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Quantitative Monographs

Is it easier to be a quant in small-caps?

Equities

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Quantitative

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Is it easier for quant investors in small-caps?

Over the last ten years it appears that in Europe the classic quantitative strategies would have performed better in the small-cap universe, but in the US large-cap style portfolios would have been more successful.

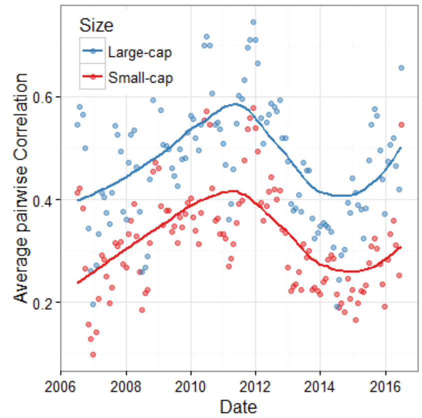
In Europe small-cap quant strategies are more effective

The breadth of the European small-cap market is much greater so there are more opportunities for investors. Also, classic quant signals seem to have greater predictive power (IC) in European small-caps vs large-caps. These effects offset the greater trading costs in small-caps (under our costs model), making small-cap quant strategies more successful in Europe.

Large-cap quant strategies more successful in the US

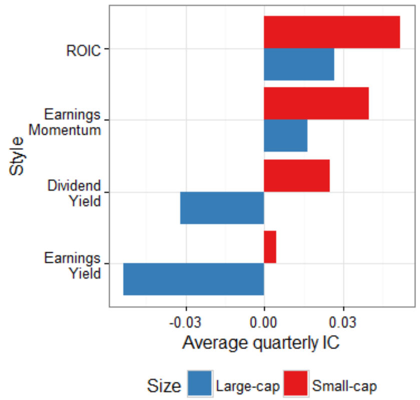
The effects of greater breadth and higher ICs are smaller in the US than in Europe, and are not enough to offset the impact of the higher trading costs which US small-cap investors face. This means quant strategies look less attractive in small-cap US.

Figure 1: European small-caps have greater breadth …



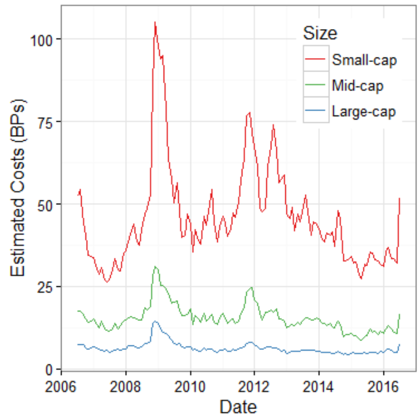
Source: UBS Quantitative Research

Figure 2: and higher information coefficients …



Source: UBS Quantitative Research

Figure 3: … but also higher trading costs than large-caps



Source: UBS Quantitative Research

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Summary

Are quantitative strategies more effective in a small-cap universe?

Investors sometimes ask us if quantitative strategies are more effective in small-cap universes than in large-cap universes. There is some motivation for this idea. Small-cap markets do appear to be less efficient than large-cap markets in some respects. For example, some quantitative signals, such as the earnings announcement drift, seem to have a longer half-life amongst small-caps than large-caps. Theoretically, that should make it easier for quantitative strategies to identify mis-pricings amongst small-cap names, and hence for quant strategies to perform better there than in large-caps.

In this note, we examine some empirical evidence to address this question. We start from the fundamental law of active management which states that:

$$\text{Information ratio} = \text{information coefficient } \times \sqrt{\text{breadth}}$$

This implies that there are two factors which affect the performance of a strategy:

i) **Information coefficient** (IC) of your signal

ii) **Breadth** of your universe (how many independent bets there are)

to which we would add a third:

iii) **Trading costs**

To answer whether it is easier for quantitative investors in small-cap or large-cap universes, we've broken down our analysis into parts based on these three categories.

Small-cap universe = higher trading costs, higher breadth and higher ICs

As you would expect, in both the US and Europe, trading costs are much higher amongst small-cap stocks. This difference in trading costs has narrowed in recent years, but there is still a big gap, which makes it harder for small-cap investors.

The breadth of the small-cap universes is higher in both the US and in Europe, but the difference is much more pronounced in the European universe. The information coefficient of traditional quantitative strategies, like value or price momentum, are typically higher in the small-cap universe than amongst the large-cap names. However, again, we find that this gap is more pronounced in Europe.

Some evidence that quant investing has been more effective in European small-caps …

In Europe, we find that, overall, the negative impact of the higher trading costs that small-cap investors face is offset by the higher breadth and greater predictive power of traditional quantitative signals in that universe. It appears that, over the last ten years, quantitative investors probably would have been more successful in the small-cap universe.

… but not US small-caps

This did not hold true in the US. There, it appeared that the higher trading costs are not fully offset by higher ICs and higher breadth of the small-cap universe. It seems that over the last ten years, most traditional quantitative investors would probably have done better in large-caps rather than small-caps.

Data

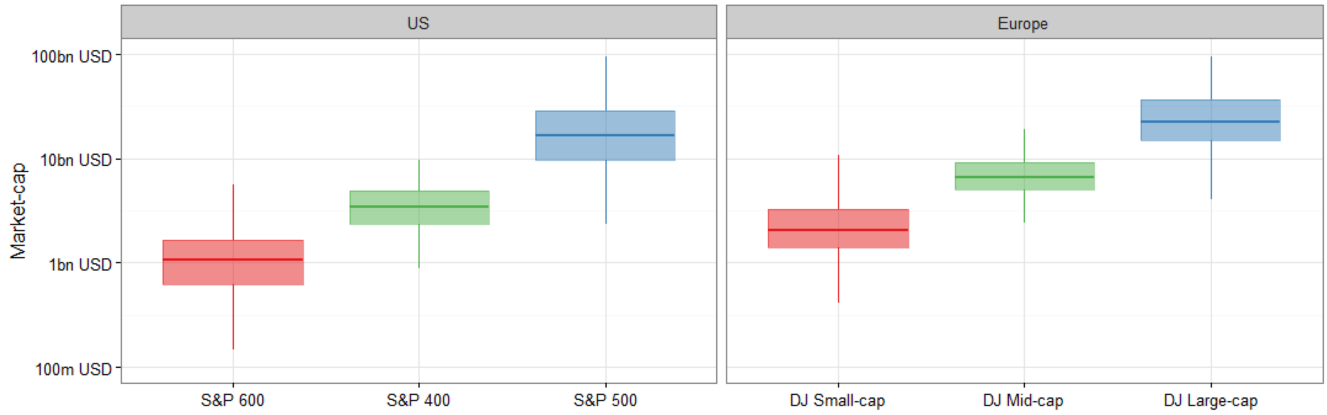
We consider a European universe and a US universe of stocks. For the European universe we define our size baskets as the European constituents of the Dow Jones small-cap, mid-cap and large-cap indices. For the US, our universe is the S&P 1500, which consists of the S&P 500, the S&P mid-cap 400 and the S&P Small-cap 600.

