Constructing and Testing Alternative Versions of the Fama-French and Carhart Models in the UK

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Abstract

The aim of this paper is to construct and test alternative versions of the Fama-French and Carhart models for the UK market. We conduct a comprehensive analysis of such models, forming risk factors using approaches advanced in the recent literature including value weighted factor components and various decompositions of the risk factors. We also test whether such factor models can at least explain the returns of large firms. Despite these various approaches, we join Michou, Mouselli and Stark (2007) and Fletcher (2010) in demonstrating that such factor models fail to reliably describe the cross-section of returns in the UK.

The data and factors underlying this paper can be downloaded from:
(address in with authors versions only)

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Introduction

Despite its frequent use in empirical research, there is little evidence to suggest that the Fama-French 3-factor (FF) model adequately describes the cross-section of stock returns in the UK. Michou, Mouselli and Stark (2007, hereafter MMS) show that no matter which "recipe" for factor construction is followed, none "emerge with a clean bill of health". Fletcher and Kihanda (2005) examine whether conditional versions of the CAPM perform any better, whilst Fletcher (2010) extends this work further, first by examining a conditional version of the FF model, second by examining the importance of the "no arbitrage" restriction, and third by constructing "value" factors using the dividend yield, a method that enables the time period of study to be extended back to 1964. However, Fletcher concludes that, "These results suggest we still have not found a good model that can capture the risk and return dynamics in UK stock returns".

This motivates us to extend the search for such a model in a number of different ways. First, we consider whether the addition of a "momentum" or "Carhart" factor can rescue the basic FF model. We examine if any of the alternative specifications of the factors examined by MMS in association with a Carhart (1997) factor improves on the position, and investigate the alternative of extending the Gregory, Harris and Michou (2001, GHM) factor approach to obtain a UK equivalent of the US UMD momentum factor available on Ken French's website. This differs from the basic Carhart (1997) factor as it is formed by intersecting size and momentum portfolios. Second, we note the Cremers, Petajisto and Zitzewitz (2010, hereafter CPZ) critique of the construction of the FF factors and follow their proposal on value-weighting (rather than equally weighting) the individual component portfolios of the FF factors. Third, we examine the potential impact of decomposition approaches to the factors, along the lines of Zhang (2008) and CPZ.[1] Fourth, we also examine whether the addition of

[1] A similar approach can be found in an earlier version of Fama and French (2011).

[2] In particular, privatisations of utilities and the rail industry during our observation period have led to the emergence of significant new sectors. These changes are essentially the result of political choices

the APT factors identified in Clare, Priestly and Thomas (1997) improves the FF model. Finally, we test the performance of these alternative models when factors and portfolios are constructed only from the largest 350 firms by market capitalisation, in an attempt to see if we can find a model that works at least for larger and more liquid firms.

Given that we investigate both three and four factor models, we first test these models against portfolios formed by intersecting sorts on size and book-to-market (BTM), and by sequential sorts on size, BTM and momentum. Both Lo and MacKinlay (1990) and Lewellen, Nagel and Shanken (2010) warn against relying on tests of a model on portfolios whose characteristics have been used to form the factors in the first place. Lewellen et al. (2010, p.182) suggest, *inter alia*, tests based on portfolios formed on either industries or volatility. MMS follow this advice by testing on industry portfolios, showing that no factors appear to be priced when tested against this more demanding set of portfolios. In this paper, we follow the Lewellen et al. (2010) suggestion of testing on volatility. We do this partly to extend the range of test portfolios used in the UK, given that MMS test against industry portfolios, and partly to avoid difficulties caused by certain industry changes in the UK.[2] In addition, recent work by Brooks, Li and Miffre (2011) raise the intriguing possibility that idiosyncratic risk may be priced in the US, which makes testing against portfolios formed on the basis of past volatility interesting.

Despite our attempts at alternative methods of factor construction, it turns out that once we move away from tests on the size and BTM portfolios, the performance of the models is anything but robust. This is probably not surprising, given the recent results in MMS and Fletcher (2010). One explanation for this poor performance is that there are limits to arbitrage, especially in smaller stocks. These might come about because of liquidity constraints and limits to stock availability in smaller firms, or because short selling constraints might limit the ability of investors to short over-priced "loser" stocks or over-priced "glamour" stocks (Ali and Trombley, 2006; Ali, Huang and Trombley, 2003). Yet as Thomas (2006) points out, it is not difficult to

[2] In particular, privatisations of utilities and the rail industry during our observation period have led to the emergence of significant new sectors. These changes are essentially the result of political choices and so differ from structural changes brought about by technological innovation.

short-sell most large capitalisation stocks. Given that we would expect such limits to arbitrage to be considerably less in larger stocks, we repeat all of our tests on a sub-sample of the 350 largest UK firms, forming both factors and test portfolios from this smaller universe of stocks. The good news is that when we do so, we cannot reject the null hypothesis of the intercept being jointly zero for any of our models tested against all our test portfolios in the first-stage Gibbons, Ross and Shanken (1989, GRS) test. Further, depending on the model, in the second-stage Fama_MacBeth regressions, the intercept is not significantly different from zero, the value factor (*hml*) is positively priced in general, and the market risk premium is positively priced in rolling regressions for one version of the CPZ model when we test against the size and BTM portfolios. When we test against the three-way sorted portfolios, *HML*, momentum and the market risk premium seem to be priced, and priced at plausible levels in some specifications of the model. Unfortunately, the bad news is that these models fail to be consistent when confronted with the more demanding volatility-based portfolio test. In tests on these portfolios, only momentum is positively priced, and then only when models are estimated on a non-rolling basis.

We do not attempt to 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).[3] This is an interesting, although demanding, task worthy of a detailed paper in its own right. We leave this for future research, but we hope that it is one we can help facilitate through this paper.

Data and method

We collect our data by cross-matching from the following databases: The London Business School Share Price Database, from which we obtain the monthly stock returns, market capitalisation data. and also key dates of first listing and de-listing; Datastream; Thomson One Banker; tailored Hemscott data (from the Gregory,

[3] 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 (http://xfi.exeter.ac.uk/)

Tharyan and Tonks [2011] study of directors' trading) obtained by subscription; and hand collected data on bankrupt firms from Christidis and Gregory (2010), from which we obtain estimates of book value used in the computation of the BTM ratios used in portfolio formation. 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. Data covers the period from October 1980 to December 2010.

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 GHM 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 BTM breakpoints on the 30th and 70th percentiles of the largest 350 firms, whereas DNQ 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. For the reasons outlined in the introduction, we believe it is important to consider the likely investable universe for large investors, and given the weight of the evidence in MMS, we follow the largest 350 firms method found in Gregory et al. (2001, 2003) and Gregory and Michou (2009, hereafter GM). However, we also construct and test our models using the alternative Dimson et al. (2003) 70th percentile breakpoints, the Al-Horani et al. 50th percentile breakpoints together with the Fletcher (2001) and Fletcher and Kihanda (2005) factor construction methods. An excellent and detailed review of the methods used in UK portfolio construction can be found in MMS. Given that our evidence on these alternative factor specifications is similar to that in MMS, we do not report these tests in the paper, although full test results are available from the authors on request.

In detail, 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 BTM respectively: S/H; S/M; S/L B/H; B/M; B/L. For the size cut-off we use the median market capitalisation of the largest 350 companies (our proxy for the Fama-French NYSE cut-off) and we use this 350 group of stocks to set the cut-offs for the BTM portfolios.

The *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 values (to compute the BTM ratios) can be collected from any of Datastream, Hemscott, the LSPD or the hand-collected data from Christidis and Gregory (2010). Following 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 match March year *t* accounting data with 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 BTM 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. The market risk premium, *rmrf* is then *Rm-Rf*.

We form the *umd* 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 in the construction of the factor. 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 30th and 70th 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), where U denotes the high momentum portfolio and D the low momentum portfolio. However, we also form an alternative *umd* factor, *umd_car*, by following the approach in Carhart (1997). By construction, this factor is not inter-acted with the size factor. Finally, noting the negative correlation between momentum and value factors,[4] we investigated two alternative specifications of *umd*, one formed by inter-acting BTM (rather than size) with prior return, and also a decomposition of *umd* into a "value" and "glamour" component. As neither of these specifications appeared to lead to an improved model we omit the tests of these factors for space reasons.

Zhang (2008) and CPZ consider that a decomposition of the FF factors may be helpful, as does an earlier version of the Fama-French (2011) paper. The intuition is that value effects may differ between large and small firms. Perhaps more importantly, CPZ argue that the FF practice of weighting the six constituent portfolios equally gives a disproportionate weight to small value stocks. So in this paper, we report the result of using a Zhang (2008) type decomposition of the FF *hml* factor into small (*hmls*) and large (*hmlb*) firm components, a CPZ-style market capitalisation weighting of the *smb, hml* and *umd* component portfolios, which we label *smb*_CPZ, *hml*_CPZ, *umd*_CPZ respectively, and a CPZ decomposition of: the *hml* factor into big and small firms (*BHML_CPZ* and *SHML_CPZ),* together with a decomposition of the *smb* factor into a mid-cap minus large cap factor (*MMB_CPZ*) and a small cap minus mid-cap factor (*SMM_CPZ*). Using these factors we construct the following models.

Basic models

- Basic FF –using rmrf, smb and hml
- Basic Carhart – using rmrf, smb, hml and umd

Value weighted factor components models

- CPZ-FF – using rmrf, smb_CPZ and hml_CPZ
- CPZ-Carhart - using rmrf, smb_CPZ, hml_CPZ and umd_CPZ

Decomposed factor models

- Zhang_decomposition – using rmrf, smb, hmls, hmlb and umd
- CPZ-decomposition- using rmrf, MMB, SMM, BHML_CPZ, SHML_CPZ and umd_CPZ

[4] Clifford (1997) notes a similar effect in the US.

We then construct the following portfolios and use the value-weighted returns on these portfolios in our tests:[5]

1. 25 (5x5) intersecting size and BTM
   - 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. 27 (3x3x3) sequentially sorting on size, BTM 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 BTM groups.
   - Then within each of these 9 portfolios we form 3 momentum groups.

3. 25 portfolios ranked on prior 12-month standard deviation of returns.

For our large firm tests, we use the basic models, the value weighted components models and the Zhang decomposition together with a modified the Cremers decomposition model as below.

- CPZ-decomposition- using rmrf, smb_CPZ, BHML_CPZ, SHML_CPZ and umd_CPZ

We then form the 25 intersecting size and BTM portfolios using five size and five groups using only the largest 350 firms., limit the sequentially sorted size, value and momentum portfolios to a 2 x 2 x 3 sort and finally we limit the volatility portfolios to 15 groups.[6]

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 UK 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. To take account of these investment criteria we define "large" firms as being the upper quartile of the largest 350 firms (excluding financials) by market capitalisation. "Small" becomes anything not in the top 350 firms.[7]

[5] In the interests of brevity, we do not detail all of the portfolios we used here, but portfolios based on size, book to market, momentum and varying combinations of these are available on our website.
[6] We also tested our results using twelve portfolios, with very similar results.
[7] However, note that we also form an "Alternative 350 group" and "DNQ group", together with simple decile and quintile portfolios for both size and book-to-market, for those who believe that alternative

Our decision to include only Main Market stocks follow 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 BTM and market capitalisations available to form the basic intersecting 5x5 size and BTM portfolios. There are a further 70 firms that are included in our negative BTM portfolios. This number then falls away progressively to 1,100 (plus 58 negative BTM) 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[8]), 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, that most of these are very small firms. The AIM 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.

Factor and portfolio summaries

First, in Table 1, we report the summary statistics for our factors. We note that none of the size factors, nor any of the decomposed elements of the size factors, are significantly different from zero. No matter how they are defined, the *hml* factors are, at the 10% level at least, but intriguingly breaking down *hml* into small and large elements following Zhang (2008) raises the standard deviation of the elements so that neither element is reliably different from zero at the 10% level in two-tailed tests. However, using the CPZ-decomposition, SHML_CPZ is significantly different from zero, although BHML_CPZ fails to be. Momentum has the highest mean of any of

definitions of size and book to market are more appropriate. Inferences on factors and test portfolios formed on these groupings do not change.

[8] See http://www.londonstockexchange.com/statistics/historic/main-market/main-market.htm (accessed 09 Sept 2011)

the factors (0.77% per month), but also exhibits the greatest negative skewness and the largest kurtosis. Switching from Fama-French to CPZ weightings of the constituent portfolios increases the mean, median and the standard deviation of the *smb* and *hml* factors, with a marked decrease in kurtosis for the latter. For *umd* the mean and median are reduced, whilst the standard deviation is increased. For the decompositions of the *hml* factor, conclusions on whether the effect is larger or smaller in big or small stocks depends upon the method of decomposition.

