Academic Research Monitor
Quality and Size 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

Sebastian Lancetti, CFA
Analyst
sebastian.lancetti@ubs.com
+1-203-719 4045

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

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

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

Aspects of Quality and Size investing

In this issue of our update of recent academic advances, we first focus on two papers that aim to redefine "quality" for equity stocks. These papers were presented at our recent Boston Quantitative Conference that took place on May 1st, 2015, by Joseph Gerakos from University of Chicago, Booth School of Business. The third paper that we review has recently attracted a lot of interest and focuses on the interplay between equity quality and size premia and resurrects the latter.

Redefining Quality: from Gross Profitability to Operating Profitability

Gross profitability (gross profit divided by book value of assets) has been one of the most popular proxies for "quality". The first paper that we review shows that operating profitability, a revamped version of gross profitability after adjusting for SG&A (but excluding R&D), is a stronger predictor of stock returns. The top decile of US stocks with the largest operating profitability outperforms the bottom decile by 31bps per month (75bps alpha, adjusting for market, value and size factors) over 1963-2013.

One step further: strip out Accruals to get Cash-based Operating Profitability

Expected returns increase with profitability, but decrease with accruals (the "accrual" anomaly). Given that accruals are included in all accounting measures of profitability, the second paper that we review strips our accruals from operating profitability and introduces a cash-based variant of operating profitability that turns out to be an even stronger predictor of returns, generating a high-minus-low decile return of 47bps per month (90bps alpha, adjusting for market, value and size factors) over 1963-2013.

Control for junk firms and resurrect the Size premium

The size premium (small-minus-large cap) has been one of the weakest equity premia, especially following its publication in the early 1980's. Not anymore. The last paper that we review resurrects the size premium by first controlling for quality. Screening out the "junk" (bad quality) part of the equity universe gives rise to a healthy and stable across time and specifications size premium. We empirically confirm these findings for the US and European MSCI universes, but find mixed results for Japan and Asia ex. Japan.

Introduction

This issue of our Academic Research Monitor explores various aspects of quality and size investing based on the findings of three recent academic papers (see Figure 1).[1]

Quality investing – guest talk at our Boston Quantitative Conference by Joseph Gerakos

Starting with quality, we review two recent papers that were presented by Joseph Gerakos from the University of Chicago, Booth School of Business at our recent Quantitative Conference that took place in Boston on the 1st of May, 2015. The aim of these papers is to explore the quality premium[2] through a careful evaluation of one of the most prevalent measures of quality, which is gross profitability, introduced by Novy-Marx (2013) and studied in detail last year in our Academic Research Monitor (January 2014). These new papers redefine gross profitability and introduce cleaner proxies of profitability, termed the operating profitability and the cash-based operating profitability.

Size premium is resurrected once we control for quality/junk

Turning our attention to size, we review a recent paper that has attracted a lot of interest. The size premium has probably been the weakest premium from the long list of equity premia suggested by the academic literature. Not anymore. This new paper resurrects the size premium by first controlling for quality. Screening out the "junk" (bad quality) names from the universe of stocks results in a healthy size premium and stable across time and specifications. We replicate the methodology and evaluate the validity of the findings in various global regions and find similarly convincing patterns in the US but less so in Europe and Japan. The results are far weaker in Asia ex. Japan, but this might be largely driven by the large non-homogeneity of the countries in the region.

Figure 1: Papers on Quality and Size

"Deflating Profitability" *Ray Ball, Joseph Gerakos, Juhani Linnainmaa and Valeri Nikolaev*	SSRN working paper, October 2014 Forthcoming at *Journal of Financial Economics*, 2015
"Accruals, Cash Flows, and Operating Profitability in the Cross Section of Stock Returns" *Ray Ball, Joseph Gerakos, Juhani Linnainmaa and Valeri Nikolaev*	SSRN working paper, April 2015
"Size Matters, If You Control Your Junk" *Clifford Asness, Andrea Frazzini, Ronen Israel, Tobias Moskowitz and Lasse Pedersen*	SSRN working paper, April 2015

Source: UBS

[1] We recently presented an overview of recent academic findings on Momentum Investing in our Academic Research Monitor (January 2015).

[2] For our work on defining quality, see our recent Quantitative Monographs:

- "Investing in Quality" (17 April 2014)
- "Extending our Quality Model to Financials" (18 March 2015)

"Deflating Profitability"

by Ray Ball, Joseph Gerakos, Juhani Linnainmaa and Valeri Nikolaev

There is vast empirical evidence that establishes a link between accounting information and the cross-section of stock returns. A recent paper by Novy-Marx (2013) that has attracted a lot of interest and has featured in our Academic Research Monitor (January 2014) documents a strong link between gross profitability and future equity returns[3], claiming that gross profitability is the cleanest accounting measure of true economic profitability, compared to other conventional profitability measures like ROE (net income to book value of equity). Gross profitability is defined as the ratio of the gross profit (revenues minus cost of goods sold, COGS) and the book value of total assets:

$$Gross\ Profitability = \frac{Gross\ Profit}{Book\ Value\ of\ Total\ Assets}$$

Why is gross profitability a better predictor of returns than ROE?

In their recent paper, Ray Ball, Joseph Gerakos, Juhani Linnainmaa and Valeri Nikolaev investigate further the predictive ability of the gross profitability measure and re-evaluate whether it has indeed greater predictive power than "bottom line" net income (proxied by income before extraordinary items). In doing so, they focus explicitly on the nature of both the nominator of the profitability ratio (gross profit for gross profitability, net income for ROE) and the deflator (book value of total assets for gross profitability, book value of equity for ROE).

The paper is split into two large sections. The first part investigates the reason why gross profitability is a better predictor of future returns than net income. The authors find that the reason is solely related to the type of deflator that is used in the definition of the profitability ratio. Given this finding, the second part focuses on constructing an even better measure of profitability, which is termed as the *operating profitability* and is shown to exhibit a much stronger link with expected stock returns than either the gross profitability or the ROE. We next review briefly the methodology and findings of both parts.

The choice of the deflator should match cash flow rights

The first part compares the forecasting ability of gross profit and income before extraordinary items when different deflators are applied to these two variables. In principle, the choice of the deflator should match the cash flow rights. Along these lines, gross profit, which is calculated prior to deducting interest expense, should be deflated by total assets (AT, henceforth) that are financed by both debt and equity. In contrast, net income, which is calculated after deducting the interest expense, should be deflated by either the book value of equity (BE, henceforth) or the market value of equity (ME, henceforth). Using monthly data between July 1963 and December 2013, the authors report simple correlations between different profitability ratios across all US firms ex. financials (using return data from CRSP and accounting data from Compustat) and find that the deflator choice affects substantially the properties of the profit variable. As an example, the correlation between gross profit deflated by AT with gross profit deflated by ME is only 0.10, whereas the correlation between income before extraordinary items deflated by AT with income before extraordinary items deflated by ME is only 0.19. Finally, the correlation of gross profit and income before extraordinary items is 0.40 when both are deflated by AT, and only 0.19 when both are deflated by ME.

The choice of the deflator affects substantially the properties of the profit variable

[3] Novy-Marx (2013) confirms his findings using (a) cross-sectional Fama and MacBeth (1973) regressions and (b) gross-profitability sorted portfolios, where the basket of stocks with the highest gross profitability outperforms the basket of stocks with lowest gross profitability.

Cross-sectional regressions

The analysis continues with Fama and MacBeth (1973) cross-sectional regressions where stock returns are forecast by last month's profitability ratios (gross profit or income before extraordinary items, both deflated by either AT, ME or BE) and other control variables[4]. The authors conduct their regressions separately for All-but-Microcaps and Microcaps universes; the breakpoint between the two is the 20th percentile of the NYSE market capitalisation distribution. Overall, they find that gross profit and income before extraordinary items have similar explanatory power when they are deflated by the same deflator for the All-but-Microcaps universe. For Microcaps, gross profit appears to be a better predictor. The most important finding is that the choice of the deflator has a very strong effect on the relation between profitability measures and future stock returns. The significance of the profitability ratios is the largest when the AT is the deflator, falls when BE is the deflator and is the smallest when ME is the deflator.

