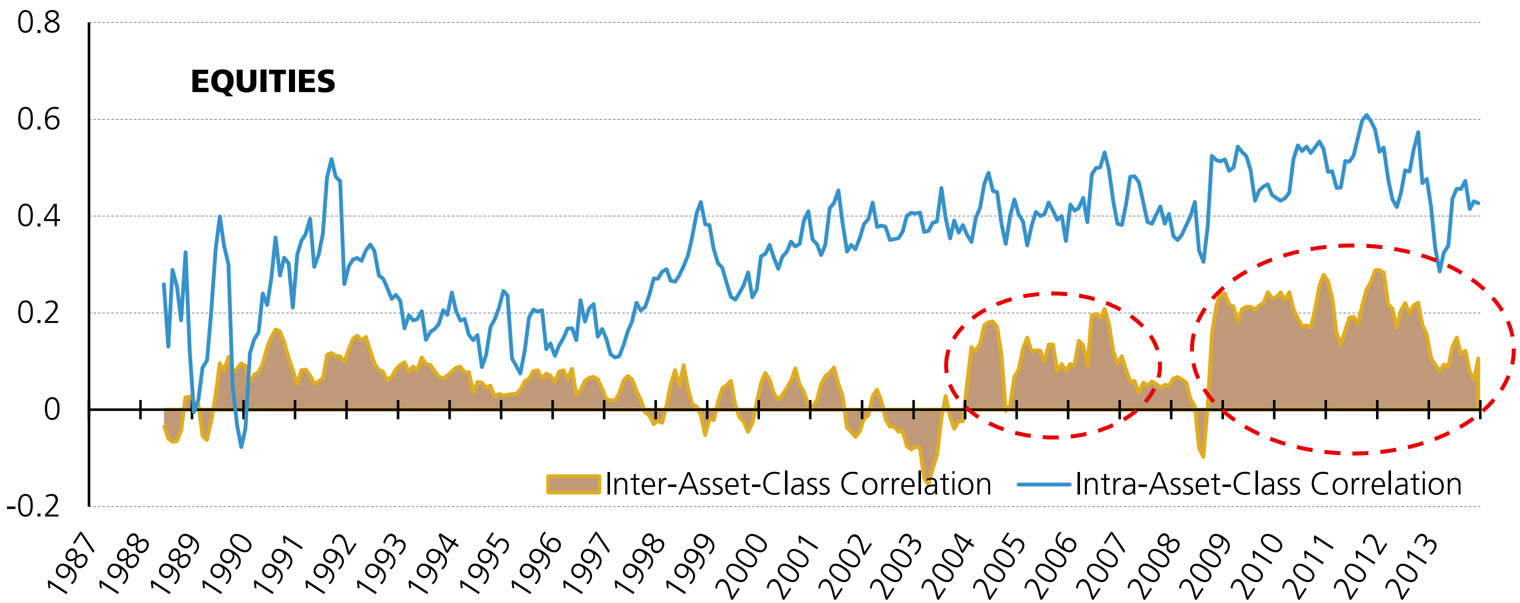


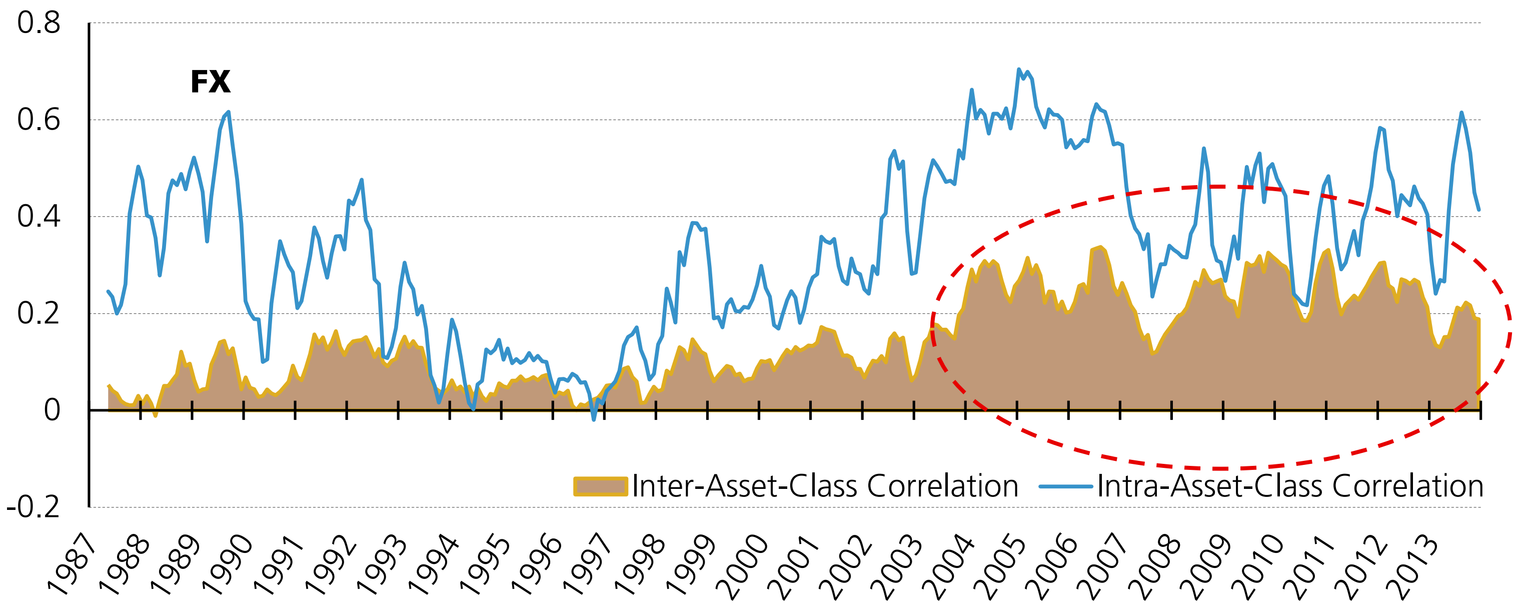


Source: UBS Quantitative Research

UBS

Intra and Inter Asset-Class Correlations

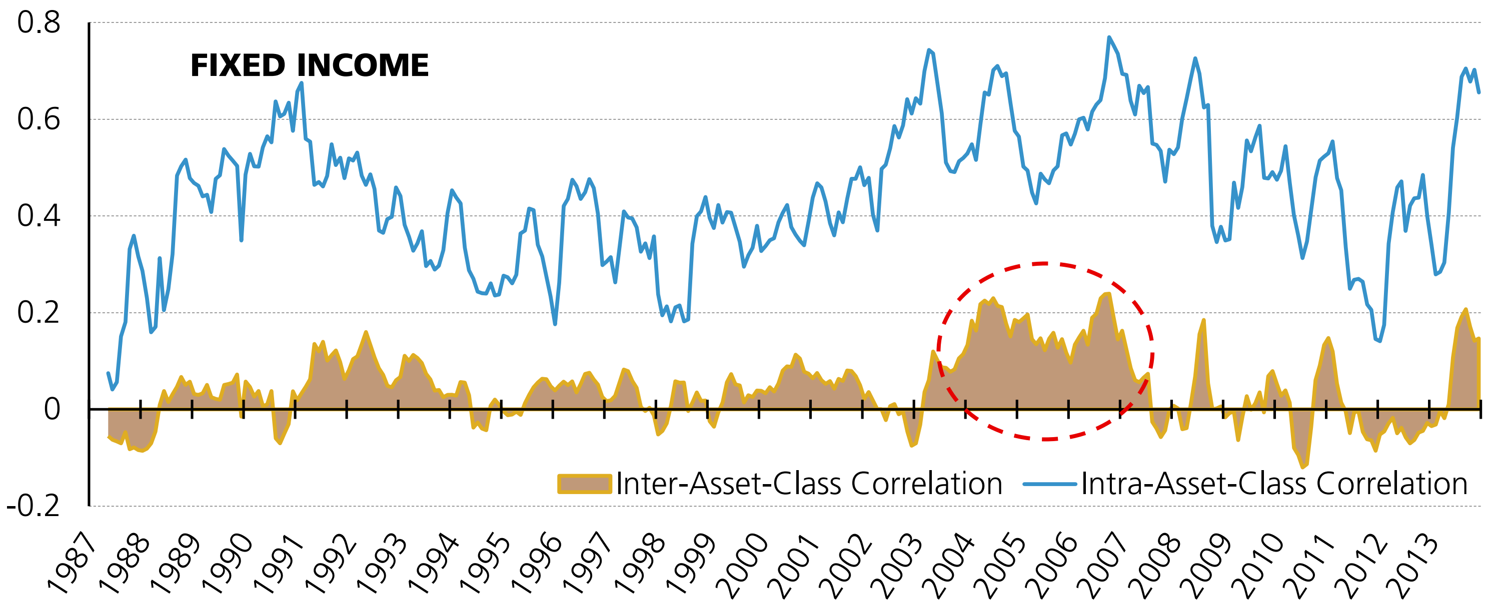




Source: UBS Quantitative Research

UBS

Intra and Inter Asset-Class Correlations



- The degree of co-movement has dramatically increased post-2004
- However, fixed income assets have been become de-correlated after 2007
- Two rough clusters: Fixed Income and non-Fixed Income → "*Risk on/Risk off*"
- Pairwise correlations are ignored by a Volatility-Parity allocation.
- How to account for such information in portfolio construction?..."True Risk Parity"

UBS

Risk-Parity (aka Equal Risk Contribution - ERC)

- Define Marginal Contribution to Risk (*MCR*): $MCR_i = \frac{\partial \sigma_P}{\partial w_i}$, where σ_P denotes portfolio volatility
- It can be trivially shown that:

$$\sum_{j=1}^{N} w_j \cdot MCR_j = \sigma_P$$

  ❖ Contrast this with: $\sum_{j=1}^{N} w_j \cdot \sigma_j \geq \sigma_P$

- RP Objective: equate the weighted *MCR*'s:

$$\boxed{w_i^{RP} \cdot MCR_i = constant, \forall i}$$

- Optimisation:

Maximise: $\sum_{i=1}^{N} \log(w_i)$
Subject to: $\sigma_P(\boldsymbol{w}) = \sqrt{\boldsymbol{w}' \cdot \boldsymbol{\Sigma} \cdot \boldsymbol{w}} \leq \sigma_{TGT}$

- Initial weights: $w_i^{RP,init} = w_i^{VP} = \frac{(\sigma_i)^{-1}}{\sum_{j=1}^{N} (\sigma_j)^{-1}}, \forall i$
- Post-optimisation rescaling of weights is permitted so to get weights in [0,1].
- Logarithmic weights are also used by Kaya (2012), Kaya and Lee (2012) and Roncalli (2014).