Europe = European constituents of DJ small, mid and large-cap

US = S&P 500, S&P 400 and S&P 600

Figure 4 shows the distribution of market caps amongst the various universes. The S&P small-cap 600 has a median market cap of around 1bn USD, the mid-cap market cap is typically around 3.4bn and the S&P 500 stocks have a median market cap of roughly 15bn USD. The European universe is slightly narrower than the US universe. The European small-cap stocks have a median market cap of around 2bn USD compared to 6.7bn USD for mid-caps and 24bn USD for large cap stocks.

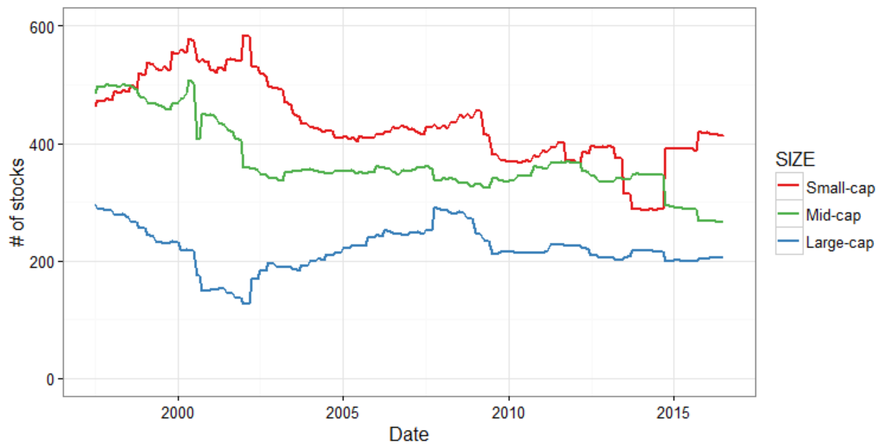
Figure 4: Box-plots showing the distribution of market-caps of small, mid and large-cap universes



Source: UBS Quantitative Research. Data is as of 30th June 2016. Please note the log scale.

While the number of stocks in the S&P indices is fixed, the number of stocks in the European size baskets can change through time, as Figure 5 illustrates.

Figure 5: Number of stocks in the European size baskets



Source: UBS Quantitative Research

Breadth

The breadth of a universe does not have a standard definition, but we have tried to proxy for breadth in three different ways:

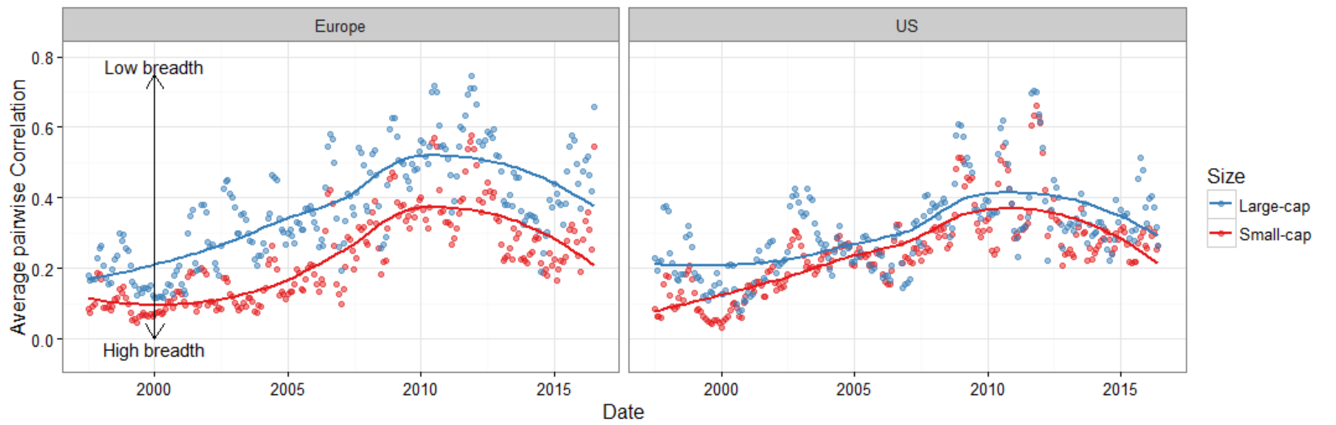
i) **Average pairwise correlation** of stocks – if all the stocks move together, that suggests low breadth.

ii) **Diversification ratio**, which is the ratio of the risk of the portfolio assuming no diversification to its actual risk, i.e. $\sum_i \sigma_i w_i / \sqrt{w^T \Sigma w}$ – a lower diversification ratio suggests lower breadth.

iii) **Absorption ratio**, which is the proportion of the cross-sectional risk which can be explained by the first 10 statistical risk factors – a higher value suggests lower breadth.

Figure 6 shows the average pairwise correlation in each size basket. There is a long-term trend of increasing pairwise correlation in the markets (although this has slipped back somewhat since 2010) but small-cap stocks consistently co-move less than large-cap stocks. This difference is more pronounced in Europe than in the US.