Portfolio tests

The above results are corroborated using portfolio sorts. Along these lines, the authors sort the stock universe based on various profitability ratios (i.e. using gross profit or income before extraordinary items, both deflated by either AT or ME), and construct high-minus-low value-weighted portfolios. They find that both profit variables generate portfolios with similar Fama and French (1993) 3-factor alphas, when compared using the same deflator. Interestingly, these alphas are economically large and statistically significant when AT is used as the deflator, but turn small and statistically insignificant when ME is used as the deflator.[5]

How does assets-deflated profitability differ from price-deflated profitability?

What is clear from the above analysis is that the deflator matters the most in the definition of a profitability ratio. In order to explain the difference between assets-deflated profitability and price-deflated profitability, the authors present the following identities:

$$\frac{\pi}{AT} = \frac{\pi}{ME} \cdot \frac{ME}{AT} \; and \; \frac{\pi}{AT} = \frac{\pi}{BE} \cdot \frac{BE}{AT}$$

where π denotes some profitability variable (gross profit, net income etc.). Evidently, deflating by AT implies an interaction between deflating by ME (or BE) and the inverse of market (or book) leverage, AT/ME (or AT/BE). As a consequence, the fact that assets-deflated profitability enjoys stronger predictive power than price-deflated profitability in a linear regression framework can be either due to leverage or due to the interaction (product) between profitability and leverage, as presented in the above equations. In order to disentangle the effects of the various components and their respective products, the authors conduct a second series of Fama and MacBeth regressions using separately the various components of gross profitability as well as their respective products. In brief, they find that it is indeed the interaction of profitability with market leverage that is driving the results.

Redefining Profitability:

From gross profitability to operating profitability

Following from the above findings, the authors explore in detail all the accounting variables that are used in the definition of income before extraordinary items and using Novy-Marx's (2013) original motivation for a "cleaner measure of predictability", they suggest subtracting not only the cost of goods sold from revenues (as is the case for gross profit), but also the selling, general & administrative expenses (SG&A) excluding the research & development

[4] Following Novy-Marx (2013), the authors control for log(ME/BE), ME, past month's returns to capture short-term reversals and past 12-month returns excluding the most recent month to capture momentum.
[5] Similar results hold when the authors construct portfolios based on cash flow-to-price or cash flow-to-asset ratios. The Fama and French (1993) 3-factor alpha of a high-minus-low decile portfolio is statistically insignificant for the former and statistically strong for the latter.

expenditure. As also supported by Novy-Marx (2013), R&D costs may not be directly related to the contemporaneous profitability of the firm as their aim is to increase future profitability. Along these lines, subtracting them from SG&A is what the authors of the current paper suggest. The complication is that Compustat reports SG&A in the item XSGA, which includes R&D costs (XRD item). As a consequence, there exists an intermediate adjustment in the dataset in order for the Compustat reported variable to be adjusted by the R&D costs.

Following all the above, the authors define the following measure of profitability:

$$Operating\ Profitability = \frac{Gross\ Profit - (SG\&A - R\&D)}{Book\ Value\ of\ Total\ Assets}$$

Using Fama and MacBeth regressions, the authors find that operating profitability is a stronger predictor of future returns than gross profitability across both All-but-Microcaps and Microcaps universes. Sorting stocks into deciles based on operating profitability results in a high-minus-low excess return of 31bps per month and a Fama and French (1993) alpha of 75bps per month, both statistically significant. Contrasted against gross profitability, the respective values are 35bps per month for the excess returns and just 55bps per month for the alpha; see Figure 2.

Figure 2: Portfolio Sorts: Gross Profitability versus Operating Profitability

Portfolio	Average return	Three-factor model α	b_{mkt}	b_{smb}	b_{hml}
		Gross profitability			
1 (low)	0.324	−0.164	0.944	0.049	0.117
	(1.68)	(−1.85)	(45.15)	(1.65)	(3.67)
10 (high)	0.677	0.382	0.903	−0.053	−0.276
	(3.46)	(4.55)	(45.56)	(−1.88)	(−9.16)
High-Low	0.353	0.546	−0.041	−0.101	−0.392
	(2.57)	(4.10)	(−1.30)	(−2.29)	(−8.22)
		Operating profitability			
1 (low)	0.221	−0.461	1.177	0.480	0.061
	(0.85)	(−4.70)	(50.86)	(14.70)	(1.75)
10 (high)	0.528	0.289	0.932	−0.081	−0.437
	(2.64)	(4.85)	(66.17)	(−4.10)	(−20.43)
High-Low	0.307	0.750	−0.245	−0.561	−0.498
	(2.03)	(6.25)	(−8.66)	(−14.06)	(−11.60)

Source: "*Deflating Profitability*" by R. Ball, J. Gerakos, J. Linnainmaa and V. Nikolaev; reproduced from the presentation at UBS Quantitative Investment Conference, May 1, 2015, Boston. The table presents excess returns and Fama and French (1993) decompositions for gross profitability and operating profitability sorted value-weighted portfolios. The sample period is July 1963 to December 2013.

The profitability premium does not appear to be due to mispricing

Having identified a stronger predictor of stock returns, the paper concludes by asking whether the predictive ability of operating profitability is due to mispricing or instead this new variable constitutes a priced factor (and therefore the positive returns constitute compensation for some type of systematic risk). By running Fama and MacBeth (1973) regressions with lags on the operating profitability up to 10 years, they find statistically strong long-term effects which are difficult to reconcile with market mispricing that, in turn, is more likely to be a short-term effect.

Last word

Overall, operating profitability is a new interesting predictor of stock returns when it comes to identifying quality firms. Statistically robust, but also economically motivated (measure profitability using only costs that matter and exclude costs that aim to increase future profitability, like R&D costs or advertising). We aim to investigate the properties of this quality proxy in our future research reports.

"Accruals, Cash Flows, and Operating Profitability in the Cross Section of Stock Returns"

by Ray Ball, Joseph Gerakos, Juhani Linnainmaa and Valeri Nikolaev

Profitability premium versus the accrual anomaly

Following from the findings of the previous paper, a follow-up paper by the same authors investigates (even) further the relationship between profitability and returns. The authors motivate their new paper with two contradicting statements:

- Expected returns **increase** in profitability (Ball and Brown, 1968, Novy-Marx, 2013 and Ball, Gerakos, Lunnainmaa and Nikolaev, 2015a).
- Expected returns **decrease** in accruals (Sloan, 1996); the "accrual anomaly".

The various measures of profitability, like net income, gross profitability or operating profitability all include accruals. The important research question therefore is whether stripping out accruals from the measure of profitability can strengthen the profitability premium.

What are accruals?

To start with, we give a brief definition of "accruals". Firm earnings are calculated as the difference between revenues and expenses over a certain time period. The two components of earnings, revenues and expenses, are not simply calculated in accounting terms as the total value of *actual* cash flows (i.e. actual cash receipts and actual expenses respectively over the period of interest), but also account for cash flows (receipts and expenses) that can occur in future or prior periods as long as these cash flows relate to the value of goods and services delivered to customers during the period of interest. In other words, accruals capture all types of non-contemporaneous, but relevant to the period of interest, cash-flows.

Redefining Profitability (again):

From operating profitability to cash-based operating profitability

Following the above, the authors start from the measure of operating profitability that we presented in detail in the previous review (revenues, minus cost of goods sold, minus selling, general & administrative expenses, but including research & development expenses, all scaled by the book value of total assets) and remove all the accrual components from the calculation. These accrual components include changes in accounts receivable, inventory, pre-paid expenses, deferred revenue, accounts payable and accrued expenses, and are estimated using balance sheet data from Compustat. The adjusted measure of profitability is termed by the authors as the ***cash-based operating profitability***, because it contains information about actual revenues and expenses. The authors use exactly the same universe as for the previous paper that we reviewed and calculate all the required measures for all CRPS/Compustat firms excluding financials. Interestingly enough, as reported in Figure 3, even though operating profitability is largely and positively correlated with its cash-based variant, the former is positively correlated with accruals, whereas the latter is negatively correlated with accruals. In other words, profitable firms due to high accruals appear to generate low cash flows and, conversely, firms with high cash flows tend to record low or negative accruals.