UBS

Note: For comparison between VP and RP see Appendix B.

Risk-Parity

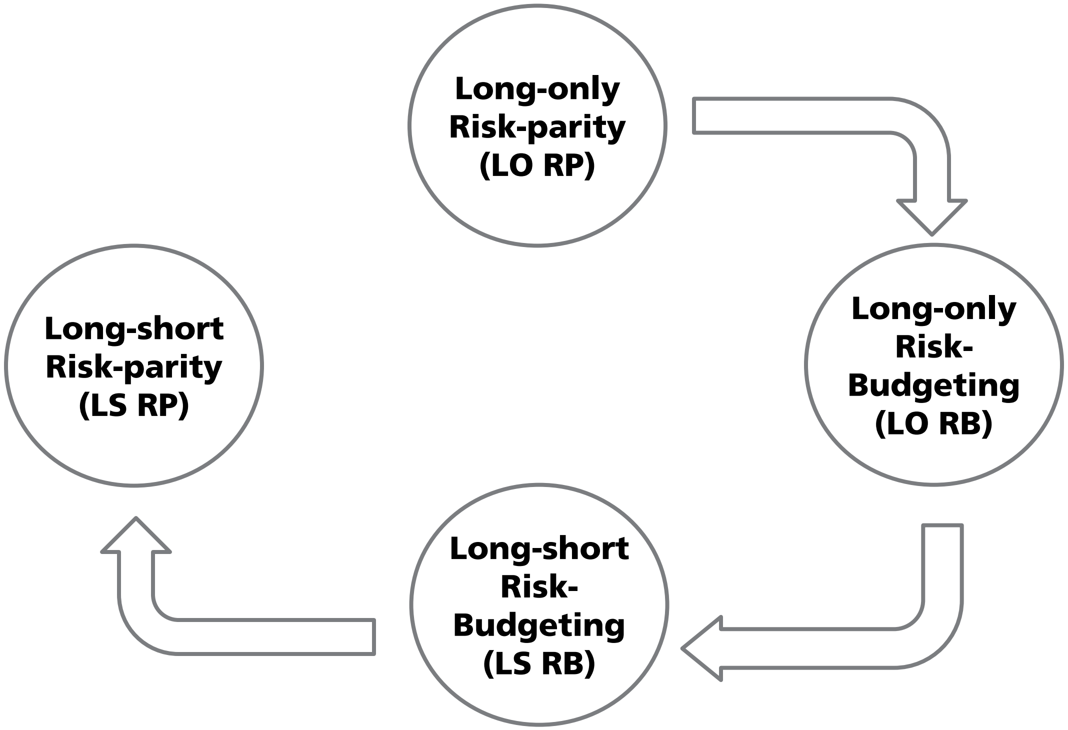
- Advantages:
  - Attractive risk-return profile
  - True equal distribution of risk across portfolio constituents
  - Robust against parameter estimation error (acts like shrinkage)
  - Naturally constrained (the optimisation does not allow negative weights or position flips)
  - Lower turnover than minimum-variance or mean-variance portfolios

- Criticisms:
  - No information about expected returns is used
  - Substantial leverage for low-volatility assets (e.g. bonds)
  - Does not offer guidance as to which assets should be included in the portfolio; whatever enters the optimisation will bear a non-zero weight.
  - Highly correlated assets will bear a larger aggregate weight than what a single asset would bear ("identical asset problem")

Extending Risk-Parity to a Long-Short Framework

- The risk-parity formulation that has been presented only applies to long-only portfolio
  - ❖ If anything, $\log(w_i)$ can only be defined for positive weights.

- How to go from long-only risk-parity to a long-short one:
  1. Start with **long-only risk-parity**
  2. Introduce/extend to long-only risk-budgeting
  3. Extend long-only risk-budgeting to long-short risk-budgeting
  4. Simplify long-short risk-budgeting down to **long-short risk-parity**



Long-Only Risk-Budgeting

- Risk-parity equates the weighted marginal contribution to risk from all assets
- **Risk-budgeting** (RB) allocates weights so that the assets contribute an amount to the overall portfolio volatility that is **proportional** to a certain **positive asset-specific score**, s_i
- From RP objective:

$$w_i^{RP} \cdot MCR_i = constant, \forall i$$

- To RB objective:

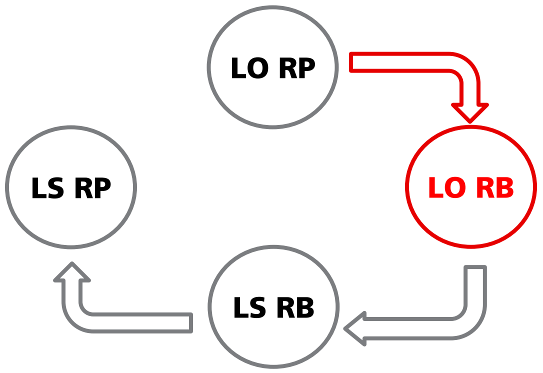
$$w_i^{RB} \cdot MCR_i \propto s_i, \forall i$$

- Optimisation (also shown in Kaya and Lee, 2012):

Maximise: $\sum_{i=1}^{N} s_i \cdot log(w_i)$

Subject to: $\sigma_P(\boldsymbol{w}) = \sqrt{\boldsymbol{w}' \cdot \boldsymbol{\Sigma} \cdot \boldsymbol{w}} \leq \sigma_{TGT}$

- Initial weights: $w_i^{RB,init} = \frac{s_i \cdot (\sigma_i)^{-1}}{\sum_{j=1}^{N} s_j \cdot (\sigma_j)^{-1}}, \forall i$



UBS

Long-Short Risk-Budgeting

- Can we allow for negative asset-specific scores?
  - ❖ Positive scores → Long positions
  - ❖ Negative scores → Short positions
- The resulting net weights must agree with the asset-specific scores in their sign:

$$sign\left(w_i^{Net,RB}\right) = sign(s_i), \qquad \forall i$$

- The RB objective becomes:

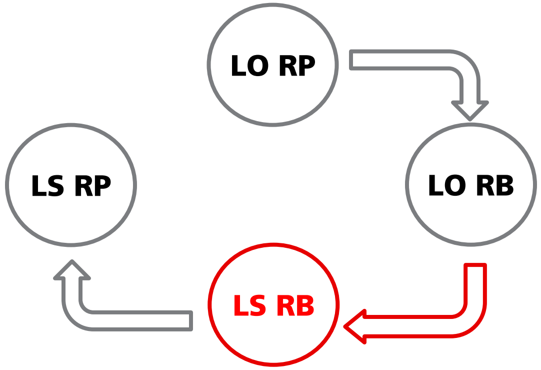
$$w_i^{Net,RB} \cdot MCR_i \propto |s_i|, \forall i$$

- Optimisation:

$$\text{Maximise: } \sum_{i=1}^{N} |s_i| \cdot log(|w_i|)$$

$$\text{Subject to: } \sigma_P(\boldsymbol{w}) = \sqrt{\boldsymbol{w}' \cdot \boldsymbol{\Sigma} \cdot \boldsymbol{w}} \leq \sigma_{TGT}$$

- Initial weights: $w_i^{Net,RB,init} = \dfrac{s_i \cdot (\sigma_i)^{-1}}{\sum_{j=1}^{N} |s_j| \cdot (\sigma_j)^{-1}}$



Long-Short Risk-Parity and Trend-Following

- Notice that if all asset-specific scores are equal in absolute value, we are back to risk-parity:

$$if\ |s_i| = |s_j|, \forall i, j$$

$$\Rightarrow \text{Long—Short Risk—Budgeting:}\ \ w_i^{Net,RB} \cdot MCR_i \propto 1$$

$$\Rightarrow w_i^{Net,RB} \cdot MCR_i = constant, \forall i \Rightarrow \text{Risk} - \text{Parity}$$

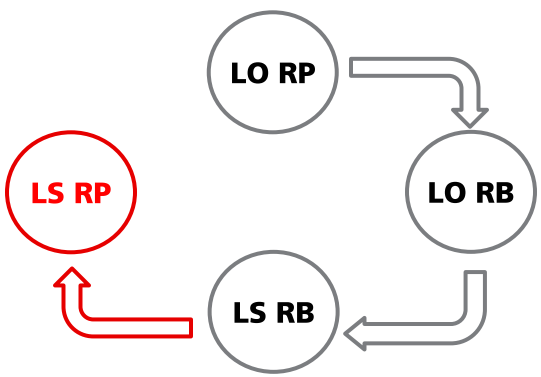
- However, this framework now allows for long and short positions!
- Trend-following signal: $s_i = sign\left(ret_i^{12M}\right) = \pm 1 \Rightarrow |s_i| = |s_j|, \forall i, j$
- Long-Short risk-budgeting optimisation boils down to a long-short risk-parity optimisation.
- Optimisation:

Maximise: $\sum_{i=1}^{N} log(|w_i|)$
Subject to: $\sigma_P(\boldsymbol{w}) = \sqrt{\boldsymbol{w}' \cdot \boldsymbol{\Sigma} \cdot \boldsymbol{w}} \leq \sigma_{TGT}$