The correlations in Table 2 reveal that despite the difference in weightings between FF and CPZ factors, the correlations are strongly positive: 0.92 in the case of *smb*, 0.88 in the case of *hml*, and 0.97 in the case of *umd*. Decomposing the factors reveals that the large and small firm components of *hml* are significantly positively correlated, but perhaps not as strongly as one might suppose. For the Zhang (2008) decomposition the correlation is 0.43, whilst for the CPZ decomposition it is only 0.33. However, the correlation between alternative factor constructions is strong: 0.98 for the large firm element of *hml*, and 0.62 for the small firm element. The CPZ decomposition of the size effect reveals that MMB_CPZ and SMM_CPZ have a correlation of only 0.05. One striking feature of the correlation table is the negative correlation between *hml* and momentum. This is -0.5 in the case of the FF factors, and -0.4 in the case of the CPZ factors. This led us to investigate several alternatives in our subsequent tests, which we do not report for space reasons. First, we examined a "pure" Carhart (1997) factor, constructed without intersecting with size effects.[9] Second, we examined whether such a factor performed better in association with factors formed using the Al-Horani et al. (2003), Fletcher (2001), Fletcher and Kihanda (2005), and DNQ(2003) approaches to factor construction. Third, we investigated constructing the factor by inter-acting momentum and value portfolios. As none of these alternatives changed our reported results in any way, we do not report them here, but results are available from the authors on request.

We now proceed to describe the characteristics of the main portfolios described above. For reasons of space we do not report these results for all the test portfolios we formed, but these portfolios can be downloaded from our website. In Tables 3-5,

[9] The mean of this factor, at 0.287% per month, is considerably smaller than the mean of the size-intersected UMD factor reported in Table 1. The correlation with the UMD factor is 0.712.

we report the mean, standard deviation (SD), skewness, maximum, minimum, median and kurtosis for each value-weighted portfolio[10]. Table 3 reports results for 25 intersecting size and BTM portfolios formed as described above. The general tendency within size categories is for returns to increase as BTM ratio increases, although the effect is not completely monotonic in all of the 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 exceptions being kurtosis in the second smallest (S2) and medium size groupings.

Our next set of portfolios reported in Table 4 are the value-weighted 27 (3x3x3) portfolios *sequentially* sorted on size, BTM and momentum. In the table, the first letter denotes size (Small, S; Medium, M; Large, L), the second the BTM category (Low or "Glamour", G; Medium, M; High, or "value", V), and the third momentum (Low, L; Medium, M; High, H). Compared to (unreported) sorts based upon size and momentum, and to the summary factors reported in Table 1, the return patterns here are intriguing, as they suggest a much lower momentum effect when BTM 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[11]) 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.[12]

Finally, mindful of the arguments advanced in Lewellen et al. (2010), we report the characteristics of the 25 portfolios formed on the basis of prior 12-month standard deviations in Table 5. These portfolios are striking in several respects. First, past

[10] Note that equally weighted versions are also available for download.
[11] 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.
[12] Results for size and momentum portfolios are available on our website.

volatility seems to predict future volatility. As we progress from the low standard deviation (SD1) to high standard deviation (SD25) portfolios, standard deviations of the portfolio returns tend to increase. Whilst the effect is not monotonic, the SD25 portfolio has a standard deviation of over twice that of the SD1 portfolio. However, returns do not obviously increase with standard deviation – indeed the lowest mean return portfolio is SD25. Of course, this is not inconsistent with standard portfolio theory provided that higher risk portfolios have an offsetting effect from lower correlations with other assets. There are no obvious patterns that emerge in either skewness or kurtosis across these portfolios.

Tests of factor models

Full sample results

We now turn from the descriptive statistics of factors and portfolios to the central theme of this paper, our asset pricing tests. Following MMS, we start with the standard tests of an asset pricing model described in Cochrane (2001, Ch.12) for our alternative Fama-French and Carhart factors on the test portfolios described above. The basic test requirement is that intercepts should be jointly zero. Despite the fact that it leads to some rather dense tables, we do not merely report the intercepts, F-statistics and p-values from the GRS test, but instead report the individual portfolio coefficients. These are revealing, particularly in the case of the standard deviation test portfolios.

In Table 6, we report the results when models are tested using the size and BTM portfolios. Each Table has three panels, where Panel A reports the results from a basic models, Panel B reports the results of the value-weighted factor components models, and Panel C reports the decomposed factor models. Turning to Table 6 Panel A, we see that the basic FF model passes the GRS test, and only two of the 25 intercept terms are significant, with both of these failures are in the small firm value end categories. Size exposures tend to decline as *hml* exposure increases in the small to mid size groupings. Not surprisingly, given their construction, *smb* and *hml* loadings behave as one would expect as we move across size and across “value” categories. The basic Carhart model does not change inferences with regard to size and BTM loadings. Whilst the model passes the GRS test, there are now three significant intercepts, two of them in the portfolios that exhibited the same result in the FF model. The additional portfolio that fails the intercept test is another “value” portfolio, this time M3H. Intriguingly, momentum only loads significantly in seven portfolios, with five of these being negative loadings. There is no consistent pattern in these loadings. Finally, note that the average adjusted R-squared is almost imperceptibly different between the two models, at 0.783 and 0.784 for the basic FF and Carhart models respectively.

Turning to the CPZ factors in Panel B, we first observe that both models pass the GRS test. The mean adjusted R-squared is slightly lower than that of the basic models in Panel A, which is perhaps not surprising given the closer relationship between portfolio and factor construction in the FF definitions of factors. For the CPZ version of the FF model (CPZ-FF), we detect three significant alphas, but these are only significant at the 10% level. Whilst this is approximately what one would expect by chance, these are exactly the same portfolios that failed the intercept test in Panel A. Intriguingly, using the CPZ factors increases exposure to the market factor in all of the small to mid size portfolios, with marginal decreases in the larger portfolios. Introducing the momentum factor, in the last five columns of the table, leads to three intercepts being significant at the 5% level, with one being significant at the 10% level. Considering the CPZ-Carhart model, we see that there are thirteen cases of significant momentum exposure, and the pattern seems clearer than in the basic model reported in Panel A. In the smaller portfolios, *umd_CPZ* exposure seems to be positive for “glamour” stocks. In all but the largest size groupings it is negative in “value” stocks, but this effect fails to hold in the “big” portfolios, where B3 and B4 (but not BH) have significant positive exposures. At least as far as the four factor model goes, it seems that value weighting the component portfolios can have an important impact on inferences.

Finally, in Panel C we explore the effect of disaggregating factor components. Doing so seems to increase the mean R-squared compared to the aggregated models, whilst leaving the GRS tests unaffected. The Zhang (2008) model, though, produces four significant alphas, and these are concentrated in the smallest stocks. A particularly striking feature of the CPZ-decomposition is that it seems able to price the problematic small stock portfolios. The only significant intercept at the 5% level is M3H, and at the 10% level B4H, both of which are positive. However, both models produce some odd factor loadings on the decomposed elements of the factors. For example, the small stock "value" portfolios in both models show a significant positive exposure to the large firm *hml* element, whilst the largest firms have an exposure to the small firm element. Whilst this may be expected if the factors were highly correlated, Table 2 suggests that the decomposed CPZ factors in particular are not highly correlated.

Table 7 tests these factors on the sequentially-sorted size, BTM and momentum portfolios. Surprisingly, given these portfolios bear a relationship to the way factors are formed, all six of our models fail the basic GRS test. Panel A shows that the basic FF has six significant alphas, with four of these occurring in small size groupings. Adding *umd* improves matters marginally, with four significant alphas occurring, but the GRS F-test is still a highly significant 1.75. Despite its failure to adequately describe the cross-section of returns in the portfolios, the momentum exposure effects are interesting, and confirm the effects observed in Table 4 that momentum exposure is not consistent across size and BTM groupings.

Table 7 Panel B proves that changing the factor component weightings does not improve the performance of either model. The CPZ-FF model produces seven significant alphas, five of them amongst smaller firms, whilst the CPZ-Carhart model produces a pretty much identical result. Intriguingly, of the 20 significant *umd_CPZ* loadings, 18 of them are negative.

Finally, in Panel C we report the decomposed factor model results. These decompositions do nothing to rescue the models, with five significant alphas in the Zhang (2008) model and six in the CPZ-decomposition. Note that the prominence of negative *umd* loadings remains in these models. Overall, the disappointing ability of any of these models to price portfolios which ultimately reflect, at least to some degree, the characteristics used to form the factors, is not promising. With that in mind, we now turn to the more demanding tests based upon our volatility-ranked portfolios.

Overall, the results in Table 8 are perhaps better than one might expect given that Lo and MacKinlay (1990) and Lewellen et al. (2010) counsel against testing a model on portfolios whose characteristics have been used to form the factors. In the basic FF model (Panel A), we see that there are three significant alphas and that the model fails the GRS test, at the 10% level. However, the four factor model produces only two significant alphas and passes the GRS test. Particularly interesting are the factor loadings across these portfolios. In both models, beta (market factor) exposure increases from 0.71 to 1.22 for both models as one moves up from the SD1 to the SD25 portfolio, and the exposure to the *smb* factor also tends to increase, although neither effect is monotonic. No such clear patterns emerge in *hml* exposure, but it is noticeable that the five riskiest portfolios have a significant negative exposure to the factor. Finally, there is no obvious pattern in *umd* exposure. The beta effect is particularly important given the portfolio returns discussion above, in that it appears that the added riskiness of the high standard deviation portfolios is systematic, not idiosyncratic, and yet returns do not obviously increase in line with this exposure as theory suggests. This, we suspect, may be important in explaining the failures which we discuss later.

In Panel B, we see the effect of changing to the CPZ weightings. For the CPZ-FF model, the GRS test fails at the 10% level, and the number of significant alphas is three. The CPZ-Carhart model passes this test, though with four significant alphas. As in the basic tests of Panel A, the less risky portfolios have positive alphas. Here, the most risky (SD25) has a negative alpha. We also observe that three out of the five riskiest portfolios have a significant positive exposure to *umd*, with no significant exposures amongst the least risky groups, which suggests that momentum may be capturing some risk characteristic, although not in a totally convincing fashion. Finally, an interesting feature of the CPZ weightings is that they increase the range of observed betas, with the riskiest portfolios now having betas of 1.32 and 1.33 from the three and four-factor models respectively.

In Table 8 Panel C, we report the results using decomposed factors. First note that we cannot reject the null hypothesis for either model. Zhang (2008) decomposition again shows the pattern of positive alphas amongst the less risky portfolios. For this model, decomposing *hml* seems to dampen down the variation in betas slightly, compared with the basic Carhart-type model in Panel A. It is also notable that *hmlb* and *hmls* exposures tend to have opposite signs. A similar effect is observed in the CPZ-decomposition of *hml*.

In conclusion, on the first stage tests, the various specifications of the Carhart model all pass the GRS test when tested, as suggested by Lewellen et al. (2010), on volatility-ranked portfolios. This is perhaps surprising, given the results from testing on the sequentially sorted portfolios, and so we tested our factors on 5x5 portfolios sorted by intersecting size and momentum. The (unreported) tests show that we can reject the null hypothesis of alphas not being jointly significantly different from zero for all our models. It seems that the real difficulty for our models is pricing momentum effects, particularly in small stocks. We return to this point later.

We now turn to the second-stage regression tests, and in Table 9 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 coefficients (the “Rolling” regression columns) when we test on the 25 size and BTM portfolios. 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. Panel A shows the results from the basic FF and basic Carhart models in the top rows, whilst the bottom rows show the results using CPZ value weighted components Model. Panel B shows results from the decomposed factor models of Zhang (2008) and CPZ. 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.

Turning to Table 9, Panel A, we observe that for the basic FF model, whether estimated on a fixed or rolling basis, we cannot reject the null hypothesis that pricing errors are significantly different from zero. However, when estimated on a rolling basis the intercept term (_cons) is significantly positive. For both bases, only *hml* is priced, and at a level which is not inconsistent with the factor mean in Table 1. However, *rmrf* is nowhere near being significant. The basic Carhart model represents an improvement in terms of both rolling and single regressions satisfying the chi-squared test and the zero-intercept requirement. Note, though, that the implied price of *hml* shows a marked increase. The cross-sectional R-squared is also slightly higher. Using CPZ weightings does not change any of the inferences, and except where rolling regressions are used in the context of the CPZ-FF model, the zero intercept requirement is satisfied. The implied factor price on *hml_CPZ* is greater than that on *hml*, and in all cases the price is higher than the mean value reported in Table 1.