Figure 3: Correlation Matrix

	OP	Accruals	CbOP
OP	1		
Accruals	0.165	1	
CbOP	0.844	-0.253	1

Source: "*Accruals, Cash Flows, and Operating Profitability in the Cross Section of Stock Returns*" by R. Ball, J. Gerakos, J. Linnainmaa and V. Nikolaev; reproduced from the presentation at UBS Quantitative Investment Conference, May 1, 2015, Boston. The table presents correlations between operating profitability (OP), accruals and cash-based operating profitability (CbOP). The sample period is July 1963 to December 2013.

The empirical analysis follows the methodology of the first paper that we reviewed in this ARM; first, looking into the forecasting ability of cash-based operating profitability using Fama and MacBeth (1973) cross-sectional regressions and then constructing portfolio sorts based on this measure of profitability.

Cross-sectional regressions

Regressing stock returns cross-sectionally on past month's measures of operating profitability and accruals (along with other controls: price-to-book ratio, market capitalisation, past month's returns and past 12-month returns excluding the most recent month) on a Fama and MacBeth (1973) framework confirms the existing

evidence that operating profitability bears a positive and statistically strong coefficient, whereas accruals bear a negative and statistically strong coefficient; the results remain strong whether the variables are used separately or jointly in the forecasting regression (as shown in Figure 3, OP and accruals are weakly correlated, so the fact that both survive is largely expected). In other words, operating profitability does not explain the accrual anomaly and vice versa.

The more interesting patterns emerge when the authors use the cash-based operating profitability measure as a predictor of equity returns. This variable enjoys the largest statistical significance compared to operating profitability or accruals and completely eliminates the statistical significance of these other two variables, when they are all included in the regressions. This finding remains strong both across All-but-Microcaps and Microcaps universes; the breakpoint between the two is the 20th percentile of the NYSE market capitalisation distribution. The finding is also robust to a different estimation methodology of accruals using cash flow statement information (data is only available from 1988 onwards) instead of balance sheet information. Overall, cash-based operating profitability has the strongest predictive power and completely subsumes the accrual anomaly, that both the Fama and French (1993) 3-factor and the Fama and French (2015) 5-factor models fail to explain.

Portfolio single-sorts

Moving to portfolio sorts, the authors sort all stocks into deciles based on operating profitability, accruals and cash-based operating profitability and construct high-minus-low portfolios. Excess returns and Fama and French (1993) alphas are presented in Figure 4. All spread portfolios generate statistically strong excess returns and alphas with the expected signs; positive for profitability measures and negative for accruals. Between the profitability measures, the cash-based variant generates larger estimates (47bps vs. 29bps of excess returns and 90bps vs. 75bps of alpha) that also enjoy larger statistical significance.

Figure 4: Portfolio Sorts: Operating Profitability, Accruals and Cash-based OP

	Operating profitability		Accruals		Cash-based operating profitability	
Portfolio	Average return	FF3 α	Average return	FF3 α	Average return	FF3 α
1 (low)	0.268	−0.469	0.695	0.219	0.146	−0.556
	(1.04)	(−4.42)	(3.04)	(2.13)	(0.55)	(−6.75)
2	0.402	−0.225	0.611	0.136	0.337	−0.318
	(2.02)	(−2.88)	(3.19)	(1.79)	(1.57)	(−3.99)
9	0.524	0.085	0.440	−0.019	0.616	0.177
	(2.83)	(1.42)	(2.05)	(−0.27)	(3.24)	(3.15)
10 (high)	0.558	0.284	0.311	−0.208	0.620	0.347
	(2.83)	(4.68)	(1.22)	(−2.49)	(3.23)	(5.90)
High-Low	0.289	0.752	−0.384	−0.427	0.474	0.903
(deciles)	(1.84)	(5.99)	(−2.76)	(−3.25)	(3.16)	(8.50)

Source: "*Accruals, Cash Flows, and Operating Profitability in the Cross Section of Stock Returns*" by R. Ball, J. Gerakos, J. Linnainmaa and V. Nikolaev; reproduced from the presentation at UBS Quantitative Investment Conference, May 1, 2015, Boston. The table presents excess returns and Fama and French (1993) 3-factor alphas for operating profitability, accruals and cash-based operating profitability sorted value-weighted portfolios. The sample period is July 1963 to December 2013.

Portfolio double-sorts

The cash-based operating profitability explains the accrual anomaly

More interesting results emerge when the operating profitability measures are interacted with accruals in dependent double sorts. Sorting first by operating profitability into deciles and subsequently sorting by accruals within each profitability decile, the authors find that operating profitability cannot explain the accrual anomaly. A profitability neutral (i.e. average across the profitability deciles) high-minus-low accruals portfolio exhibits an alpha of -31bps with a t-statistic equal to -3.62, hence highly statistically significant. On the contrary, sorting first by cash-based operating profitability and then by accruals completely eliminates the

accrual anomaly. The profitability neutral high-minus-low accruals portfolio exhibits an alpha of -4bps that is not statistically significant (t-statistic of -0.42).

The new Profitability Factor

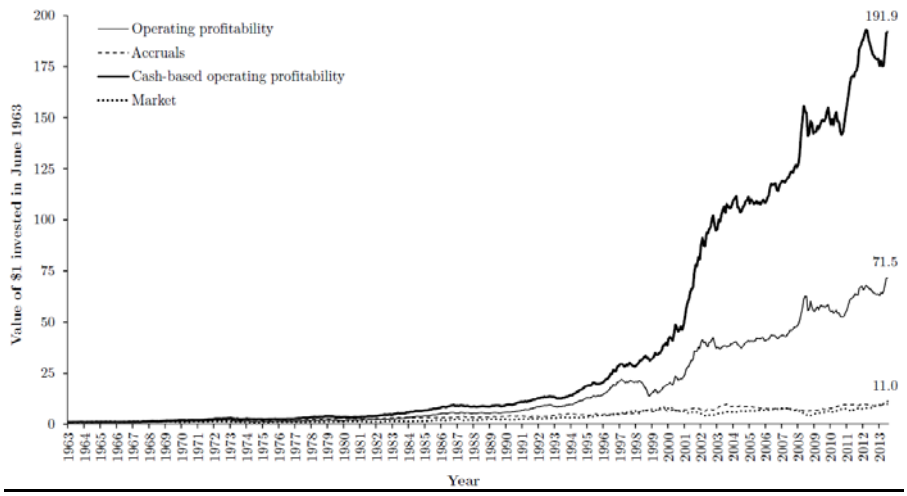
➔ **Explains the accrual anomaly**

The accrual anomaly seems to be driven by low cash profitability and not by high accruals

Following the above empirical evidence, the authors go on and construct a cash-based profitability factor using the conventional 2x3 size-neutral Fama and French (1993) methodology (i.e. the same methodology that is used for the construction of the HML factor). This factor, when used along with the traditional Fama and French (1993) 3-factor model, is shown to perform significantly well in explaining the cross-section of returns of 25 size and accruals double-sorted value-weighted portfolios; this is a cross-section of returns that neither the Fama and French (1993) model can explain, nor its 4-factor extension that contains a factor based on operating profitability. It's the cash-based variant of operating profitability that makes the big difference.

The authors then investigate the ex-post (i.e. using the full sample to calculate portfolio weights) maximum Sharpe ratio of a mean-variance efficient portfolio that combines profitability or accrual factors along with the conventional market, size, value and momentum factors. The maximum ex-post Sharpe ratio for an allocation on the conventional four factors is 1.07, which increases to 1.13 if we include the accruals factor and to 1.40 if we include an operating profitability factor. Including both factors increases the ex-post Sharpe ratio to 1.58. However, this is nowhere close the Sharpe ratio that can be achieved using the cash-based profitability factor along with the four traditional factors, which is 1.70. Importantly enough, adding the accruals factor only increases this marginally to 1.72, hence rendering this factor no longer valuable. Overall, this analysis shows that an investor would have been better off adding just the cash-based operating profitability factor to their investment opportunity set than any linear combination of the operating profitability factor and the accruals factor. This is a strong result.

