# Academic Research Monitor
## Quality, Low-Risk and Momentum Investing

**Equities**

Global
Quantitative

**Nick Baltas, PhD**
Analyst
nick.baltas@ubs.com
+44-20-7568 3072

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

**Claire Jones, CFA**
Analyst
claire-c.jones@ubs.com
+44-20-7568 1873

**Josie Gerken, PhD**
Analyst
josephine.gerken@ubs.com
+44-20-7568 3560

**Desi Ivanova**
Associate Analyst
desi-r.ivanova@ubs.com
+44-20-7568 0000

Paul Winter
Analyst
paul-j.winter@ubs.com
+61-2-9324 2080

Josh Holcroft
Analyst
josh.holcroft@ubs.com
+852-2971 7705

Shanle Wu, PhD
Analyst
shanle.wu@ubs.com
+852-2971 7513

Oliver Antrobus, CFA
Analyst
oliver.antrobus@ubs.com
+61-3-9242 6467

Pieter Stoltz
Analyst
pieter.stoltz@ubs.com
+61-2-9324 3779

**Latest academic advances on factor investing**

What is driving the high returns of high momentum, high quality and low beta stocks? Is it rational risk, irrational behaviour or mispricing? We track the latest academic advances on factor investing and provide insight on these questions.

**Momentum as compensation for downside risk**

Winner stocks tend to exhibit higher downside betas and lower upside betas than loser stocks, the first paper that we review suggests. This constitutes evidence that momentum returns represent compensation for bearing downside risk and appears to be in line with recent analyses on the nature of momentum crashes.

**Has momentum stopped working? We think not.**

The second paper that we review conducts a sub-sample analysis on momentum profitability in the US between 1965 and 2012 and finds that it has been significantly reduced in the most recent period 1999-2012, even if one excludes the March 2009 crash. The result has been rather intriguing and we therefore provide back-test results across several global regions (North America, UK, Europe ex. UK, Japan, Asia ex. Japan). In sharp contrast to the findings of the paper, we do not find evidence of momentum's relative underperformance in the most recent sub-period across any of the regions that we tested. We attribute the disagreement in the results in the construction of the momentum signal; we use the common (12, 1, 1) methodology: 12-month momentum signal, 1-month gap, 1-month holding, as opposed to the (6, 0, 6) used in the paper.

**High quality is behavioural; Low-risk is due to model misspecification for betas**

The last two papers that we review explore the profitability of high-quality and low-risk investing. Regarding quality, the first paper claims that research analysts typically make significantly larger forecast mistakes and are more optimistic about low quality firms. As for low-risk, the second paper argues that it is non-linearities in stock returns that are not accounted for by CAPM; in other words, the risk of low-beta stocks is not correctly estimated using just the linear CAPM beta.

# Introduction

In this issue of our Academic Research Monitor we return to the topic of factor investing which we have discussed in several earlier editions of the ARM:

**Latest academic advances on…**

- Momentum Investing (January 2015)
- Quality and Size Investing (May 2015)
- Value Investing (December 2015)
- Low-Risk Investing (January 2016)
- Factor Combination (September 2016)

For this issue we focus on a number of papers around momentum, and quality (and low risk) investing (see Figure 1).

- **Momentum**

The first paper shows that momentum can be explained by breaking the market beta into upside and downside betas – momentum stocks have a higher downside and lower upside beta. The second momentum paper argues that momentum has in fact stopped "working" in the most recent period (1999-2012). Intrigued by the findings, we provide back-tests across global regions and find contradicting results, which we attribute to methodological differences.

- **Quality / Low-risk**

The other two papers introduce new explanations for the quality and low risk (betting against beta) anomalies. Behavioural effects and beta mis-estimation are put forward as potential explanations of these patterns.

**Figure 1: Papers on factor investing**

| | |
|---|---|
| "Upside and Downside Risks in Momentum Returns"<br>*Victoria Dobrynskaya* | SSRN working paper, November 2015 |
| "Has Momentum Lost Its Momentum?"<br>*Debarati Bhattacharya, Wei-Hsien Li and Gokhan Sonaer* | *Review of Quantitative Finance & Accounting, 2015* |
| "The Excess Returns of 'Quality' Stocks: A Behavioral Anomaly"<br>*Jean-Philippe Bouchaud, Ciliberti Stefano, Augustin Landier, Guillaume Simon and David Thesmar* | SSRN working paper, February 2016 |
| "The Betting Against Beta Anomaly: Fact or Fiction?"<br>*Axel Buchner and Niklas Wagner* | SSRN working paper, December 2015 |

Source: UBS.

## "Upside and Downside Risks in Momentum Returns"

### by Victoria Dobrynskaya

**CAPM cannot explain the price momentum anomaly**

Building on the work by Jegadeesh and Titman (1993), Victoria Dobrynskaya shows that the returns to price momentum strategies cannot be well explained by the traditional CAPM model - past winner portfolios typically have a lower beta than past loser portfolios, but also higher returns, which contradicts CAPM.