We next turn to the decomposed factor model results in Table 9 Panel B. Looking at the Zhang (2008) decomposition first, we see that the chi-squared test and zero-intercept requirements are both met. Both *hmls* and *hmlb* elements appear to be significantly priced in the single regression model, although the implied price of the former is a good deal higher than implied by the Table 1 mean. Using rolling regressions results in lower estimates and *hmls* being not significantly priced. Again, there is no hint that either market risk or *smb* is a priced factor. As regards the CPZ decomposition, inferences from the single regression model are similar to those from the Zhang (2008) model. Both *BHML_CPZ* and *SHML_CPZ* are priced. However, in the rolling regression test whilst these two remain significantly priced, the *umd_CPZ* factor is also significantly priced, and all three factors are priced at a level that is consistent with their sample period means.

When we try and run the Fama-MacBeth tests on the sequentially sorted size, BTM and momentum portfolios, the results are disappointing. First, for all our models no matter whether they are run on a single or rolling estimation basis, we can reject the null hypothesis that the pricing errors are jointly zero. Turning to the individual models, in Panel A we see that for the basic FF model the intercept is significantly positive for both single and rolling estimates, although in the case of the former *hml* is significantly priced. For the basic Carhart model, although the intercept is zero and *hml* appears to be priced, the chi-squared test strongly rejects the null of no significant pricing errors. The CPZ weighted factors fail to rescue either model, in that besides the chi-squared test failure, all of the intercept terms are significantly positive, at the 10% level at least.

The decomposition models in Panel B of Table 10 are a modest improvement, with components being priced in a fashion consistent with pricing in the Table 9 tests, but of course the chi-squared test is significant (at the 10% level in the case of the CPZ model) and earlier we saw that the GRS test was failed for these portfolio and model combinations.

In Table 11, we report the results of the Fama-Macbeth test on the 25 standard deviation portfolios. Turning first to Panel A, we first note that the chi-squared tests show that we can accept the null hypothesis that pricing errors are jointly zero for all the models. Unfortunately, for the basic FF model we see that whether a single regression or rolling regressions are employed, no factors are significantly priced, but that the constant is significant and positive. For the basic Carhart model, conclusions vary according to whether a single regression or rolling regressions are employed. For the former, nothing is priced, but for the latter, the constant is significant and *hml* is significantly priced at the 10% level. Using CPZ weightings, the constant is always significant and positive. In the rolling regression version of the CPZ-FF model, the market factor is negatively priced. In both the single and rolling versions of the CPZ-Carhart model, none of the factors are priced. Turning to the decomposed factor results in Table 11, Panel B, we again see that we can accept the null hypothesis of no significant pricing errors for all our models. Unfortunately for the Zhang (2008) decomposition, nothing is priced except for the constant term in the rolling regressions. With the CPZ decomposition run on a single regression basis, *umd_CPZ* is priced, although at a level that is roughly twice its sample period mean. However, when we switch to rolling regressions, we observe that the sign on *umd_CPZ* switches, although the coefficient is insignificant, and that *BHML_CPZ* now appears to be priced. However, the level of pricing implied is some five times its sample mean.

In conclusion on these pricing tests, if we follow the Lewellen et al (2010) recommendations of looking at GRS and chi-squared tests, examining whether constant terms are significant, and checking whether the implied prices of factors seem plausible, we are forced to be sceptical on whether these models actually tell us anything about risk pricing in the UK.

One interesting feature of the tests is that when the models are tested on the portfolios used to form the factors, the single regression tests yield slightly higher cross-sectional R-squared than the rolling regressions. This is consistent either with a mean reversion effect in the factor loadings in these portfolios, or with the rolling regressions simply being noisier estimates of the true factor loadings. However, we do not observe such an effect when testing models on the volatility-ranked portfolios, when there is little to choose between the single and rolling regressions. Indeed, if anything the rolling regression approach provides weak evidence that *hml* (or a component of it in the case of the decomposed CPZ model) may be priced in the CPZ and decomposed models, whereas the single regression approach suggests otherwise. Given the weak explanatory power of these models, it is unwise to make too much of this, but it may be that factor loadings are more likely to be time varying when test portfolios are formed on characteristics that are not used in factor construction. Although we do not formally test this conjecture here, we note that this is entirely consistent with the evidence on industry factor loadings reported in Fama and French (1997) and Gregory and Michou (2009).

Before we reject these factor models totally, we run two further groups of tests. First, we undertake the robustness checks described below, in order to first test whether omitted variables explain our results, and second to see whether the period over which factor loadings are estimated has any impact. Then, motivated by the results above which suggest that the models have particular difficulty in pricing smaller stocks, we examine whether an adequate asset pricing model can be established for larger stocks.

Robustness checks

Our first robustness checks extend the above models by including two variants of the Clare, Priestly and Thomas (1997) APT model. We do this because, if such APT factors are priced, and in a manner not fully captured by size, BTM and momentum-based factors, then the above results might be explained by an omitted variables problem. First, we simply run the Clare et al. (1997) base model with all their variables excluding retail bank lending.[13] Second, we include their variables as an extension to the FF and Carhart models. They do not appear to add anything to the

[13] We exclude bank lending for several reasons. First, the data is not currently available as a monthly series for our whole sample period. Second, Clare et al (1997) use the first difference of the natural logarithm of bank lending and as we find the series has negative values, using their definition on our observed data series is not possible here. We also note that this data series is extremely volatile on a monthly basis.

basic FF and Carhart models, and none of these variables are priced in the Fama-MacBeth regressions, and so we do not report the results here.

Kothari, Shanken and Sloan (1995) show that conclusions drawn on tests of the CAPM are sensitive to the period over which betas are estimated. To test whether such an effect is important in the UK, we follow Fletcher (2010) and run tests using quarterly data. The principal effect on our results is that the spread of observed betas appears to increase in tests using the 25 standard deviation portfolios. However, our observations on the pricing of risk factors in the second stage regression tests do not change.

Whilst results from the robustness checks above are not reported for space reasons, they are available from the authors on request.

Large firm tests

Fama and French (2011) note that smaller stocks are particularly challenging to price. As we observe above, whilst there may be good reasons why arbitrage activity is restricted in smaller stocks, those reasons do not apply to the universe of larger and more liquid stocks. As a proxy for this tradable universe, we next limit our factor formation and test portfolios to the largest 350 firms (excluding financials) by market capitalisation.[14][15] Factor means are close to zero for *smb*, 0.32% per month for *hml*, and 0.63% per month for *umd*. Our test portfolios are the 5x5 size and BTM sorts as before, but for the sequential portfolios we use a 2x2x3 sort, giving 12 portfolios, and we also form 12 prior volatility portfolios.

We do not report the detailed GRS tests for each set of portfolios as we do for the full sample, but instead report just the GRS F-test statistic, the associated p-value, and the average adjusted R-squared across all the test portfolios. These results are reported in Table 12, and the results are striking. Using each of our 6 models, and each of our three portfolio formation methods, we only reject the null hypothesis of alphas being jointly zero in one case, which is for the CPZ-FF model tested on the standard

[14] Note that this is a proxy for the FTSE 350 index, which was unavailable at the start of our study period.

[15] We are grateful to the editor, Peter Pope, for suggesting these large firm only tests.

deviation portfolios. The FF models do well when tested on the size and BTM portfolios, and the Carhart models do better when tested on the size, BTM and momentum portfolios, which is not surprising given that as Fama and French (2011) observe, these models are playing "home games". Note also that the decomposed factor models of Zhang (2008) and CPZ seem to do a little better than the aggregated models.

Tables 13-15 then report the full Fama-MacBeth tests. Turning to the tests based on size and BTM sorted portfolios first, we see that the Table 13, Panel A results suggest that the basic FF model has an insignificant chi-squared test for both single and rolling regressions, with a constant term not significantly different from zero. The *hml* factor seems to be priced at plausible levels in both specifications, and although *rmrf* has a positive coefficient, no other factors are significantly priced. Moving to the basic Carhart model does not change these basic conclusions, and neither does the adoption of the CPZ weightings of the factor components make much difference.

In Table 13, Panel B, we examine the Zhang (2008) and CPZ decomposition models, first noting that we cannot reject the null hypothesis of no jointly significant pricing errors for either model no matter how the coefficient estimates are formed. In the Zhang (2008) model only *hmlb* is priced, suggesting that the value premium is more important in the largest sub-set of firms. However, when the CPZ-decomposition model is estimated on a single regression basis, both *BHML_CPZ* and *SHML_CPZ* appear to be priced. These conclusions change when the model is estimated on a rolling basis, when the market risk premium, *rmrf*, and *BHML_CPZ* are priced. Taken as a whole, these results suggest that *hml* is consistently priced, that the large firm element of this value premium is consistently priced, but that conclusions on the pricing of other factors are sensitive both to the model employed and on whether or not rolling estimates are made.

We next examine the performance of these models when tested against size, BTM and momentum portfolios. Table 14, Panel A reveals that both the basic and CPZ versions of the FF models fail the chi-squared test when estimated using rolling regressions. Furthermore, none of the factors in either version of the model are priced. When we switch to the basic Carhart model, estimated on a single regression basis, both *hml* and *umd* appear to be priced, the intercept term is zero, and we cannot reject the null hypothesis of no significant pricing errors. However, the implied prices of the factors are some way in excess of the sample means. We also note that the market factor is close to being significant at the 10% level, although the factor price implied again seems high. When we estimate the model on a rolling basis, we can reject the null hypothesis and no factors are priced. For the CPZ-Carhart model, whilst we are not able to reject the null hypothesis for either single or rolling regression estimates and the intercept is not significantly different from zero in either case, the conclusion on which factor is priced differ according to how the regression is estimated. For the single regression basis, *hml_CPZ* is priced, whilst for the rolling regression basis it is *umd_CPZ* that is priced.

The decomposed models in Table 14 Panel B all pass the chi-squared test for the joint significance of pricing errors, and in all cases the intercept term is insignificant. When we estimate the Zhang (2008) model on a single regression basis, it appears that *rmrf*, *hmls*, *hmlb* and *umd* factors are all priced. Unfortunately, whilst the *hml* components and momentum are priced at plausible levels, the implied price of the market factor, at 1.6% per month, seems to be three times higher than might reasonably be expected. When we switch to estimating the model on a rolling basis, only *hmls* is priced. The alternative CPZ specification, estimated on a single regression basis, again shows that *rmrf* and momentum are priced, along with *SHML*. Once again, though, the implied price of the market risk factor is implausible. When estimated on a rolling regression basis, only *SHML_CPZ* and *umd_CPZ* are priced. Taken as a whole, it seems the Fama and French (2011) conclusion, that portfolios formed using size and momentum are difficult to price, remains even when we limit the model to larger and more liquid firms.

As before, we conclude our asset pricing tests by employing our portfolios formed on the basis of prior 12-month standard deviation. From the tests in Panel A, it is clear that we can reject the basic FF model no matter how the factors are formed. Despite the chi-squared tests being insignificant, factors are never priced at levels even close to being significant. A similar conclusion is reached when estimating the basic Carhart model on a rolling basis. When the models are estimated using a single regression, *umd* and *umd_CPZ* are both priced, but at implausibly high levels.

Finally, we turn to the decomposed models in Table 15, Panel B. Briefly summarised, disaggregation adds little to the Carhart models described earlier. In both cases, momentum is priced only when single regression estimates are made. Whilst the implied prices are still high, they are somewhat dampened down compared to the estimates from Panel A. Unfortunately, then, it appears that even restricting the pricing model to large firms fails to lead to a wholly convincing model when subject to the more stringent tests suggested by Lewellen et al. (2010).

