The Fama-French and Momentum Portfolios and Factors in the UK

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Abstract

The primary aim of this paper is to make available the Fama-French and Momentum portfolios and factors for the UK market to the wide community of UK academic and post-graduate researchers. As Michou, Mouselli and Stark (2007) note, there is no freely downloadable equivalent to the data on Ken French's US website, and this paper is directed at remedying this situation. We depart from the majority of previous UK studies (with the exception of Agarwal and Taffler, 2008) by forming portfolios on 30th September each year, which we argue is more appropriate for the UK. Although we construct factors *and* portfolios for the UK, by extending tests to portfolios formed on differing bases, we add to the caution expressed in Michou, Mouselli and Stark (2007) on whether such factor models completely capture risk in the UK. Our recommendation is that any tests of long run abnormal returns in UK be based on characteristic-matched portfolios. The data underlying this paper can be downloaded from: http://xfi.exeter.ac.uk/researchandpublications/portfoliosandfactors/

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Introduction

Our starting point in this paper is the Michou, Mouselli and Stark (2007, hereafter MMS) observation that with the exception of the factors used in the Dimson et al. (2003) study, which covers the period 1955-2001, no UK SMB and HML factors are available on a timely basis. Taking this further, despite the wide-ranging literature on momentum, no Carhart (1997) momentum factors are available for the UK. Perhaps of more concern is that MMS show that no matter which "recipe" for factor construction is followed, none "emerge with a clean bill of health". As the authors note, this suggests that the modelling of abnormal returns leaves room for improvement.

One way of addressing this issue is through the construction of alternative factors. For example, Gregory and Michou (2009) note that the Al-Horani, Pope and Stark (2003) method of including a research and development factor has potential over the limited period for which data is available. Gregory and Michou also explore whether rolling or conditional estimates of factor models improve the estimation of industry cost of capital. However, an alternative approach for researchers interested in the estimation of long run UK abnormal returns is the use of characteristics matched portfolios. Whilst these are available to freely download and use for the US, along with the Fama-French factors, from Ken French's website: (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html), no such characteristics matched portfolio data are available for the UK. Although Stefan Nagel provides some excellent long-run UK data, including the FF factors and 16 size and book-to-market portfolios, back to 1955, these data only run up to 2001[1]. In the spirit of Ken French's free provision of this data to the international academic community, and Stefan Nagel's free provision of a prior UK dataset, our intention is to make the data in this paper freely available to the same academic community for *bona fide* academic research, and to update this data on an annual basis. Furthermore, by including hand collected data not available in electronic format, we believe that our data is as free from survivorship bias as is possible. The portfolio and factor data

[1] See: http://faculty-gsb.stanford.edu/nagel/datapapers.html

in this paper, plus many additional data and Stata routines can be found on http://xfi.exeter.ac.uk/researchandpublications/portfoliosandfactors/.

It was not our intention in this paper to replicate asset pricing tests of our factors, which can be found in MMS. However, we discovered that the combination of September factor and portfolio formation and the replication of the Fama-French portfolios using the FTSE 350 as a cut-off can change the conclusion on the ability of the Fama-French factors to price the 25 size and book to market portfolios, depending on how those portfolios are formed. Furthermore, we find that the inclusion of a momentum factor seems to be capable of pricing 27 portfolios sorted on size, book-to-market, and momentum. In both cases the Gibbons, Ross and Shanken (1989, hereafter GRS) test fails to reject the null hypothesis of jointly significant intercept terms. However, neither model has the ability to price portfolios sorted on criteria other than those used to form the factors. Furthermore, as in MMS, we can reject the hypothesis that the intercept term is zero for any of these portfolios for both FF and Carhart models. This is important, as simply moving to a Carhart model fails to solve the problem of an inadequate factor pricing model for the UK.

However, we do not examine the information content of the factors, as in Mouselli, Michou and Stark (2008), although it is important to note that the latter does provide some evidence for an economic interpretation of the HML factor. Neither is it our intention to undertake an analysis of the properties of long run abnormal returns using control portfolios, as in Lyon et al. (1999). This is an interesting, although demanding, task worthy of a detailed paper in its own right. We leave this for other researchers, but we hope that it is one we can help facilitate through this paper. To encourage such work, we include in our datasets not only the monthly returns to control portfolios, but also the breakpoints for portfolio formation each year. All factors, portfolios and the corresponding cut-offs used in their formation are downloadable from our website. The website also provides links to several Stata modules freely downloadable to use including GRSTEST- module to perform the Gibbons, Ross and Shanken (1989) test, FMTEST- to perform the Fama-MacBeth (1973) two-pass CSR test with rolling or non-rolling betas and Shanken (1992) EIV adjustment and HALLT-SKEWT- to perform bootstrapped skewness adjusted t-statistic written by one of the co-authors .

Data and method

Our data sources involve cross-matching company data from the following data bases: The London Business School Share Price Database, which includes data on monthly returns, market capitalisation and also key dates of first listing and de-listing; Datastream; tailored Hemscott data (from the Gregory, Tharyan and Tonks [2008, 2009] studies of directors' trading) obtained by subscription; and hand collected data on bankrupt firms from Gregory and Huang (2009). The Hemscott, Datastream and Gregory and Huang (2009) data are used to obtain estimates of book value used in portfolio formation. The LSPD data are used for the monthly share returns and market capitalisation data. Combining these data sources means that we are able to infill any missing data on any one firm in either of the Hemscott or Datastream sources.

Our central problem in forming the factors and portfolios is to find a UK proxy for the NYSE break points used to form the portfolios and factors on Ken French's website. This is an important issue as the London Stock Exchange exhibits a large "tail" of small and illiquid stocks, which are almost certainly not part of the tradable universe of the major institutional investors that make up a large part of the UK market. Both Gregory, Harris and Michou, hereafter GHM (2001) and Dimson, Nagel and Quigley (2003, hereafter DNQ) recognise the importance of this by using the median of the largest (by market capitalisation) 350 firms and the 70th percentile of firms respectively in forming the size breakpoints for market value, in both cases excluding financial stocks. Gregory et al. (2001) base their book-to-market breakpoints on the 30th and 70th percentiles of the largest 350 firms, whereas Dimson et al. (2003) use the 40th and 60 percentiles. More typically, other UK studies (Al-Horani et al., 2003; Fletcher, 2001; Fletcher and Forbes, 2002; Hussain et al., 2002; Liu et al., 1999 and Miles and Timmerman, 1996) use the median of all firms. In this paper, given the importance of considering the investable universe, and given the weight of the evidence in MMS, we follow the largest 350 firms method found Gregory et al. (2001, 2003) and Gregory and Michou (2009, hereafter GM). However, we also provide data using the alternative Dimson et al. (2003) 70th percentile breakpoints. An excellent and detailed review of the methods used in UK portfolio construction can be found in Michou et al. (2007).

In detail, we form our portfolios as follows. Using our proxy for the Fama-French NYSE cut-off we use the median firm in the largest 350 companies (excluding financials) by market capitalisation for the size breakpoint, and use the top 350 firms to set the cut-offs for the book-to-market portfolios. For the FF factors we form the following six intersecting portfolios, where "S" denotes small, "B" denotes big, and "H", "M" and "L" denotes high, medium and low book to market respectively: S/H; S/M; S/L B/H; B/M; B/L. The usual SMB and HML factor portfolios (see below) are then formed using the universe of UK main-market stocks for which market capitalisation, returns, and book-to-market ratios can be constructed from any of Datastream, Hemscott, the LSPD or the hand-collected data from Gregory and Huang (2009). Following the logic in Agarwal and Taffler (2008), who note that 22% of UK firms have March year ends, with only 37% of firms having December year ends, we use March year *t* accounting data and end of September year *t* market capitalisation data. The portfolios are formed at the beginning of October in year *t* and financial firms are excluded from portfolios, as are negative book-to-market stocks and AIM stocks. Exactly as described on Ken French's website, the factors are constructed using the 6 value-weighted portfolios so that SMB is the average return on the three small portfolios minus the average return on the three big portfolios, whilst HML is the average return on the two value portfolios minus the average return on the two growth portfolios. For the market return, *Rm*, we use the total return on the FT All Share Index, and for *Rf*, the risk free rate, we use the one month return on Treasury Bills.

