Forward-looking estimates of factor risk and return

In this paper we explore how much 'juice' is left in factors and how their performance profile may change in the future.

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EXECUTIVE SUMMARY

Many investors either currently hold factor-based investing (FBI) strategies or are considering investments in this area. To understand the attractiveness of such strategies they need to understand their expected return and risk. In this paper we give a framework for estimating factor risk and return. We apply it to five major equity factors commonly in use today – size, value, low risk, momentum and quality but the framework is more widely applicable to other possible factors.

Our key messages are:

- Past performance is only a guide to understanding factor returns. We believe it is prudent to assume lower performance from factors than that has been achieved in the past, largely due to data mining biases in academic studies and informed trading effects after publication of the factor.
- To mitigate these issues one could consider only a factor's performance after publication of the factor in an academic journal. Another approach is to take an academic study's factor return data (which is considered "in-sample") and "haircut" its published risk efficiency. Based on the literature and our own findings we believe that a 50% haircut to in-sample risk efficiency seems reasonable. These two approaches can be combined to get a more statistically-robust estimate for future performance than either alone.
- Much uncertainty remains - our approach only takes into account historic performance of a particular implementation of a factor. This means a wide range of beliefs remain justifiable. But we suggest that a long-only portfolio equally weighted across the five factors might expect to outperform the market index by around 1% per annum, before costs and fees, with volatility around 5% lower[1] than the market cap index. This is based on using deliberately simple factor construction methodology - more advanced approaches could be ascribed higher returns (akin to alpha/active manager outperformance).
- Lastly, we find no evidence that the ability to short stocks increases risk-adjusted performance when focusing only on large and mid-cap stocks. Given that shorting small caps may be challenging and costly (if not practically impossible), this indicates that long-only investors are, in general, not missing out from the decision to avoid shorting stocks.

1. In a relative sense i.e. multiply the market cap index volatility by 0.95

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A RECAP ON EQUITY FACTORS

Factor-based investing seeks to identify the underlying characteristics that drive performance and allocate to strategies exposed to those same characteristics. In equities, some of the common factors that have been identified over the past 50 years come under the labels of size, value, low risk, momentum and quality. A description of these can be found in the appendix and in one of our previous papers.[2] Each factor has a possible combination of reasons – structural, behavioural and risk-based – that may explain why that factor exposure may be rewarded and generate excess return. However the natural question to ask is how much more? And how much additional risk needs to be taken to achieve these returns?

DEFINING FACTOR RETURNS

When measuring factor returns, we generally begin with the return to a portfolio of stocks exposed to that factor. For example, for the case of the value factor, we would form a portfolio of stocks that all score highly on a value variable like book-to-price. However, the returns of this portfolio will be heavily influenced by general market movements and not how value stocks perform in relation to the broader market. In order to accurately isolate the impact of the factor alone, we use a process known as 'beta-neutralisation'. This process effectively goes short an amount of the market cap index alongside the portfolio of value stocks such that market returns are hedged out and the pure value factor return is all that remains.[3] By studying these beta-neutralised returns we can understand the degree to which a factor offers rewarded risk.

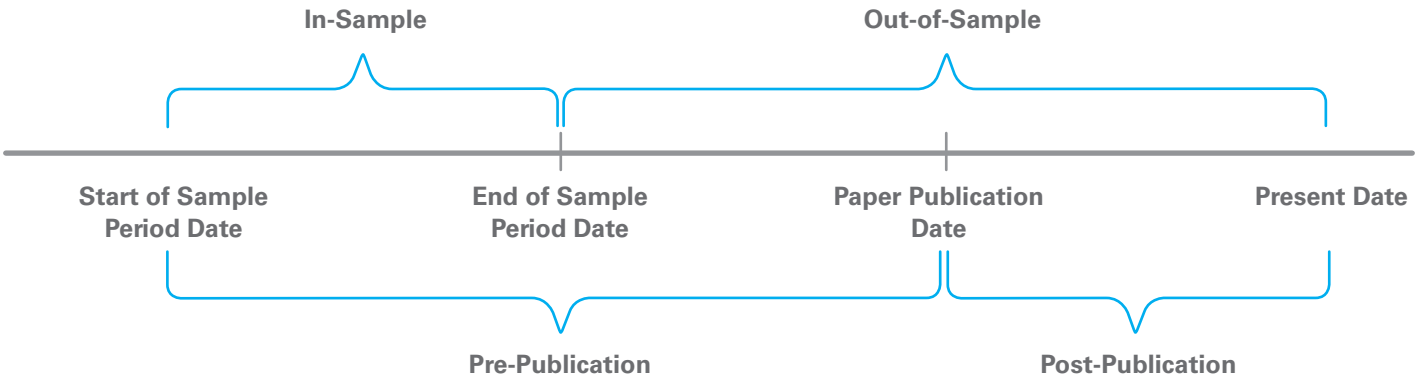
The process above is slightly different from standard academic practice where instead of the short market cap index position, a short portfolio of stocks that are least exposed to a factor is used instead (e.g. the stocks that score the lowest on the book-to-price variable). This would lead to a portfolio that is long the stocks most exposed to a factor and short those stocks least exposed. We recognise that most of our clients will not invest in strategies that short individual stocks and hence we avoid this in our process. Later on we show that the choice in the short leg, the decision whether to short individual stocks or to short a market cap index, doesn't actually affect risk efficiency greatly for large/mid-cap focused strategies (which is the market segment most investors are concerned with).