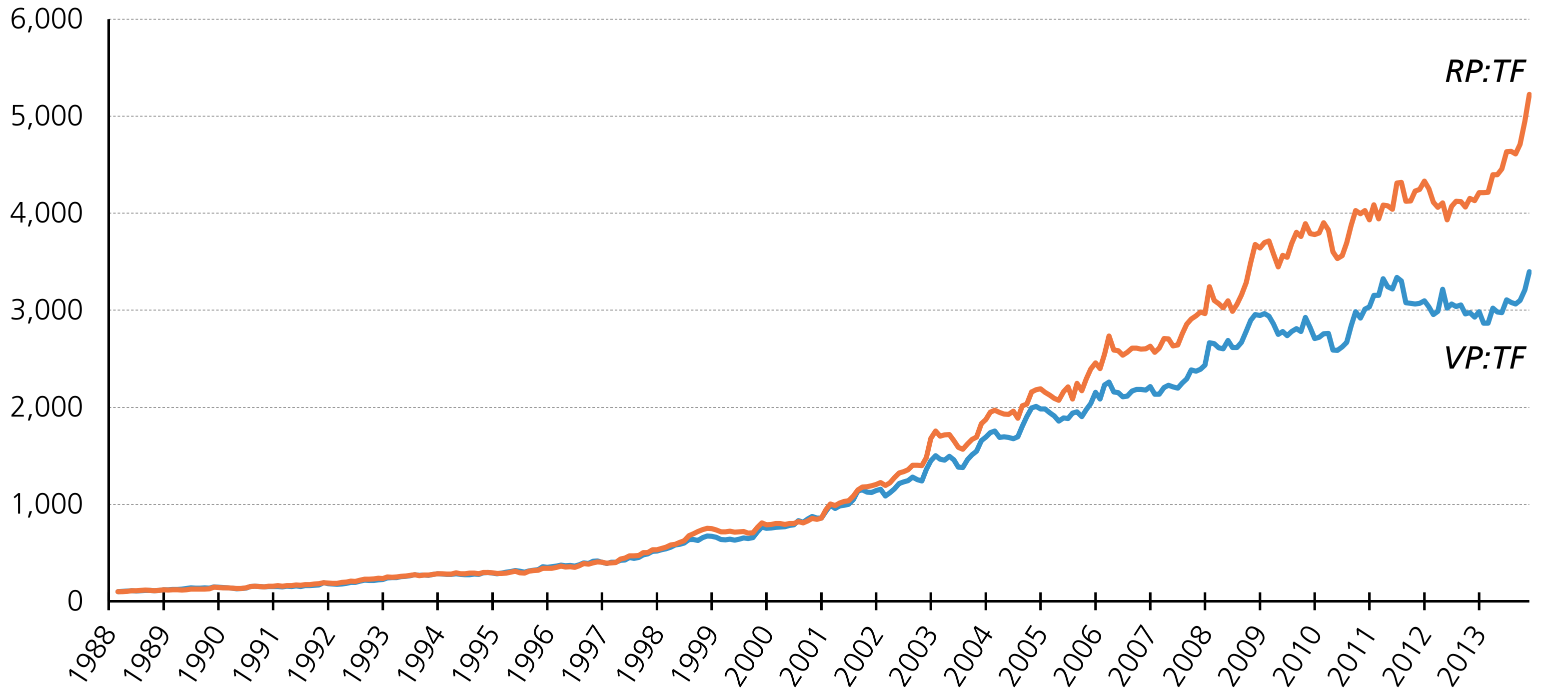
- Initial weights: $w_i^{Net,RP,init} = sign\left(ret_i^{12M}\right) \cdot \frac{(\sigma_i)^{-1}}{\sum_{j=1}^{N}(\sigma_j)^{-1}}$

- Risk-Parity Trend-Following ($RP{:}TF$) strategy:

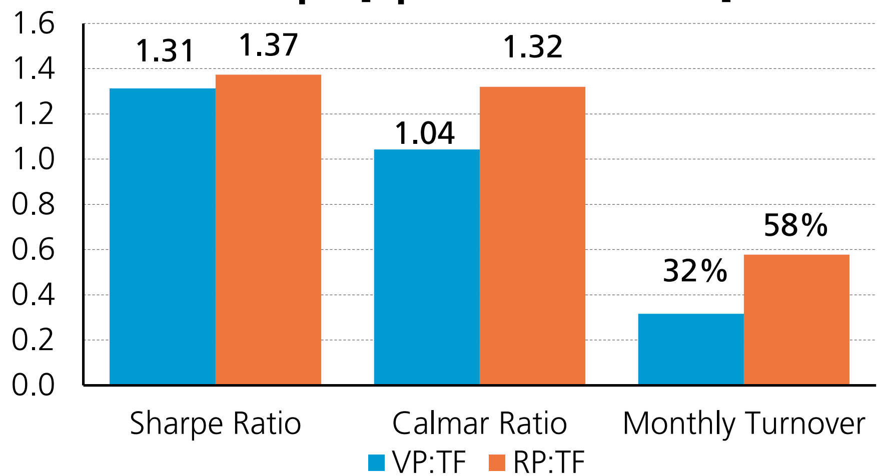
$$r_{t,t+1}^{RP:TF} = \frac{\sigma_{TGT}}{\sigma_t^{TF}} \sum_{i=1}^{N_t} w_t^{i,Net,RP} \cdot r_{t,t+1}^i$$



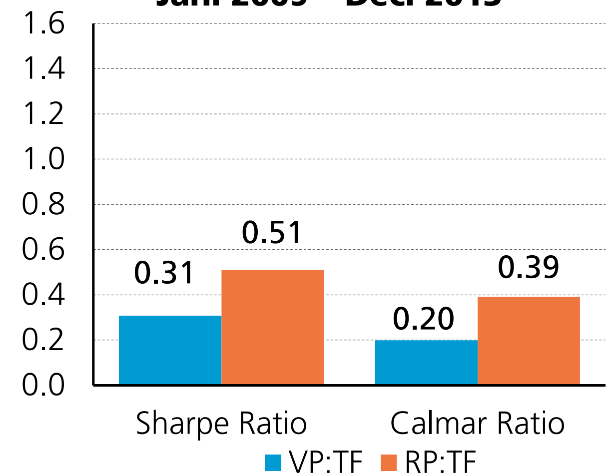
Trend-following: Performance Statistics



Full Sample [Apr. 1988 – Dec. 2013]



Jan. 2009 – Dec. 2013



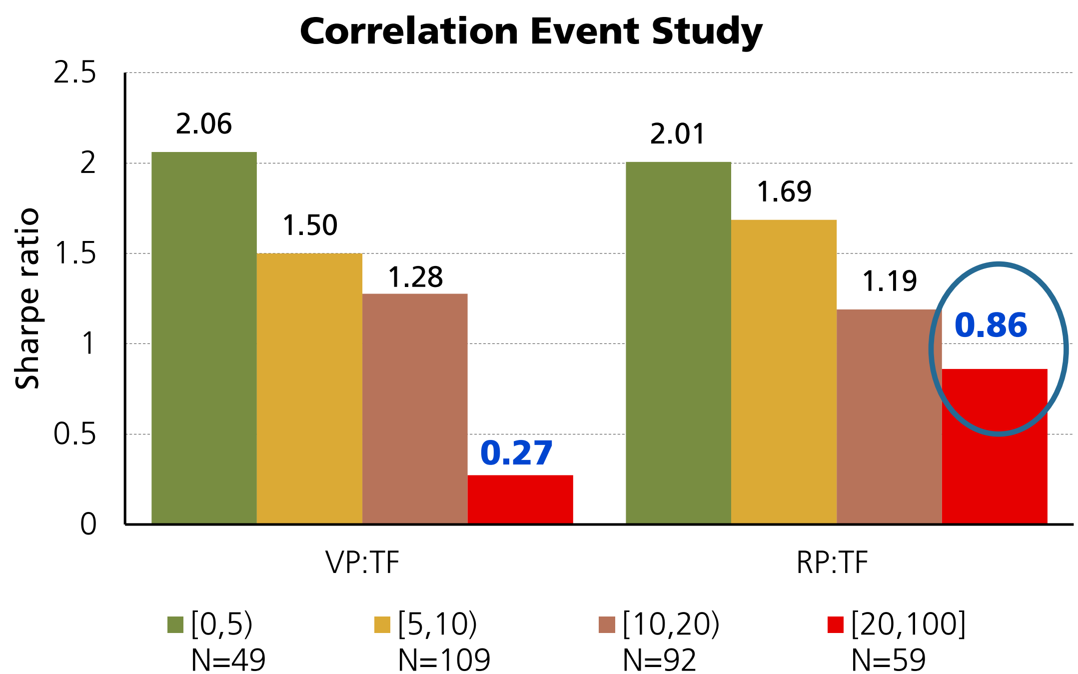
UBS

Note: For rolling Sharpe ratio see Appendix C.

Source: UBS Quantitative Research

Correlation Event Study – Revisited

- How do RP portfolios perform in extreme-correlation regimes?



Source: UBS Quantitative Research.
For illustrative purposes only

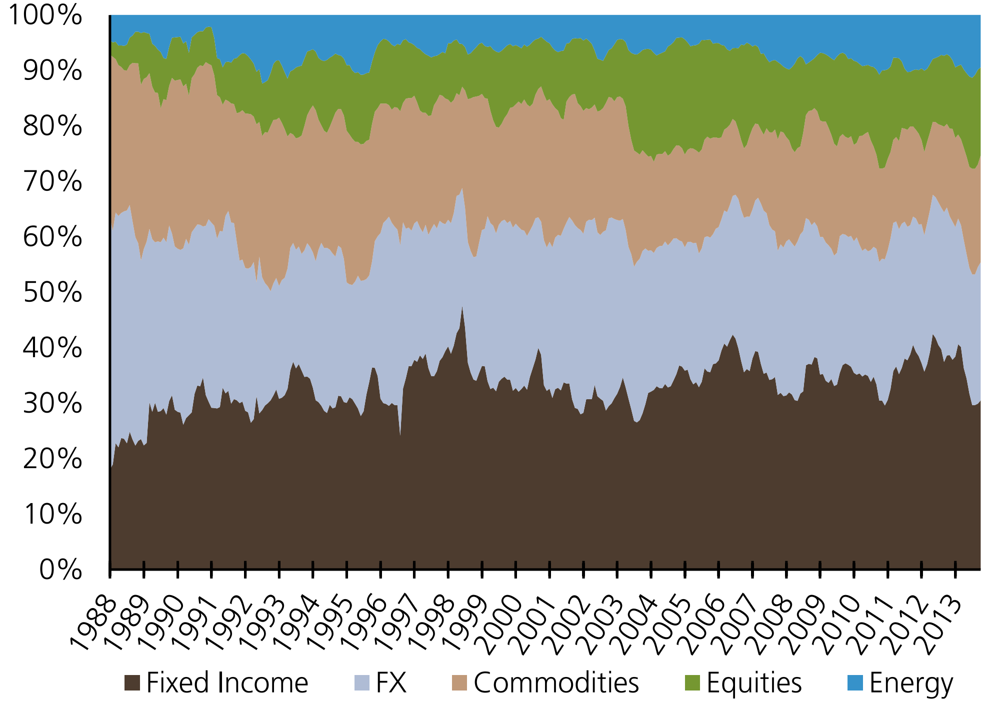
- RP constitutes a genuine improvement to naïve VP, especially in periods of high correlations.
- *Word of Caution*: In an environment that markets do not trend at all, a more sophisticated weighting scheme like Risk-Parity can only do so much.

From VP to RP – Weight vs. Risk Allocation

- *Gross weight allocation* and respective *risk allocation* per asset class.