We form the momentum factor based on the methodology described on the Ken French's website as follows. We use six portfolios formed on size and prior (2-12) returns to construct UMD. The portfolios, which are formed monthly, are the intersections of 2 portfolios formed on size and 3 portfolios formed on prior (2-12) return. The monthly size breakpoint is our proxy for the Fama-French NYSE cut-off i.e. the median firm in the largest 350 companies (excluding financials) by market capitalisation. The monthly prior (2-12) return breakpoints are the 30^{th} and 70^{th} of prior (2-12) performance of the largest 350 companies each month. Following the US procedure on Ken French's website, the momentum factor, UMD, is then calculated as 0.5 (S/U + B/U) - 0.5 (S/D + B/D).

Besides the portfolios described above, we then calculate the following portfolios on both an equally weighted and value-weighted basis:

1. 25 (5x5) intersecting size and book to market (BTM) portfolios "350 groups"–
    - 5 size portfolios – 4 portfolios formed from the largest 350 firms + 1 portfolio formed from the rest.
    - 5 B/M portfolios – based on the largest 350 firms.
2. 25 (5x5) intersecting size and book to market (BTM) portfolios ("Alternative 350 groups")–
    - 5 size portfolios – 3 portfolios formed from the largest 350 firms + 2 small portfolios formed from the rest.
    - 5 B/M portfolios formed from all firms.
3. 25 (5x5) intersecting size and book to market (BTM) portfolios("DNQ groups") –
    - 5 size portfolios – 3 portfolios formed from the largest (70th percentile) firms + 2 portfolios formed from the rest.
    - 5 B/M portfolios formed from all firms.

4. 25 (5x5) intersecting size and momentum portfolios –
    - 5 size portfolios – 4 portfolios from the largest 350 + 1 portfolio from the rest
    - 5 Momentum portfolios – based on the largest 350 firms.

5. 27 (3x3x3) sequentially sorting on size, book-to-market and momentum portfolios, using the size, BTM and momentum –
    - 3 Size portfolios – 2 portfolios formed from the largest 250 firms + 1 group from the rest
    - Then within each size group we create 3 B/M groups.
    - Then within each of these 9 portfolios we form 3 momentum groups.

6. 5 size portfolios – 4 portfolios from the largest 350 firms + 1 from the rest
7. 5 simple quintile size portfolios
8. 10 simple decile size portfolios;
9. 5 book-to-market (BTM) portfolios- formed from B/M of the largest 350 firms
10. 5 simple quintile BTM portfolios
11. 10 simple decile BTM portfolios;
12. 1 portfolio of negative book to market stocks.

In particular, we emphasise that our choice of partitioning the size portfolios on the basis of the largest 350 stocks is designed to capture the investable universe for institutional investors. Our conversations with practicing fund managers and analysts suggest that large international investors may view the opportunity set of UK firms as comprising the FTSE100 set of firms at best. Thus we define "large" firms as being the upper quartile of the largest 350 firms (or 70th percentile using the DNQ cut-offs) by market capitalisation. “Small” becomes anything not in the top 350 firms. However, note that we also form the “Alternative 350 group”, “DNQ group” together with simple decile and quintile portfolios for both size and book-to-market for those who believe that alternative definitions of size and book to market are more appropriate.

Our decision to include only Main Market stocks follows Nagel (2001) and DNQ. However, we note that there has been a major change in the number of firms listed on the main market of the London Stock Exchange since 1997. The number of listed firms in our portfolios peaks in 1997, where there are 1,393 non-financial firms with book-to-market and market capitalisations available to form the basic intersecting 5x5 size and book to market portfolios. There are a further 70 firms that are included in our negative book to market portfolios. This number then falls away progressively to 1,100 (plus 58 negative B/M) in 2000, ending up at only 563 firms by the time financials have been excluded, plus 21 negative B/M stocks, in 2008. This rather alarming decline caused us to cross check the LSPD data with the London Stock Exchange website, and in December 1998 (the earliest month for which data are available on the LSE website[2]), there are 2,087 UK listed companies trading on the Main Market, and 307 AIM stocks trading. By December 2008, this figure has fallen to 1,142 firms trading on the Main Market but a rise to 1,512 firms listed on AIM, of which 1,136 have market capitalisations of less than £25m. Essentially there have been a large number of migrations from Main Market to AIM. Note, though, just how small most of these firms are. The market is dominated by a large number of small, illiquid stocks. For this reason, we have, for the analysis in this paper, excluded these firms from the factors and portfolios, although a set of portfolios and factors *including* AIM stocks is available on our website.

Factor results

First, in Table 1, we report the summary statistics for our factors. Panel A show the results for the factors following the GHM and DNQ methods, but using end-September formation, Panel B shows the correlation between those factors, whilst for comparison Panel C records the last available update of the GM dataset with end-Sept

[2] See http://www.londonstockexchange.com/statistics/historic/main-market/main-market.htm

factors reported over the same period. Finally, Panel D reports the correlation coefficients between the end-June and end-Sept estimates for the over-lapping estimation period. Several points are worth noting. First, in Panel A, both the DNQ nor GHM specified SMB factors are very small (minus 4 basis points and plus 3 basis points per month respectively) and neither is significantly different from zero. By contrast, both versions of HML and momentum (UMD) factors are highly significant, as is the market risk premium. Both t-tests (assuming unequal variances) and a non-parametric Wilcoxon signed rank sum test indicate there are no significant differences between the DNQ and GHM formation techniques. Panel B reveals that they are highly correlated both using the more usual Pearson correlations as well as Spearman rank correlations. Furthermore, none of the HML, SMB or RMRF factors appears to exhibit cross-correlation with one another. Thus far, we have simply shown that changing from end June to end September formation does not alter the general impression of these factors gained in MMS. Note, however, that following the Fama-French formation rules for the momentum factors does induce a significant negative correlation between UMD and HML factors. This is not surprising, as by construction the UMD factor is designed to isolate the small firm, but not the book to market, effect. Last, note that the skewness of SMB and HML factors is not significantly negative using either DNQ or GHM formations, but UMD and RMRF factors exhibit significant negative skewness at the 1% level. All factors show significant levels of kurtosis at the 1% level.

Having shown that DNQ factors look very similar to GHM factors, we now drop the former from our analysis for the remainder of the paper, but all of the DNQ factors and portfolios are downloadable from our website.

In Panel C, we show that end-September formation produces SMB and HML factors with means that are not significantly different from those that arise using end-June formation. Parametric and non-parametric tests again confirm that the differences are not significant. Note, however, that there are differences in skewness and kurtosis that result from the shift in formation dates. The end-June (GM) formation gives rise to an SMB factor which is significantly negatively skewed. Intriguingly, the end-June portfolios exhibit substantially greater levels of kurtosis. Note also that whilst significant, correlations between factors reported in Panel D are considerably lower than those reported in Panel B. This suggests that formation date has a more important impact on the factors than switching formation methods from GHM to DMS approaches. Last, note that by construction the WML factor of GM is different from the UMD factor. GM construct a factor purely on the basis of momentum, whereas here we follow the Fama-French procedure described on Ken French's website.

Portfolio summaries

We now proceed to describe the characteristics of the portfolios described above. For reasons of space we do not report these results for the DNQ version of the portfolios, but both these and our "350" portfolios can be downloaded from our website. In Tables 2 – 9, we report the mean, standard deviation (SD), inter-quartile range (iqr), skewness, kurtosis, maximum and minimum for each value-weighted portfolio[3]. We start, in Table 2, with the six portfolios used to form the Fama-French factors themselves. The first letter in any portfolio descriptor denotes size, and the second the book-to-market category, so for example SL denotes small – low book to market (i.e. "small-glamour" stocks), whilst BH denotes big and high book to market (i.e. "large value" stocks). Consistent with results reported elsewhere in the literature, the highest returns are recorded by the small value portfolio (132 basis points per month), closely followed by the large value portfolio (129 basis points). The lowest returns are in the small-glamour portfolio (70 basis points). The small glamour portfolio also has the highest standard deviation of returns, the largest inter-quartile range, and the most negative skewness. Note, though, that the portfolio with the lowest standard deviation and inter-quartile range is actually the large glamour portfolio. However, it has substantially more negative skewness and far greater kurtosis than the large value portfolio. Furthermore, the minimum, maximum and median returns are all less than those on the large value portfolio.

Table 3 reports results for the value-weighted size decile portfolios. Again consistent with prior research, returns decrease almost (but not quite) monotonically with size. Risk, as measured by either standard deviation or inter-quartile range, appears not to change much, save for the fact that the largest stock portfolio is less risky. However,

[3] Note that equally weighted versions are also available for download.

skewness tends to become more negative as size increases, at least through the first four size categories.