There is also, of course, a lot of choice on how to define and implement a factor even when one has put aside the 'short-market' or 'short-stocks' decision. There are many design choices involved in creating a factor portfolio, for example the selection of the top 20% of stocks exposed to a factor versus selection of the top 30%, the different ways to define factors (e.g. book-to-price or earnings-to-price) or the various methods possible in weighting the selected stocks (e.g. equal-weighted or market cap-weighted). We have tried to take a deliberately simple approach for the five major equity factors – our data sources are given in the appendix with most factors following the Fama-French methodology.[4] More advanced approaches may result in higher returns which could be justified to persist through time though this would be akin to 'alpha' (or active manager outperformance of a simple factor benchmark).

PAST PERFORMANCE – ONLY A GUIDE

Figure 1 below shows the various dates involved that are potentially significant to factor performance.

Figure 1. Significant dates to factor performance



2. See **"The Rise of Factor-Based Investing"** by A Das & A Pioch, LGIM, November 2016
3. This effectively causes the factor returns to have a beta of zero, hence the term "beta-neutralised".
4. For a description see **Kenneth French's data library**

When a paper is written it will look at some historic window of time to base its conclusions on. This window of returns is called the in-sample period. Everything after this period is out-of-sample. Sometime after the end of sample period date, the paper will be published. This is another important date; data after this date is considered 'post-publication'.

There are three potential reasons that performance in the in-sample period may not be representative of future performance. These are:

- **Data-mining bias:** Data-mining is the practice of trawling through historical data in an effort to find significant patterns. Particularly with the advent of modern computing, this enables a researcher to conduct numerous tests on historical data. If the number of tests conducted is not taken into account then this can lead to obtaining many seemingly significant results which are really just due to pure chance. It is often difficult to conclude just how many different tests have been conducted when reading an academic paper. Hence there remain possible data-mining biases in these studies.

- **Informed trading:** as investors become increasingly aware of the existence of a rewarded factor, the factor may become less profitable relative to the past as investors attempt to exploit the factor. We note though that those factors that are driven by a risk-based argument, e.g. size and value, which tend to be riskier than stocks in the broader market, may continue to be rewarded even as awareness of factors increases. This is because these factors are rewarded in part due to simply carrying more risk.

- **Survivorship bias:** the factors investors focus upon today may just be the ones lucky enough to continue to perform well out-of-sample. There may be many other factors discovered in the past that haven't survived the test of time. This is similar in concept to successful stocks today being those that have survived and that an investor in the past without foresight may have invested in many stocks that subsequently went bust.

OUR APPROACH TO ESTIMATING RISK EFFICIENCY

A key consideration for judging the attractiveness of a particular factor is its 'risk efficiency'. We define risk efficiency by a factor's return per unit volatility, known as its Sharpe ratio, based on a factor's historical beta-neutralised returns.

To estimate future risk efficiency one could mitigate the issues of the previous section (i.e. data-mining bias, informed trading and survivorship bias) by only considering factor performance post-publication. This is very useful but in some cases, for example for the quality factor, there is relatively little post-publication data. We also think it is desirable to have a framework that can potentially apply more broadly than the five major equity factors, possibly to risk premia in other asset classes.

Another approach is to take in-sample return data from an academic study and "haircut" the historic performance of the factor by an appropriate amount (e.g. reduce it by a fixed percentage). Based on the literature[5] and our own findings we believe that a 50% haircut to in-sample risk efficiency is reasonable. Our approach is to combine these two methods to get a more statistically-robust estimate for future risk efficiency than either alone. Our process is shown in Figure 2.