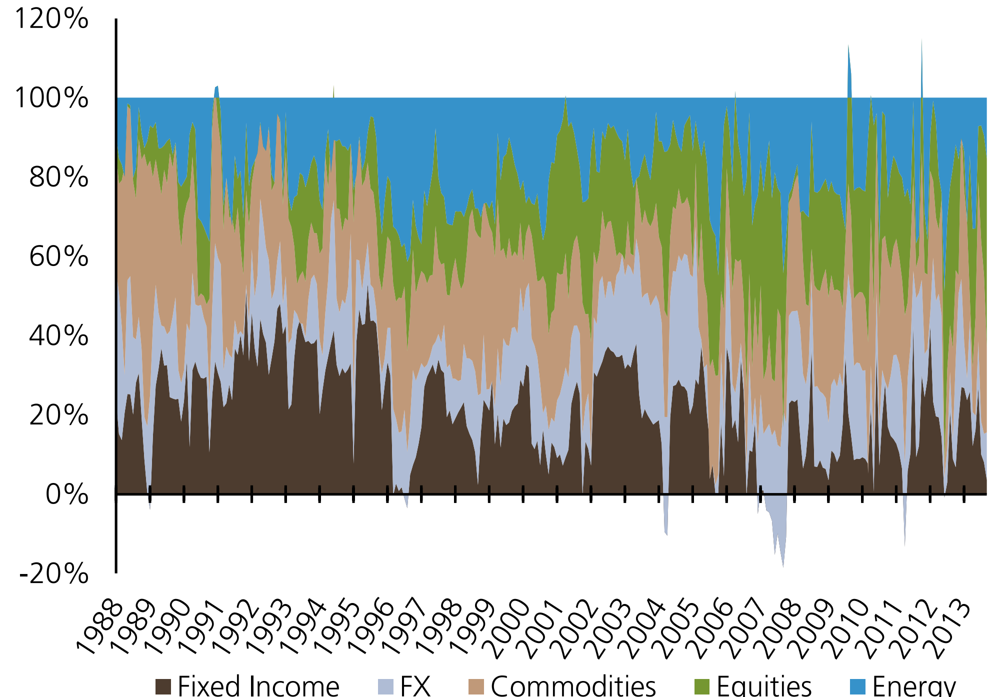
- From Volatility-Parity…

Sum of Gross Weights per asset class



Source: UBS Quantitative Research

Percentage contribution to risk per asset class



Source: UBS Quantitative Research

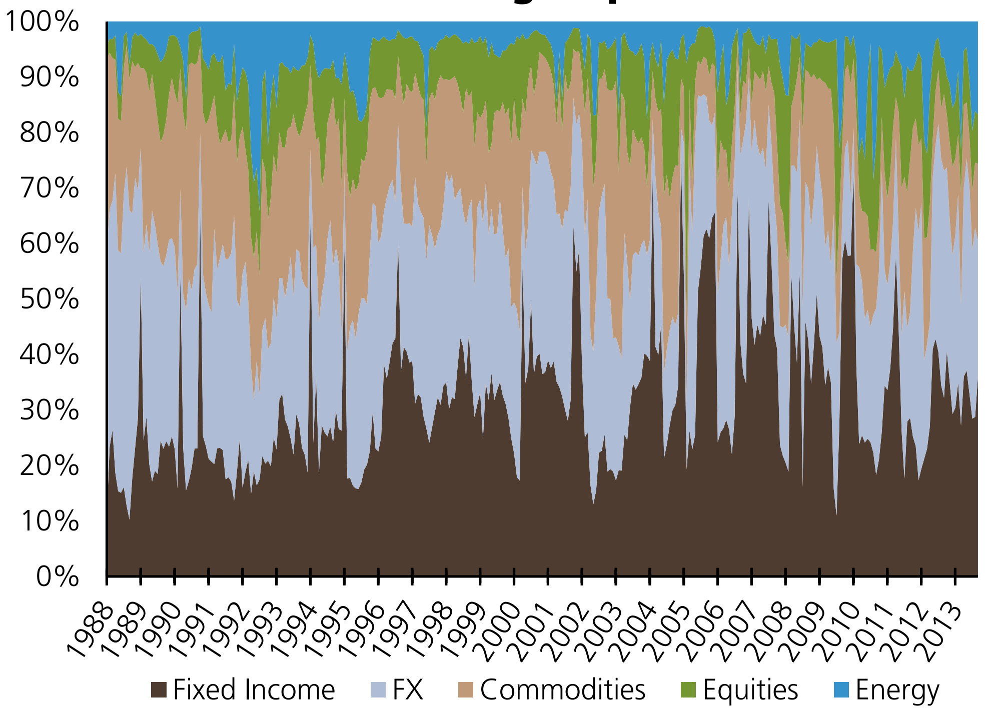
UBS

From VP to RP – Weight vs. Risk Allocation

- *Gross weight allocation* and respective *risk allocation* per asset class.

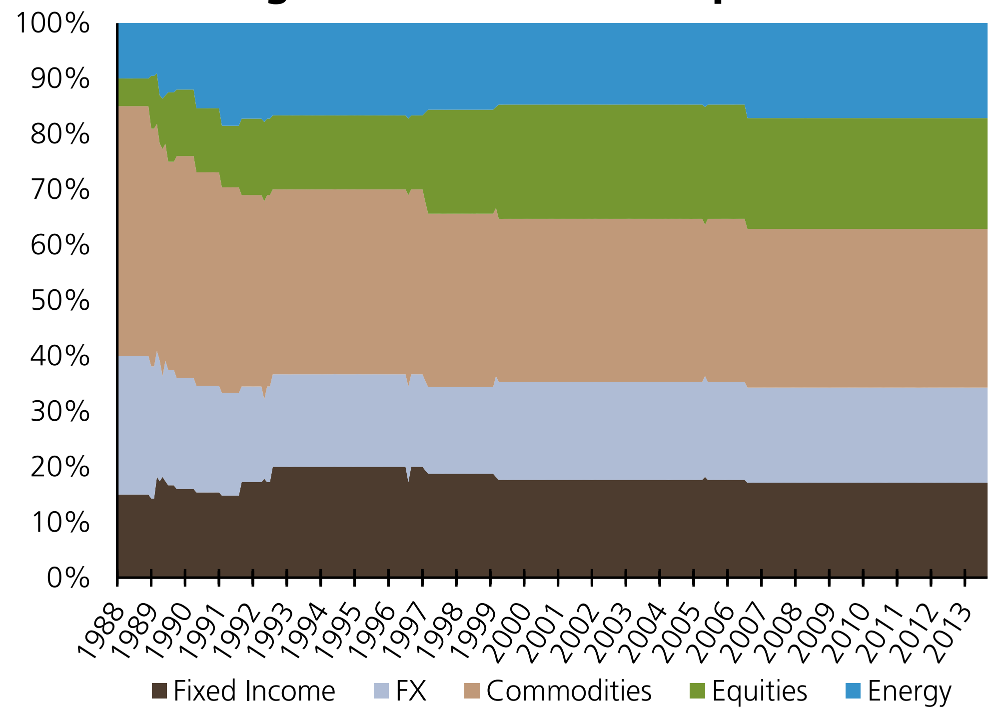
- From Volatility-Parity…to *Risk-Parity*

Sum of Gross Weights per asset class



Source: UBS Quantitative Research

Percentage contribution to risk per asset class

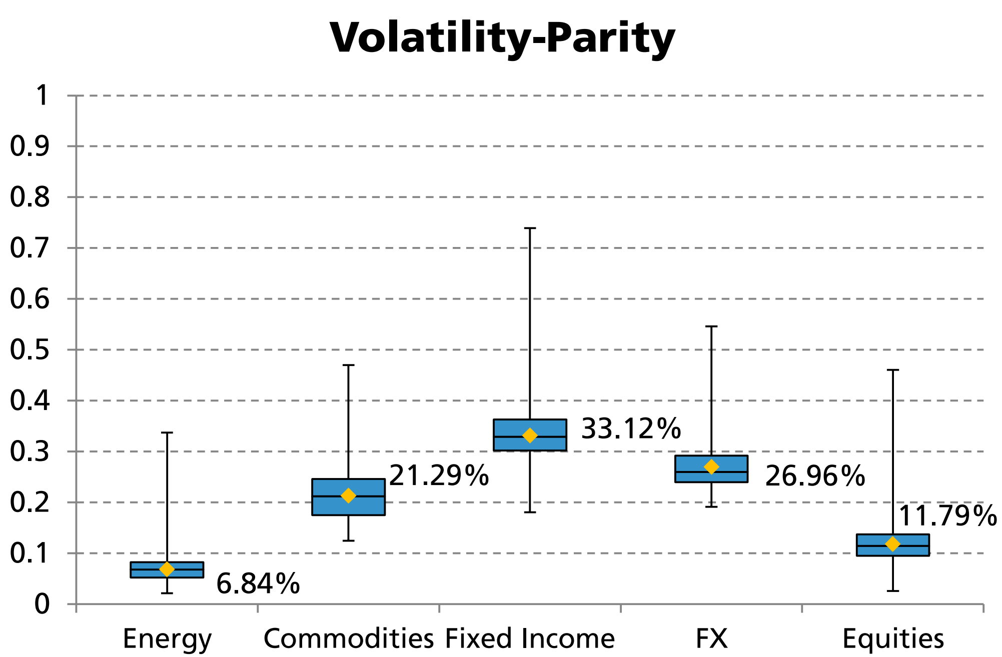


Source: UBS Quantitative Research

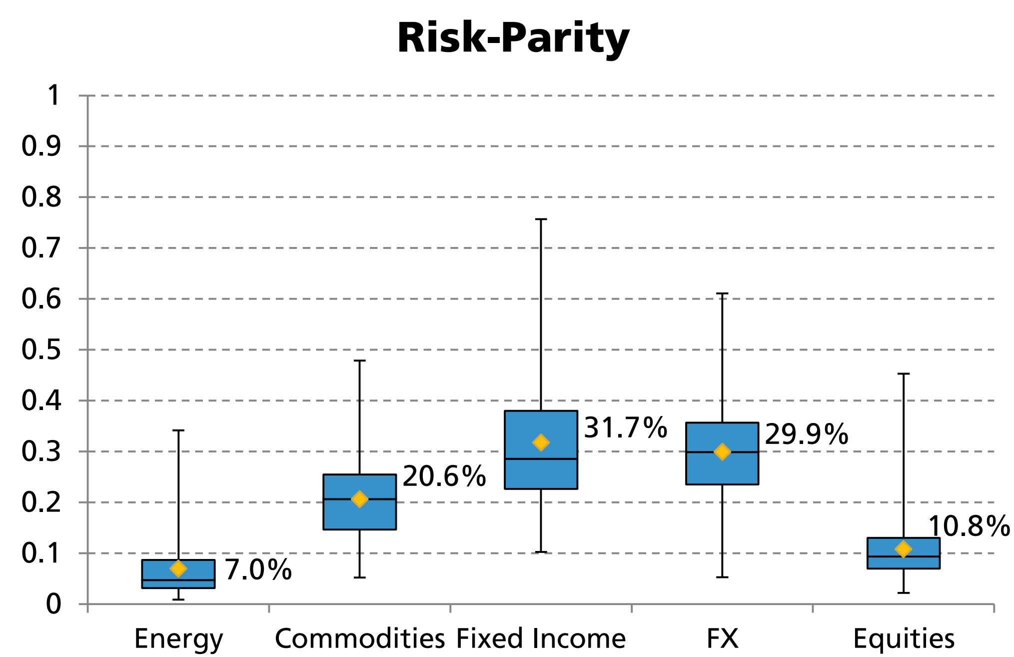
- *Equal Risk Contribution* across assets and consequently asset classes.