Table 4 shows the returns for ten value-weighted portfolios formed on the basis of book-to-market ratio. The general tendency is for mean returns to increase as we move across from "glamour" (V1) to "value" categories, but the effect is not monotonic. The extreme "value" category records a monthly return of 185 basis points, compared to the extreme "glamour" return of only 68 basis points. Also of note, and in some contrast to the GHM (2003) findings, is the fact that risk, as measured by standard deviation and inter-quartile range, is actually highest in the two highest "value" portfolios. However, these two portfolios exhibit smaller negative skewness and less kurtosis than the two lowest book to market portfolios. Given that we run these portfolios up to December 2008, we suspect that the differences between our results and the GHM (2003) results simply reflect recent economic events, rather than the switch in portfolio formation dates to end-September.

Table 5 reports the statistics for the Fama-French size and momentum portfolios. The first letter denotes size, the second the momentum category, so for example SL denotes small – low momentum, whilst BH denotes big and high momentum. The highest returns are recorded by the small-high momentum group of firms (157 basis points per month) whilst the lowest returns accrue to the small-low momentum category (52 basis points per month). All the portfolios exhibit negative skewness and kurtosis, but the highest level of kurtosis (and, indeed, the minimum return and highest inter-quartile range) is found in the large-high momentum portfolio. It is also worth noting that within size categories, "low momentum" stocks appear to have levels of skewness and kurtosis slightly closer to zero than "high momentum" stocks, and also have lower minima and maxima, whilst the lowest risk (in terms of standard deviation and inter-quartile range) are the central (i.e. medium momentum) portfolios.

Table 6 gives the summary statistics for the standard five-by-five value-weighted portfolio returns, These are 25 intersecting size and book to market (BTM) portfolios for the "350 groups"– 5 size portfolios, with 4 portfolios formed from the largest 350 firms + 1 portfolio formed from the rest, and 5 B/M portfolios – with breakpoints based on the largest 350 firms. In the Table, the first character denotes size, the second the book-to-market category, so for example SL denotes small – low book to market, S2 denotes size and second lowest book to market category, whilst B4 denotes big and fourth highest book to market category, and BH denotes big and high book to market. However, outside the smallest and largest categories, we use three characters, so that, for example, M34 denotes the middle (third) size portfolio and the fourth largest book to market portfolio. The general tendency within size categories is for returns to increase as book-to-market ratio increases, although the effect is not completely monotonic in the medium and largest size categories. The general pattern appears to be for skewness to be more negative and kurtosis to be greater in the "glamour" category than the "value" category within any size group, with the sole exception being kurtosis in the second smallest (S2) size grouping.

Table 7 reports the "Alternative" version of portfolio formation, where the portfolios are 25 (5x5) intersecting size and book to market (BTM) portfolios for the "Alternative 350 groups", where we have 5 size portfolios with 3 (as opposed to 4) portfolios formed from the largest 350 firms + 2 small portfolios formed from the rest, and 5 B/M portfolios – with breakpoints based on *all* firms, rather than the largest 350. The most striking difference, perhaps not surprisingly, is in the smallest category of firms, where there is far less variation by "value" category than wee see in Table 6. The remaining portfolios (again, not surprisingly) exhibit patterns generally similar to those in Table 6. Whilst some might find this sub-division of portfolios more appealing, the small portfolio in this version comprises some very small stocks, almost certainly not part of the tradable universe for many investment funds. Nonetheless, this has a certain utility – for example, in long run event studies we may well be cautious of apparently anomalous results that are mainly driven by this group of firms. However, we caution against simply dividing the UK market into quintiles based on size. A moment's reflection shows why. Over the long run, there are, on average, 1,095 firms (excluding negative B/M stocks) in our dataset (once we have excluded financial stocks). Simply dividing into quintiles ensures that the groups of stocks that are likely to comprise the tradable universe for substantial institutional investors would be concentrated in the largest two portfolios, with the balance, of far less economic interest, being allocated across the three remaining portfolios. Such a distribution seems of limited value.

Table 8 shows the statistics for the 25 size and momentum portfolios. These are the 5x5 intersecting size and momentum portfolios for the "350 groups"– 5 size portfolios, with 4 portfolios formed from the largest 350 firms + 1 portfolio formed from the rest, and 5 momentum portfolios – with breakpoints based on the largest 350 firms. The first character denotes size, the second the momentum category, so for example SL denotes small – low momentum, S2 denotes small and second lowest momentum category, whilst B4 denotes the largest size quintile and fourth highest book to market category, and BH denotes big and high book to market. However, outside the smallest and largest categories, we use three characters, so that, for example, M34 denotes the middle (third) size portfolio and the fourth largest momentum portfolio. The most striking result in this group of portfolios is that within any size category, it is always the lowest momentum group that has the poorest returns, whilst the highest momentum group has the highest returns. Within each size category, the relationship tends to follow a pattern of increasing as we progress from low to high momentum, although the effect is not monotonic in every size grouping. Note, though, that risk (as measured by standard deviation and inter-quartile range) tends to follow a "U" shaped pattern, with the high and low momentum portfolios being more risky than the central portfolios in any size group. However, they do not appear to exhibit more skewness or kurtosis, with the patterns here varying across size groups. One final point is worth noting here. The biggest difference in returns within size groups is, on average, between the lowest and next lowest momentum portfolios.

Our final set of portfolios reported in Table 9 are the value-weighted 27 (3x3x3) portfolios *sequentially* sorted on size, book-to-market and momentum. The three size portfolios are two portfolios formed from the largest 250 firms plus one group from the remainder. Then within each size group we create three B/M groups. Finally, from within each of these 9 portfolios we form 3 momentum groups. The first letter denotes size (Small, S; Medium, M; Large, L), the second the book to market category (Low or "Glamour", G; Medium, M; High, or "value", V), and the third momentum (Low, L; Medium, M; High, H). The return patterns here are intriguing, as they suggest a much lower momentum effect when book-to-market is also controlled for. Indeed, within the "small value" set of firms, momentum effects are actually reversed. However, what is striking here is that *sequentially* sorting, as opposed to forming intersecting portfolios, seems to substantially dampen down any momentum effect. Sequential sorting (within any size category[4]) has the effect of ensuring each sub-group has equal numbers of firms within it, whereas intersecting portfolios can have quite different numbers of firms within each portfolio. In practice, it emerges that different numbers of firms within sub-categories is only an issue within the smallest market capitalisation quintile, where intriguingly there is a concentration of firms in the low momentum category. Fully 39% of all the smallest quintile stocks fall into this "low momentum" group.

Tests of FF 3-factor and Carhart 4-factor models.

As we noted at the outset, this is not intended to be an asset pricing paper. Nonetheless, in the spirit of MMS it seems reasonable to run the standard tests of an asset pricing model described in Cochrane (2001, Ch.12) of our Fama-French and Carhart factors on the various portfolios described above. MMS draw attention to the literature on the need to test asset pricing models on alternative portfolios, which is the task we undertake here. In Table 9 we report the results of running the Gibbons, Ross and Shanken (1989) test, which is an F-test that all the alphas are jointly zeroWe run this test for our 25 size and B/M portfolios, using both alternatives for the formation rule (that is, dividing the top 350 firms into four groups, or three groups, with the remaining firms comprising the small portfolio or the remaining firms being split into two size groups, the "Alternative 350" group). We also run the GRS test for the size and book to market deciles, the 25 size and momentum portfolios, and the 27 size, book to market and momentum portfolios. The test is run for both the Fama-French 3-factor model and the Carhart 4-factor model. For reasons of space we do not report the intercepts for each of the portfolios, but merely report the F-statistics and p-values from the GRS test. The results in Table 10 are in line with what one might expect given the Lo and MacKinlay (1990) and Lewellen, Nagel and Shanken (2009) counsel against testing a model on portfolios whose characteristics have been used to form the factors. First, note that the results obtained are sensitive to the cut-offs used to form the size portfolios. We show that when the 3-factor model is tested against our 350 formation rule, we cannot reject the hypothesis that the alpha terms are jointly zero, although we can do so simply by switching to the "Alternative 350" definition for the portfolio. This is similar to the MMS conclusion that the null

[4] Recall that by design we form the size portfolios so that the largest two size groupings by market capitalisation have fewer firms than the smallest size groups.

hypothesis can be rejected, bearing in mind the different way in which the portfolios are formed (theirs are size quartile portfolios based on all stocks). However, it is worth noting that this failure to price the portfolios adequately is driven by the smallest stock portfolios, where alphas are significant for four out of the five portfolios. By contrast, it is significant (at the 10% level) for only one out of the remaining 20 larger firm portfolios. As with MMS, once we try testing the three factor model on portfolios constructed on some basis other than size and book-to-market, we can always reject the null hypothesis. Consistent with the above results, when we try and price the size decile portfolios, the alphas are significant (at the 10% level at least) for the smallest four deciles, but not significant for the largest six deciles. In effect what we see from the F-test is that a lot of the failure to price portfolios gets driven by smaller stocks. Note, however, that once we include momentum in the portfolio construction the p-value from the F-test falls sharply.