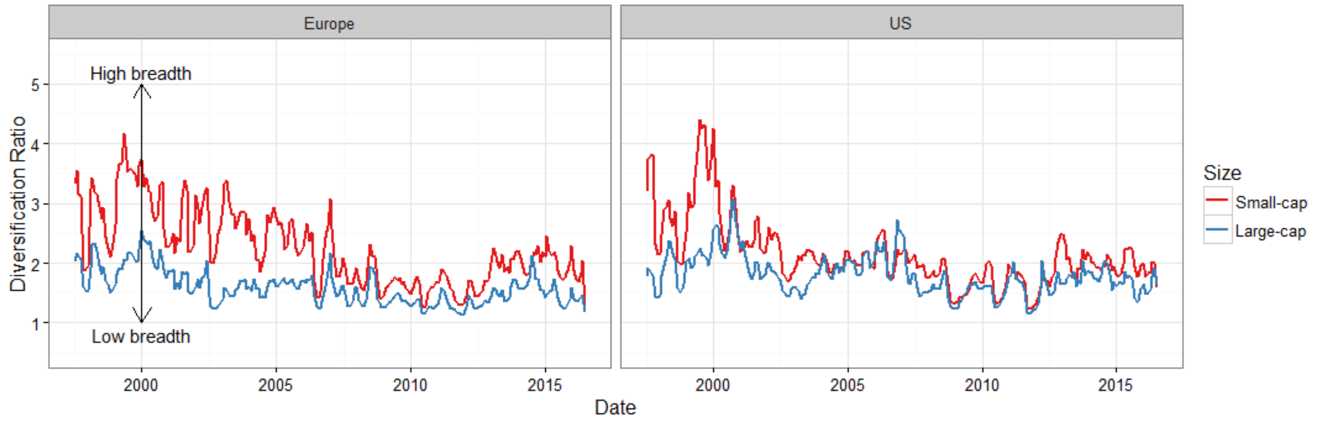
Figure 6: Average pairwise correlation in large-cap and small-cap markets



Source: UBS Quantitative Research, correlation is computed with daily data over the previous quarter

Figure 7 shows the diversification ratios through time and in each universe. This is nearly always higher amongst small-cap stocks than amongst large-cap stocks. This suggests that diversification is having a greater impact amongst small-cap stocks and hence that these names have a higher breadth. However, the gap in diversification ratios between the small-cap and large-cap universes has reduced in recent years, particularly in the US – it appears that the difference in breadth is reducing. This is not surprising given that the average pairwise correlation has increased through time (see Figure 6).

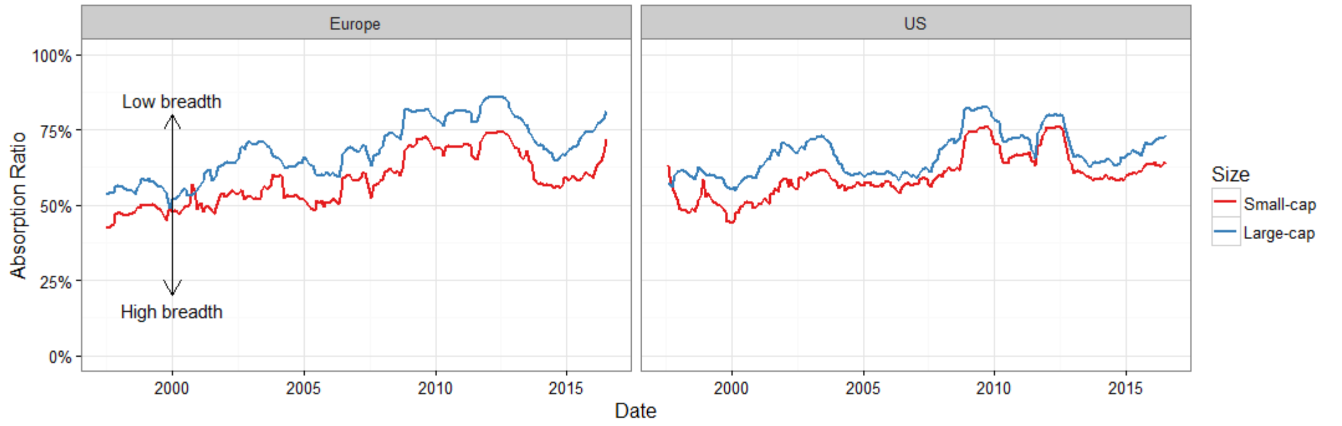
Figure 7: Diversification ratio in large-cap and small-cap markets



Source: UBS Quantitative Research, the diversification ratio is a measure of how much higher the risk would be without the effect of diversification, ratio is estimated using the previous quarter of daily returns.

The absorption ratio measures how effective a simple statistical cross-sectional risk model would be in that universe. A lower value suggests the risk model would be less effective and implies that universe has a higher breadth. As Figure 8 illustrates, it is clear that the small-cap universes tend to have a higher breadth, but the difference is again more clear-cut in Europe than in the US.

Figure 8: Absorption ratio in large-cap and small-cap markets



Source: UBS Quantitative Research, the absorption ratio is the proportion of the cross-sectional risk explained by the first 10 statistical risk factors

In every case, it appears that the small-cap names have greater breadth than the large-cap names, which suggests that there are greater opportunities for small-cap investors, but the difference is much less pronounced in the US.

Small-caps appear to have greater breadth, but the difference is smaller in the US

Costs

There are very different trading costs amongst the small-cap and large-cap universes and this can have a big impact on the performance of investment strategies, but unfortunately, it is difficult to estimate costs exactly. For any number of reasons, different investors face different trading costs and it is hard to give estimates for costs that will be relevant to both small, high frequency investors and to billion dollar funds that trade over the course of weeks or months.

We have tried anyway. We use a very simple costs model to try and estimate the costs faced by investors in each universe back through time[1]. While these costs may differ from costs a particular investor faces, the overall analysis, and in particular how our estimated costs change should still be meaningful.