UBS

From VP to RP – Unconditional Weight Distribution



Source: UBS Quantitative Research



Source: UBS Quantitative Research

- Similar distribution, but RP has larger interquartile ranges
- … →larger turnover, but this was expected
- The two weighting schemes are only different because of correlations.

Concluding Remarks

- One reason for the underperformance of trend-following strategies in the post-crisis period has been the substantial co-movement of assets and asset classes
- Trend-following can benefit significantly from a risk-parity allocation, especially in periods of substantial co-movement.
- Risk-parity is generally considered a long-only allocation scheme
- We extend risk-parity to a long-short framework and show that it can significantly improve the risk-adjusted performance of trend-following in periods of high correlation.

UBS

Appendix A - Working with Futures Contracts

- Building continuous futures price-series:
  - Futures contracts are short-lived instruments, only active until the delivery date.
  - In theory, unfunded investments; in practice, initial margin payment is required.
  - We use Bloomberg's custom-made continuous *generic* price-series using *backwards-ratio price adjustment*, so that no "price jump" (fictitious return) occurs on a roll-over day.
  - Screen <GFUT> in Bloomberg provides a number of choices regarding the construction of the generic futures series.
- Construction of "excess" returns:
  - Assume a "front" futures contract priced at $F_{t,T}$ at the end of month t maturing at T.
  - Assume the contract is *not* within its delivery month, i.e. $t < t+1 < T$.
  - At the end of month $t+1$, it is priced at $F_{t+1,T}$.
  - Entering the contract at time t involves initial margin of M_t, which, in turn, grows at r_t^f
  - The excess return of the futures contracts in $[t, t+1]$ is (assuming no variation margin):

$$r_{t,t+1}^{xs} = \frac{\left[M_t\left(1+r_t^f\right) + \left(F_{t+1,T} - F_{t,T}\right)\right] - M_t}{M_t} - r_t^f = \frac{F_{t+1,T} - F_{t,T}}{M_t}$$

  - For a "*fully-collateralised*" position, $M_t = F_{t,T}$:

$$r_{t,t+1} \equiv r_{t,t+1}^{xs,fc} = \frac{F_{t+1,T} - F_{t,T}}{F_{t,T}}$$

  - We use this formula to calculate monthly holding returns for the strategy backtesting.

UBS

Appendix B: Volatility-Parity versus Risk-Parity

- Volatility-parity weights:

$$w_i^{VP} \propto \frac{1}{\sigma_i}$$

- Risk-parity weights are such that: $w_i^{RP} \cdot MCR_i = constant, \forall i$

It can be shown that: $MCR_i = \frac{\partial \sigma_P(\boldsymbol{w})}{\partial w_i} = \sigma_i \cdot \rho_{i,P}(\boldsymbol{w})$

$\rho_{i,P}(\boldsymbol{w})$: correlation of asset i with the overall portfolio.

$$\Rightarrow \quad w_i^{RP} \propto \frac{1}{MCR_i} = \frac{1}{\sigma_i} \cdot \frac{1}{\rho_{i,P}(\boldsymbol{w}^{RP})}$$

Caution: the above result is not a closed-form solution…

- Risk-parity over-weights:
  - *Low-volatility* assets
  - *De-correlated* assets (i.e. assets with lower correlation with the rest of the universe)

UBS

Appendix B: Volatility-Parity versus Risk-Parity

- Divide by parts:

$$\frac{w_i^{RP}}{w_i^{VP}} \propto \frac{1}{\rho_{i,P}(\boldsymbol{w}^{RP})}$$

<u>Caution:</u> this result is a proportionality statement → qualitative conclusions only

- When an asset correlates more with the universe, its RP weight falls relative to $\frac{1}{\sigma}$

- When an assets de-correlates, its RP weight increases relative to $\frac{1}{\sigma}$

- Using the weight normalisation (sum of weights is 100%), we deduce the following illustrative comparison:

$$\underbrace{w_i^{VP} = \frac{(\sigma_i)^{-1}}{\sum_{j=1}^{N}(\sigma_j)^{-1}}}_{Closed-form\ Solution} \quad \text{vs.} \quad \underbrace{w_i^{RP} = \frac{(MCR_i)^{-1}}{\sum_{j=1}^{N}(MCR_j)^{-1}}}_{\substack{non-closed-form\ expression \\ \rightarrow Numerical\ Solution}}$$

- The two weighting schemes are identical if all correlations are equal [see next page]

UBS

Appendix B: Volatility-Parity versus Risk-Parity

- The Marginal Contribution to Risk (MCR) is defined as the change in portfolio volatility $\sigma_P(\boldsymbol{w})$ for a marginal change in the weight of each asset i, w_i:

$$MCR_i = \frac{\partial \sigma_P(\boldsymbol{w})}{\partial w_i} = \frac{(\boldsymbol{\Sigma} \cdot \boldsymbol{w})_i}{\sigma_P(\boldsymbol{w})} \qquad \textbf{(1)}$$

- If the pairwise correlation is constant across all pairs and equal to $\bar{\rho}$ then (1) simplifies to:

$$MCR_i(\bar{\rho}) = \frac{\sigma_i}{\sigma_P(\boldsymbol{w})}\left[w_i \cdot \sigma_i \cdot (1-\bar{\rho}) + \bar{\rho}\sum_{j=1}^{N} w_j \cdot \sigma_j\right] \qquad \textbf{(2)}$$

- The Risk-Parity objective is:

$$w_i^{RP} \cdot MCR_i = constant, \forall i \Leftrightarrow w_i^{RP} \cdot MCR_i = w_j^{RP} \cdot MCR_j, \forall i,j \qquad \textbf{(3)}$$

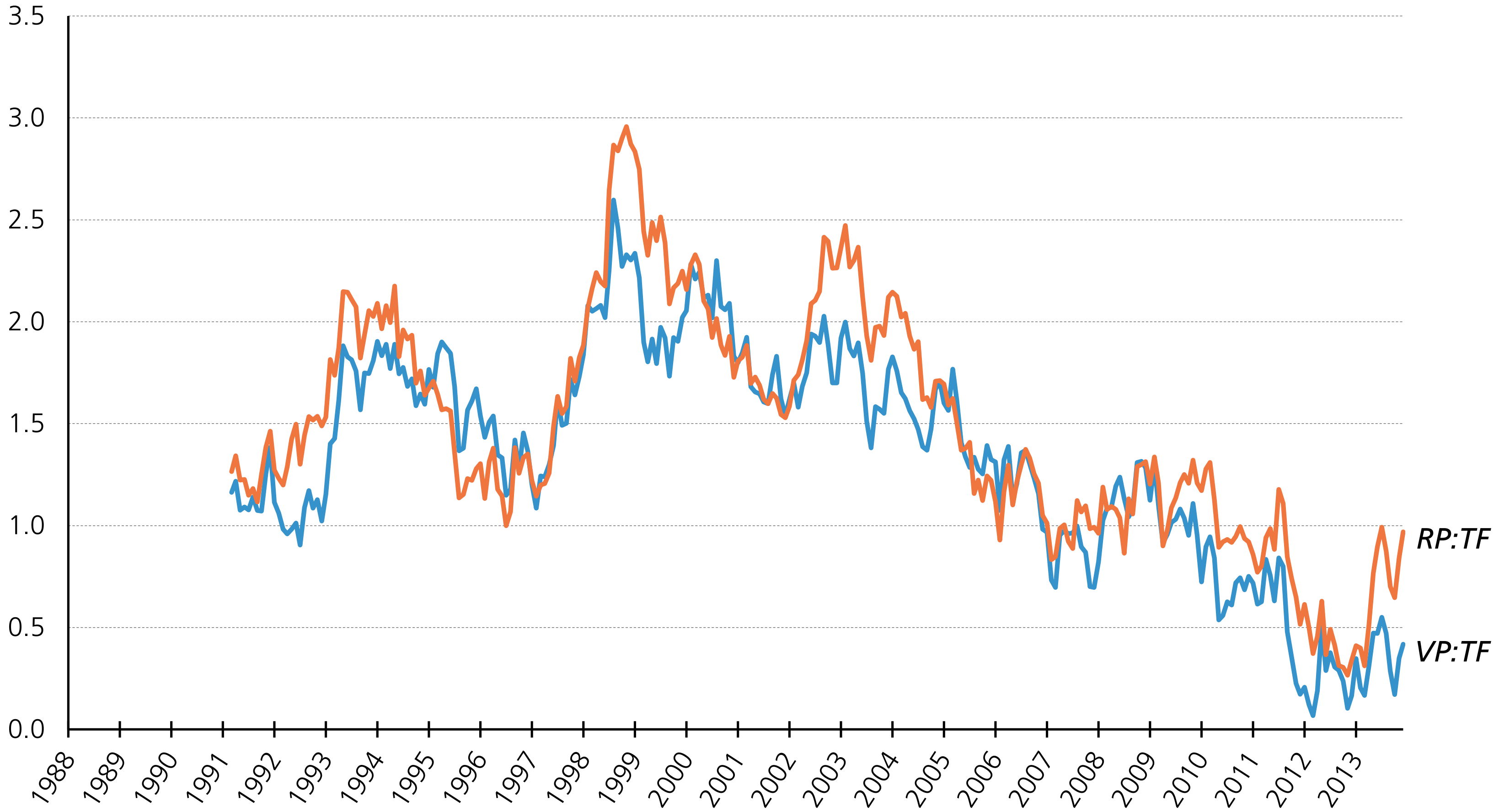
- Combining (2) – for i and j – and (3) leads to:

$$\underbrace{\left(w_i \cdot \sigma_i - w_j \cdot \sigma_j\right)}_{A} \cdot \underbrace{\left[\left(w_i \cdot \sigma_i + w_j \cdot \sigma_j\right)(1-\bar{\rho}) + \bar{\rho}\sum_{m=1}^{N} w_m \cdot \sigma_m\right]}_{B} = 0, \forall i,j \qquad \textbf{(4)}$$