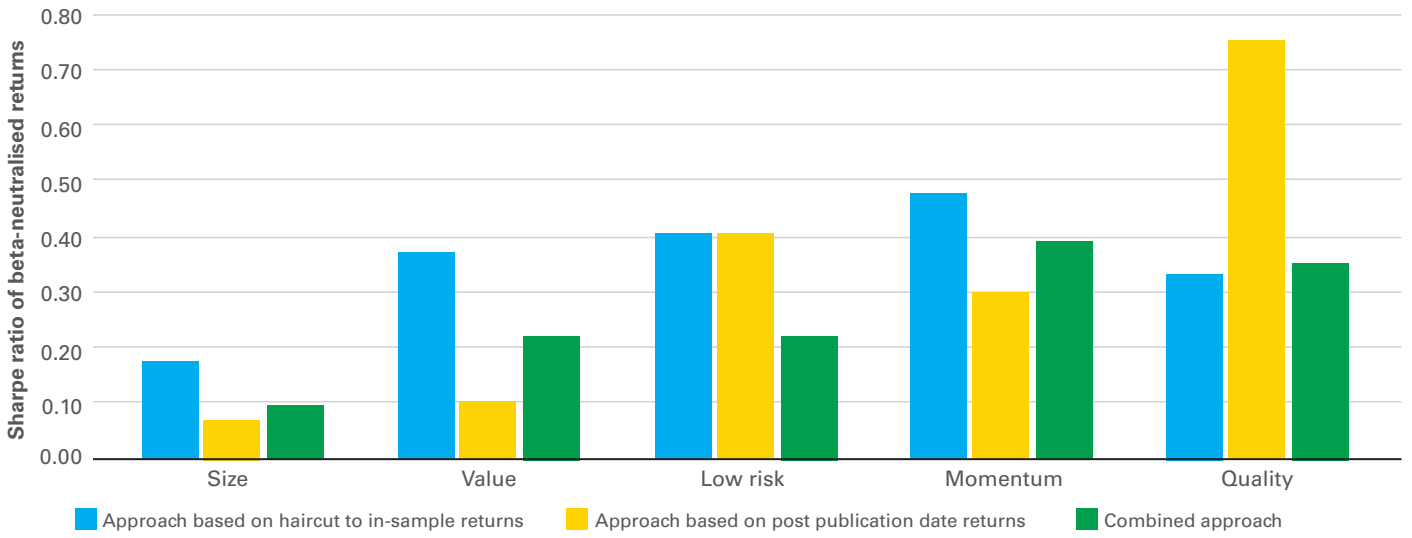
Figure 2. Our process for estimating the risk efficiency of factors

Step	Estimating future Sharpe ratios
1	Calculate the historic beta-neutralised returns of the factor
2	Calculate the average return of the in-sample historic returns of the paper that popularised that factor
3	Apply a 50% haircut to the average return from step 2 to allow for degradation effects
4	Calculate the average return post-publication. These returns are already impacted by biases and informed trading effects, so no haircuts are applied
5	Weight the returns from steps 3 and 4 by length of time to obtain an overall return for the factor
6	Divide the return from step 5 by the volatility experienced over the combined period (in sample plus post publication) to obtain the estimated Sharpe ratio of the factor

5. See "Does Academic Research Destroy Stock Return Predictability?" by RD McLean & J Pontiff, Journal of Finance (2016), 71, 1: 5-32

The results[6] of applying this process are shown in Figure 3.

Figure 3. Estimates of future risk efficiency of equity factors



Note that Quality has a much shorter post-publication period versus the other factors which can help to explain the more extreme value shown (see Appendix for dates). These estimates to do not take into account the impact of transaction costs (both direct and indirect). Transaction costs are likely to impact the Momentum factor much more than the other factors due to the strategy's relatively high turnover levels.

Source: LGIM calculations.

CONSIDERABLE SUBJECTIVITY REMAINS

There is still much uncertainty - this approach only takes into account historic performance of a particular implementation of a factor. Statistical analysis of historic returns can only help so much and there is a range of other considerations. These include how robust the underlying behavioural and structural explanations for their historic success are. This means a wide range of beliefs remain justifiable, even including the sceptic's view that one cannot expect any future outperformance.

There are also some reasons to believe that risk efficiency of factors could broadly equalise in the future. These include relative efficiency arguments - if one of the factors had a higher Sharpe ratio than the other factors, it is possible it could be bid-up until this relative advantage disappears (which requires less capital than trying to arbitrage away an entire factor itself). There are also data-mining bias arguments – it may be sensible to haircut high Sharpe ratios by more as they are more likely to be the result of data mining biases.