In order to correct for this, the author looks at the downside and upside betas separately. The author examines two regressions, the traditional CAPM model and an upside/downside model:

(1) Traditional CAPM: $r_{i,t} = \alpha_i + \beta_i \cdot r_{mkt,t} + \varepsilon_{i,t}$

(2) $r_{i,t} = \alpha_i + \beta_i^- \cdot r_{mkt,t} + \gamma_i . r_{mkt,t} \cdot I_{\{r_{mkt,t}>0\}} + \varepsilon_{i,t}$

**Consider upside and downside risk separately**

Combining the betas from these two regressions allows us to define the relative upside and downside betas:

Upside Beta, $\beta_i^+ = \beta_i^- + \gamma_i$

Relative Downside Beta, $\beta_i^- - \beta_i$

Relative Upside Beta, $\beta_i^+ - \beta_i$

Dividing the betas into upside and downside betas seems intuitive. Investors are not typically very concerned about upside risk (unexpected gains are usually welcome, even though they may increase tracking errors) but dislike downside risk and require compensation for holding stocks with exposure to downside risk. The relative downside beta, rather than the more typically seen downside beta, measures the additional market risk on the downside after taking the overall market risk into account. This definition makes it easier to see what is driving the returns.

**A broad universe of momentum portfolios are studied**

For her empirical analysis, the author defines price momentum as the return from 12 months ago to 1 month ago, and looks at the return over the following month. The paper discusses a very wide range of universes / strategies based on this price momentum signal, including:

i) US price momentum decile portfolios from 1927-2013, from the Kenneth French's data library;

ii) Price momentum quintile portfolios built in five regions (global, Europe, Asia Pacific, Japan and North America) from 1990-2013;

iii) Double sort global portfolios based on size and price momentum (e.g. small-cap loser stocks) from the Kenneth French's data library;

iv) Portfolios of country indices based upon the momentum of their country returns;

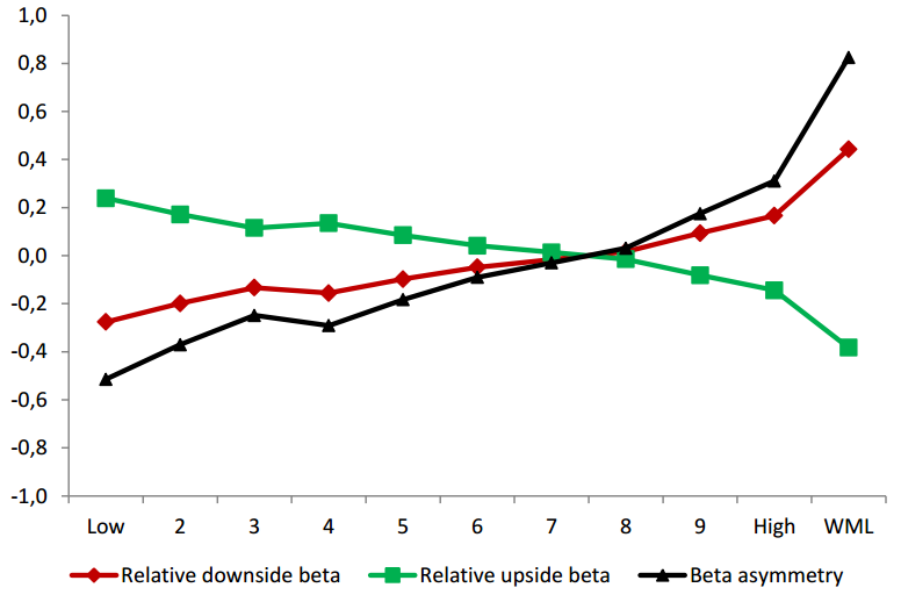
v) Currency momentum portfolios, based on a universe of 45 currencies, 1984-2013.

The conclusions in each case are very similar, so we will not give the full breakdown of results here.

There are several key results. Firstly, there is a strong pattern in the relative downside betas and relative upside betas, with past winner portfolios having higher downside risk and lower upside risk than loser portfolios; see Figure 2 for the ten decile momentum portfolios in the US. This result is statistically significant. What is more, in several of the universes that the author considers, this pattern is monotonic across the decile portfolios.

**Past winners have higher relative downside risk than past losers**

**Figure 2: Relative upside and downside risks of US momentum portfolios**




Source: "*Upside and Downside Risks in Momentum Returns*" by V. Dobrynskaya; Figure 1, reproduced with permission. The figure shows the OLS estimates of relative downside and upside betas and beta asymmetry ($\beta^- - \beta^+$) of 10 US value-weighted momentum portfolios, and the winner-minus-loser (WML) portfolio. Sample period: January 1927 - July 2013.

Secondly, while the CAPM relationship does not explain the cross-sectional returns of the momentum portfolios very well, a regression which includes the relative downside risk can explain the returns pretty effectively:

**Relative downside risk is a priced factor in the cross-section of momentum portfolio returns**

$$r_i - r_f = \beta_i \lambda + (\beta_i^- - \beta_i)\lambda^- + \mu + \varepsilon_i,$$

where, $\lambda$ is the traditional beta premium and $\lambda^-$is the additional downside beta premium. This additional downside beta premium is found to be statistically significant across a number of different estimation methodologies used by the author.

This finding constitutes evidence that investors who buy price momentum are more exposed to downside risk, and less to upside risk. Along these lines, the positive momentum return can be explained as compensation for bearing downside risk.

**Momentum constitutes compensation for bearing downside risk**

To conclude, the evidence in this paper and the proposed explanation for momentum profits appears to be in line with recent analyses of momentum crashes; see Barroso and Santa-Clara (2015), Daniel and Moskowitz (2016) – these two papers were reviewed in our July 2013 ARM, available here – and Chabot, Ghysels and Jagannathan (2014) – this has been reviewed in our January 2015 ARM, available here.