- Under reasonable assumptions for B (…) the solution to (4) is $A = 0$, hence:

$$\frac{w_i}{w_j} = \frac{1/\sigma_i}{1/\sigma_j}, \forall i,j \Leftrightarrow \boldsymbol{Volatility\ Parity}$$

Appendix C: 36-month Rolling Sharpe Ratio

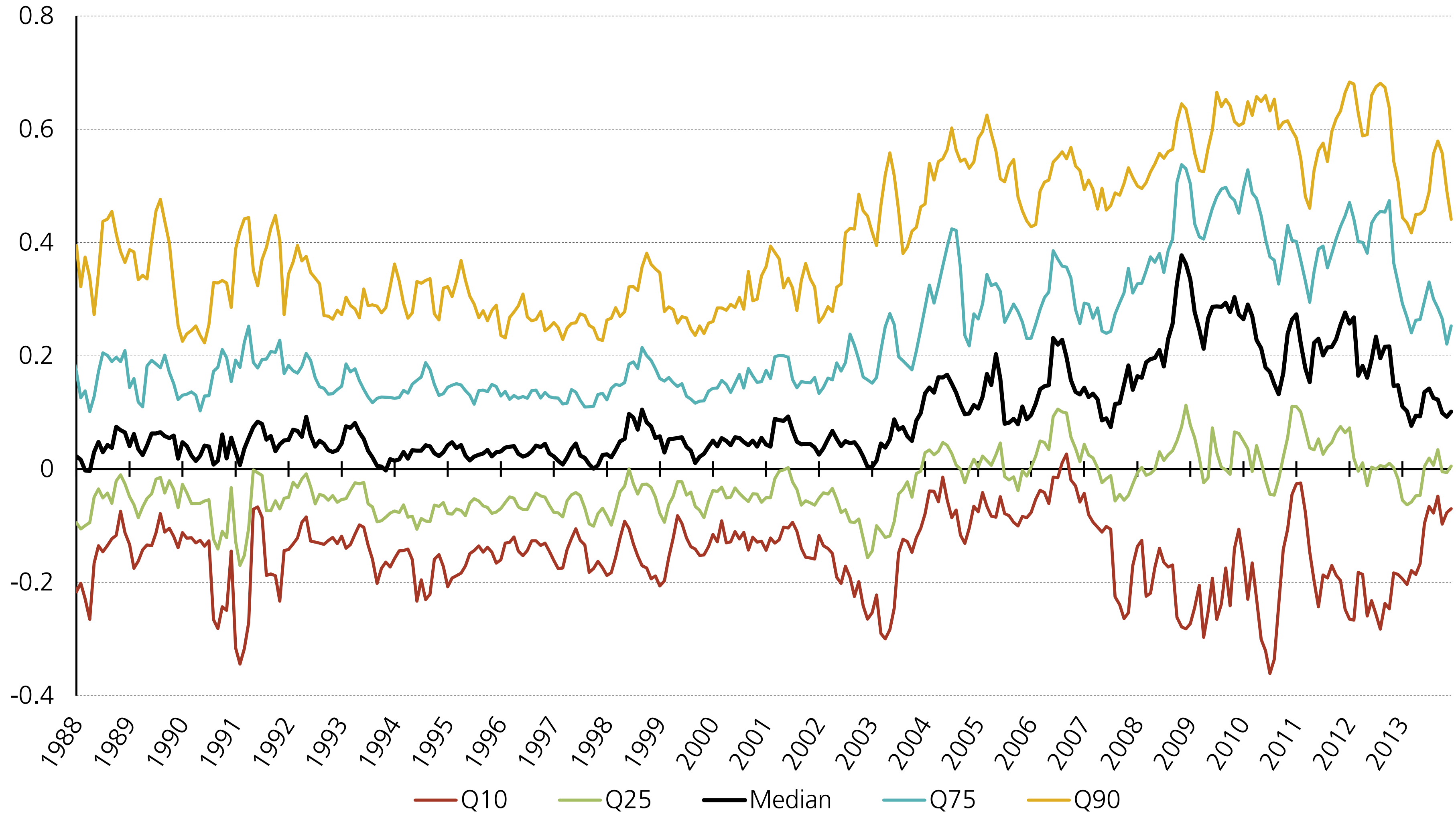


Source: UBS Quantitative Research

- The picture is similar (in terms of RP relative benefit) for long-only strategies.

Appendix D: Distribution of Pairwise Correlations

- We plot below the certain percentiles of the cross-sectional distribution of 90-day pairwise correlations between all the assets of our universe.



Source: UBS Quantitative Research

UBS

Related Literature (1/2)

- Anderson, R. M., Bianchi, S. W., & Goldberg, L. R. (2012). Will My Risk Parity Strategy Outperform?. *Financial Analysts Journal*, *68*(6), 75-93.
- Ang, A., Hodrick, R. J., Xing, Y., & Zhang, X. (2006). The Cross-section of Volatility and Expected Returns. *Journal of Finance, 61*(1), 259-299.
- Ang, A., Hodrick, R. J., Xing, Y., & Zhang, X. (2009). High Idiosyncratic Volatility and Low Returns: International and Further US Evidence. *Journal of Financial Economics, 91*(1), 1-23.
- Asness, C., Frazzini, A., & Pedersen, L. H. (2012). Leverage Aversion and Risk Parity. *Financial Analysts Journal*, *68*(1), 47-59.
- Baltas, A. N., & Kosowski, R.: (2013), Momentum Strategies in Futures Markets and Trend-Following Funds. *Available at SSRN 1968996*.
- Baltas, A. N., & Kosowski, R.: (20134), Demystifying Time-Series Momentum Strategies: Volatility Estimators, Trading Rules and Pairwise Correlations. *Available at SSRN 2140091*.
- Baker, M., Bradley, B., & Wurgler, J. (2011). Benchmarks as Limits to Arbitrage: Understanding the Low-Volatility Anomaly. *Financial Analysts Journal, 67*(1), 40-54.
- Barroso, P., & Santa-Clara, P. (2014). Momentum has its Moments. *Journal of Financial Economics, forthcoming*.
- Bernardi, S., Leippold, M., & Lohre, H. (2013). Risk-Based Commodity Investing. *Available at SSRN 2290776*.
- Bhansali, V. (2011). Beyond Risk Parity. *The Journal of Investing*, *20*(1), 137-147.
- Bhansali, V., Davis, J., Rennison, G., Hsu, J., & Li, F. (2012). The Risk in Risk Parity: A Factor Based Analysis of Asset Based Risk Parity. *Journal of Investing*, *21*(3), 102-110.
- Burnside, C., Eichenbaum, M., & Rebelo, S. (2011), Carry trade and momentum in currency markets, *Annual Review of Financial Economics* 3(1), 511–535.
- Choueifaty, Y. & Y. Coignard (2008). Towards Maximum Diversification, *Journal of Portfolio Management, 35*(1), 40-51.
- Clare, A., Seaton, J., Smith, P., & Thomas, S. (2013). The Trend is Our Friend: Risk Parity, Momentum and Trend Following in Global Asset Allocation. *Available at SSRN 2126478.*
- Covel, M. W. (2009), Trend Following: Learn to Make Millions in Up Or Down Markets, *FT Press*.
- Daniel, K. & T. Moskowitz (2013), Momentum Crashes, *Available at SSRN 2371227*.
- Driscoll, J. C., & Kraay, A. C. (1998). Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data. *Review of Economics and Statistics, 80*(4), 549-560.
- Fisher, G. S., Maymin, P. Z., & Maymin, Z. G. (2013) Risk Parity Optimality. *Available at SSRN 2188574*.

Related Literature (2/2)

- Frazzini, A., & Pedersen, L. H. (2014). Betting Against Beta. *Journal of Financial Economics, 111*(1), 1-25.
- Hallerbach, W. G. (2012). A proof of the Optimality of Volatility Weighting over time. Journal of Investment Strategies, 1(4), 87-99
- Hallerbach, W. G. (2014). On the Expected Performance of Market Timing Strategies. Journal of Portfolio Management, 40(4), 42-51.
- Hurst, B., Ooi, Y. H., & Pedersen, L. H. (2012), A century of evidence on Trend-Following Investing, *AQR Capital Management.*
- Hurst, B., Ooi, Y. H., & Pedersen, L. H. (2013). Demystifying Managed Futures. *Journal of Investment Management*, *11*(3), 42-58.
- Inker, B. (2011). The Dangers of Risk Parity. *Journal of Investing, 20*(1), 90-98.
- Jurczenko, E., Michel, T., & Teiletche, J. (2015). Generalized Risk-Based Investing. *Journal of Investment Strategies, 4*(4).
- Lee, W. (2011). Risk Based Asset Allocation: A New Answer To An Old Question?. *The Journal of Portfolio Management*, *37*(4), 11-28.
- Leote de Carvalho, R., Lu, X., & Moulin, P. (2012). Demystifying Equity Risk–Based Strategies: A Simple Alpha plus Beta Description. *Journal of Portfolio Management, 38*(3), 56-70.
- Lohre, H., Opfer, H., & Orszag, G. (2013). Diversifying risk parity. *Available at SSRN 1974446*.
- Lohre, H., Neugebauer, U., & Zimmer, C. (2012). Diversified Risk Parity Strategies for Equity Portfolio Selection, *Journal of Investing*, *21*(3), 111-128.
- Maillard, S., T. Roncalli, & J. Teiletche (2010) .The Properties of Equally Weighted Risk Contribution Portfolios, *Journal of Portfolio Management, 36*(3), 60-70.
- Menchero, J., & Davis, B. (2011). Risk Contribution is Exposure times Volatility times Correlation: Decomposing risk using the x-sigma-rho formula. *Journal of Portfolio Management, 37*(2), 97-106.
- Moskowitz, T., Ooi, Y. H., & Pedersen, L. H. (2012), Time Series Momentum, *Journal of Financial Economics* 104(2), 228 – 250.
- Newey, W. K., & West, K. D. (1987). Hypothesis Testing with Efficient Method of Moments Estimation. *International Economic Review, 28*(3), 777-787.
- Steiner, A. (2012). Risk Parity for the Masses. *Journal of Investing*, *21*(3), 129-139.
- Szakmary, A. C., Shen, Q., & Sharma, S. C. (2010), Trend-following trading strategies in commodity futures: A re-examination, *Journal of Banking and Finance* 34(2), 409–426.