In a similar vein, if we run the 4-factor model, we cannot reject the null hypothesis of all the portfolio alphas being jointly zero when we form portfolios on size, B/M and momentum. In addition, we obtain a consistent result to the 3-factor model for the 350 cut-off portfolio. However, in other cases both models fail to price portfolios formed on bases other than those employed to derive the factors, although the result for the "Alternative 350 group" is only significant at marginally over the 5% level.

In Table 11 we show the results from Fama-MacBeth (1973) estimation process using both the assumption of constant parameter estimates (the "Single" regression columns) and rolling 60-monthly estimated betas (the "Rolling" regression columns). We show results for both three and four factor models, and the estimates are expressed in terms of percent per month. The t-statistics shown are after Shanken (1992) corrections for errors-in-variables problem. The p-values corresponding to these corrected t-statistic are also shown. As we estimate these regressions using excess returns, the intercept should be zero and the coefficients on the factors should represent the market price of the risk factor. Panel A reports the results using our two alternatively defined size portfolios. Note that when we use the 350 size cut-off portfolio, we cannot reject the null hypothesis of pricing errors being jointly zero, yet only the book-to-market factor appears to be priced (using either rolling on constant betas) in either three or four factor models. The intercept terms are always insignificant. Note also that the HML factor premium is around the same level as the average premium recorded in Table 1. Switching to the “Alternative 350” size definition, we can marginally reject the null on pricing errors using the three factor model, yet now find (consistent with MMS) that the intercept is significantly positive, the market risk premium is significantly *negative*, SMB is not significant, but the HML factor remains significant. Panel B of Table 11 shows what happens when we apply these tests to the size and book to market decile portfolios. For the book-to-market portfolios, we can never reject the null of all the pricing errors being jointly zero, and the HML factor is consistently priced, although the coefficient is always above the 0.5% per month from Table 1. At the 10% level at least, the market risk premium is always priced negatively and the intercept is significantly positive, except in the case of the constant parameter estimates. For the size decile portfolios, we can always reject the null hypothesis of jointly zero pricing errors. For the three factor model, results on the HML factor are sensitive to whether or not rolling parameter estimates are employed, but the intercept is always positive and the market risk premium is always negative. Ironically, given these are size portfolios, SMB is never priced. Using the four factor, or Carhart, model, UMD is significantly negatively priced when rolling regressions are employed. Finally, in Table 11 Panel C, we show what happens when we apply the pricing tests to the 25 size and momentum, and the 27 size, book to market, and momentum portfolios. First, note that we can always reject the null hypothesis of no significant pricing errors. For the size and momentum portfolios, only HML is priced in the 3-fcator model, but the coefficient is large and negative. Employing the four factor model shows that only momentum is priced. However, when we apply the test to the 27 (3 x 3 x 3) portfolios, we see that the results are highly sensitive to whether constant parameter or rolling parameter estimates are employed. Using rolling (i.e. time-varying) estimates, no factors are significant no matter whether the three or four factor models are employed. When parameters are fixed, we find that only momentum is priced. Note that this evidence is consistent with the recent finding of Bulkley and Nawosah (2009) that momentum can be explained if “high momentum” stocks are simply those with high unconditional expected returns. As the authors point out, a general problem in testing asset pricing models is that any residual pricing errors from the model specified are liable to turn up as momentum.

Conclusion

The results of our asset pricing tests both confirm and extend the findings of MMS by applying tests to a wider set of portfolios over a longer time frame (up to December 2008 as opposed to December 2003) and also by adding tests based on the 4-factor Carhart model. We are able to provide no comfort for those seeking to employ unconditional factor models to explain or analyse the cross-section of UK stock returns. What we do not attempt here is to test whether *conditional* versions of the factor models might explain the cross-section of returns. One attempt, in Gregory and Michou (2009) shows that conditional versions of the CAPM and three-factor models as employed by Ferson and Harvey (1999) and Fama and French (1997) are unlikely to be the solution. However, conditional versions using the frameworks of any of Jaganathan and Wang (1996), Llewellen and Nagel (2006)[5] or Koch and Westheide (2008) may be the way forward. It may also be that alternative factor models, such as that proposed by Al-Horani et al. (2003), or a APT type model (e.g. Clare and Thomas, 1994) could offer a solution.

Until a convincing model of UK asset pricing comes along, whilst we caution against reliance on factor models, there is a case for using control firms whose characteristics are matched to those known to be associated with asset returns. This may be viewed as unsatisfactory and atheoretical, as Bulkley and Nawosah (2009) note, but it may also be the pragmatic solution to the dilemma of estimating long run abnormal returns in research. To this end, we offer fellow researchers a reasonable comprehensive set of UK control portfolios, complete with a file identifying the annual cut-offs. This enables the ready cross-matching of any UK firm for which characteristics can be identified with its control portfolio. Whilst, for those who still wish to put their faith in the three and four factor models, we also supply factor estimates, our strong recommendation is that long term abnormal returns for the UK be calculated using characteristic-matched portfolios.

[5] Note that although Lewellen and Nagel (2006) reject the idea of the conditional CAPM explain returns, a more recent paper by O'Doherty (2009) claims that it can explain the financial distress anomaly.

References:

Agarwal, V. and Taffler, R. (2008). 'Does Financial Distress Risk Drive the Momentum Anomaly?' *Financial Management* (Autumn), pp 461 - 484

Al-Horani, A., Pope, P.F. and Stark, A.W. (2003). 'Research and Development Activity and Expected Returns in the United Kingdom', *European Finance Review* Vol. 7, pp 27-46.

Bulkley, G. and Nawosah, V. (2009). 'Can the Cross-Sectional Variation in Expected Stock Returns Explain Momentum?', Journal of Financial and Quantitative Analysis, 44(4), August, pp 777-794.

Carhart, M. (1997). 'On Persistence in Mutual Fund Performance', *Journal of Finance,* Vol. 52*,* pp 57-82.

Clare, A.D. and Thomas, S.H. (1994). 'Macroeconomic Factors, the APT and the UK Stockmarket', *Journal of Business Finance and Accounting*, Vol. 21 (April), pp 309-330.

Cochrane, J.H. (2001). *Asset Pricing*. Princeton : Princeton University Press, 530 pp.

Dimson, E., Nagel, S. and Quigley, G. (2003). 'Capturing the Value Premium in the United Kingdom', *Financial Analysts Journal*, Vol 59(6), pp 35-45.

Fama, E.F. and French, K.R. (1992). 'The Cross Section of Expected Returns', *Journal of Finance*, Vol. 47, No. 2, pp 427-465.

Fama, E.F. and French, K.R. (1993). 'Common Risk Factors in the Returns on Stocks and Bonds', *Journal of Financial Economics,* Vol. 33, pp 3-56.

Fama, E.F. and French, K.R. (1995). 'Size and Book-to-Market Factors in Earnings and Returns', *Journal of Finance*, Vol. 50, pp 131-156.

Fama, E.F. and French, K.R. (1996). 'Multifactor Explanations of Asset Pricing Anomalies', *Journal of Finance*, Vol. 50, pp 131-155.

Fama, E.F. and French, K.R. (1997). 'Industry costs of equity', *Journal of Financial Economics*, Vol. 43, pp 153-193.

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

Ferson, W.E. and Harvey, C.R. (1999). ‘Conditioning Variables and the Cross-Section of Stock Returns’, *Journal of Finance*, Vol. 54, pp 1325-1360.

Fletcher, J. (2001). ‘An examination of predictable risk and return in UK stock returns’. *Journal of Economics and Business*, 53(6), pp 527-546.

Fletcher, J. & Forbes, D. (2002). ‘An exploration of the persistence of UK unit trust performance’. *Journal of Empirical Finance*, 9(5), pp 475-493.
Gibbons, M., Ross, S.A. and Shanken, J. (1989). ‘A test of the efficiency of a given portfolio.’ *Econometrica,* 57, pp 1121-1152.

Gregory, A., Harris, R.D.F. and Michou, M. (2001). ‘An Analysis of Contrarian Investment Strategies in the UK’ *Journal of Business Finance and Accounting*, Vol. 28/9&10, pp 1931-1228.