**Last word – Momentum crashes**

## "Has Momentum Lost its Momentum?"

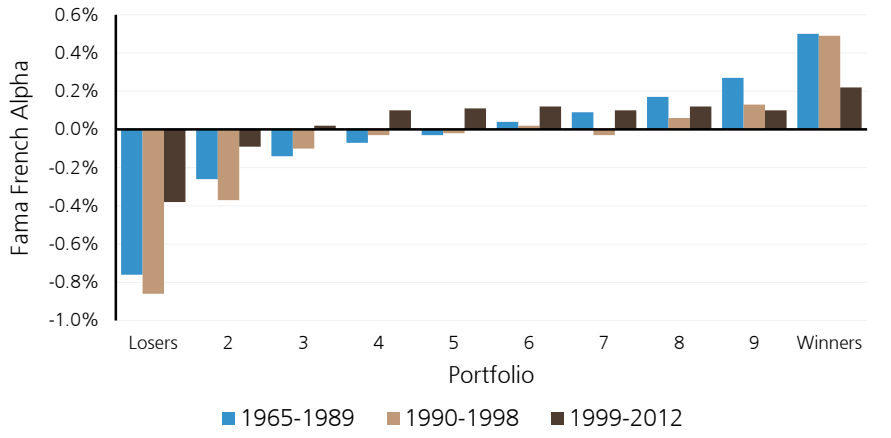
### by Debarati Bhattacharya, Wei-Hsien Li and Gokhan Sonaer

Debarati Bhattacharya, Wei-Hsien Li and Gokhan Sonaer claim that price momentum is no longer generating significant alpha. In order to test this claim, they compare the performance of price momentum over three sub-periods: 1965-1989, 1990-1998 and 1999-2012. They consider a variety of different price momentum strategies, but focus on the (6,0,6) strategy i.e. they rank stocks based on their return over the previous 6 months, create equal weighted decile portfolios and rebalance every six months. Unlike other commonly used methodologies, the authors did not include a lag in their definition of price momentum.[1]

In the first two sub-periods, they find that the winner portfolios exhibit significant and positive Fama and French (1993) alphas and the loser portfolios exhibit significant and negative alphas. In contrast, over the period from 1999-2012, the alphas of the winner and loser portfolios are not significantly different from zero (see Figure 3). This strongly suggests that the momentum strategy has stopped being profitable. Re-running this analysis, but excluding the period from 2007-2009, which includes the disastrous March '09 momentum crash, does not change this result.

**Figure 3: Fama French Alphas for momentum in three sub-periods**

**Fama-French alphas for price momentum are not significant in the most recent sub-period**




Source: UBS Quantitative Research. The chart is created using data from Table 2 in "*Has Momentum Lost Its Momentum?*" by D. Bhattacharya, W.-H. Li and G. Sonaer,

Previous work by Daniel and Moskowitz (2016) and by Cooper, Gutierrez and Hameed (2004) suggest that momentum performs better during periods of low market volatility and in rising markets, so the authors of the current paper test if the recent poor performance of momentum is due to the higher volatility and market drawdowns seen in their third sub-period from 1999 to 2012.

**It's not because market volatility is higher now**

They divide the months from 1986 to 2012 into high and low volatility depending on whether they are above or below the overall median volatility over the whole period (we must note that this introduces a forward-looking bias in the analysis). Momentum is profitable in the period from 1986 to 1998 regardless of whether the volatility is low or high, but does not generate significant profits for the period from 1999 to 2012, even during months when volatility is classified as low.

[1] In some regions this may bias down the recent performance of price momentum. We provide some empirical insight on this in the following pages.

**It's not because we have seen more down-market periods recently**

The authors also try dividing the months into "up-market" or "down-market" months based on the performance of the market over the previous three years. In the 1965-1989 sub-period the long-short momentum portfolios (buy winners, sell losers) seem to gain significant returns in up markets but not down markets. During 1990-1998 there are no down market months to test. In contrast, in the period from 1999-2012, momentum does not perform any differently in up or down markets - returns are not significant in either case.

**Why has momentum stopped working?**

It appears that the poor performance of the momentum strategy is not due to volatility or poor market performance. For that reason, the authors put forward three potential explanations for the decline in the performance of momentum strategies:

**i) The momentum anomaly is now well known and hence is arbitraged away.**

Price momentum has been widely documented and many investors now follow these strategies. If the strategy is being arbitraged away, we should expect to see investors buying winners and selling losers earlier and earlier, which will exaggerate the returns to momentum stocks during the identification period, and hence lower returns to the strategy in the holding period.

The authors do find some evidence to support this idea. It seems that, in the most recent sub-period, winner stocks have been performing better during the identification period (suggesting investors are buying up winners earlier and driving prices up) and have not had significant positive returns during the holding period (suggesting the anomaly has been arbitraged away).

**ii) Industrial production (IP) growth is no longer a priced risk premium, and the performance of momentum has been highly related to IP growth**

Liu and Zhang's (2008) paper shows that macro factors, including industrial production (IP, henceforth) growth, explain roughly one half of momentum profits, however, in the most recent sub-period the IP growth has ceased to be priced.

Regressing monthly returns to winner-loser portfolios on the three Fama-French factors and the growth rate of IP, the authors find that, while in the two earlier sub-periods the exposure to IP growth was significant and positive, it is not significantly different from zero in the period from 1999 to 2012.