Statement of Risk

Our quantitative models rely on reported financial statement information, consensus values and stock prices. Errors in these numbers are sometimes impossible to prevent (e.g. when an item is misstated by a company). Also, the models employ historical data to estimate the efficacy of stock selection strategies and the relationships among strategies, which may change in the future. Additionally, unusual company-specific events could overwhelm the systematic influence of the strategies used to rank and score stocks.

Analyst Certification

Each research analyst primarily responsible for the content of this research report, in whole or in part, certifies that with respect to each security or issuer that the analyst covered in this report: (1) all of the views expressed accurately reflect his or her personal views about those securities or issuers and were prepared in an independent manner, including with respect to UBS, and (2) no part of his or her compensation was, is, or will be, directly or indirectly, related to the specific recommendations or views expressed by that research analyst in the research report.

Required Disclosures

This report has been prepared by UBS Limited, an affiliate of UBS AG. UBS AG, its subsidiaries, branches and affiliates are referred to herein as UBS.

For information on the ways in which UBS manages conflicts and maintains independence of its research product; historical performance information; and certain additional disclosures concerning UBS research recommendations, please visit www.ubs.com/disclosures. The figures contained in performance charts refer to the past; past performance is not a reliable indicator of future results. Additional information will be made available upon request. UBS Securities Co. Limited is licensed to conduct securities investment consultancy businesses by the China Securities Regulatory Commission.

UBS Investment Research: Global Equity Rating Definitions

12-Month Rating	**Definition**	**Coverage**[1]	**IB Services**[2]
Buy	FSR is > 6% above the MRA.	49%	33%
Neutral	FSR is between -6% and 6% of the MRA.	40%	26%
Sell	FSR is > 6% below the MRA.	12%	18%
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.	less than 1%	less than 1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	less than 1%	less than 1%

Source: UBS. Rating allocations are as of 30 September 2015.
1:Percentage of companies under coverage globally within the 12-month rating category. 2:Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months. 3:Percentage of companies under coverage globally within the Short-Term rating category. 4:Percentage of companies within the Short-Term rating category for which investment banking (IB) services were provided within the past 12 months.

KEY DEFINITIONS: Forecast Stock Return (FSR) is defined as expected percentage price appreciation plus gross dividend yield over the next 12 months. **Market Return Assumption (MRA)** is defined as the one-year local market interest rate plus 5% (a proxy for, and not a forecast of, the equity risk premium). **Under Review (UR)** Stocks may be flagged as UR by the analyst, indicating that the stock's price target and/or rating are subject to possible change in the near term, usually in response to an event that may affect the investment case or valuation. **Short-Term Ratings** reflect the expected near-term (up to three months) performance of the stock and do not reflect any change in the fundamental view or investment case. **Equity Price Targets** have an investment horizon of 12 months.

EXCEPTIONS AND SPECIAL CASES: UK and European Investment Fund ratings and definitions are: Buy: Positive on factors such as structure, management, performance record, discount; **Neutral:** Neutral on factors such as structure, management, performance record, discount; **Sell:** Negative on factors such as structure, management, performance record, discount. **Core Banding Exceptions (CBE):** Exceptions to the standard +/-6% bands may be granted by the Investment Review Committee (IRC). Factors considered by the IRC include the stock's volatility and the credit spread of the respective company's debt. As a result, stocks deemed to be very high or low risk may be subject to higher or lower bands as they relate to the rating. When such exceptions apply, they will be identified in the Company Disclosures table in the relevant research piece.

Research analysts contributing to this report who are employed by any non-US affiliate of UBS Securities LLC are not registered/qualified as research analysts with the NASD and NYSE and therefore are not subject to the restrictions contained in the NASD and NYSE rules on communications with a subject company, public appearances, and trading securities held by a research analyst account. The name of each affiliate and analyst employed by that affiliate contributing to this report, if any, follows.

UBS Limited: Nick Baltas, PhD.

Unless otherwise indicated, please refer to the Valuation and Risk sections within the body of this report.

Global Disclaimer

This document has been prepared by UBS Limited, an affiliate of UBS AG. UBS AG, its subsidiaries, branches and affiliates are referred to herein as UBS.

Global Research is provided to our clients through UBS Neo, the UBS Client Portal and UBS.com (each a "System"). It may also be made available through third party vendors and distributed by UBS and/or third parties via e-mail or alternative electronic means. The level and types of services provided by Global Research to a client may vary depending upon various factors such as a client's individual preferences as to the frequency and manner of receiving communications, a client's risk profile and investment focus and perspective (e.g. market wide, sector specific, long-term, short-term, etc.), the size and scope of the overall client relationship with UBS and legal and regulatory constraints.

When you receive Global Research through a System, your access and/or use of such Global Research is subject to this Global Research Disclaimer and to the terms of use governing the applicable System.

When you receive Global Research via a third party vendor, e-mail or other electronic means, your use shall be subject to this Global Research Disclaimer and to UBS's Terms of Use/Disclaimer (http://www.ubs.com/global/en/legalinfo2/disclaimer.html). By accessing and/or using Global Research in this manner, you are indicating that you have read and agree to be bound by our Terms of Use/Disclaimer. In addition, you consent to UBS processing your personal data and using cookies in accordance with our Privacy Statement (http://www.ubs.com/global/en/legalinfo2/privacy.html) and cookie notice (http://www.ubs.com/global/en/homepage/cookies/cookie-management.html).

If you receive Global Research, whether through a System or by any other means, you agree that you shall not copy, revise, amend, create a derivative work, transfer to any third party, or in any way commercially exploit any UBS research provided via Global Research or otherwise, and that you shall not extract data from any research or estimates provided to you via Global Research or otherwise, without the prior written consent of UBS.

For access to all available Global Research on UBS Neo and the Client Portal, please contact your UBS sales representative.

This document is for distribution only as may be permitted by law. It is not directed to, or intended for distribution to or use by, any person or entity who is a citizen or resident of or located in any locality, state, country or other jurisdiction where such distribution, publication, availability or use would be contrary to law or regulation or would subject UBS to any registration or licensing requirement within such jurisdiction. It is published solely for information purposes; it is not an advertisement nor is it a solicitation or an offer to buy or sell any financial instruments or to participate in any particular trading strategy. No representation or warranty, either expressed or implied, is provided in relation to the accuracy, completeness or reliability of the information contained in this document ('the Information'), except with respect to Information concerning UBS. The Information is not intended to be a complete statement or summary of the securities, markets or developments referred to in the document. UBS does not undertake to update or keep current the Information. Any opinions expressed in this document may change without notice and may differ or be contrary to opinions expressed by other business areas or groups of UBS. Any statements contained in this report attributed to a third party represent UBS's interpretation of the data, information and/or opinions provided by that third party either publicly or through a subscription service, and such use and interpretation have not been reviewed by the third party.

Nothing in this document constitutes a representation that any investment strategy or recommendation is suitable or appropriate to an investor's individual circumstances or otherwise constitutes a personal recommendation. Investments involve risks, and investors should exercise prudence and their own judgement in making their investment decisions. The financial instruments described in the document may not be eligible for sale in all jurisdictions or to certain categories of investors. Options, derivative products and futures are not suitable for all investors, and trading in these instruments is considered risky. Mortgage and asset-backed securities may involve a high degree of risk and may be highly volatile in response to fluctuations in interest rates or other market conditions. Foreign currency rates of exchange may adversely affect the value, price or income of any security or related instrument referred to in the document. For investment advice, trade execution or other enquiries, clients should contact their local sales representative.

The value of any investment or income may go down as well as up, and investors may not get back the full (or any) amount invested. Past performance is not necessarily a guide to future performance. Neither UBS nor any of its directors, employees or agents accepts any liability for any loss (including investment loss) or damage arising out of the use of all or any of the Information.

Any prices stated in this document are for information purposes only and do not represent valuations for individual securities or other financial instruments. There is no representation that any transaction can or could have been effected at those prices, and any prices do not necessarily reflect UBS's internal books and records or theoretical model-based valuations and may be based on certain assumptions. Different assumptions by UBS or any other source may yield substantially different results.

This document and the Information are produced by UBS as part of its research function and are provided to you solely for general background information. UBS has no regard to the specific investment objectives, financial situation or particular needs of any specific recipient. In no circumstances may this document or any of the Information be used for any of the following purposes:

(i) valuation or accounting purposes;

(ii) to determine the amounts due or payable, the price or the value of any financial instrument or financial contract; or

(iii) to measure the performance of any financial instrument.

By receiving this document and the Information you will be deemed to represent and warrant to UBS that you will not use this document or any of the Information for any of the above purposes or otherwise rely upon this document or any of the Information.

Research will initiate, update and cease coverage solely at the discretion of UBS Investment Bank Research Management. The analysis contained in this document is based on numerous assumptions. Different assumptions could result in materially different results. The analyst(s) responsible for the preparation of this document may interact with trading desk personnel, sales personnel and other parties for the purpose of gathering, applying and interpreting market information. UBS relies on information barriers to control the flow of information contained in one or more areas within UBS into other areas, units, groups or affiliates of UBS. The compensation of the analyst who prepared this document is determined exclusively by research management and senior management (not including investment banking). Analyst compensation is not based on investment banking revenues; however, compensation may relate to the revenues of UBS Investment Bank as a whole, of which investment banking, sales and trading are a part.

For financial instruments admitted to trading on an EU regulated market: UBS AG, its affiliates or subsidiaries (excluding UBS Securities LLC) acts as a market maker or liquidity provider (in accordance with the interpretation of these terms in the UK) in the financial instruments of the issuer save that where the activity of liquidity provider is carried out in accordance with the definition given to it by the laws and regulations of any other EU jurisdictions, such information is separately disclosed in this document. For financial instruments admitted to trading on a non-EU regulated market: UBS may act as a market maker save that where this activity is carried out in the US in accordance with the definition given to it by the relevant laws and regulations, such activity will be specifically disclosed in this document. UBS may have issued a warrant the value of which is based on one or more of the financial instruments referred to in the document. UBS and its affiliates and employees may have long or short positions, trade as principal and buy and sell in instruments or derivatives identified herein; such transactions or positions may be inconsistent with the opinions expressed in this document.