Figure 5: Cumulative Returns



Source: "*Accruals, Cash Flows, and Operating Profitability in the Cross Section of Stock Returns*" by R. Ball, J. Gerakos, J. Linnainmaa and V. Nikolaev; reproduced from the presentation at UBS Quantitative Investment Conference, May 1, 2015, Boston. The figure presents cumulative Fama and French (1993) abnormal returns for high-minus-low value-weighted portfolios constructed with respect to operating profitability, accruals and cash-based operating profitability. The sample period is July 1963 to December 2013.

The profitability premium does not appear to be due to mispricing

As a final word and similarly to the previous paper that we reviewed, the authors show that the cash-based operating profitability exhibits long-term return predictability that extends even up to 10 years out. This constitutes evidence in favour of a risk-based explanation of the profitability premium instead of a limits-to-arbitrage/mispricing explanation that is not likely to persist for so long.

"Size Matters, if you Control your Junk"

by Clifford Asness, Andrea Frazzini, Ronen Israel, Tobias Moskowitz & Lasse Pedersen

Size Premium = Small - Large

The size premium describes the tendency of small stocks (in terms of market capitalisation) to outperform large stocks above and beyond what is captured by their market betas. This premium was first documented by Banz (1981) and subsequently became part of the Fama and French (1993) 3-factor model in the form of the SMB factor. However, the vast empirical evidence that has followed over the last few decades has substantially challenged the robustness and therefore the existence of the size premium.

Following the above empirical facts, Clifford Asness, Andrea Frazzini, Ronen Israel, Tobias Moskowitz and Lasse Pedersen, in their recent paper (which has already attracted significant interest), list the seven empirical challenges that the size premium has faced:

The seven challenges of Size

1. The size effect is small and statistically weak (if not insignificant).
2. The size effect has disappeared following its publication in the early 80's.
3. The size effect is mainly concentrated in microcap stocks, which are very illiquid, and it is therefore swamped by the trading costs.
4. Using alternative definitions of size that are not price related (the typical measure of size is market capitalisation) generates no size effect.
5. The largest part of the size premium occurs in January.
6. The size effect may just be a proxy for a liquidity effect.
7. The size effect is weak internationally, which raises the concerns of data mining.

All these patterns are empirically confirmed by the authors using either the Fama and French (1993) SMB factor (constructed using a 2x3 size and book-to-market double sort) or a Decile 1 – Decile 10 portfolio (using a univariate sort based on size) as their proxy for size. Following the documentation of the challenges, they then go on and explain all of them by controlling for quality and they effectively manage to resurrect the size premium. Over the next few pages, we will go through their empirical analysis and briefly describe their findings that give a new twist to what we have thought to be a "dead" premium.

Speaking of quality, the authors mainly refer to the Asness, Frazzini and Pedersen (2014), Quality-Minus-Junk (QMJ) factor that is constructed using a composite score of profitability, growth, safety and payout. For further details on the construction and performance of the QMJ factor, see our review of the aforementioned paper in the Academic Research Monitor (February 2014).

For the robustness of the findings, the authors conduct their analysis across various distinct sample periods (listed on the right) that relate to different phases of the size premium: the Golden Age of large returns, the Embarrassment period following its publication and the most recent Resurrection period; the entire sample period is from July 1957 to December 2012. The results of the paper hold strong across all periods and this makes the validity of the findings even stronger.

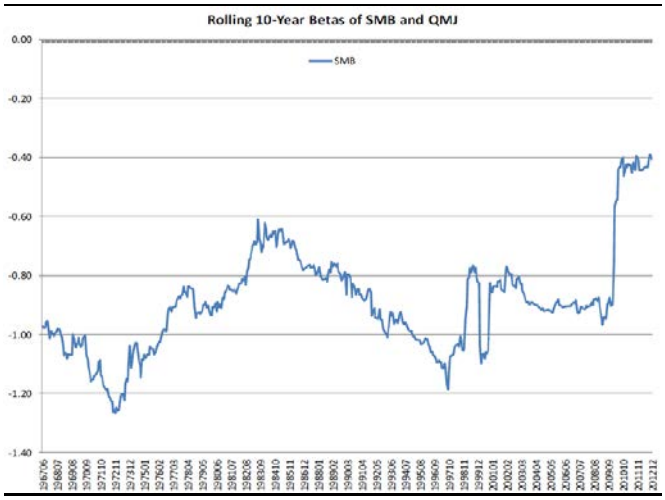
- **Full sample: 1957M07 – 2012M12**
- **Golden Age: 1957M07 – 1979M12**
- **Embarrassment: 1980M01 – 1999M12**
- **Resurrection: 2000M01 – 2012M12**

Challenge 1: The size effect is small and statistically weak

The size premium, proxied by SMB, has been indeed weak in the US for all sample periods that are tested by the authors, delivering an insignificant CAPM and Fama and French (1993) alpha (they of course exclude the SMB from the factor model,

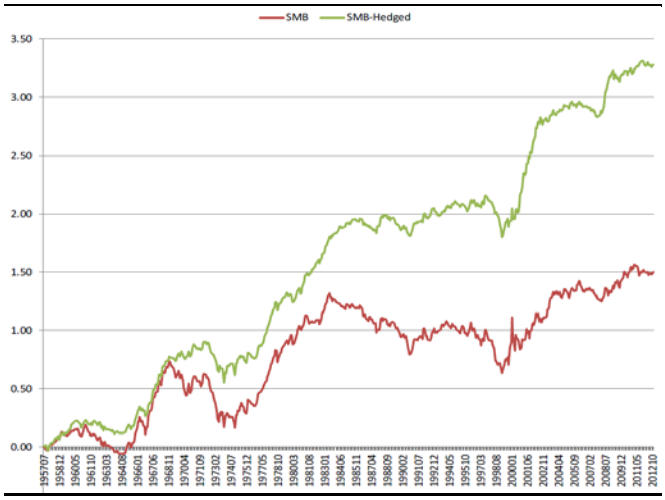
but control for lagged market returns to capture any delayed responses of stocks, particularly the small ones). However, adding the QMJ factor in the factor model completely changes the result. Across all sample periods, the SMB loads negatively on QMJ (see Figure 6 for a 120-month rolling beta estimation) and therefore generates a strong and statistically significant positive alpha, ranging between 49bps and 89bps per month for the various periods; Figure 7 presents the cumulative abnormal returns (alpha) of the SMB factor and the QMJ-hedged version of SMB using the full-sample beta (there exists an in-sample bias here, but as the authors claim, the finding is robust to using real-time rolling beta estimates).

Figure 6: 120-month Rolling Beta of SMB on QMJ



Source: "*Size Matters, if you Control your Junk*" by C. Asness, A. Frazzini, R. Israel, T. Moskowitz & L. Pedersen; part of Figure 4, reproduced with permission. The figure presents 120-month rolling beta estimates of SMB on QMJ, estimated using a model with the Fama and French (1993) factors, excluding the SMB and adding a lagged market factor and the QMJ factor.

Figure 7: SMB alpha with and without controlling for QMJ



Source: "*Size Matters, if you Control your Junk*" by C. Asness, A. Frazzini, R. Israel, T. Moskowitz & L. Pedersen; Figure 1, reproduced with permission. The figure presents the cumulative abnormal returns of the SMB factor (regressed against the Fama and French (1993) factors, excluding the SMB and adding a lagged market factor) before and after controlling for the exposure to the QMJ factor.

For additional robustness, the authors construct SMB portfolios across 30 industries and confirm the findings across each one of them; the SMB alpha increases significantly after controlling for the exposure to the quality/junk factor.