**iii) Markets have become more efficient**

To measure market efficiency the authors consider the DELAY statistic, discussed in Griffin, Kelly and Nardari (2010). This is a measure of how much information about stock (or portfolio) returns comes from lagged market returns. It is defined as the difference in the R-squared of the weekly returns regressed on weekly market returns lagged by 0, 1, 2, 3 or 4 weeks and the R-squared of the weekly returns regressed on just the current weekly market returns.

The authors of the current paper examine the average DELAY for the five size quintile portfolios in the three sub-periods. The average DELAY is much lower in the sub-period 1999-2012 compared to the two earlier sub-periods for all but the largest size portfolio. This suggests that market efficiency has increased.

**Last word**

The main result of the paper is quite intriguing; has momentum really gone away? We provide our view using a series of back-tests across various regions in the following pages.

## Our replication

As always, we have attempted to make our replication close to industry practice, which leads to some differences to the method in the paper.

The first difference is the universe. Bhattacharya et al use CRSP data, but we focus just on the Dow Jones universe, which is much narrower, and look at several different regions within that universe.

**12 month price momentum signal, lagged by a month**

The second difference is our choice of price momentum signal. The authors considered a variety of price momentum signals, but did not use a 1-month lag in their signals, which is commonly used by practitioners to avoid the well documented short term price reversal anomaly. In our analysis, we have focussed on the (12,1,1) price momentum strategy, which is one of the most popular momentum strategies  This strategy involves buying the best performing stocks from 13 months ago to 1 month ago, and holding the portfolio for 1 month.

Also, due to data constraints, our analysis begins in February 1992, so that our two sub-periods are 1992-1998 and 1999-Sep 2016.

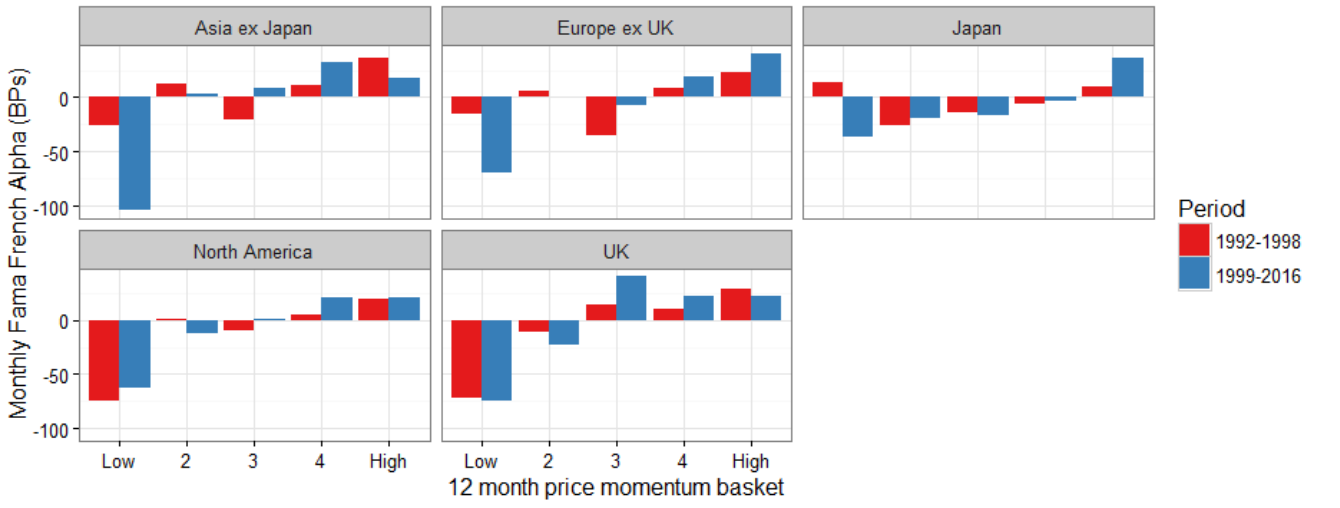
**Market cap weighted quintile portfolios**

At each month-end, for each region, we divide the universe into quintiles by our price momentum signal and market cap weight these stocks to form five portfolios. We rebalance the portfolios monthly.

We also create two long-short (top versus bottom quintile) portfolios for size, long small-cap and short large-cap ("SMB"), and for book to price, long high book to price and short low book to price ("HML").

Using the time series of monthly returns to these portfolios we run regional versions of the Fama-French model in order to estimate the respective alphas. Figure 4 shows our estimates of the alphas to each quintile portfolio in each region and time period. Figure 5 provides the numerical values.

**Figure 4: Fama French alphas for price momentum in different regions and time periods**




Source: UBS Quantitative Research

**Figure 5: Fama-French alphas for high and low price momentum portfolios**

| | | Fama French Alpha (BPs) | |
|---|---|---|---|
| | | 1992-1998 | 1999-2016 |
| Asia ex Japan | Low | -25.6 | -104.1 ** |
| | High | 36.8 | 17.9 |
| Japan | Low | 13.8 | -36.6 |
| | High | 10.3 | 36.4 * |
| North America | Low | -74.4 ** | -63.0 ** |
| | High | 20.0 | 20.5 |
| Europe ex UK | Low | -15.0 | -70.0 ** |
| | High | 23.0 | 40.3 ** |
| UK | Low | -71.8 ** | -74.0 ** |
| | High | 28.9 | 22.6 |

Source: UBS Quantitative Research, "*" indicates that a result is significant at the 10% level and "**" indicates that a result is significant at the 5% level.