Technical details of our costs model

We use a costs model discussed in Almgren et al's paper *Direct Estimation of Equity Market Impact,* May 2005. They use five key inputs to estimate the cost of a trade:

i. The **bid-ask spread (BA)**, a direct measure of charges made to the investor to buy or sell

ii. **Volatility (σ)**, if the stock is more volatile, then the price is more likely to move during execution, which leads to higher costs

iii. **Order size ($\frac{X}{V}$)** as a proportion of the average daily trading volume (ADV), larger orders tend to have bigger price impacts

iv. Length of **time (T)** allowed to complete the order, if an investor demands faster execution he will need to pay more for the privilege. For this analysis, we assume all trades are executed over the course of one day.

v. The **inverse turnover ($\frac{\phi}{V}$)**, which is the inverse of the ADV as a proportion of the shares outstanding. There will typically be less price impact with more liquid companies

They divide the price impact into two categories, permanent and temporary, giving us this model:

Figure 9: Almgren et al's Cost Model

I) $$Permanent\ price\ impact = 0.314 \cdot \sigma \cdot \frac{X}{V} \cdot \left(\frac{\Phi}{V}\right)^{0.25}$$

II) $$Temporary\ price\ impact = \frac{1}{2} \cdot permanent\ price\ impact + \mathrm{sign(X)} \cdot 0.142 \cdot \sigma \cdot \left|\frac{X}{V \cdot T}\right|^{0.6}$$

III) $$Other\ costs = 0.5\ \cdot\ BA$$

Source: Almgren et al, Direct Estimation of Equity Market Impact, May 2005

This is, of course, a simplification. There are many more factors which influence the cost to trade and for institutional investors very large trades will often be block traded, which introduces different dynamics.

Estimated costs through time

As an illustration of the costs investors face in small and large-cap universes we have estimated the median cost of buying a $250,000 of each stock in a day. Figure 10 and Figure 11 show our estimates in the European and US universes respectively.

As a sanity check, we have also plotted the estimated cost to trade in each region and year discussed in Frazzini, Israel and Moskowitz's 2012 paper "Trading Costs

[1] For a more detailed discussion of trading costs please see our Apr '15 note "Costs as a style factor"

of Asset Pricing Anomalies"[2]. This is the black line on the charts. Our costs appear comparable.

Figure 10: European cost estimates – how much does it cost to by $250,000 of a stock in a day?

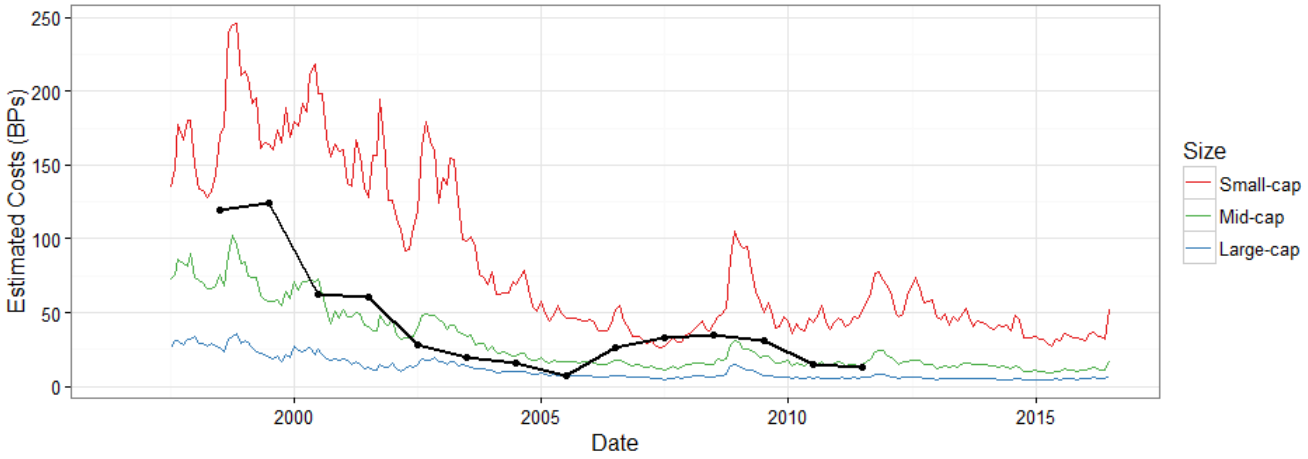
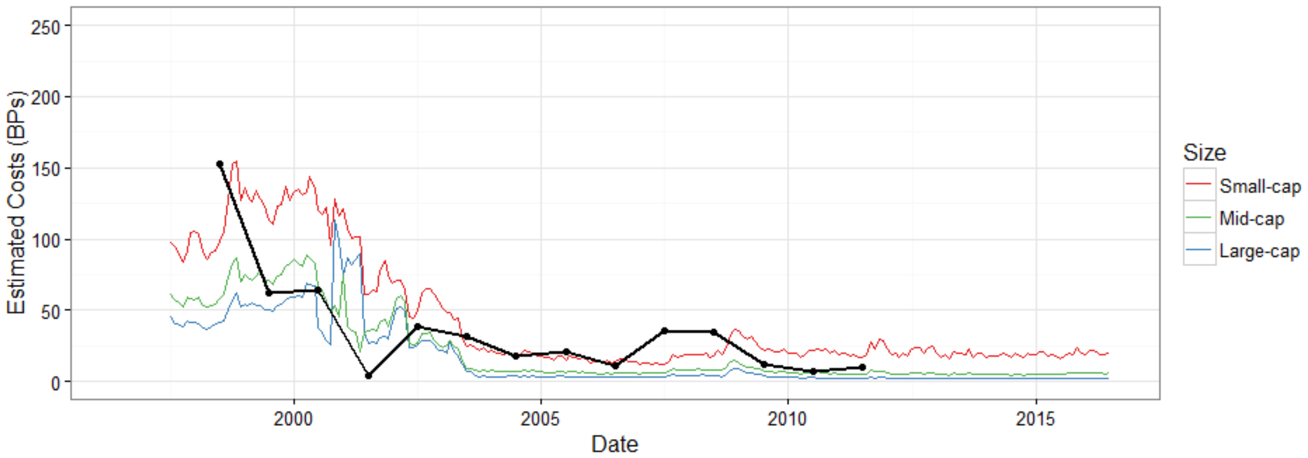


Figure 11: US cost estimates – how much does it cost to by $250,000 of a stock in a day?