Challenge 2: The size effect has disappeared following its publication

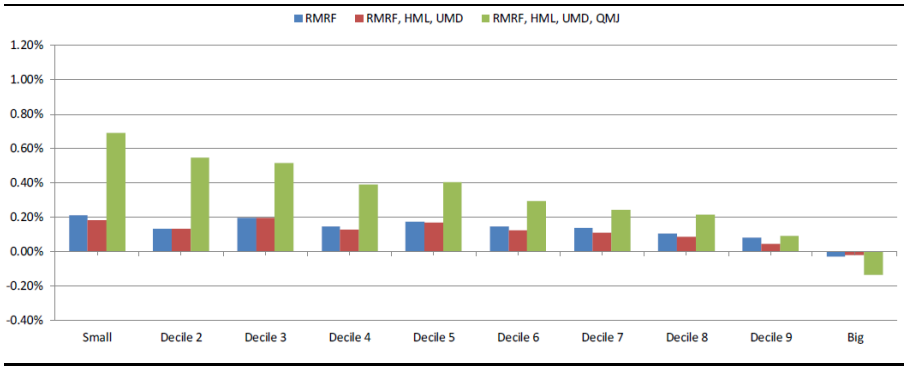
The performance of the SMB has in general been time-varying: as confirmed in Figure 7, strong during the Golden Age, very poor in the Embarrassment period and relatively good (but with statistically insignificant alpha) during the most recent Resurrection period. However, once we control for quality, the performance of the SMB factor becomes statistically strong and stable across all periods. The authors report alphas (after controlling for the market, its lagged return, value – HML, momentum – UMD and quality – QMJ) of 57bps, 50bps and 89bps per month for these distinct sample periods respectively.

The result is robust to other specifications of the quality factor (in particular using the QMJ subcomponents separately; profitability, growth, safety and payout). The result is also robust to adding other factors that can potentially capture part of QMJ's significance, like the Betting-Against-Beta (BAB) factor of Frazzini and Pedersen (2014), the Robust-minus-Weak (RMW) profitability factor and the Conservative-Minus-Aggressive (CMA) investment factor of Fama and French (2015) or a credit factor (high credit rating, above A, minus low credit rating, below C). Without delving in the very details of the results, adding QMJ in the list of factors used for the SMB return decomposition significantly reduces (or even renders insignificant) the remaining factors and strongly boosts the SMB alpha.

Challenge 3: The size effect is mainly concentrated in microcap stocks

The authors estimate the alpha of size-ranked deciles and find that these are relatively flat, going from the smallest decile to the biggest decile, when the QMJ factor is not included in the factor model. Instead, controlling for the exposure to the QMJ factor gives rise to a large dispersion of alphas across size deciles, which, importantly enough, exhibit a strong monotonic pattern from the smallest decile to the biggest decile (see Figure 8 for full sample alpha; the same pattern holds across the various subsample periods). This finding constitutes evidence that the size effect is not concentrated in the extremes.

Figure 8: Size Decile Alphas



Source: "*Size Matters, if you Control your Junk*" by C. Asness, A. Frazzini, R. Israel, T. Moskowitz & L. Pedersen; part of Figure 3, reproduced with permission. The figure presents the monthly alphas of size-sorted deciles for different factor models. The sample period is July 1957 to December 2012.

Challenge 4: Non-priced definitions of size exhibit no premium

Failing to account for exposure on QMJ results in insignificant alphas for other definitions of "size" that are not price-related, like book assets, book equity, sales, PP&E or the number of employees. Instead, controlling for quality/junk leads to positive and strongly statistically significant alphas for the –small minus large decile- size portfolio across any period that the authors tested. Interestingly enough, the full sample alphas range between 58bps and 83bps for the different non-price definitions of size and are higher than the alpha of the ordinary market-cap size definition (alpha of 49bps for the small minus large decile portfolio).

The finding is strong and robust not only at the aggregate level, but also across the 30 industries. Using alternative size definitions and controlling for quality/junk results in strong and positive alphas in the very big majority of cases.

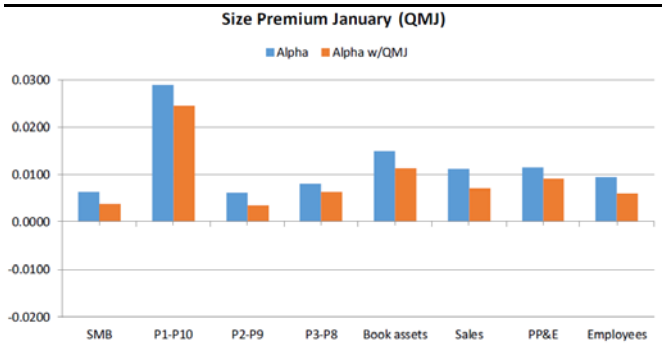
Challenge 5: The largest part of the size premium occurs in January

Without any quality control, the SMB factor is positive and statistically significant only in Januaries, whereas it turns insignificant and at time negative across all other months. However, controlling for the exposure to the QMJ factor has two distinct effects: (a) the January alpha falls, hence mitigating the very large premium in these months (see Figure 9) and (b) the non-January alpha turns positive and bears statistical significance, hence bridging the January versus non-January gap (see Figure 10). The finding is robust across various definitions of the size long-short portfolio and across various sample periods.

The fact that the size premium becomes more stable across all months once we account for quality means that the behaviour of small and junk firms is mainly responsible for exaggerating the premium in Januaries and completely eliminating

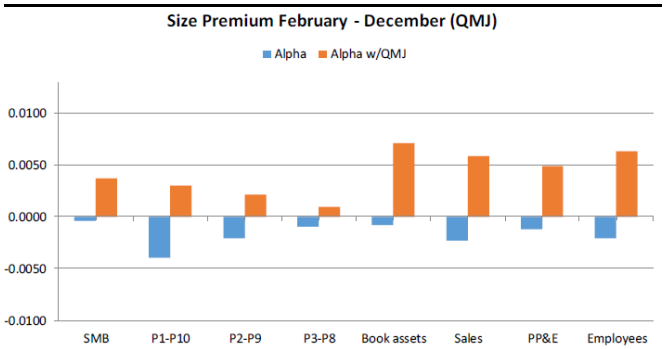
it over the rest of the year. As we will see later on in this review, the size premium is not strong across the junk subset of the equity universe.

Figure 9: Size Alphas in January



Source: "*Size Matters, if you Control your Junk*" by C. Asness, A. Frazzini, R. Israel, T. Moskowitz & L. Pedersen; part of Figure 6, reproduced with permission. The figure presents the alpha of various definitions of the size premium in Januaries (the alphas are estimated against the Fama and French (1993) factors, excluding the SMB and adding a lagged market factor) before and after controlling for the exposure to the QMJ factor. The sample period is July 1957 to December 2012.

Figure 10: Size Alphas in non-January months



Source: "*Size Matters, if you Control your Junk*" by C. Asness, A. Frazzini, R. Israel, T. Moskowitz & L. Pedersen; part of Figure 6, reproduced with permission. The figure presents the alpha of various definitions of the size premium in non-January months (the alphas are estimated against the Fama and French (1993) factors, excluding the SMB and adding a lagged market factor) before and after controlling for the exposure to the QMJ factor. The sample period is July 1957 to December 2012.

Challenge 6: The size effect may just be a proxy for a liquidity effect

The authors augment the existing factor models with three liquidity factors; a decile spread portfolio based on a composite score of turnover and bid-ask spread, the short-term reversal from Kenneth French's website and the Pastor and Stambough (2003) factor-mimicking portfolio. In the absence of the QMJ factor, the (already small and insignificant) alpha of the SMB factor reduces further as it is at times significantly exposed to the various liquidity factors. However, controlling for the QMJ factor helps again resurrecting the size premium, even in the presence of the liquidity factors, whose statistical significance is now largely reduced.

The authors comment that the QMJ factor does exhibit some exposure to liquidity risk (and this is the reason why its inclusion reduces the statistical significance of the liquidity factors), but it's not a proxy for liquidity. In fact, if QMJ was a liquidity factor, it should reduce the SMB alpha instead of increasing it in the non-January months.

Challenge 7: The size effect is weak internationally

The authors replicate their methodology using stock data from 24 countries. In that respect they construct SMB, HML, UMD and QMJ portfolios and evaluate the alpha of the size factor before and after controlling for the exposure to the QMJ factor. The findings we find overwhelming. Across all countries but Ireland, the country SMB factor is negatively exposed to the country QMJ factor and therefore its alpha increases after accounting for quality/junk.

Overall, summarising the findings of these seven challenges of the size effect, these are all largely explained by the negative exposure of size on quality. Controlling for quality/junk resurrects the size premium across various sample periods, across all months of the year and across various size definitions.