Gregory, A., Harris, R.D.F. and Michou, M. (2003). ‘Contrarian Investment and Macroeconomic Risk’ *Journal of Business Finance and Accounting*, Vol. 30, 1&2, pp 213-255.

Gregory, A. & Michou, M. (2009). ‘Industry Cost of Equity Capital: UK Evidence’. *Journal of Business Finance & Accounting*, 36(5-6), pp 679-704.

Hussain, S. I., Toms, J. S. and Diacon, S. (2002), 'Financial Distress, Market Anomalies and Single and Multifactor Asset Pricing Models: New Evidence', SSRN working paper no. 313001.

Jaganathan, R. and Wang, Z.(1996). ‘The Conditional CAPM and the Cross-Section of Expected Returns’, *Journal of Finance,* Vol. 51, No. 1, March pp 3-54.

Jegadeesh, N., Titman, S. (1993). ‘Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency’*, Journal of Finance,* Vol. 48, pp 65–91.

Jegadeesh, N., Titman, S. (2001). ‘Profitability of momentum strategies: an evaluation of alternative explanations’*, Journal of Finance,* Vol. 56, pp 699–720.

Koch, S. and Westheide C. (2009). ‘The Conditional Relation between Fama-French Betas and Return’, SSRN working paper no. 1283170

Lewellen, J. , and Nagel S. (2006). ‘The conditional CAPM does not explain asset-pricing anomalies’, *Journal of Financial Economics* 82, 289-314.

Lewellen, J. Nagel S. and Shanken, J. (2009). ‘A Skeptical Appraisal of Asset-Pricing Tests’, *Journal of Financial Economics*, forthcoming.

Lo, A. W. and MacKinlay, A.C. (1990). ‘Data-Snooping Biases in Tests of Financial Asset Pricing Models.’ *The Review of Financial Studies* 3, pp 431-467

Liu, W., Strong, N., and Xu, X.Z. (1999), ‘The Profitability of Momentum Investing,’ *Journal of Business Finance & Accounting* ,Vol. 26, pp 1043–91

Lyon, J.D., Barber, B.M. & Tsai, C. (1999). 'Improved Methods for Tests of Long-Run Abnormal Stock Returns'. *The Journal of Finance*, 54(1), pp 165-201.

Michou, M., Mouselli, S. and Stark A.W. (2007). 'Estimating the Fama and French Factors in the UK: An Empirical Review', *Manchester Business School Working paper series*, http://www.mbs.ac.uk/research/workingpapers/index.aspx?AuthorId=381

Michou, M., Mouselli, S. and Stark, A.W. (2008). 'On the Information Content of the Fama and French Factors in the UK', *Manchester Business School Working paper series*, http://www.mbs.ac.uk/research/workingpapers/index.aspx?AuthorId=381

Miles, D. & Timmermann, A.(1996). 'Variation in Expected Stock Returns: Evidence on the Pricing of Equities from a Cross-section of UK Companies.' *Economica*, 63(251), 369-382.

Nagel, S. (2001). 'Accounting Information Free Of Selection Bias: A New UK Database 1953-1999', London Business School Working Paper

O'Doherty, M.S. (2009). 'Does the Conditional CAPM Explain the Financial Distress Anomaly?' University of Iowa Working Paper.

Shanken, J. (1992). 'On the estimation of beta-pricing models.' *The Review of Financial Studies* 5 (1), pp 1–33.

Table 1 Summary statistics for factors

Panel A: GHM and DNQ cut-offs for Oct 1980-Dec 2008

	Mean	Median	SD	Skewness	Sig Skew	Kurtosis	Sig Kurt
RMRF	0.0043	0.0095	0.0463	-1.0986	***	6.9378	***
SMB350	-0.0004	-0.0013	0.0301	-0.1999	n.s.	3.9275	***
HML350	0.0050	0.0046	0.0329	-0.1398	n.s.	7.7920	***
UMD350	0.0086	0.0075	0.0387	-0.4981	***	6.7949	***
SMBDNQ	0.0003	-0.0005	0.0336	-0.1055	n.s.	4.1861	***
HMLDNQ	0.0053	0.0057	0.0272	-0.1153	n.s.	6.7866	***
UMDDNQ	0.0086	0.0077	0.0387	-0.5011	***	6.7995	***

Panel B: Correlations GHM and DNQ cut-offs for Oct 1980-Dec 2008

	smb350	hml350	umd350	smbdnq	hmldnq	umddnq	rmrf
SMB350	1.000			0.910			
HML350	-0.036	1.000			0.895		
UMD350	-0.027	-0.447	1.000			1.000	
SMBDNQ	0.919	-0.046	0.035	1.000			
HMLDNQ	-0.086	0.919	-0.468	-0.108	1.000		
UMDDNQ	-0.026	-0.446	1.000	0.035	-0.467	1.000	
RMRF	-0.001	-0.035	-0.115	-0.165	-0.015	-0.114	1.000

NB Figures above the diagonal are Spearman correlations, all of which are significant at the 1% level

Panel C: GHM cut-offs, with end-Sept and end June (GM) formation, for Oct 1980-Dec 2006

	Mean	Median	SD	Skewness	Sig Skew	Kurtosis	Sig Kurt
SMB350	0.0011	-0.0009	0.0290	-0.0085	n.s.	3.5919	*
HML350	0.0050	0.0063	0.0333	-0.1940	n.s.	7.9120	***
UMD350	0.0076	0.0075	0.0375	-0.6984	***	7.3074	***
SMBGM	-0.0005	-0.0004	0.0317	-0.3897	***	8.2265	***
HMLGM	0.0044	0.0053	0.0336	0.1200	n.s.	10.1072	***
WML	0.0016	0.0031	0.0283	-0.4883	***	6.0394	***

Panel D: Correlations for GHM cut-offs, with end-Sept and end June (GM) formation, for Oct 1980-Dec 2006

	smb350	hml350	umd350	smbgm	hmlgm	wml	rmrf
SMB350	1.000			0.773			
HML350	-0.084	1.000			0.527		
UMD350	0.049	-0.458	1.000			0.497	
SMBGM	0.686	0.072	-0.034	1.000			
HMLGM	-0.004	0.508	-0.225	-0.181	1.000		
WML	-0.201	-0.351	0.628	-0.199	-0.246	1.000	
RMRF	-0.049	-0.098	-0.103	-0.016	0.015	-0.142	1.000

Table 2: Summary statistics for the 6 Value-Weighted Fama-French Factor portfolios, October 1980 to December 2008

stats	SL	SM	SH	BL	BM	BH
mean	0.0070	0.0100	0.0132	0.0090	0.0095	0.0129
sd	0.0611	0.0529	0.0548	0.0483	0.0517	0.0530
iqr	0.0606	0.0585	0.0584	0.0531	0.0562	0.0579
skewness	-1.1655	-1.0423	-0.8385	-1.1399	-1.0835	-0.5874
kurtosis	6.7128	6.2155	5.6097	9.2914	6.6804	4.7228
max	0.2246	0.1567	0.1969	0.1473	0.1529	0.1589
p50	0.0161	0.0179	0.0181	0.0119	0.0153	0.0140
min	-0.2917	-0.2530	-0.2326	-0.3205	-0.2789	-0.2414

Statistics reported are the mean, standard deviation (SD), inter-quartile range (iqr), skewness, kurtosis, maximum and minimum. The first letter denotes size, the second the book-to-market category, so for example SL denotes small – low book to market, whilst BH denotes big and high book to market.