Source: UBS Quantitative Research & "Trading Costs of Asset Pricing Anomalies" by Frazzini A., Israel R. and Moskowitz, T, 2012

The coloured lines show the median estimated cost to buy $0.25m in each stock in the index in one day, based on our costs model. We have deflated this dollar value back through time by the index price level. We also drop stocks from our estimates where $0.25m represents more than 30% of ADV. The black line shows the value weighted average cost of trades, either in the International markets (for the European chart) or the US markets (for the US chart) over the course of the year, taken from Frazzinni et al.

As expected, the typical trading costs in the small-cap universe are considerably higher than those in the large-cap universe. This is a significant negative for investors considering investing in small-cap names.

The costs in both the small and large-cap universes have fallen considerably over the last 20 years, but have stabilised since 2005. Given this radical shift in costs, most of our subsequent analysis will focus on the previous 10 years.

Figure 12: Estimated trading costs in 2016 for small / mid / large-caps

	US	Europe
Small	20	36
Mid	6	12
Large	2	6

Source: UBS Quantitative Research

[2] For a summary of this interesting paper, please see our review in the Feb '15 edition of the Academic Research Monitor, "Smart betas, Factors and Style Investing".

Isolate the effects of breadth and costs

We are considering each of the three possible causes of differences in the performance of quant strategies in the size bands (breadth, costs, information coefficients), but before we move on to the final cause (ICs), we want to examine the effects of breadth and costs in a little more detail. To try and isolate the impact of breadth and costs we have analysed some simulated results.

We create random signals in each universe with a given expected information coeffcient and see how portfolios generated with these signals perform. Any differences in the gross performances between size bands show the effect of breadth and any differences in the net performances show the combined effects of breadth and costs.

Here is the algorithm we use for our simulations:

i. Create an artificial signal[3] with a given expected information coefficient.
   - Signal = future return + noise

ii. Create a portfolio using that signal with some simple portfolio construction rules
   - Top 50 names, but with a buffer at top 100 i.e. we only replace a name in the portfolio if it falls out of the top 100 names
   - Equal weighted
   - Rebalanced quarterly

iii. Simulate the returns to the portfolio, on both a gross and a net basis (where we assume costs based on an initial 50m USD investment).

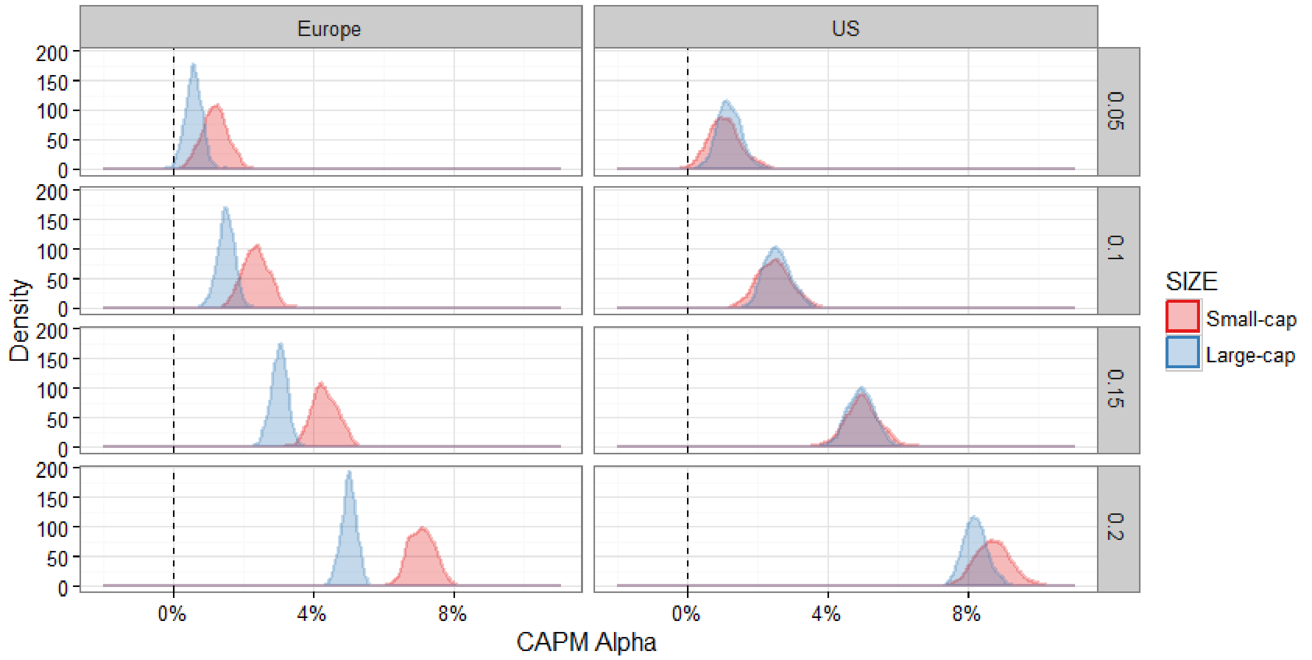
We run the algorithm 500 times to see the distribution of the gross and net CAPM alphas with different expected ICs.

Effect of breadth

Figure 13 shows the distribution of the gross CAPM alphas and hence shows the effect of breadth on its own. In Europe, the small-cap portfolio nearly always has a higher CAPM alpha than the large-cap alphas, at every level of IC. In the US, the gap between the CAPM alpha in the two universes is much smaller, with the gap only really opening up at higher levels of IC. This is because there is a much smaller difference in breadth between the US small and large-cap universes.

[3] For more details about how we create these signals please see the appendix.