To summarise, the size premium is resurrected once we control for quality/junk

The last part of the paper focuses further on the interaction between size and quality/junk using double sorts and subsequently investigates the interactions of size with value.

Size and Quality double-sorts

The authors construct 25 size–quality portfolios from a 5x5 independent sort of the equity universe. Typically junk stocks tend to be mostly small stocks, whereas quality stocks are on average larger. However, the stock universe has plenty of large and junky stocks as well as small and quality stocks and this observation makes this double-sort analysis interesting.

With only one exception, the excess returns of these double-sorted portfolios increase monotonically as we move from a small basket towards a big basket within the same quality band (hence resulting in positive small-big returns) and similarly increase monotonically as we move from a junk basket towards a quality basket within the same size band (hence resulting in positive quality-junk returns). This one and only exception is the behaviour of the size baskets across the junk part of the universe, where the relationship between size and returns breaks down. The excess returns do not increase monotonically from the small to the big basket and the small-big return might be positive, but it's statistically insignificant. In other words, controlling for the junk stocks, can resurrect the size premium. Most of the size challenges that were explained above are effectively caused by the fact that junk stocks are illiquid and have higher volatility and high January returns.

The QMJ factor explains most of the pricing failures of the Fama and French (1993) model

Finally, the authors investigate various asset pricing challenges and evaluate whether controlling for the QMJ factor can help the pricing ability of factor models. Briefly, the QMJ factor eliminates the positive alpha of the size factor among value stocks and the negative alpha of the size factor among growth stocks; these have been the most prevalent failures of the original Fama and French (1993) 3-factor model, which weren't even completely alleviated by the extended Fama and French (2015) 5-factor model[6]. Equivalently, the QMJ factor eliminates the spread between the value premia among smalls and large stocks.

Last word

Overall, it suffices to argue that the empirical evidence presented in this paper we consider overwhelming. The results are robust to various methodological permutations and the main message is clear: the size premium is not a dead premium once we control for quality/junk. Screening out the junk part of the equity universe gives rise to a strong and stable return premium between small and large stocks.

Evaluating the size-quality link across global regions

Our in-house replication

Intrigued by the strong statistical evidence on the resurrected size premium after controlling for quality, we decided to replicate the analysis in a US universe and also explore the size-quality dynamics across three other global regions: Europe, Japan and Asia ex. Japan.

The empirical analysis of the paper that was presented above has been conducted at the CRSP universe and the definition of quality/junk followed the Asness, Frazzini and Pedersen (2014) is mega-composite of composites for profitability (6 components), growth (6 components), safety (5 components) and payout (3 components); see our review of that paper in the Academic Research Monitor (February 2014).

[6] See our review of the Fama and French (2015) 5-factor model in the Academic Research Monitor (February 2014).

Contrary to the above and in order to achieve transparency and replicability for our results, we limit our universe to the constituents of the MSCI indices of the different regions and we proxy quality using just ROIC. Our dataset starts in January 1996 and goes up to the end of April 2015.

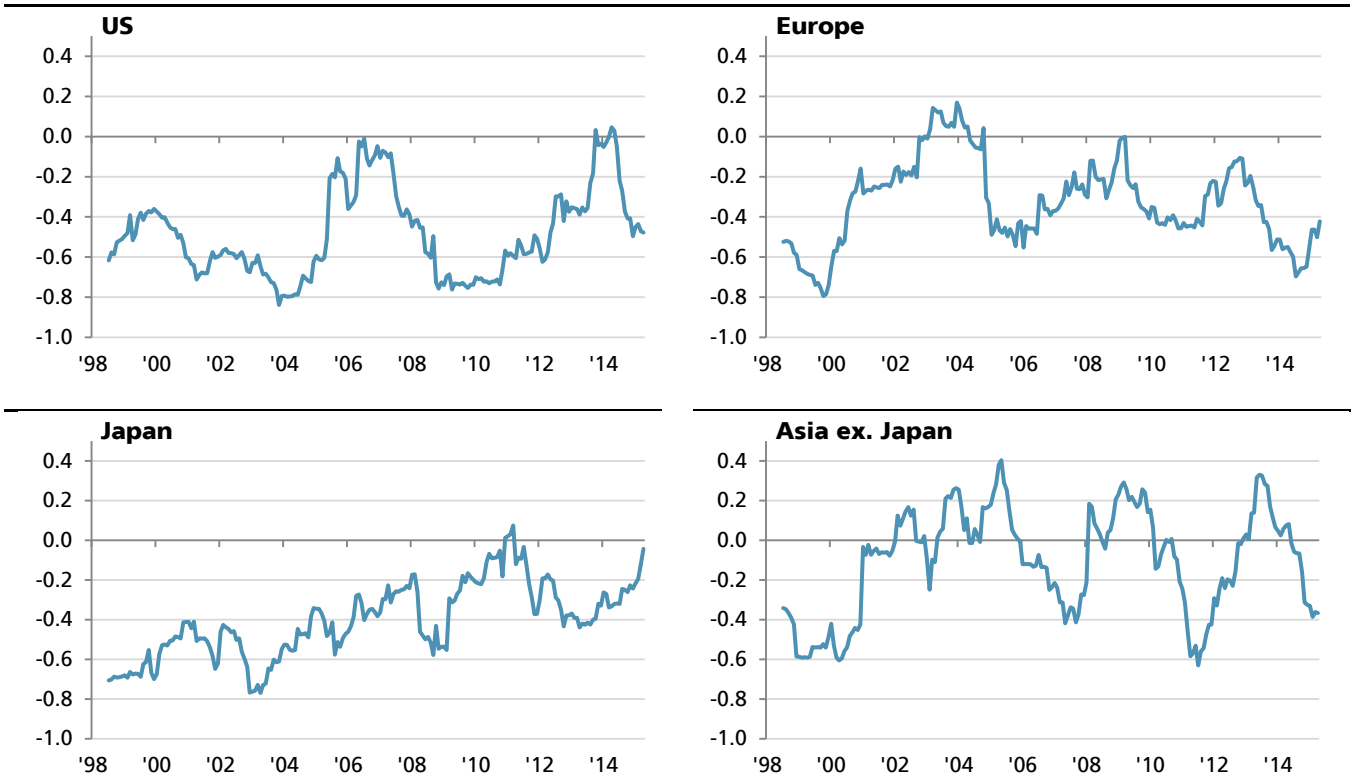
- **MSCI universe**
- **US, Europe, JP, Asia ex. JP**
- **Quality proxy: ROIC**
- **Sample: 1996M01 – 2015M04**

First, we construct a size and a quality factor per region using market capitalisation and ROIC sorts respectively at the end of each June across our sample period. Based on these univariate sorts we construct five quintile value-weighted portfolios per ranking variable. The size factor is formed as the small-minus-big quintile spread portfolio, whereas the quality factor is formed as the high-minus-low quintile spread portfolio. The composition of these portfolios remains the same between July and June of the following year, when the new round of rebalancing takes place. For additional robustness, we have also experimented with monthly rebalancing and the results remain qualitatively similar. Finally, all returns are expressed in USD.

In line with expectations, negative correlation between size and quality in most regions but Asia ex. Japan

Figure 11 presents a 24-month rolling correlation between our baseline size and quality factors. These plots should be studied alongside Figure 6 (120-month rolling beta of SMB on QMJ on a multivariate regression setting), even though there exist important methodological differences between the paper and our approach (correlation versus multivariate betas, size of the rolling window, factor construction, equity universe). After acknowledging these differences, it's important to highlight that the correlation between size and quality factor has historically been negative in the US, Europe and Japan, with, however, various periods of decoupling. Interestingly enough, Asia ex. Japan is rather different compared to the rest of the regions with correlation flipping signs so often to make any other bold statement about it.