Table 3: Summary statistics for the value-weighted size decile portfolios, October 1980 to December 2008

stats	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
mean	0.0208	0.0163	0.0124	0.0117	0.0112	0.0109	0.0101	0.0101	0.0103	0.0100
sd	0.0543	0.0547	0.0528	0.0529	0.0538	0.0542	0.0551	0.0552	0.0569	0.0460
iqr	0.0554	0.0585	0.0596	0.0621	0.0571	0.0576	0.0554	0.0594	0.0601	0.0480
skewness	0.4253	-0.2805	-0.7158	-0.7268	-0.5520	-0.8243	-0.9836	-1.1834	-1.0170	-0.9979
kurtosis	6.3637	5.2469	5.5322	5.1549	5.0777	5.3424	6.1044	6.7213	6.1310	7.2689
max	0.3172	0.2216	0.1633	0.1396	0.1784	0.1619	0.1673	0.1779	0.1679	0.1454
p50	0.0201	0.0171	0.0140	0.0167	0.0156	0.0162	0.0159	0.0187	0.0169	0.0141
min	-0.1765	-0.2098	-0.2429	-0.2239	-0.2256	-0.2360	-0.2403	-0.2553	-0.2871	-0.2699

Statistics reported are the mean, standard deviation (SD), inter-quartile range (iqr), skewness, kurtosis, maximum and minimum. S1 is the smallest portfolio by market capitalisation, S10 is the largest

Table 4: Summary statistics for the value-weighted book-to-market decile portfolios, October 1980 to December 2008

stats	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
mean	0.0068	0.0091	0.0062	0.0107	0.0108	0.0125	0.0152	0.0140	0.0135	0.0185
sd	0.0534	0.0484	0.0571	0.0526	0.0538	0.0535	0.0556	0.0544	0.0605	0.0742
iqr	0.0584	0.0496	0.0611	0.0573	0.0620	0.0620	0.0610	0.0613	0.0669	0.0892
skewness	-1.2046	-1.1957	-1.4172	-0.8733	-1.0046	-0.4658	-0.8770	-0.5442	-0.4641	-0.2987
kurtosis	9.0088	8.9152	7.6935	6.3990	5.7384	5.3322	6.3712	4.7342	5.0246	4.3440
max	0.1400	0.1337	0.1557	0.1427	0.1558	0.1885	0.1642	0.1669	0.2413	0.2351
p50	0.0109	0.0133	0.0134	0.0119	0.0153	0.0148	0.0196	0.0171	0.0199	0.0211
min	-0.3498	-0.3128	-0.3188	-0.2806	-0.2392	-0.2627	-0.3066	-0.2237	-0.2298	-0.2962

Statistics reported are the mean, standard deviation (SD), inter-quartile range (iqr), skewness, kurtosis, maximum and minimum. V1 is the lowest market to book ("glamour") portfolio, V10 the highest ("value").

Table 5: Summary statistics for the 6 Value-Weighted Size and Momentum portfolios, October 1980 to December 2008

stats	SL	SM	SH	BL	BM	BH
mean	0.0052	0.0109	0.0157	0.0058	0.0115	0.0126
sd	0.0585	0.0478	0.0534	0.0578	0.0465	0.0526
iqr	0.0586	0.0503	0.0548	0.0593	0.0496	0.0617
skewness	-0.9643	-1.3154	-1.2188	-0.7189	-0.8582	-1.2275
kurtosis	6.3164	7.2934	6.6459	5.9475	6.6428	7.8446
max	0.1822	0.1362	0.1684	0.1847	0.1482	0.1248
p50	0.0108	0.0172	0.0250	0.0091	0.0127	0.0166
min	-0.2537	-0.2474	-0.2685	-0.2903	-0.2604	-0.3154

Statistics reported are the mean, standard deviation (SD), inter-quartile range (iqr), skewness, kurtosis, maximum and minimum. The first letter denotes size, the second the momentum category, so for example SL denotes small – low momentum, whilst BH denotes big and high momentum.

Table 6: Summary statistics for the 5 x 5 Value-Weighted Fama-French Size and book-to-market portfolios, Largest 350 cutoffs, October 1980 to December 2008

stats	SL	S2	S3	S4	SH	S2L	S22	S23	S24	S2H	M3L	M32	M33
mean	0.0070	0.0079	0.0100	0.0114	0.0143	0.0067	0.0083	0.0101	0.0106	0.0124	0.0059	0.0065	0.0105
sd	0.0661	0.0576	0.0514	0.0531	0.0531	0.0680	0.0614	0.0551	0.0616	0.0629	0.0740	0.0624	0.0600
iqr	0.0636	0.0588	0.0539	0.0549	0.0558	0.0669	0.0665	0.0649	0.0748	0.0666	0.0780	0.0695	0.0669
skewness	-0.8733	-0.7872	-0.7411	-0.8078	-0.6376	-0.7744	-1.0143	-0.5905	-0.3995	-0.0888	-1.1583	-1.0201	-1.1778
kurtosis	6.6349	5.1177	5.6208	5.4610	5.1262	5.3282	6.2286	4.8404	5.0364	7.0475	7.7935	5.7999	7.2288
max	0.2443	0.1570	0.1510	0.1696	0.1763	0.2498	0.1635	0.1801	0.2147	0.3731	0.3202	0.1495	0.1411
p50	0.0150	0.0120	0.0142	0.0149	0.0163	0.0137	0.0106	0.0127	0.0136	0.0168	0.0123	0.0132	0.0189
min	-0.3275	-0.2440	-0.2050	-0.2219	-0.2253	-0.2807	-0.2990	-0.2202	-0.2643	-0.2245	-0.3731	-0.2835	-0.3208

stats	M34	M3H	B4L	B42	B43	B44	B4H	BL	B2	B3	B4	BH
mean	0.0100	0.0152	0.0081	0.0089	0.0112	0.0124	0.0133	0.0088	0.0074	0.0098	0.0132	0.0125
sd	0.0631	0.0653	0.0641	0.0580	0.0578	0.0649	0.0649	0.0518	0.0539	0.0541	0.0528	0.0582
iqr	0.0686	0.0751	0.0692	0.0613	0.0625	0.0746	0.0684	0.0567	0.0611	0.0620	0.0568	0.0654
skewness	-0.5643	-0.5584	-0.7755	-0.9678	-0.7360	-0.6661	-0.8468	-1.0699	-1.0387	-0.7764	-0.9296	-0.3873
kurtosis	4.6577	5.5609	7.1653	7.1081	5.8925	5.0284	5.9998	8.9972	6.4739	5.5273	7.4698	4.6407
max	0.2062	0.2627	0.2897	0.1773	0.1966	0.1855	0.1958	0.1379	0.1531	0.1628	0.1532	0.2094
p50	0.0161	0.0183	0.0165	0.0092	0.0125	0.0169	0.0177	0.0104	0.0142	0.0126	0.0150	0.0177
min	-0.2606	-0.2812	-0.3285	-0.3194	-0.2784	-0.2832	-0.3260	-0.3435	-0.2891	-0.2384	-0.3099	-0.2023

These are 25 (5x5) intersecting size and book to market (BTM) portfolios for the "350 groups"– 5 size portfolios, with 4 portfolios formed from the largest 350 firms + 1 portfolio formed from the rest, and 5 B/M portfolios – with breakpoints based on the largest 350 firms. The first character denotes size, the second the book-to-market category, so for example SL denotes small – low book to market, S2 denotes size and second lowest book to market category, whilst B4 denotes big and fourth highest book to market category, and BH denotes big and high book to market. However, outside the smallest and largest categories, we use three characters, so that, for example, M34 denotes the middle (third) size portfolio and the fourth largest book to market portfolio. Statistics reported are the mean, standard deviation (SD), inter-quartile range (iqr), skewness, kurtosis, maximum and minimum.

Table 7: Summary statistics for the 5 x 5 Value-Weighted Fama-French Size and book-to-market portfolios, Alternative 350 cut-offs, October 1980 to December 2008

stats	SL	S2	S3	S4	SH	S2L	S22	S23	S24	S2H	M3L	M32	M33
mean	0.0152	0.0118	0.0140	0.0129	0.0155	0.0063	0.0080	0.0093	0.0112	0.0140	0.0066	0.0085	0.0109
sd	0.0713	0.0715	0.0602	0.0524	0.0516	0.0683	0.0580	0.0518	0.0546	0.0553	0.0657	0.0592	0.0544
iqr	0.0791	0.0727	0.0695	0.0577	0.0603	0.0629	0.0616	0.0554	0.0540	0.0574	0.0700	0.0634	0.0651
skewness	-0.0588	-0.1800	-0.2380	-0.3498	-0.2576	-1.0670	-0.8115	-0.7531	-0.8309	-0.6580	-0.9084	-1.0954	-0.7791
kurtosis	4.6766	5.9244	5.0255	4.5871	5.3615	7.9158	5.1284	5.6728	5.5608	5.0077	6.1681	6.3525	5.2797
max	0.2599	0.3458	0.2340	0.2001	0.2401	0.2442	0.1580	0.1471	0.1849	0.1879	0.2509	0.1504	0.1527
p50	0.0162	0.0130	0.0158	0.0131	0.0148	0.0135	0.0118	0.0133	0.0166	0.0180	0.0128	0.0135	0.0156
min	-0.2525	-0.2685	-0.2219	-0.1944	-0.2039	-0.3944	-0.2488	-0.2089	-0.2313	-0.2319	-0.2912	-0.2960	-0.2471

stats	M34	M3H	B4L	B42	B43	B44	B4H	BL	B2	B3	B4	BH
mean	0.0118	0.0116	0.0074	0.0064	0.0110	0.0116	0.0140	0.0086	0.0075	0.0100	0.0132	0.0129
sd	0.0602	0.0623	0.0663	0.0600	0.0600	0.0618	0.0641	0.0515	0.0534	0.0535	0.0528	0.0564
iqr	0.0713	0.0679	0.0672	0.0663	0.0666	0.0681	0.0712	0.0588	0.0604	0.0603	0.0563	0.0638
skewness	-0.5848	-0.3251	-1.0008	-1.1466	-1.0160	-0.6499	-0.9523	-1.1474	-1.0786	-0.8331	-0.8892	-0.4275
kurtosis	5.4156	5.8709	7.0972	6.2560	6.9729	5.5115	6.2677	9.3215	6.7308	5.6742	7.0060	4.5609
max	0.2165	0.3153	0.2575	0.1587	0.1702	0.1928	0.1628	0.1314	0.1486	0.1559	0.1522	0.2021
p50	0.0145	0.0171	0.0139	0.0122	0.0167	0.0164	0.0202	0.0106	0.0140	0.0129	0.0150	0.0166
min	-0.2790	-0.2153	-0.3062	-0.2769	-0.3133	-0.2818	-0.3194	-0.3455	-0.2950	-0.2408	-0.3005	-0.2066