The Sharpe ratio estimates in Figure 3 under the combined approach range from 0.1 to 0.4. For the purposes of our illustrative results, shown below, we have assumed the Sharpe ratio for each factor is 0.2. In practice a wide range of assumptions are sensible (including non-equal Sharpe ratios), depending on the extent that investors believe in different factors.

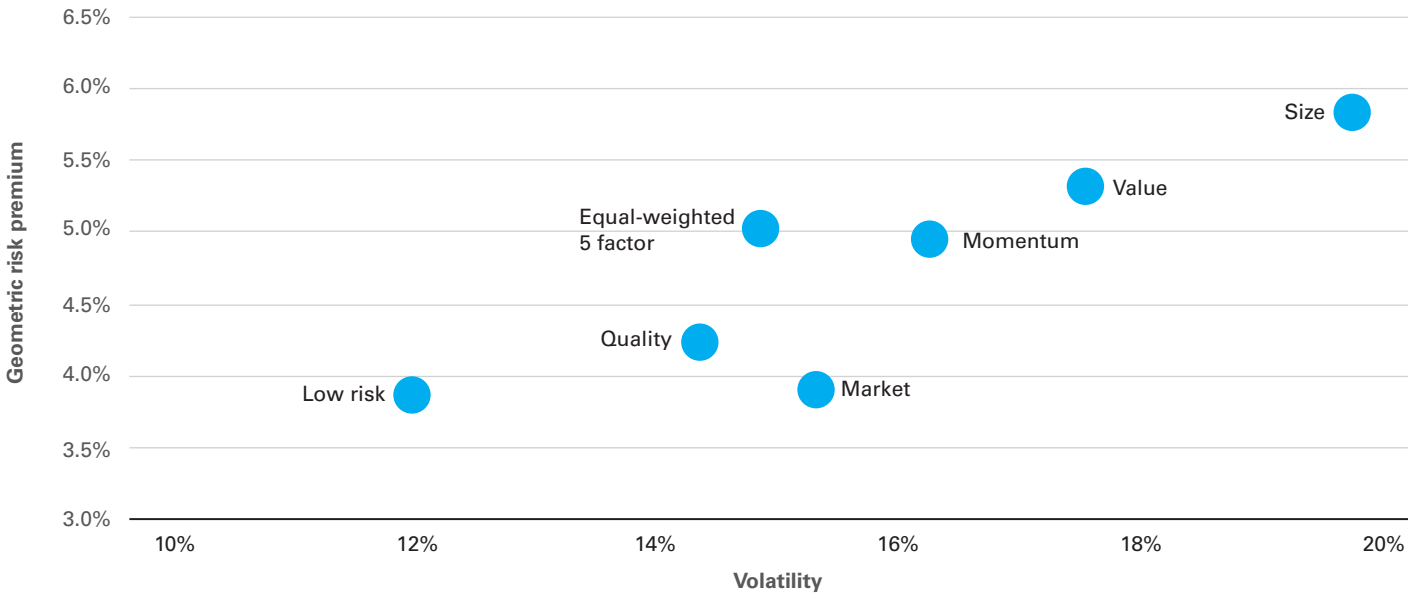
PUTTING IT ALL TOGETHER

So far we have only looked at the risk efficiency (as defined by the Sharpe ratio) for the five major equity factors. To derive expected factor risk premia we estimate the risk of each factor and multiply these with our estimated Sharpe ratios. Our estimates of factor risk are based purely on historic volatility[7] which is fairly stable over different time periods. Finally, we integrate our beta-neutralised factor returns with market returns to understand how long-only factor-based portfolios may behave from a total return perspective.

Figure 4 shows the key results of our calculations – namely the expected rate of return over gilts (the 'geometric risk premium') and the expected volatility of the five major equity factors and a portfolio equally-weighted to these five factors. A table outlining our calculations is given in the appendix.

6. Arithmetic Sharpe ratios shown. Note that the high Sharpe ratio for quality based on post-publication returns (i.e. the red bar for quality) may be driven by the relatively short span of time this reflects (i.e. December 2010 to January 2017).
7. Technically an exponentially weighted volatility with half-life of c.20 years. This gives greater weight to data post-publication than before.