In sharp contrast to the authors, we do not see any significant decline in the Fama French alphas of the price momentum strategies between the two sub-periods in any of the regions, although they were not always significant.

**We do not see a decline in the price momentum Fama French alphas**

## "The Excess Returns of 'Quality' Stocks: A Behavioral Anomaly"

### by Jean-Philippe Bouchaud, Ciliberti Stefano, Augustin Landier, Guillaume Simon and David Thesmar

**Anomaly versus risk**

The question of whether an "anomaly" has a behavioural or risk-based (i.e. rational) explanation (or, as we will see in the next paper, is a problem of the underlying model being misspecified) is a continuing discussion for all the anomalies in the literature. This paper by Jean-Philippe Bouchaud, Ciliberti Stefano, Augustin Landier, Guillaume Simon and David Thesmar contributes to the debate for the quality anomaly and comes down on the side of it having a behavioural justification.

**Quality is positively skewed and unlikely to crash, and so cannot be justified as a risk premium**

The authors first attempt to reject the risk-based explanation for quality. Their main definition of quality is Operating Cash-Flows to Total Assets, but in their first section they also consider Return on Assets (EBIT / Total Assets) and Return on Equity (Net Income / Common Equity). They show that all three of these quality strategies in the US[2] have a positive (if small) skewness and a very low probability of having a return below minus two standard deviations, which they use as a measure of the likelihood of a crash; see Figure 6. Interestingly, when they construct a low volatility long-short portfolio, they find that it exhibits negative skewness. They argue that, taken together, these two facts (positive skewness for quality portfolios, negative skewness for the low-volatility portfolio) "*make the risk premium interpretation [of quality's outperformance] very unlikely*".

**Figure 6: Risk return profile of eight long-short strategies**

| | Sharpe Ratio | β | β- | Skewness | $P(r_t < -2\sigma)$ |
|---|---|---|---|---|---|
| Market - short rate | 0.47 | 1 | 1 | -0.130 | 0.031 |
| Low volatility | 0.43 | -0.015 | 0.000 | -0.060 | 0.032 |
| Book to market | 0.20 | 0.029 | 0.110 | 0.035 | 0.025 |
| Repurchases | 0.55 | 0.010 | 0.040 | -0.053 | 0.019 |
| Momentum | 0.43 | -0.410 | -0.100 | -0.007 | 0.025 |
| Industry Leaders | 0.48 | -0.160 | -0.140 | 0.008 | 0.029 |
| Accruals | 0.77 | 0.140 | -0.027 | 0.027 | 0.018 |
| ROE | 0.55 | -0.025 | -0.033 | 0.021 | 0.010 |
| Cash-Flows | 1.20 | -0.016 | -0.055 | 0.060 | 0.021 |
| ROA | 0.46 | -0.025 | -0.054 | 0.080 | 0.010 |

Source: "*The excess returns of "quality" stocks: a behavioural anomaly*" by J.-P. Bouchaud, C. Stefano, A. Landier, G. Simon and D. Thesmar; part of Table 1, reproduced with permission. The table reports the Sharpe Ratio, market beta, beta on negative market months, a measure of skewness (mean – median divided by standard deviation), and the frequency of months with returns lower than two standard deviations.

**Analysts neglect the information in quality**

The authors then contend that "*a more plausible interpretation*" is that investors "*systematically underweight the information contained in quality-like signals*". Or to put in another way, investors are focussing too much on other indicators such as EPS, momentum, volatility etc. To test this thesis they regress the errors in analyst return targets (price target / current price) on cash-flows over assets and find that the intercept is positive (i.e. analysts are optimistic on average), but the

[2] Their long-short portfolios are built from the largest 1,500 stocks in CRSP over 1990-2012. They rank the signal from -0.5 to +0.5 which becomes the portfolio weight. This is then hedged by shorting the market using the rolling beta from the preceding 24 months.

slope is negative. In the authors' words, "*analysts, at best, neglect the information contained in cash-flow statement – or even weight it with the wrong sign*".

In more detail, the authors use the IBES data over the period 2003-2012 and calculate the average analyst price target, $FP_{t+12}$ each month and estimate the forecast return as $FR_{t+12} = FP_{t+12}/P_t - 1$. From this they calculate the expectation mistake:

$$mistake = FR_{t+12} - R_{t+12}$$

where $R_{t+12}$ is the realised return. The average mistake over the entire sample is +8% (with a median of +6%), i.e. analysts are on average optimistic.

They then run the following regression:

$$mistake_{i,t} = \beta \cdot Quality_{i,t} + controls_{i,t} + \epsilon_{i,t}$$

where the controls include various firm characteristics and a time fixed effect.

**Analysts make significantly larger forecast mistakes about low-quality firms**

Using Operating Cash-Flows to Total Assets as their definition of quality (the results remain robust to using ROA or ROE instead), the authors find that the beta in the above regression is significantly negative (with or without controls). This effectively means that analysts make significantly larger forecast mistakes about low quality firms; put differently, analysts are on average more optimistic about low quality firms.