Conclusion

Our first contribution in this paper has been to test multiple versions of the FF and Carhart models, using different approaches to factor construction, including the market capitalisation weightings of the constituent components of *smb* and *hml* along the lines suggested by Cremers et al. (2010). We also extend these basic models by including the factor decompositions suggested by Zhang (2008) and Cremers et al. (2010). Our second contribution is then to subject these models to various robustness checks, including the addition of the Clare et al. (1997) APT factors, the examination of quarterly estimation of factor loadings, and testing the model using factors and test portfolios formed from larger and more liquid firms. Throughout, we are mindful of the "sceptical" approach to asset pricing advocated by Lewellen et al. (2010) and subject our asset pricing models to the following requirements: i) that they have to price portfolios formed on the basis of a variable not used to form the factors themselves (and here we follow their suggestion of using test portfolios formed on the basis of prior volatility); ii) requiring that in addition to satisfying the null hypothesis of no jointly significant pricing errors, intercepts should be zero, and iii) that the implied factor prices should be plausible. Whilst we can find models that price BTM portfolios, at least when we restrict the analysis to larger firms, as Fama and French (2011) note, such models are playing "home games". Unfortunately, when confronted with "away games", such models prove to be anything but robust.

The results of our asset pricing tests confirm and extend the findings of MMS by applying tests to a wider set of portfolios over a longer time frame (up to December 2010 as opposed to December 2003) and also by adding tests based on the 4-factor Carhart model. Along with Fletcher (2010), 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. More recently, Fletcher (2010) finds that a conditional version of the FF model is the best performing model in his range of tests, although it performs poorly in out of sample tests. However, conditional versions using the frameworks of any of Jaganathan and Wang (1996), Lewellen and Nagel (2006)[16] or Koch and Westheide (2009) may offer a way forward.

A further possibility is that the estimation window for factor loadings matters. In the spirit of Kothari et al. (1995), we have examined whether quarterly estimation windows make a difference, finding that they do not. A longer run series of data, such as that used in Fletcher (2010), might allow testing using annual estimation of factor loadings, as in Kothari et al. (1995). Such an approach would be interesting if factor loadings were time varying but mean-reverting. Alternatively, we could explore the other extreme. If factor loadings are time-varying, but with no tendency to mean revert, then using long run estimation windows may bias our tests against our factor models, even if they hold. We note that UK regulators tend to favour the estimation of betas using daily or weekly betas, rather than monthly betas. So an interesting question for future research is whether either very long windows using annual data, or alternatively much shorter windows using daily or weekly data, would result in more reliable models.

Alternatively, it may be that there are simply better factors that might explain the cross-section of returns. Chen, Novy-Marx and Zhang (2011) propose supplementing the market factor with factors reflecting investment and return on equity. Other candidates for potential factors might include variables related to financial distress.

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[16] 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.

A further potential line of enquiry is to examine whether asset pricing tests are better tested using implied, rather than realised, cost of capital. One argument, found in Lee et al. (2009), is that models of expected return fail asset pricing tests because realised returns are "extremely noisy" proxies for expected returns. Using an alternative model of implied cost of capital, Hou et al. (2010) show that some anomalies found in realised returns disappear in tests using implied returns.

Of course, our suggestions above assume that empirically observed effects such as the "value" premium and momentum are manifestations of rational risk pricing. For example, Campbell and Vuolteenaho (2004) and Zhang (2005) provide plausible explanations as to why the "value" premium might be observed, whilst Bulkley and Nawosah (2009) suggest a rational-risk pricing explanation for the momentum effect. In contrast, Lewellen and Nagel (2006) argues that the value premium is too large to be explained by time-varying beta effects, whilst most recently Antoniou, Doukas and Subrahmanyam (2012) show that momentum strategies only yield significant returns when investors are optimistic. Whether Fama's (1991) hope for a "coherent story" on pricing such effects is realised ultimately depends on the answer to the deeply controversial question of whether value and momentum effects are in part attributable to behavioural effects.

Meanwhile, until a convincing model of UK asset pricing comes along, we can only caution against reliance on US-derived factor models in empirical tests. There may be 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. That said, a counter-argument is that there may be too many potential criteria against which to match. Future research could usefully examine which criteria are important to match against by running simulation tests along the line of those undertaken by Lyon et al. (1999) and Loughran and Ritter (2000).

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Table 1: Summary statistics for the alternative Fama-French and Carhart (Momentum) factors, October 1980 to December 2010

stats	rmrf	smb	hml	umd	smb_CPZ	hml_CPZ	umd_CPZ	hmls	hmlb	MMB_CPZ	SMM_CPZ	BHML_CPZ	SHML_CPZ
mean	0.51%	0.09%	0.31%	0.77%	0.26%	0.37%	0.68%	0.31%	0.34%	0.11%	0.15%	0.33%	0.38%
sd	4.67%	3.23%	3.40%	4.16%	4.18%	3.72%	4.76%	4.94%	3.94%	3.15%	2.58%	4.08%	4.22%
skewness	-1.006	0.416	-0.675	-1.262	0.416	-0.539	-0.986	1.268	-0.399	0.170	0.060	-0.256	-0.597
max	13.28%	17.73%	13.16%	14.06%	19.07%	13.09%	19.28%	34.50%	12.03%	19.05%	9.86%	14.81%	23.97%
min	-27.06%	-11.83%	-21.08%	-27.37%	-14.22%	-18.32%	-31.10%	-22.76%	-17.06%	-14.62%	-9.62%	-16.17%	-26.59%
p50	0.98%	-0.03%	0.39%	0.80%	0.07%	0.49%	0.56%	0.14%	0.34%	0.03%	0.07%	0.34%	0.25%
kurtosis	6.509	6.363	10.04	10.873	5.271	5.903	10.337	15.72	5.119	7.877	4.71	4.794	13.618

The Table reports the summary statistics for alternative definitions of the Fama-French and Carhart (momentum) factors. *Rmrf* is the market risk premium, *smb*, *hml* and *umd* are as defined in the text and on Ken French's website, with breakpoints formed using the largest 350 UK firms. *Smb_CPZ*, *hml_CPZ* and *umd_CPZ* are formed using the market capitalisations of the intersecting size and book-to-market (BTM), and size and momentum portfolios as described in Cremers et al. (2010). *hmls* and *hmlb* are decompositions of the *hml* factor as in Zhang (2008), whilst *MMB_CPZ* is the mid-cap minus large cap factor, *SMM_CPZ* is the small cap minus mid-cap factor, and *BHML_CPZ* and *SHML_CPZ* are the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010). Statistics reported are the mean, standard deviation (SD), skewness, maximum (max), minimum (min), median (p50), and kurtosis.

Table 2: Correlations

	rmrf	smb	hml	umd	smb_CPZ	hml_CPZ	umd_CPZ	hmls	hmlb	MMB_CPZ	SMM_CPZ	BHML_CPZ	SHML_CPZ
rmrf	1.00												
smb	0.01	1.00											
hml	0.05	-0.07	1.00										
umd	-0.15	-0.08	-0.50	1.00									
smb_CPZ	-0.08	0.92	0.01	-0.09	1.00								
hml_CPZ	0.11	0.04	0.88	-0.43	0.11	1.00							
umd_CPZ	-0.12	-0.12	-0.46	0.97	-0.13	-0.40	1.00						
hmls	-0.05	0.00	0.75	-0.44	0.08	0.56	-0.41	1.00					
hmlb	0.11	-0.02	0.83	-0.39	0.04	0.97	-0.36	0.43	1.00				
MMB_CPZ	0.17	0.85	0.13	-0.26	0.79	0.25	-0.27	0.22	0.15	1.00			
SMM_CPZ	-0.33	0.45	-0.14	0.18	0.66	-0.12	0.13	-0.14	-0.12	0.05	1.00		
BHML_CPZ	0.09	-0.04	0.79	-0.34	0.03	0.95	-0.32	0.40	0.98	0.11	-0.09	1.00	
SHML_CPZ	-0.08	-0.16	0.67	-0.38	-0.09	0.44	-0.32	0.62	0.35	-0.02	-0.12	0.33	1.00

The Table reports the correlations between alternative definitions of the Fama-French and Cahart (momentum) factors. *Rmrf* is the market risk premium, *smb*, *hml* and *umd* are as defined as in the text and on Ken French's website, with breakpoints formed using the largest 350 UK firms. *Smb_CPZ*, *hml_CPZ* and *umd_CPZ* are formed using the market capitalisations of the intersecting size and book-to-market (BTM), and size and momentum portfolios as described in Cremers et al. (2010). *hmls* and *hmlb* are decompositions of the *hml* factor as in Zhang (2008), whilst *MMB_CPZ* is the mid-cap minus large cap factor, *SMM_CPZ* is the small cap minus mid-cap factor, and *BHML_CPZ* and *SHML_CPZ* are the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010).

Table 3: Summary statistics for the 5 x 5 Value-Weighted Size and book-to-market portfolios, October 1980 to December 2010

stats	SL	S2	S3	S4	SH	S2L	S22	S23	S24	S2H	M3L	M32	M33
mean	1.17%	1.06%	1.25%	1.44%	1.47%	0.88%	1.00%	1.09%	1.28%	1.30%	0.94%	0.93%	1.21%
sd	6.71%	6.03%	5.18%	5.31%	5.28%	6.92%	5.95%	5.68%	6.14%	6.26%	7.12%	6.03%	5.89%
skewness	-63.06%	-20.29%	-42.93%	-44.18%	-27.47%	-48.69%	-97.53%	-30.07%	-36.59%	32.75%	-89.72%	-90.51%	-115.48%
max	26.44%	28.42%	23.08%	25.71%	25.85%	29.44%	16.92%	26.86%	21.95%	39.35%	33.38%	14.99%	13.75%
min	-32.75%	-24.33%	-20.73%	-22.19%	-22.53%	-28.07%	-26.83%	-22.30%	-26.43%	-22.45%	-34.23%	-28.35%	-32.08%
median	1.73%	1.40%	1.49%	1.76%	1.57%	1.51%	1.27%	1.22%	1.61%	1.64%	1.44%	1.46%	1.77%
kurtosis	6.69	5.82	5.87	6.24	6.05	5.42	5.93	5.36	5.17	8.64	7.76	5.31	7.41

stats	M34	M3H	B4L	B42	B43	B44	B4H	BL	B2	B3	B4	BH
mean	1.14%	1.64%	1.08%	1.09%	1.29%	1.39%	1.49%	0.95%	0.90%	1.11%	1.35%	1.29%
sd	6.10%	6.86%	6.39%	5.82%	5.73%	6.53%	6.60%	4.98%	5.13%	5.48%	5.52%	5.70%
skewness	-47.83%	22.64%	-44.01%	-84.94%	-69.59%	-34.82%	-54.69%	-110.80%	-88.89%	-59.34%	-95.05%	-38.59%
max	20.15%	43.16%	33.45%	22.16%	19.39%	28.85%	26.15%	13.56%	16.55%	16.41%	17.49%	20.73%
min	-26.06%	-27.64%	-32.85%	-31.94%	-27.84%	-28.32%	-32.60%	-34.35%	-28.91%	-23.84%	-30.99%	-20.00%
median	1.67%	1.81%	1.70%	1.18%	1.30%	1.80%	1.74%	1.12%	1.27%	1.25%	1.57%	1.74%
kurtosis	4.73	8.04	8.19	7.09	5.88	5.24	6.05	9.67	6.45	5.02	7.38	4.57

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 BTM portfolios – with breakpoints based on the largest 350 firms. The first character denotes size, the second the BTM category, so for example SL denotes small – low BTM, S2 denotes size and second lowest BTM category, whilst B4 denotes big and fourth highest BTM category, and BH denotes big and high BTM. 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), skewness, maximum (max), minimum (min), median (p50), and kurtosis.