Figure 13: Distribution of gross CAPM alpha with different expected ICs

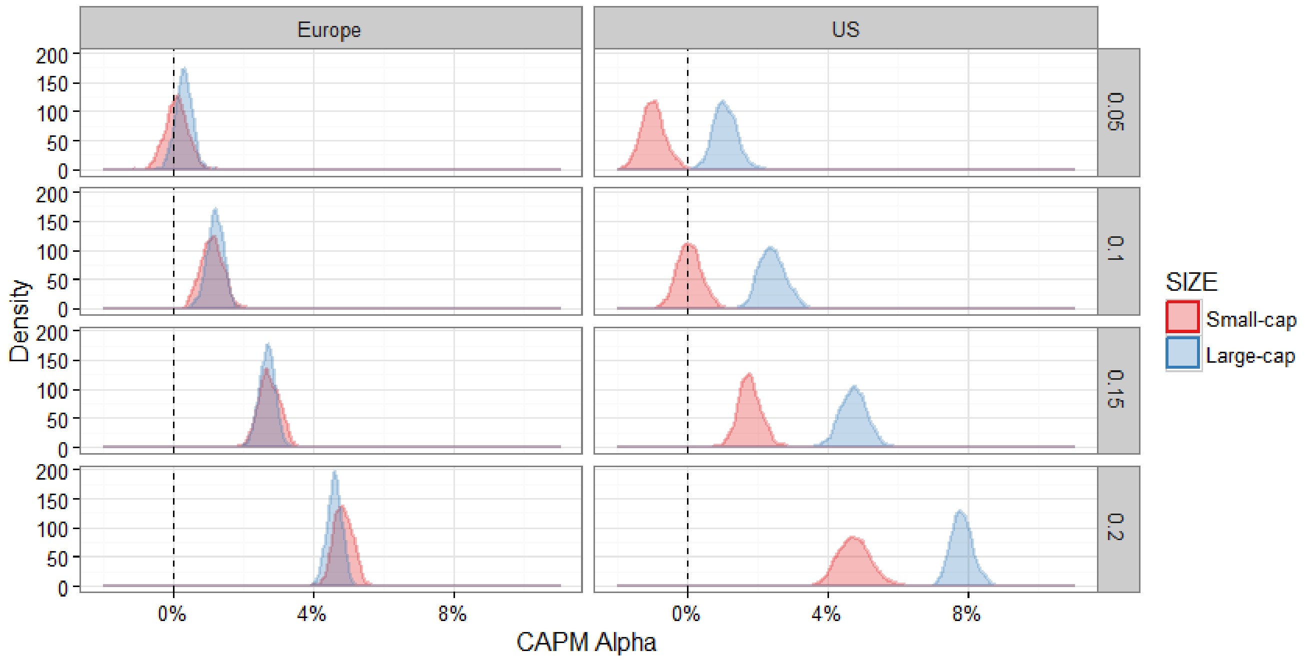


Source: UBS Quantitative Research, our sample time period is Jan 2005 to Dec 2015.

Effects of breadth AND costs

If we repeat the analysis again, but this time incorporating trading costs into our estimates for portfolio performances then we can see the combined effect of breadth and costs. This is shown in Figure 14. In Europe, it looks like the higher costs that small-caps face cancels out the effect of their greater breadth, so that the small-caps and large-caps perform broadly in-line. In the US, where small-caps had only a small lead on a gross basis, the large-caps dominate after costs.

Figure 14: Distribution of net CAPM alpha with different expected ICs



Source: UBS Quantitative Research, our sample time period is Jun 2006 to Jun 2016

Information Coefficients

Quantitative Signals

The last piece of the puzzle is the information coefficients of quantitative investment signals in the small-cap and large-cap universes. We look at 20 of the classic styles used in quantitative investing. These are all factors which are commonly discussed and used in factor screens, including value, growth, momentum, quality and risk styles.

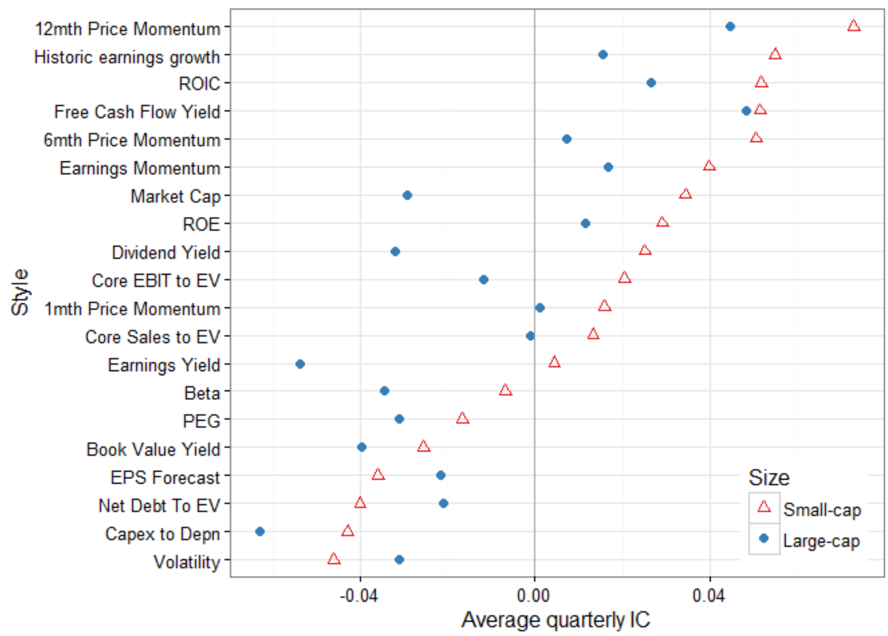
Figure 15: Our styles

Style Family	Style	Style Family	Style
Value	Earnings Yield	Growth	EPS Forecast Growth
	Book Value Yield		Historic earnings growth
	Core EBIT to EV		PEG
	Dividend Yield	Momentum	1 mth Price Momentum
	Free Cash Flow Yield		6 mth Price Momentum
	Core Sales to EV		12 mth Price Momentum
Quality	ROE		Earnings Momentum
	ROIC	Risk	Volatility
	Net Debt To EV		Beta
	Capex to Depn	Size	Market Cap

Source: UBS Quantitative Research

The Information Coefficient (IC) is the correlation between your signal and the future return. A higher IC suggests your style is more reliable and useful as an investment signal. However, be cautious: for some styles, we *want* a negative IC. For example, we typically buy low volatility stocks, so we want low volatility to be associated with outperformance and vice versa.