In two further regressions the authors replace the left hand side of the above regression with either the forecast return $FR_{t+12}$ or the realised return $R_{t+12}$. In the first case the beta is negative but only significant without the controls; in the second case, it is significantly positive even when volatility is included as a control variable. This latter result shows that quality is a predictor of future returns.

The authors conclude that "*the quality anomaly arises from non-optimal weighting of profitability information by analysts*". We would tend to agree with this interpretation. Much of an analyst's training is focused on how to value a company; and as such they focus their attention on whether a stock is trading below "fair value". Our most recent analysis of quality is available in *Investing in Quality* (April 2014) and *Extending our Quality Models to Financials* (March 2015). We have also touched on quality investing in two previous Academic Research Monitors (February 2014, available here and May 2015, available here).

## "The Betting Against Beta Anomaly: Fact or Fiction?"

### by Axel Buchner and Niklas Wagner

Following on from the previous paper on the explanation for quality, this recent paper by Axel Buchner and Niklas Wagner puts forward a new theoretical reason for the low risk or "betting against beta" anomaly.

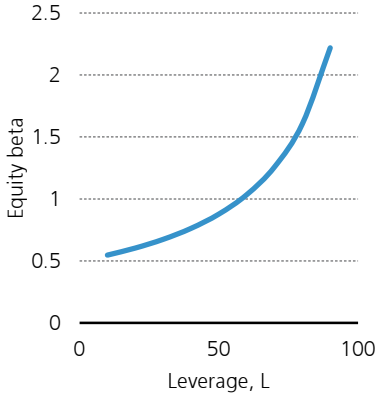
The low risk anomaly has attracted a large number of explanations from academia; for a summery see our recent quant monographs *Do low-volatility stocks have interest-rate risk?* (September 2016) and *Low-Risk Investing: perhaps not everywhere* (July 2015). We have also touched on low-risk investing in two previous Academic Research Monitors (December 2013, available here and February 2016, available here).

In the current paper the authors add to the list of potential explanations and propose that this anomaly is "*due to pricing errors, which arise given that the CAPM does not take non-linearities in stock returns into account*".

The basis for their argument goes back to the Black-Scholes-Merton model which argues that the equity of a firm is a call option written on the value of firm's assets. This means that the returns to equities are non-linear – especially for firms which are highly leveraged. Hence a linear CAPM type regression may suffer from model misspecification. They admit that this observation by itself is not a new one.[3]

The paper then goes into a theoretical derivation of the instantaneous beta of the equity as a function of the beta of the underlying firm. This shows that the beta increases as leverage increases, and falls as the value of the firm increases. Figure 7 gives an example of how the beta changes with the amount of borrowings a firm has. Given that the value of the firm's assets changes stochastically, the beta itself follows a stochastic process.

**Figure 7: Beta against leverage**




Source: UBS Quantitative Research. The chart shows the theoretical equity beta for a company with assets of 100 and borrowings of L with a three year time to maturity. Risk free rates are 5%. The beta of the firm is 0.5 and the volatility of the assets is 20%.

After showing how the beta is time varying the authors then assume that the equity is correctly priced under this model and investigate the errors (i.e. the alphas) in an OLS based CAPM regression. They show that the alpha from the OLS regression, $\alpha_{OLS}$, can be approximated as

$$\alpha_{OLS} \approx Cov(\beta_t, R_{Mkt,t})$$

i.e. the covariance of the stock's beta with the returns to the market.

Although this expression cannot be solved analytically, it can be estimated via a Monte-Carlo simulation.

Their results show that firstly the CAPM pricing errors are always negative. This negative sign implies that betas and market returns are negatively correlated[4]: as the market rises the value of the assets is likely to rise, the leverage will fall and hence the beta is likely to fall.

Secondly, the errors become more negative as the leverage of the firm increases, and importantly become more negative as the beta increases: high beta names

[3] Schneider, Wagner and Zechner (2016) present similar arguments. See our review of their paper in our April 2016 ARM.
[4] See the paper for the details of the simulation, but we note that they set the correlation of the firm value with the market to 0.5.

have a negative alpha. In their simulations the magnitude of the alphas is comparable to those from Frazzini and Pedersen (2014).

**Our view – identifying a caveat in the research methodology**

There is, in our opinion, a weakness in the paper. Their model (and simulation) is based on a market return and the return to the assets of the firm. These returns, plus the assumed leverage of the firm, allow them to calculate the beta of the equity to their market return. There is a problem with this structure as they assume the value of the assets of the firm is linearly related to the market. This implies that the market is actually a weighted average of asset returns rather than equity returns.

However, in practice, we do not calculate betas against a "total asset" market but, instead, against an equity market. This suggests to us that a better simulation would be to repeat their analysis in simulating the value of an equity, but repeat this a number of times to create a set of equities all of which are non-linear which could be combined to create an equity index. One should then calculate the OLS betas against this equity index rather than against the "total asset" market as used in the paper. We wonder whether one would obtain the same results as reported in the paper with this set up.

# References


Barroso, P., & Santa-Clara, P. (2015). Momentum has its moments. *Journal of Financial Economics, 116*(1), 111-120.

Bhattacharya, D., W-H. Li and G. Sonaer, (2015). Has Momentum Lost Its Momentum? *Review of Quantitative Finance and Accounting, Forthcoming*. *Available at SSRN:* 2791138.

Bouchaud, J-P., C. Stefano, A. Landier, G. Simon and D. Thesmar (2016). The Excess Returns of 'Quality' Stocks: A Behavioral Anomaly. *Available at SSRN:* 2717447.