Table 4: Summary statistics for the 3 x 3 x 3 size, book-to-market and momentum portfolios, October 1980-December 2010.

stats	SGL	SGM	SGH	SML	SMM	SMH	SVL	SVM	SVH	MGL	MGM	MGH	MML	MMM
mean	0.80%	0.98%	1.27%	1.29%	1.33%	1.55%	2.17%	1.43%	1.72%	0.97%	0.79%	0.99%	1.04%	1.24%
sd	6.78%	5.31%	6.16%	6.77%	5.45%	5.96%	8.98%	6.10%	5.21%	6.53%	6.02%	7.14%	6.06%	5.52%
skewness	1.09	-0.60	-0.71	-0.35	-0.17	1.82	1.76	0.24	-0.34	-0.12	-1.05	-1.23	-0.49	-0.52
max	54.69%	19.77%	29.44%	31.50%	33.79%	58.37%	62.59%	40.18%	22.29%	29.94%	17.36%	29.71%	21.88%	21.19%
min	-24.65%	-24.65%	-31.42%	-36.50%	-24.74%	-21.71%	-23.51%	-21.81%	-21.45%	-25.43%	-30.51%	-39.03%	-27.62%	-26.62%
median	0.87%	1.22%	1.78%	1.10%	1.76%	1.87%	1.64%	1.63%	1.86%	1.12%	1.10%	1.79%	1.42%	1.31%
kurtosis	14.46	5.91	7.16	7.03	8.97	26.22	13.95	8.33	5.43	5.29	6.57	7.88	5.22	5.44

stats	MMH	MVL	MVM	MVH	BGL	BGM	BGH	BML	BMM	BMH	BVL	BVM	BVH
mean	1.22%	1.39%	1.23%	1.42%	0.84%	0.91%	1.05%	1.04%	0.98%	1.14%	1.27%	1.32%	1.43%
sd	6.50%	9.12%	6.33%	6.26%	5.25%	5.06%	5.98%	6.17%	5.10%	6.38%	6.43%	5.82%	5.62%
skewness	-0.98	3.25	-0.13	-0.68	-0.68	-0.59	-1.45	-0.37	-0.80	-1.09	-0.40	-0.26	-0.85
max	31.29%	97.21%	33.13%	24.10%	16.67%	16.63%	13.67%	22.69%	16.29%	18.70%	23.33%	24.35%	21.59%
min	-35.56%	-27.40%	-24.27%	-27.62%	-29.00%	-26.16%	-37.32%	-23.08%	-29.52%	-29.36%	-21.08%	-23.58%	-28.42%
median	1.72%	1.15%	1.53%	2.02%	0.97%	1.14%	1.46%	1.69%	1.30%	1.50%	1.69%	1.55%	1.57%
kurtosis	8.47	36.85	5.66	5.82	5.97	5.66	8.90	4.32	6.92	6.59	4.49	4.74	6.85

The Tables show the 27 (3x3x3) portfolios, *sequentially* sorted on size, book-to-market (BTM) 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 BTM 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 BTM 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), skewness, maximum (max), minimum (min), median (p50), and kurtosis.

Table 5: Summary statistics for the 25 Value-Weighted prior 12-month standard deviation portfolios, October 1980 to December 2010

stats	SD1	SD2	SD3	SD4	SD5	SD6	SD7	SD8	SD9	SD10	SD11	SD12	SD13
mean	1.24%	1.40%	1.20%	0.93%	1.32%	1.08%	1.21%	0.94%	1.02%	1.61%	1.29%	1.03%	1.26%
sd	4.78%	4.60%	4.91%	5.32%	5.09%	5.40%	4.90%	6.10%	5.87%	5.88%	5.77%	6.04%	6.06%
skewness	-0.19	-0.49	-0.91	-0.78	-0.59	-0.72	-0.47	-0.86	-1.05	-0.81	-0.34	-0.49	-0.47
max	19.52%	18.08%	15.63%	15.61%	19.30%	19.53%	16.39%	17.82%	20.49%	26.44%	19.93%	25.74%	21.92%
min	-19.93%	-23.24%	-30.36%	-30.58%	-24.48%	-22.51%	-19.91%	-32.66%	-30.68%	-28.99%	-27.78%	-27.16%	-26.42%
median	1.68%	1.45%	1.55%	1.24%	1.67%	1.26%	1.34%	1.31%	1.56%	1.78%	1.66%	1.49%	1.84%
kurtosis	4.92	6.50	7.95	6.56	5.21	4.98	4.68	6.29	7.22	7.11	5.20	6.27	4.93

stats	SD14	SD15	SD16	SD17	SD18	SD19	SD20	SD21	SD22	SD23	SD24	SD25
mean	1.25%	1.09%	1.05%	0.94%	1.14%	1.23%	1.60%	1.37%	1.07%	1.13%	1.40%	0.78%
sd	6.53%	6.47%	6.30%	7.01%	6.96%	7.29%	7.73%	7.29%	7.82%	9.34%	8.32%	11.30%
skewness	-1.09	-0.34	-0.60	-0.45	-0.62	-0.61	-0.03	-0.44	0.25	0.28	-0.07	0.68
max	17.51%	25.79%	20.67%	20.22%	23.64%	21.91%	36.81%	22.49%	44.30%	45.23%	37.48%	64.56%
min	-37.40%	-32.27%	-33.48%	-26.78%	-31.07%	-33.58%	-32.63%	-25.73%	-23.62%	-27.74%	-29.23%	-40.75%
median	1.74%	1.39%	1.52%	1.43%	1.12%	1.27%	1.67%	1.43%	1.18%	1.55%	1.76%	0.69%
kurtosis	7.10	5.74	5.68	4.02	5.32	5.32	5.42	4.39	5.83	5.63	4.94	9.16

These are 25 portfolios of firms ranked on their prior 12-month standard deviation of returns. SD1 is the portfolio with the lowest prior standard deviation, SD25 the portfolio with the highest. Statistics reported are the mean, standard deviation (SD), skewness, maximum (max), minimum (min), median (p50), and kurtosis.

Table 6: GRS Test Results for the Size and B/M Portfolios:
Panel A. Basic Models

	Basic FF				Basic Carhart				
Portfolios	rmrf	smb	hml	_cons	rmrf	smb	hml	umd	_cons
SL	0.99	1.09	-0.37	0.00	1.00	1.10	-0.32	0.09	0.00
	29.12	*21.96*	*-7.93*	*0.59*	*29.22*	*22.11*	*-5.87*	*1.99*	*0.02*
S2	0.83	1.07	-0.16	0.00	0.83	1.07	-0.17	-0.02	0.00
	24.91	*22.05*	*-3.46*	*0.02*	*24.56*	*21.75*	*-3.20*	*-0.43*	*0.14*
S3	0.79	0.91	0.05	0.00	0.79	0.91	0.06	0.01	0.00
	33.26	*26.48*	*1.59*	*1.50*	*32.93*	*26.24*	*1.57*	*0.39*	*1.33*
S4	0.83	0.90	0.27	0.00	0.83	0.90	0.29	0.03	0.00
	35.63	*26.76*	*8.50*	*2.52*	*35.42*	*26.65*	*7.87*	*1.05*	*2.14*
SH	0.81	0.87	0.43	0.00	0.81	0.87	0.42	-0.01	0.00
	39.07	*28.96*	*15.01*	*2.71*	*38.55*	*28.57*	*12.66*	*-0.54*	*2.75*
S2L	1.03	0.92	-0.63	0.00	1.04	0.92	-0.59	0.06	0.00
	27.27	*16.68*	*-12.02*	*-0.64*	*27.18*	*16.69*	*-9.77*	*1.20*	*-0.95*
S22	0.94	0.81	-0.01	0.00	0.93	0.81	-0.03	-0.04	0.00
	27.15	*16.24*	*-0.15*	*-0.79*	*26.74*	*15.95*	*-0.60*	*-0.92*	*-0.51*
S23	0.89	0.75	0.19	0.00	0.88	0.74	0.16	-0.04	0.00
	26.75	*15.62*	*4.15*	*-0.47*	*26.33*	*15.33*	*3.08*	*-1.00*	*-0.18*
S24	0.98	0.82	0.25	0.00	0.97	0.82	0.24	-0.02	0.00
	28.67	*16.70*	*5.39*	*0.32*	*28.28*	*16.46*	*4.42*	*-0.44*	*0.43*
S2H	0.97	0.84	0.58	0.00	0.96	0.83	0.55	-0.06	0.00
	31.46	*18.85*	*13.73*	*-0.19*	*30.99*	*18.49*	*11.17*	*-1.37*	*0.20*
M3L	1.12	0.86	-0.66	0.00	1.12	0.85	-0.68	-0.04	0.00
	30.73	*16.26*	*-13.09*	*-0.49*	*30.28*	*15.97*	*-11.72*	*-0.86*	*-0.23*
M32	1.07	0.59	-0.07	0.00	1.06	0.57	-0.12	-0.08	0.00
	33.95	*12.88*	*-1.58*	*-1.55*	*33.46*	*12.52*	*-2.39*	*-2.02*	*-0.94*
M33	1.01	0.63	0.16	0.00	1.01	0.63	0.16	0.00	0.00
	31.98	*13.65*	*3.57*	*0.03*	*31.61*	*13.50*	*3.10*	*0.04*	*0.02*
M34	1.03	0.57	0.46	0.00	1.01	0.55	0.39	-0.11	0.00
	31.89	*12.19*	*10.27*	*-1.02*	*31.44*	*11.81*	*7.66*	*-2.50*	*-0.30*
M3H	1.05	0.85	0.67	0.00	1.04	0.83	0.60	-0.11	0.00
	28.94	*16.12*	*13.35*	*1.44*	*28.49*	*15.74*	*10.42*	*-2.30*	*2.03*
B4L	1.09	0.51	-0.57	0.00	1.10	0.51	-0.55	0.03	0.00
	32.47	*10.36*	*-12.24*	*0.44*	*32.23*	*10.35*	*-10.17*	*0.76*	*0.21*
B42	1.06	0.41	-0.04	0.00	1.05	0.41	-0.07	-0.04	0.00
	33.62	*9.09*	*-1.02*	*-0.36*	*33.14*	*8.87*	*-1.34*	*-0.91*	*-0.10*
B43	1.04	0.37	0.22	0.00	1.03	0.36	0.20	-0.03	0.00
	33.68	*8.19*	*5.09*	*0.55*	*33.20*	*7.99*	*3.97*	*-0.84*	*0.76*
B44	1.14	0.49	0.37	0.00	1.13	0.48	0.30	-0.11	0.00
	32.62	*9.70*	*7.66*	*0.42*	*32.16*	*9.33*	*5.42*	*-2.43*	*1.07*

B4H	1.11	0.50	0.61	0.00	1.09	0.47	0.52	-0.15	0.00
	31.99	*9.88*	*12.75*	*0.69*	*31.62*	*9.46*	*9.50*	*-3.26*	*1.58*
BL	0.90	-0.28	-0.50	0.00	0.89	-0.29	-0.53	-0.05	0.00
	38.32	*-8.35*	*-15.54*	*0.80*	*37.78*	*-8.48*	*-14.17*	*-1.46*	*1.18*
B2	0.96	-0.16	-0.15	0.00	0.96	-0.16	-0.16	-0.02	0.00
	34.66	*-3.99*	*-3.98*	*-0.87*	*34.21*	*-4.01*	*-3.64*	*-0.42*	*-0.72*
B3	1.05	-0.01	0.00	0.00	1.05	0.00	0.03	0.05	0.00
	37.28	*-0.30*	*0.00*	*-0.06*	*37.15*	*-0.09*	*0.72*	*1.43*	*-0.45*
B4	1.02	-0.16	0.23	0.00	1.03	-0.14	0.28	0.08	0.00
	34.65	*-3.67*	*5.61*	*1.38*	*34.78*	*-3.35*	*5.94*	*2.14*	*0.74*
BH	0.89	-0.35	0.52	0.00	0.89	-0.35	0.50	-0.04	0.00
	25.13	*-6.72*	*10.68*	*0.74*	*24.73*	*-6.77*	*8.76*	*-0.90*	*0.96*
GRS	1.27				1.22				
p	0.18				0.22				
Mean R^2	0.78				0.78				

The Table reports the results of the first-stage regression tests of the returns of the 25 intersecting portfolios sorted size and book-to-market (BTM) on the Fama-French and Carhart factors, together with the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. For the portfolios, the first character denotes size, the second the BTM category, so for example SL denotes small – low BTM, S2 denotes size and second lowest BTM category, whilst B4 denotes big and fourth highest BTM category, and BH denotes big and high BTM category. 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 BTM portfolio. The factors are *rmrf,* the market risk premium, *smb*, *hml* and *umd* are factors as defined in the text and on Ken French's website, with breakpoints formed using the largest 350 UK firms. For each of the portfolios the table reports two rows; with the coefficient in the top row and the corresponding t-statistic in the bottom row.

Table 6: GRS Test Results for the Size and B/M Portfolios:
Panel B. Value-Weighted Factor Components Models.