Figure 16: European Average Quarterly ICs

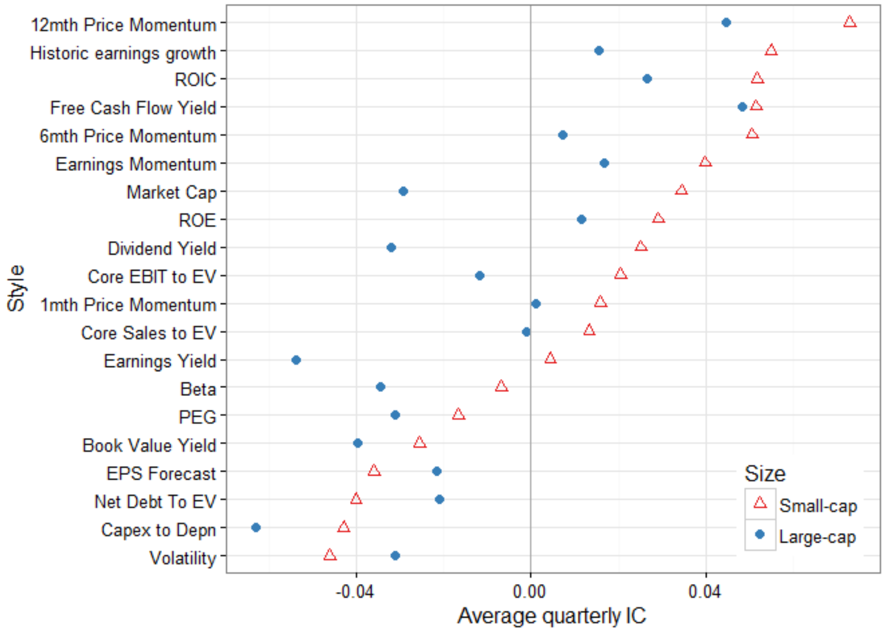


Source: UBS Quantitative Research, our sample time period is Jun 2006 to Jun 2016. For illustrative purposes only

Most styles have better ICs amongst European small-caps than European large-caps

Taking this directionality into account, it looks like 15 out of our 20 styles had a better average quarterly IC amongst small-cap stocks than amongst large-caps over the last ten years in Europe. Quant signals appear to have been more reliable amongst small-caps here.

Figure 17: US Average Quarterly ICs



Source: UBS Quantitative Research, our sample time period is Jun 2006 to Jun 2016. For illustrative purposes only

Gap in ICs is narrower in the US

As Figure 17 illustrates, it appears that quant signals have had lower ICs in the US than in Europe, in both the small-cap and large-cap universes, over the last ten years. Also, while the average quarterly ICs were typically higher amongst small-caps, the gap between the large-cap and small-caps average ICs is much narrower.

Quantitative strategies

Finally, we examine the performance of quantitative strategies in the small-cap and large-cap universes by building portfolios of stocks by each style.

Create style portfolios

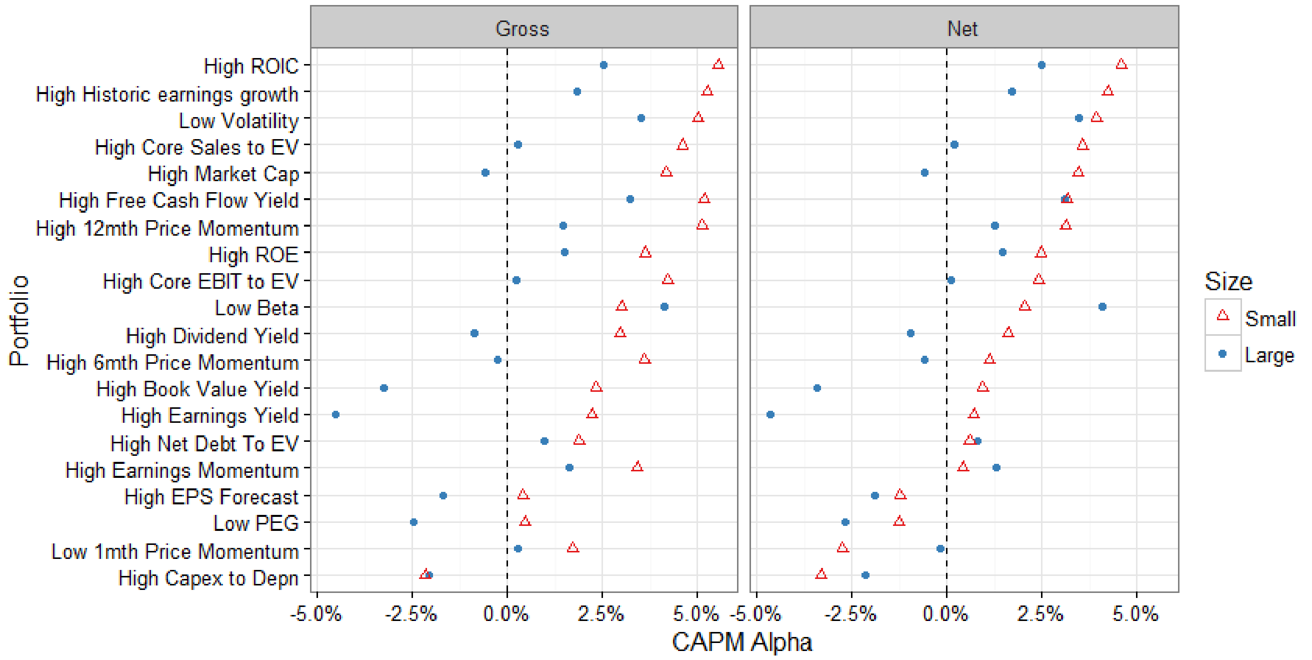
The portfolios are:

- Long only
- Thirds e.g. top third by earnings yield
- Cap weighted
- Rebalanced quarterly

We assume that we start our portfolios with an initial investment of $50m in June 2006. This is important for our trading costs estimations.