Buchner, A. and N. Wagner, (2015). The Betting Against Beta Anomaly: Fact or Fiction? *Available at SSRN:* 2703752.

Chabot, B. R., Ghysels, E., & Jagannathan, R. (2014). Momentum Trading, Return Chasing and Predictable Crashes. *Available at SSRN:* 2539800.

Cooper, M. J., Gutierrez, R. C., & Hameed, A. (2004). Market states and momentum. *Journal of Finance, 59*(3), 1345-1365.

Daniel, K. D., & Moskowitz, T. J. (2016). Momentum Crashes. *Journal of Financial Economics, forthcoming*.

Dobrynskaya, V., (2015) Upside and Downside Risks in Momentum Returns. *Available at SSRN:* 2695001.

Fama, E. F., & French, K. R. (1993). Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics, 33*(1), 3-56.

Frazzini, A. and L. H. Pedersen (2014). Betting against beta. *Journal of Financial Economics, 111*(1), 1-25.

Griffin, J. M., Kelly, P. J., & Nardari, F. (2010). Do market efficiency measures yield correct inferences? A comparison of developed and emerging markets. *Review of Financial Studies, 23*(8), 3225-3277.

Jegadeesh, N., & Titman, S. (1993). Returns to buying winners and selling losers: Implications for stock market efficiency. *Journal of Finance, 48*(1), 65-91.

Liu, L. X., & Zhang, L. (2008). Momentum profits, factor pricing, and macroeconomic risk. *Review of Financial Studies, 21*(6), 2417-2448.

Schneider, P., Wagner, C., & Zechner, J. (2016). Low Risk Anomalies?. *Available at SSRN*: 2593519.

## UBS Equity Quantitative Research publications

### Monographs, Keys and Q-Series

| Title | Date |
|---|---|
| Systematic Strategies for Single-Stock Futures | Oct-16 |
| Irrational asset management | Oct-16 |
| China domestic market – alpha for quantitative investors | Oct-16 |
| Are you already timing styles successfully? | Sep-16 |
| Do low-volatility stocks have interest-rate risk? | Sep-16 |
| What does splitting the financials sector change? | Aug-16 |
| Harvesting Yield from Cross-Asset Carry | Aug-16 |
| When is the stock market likely to correct? | Aug-16 |
| Is it easier to be a quant in small cap? | Aug-16 |
| Follow the smart money | Jul-16 |
| How can supply chains improve earnings visibility? | Jul-16 |
| Where are the attractive dividend paying stocks? | Mar-16 |
| Why does increasing volatility matter? | Feb-16 |
| What crowded positions are bubbling up in equity markets | Feb-16 |
| What happened to Value, and when will it return? | Jan-16 |
| Who benefits from automation? | Nov-15 |
| The Spectre of Equity-Bond allocation | Nov-15 |
| Dynamic Asset Allocation | Nov-15 |
| How will demographics shape investing for the next ten years? | Nov-15 |
| Surfing the macro wave | Sep-15 |
| Why blame Risk-parity and CTAs? | Sep-15 |
| Bonds are better: asset allocation in target dated funds | Sep-15 |
| Low-Risk Investing: perhaps not everywhere | Jul-15 |
| Cost efficient trading with time varying alphas | Jul-15 |
| The Madness of Crowds | Jul-15 |
| Lessons from Behavioural Finance | Jul-15 |
| Understanding Size Investing | Jun-15 |
| Safe Dividends in Times of Financial Repression | Jun-15 |

### Academic Research Monitor

| Topic | Date |
|---|---|
| Combining Smart Beta Factors | Sep-16 |
| Portfolio Construction and Overfitting | Jul-16 |
| UBS Equity Markets Conference | May-16 |
| European Quantitative Conference 2015 Highlights | Apr-16 |
| Does Oil matter for Equity Markets? | Mar-16 |
| Low Risk Investing | Feb-16 |
| Value Investing | Dec-15 |
| Analyst Forecasts and Measuring Distance | Nov-15 |
| UBS Market Microstructure Conference | Oct-15 |
| Equity Risk Premium Forecasting and Market Timing | Sep-15 |
| Behavioural Investing Patterns | Jul-15 |
| Quality and Size Investing | May-15 |
| European Quantitative Conference 2015 Highlights | Apr-15 |
| Smart Beta, Factors and Style Investing | Feb-15 |
| Momentum-Investing | Jan-15 |
| Investment Strategies & Textual Analysis Signals | Dec-14 |
| Commodity Risk & Institutional Investing Habits | Nov-14 |
| Index Membership, Investor (in)attention to News & Spurious Correlations | Sep-14 |
| Forecasting the Equity Risk Premium | Aug-14 |
| Implied Cost of Capital & Shorting Premium | Jun-14 |
| Trend Following | Mar-14 |
| Factor investing & Quality | Feb-14 |
| Quality & Gross Profitability | Jan-14 |
| Minimum variance: valuation, concentration and exchange rates | Dec-13 |
| Liquidity & back test overfitting | Oct-13 |
| News and its effect on asset prices | Sep-13 |