These are 25 (5x5) intersecting size and book to market (BTM) portfolios for the "Alternative 350 groups"– 5 size portfolios – 3 portfolios formed from the largest 350 firms + 2 small portfolios formed from the rest, and 5 B/M portfolios – with breakpoints based on *all* firms. The first character denotes size, the second the book-to-market category, so for example SL denotes small – low book to market, S2 denotes size and second lowest book to market category, whilst B4 denotes big and fourth highest book to market category, and BH denotes big and high book to market. However, outside the smallest and largest categories, we use three characters, so that, for example, M34 denotes the middle (third) size portfolio and the fourth largest book to market portfolio. Statistics reported are the mean, standard deviation (SD), inter-quartile range (iqr), skewness, kurtosis, maximum and minimum.

Table 8: Summary statistics for the 5 x 5 Value-Weighted Fama-French Size and Momentum portfolios, Largest 350 cutoffs, October 1980 to December 2008

stats	SL	S2	S3	S4	SH	S2L	S22	S23	S24	S2H	M3L	M32	M33
mean	0.0030	0.0078	0.0108	0.0131	0.0191	0.0030	0.0081	0.0107	0.0138	0.0155	0.0063	0.0109	0.0133
sd	0.0599	0.0472	0.0457	0.0459	0.0565	0.0692	0.0573	0.0528	0.0537	0.0643	0.0728	0.0561	0.0542
iqr	0.0587	0.0465	0.0500	0.0493	0.0589	0.0700	0.0610	0.0609	0.0617	0.0669	0.0759	0.0639	0.0597
skewness	-0.7200	-1.2719	-1.3337	-1.1666	-1.0469	-0.9207	-0.9092	-1.1057	-1.0931	-1.0409	-0.6340	-0.8159	-0.7149
kurtosis	5.9769	6.9432	7.3476	6.4303	6.0731	5.3415	6.0582	6.1256	6.8483	5.9968	6.5709	5.5930	5.6049
max	0.1845	0.1248	0.1203	0.1297	0.1854	0.1851	0.1739	0.1504	0.1713	0.2081	0.3161	0.1572	0.1635
p50	0.0089	0.0159	0.0171	0.0191	0.0289	0.0076	0.0129	0.0180	0.0180	0.0227	0.0103	0.0144	0.0169
min	-0.2675	-0.2293	-0.2329	-0.2250	-0.2574	-0.2713	-0.2921	-0.2572	-0.2906	-0.2791	-0.3189	-0.2644	-0.2647

stats	M34	M3H	B4L	B42	B43	B44	B4H	BL	B2	B3	B4	BH
mean	0.0120	0.0145	0.0056	0.0110	0.0125	0.0129	0.0174	0.0043	0.0096	0.0125	0.0108	0.0130
sd	0.0527	0.0613	0.0698	0.0562	0.0525	0.0532	0.0632	0.0658	0.0498	0.0496	0.0499	0.0580
iqr	0.0585	0.0661	0.0751	0.0608	0.0559	0.0617	0.0661	0.0676	0.0532	0.0604	0.0573	0.0636
skewness	-1.2839	-0.9559	-0.4950	-0.8148	-0.8636	-1.0234	-0.3660	-0.6354	-0.6749	-0.5663	-0.9333	-1.3019
kurtosis	7.8192	6.7011	4.8395	5.3575	6.8434	7.3166	6.8143	6.1293	5.9207	5.1322	7.4798	8.0731
max	0.1367	0.2431	0.2441	0.1603	0.1781	0.1603	0.3023	0.2443	0.1575	0.1531	0.1363	0.1439
p50	0.0178	0.0192	0.0144	0.0165	0.0177	0.0138	0.0213	0.0062	0.0125	0.0127	0.0150	0.0196
min	-0.2998	-0.3003	-0.2852	-0.2657	-0.2821	-0.3104	-0.3063	-0.3412	-0.2637	-0.2322	-0.3023	-0.3276

These are 25 (5x5) intersecting size and momentum portfolios for the "350 groups"– 5 size portfolios, with 4 portfolios formed from the largest 350 firms + 1 portfolio formed from the rest, and 5 momentum portfolios – with breakpoints based on the largest 350 firms. The first character denotes size, the second the momentum category, so for example SL denotes small – low momentum, S2 denotes small and second lowest momentum category, whilst B4 denotes the largest size quintile and fourth highest book to market category, and BH denotes big and high book to market. However, outside the smallest and largest categories, we use three characters, so that, for example, M34 denotes the middle (third) size portfolio and the fourth largest momentum portfolio. Statistics reported are the mean, standard deviation (SD), inter-quartile range (iqr), skewness, kurtosis, maximum and minimum.

Table 9: Summary statistics for the 3 x 3 x 3 size, book-to-market and momentum portfolios, October 1980-December 2008.

stats	SGL	SGM	SGH	SML	SMM	SMH	SVL	SVM	SVH	MGL	MGM	MGH	MML	MMM
mean	0.0057	0.0083	0.0107	0.0086	0.0112	0.0139	0.0191	0.0129	0.0163	0.0071	0.0068	0.0085	0.0092	0.0109
sd	0.0620	0.0522	0.0606	0.0626	0.0514	0.0516	0.0838	0.0568	0.0508	0.0638	0.0603	0.0724	0.0600	0.0552
iqr	0.0654	0.0588	0.0632	0.0676	0.0521	0.0537	0.0819	0.0620	0.0559	0.0703	0.0619	0.0714	0.0665	0.0609
skewness	-0.3161	-0.8264	-1.0325	-1.0293	-0.9965	-0.8567	1.2847	-0.5140	-0.5992	-0.2858	-1.1234	-1.2593	-0.6042	-0.6926
kurtosis	5.0810	5.9338	6.6200	7.0202	6.7099	6.0324	12.2530	5.0306	5.2479	5.1792	6.6202	7.8500	5.1064	5.3521
max	0.2327	0.1696	0.1763	0.1434	0.1595	0.1519	0.6259	0.1916	0.1735	0.2994	0.1779	0.2971	0.1858	0.1795
p50	0.0075	0.0129	0.0178	0.0105	0.0176	0.0173	0.0162	0.0163	0.0182	0.0093	0.0110	0.0170	0.0137	0.0124
min	-0.2465	-0.2451	-0.3142	-0.3650	-0.2474	-0.2178	-0.2351	-0.2181	-0.2145	-0.2543	-0.3051	-0.3903	-0.2686	-0.2719

stats	MMH	MVL	MVM	MVH	BGL	BGM	BGH	BML	BMM	BMH	BVL	BVM	BVH
mean	0.0107	0.0108	0.0113	0.0124	0.0077	0.0090	0.0094	0.0087	0.0095	0.0095	0.0117	0.0120	0.0143
sd	0.0637	0.0725	0.0595	0.0616	0.0532	0.0511	0.0612	0.0589	0.0512	0.0638	0.0635	0.0569	0.0531
iqr	0.0693	0.0747	0.0671	0.0691	0.0605	0.0585	0.0610	0.0681	0.0557	0.0618	0.0640	0.0648	0.0618
skewness	-1.3471	-0.2394	-0.6050	-0.9215	-0.6631	-0.5968	-1.4255	-0.6243	-0.8389	-1.1908	-0.5082	-0.4666	-0.7947
kurtosis	8.0170	5.5999	4.6735	5.9449	5.9647	5.7687	8.6792	4.4835	7.1713	6.6432	4.6760	4.5564	6.0283
max	0.1641	0.3264	0.1994	0.2197	0.1667	0.1663	0.1367	0.1559	0.1629	0.1870	0.2333	0.1829	0.1697
p50	0.0175	0.0112	0.0153	0.0207	0.0093	0.0123	0.0142	0.0169	0.0127	0.0143	0.0177	0.0155	0.0149
min	-0.3556	-0.2740	-0.2368	-0.2853	-0.2900	-0.2616	-0.3732	-0.2308	-0.2952	-0.2936	-0.2108	-0.2358	-0.2842