Figure 18 shows that, In Europe, all but two of the strategies would have outperformed in the small-cap universe over the large-cap on a gross basis, but, after costs have been taken into account that drops to 15 out of the 20 strategies.

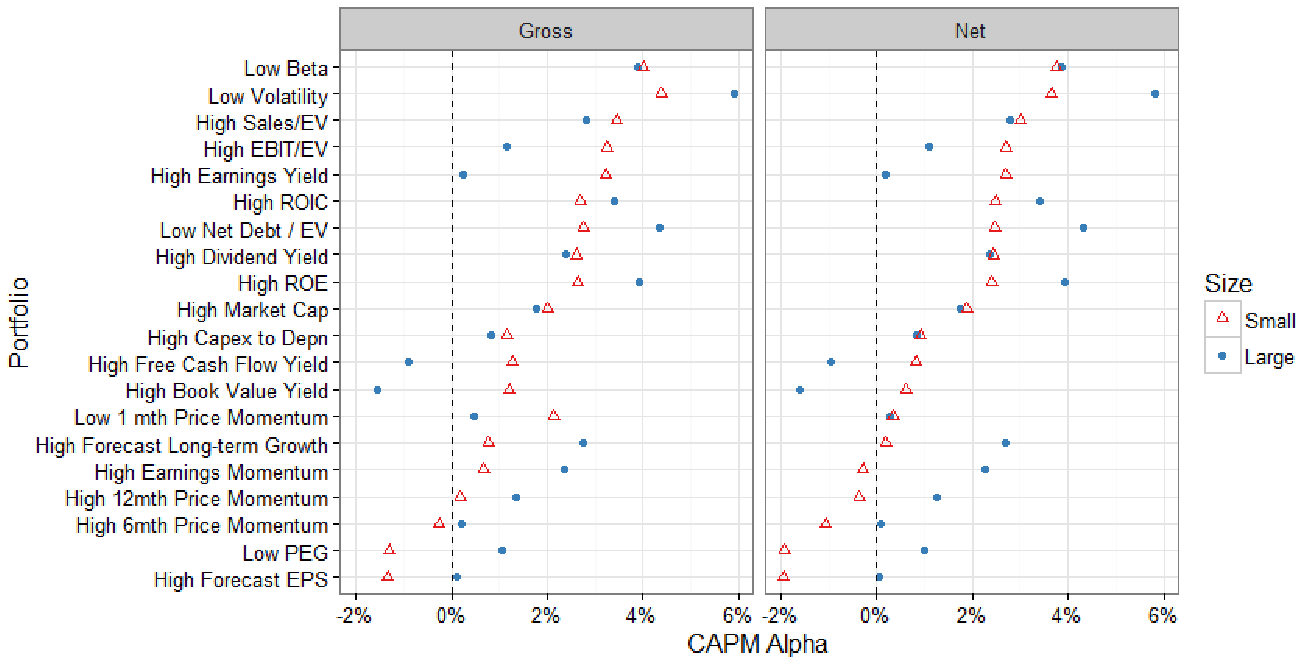
Figure 18: Europe, CAPM alpha of strategies in small-cap and large-cap universes



Source: UBS Quantitative Research, our sample time period is Jun 2006 to Jun 2016, CAPM alpha is versus the overall benchmark i.e. DJ Europe or S&P 1500. For illustrative purposes only

In the US, as Figure 19 illustrates, the small-cap strategies would not have been as successful. Only half of the small-cap portfolios would have outperformed their large-cap peers on a net basis, and that falls to just 8 out of 20 once we look at the net returns.

Figure 19: US, CAPM alpha of strategies in small-cap and large-cap universes



Source: UBS Quantitative Research, our sample time period is Jun 2006 to Jun 2016, CAPM alpha is versus the overall benchmark i.e. DJ Europe or S&P 1500. For illustrative purposes only

It seems that European quantitative investors would probably have found the small-cap universe easier than the large-caps, over the last ten years, but this would not have been true in the US.

Conclusions

Small-cap styles were often more successful in Europe, but in the US large-cap quant styles outperformed.

Are there more opportunities for quantitative investors in the small-cap universe? Looking at the historic performances of classic quantitative strategies, it appears that, for Europe small-cap style portfolios would have performed better, but in the US, the large-cap style portfolios would have been more successful.

Performance = breadth + IC + trading costs

To understand what is driving this difference we break the performance of quantitative strategies down into three parts: the breadth of the universe, the information coefficient of the signal you use to build your portfolios and the trading costs you face.

In Europe, higher costs are offset by greater breadth and better ICs …

For European investors, the greater trading costs which a small-cap investor faces appear to be offset by the greater breadth amongst the small-caps and the higher ICs which the traditional quantitative signals achieved in the small-cap universe. Overall, the majority of the European small-cap styles would have been more effective than their large-cap counterparts.

… but not in the US

The US small-cap universe is also broader than the large-cap universe, but only slightly. The ICs of the classic quantitative signals in the small-cap universe do tend to be higher, but again, only slightly. It appears that the effects of greater breadth and higher ICs are smaller in the US than in Europe, and are not enough to offset the impact of the higher trading costs which US small-cap investors face.

Appendix

Generating random signals with a given IC

We define our signal as the sum of the future return and a noise term which is independent and normally distributed with mean zero and variance σ_{noise}^2:

$$signal_t = r_{t,t+1} + noise_t \text{ } where \text{ } noise \sim N(0, \sigma_{noise}^2)$$

The correlation between our signal and the future return is:

$$\rho_{r,signal} = \frac{cov(r, signal)}{\sigma_r \sigma_{signal}} = \frac{cov(r, r + noise)}{\sigma_r \sigma_{r+noise}} = \frac{\sigma_r^2}{\sigma_r \sqrt{\sigma_r^2 + \sigma_{noise}^2)}}$$

If we set the variance of the noise term to be:

$$\sigma_{noise}^2 = \frac{\sigma_r^2(1 - x^2)}{x^2}$$

Then the correlation simplifies down to x.

So, by careful choice of the variance of noise term, we can create a random signal with a given expected Information Coefficient (here called x).

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