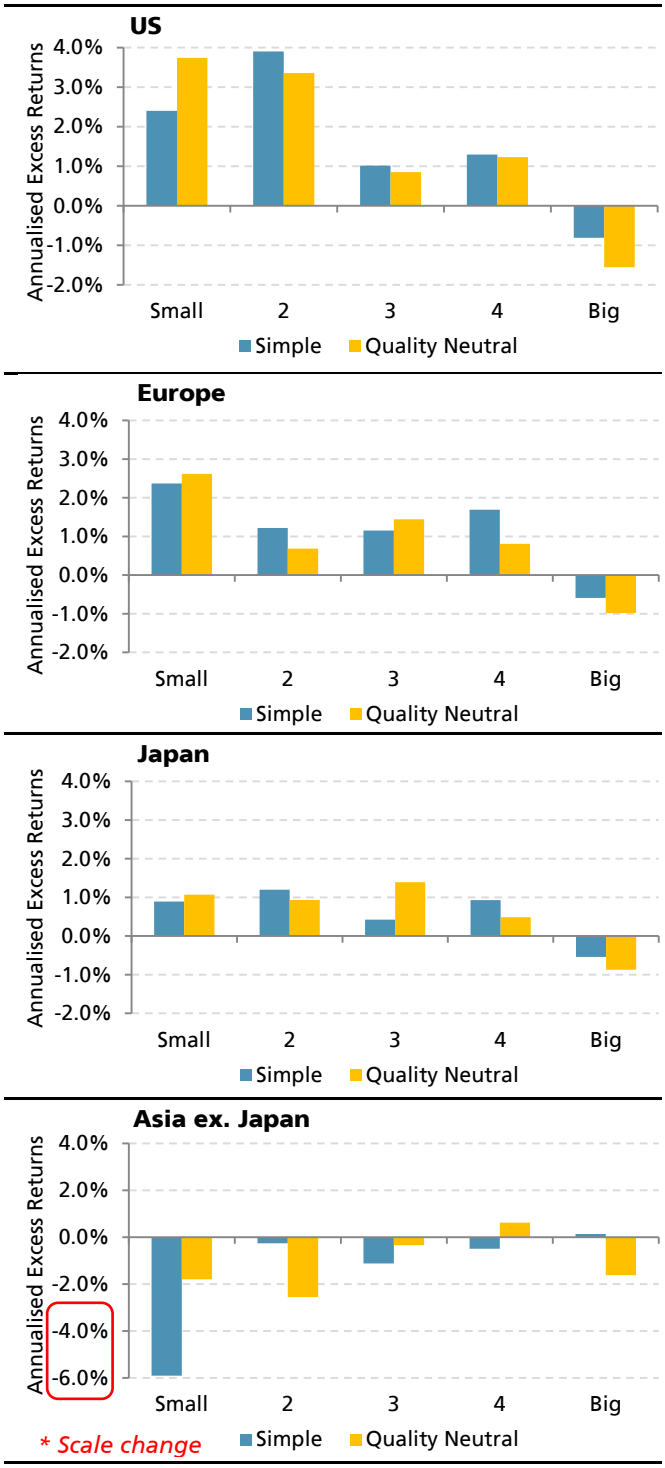
Figure 11: 24-month Rolling Correlation between Size and Quality (ROIC) factors



Source: UBS Quantitative Research. The figures present the 24-month rolling correlation between a size factor (small-minus-big quintile portfolio, based on market capitalisation at the end of June) and a quality factor (high-minus-low quintile portfolio, based on ROIC at the end of June) for four regions. The long and short sides of the factors are value-weighted portfolios and all returns are expressed in USD. The sample period goes from January 1996 to April 2015.

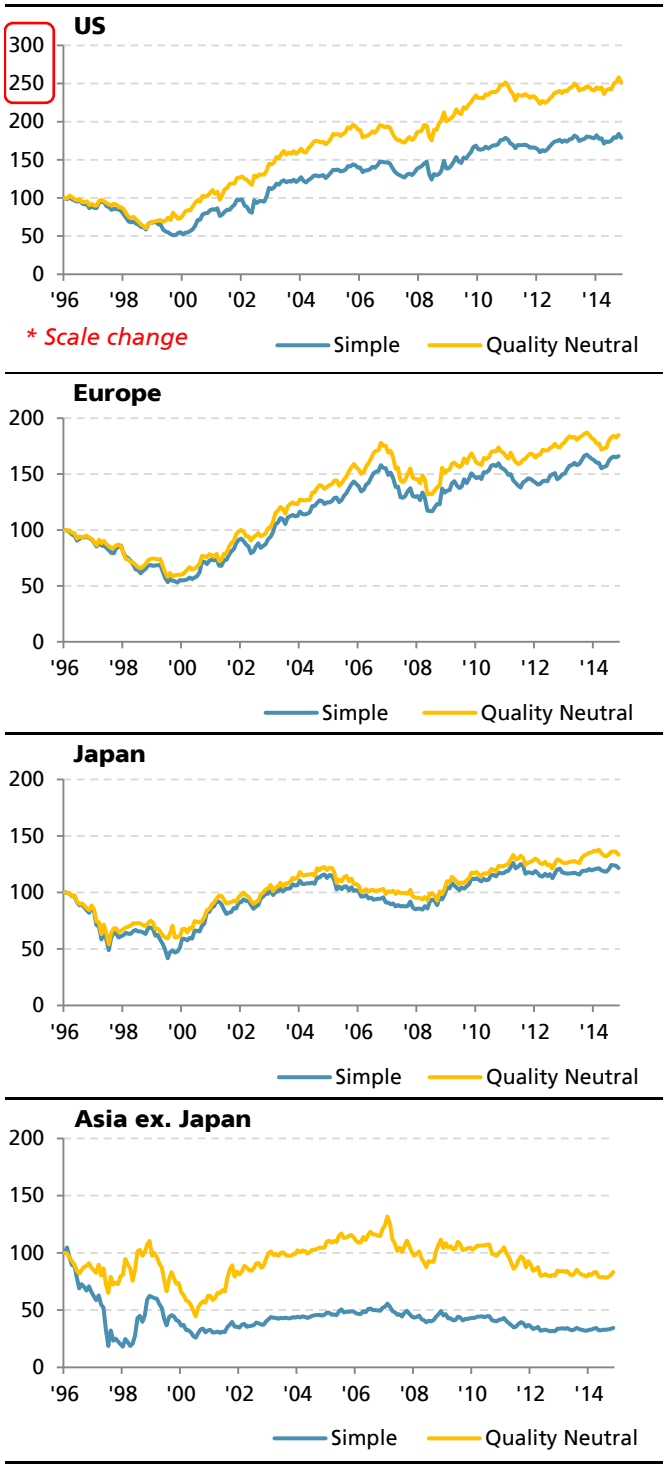
Having documented the negative correlation between size and quality in most regions (in broad agreement with the findings of the paper), we report in Figure 12 the annualised returns –in excess of the overall market for each region– of the five size quintiles before and after controlling for quality. In order to control for quality, we perform a dependent 5x5 double-sort, first by ROIC and then, within each quality basket, by size. The quality neutral size baskets consist of all stocks that appear in the respective size subset of each quality quintile.

Figure 12: Simple and Quality Neutral Size Quintiles



Source: UBS Quantitative Research. The figures present annualised returns –in excess of the overall market for each region– of five size quintiles before and after controlling for quality. In order to control for quality, a dependent 5x5 double-sort is performed, first by ROIC and then, within each quality basket, by size. The quality neutral size baskets consist of all stocks that appear in the respective size subset of each quality quintile. All portfolios are value-weighted, all returns are in USD and the sample period is from January 1996 to April 2015.

Figure 13: Cumulative Returns after neutralising quality



Source: UBS Quantitative Research. The figures cumulative returns for a small-minus-big quintile portfolio based on size, before and after controlling for quality for four different regions. The long and short sides of the portfolios are value-weighted and all returns are expressed in USD. The sample period goes from January 1996 to April 2015.