Global Disclaimer (continued)

United Kingdom and the rest of Europe: Except as otherwise specified herein, this material is distributed by UBS Limited to persons who are eligible counterparties or professional clients. UBS Limited is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. **France:** Prepared by UBS Limited and distributed by UBS Limited and UBS Securities France S.A. UBS Securities France S.A. is regulated by the ACPR (Autorité de Contrôle Prudentiel et de Résolution) and the Autorité des Marchés Financiers (AMF). Where an analyst of UBS Securities France S.A. has contributed to this document, the document is also deemed to have been prepared by UBS Securities France S.A. **Germany:** Prepared by UBS Limited and distributed by UBS Limited and UBS Deutschland AG. UBS Deutschland AG is regulated by the Bundesanstalt fur Finanzdienstleistungsaufsicht (BaFin). **Spain:** Prepared by UBS Limited and distributed by UBS Limited and UBS Securities España SV, SA. UBS Securities España SV, SA is regulated by the Comisión Nacional del Mercado de Valores (CNMV). **Turkey:** Distributed by UBS Limited. No information in this document is provided for the purpose of offering, marketing and sale by any means of any capital market instruments and services in the Republic of Turkey. Therefore, this document may not be considered as an offer made or to be made to residents of the Republic of Turkey. UBS AG is not licensed by the Turkish Capital Market Board under the provisions of the Capital Market Law (Law No. 6362). Accordingly, neither this document nor any other offering material related to the instruments/services may be utilized in connection with providing any capital market services to persons within the Republic of Turkey without the prior approval of the Capital Market Board. However, according to article 15 (d) (ii) of the Decree No. 32, there is no restriction on the purchase or sale of the securities abroad by residents of the Republic of Turkey. **Poland:** Distributed by UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce regulated by the Polish Financial Supervision Authority. Where an analyst of UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce has contributed to this document, the document is also deemed to have been prepared by UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce. **Russia:** Prepared and distributed by UBS Bank (OOO). **Switzerland:** Distributed by UBS AG to persons who are institutional investors only. UBS AG is regulated by the Swiss Financial Market Supervisory Authority (FINMA). **Italy:** Prepared by UBS Limited and distributed by UBS Limited and UBS Italia Sim S.p.A. UBS Italia Sim S.p.A. is regulated by the Bank of Italy and by the Commissione Nazionale per le Società e la Borsa (CONSOB). Where an analyst of UBS Italia Sim S.p.A. has contributed to this document, the document is also deemed to have been prepared by UBS Italia Sim S.p.A. **South Africa:** Distributed by UBS South Africa (Pty) Limited (Registration No. 1995/011140/07), an authorised user of the JSE and an authorised Financial Services Provider (FSP 7328). **Israel:** This material is distributed by UBS Limited. UBS Limited is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. UBS Securities Israel Ltd is a licensed Investment Marketer that is supervised by the Israel Securities Authority (ISA). UBS Limited and its affiliates incorporated outside Israel are not licensed under the Israeli Advisory Law. UBS Limited is not covered by insurance as required from a licensee under the Israeli Advisory Law. UBS may engage among others in issuance of Financial Assets or in distribution of Financial Assets of other issuers for fees or other benefits. UBS Limited and its affiliates may prefer various Financial Assets to which they have or may have Affiliation (as such term is defined under the Israeli Advisory Law). Nothing in this Material should be considered as investment advice under the Israeli Advisory Law. This Material is being issued only to and/or is directed only at persons who are Eligible Clients within the meaning of the Israeli Advisory Law, and this material must not be relied on or acted upon by any other persons. **Saudi Arabia:** This document has been issued by UBS AG (and/or any of its subsidiaries, branches or affiliates), a public company limited by shares, incorporated in Switzerland with its registered offices at Aeschenvorstadt 1, CH-4051 Basel and Bahnhofstrasse 45, CH-8001 Zurich. This publication has been approved by UBS Saudi Arabia (a subsidiary of UBS AG), a Saudi closed joint stock company incorporated in the Kingdom of Saudi Arabia under commercial register number 1010257812 having its registered office at Tatweer Towers, P.O. Box 75724, Riyadh 11588, Kingdom of Saudi Arabia. UBS Saudi Arabia is authorized and regulated by the Capital Market Authority to conduct securities business under license number 08113-37. **Dubai:** The information distributed by UBS AG Dubai Branch is intended for Professional Clients only and is not for further distribution within the United Arab Emirates. **United States:** Distributed to US persons by either UBS Securities LLC or by UBS Financial Services Inc., subsidiaries of UBS AG; or by a group, subsidiary or affiliate of UBS AG that is not registered as a US broker-dealer (a **'non-US affiliate'**) to major US institutional investors only. UBS Securities LLC or UBS Financial Services Inc. accepts responsibility for the content of a document prepared by another non-US affiliate when distributed to US persons by UBS Securities LLC or UBS Financial Services Inc. All transactions by a US person in the securities mentioned in this document must be effected through UBS Securities LLC or UBS Financial Services Inc., and not through a non-US affiliate. UBS Securities LLC is not acting as a municipal advisor to any municipal entity or obligated person within the meaning of Section 15B of the Securities Exchange Act (the "Municipal Advisor Rule"), and the opinions or views contained herein are not intended to be, and do not constitute, advice within the meaning of the Municipal Advisor Rule. **Canada:** Distributed by UBS Securities Canada Inc., a registered investment dealer in Canada and a Member-Canadian Investor Protection Fund, or by another affiliate of UBS AG that is registered to conduct business in Canada or is otherwise exempt from registration. **Brazil:** Except as otherwise specified herein, this material is prepared by UBS Brasil CCTVM S.A. to persons who are eligible investors residing in Brazil, which are considered to be: (i) financial institutions, (ii) insurance firms and investment capital companies, (iii) supplementary pension entities, (iv) entities that hold financial investments higher than R$300,000.00 and that confirm the status of qualified investors in written, (v) investment funds, (vi) securities portfolio managers and securities consultants duly authorized by Comissão de Valores Mobiliários (CVM), regarding their own investments, and (vii) social security systems created by the Federal Government, States, and Municipalities. **Hong Kong:** Distributed by UBS Securities Asia Limited and/or UBS AG, Hong Kong Branch. **Singapore:** Distributed by UBS Securities Pte. Ltd. [MCI (P) 018/09/2015 and Co. Reg. No.: 198500648C] or UBS AG, Singapore Branch. Please contact UBS Securities Pte. Ltd., an exempt financial adviser under the Singapore Financial Advisers Act (Cap. 110); or UBS AG, Singapore Branch, an exempt financial adviser under the Singapore Financial Advisers Act (Cap. 110) and a wholesale bank licensed under the Singapore Banking Act (Cap. 19) regulated by the Monetary Authority of Singapore, in respect of any matters arising from, or in connection with, the analysis or document. The recipients of this document represent and warrant that they are accredited and institutional investors as defined in the Securities and Futures Act (Cap. 289). **Japan:** Distributed by UBS Securities Japan Co., Ltd. to professional investors (except as otherwise permitted). Where this document has been prepared by UBS Securities Japan Co., Ltd., UBS Securities Japan Co., Ltd. is the author, publisher and distributor of the document. Distributed by UBS AG, Tokyo Branch to Professional Investors (except as otherwise permitted) in relation to foreign exchange and other banking businesses when relevant. **Australia:** Clients of UBS AG: Distributed by UBS AG (Holder of Australian Financial Services License No. 231087). Clients of UBS Securities Australia Ltd: Distributed by UBS Securities Australia Ltd (Holder of Australian Financial Services License No. 231098). Clients of UBS Wealth Management Australia Ltd: Distributed by UBS Wealth Management Australia Ltd (Holder of Australian Financial Services Licence No. 231127). This Document contains general information and/or general advice only and does not constitute personal financial product advice. As such, the Information in this document has been prepared without taking into account any investor's objectives, financial situation or needs, and investors should, before acting on the Information, consider the appropriateness of the Information, having regard to their objectives, financial situation and needs. If the Information contained in this document relates to the acquisition, or potential acquisition of a particular financial product by a 'Retail' client as defined by section 761G of the Corporations Act 2001 where a Product Disclosure Statement would be required, the retail client should obtain and consider the Product Disclosure Statement relating to the product before making any decision about whether to acquire the product. The UBS Securities Australia Limited Financial Services Guide is available at: www.ubs.com/ecs-research-fsg. **New Zealand:** Distributed by UBS New Zealand Ltd. The information and recommendations in this publication are provided for general information purposes only. To the extent that any such information or recommendations constitute financial advice, they do not take into account any person's particular financial situation or goals. We recommend that recipients seek advice specific to their circumstances from their financial advisor. **Korea:** Distributed in Korea by UBS Securities Pte. Ltd., Seoul Branch. This document may have been edited or contributed to from time to time by affiliates of UBS Securities Pte. Ltd., Seoul Branch. **Malaysia:** This material is authorized to be distributed in Malaysia by UBS Securities Malaysia Sdn. Bhd (Capital Markets Services License No.: CMSL/A0063/2007). This material is intended for professional/institutional clients only and not for distribution to any retail clients. **India:** Prepared by UBS Securities India Private Ltd. (Corporate Identity Number U67120MH1996PTC097299) 2/F, 2 North Avenue, Maker Maxity, Bandra Kurla Complex, Bandra (East), Mumbai (India) 400051. Phone: +912261556000. It provides brokerage services bearing SEBI Registration Numbers: NSE (Capital Market Segment): INB230951431, NSE (F&O Segment) INF230951431, NSE (Currency Derivatives Segment) INE230951431, BSE (Capital Market Segment) INB010951437; merchant banking services bearing SEBI Registration Number: INM000010809 and Research Analyst services bearing SEBI Registration Number: INH000001204. UBS AG, its affiliates or subsidiaries may have debt holdings or positions in the subject Indian company/companies. Within the past 12 months, UBS AG, its affiliates or subsidiaries may have received compensation for non-investment banking securities-related services and/or non-securities services from the subject Indian company/companies. The subject company/companies may have been a client/clients of UBS AG, its affiliates or subsidiaries during the 12 months preceding the date of distribution of the research report with respect to investment banking and/or non-investment banking securities-related services and/or non-securities services. With regard to information on associates, please refer to the Annual Report at: http://www.ubs.com/global/en/about_ubs/investor_relations/annualreporting.html

The disclosures contained in research documents produced by UBS Limited shall be governed by and construed in accordance with English law.

Contact Information

UBS Limited
1 Finsbury Avenue
London

Tel: +44-207-567 8000

www.ubs.com