Figure 4: Return and risk estimates for major long-only equity factors



There are a number of interesting results, including:

- A long-only portfolio equally weighted across the five factors (purely intended as an example of a diversified factor portfolio) might expect to outperform the market index by around 1% per annum and with a volatility around 5% lower than the market cap index (i.e. you multiply the volatility of the market index by 0.95).

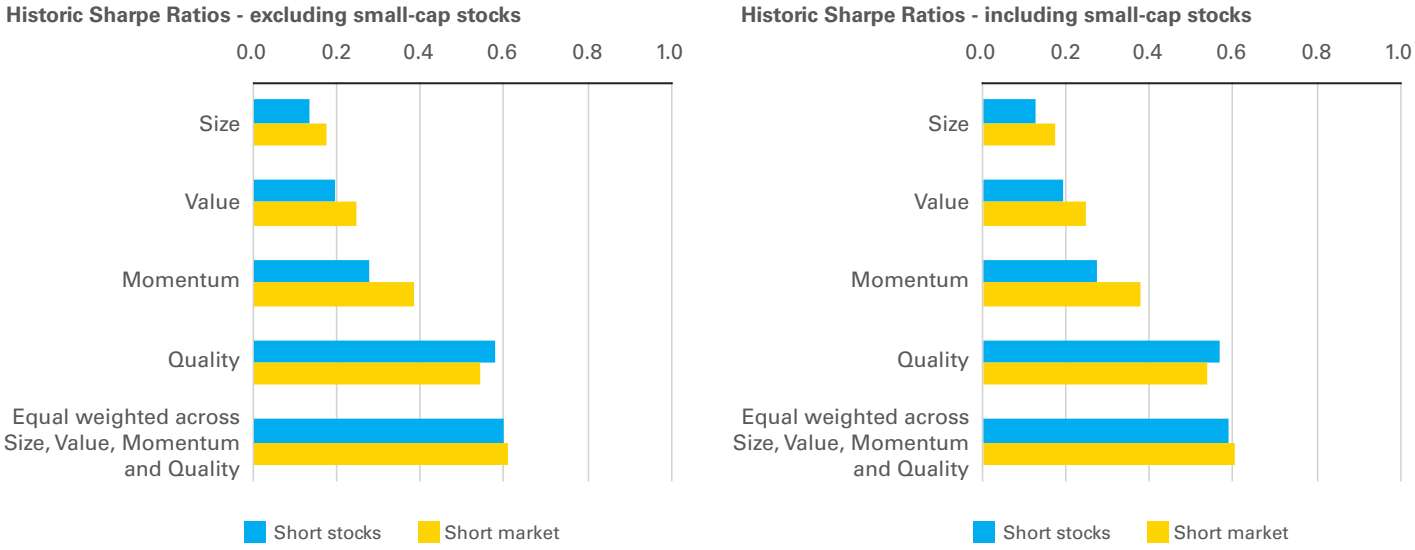
- Whilst some of the factors are expected to earn a higher return than this equally weighted portfolio (e.g. value), they are more risky and less risk-efficient

In this long-only context, market risk obscures some of the diversification benefits of blending factors (indeed in the calculation table in the appendix we find that blending factors doubles risk efficiency in the absence of market risk). But there is another reason to diversify – it mitigates 'parameter uncertainty', the possibility that the parameters we have estimated are wrong. In particular, the Sharpe ratios of the beta-neutralised returns might really be unequal (in fact they are almost certainly unequal but nobody knows what the ranking should be!). This helps promote diversification – you don't want to gamble that you have concentrated on a factor with the lowest 'true' risk efficiency.

SHORTING STOCKS

An interesting question is the extent to which long-only investors are disadvantaged relative to investors who can also short stocks that have the opposite properties to desired (i.e. large, expensive, low quality, etc.)

Figure 5: Historic risk efficiencies of factors



To answer this, we compared the historic risk efficiencies of factors where we either short stocks[8] or short the whole market. The results are shown in Figure 5.

Due to data limitations, the low risk factor was excluded from this comparison. Results allowing all stocks are shown on the left. On the right we focused only on large and mid-cap stocks (other than when looking at the size factor).

The chart on the left shows that the ability to short small-cap stocks could, in theory, confer a significant advantage. This is mainly because it reduces the correlation between long/short factors, leading to a large diversification benefit. It also appears to be quite beneficial to short small low quality stocks. However, in practice shorting small caps may incur significant stock borrow costs or may be impossible to implement due to a lack of stock available for shorting. When focusing only on large and mid-cap stocks (except for size where one goes long small-cap stocks) we find no historic evidence that the ability to short stocks increases risk-adjusted performance.