	CPZ-FF				CPZ-Carhart				
Portfolios	rmrf	smb_CPZ	hml_CPZ	_cons	rmrf	smb_CPZ	hml_CPZ	umd_CPZ	_cons
SL	1.08	0.91	-0.29	0.00	1.09	0.92	-0.23	0.10	0.00
	31.04	*23.36*	*-6.52*	*-0.57*	*31.48*	*23.75*	*-5.01*	*2.85*	*-1.16*
S2	0.91	0.89	-0.16	0.00	0.91	0.89	-0.16	0.01	0.00
	28.90	*25.21*	*-4.11*	*-1.07*	*28.74*	*25.07*	*-3.72*	*0.19*	*-1.08*
S3	0.85	0.74	-0.02	0.00	0.85	0.74	-0.02	0.00	0.00
	39.43	*30.58*	*-0.85*	*0.52*	*39.20*	*30.40*	*-0.74*	*0.10*	*0.49*
S4	0.88	0.68	0.15	0.00	0.88	0.68	0.14	-0.01	0.00
	37.10	*25.85*	*4.90*	*1.67*	*36.85*	*25.66*	*4.40*	*-0.33*	*1.70*
SH	0.86	0.68	0.25	0.00	0.85	0.67	0.22	-0.06	0.00
	40.87	*28.75*	*9.52*	*1.89*	*40.82*	*28.63*	*7.80*	*-2.90*	*2.47*
S2L	1.11	0.73	-0.43	0.00	1.12	0.75	-0.35	0.15	0.00
	25.24	*14.95*	*-7.72*	*-1.44*	*25.76*	*15.39*	*-6.01*	*3.23*	*-2.10*
S22	0.99	0.59	-0.03	0.00	0.98	0.59	-0.04	-0.02	0.00
	27.00	*14.37*	*-0.72*	*-1.30*	*26.79*	*14.23*	*-0.89*	*-0.58*	*-1.15*
S23	0.93	0.50	0.02	0.00	0.92	0.49	-0.02	-0.09	0.00
	25.53	*12.27*	*0.47*	*-0.63*	*25.34*	*12.06*	*-0.41*	*-2.24*	*-0.15*
S24	1.02	0.58	0.09	0.00	1.02	0.57	0.07	-0.06	0.00
	27.82	*14.06*	*2.05*	*-0.02*	*27.59*	*13.87*	*1.30*	*-1.57*	*0.30*
S2H	1.00	0.53	0.32	0.00	0.99	0.52	0.25	-0.15	0.00
	26.66	*12.66*	*6.73*	*-0.26*	*26.64*	*12.46*	*4.93*	*-3.70*	*0.52*
M3L	1.18	0.60	-0.43	0.00	1.19	0.60	-0.39	0.07	0.00
	25.72	*11.61*	*-7.36*	*-1.10*	*25.77*	*11.70*	*-6.28*	*1.41*	*-1.38*
M32	1.10	0.35	-0.02	0.00	1.09	0.35	-0.04	-0.03	0.00
	31.52	*9.07*	*-0.53*	*-1.81*	*31.28*	*8.94*	*-0.84*	*-0.92*	*-1.58*
M33	1.04	0.38	0.09	0.00	1.04	0.38	0.08	-0.03	0.00
	30.07	*9.93*	*2.16*	*-0.24*	*29.84*	*9.81*	*1.74*	*-0.68*	*-0.09*
M34	1.05	0.32	0.27	0.00	1.03	0.30	0.19	-0.16	0.00
	28.40	*7.69*	*5.71*	*-0.88*	*28.49*	*7.41*	*3.83*	*-4.15*	*-0.02*
M3H	1.08	0.49	0.37	0.00	1.06	0.47	0.26	-0.21	0.00
	24.18	*9.74*	*6.48*	*1.21*	*24.27*	*9.50*	*4.45*	*-4.48*	*2.15*
B4L	1.14	0.42	-0.44	0.00	1.15	0.43	-0.39	0.10	0.00
	30.63	*10.05*	*-9.26*	*-0.19*	*30.97*	*10.33*	*-7.67*	*2.56*	*-0.72*
B42	1.09	0.29	-0.10	0.00	1.08	0.29	-0.13	-0.06	0.00
	33.57	*8.05*	*-2.37*	*-0.56*	*33.34*	*7.87*	*-2.88*	*-1.79*	*-0.17*
B43	1.05	0.21	0.16	0.00	1.04	0.21	0.13	-0.05	0.00
	32.59	*5.95*	*3.86*	*0.40*	*32.35*	*5.79*	*3.05*	*-1.39*	*0.68*
B44	1.16	0.29	0.26	0.00	1.15	0.28	0.20	-0.13	0.00
	30.97	*6.94*	*5.55*	*0.28*	*30.91*	*6.68*	*3.98*	*-3.21*	*0.95*

B4H	1.11	0.27	0.47	0.00	1.10	0.25	0.38	-0.18	0.00
	29.42	*6.45*	*9.80*	*0.58*	*29.65*	*6.15*	*7.56*	*-4.64*	*1.55*
BL	0.91	-0.15	-0.52	0.00	0.91	-0.15	-0.52	0.00	0.00
	42.52	*-6.07*	*-19.00*	*1.27*	*42.24*	*-6.06*	*-17.64*	*-0.21*	*1.29*
B2	0.96	-0.11	-0.16	0.00	0.96	-0.11	-0.17	-0.01	0.00
	34.68	*-3.42*	*-4.57*	*-0.69*	*34.44*	*-3.44*	*-4.37*	*-0.40*	*-0.59*
B3	1.04	-0.02	0.04	0.00	1.05	-0.02	0.07	0.06	0.00
	36.85	*-0.74*	*1.12*	*-0.12*	*37.01*	*-0.55*	*1.77*	*1.92*	*-0.52*
B4	0.99	-0.17	0.28	0.00	0.99	-0.17	0.31	0.07	0.00
	34.68	*-5.44*	*7.78*	*1.53*	*34.98*	*-5.22*	*8.16*	*2.41*	*1.00*
BH	0.83	-0.27	0.66	0.00	0.83	-0.27	0.65	-0.02	0.00
	25.75	*-7.54*	*16.16*	*0.74*	*25.55*	*-7.55*	*14.72*	*-0.57*	*0.84*
GRS	1.01				1.09				
p	0.45				0.35				
Mean R^2	0.75				0.76				

The Table reports the results of the first-stage regression tests of the returns of the 25 intersecting portfolios sorted size and book-to-market (BTM) on the Fama-French and Carhart factors, together with the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. For the portfolios, the first character denotes size, the second the BTM category, so for example SL denotes small – low BTM, S2 denotes size and second lowest BTM category, whilst B4 denotes big and fourth highest BTM category, and BH denotes big and high BTM category. 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 BTM portfolio. The factors are *rmrf*, the market risk premium, *smb_CPZ*, *hml_CPZ* and *umd_CPZ*, formed using the market capitalisations of the intersecting size and BTM, and size and momentum portfolios as described in Cremers et al. (2010). For each of the portfolios the table reports two rows; with the coefficient in the top row and the corresponding t-statistic in the bottom row.

Table 6: GRS Test Results for the Size and B/M Portfolios: Panel C. Decomposed Factor Models

	Zhang Decomposition						CPZ-Decomposition						
Portfolios	rmrf	smb	hmls	hmlb	umd	_cons	rmrf	MMB	SMM	BHML	SHML	umd_CPZ	_cons
SL	0.98	1.13	-0.21	0.03	0.12	0.00	1.04	0.77	0.92	0.00	-0.49	0.01	0.00
	28.06	*22.75*	*-5.43*	*0.55*	*2.59*	*-0.30*	*34.34*	*17.72*	*16.92*	*0.03*	*-14.33*	*0.26*	*0.10*
S2	0.82	1.08	-0.14	0.03	-0.01	0.00	0.88	0.77	0.91	0.02	-0.37	-0.07	0.00
	23.87	*22.30*	*-3.67*	*0.56*	*-0.32*	*0.05*	*29.47*	*17.82*	*17.02*	*0.62*	*-11.07*	*-2.33*	*-0.08*
S3	0.79	0.91	0.03	0.03	0.02	0.00	0.85	0.74	0.74	-0.01	0.02	0.01	0.00
	32.53	*26.33*	*1.09*	*1.06*	*0.51*	*1.28*	*36.28*	*21.80*	*17.57*	*-0.45*	*0.59*	*0.43*	*0.33*
S4	0.83	0.88	0.09	0.13	0.01	0.00	0.89	0.75	0.66	0.06	0.15	0.02	0.00
	33.89	*25.39*	*3.24*	*3.94*	*0.18*	*2.43*	*35.58*	*20.91*	*14.79*	*2.08*	*5.35*	*0.83*	*1.27*
SH	0.82	0.84	0.19	0.14	-0.03	0.00	0.91	0.71	0.76	0.07	0.32	-0.02	0.00
	37.10	*26.70*	*7.95*	*4.82*	*-1.12*	*2.95*	*50.75*	*27.45*	*23.83*	*3.54*	*15.74*	*-0.95*	*1.34*
S2L	1.01	0.98	-0.35	-0.03	0.10	0.00	1.04	0.68	0.63	-0.09	-0.47	0.09	0.00
	25.40	*17.35*	*-8.00*	*-0.65*	*1.99*	*-1.36*	*24.22*	*10.94*	*8.11*	*-1.74*	*-9.61*	*2.08*	*-1.33*
S22	0.92	0.81	-0.08	0.05	-0.05	0.00	0.95	0.69	0.43	-0.04	0.02	0.01	0.00
	26.16	*16.20*	*-2.05*	*1.11*	*-1.16*	*-0.44*	*24.12*	*12.14*	*6.13*	*-0.79*	*0.47*	*0.31*	*-1.18*
S23	0.89	0.73	0.10	-0.04	-0.07	0.00	0.88	0.67	0.28	-0.08	0.12	-0.03	0.00
	26.22	*15.03*	*2.77*	*-0.80*	*-1.55*	*0.10*	*23.23*	*12.13*	*4.05*	*-1.76*	*2.74*	*-0.68*	*-0.35*
S24	0.98	0.80	0.12	0.02	-0.05	0.00	0.98	0.76	0.37	-0.01	0.16	0.00	0.00
	27.86	*15.95*	*3.13*	*0.40*	*-1.03*	*0.70*	*25.71*	*13.72*	*5.37*	*-0.31*	*3.68*	*0.08*	*0.03*
S2H	0.99	0.79	0.35	0.07	-0.06	0.00	0.94	0.82	0.21	0.07	0.25	-0.06	0.00
	31.81	*17.78*	*10.27*	*1.72*	*-1.60*	*0.40*	*25.64*	*15.47*	*3.16*	*1.62*	*6.10*	*-1.67*	*0.29*
M3L	1.09	0.91	-0.36	-0.07	0.02	0.00	1.02	0.80	0.10	-0.16	-0.45	0.07	0.00
	27.55	*16.31*	*-8.30*	*-1.41*	*0.36*	*-0.80*	*23.26*	*12.52*	*1.27*	*-3.11*	*-9.16*	*1.57*	*-0.43*
M32	1.04	0.59	-0.14	0.08	-0.08	0.00	0.99	0.60	-0.05	-0.01	-0.08	0.02	0.00
	32.86	*13.07*	*-4.05*	*1.84*	*-2.04*	*-1.03*	*28.34*	*11.99*	*-0.86*	*-0.24*	*-1.92*	*0.44*	*-1.24*
M33	1.00	0.61	-0.01	0.11	-0.03	0.00	0.96	0.65	0.02	0.03	0.05	0.04	0.00
	30.76	*13.26*	*-0.15*	*2.49*	*-0.65*	*0.28*	*27.31*	*12.87*	*0.33*	*0.81*	*1.24*	*1.01*	*0.07*
M34	1.03	0.52	0.22	0.04	-0.13	0.00	0.97	0.64	-0.08	0.01	0.24	-0.07	0.00
	31.05	*10.98*	*6.02*	*0.97*	*-3.08*	*0.02*	*27.87*	*12.78*	*-1.26*	*0.36*	*6.08*	*-1.90*	*-0.24*
M3H	1.09	0.78	0.50	-0.01	-0.09	0.00	0.98	0.88	0.01	0.03	0.28	-0.11	0.00
	32.14	*16.25*	*13.35*	*-0.28*	*-2.08*	*2.20*	*23.20*	*14.35*	*0.08*	*0.66*	*5.79*	*-2.48*	*2.27*
B4L	1.09	0.56	-0.21	-0.17	0.08	0.00	1.05	0.51	0.15	-0.17	-0.30	0.11	0.00
	29.89	*10.76*	*-5.35*	*-3.41*	*1.79*	*-0.28*	*27.25*	*9.07*	*2.16*	*-3.91*	*-6.84*	*2.83*	*-0.14*
B42	1.06	0.41	0.02	-0.10	-0.03	0.00	0.98	0.54	-0.12	-0.10	-0.03	0.01	0.00
	33.06	*9.03*	*0.69*	*-2.24*	*-0.76*	*-0.13*	*30.61*	*11.76*	*-2.11*	*-2.84*	*-0.70*	*0.16*	*0.07*
B43	1.03	0.35	0.05	0.11	-0.05	0.00	0.97	0.49	-0.14	0.05	0.12	0.02	0.00
	32.48	*7.69*	*1.35*	*2.64*	*-1.19*	*0.89*	*30.60*	*10.77*	*-2.48*	*1.37*	*3.24*	*0.75*	*0.74*
B44	1.13	0.45	0.10	0.15	-0.13	0.00	1.05	0.64	-0.18	0.08	0.12	-0.05	0.00
	31.40	*8.87*	*2.42*	*3.07*	*-2.82*	*1.24*	*29.19*	*12.35*	*-2.76*	*1.92*	*2.90*	*-1.31*	*1.23*
B4H	1.09	0.44	0.14	0.28	-0.18	0.00	1.01	0.66	-0.19	0.17	0.22	-0.10	0.00