Figure 12 should be studied alongside Figure 8 even though the differences in methodology are substantial (we perform quality neutralisation using portfolio sorts instead of beta hedging against a quality factor, as this is the most natural real-life implementation of a quality-neutral portfolio). The US pattern effectively

Confirming the US finding:

Controlling for quality strengthens the size premium.

mimics the findings of the paper in that the returns decrease much more aggressively from the small quintile towards the big quintile once we control for quality (though not completely monotonically in our case). Figure 13 presents the cumulative returns of the small-minus-big portfolios before and after controlling for quality and the outperformance of the quality-neutral variant is rather pronounced over the entire sample period in the US. As reported in Figure 14 the small-minus-big portfolio achieves a statistically insignificant monthly return of 32bps (t-statistic of 1.32, using White (1980) heteroskedasticity robust standard errors), which increases substantially to a statistically significant return of 46bps per month (t-statistic of 2.20), after controlling for quality.

Similar, but statistically weak findings across the other regions

Moving to the other regions, Europe, Japan and Asia ex. Japan, we can argue that the small-minus-big spread becomes uniformly larger once we control for quality, effectively due to the negative unconditional correlation between size and quality, but, however, the results do not share the same statistical significance as in the US. It's only the quality neutral size portfolio for Europe that gets close to statistical significance –if anything– with a t-statistic of 1.58 and a p-value of 12%.

Broadly speaking, the reason why we fail to document strong statistically significant benefit can be attributed to a number of factors, like for example the smaller sample period and the fact that our equities universe (MSCI constituents) typically contains larger-cap firms, where the size-minus-big spread is by construction attenuated.

Regarding the international evidence, and in order to draw parallels to the findings of the paper that we reviewed, the authors conduct a country-specific analysis across 24 countries (see Challenge 7 in page 12) and report an increase in the SMB alpha, after controlling for the quality factor QMJ in a multivariate regression setting. The authors do not report the excess returns of the size factor before or after controlling for quality and they do not report any pre- or post-neutralisation statistics regarding the statistical significance of the findings, so we cannot directly compare our results to theirs. They simply argue that in 23 out of the 24 countries the point estimate of the alpha increases after controlling for quality, because the beta of the country SMB on the country QMJ is negative. This is in line with our findings. The size premium does indeed increase after controlling for quality.

Figure 14: Performance Statistics

		Monthly Returns	t-value	p-value
US	Simple	0.32%	1.32	0.19
	Quality Neutral	0.46%	2.20	0.03
Europe	Simple	0.28%	1.29	0.20
	Quality Neutral	0.32%	1.58	0.12
Japan	Simple	0.19%	0.63	0.53
	Quality Neutral	0.20%	0.79	0.43
Asia ex Japan	Simple	-0.01%	-0.02	0.99
	Quality Neutral	0.07%	0.18	0.86

Source: UBS Quantitative Research. The table reports the average monthly returns for a small-minus-big quintile portfolio based on size, before and after controlling for quality for four different regions. The long and short sides of the portfolios are value-weighted and all returns are expressed in USD. The sample period goes from January 1996 to April 2015. The t-statistics and the respective p-value are calculated using White (1980) heteroskedasticity robust standard errors.

Before concluding this ARM, we should spend a few lines to discuss the performance of the size style in Asia ex Japan. As shown in Figure 13 and Figure 14, the baseline size strategy has remained flat after an initial drawdown between 1996 and 2000. A possible reason for this flat performance can be the extremely non-homogenous nature of the universe, which consists of HK, Singapore, Taiwan, Australia and New Zealand. Based on our experience, the size style behaves very differently within different countries in this region. In Australia, large-cap stocks have consistently outperformed small-caps. This may be due to the market structure in this country. Several important Australian sectors are dominated by just a handful of large firms, giving them strong pricing power. This gives larger firms an advantage and makes small-minus-big a strong underperformer in this country. In contrast, in South Korea, small-cap stocks have consistently outperformed large-caps over the last 10 years. Our simple approach to building size portfolios across the entire region –hence not country neutral– might therefore be inappropriate for this particular region.

What is wrong with Asia ex. Japan?

…largely non-homogeneous

References

Asness, C. S., Frazzini, A., & Pedersen, L. H. (2014). Quality Minus Junk. *Available at SSRN* http://ssrn.com/abstract=2312432.

Asness, C., Frazzini, A., Israel, R., Moskowitz, T., & Pedersen, L. H. (2015). Size Matters, if You Control Your Junk. *Available at SSRN:* http://ssrn.com/abstract=2553889.

Ball, R., & Brown, P. (1968). An Empirical Evaluation of Accounting Income Numbers. *Journal of Accounting Research,6*,159-178.

Ball, R., Gerakos, J., Linnainmaa, J. T., & Nikolaev, V. V. (2015a). Deflating Profitability. *Journal of Financial Economics, forthcoming*.

Ball, R., Gerakos, J., Linnainmaa, J. T., & Nikolaev, V. V. (2015b). Accruals, Cash Flows, and Operating Profitability in the Cross-Section of Stock Returns. *Available at SSRN:* http://ssrn.com/abstract= 2587199

Banz, R. W. (1981). The Relationship between Return and Market Value of Common Stocks. *Journal of Financial Economics, 9*(1), 3-18.

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.

Fama, E. F., & French, K. R. (2015). A Five-Factor Asset Pricing Model. *Journal of Financial Economics, 116*(1), 1-22.

Fama, E. F., & MacBeth, J. D. (1973). Risk, Return, and Equilibrium: Empirical Tests. *Journal of Political Economy, 81*(3), 607-636.

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

Novy-Marx, R. (2013). The Other Side of Value: The Gross Profitability Premium. *Journal of Financial Economics, 108*(1), 1-28.

Sloan, R. (1996). Do Stock Prices Fully Reflect Information in Accruals and Cash Flows about Future Earnings? *Accounting Review, 71*(3), 289-315.

White, H. (1980). A Heteroskedasticity-consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity. *Econometrica, 48*(4), 817-838.

UBS Equity Quantitative Research team

UK – London

Nick Baltas	+44-20-7568 3072
Maylan Cheung	+44-20-7568 4477
Ian Francis	+44-20-7568 1872
Simon Iley	+44-20-7568 6327
David Jessop	+44-20-7567 9882
Claire Jones	+44-20-7568 1873
Manoj Kothari	+44-20-7568 1997
Leon Schelhase	+44-20-7568 2346
Simon Stoye	+44-20-7568 1876
Christine Vargas	+44-20-7568 2409

US – New York

Sebastian Lancetti	+1-203-719 4045

Hong Kong

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

UBS Equity Quantitative Research publications

Monographs

Title	Date
Cross-Asset Seasonality	Mar-15
Extending our quality model to financials	Mar-15
Where are the crowded trades?	Jan-15
Stock Selection using Machine Learning	Jan-15
Investing in Growth	Jan-15
Harvesting Cross-Asset Value	Dec-14
How to avoid 'Torpedoes'	Nov-14
US Quantitative Conference Highlights	Nov-14
What happens when volatility normalises?	Oct-14
Watch out for macro risk: the impact on China H- and A-share markets	Oct-14
Three key questions on low volatility	Oct-14
Trading around M&A announcements in the US	Sep-14
Investing in Value	Sep-14
How to avoid 'torpedoes' in Asia	Jul-14
Correlation, De-correlation and Risk-Parity	Jun-14
Risk-Parity versus Mean-Variance	May-14
Timing the US earnings yield style	May-14
Investing in Quality	Apr-14
How Asian stocks trade after earnings surprises	Mar-14
From forecasts to portfolios	Jan-14
Three reasons why high-risk underperformed	Dec-13
Trend following meets risk parity	Dec-13

Academic Research Monitor

Topic	Date
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
European Quantitative Conference 2014 Highlights	May-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
Asset pricing & skewness	Aug-13
Timing momentum & risk parity	Jul-13

PAS User Guides

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

Statement of Risk

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.

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%	37%
Neutral	FSR is between -6% and 6% of the MRA.	43%	33%
Sell	FSR is > 6% below the MRA.	12%	20%
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 31 March 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; David Jessop; Claire Jones, CFA. **UBS Securities LLC:** Sebastian Lancetti, CFA. **UBS Securities Australia Ltd:** Paul Winter; Oliver Antrobus, CFA. **UBS AG Hong Kong Branch:** Josh Holcroft.

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.

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. **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) 016/09/2014 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 SEBI Registration Numbers: NSE (Capital Market Segment): INB230951431, NSE (F&O Segment) INF230951431, BSE (Capital Market Segment) INB010951437.

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