OTHER CONSIDERATIONS

There is an array of other considerations that can be made when estimating future returns and risk. For example, there are some reasons to believe that correlations between factors could increase in the future. Given the increasing focus on multi-factor indices, investors will trade packages of factors more commonly buying and selling factors at the same time.

Increased interest in factors may also lead to crowding, but could also give a tail-wind to performance in the short to medium-term. The topic of crowding in factors will be explored in a later paper.

In this paper we have concentrated on estimating factor risk and return from a strategic viewpoint. However, some investors also believe that they may be able to tactically 'time' factors by changing their exposure to the different factors over time. As a result these investors are ascribing time-varying expected returns to factors.

CONCLUSION

In this paper we have set out a possible framework for understanding the likely risk and return from equity factors in the future. In particular we found that a long-only portfolio equally weighted across the five factors might be expected to outperform the market index by around 1% per annum, before costs and fees, with a volatility around 5% lower (in relative terms) than that of the market cap index. However we have seen that a range of other estimates and views remain justifiable and that much uncertainty remains.

8. For the purposes of our calculations, long/short factors were also beta-neutralised to ensure the long/short factors did not pick up any market directional bias.

APPENDIX

Data sources:

Factor	Description	Source	Comments
Size	The size factor refers to the market capitalisation of a company, with mid- and small-cap having more exposure to this factor than large-cap companies	Kenneth French Data Library (uses market cap as definition)	Includes small cap
Value	The value factor considers how 'cheap' a stock is relative to others based on comparing a stock's price to company financial data such as earnings, cashflows, sales or book value	Kenneth French Data Library (uses book-to-price as definition)	Excludes small cap
Momentum	Momentum is typically characterised by a stock's return over the past 12 months, with strong momentum indicative of high historical returns	Kenneth French Data Library (uses 12 month omitting most recent month total return as definition)	Excludes small cap
Quality	Quality companies are those that produce strong, sustainable returns for shareholders; this factor is usually defined by a combination of measures including high profitability, low investment and/or low leverage	Kenneth French Data Library (uses profitability and investment as definitions)	50% x profitability + 50% x investment Excludes small cap
Low risk	The low risk factor in academic literature is defined variously as low stock price volatility, low market beta or low idiosyncratic volatility, though all the definitions rest on a similar behavioural concept of low risk investing	Pre March 2002: AQR Data Library (uses low beta as definition) March 2002 onwards: LGIM calculations based on a top 30% low volatility portfolio	Modified AQR returns to account for dollar value imbalance in long and short legs; assumes 50% of alpha comes from each of long and short legs Excludes small cap

Key dates for factors:

Factor	Sample start date	Sample end date	Publication date
Size	July 1926	December 1975	March 1981
Value	July 1963	June 1990	June 1992
Momentum	January 1965	December 1989	March 1993
Profitability	July 1963	December 2010	April 2013
Investment	July 1968	June 2003	August 2008
Low risk	December 1930	December 1965	December 1972

Calculations:

Row	Description	Market	Size	Value	Low risk	Momentum	Quality	Equal-weighted 5 factor
A	Volatility of beta-neutralised returns	0.0%	9.1%	8.7%	5.0%	6.6%	3.3%	3.2%
B	Sharpe ratio of factor[9] (assumed except for equal-weighted which is calculated)	N/A	0.20	0.20	0.20	0.20	0.20	C/A = 0.41
C	Alpha of factor = A x B	0.0%	1.8%	1.7%	1.0%	1.3%	0.7%	Average of figures for 5 factors = 1.3%
D	Beta of long-only factor	1.00	1.15	1.00	0.71	0.97	0.91	Average of figures for 5 factors = 0.95
E	Beta risk premium = D x Equity Risk Premium[10]	4.9%	5.6%	4.9%	3.5%	4.8%	4.5%	4.6%
F	Total arithmetic risk premium = C + E	4.9%	7.4%	6.6%	4.5%	6.1%	5.1%	5.9%
G	Volatility of overall returns (not beta-neutralised)	15.3%	19.8%	17.6%	12.0%	16.3%	14.4%	14.9%
H	Total geometric risk premium ≈ $F - G^2/2$	3.9%	5.8%	5.3%	3.9%	5.0%	4.2%	4.9%
I	Geometric Sharpe ratio of long-only returns = H/G	0.25	0.29	0.30	0.32	0.30	0.30	0.34

Source: LGIM calculations

9. Arithmetic Sharpe ratio of beta-neutralised returns
10. Arithmetic and assumed to equal 4.9% here