	30.19	8.52	3.55	5.76	-3.98	1.86	28.63	12.85	-2.99	4.29	5.62	-2.64	1.76
BL	0.93	-0.26	0.04	-0.53	0.00	0.00	0.93	-0.23	-0.09	-0.47	0.06	0.03	0.00
	45.08	-8.86	1.72	-19.31	0.09	0.82	41.07	-7.15	-2.11	-18.15	2.18	1.13	0.44
B2	0.97	-0.15	0.02	-0.18	-0.01	0.00	0.96	-0.12	-0.11	-0.17	0.01	-0.01	0.00
	34.65	-3.88	0.52	-4.81	-0.14	-0.80	32.18	-2.82	-2.12	-5.05	0.15	-0.26	-0.64
B3	1.05	0.00	-0.01	0.06	0.06	0.00	1.06	-0.05	0.03	0.07	-0.02	0.04	0.00
	36.56	-0.10	-0.33	1.65	1.54	-0.52	34.55	-1.07	0.52	1.87	-0.69	1.29	-0.39
B4	1.01	-0.16	-0.02	0.28	0.06	0.00	1.01	-0.14	-0.12	0.26	0.06	0.07	0.00
	34.40	-3.84	-0.71	7.18	1.51	0.97	33.02	-3.28	-2.22	7.46	1.79	2.11	0.95
BH	0.84	-0.37	-0.05	0.65	-0.04	0.00	0.86	-0.36	-0.08	0.66	-0.10	-0.09	0.00
	28.02	-8.69	-1.62	16.22	-1.04	0.96	27.09	-7.74	-1.38	18.04	-2.69	-2.92	1.42
GRS	1.14						0.97						
P	0.30						0.51						
Mean R^2	0.79						0.80						

The Table reports the results of the first-stage regression tests of the returns of the 25 intersecting portfolios sorted size and book-to-market (BTM) on the Fama-French and Carhart factors, together with the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. For the portfolios, the first character denotes size, the second the BTM category, so for example SL denotes small – low BTM, S2 denotes size and second lowest BTM category, whilst B4 denotes big and fourth highest BTM category, and BH denotes big and high BTM category. 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 BTM portfolio. The factors are *rmrf*, the market risk premium, *hmls* and *hmlb*, the decompositions of the *hml* factor as in Zhang (2008), *MMB_CPZ*, the mid-cap minus large cap factor, *SMM_CPZ*, the small cap minus mid-cap factor, *BHML_CPZ* and *SHML_CPZ* the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010). For each of the portfolios the table reports two rows; with the coefficient in the top row and the corresponding t-statistic in the bottom row.

Table 7: GRS Test Results for the Size x B/M x Momentum Portfolios:
Panel A. Basic Models

	Basic FF				Basic Carhart				
Portfolios	rmrf	smb	hml	_cons	rmrf	smb	hml	umd	_cons
SGL	0.92	1.29	0.14	0.00	0.89	1.24	-0.03	-0.28	0.00
	25.43	*24.50*	*2.79*	*-2.39*	*25.56*	*24.62*	*-0.60*	*-6.17*	*-0.71*
SGM	0.82	0.87	-0.02	0.00	0.82	0.88	0.00	0.02	0.00
	30.27	*22.37*	*-0.51*	*-0.71*	*30.03*	*22.22*	*-0.11*	*0.64*	*-0.86*
SGH	0.95	1.02	-0.11	0.00	0.95	1.02	-0.09	0.04	0.00
	30.64	*22.71*	*-2.70*	*1.03*	*30.48*	*22.64*	*-1.81*	*1.03*	*0.70*
SML	0.91	1.08	0.44	0.00	0.90	1.07	0.38	-0.09	0.00
	21.56	*17.77*	*7.57*	*0.08*	*21.15*	*17.40*	*5.69*	*-1.69*	*0.54*
SMM	0.80	0.90	0.33	0.00	0.80	0.89	0.31	-0.02	0.00
	28.60	*21.97*	*8.42*	*1.19*	*28.20*	*21.66*	*6.97*	*-0.57*	*1.30*
SMH	0.81	0.96	0.38	0.00	0.81	0.96	0.38	-0.01	0.00
	22.69	*18.51*	*7.74*	*2.13*	*22.40*	*18.27*	*6.56*	*-0.21*	*2.10*
SVL	1.02	1.29	0.85	0.01	0.99	1.25	0.67	-0.29	0.01
	15.80	*13.76*	*9.49*	*2.28*	*15.38*	*13.35*	*6.55*	*-3.49*	*3.19*
SVM	0.86	0.89	0.53	0.00	0.85	0.87	0.45	-0.13	0.00
	24.65	*17.61*	*10.88*	*1.04*	*24.24*	*17.21*	*8.06*	*-2.80*	*1.78*
SVH	0.77	0.73	0.33	0.01	0.78	0.74	0.38	0.08	0.00
	24.69	*16.17*	*7.58*	*3.94*	*24.82*	*16.36*	*7.58*	*2.00*	*3.25*
MGL	1.06	0.89	-0.32	0.00	1.05	0.88	-0.35	-0.05	0.00
	31.27	*18.12*	*-6.84*	*-0.82*	*30.80*	*17.79*	*-6.49*	*-1.15*	*-0.47*
MGM	1.03	0.66	-0.09	0.00	1.01	0.64	-0.20	-0.18	0.00
	31.72	*14.11*	*-1.97*	*-2.28*	*31.55*	*13.70*	*-3.93*	*-4.33*	*-1.05*
MGH	1.13	0.82	-0.55	0.00	1.13	0.82	-0.55	-0.01	0.00
	28.22	*14.11*	*-9.95*	*-0.39*	*27.88*	*13.94*	*-8.64*	*-0.13*	*-0.34*
MML	0.93	0.77	0.31	0.00	0.91	0.74	0.20	-0.18	0.00
	25.60	*14.59*	*6.19*	*-1.05*	*25.28*	*14.18*	*3.49*	*-3.87*	*0.04*
MMM	0.94	0.64	0.17	0.00	0.93	0.63	0.15	-0.04	0.00
	32.46	*15.25*	*4.28*	*0.52*	*31.98*	*14.96*	*3.19*	*-1.00*	*0.77*
MMH	1.09	0.72	0.19	0.00	1.08	0.71	0.14	-0.09	0.00
	30.00	*13.80*	*3.82*	*-0.24*	*29.53*	*13.45*	*2.37*	*-1.87*	*0.28*
MVL	1.21	1.35	1.01	0.00	1.15	1.27	0.69	-0.52	0.00
	23.42	*18.12*	*14.26*	*-1.00*	*24.11*	*18.42*	*9.20*	*-8.34*	*1.26*
MVM	1.01	0.76	0.58	0.00	1.01	0.76	0.55	-0.04	0.00
	32.27	*16.81*	*13.43*	*-0.78*	*31.79*	*16.51*	*11.08*	*-1.00*	*-0.47*
MVH	1.04	0.64	0.40	0.00	1.03	0.64	0.39	-0.02	0.00
	29.76	*12.66*	*8.36*	*0.77*	*29.35*	*12.45*	*6.95*	*-0.51*	*0.88*
BGL	0.92	-0.13	-0.12	0.00	0.89	-0.17	-0.27	-0.24	0.00
	26.66	*-2.56*	*-2.63*	*-0.99*	*26.67*	*-3.41*	*-5.15*	*-5.53*	*0.54*

BGM	0.88	-0.24	-0.23	0.00	0.87	-0.25	-0.28	-0.08	0.00
	27.38	*-5.19*	*-5.26*	*-0.13*	*26.92*	*-5.44*	*-5.56*	*-1.99*	*0.42*
BGH	1.00	0.00	-0.63	0.00	1.01	0.01	-0.61	0.05	0.00
	27.97	*0.06*	*-12.82*	*0.91*	*27.82*	*0.20*	*-10.56*	*0.99*	*0.60*
BML	1.12	0.08	0.21	0.00	1.10	0.04	0.08	-0.20	0.00
	31.18	*1.46*	*4.20*	*-1.11*	*31.03*	*0.86*	*1.47*	*-4.45*	*0.13*
BMM	0.95	0.00	-0.06	0.00	0.97	0.03	0.03	0.16	0.00
	33.64	*0.04*	*-1.66*	*-0.48*	*34.80*	*0.67*	*0.79*	*4.46*	*-1.70*
BMH	1.13	0.08	-0.06	0.00	1.13	0.08	-0.06	0.01	0.00
	27.87	*1.37*	*-1.11*	*-0.05*	*27.56*	*1.37*	*-0.90*	*0.12*	*-0.08*
BVL	1.04	0.18	0.71	0.00	1.02	0.15	0.60	-0.18	0.00
	28.07	*3.27*	*13.89*	*-0.47*	*27.76*	*2.77*	*10.29*	*-3.77*	*0.58*
BVM	1.03	0.13	0.45	0.00	1.02	0.12	0.39	-0.09	0.00
	33.14	*2.92*	*10.43*	*0.42*	*32.67*	*2.59*	*7.90*	*-2.28*	*1.03*
BVH	0.95	-0.22	0.23	0.00	0.96	-0.21	0.27	0.08	0.00
	25.78	*-4.07*	*4.46*	*1.83*	*25.79*	*-3.82*	*4.65*	*1.57*	*1.33*
GRS	2.23				1.75				
p	0.00				0.01				
Mean R^2	0.73				0.74				

The Table reports the results of the first-stage regression tests of the returns of the 27 sequentially sorted size, book-to-market (BTM) and momentum portfolios on the Fama-French and Carhart factors, together with the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. For the portfolios, the first letter denotes size (Small, S; Medium, M; Large, L), the second the BTM category (Low or "Glamour", G; Medium, M; High, or "value", V), and the third momentum (Low, L; Medium, M; High, H) category. The factors are *rmrf*, the market risk premium, *smb*, *hml* and *umd* are as defined in the text and on Ken French's website, with breakpoints formed using the largest 350 UK firms. For each of the portfolios the table reports two rows; with the coefficient in the top row and the corresponding t-statistic in the bottom row.