The Tables show the 27 (3x3x3) portfolios, *sequentially* sorted on size, book-to-market and momentum. The three size portfolios are two portfolios formed from the largest 250 firms plus one group from the remainder. Then within each size group we create three B/M groups. Finally, from within each of these 9 portfolios we form 3 momentum groups. The first letter denotes size (Small, S; Medium, M; Large, L), the second the book to market category (Low or “Glamour”, G; Medium, M; High, or “value”, V), and the third momentum (Low, L; Medium, M; High, H). Statistics reported are the mean, standard deviation (SD), inter-quartile range (iqr), skewness, kurtosis, maximum and minimum.

Table 10. Results from GRS (1989) F – test

Portfolios	3-factor		4-factor	
	GRS F-test	p-value	GRS F-test	p-value
25 (5x5) Size & B/M	1.1702	0.2648	0.9073	0.5955
25 (5x5) Size & B/M (Alternative cut-off)	1.5837	0.0402	1.5350	0.0517
27 (3x3x3) Size, B/M, Momentum	1.8631	0.0068	1.2194	0.2131
Size decile portfolios	4.4880	0.0000	3.6278	0.0001
B/M Decile portfolios	1.8833	0.0466	2.3470	0.0110
25 (5x5) Size & Momentum portfolios	5.8871	0.0000	3.9514	0.0000

Table 11: Cross-sectional regressions for the three and four factor models:

Panel A: With alternative definitions of the 25 (5x5) size and book-to-market portfolios as dependent variables

5 x 5 350 Portfolios	Single			Rolling			Single			Rolling		
Variable	**Mean**	**sh-t**	**sh-p**	**Mean**	**sh-t**	**sh-p**	**Mean**	**sh-t**	**sh-p**	**Mean**	**sh-t**	**sh-p**
cons	0.581	1.320	0.187	0.543	1.590	0.113	0.398	0.870	0.383	0.347	0.940	0.348
rmrf	-0.191	-0.390	0.694	-0.320	-0.920	0.356	0.040	0.080	0.937	-0.021	-0.060	0.953
smb	-0.059	-0.350	0.723	-0.098	-0.530	0.593	-0.062	-0.370	0.710	-0.112	-0.610	0.545
hml	0.533	2.740	0.007	0.454	2.290	0.023	0.549	2.840	0.005	0.467	2.380	0.018
umd							0.280	0.540	0.591	0.338	1.020	0.308
Cross-sect R2	0.600			0.590			0.600			0.600		
chi-squared	22.792			29.432			20.377			27.986		
p-value	0.414			0.133			0.498			0.141		
5 x 5 Alternative 350 Portfolios												
cons	1.429	2.720	0.007	1.070	2.630	0.009	1.408	2.720	0.007	0.798	1.860	0.063
rmrf	-1.030	-2.050	0.041	-0.896	-2.230	0.026	-1.003	-1.950	0.052	-0.571	-1.300	0.196
smb	-0.016	-0.100	0.923	-0.046	-0.240	0.810	-0.018	-0.110	0.916	-0.047	-0.250	0.805
hml	0.531	2.740	0.006	0.474	2.430	0.016	0.533	2.780	0.006	0.476	2.460	0.015
umd							-0.111	-0.200	0.842	-0.021	-0.060	0.955
Cross-sect R2	0.600			0.600			0.610			0.610		
chi-squared	30.735			30.263			31.348			31.255		
p-value	0.102			0.112			0.068			0.070		

The Table reports the results of Fama-Macbeth regressions, with sh-t and sh-p denoting the t-test and p-values from the Shanken (1992) errors-in-variables adjusted tests

Panel B: With the decile size and book-to-market portfolios as dependent variables

B/M Portfolios	Single			Rolling			Single			Rolling		
Variable	**Mean**	**sh-t**	**sh-p**	**Mean**	**sh-t**	**sh-p**	**Mean**	**sh-t**	**sh-p**	**Mean**	**sh-t**	**sh-p**
cons	2.254	1.550	0.123	1.879	1.980	0.048	2.254	1.600	0.112	1.765	1.780	0.077
rmrf	-1.906	-1.960	0.051	-1.645	-2.320	0.021	-1.904	-1.940	0.053	-1.459	-1.870	0.062
smb	0.619	1.150	0.252	0.055	0.140	0.892	0.618	1.140	0.256	-0.013	-0.030	0.974
hml	0.705	3.150	0.002	0.603	2.990	0.003	0.706	3.130	0.002	0.609	2.860	0.005
umd							-0.177	-0.310	0.756	0.008	0.020	0.988
Cross-sect R2	0.590			0.550			0.590			0.570		
chi-squared	3.202			8.299			3.306			4.646		
p-value	0.866			0.307			0.770			0.590		
Size Portfolios												
cons	2.440	2.900	0.004	1.842	2.750	0.006	1.919	1.640	0.101	2.079	2.710	0.007
rmrf	-1.991	-3.820	0.000	-1.738	-2.960	0.003	-1.391	-1.770	0.077	-2.083	-3.090	0.002
smb	-0.271	-1.420	0.155	0.000	0.000	0.999	-0.276	-1.450	0.147	0.049	0.230	0.815
hml	1.606	2.560	0.011	0.501	1.100	0.271	1.715	2.760	0.006	0.372	0.750	0.455
umd							0.259	0.270	0.784	-1.183	-1.840	0.067
Cross-sect R2	0.690			0.700			0.730			0.710		
chi-squared	26.789			20.065			28.661			15.102		
p-value	0.000			0.005			0.000			0.020		

The Table reports the results of Fama-Macbeth regressions, with sh-t and sh-p denoting the t-test and p-values from the Shanken (1992) errors-in-variables adjusted tests

Panel C: With the 25 (5x5) size and momentum portfolios and the 27 (3 x 3 x3) Size, book-to-market and momentum portfolios as dependent variables

5 x 5 Size & Momentum Portfolios	Single			Rolling			Single			Rolling		
Variable	Mean	sh-t	sh-p	Mean	sh-t	sh-p	Mean	sh-t	sh-p	Mean	sh-t	sh-p
cons	1.288	2.440	0.015	0.675	1.480	0.141	0.589	1.280	0.201	0.282	0.710	0.479
rmrf	-0.750	-1.590	0.113	-0.239	-0.590	0.557	-0.087	-0.180	0.854	0.121	0.310	0.753
smb	0.004	0.020	0.982	-0.156	-0.800	0.425	-0.009	-0.050	0.962	-0.085	-0.440	0.662
hml	-1.285	-3.730	0.000	-0.926	-3.350	0.001	-0.212	-0.460	0.643	-0.274	-1.070	0.284
umd							0.881	4.050	0.000	0.845	3.380	0.001
Cross-sect R2	0.640			0.610			0.670			0.650		
chi-squared	90.228			102.232			96.715			115.539		
p-value	0.000			0.000			0.000			0.000		
3 x 3 x 3 Size, B/M & Momentum Portfolios												
cons	0.832	2.070	0.039	0.584	1.610	0.109	0.412	0.930	0.353	0.400	1.100	0.271
rmrf	-0.433	-0.960	0.336	-0.361	-0.990	0.323	0.055	0.120	0.907	-0.113	-0.320	0.752
smb	-0.037	-0.210	0.832	-0.058	-0.320	0.751	-0.035	-0.200	0.842	-0.055	-0.290	0.770
hml	0.447	2.270	0.024	0.294	1.450	0.149	0.555	2.880	0.004	0.284	1.390	0.165
umd							0.763	2.070	0.039	0.321	1.150	0.251
Cross-sect R2	0.580			0.580			0.590			0.580		
chi-squared	44.646			52.064			35.811			50.688		
p-value	0.006			0.001			0.043			0.001		

The Table reports the results of Fama-Macbeth regressions, with sh-t and sh-p denoting the t-test and p-values from the Shanken (1992) errors-in-variables adjusted tests