### PAS User Guides

| | | | |
|---|---|---|---|
| PAS Macros | Feb-16 | Reports | Apr-14 |
| Quick Reference Guide | Nov-15 | Risk Parity | Feb-13 |
| Risk Parity and Composite Assets | Jan-15 | Advanced Analysis | Oct-12 |
| Introduction to the UBS Portfolio Analysis System | Jan-15 | Risk Models | Nov-11 |
| Long-Short Analysis | Jan-15 | UBS Hybrid Risk Model | Dec-10 |
| Installation | May-14 | Quick Portfolio Analysis | Jul-10 |

### R Advice

| | | | |
|---|---|---|---|
| Rolling window calculations – which package to use | Oct-16 | Optimising in Rs | Aug-16 |
| Getting started with random forests | Sep-16 | Speeding up R / Plotting correlation matrices | Jun-16 |

# Team


## UK – London

| | |
|---|---|
| Nick Baltas | +44-20-7568 3072 |
| Maylan Cheung | +44-20-7568 4477 |
| Ian Francis | +44-20-7568 1872 |
| Josie Gerken | +44-20-7568 3560 |
| Simon Iley | +44-20-7568 6327 |
| Desi Ivanova | +44-20-7568-1754 |
| David Jessop | +44-20-7567 9882 |
| Claire Jones | +44-20-7568 1873 |
| Manoj Kothari | +44-20-7568 1997 |
| Simon Stoye | +44-20-7568 1876 |
| Christine Vargas | +44-20-7568 2409 |

## Hong Kong

| | |
|---|---|
| Cathy Fang (Shanghai) | +86-021-3866 8891 |
| Josh Holcroft | +852-2971 7705 |
| Shanle Wu | +852-2971 7513 |

## Australia– Sydney

| | |
|---|---|
| Oliver Antrobus | +61-3-9242 6467 |
| Luke Brown | +61-2-9324 3620 |
| Pieter Stoltz | +61-2-9324 3779 |
| Paul Winter | +61-2-9324 2080 |
| Jenevieve Zhang | +61-2-9324 2247 |


### Valuation Method and Risk Statement

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, (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, (3) the articles in this document are based on third party research as disclosed in each piece; however, where this methodology has been applied to a dataset, full responsibility for its application and/or extrapolation is accepted by the analyst.

## 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 acts or may act as principal in the debt securities (or in related derivatives) that may be the subject of this report. This recommendation was finalized on: 04 November 2016 01:29 PM GMT.

**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.

**UBS Investment Research: Global Equity Rating Definitions**

| 12-Month Rating | Definition | Coverage[1] | IB Services[2] |
|---|---|---|---|
| **Buy** | FSR is > 6% above the MRA. | 45% | 28% |
| **Neutral** | FSR is between -6% and 6% of the MRA. | 39% | 25% |
| **Sell** | FSR is > 6% below the MRA. | 15% | 17% |
| **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 2016.
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 FINRA. Such analysts may not be associated persons of UBS Securities LLC and therefore are not subject to the FINRA restrictions 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; David Jessop; Claire Jones, CFA; Josie Gerken, PhD; Desi Ivanova. **UBS Securities Australia Ltd:** Paul Winter; Oliver Antrobus, CFA; Pieter Stoltz. **UBS AG Hong Kong Branch:** Josh Holcroft; Shanle Wu, PhD.

Unless otherwise indicated, please refer to the Valuation and Risk sections within the body of this report. For a complete set of disclosure statements associated with the companies discussed in this report, including information on valuation and risk, please contact UBS Securities LLC, 1285 Avenue of Americas, New York, NY 10019, USA, Attention: Investment Research.

## 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 and, in certain instances, 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.

All Global Research is available on UBS Neo. Please contact your UBS sales representative if you wish to discuss your access to UBS Neo.

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.**

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.

UBS has policies and procedures, which include, without limitation, independence policies and permanent information barriers, that are intended, and upon which UBS relies, to manage potential conflicts of interest and control the flow of information within divisions of UBS and among its subsidiaries, branches and affiliates. For further information on the ways in which UBS manages conflicts and maintains independence of its research products, historical performance information and certain additional disclosures concerning UBS research recommendations, please visit www.ubs.com/disclosures.

Research will initiate, update and cease coverage solely at the discretion of UBS Investment Bank Research Management, which will also have sole discretion on the timing and frequency of any published research product. The analysis contained in this document is based on numerous assumptions. All material information in relation to published research reports, such as valuation methodology, risk statements, underlying assumptions (including sensitivity analysis of those assumptions), ratings history etc. as required by the Market Abuse Regulation, can be found on NEO. 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, and UBS's subsidiaries, branches and affiliates as a whole.

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.

**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 Limited, Italy Branch. Where an analyst of UBS Limited, Italy Branch has contributed to this document, the document is also deemed to have been prepared by UBS Limited, Italy Branch. **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. **Mexico:** This report has been distributed and prepared by UBS Casa de Bolsa, S.A. de C.V., UBS Grupo Financiero, an entity that is part of UBS Grupo Financiero, S.A. de C.V. and is an affiliate of UBS AG. This document is intended for distribution to institutional or sophisticated investors only. Research reports only reflect the views of the analysts responsible for the reports. Analysts do not receive any compensation from persons or entities different from UBS Casa de Bolsa, S.A. de C.V., UBS Grupo Financiero, or different from entities belonging to the same financial group or business group of such. For Spanish translations of applicable disclosures, please see www.ubs.com/disclosures. **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) 007/09/2016 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). 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. UBS New Zealand Ltd is not a registered bank in New Zealand. 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:** Distributed 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.