Table 7: GRS Test Results for the Size x B/M x Momentum Portfolios: Panel B. Value -Weighted Factor Components Models

	CPZ-FF				CPZ-Carhart				
Portfolios	rmrf	smb_CPZ	hml_CPZ	_cons	rmrf	smb_CPZ	hml_CPZ	umd_CPZ	_cons
SGL	1.00	1.01	0.05	-0.01	0.98	0.98	-0.06	-0.22	0.00
	28.37	*25.51*	*1.15*	*-3.44*	*29.09*	*26.08*	*-1.24*	*-6.23*	*-2.24*
SGM	0.88	0.70	-0.06	0.00	0.88	0.70	-0.05	0.03	0.00
	33.58	*24.03*	*-1.90*	*-1.68*	*33.51*	*24.00*	*-1.40*	*0.96*	*-1.85*
SGH	1.02	0.82	-0.13	0.00	1.02	0.83	-0.11	0.05	0.00
	33.74	*24.34*	*-3.46*	*0.04*	*33.79*	*24.41*	*-2.64*	*1.51*	*-0.27*
SML	0.97	0.86	0.25	0.00	0.96	0.84	0.20	-0.11	0.00
	23.45	*18.53*	*4.88*	*-0.50*	*23.27*	*18.33*	*3.58*	*-2.55*	*0.04*
SMM	0.86	0.66	0.13	0.00	0.85	0.66	0.11	-0.06	0.00
	28.33	*19.65*	*3.53*	*0.65*	*28.11*	*19.44*	*2.58*	*-1.85*	*1.02*
SMH	0.87	0.72	0.14	0.00	0.86	0.71	0.10	-0.09	0.00
	22.90	*16.89*	*2.95*	*1.67*	*22.70*	*16.68*	*1.91*	*-2.20*	*2.10*
SVL	1.07	0.97	0.64	0.01	1.05	0.94	0.51	-0.27	0.01
	16.55	*13.36*	*7.81*	*1.85*	*16.43*	*13.18*	*5.85*	*-4.03*	*2.69*
SVM	0.91	0.69	0.33	0.00	0.89	0.67	0.25	-0.15	0.00
	25.34	*17.10*	*7.26*	*0.56*	*25.37*	*16.99*	*5.30*	*-4.12*	*1.42*
SVH	0.81	0.55	0.12	0.01	0.81	0.55	0.12	-0.01	0.01
	24.78	*14.97*	*2.87*	*3.49*	*24.62*	*14.86*	*2.59*	*-0.17*	*3.45*
MGL	1.12	0.65	-0.23	0.00	1.12	0.65	-0.22	0.03	0.00
	29.08	*15.02*	*-4.75*	*-1.45*	*28.97*	*14.99*	*-4.16*	*0.62*	*-1.55*
MGM	1.07	0.45	-0.06	0.00	1.06	0.43	-0.12	-0.11	0.00
	30.19	*11.25*	*-1.40*	*-2.58*	*30.09*	*11.02*	*-2.45*	*-3.00*	*-1.93*
MGH	1.19	0.59	-0.39	0.00	1.20	0.60	-0.36	0.07	0.00
	25.77	*11.42*	*-6.68*	*-0.97*	*25.81*	*11.51*	*-5.67*	*1.35*	*-1.23*
MML	0.97	0.51	0.20	0.00	0.95	0.49	0.12	-0.16	0.00
	24.59	*11.52*	*3.99*	*-1.28*	*24.56*	*11.30*	*2.30*	*-3.85*	*-0.47*
MMM	0.97	0.41	0.07	0.00	0.97	0.40	0.04	-0.06	0.00
	30.32	*11.38*	*1.69*	*0.23*	*30.10*	*11.18*	*0.87*	*-1.85*	*0.61*
MMH	1.12	0.44	0.05	0.00	1.11	0.43	0.00	-0.12	0.00
	27.97	*9.78*	*1.07*	*-0.37*	*27.84*	*9.55*	*-0.09*	*-2.87*	*0.23*
MVL	1.26	0.86	0.61	0.00	1.21	0.80	0.35	-0.54	0.00
	20.30	*12.37*	*7.86*	*-0.97*	*21.48*	*12.73*	*4.62*	*-9.00*	*0.83*
MVM	1.04	0.43	0.34	0.00	1.03	0.42	0.27	-0.13	0.00
	26.77	*9.99*	*6.87*	*-0.64*	*26.66*	*9.76*	*5.26*	*-3.09*	*0.01*
MVH	1.07	0.37	0.15	0.00	1.06	0.36	0.09	-0.13	0.00
	26.76	*8.37*	*2.92*	*0.75*	*26.64*	*8.13*	*1.60*	*-2.98*	*1.37*
BGL	0.92	-0.09	-0.14	0.00	0.90	-0.11	-0.23	-0.18	0.00

	26.65	*-2.28*	*-3.27*	*-0.85*	*26.92*	*-2.84*	*-5.03*	*-5.04*	*0.19*
BGM	0.88	-0.17	-0.29	0.00	0.87	-0.18	-0.33	-0.07	0.00
	28.58	*-4.90*	*-7.57*	*0.25*	*28.37*	*-5.10*	*-7.83*	*-2.08*	*0.68*
BGH	1.03	0.05	-0.54	0.00	1.04	0.06	-0.49	0.11	0.00
	27.60	*1.20*	*-11.50*	*0.75*	*27.96*	*1.46*	*-9.72*	*2.66*	*0.19*
BML	1.11	0.03	0.19	0.00	1.09	0.01	0.10	-0.18	0.00
	30.74	*0.73*	*4.20*	*-1.13*	*31.07*	*0.27*	*2.16*	*-4.85*	*-0.13*
BMM	0.95	-0.01	-0.05	0.00	0.97	0.00	0.02	0.14	0.00
	33.40	*-0.31*	*-1.48*	*-0.47*	*34.70*	*0.15*	*0.40*	*4.77*	*-1.47*
BMH	1.13	0.01	0.01	0.00	1.13	0.01	0.04	0.06	0.00
	27.46	*0.18*	*0.24*	*-0.14*	*27.50*	*0.31*	*0.74*	*1.38*	*-0.43*
BVL	1.01	0.07	0.71	0.00	1.00	0.05	0.63	-0.16	0.00
	28.77	*1.83*	*16.07*	*-0.68*	*28.95*	*1.43*	*13.55*	*-4.48*	*0.25*
BVM	1.02	0.03	0.39	0.00	1.01	0.02	0.34	-0.11	0.00
	31.87	*0.94*	*9.70*	*0.45*	*31.83*	*0.63*	*7.85*	*-3.27*	*1.12*
BVH	0.92	-0.22	0.27	0.00	0.92	-0.21	0.29	0.04	0.00
	25.21	*-5.35*	*5.86*	*2.00*	*25.20*	*-5.22*	*5.85*	*1.10*	*1.73*
GRS	2.01				1.80				
p	0.00				0.01				
Mean R^2	0.71				0.72				

The Table reports the results of the first-stage regression tests of the returns of the 27 sequentially sorted size, book-to-market (BTM) and momentum portfolios on the Fama-French and Carhart factors, together with the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. For the portfolios, the first letter denotes size (Small, S; Medium, M; Large, L), the second the BTM category (Low or "Glamour", G; Medium, M; High, or "value", V), and the third momentum (Low, L; Medium, M; High, H) category. The factors are *rmrf*, the market risk premium, *smb_CPZ*, *hml_CPZ* and *umd_CPZ*, formed using the market capitalisations of the intersecting size and BTM, and size and momentum portfolios as described in Cremers et al. (2010). For each of the portfolios the table reports two rows; with the coefficient in the top row and the corresponding t-statistic in the bottom row.

Table 7: GRS Test Results for the Size x B/M x Momentum Portfolios: Panel C. Decomposed Factor Models

	Zhang Decomposition						CPZ-Decomposition						
Portfolios	rmrf	smb	hmls	hmlb	umd	_cons	rmrf	MMB	SMM	BHML	SHML	umd_CPZ	_cons
	0.89	1.25	-0.02	0.02	-0.27	0.00	0.95	0.97	0.94	0.00	-0.15	-0.25	0.00
SGL	*25.11*	*24.85*	*-0.39*	*0.45*	*-5.89*	*-0.84*	*26.65*	*18.82*	*14.59*	*0.08*	*-3.68*	*-6.80*	*-1.80*
	0.81	0.88	-0.06	0.05	0.01	0.00	0.88	0.68	0.72	0.00	-0.06	0.02	0.00
SGM	*29.42*	*22.50*	*-1.83*	*1.39*	*0.37*	*-0.79*	*30.95*	*16.56*	*14.14*	*-0.14*	*-1.76*	*0.65*	*-1.73*
	0.94	1.03	-0.09	0.05	0.05	0.00	1.00	0.76	0.83	0.01	-0.21	0.01	0.00
SGH	*29.80*	*23.09*	*-2.49*	*1.20*	*1.24*	*0.58*	*31.82*	*16.82*	*14.66*	*0.36*	*-5.90*	*0.40*	*0.27*
	0.90	1.04	0.17	0.14	-0.11	0.00	1.00	0.89	0.91	0.06	0.29	-0.06	0.00
SML	*20.87*	*16.90*	*3.56*	*2.35*	*-1.97*	*0.68*	*23.49*	*14.51*	*11.90*	*1.27*	*6.07*	*-1.49*	*-0.63*
	0.81	0.87	0.17	0.05	-0.04	0.00	0.87	0.74	0.65	0.00	0.25	-0.01	0.00
SMM	*27.86*	*20.86*	*5.28*	*1.26*	*-1.07*	*1.55*	*28.45*	*16.58*	*11.85*	*-0.12*	*7.14*	*-0.22*	*0.29*
	0.83	0.92	0.19	0.04	-0.04	0.00	0.89	0.76	0.72	0.00	0.22	-0.05	0.00
SMH	*22.09*	*17.42*	*4.75*	*0.81*	*-0.92*	*2.41*	*22.25*	*13.28*	*10.11*	*0.00*	*4.87*	*-1.12*	*1.60*
	0.98	1.20	0.19	0.42	-0.31	0.01	1.09	1.06	0.99	0.33	0.35	-0.22	0.01
SVL	*15.05*	*12.95*	*2.63*	*4.78*	*-3.75*	*3.28*	*16.20*	*10.85*	*8.15*	*4.28*	*4.55*	*-3.21*	*2.29*
	0.86	0.84	0.20	0.16	-0.15	0.00	0.94	0.70	0.76	0.12	0.28	-0.12	0.00
SVM	*23.78*	*16.40*	*4.96*	*3.39*	*-3.15*	*1.95*	*26.06*	*13.49*	*11.74*	*2.82*	*6.86*	*-3.16*	*0.74*
	0.80	0.71	0.23	0.02	0.06	0.01	0.85	0.63	0.56	-0.02	0.31	0.06	0.00
SVH	*24.97*	*15.64*	*6.64*	*0.57*	*1.52*	*3.50*	*25.82*	*13.29*	*9.56*	*-0.58*	*8.39*	*1.71*	*2.77*
	1.04	0.91	-0.18	-0.02	-0.01	0.00	1.00	0.86	0.23	-0.09	-0.23	0.06	0.00
MGL	*29.29*	*18.15*	*-4.58*	*-0.53*	*-0.27*	*-0.87*	*25.77*	*15.38*	*3.27*	*-2.02*	*-5.26*	*1.44*	*-0.96*
	0.99	0.65	-0.18	0.04	-0.18	0.00	1.00	0.53	0.25	-0.05	-0.08	-0.09	0.00
MGM	*30.91*	*14.38*	*-5.11*	*0.86*	*-4.47*	*-1.11*	*26.74*	*9.80*	*3.64*	*-1.20*	*-1.83*	*-2.27*	*-1.75*
	1.10	0.87	-0.37	-0.03	0.01	0.00	1.13	0.57	0.45	-0.12	-0.36	0.04	0.00
MGH	*26.74*	*14.88*	*-8.18*	*-0.57*	*0.19*	*-0.57*	*23.22*	*8.16*	*5.17*	*-2.15*	*-6.66*	*0.80*	*-0.68*
	0.92	0.73	0.10	0.06	-0.19	0.00	0.88	0.80	0.12	0.00	0.17	-0.07	0.00
MML	*25.03*	*13.95*	*2.48*	*1.25*	*-3.99*	*0.11*	*22.87*	*14.37*	*1.74*	*0.01*	*3.99*	*-1.87*	*-0.62*
	0.94	0.62	0.08	0.02	-0.05	0.00	0.90	0.64	0.09	-0.02	0.09	0.01	0.00
MMM	*31.59*	*14.70*	*2.32*	*0.62*	*-1.27*	*0.91*	*27.93*	*13.87*	*1.49*	*-0.43*	*2.57*	*0.16*	*0.60*
	1.08	0.70	0.03	0.01	-0.13	0.00	1.03	0.68	0.08	-0.03	0.04	-0.06	0.00
MMH	*28.91*	*13.16*	*0.71*	*0.21*	*-2.63*	*0.61*	*25.08*	*11.40*	*1.02*	*-0.71*	*0.83*	*-1.39*	*0.35*
	1.21	1.22	0.60	-0.01	-0.48	0.00	1.11	1.31	0.24	0.05	0.35	-0.42	0.00
MVL	*27.26*	*19.28*	*12.25*	*-0.22*	*-8.47*	*1.26*	*20.18*	*16.49*	*2.41*	*0.85*	*5.59*	*-7.39*	*0.82*
	1.03	0.71	0.28	0.12	-0.07	0.00	0.97	0.73	0.08	0.11	0.20	-0.05	0.00
MVM	*30.91*	*15.11*	*7.79*	*2.77*	*-1.66*	*-0.09*	*24.96*	*13.09*	*1.20*	*2.44*	*4.67*	*-1.32*	*-0.07*
	1.06	0.60	0.23	-0.03	-0.07	0.00	1.01	0.64	0.06	-0.06	0.24	-0.04	0.00
MVH	*29.08*	*11.58*	*5.78*	*-0.68*	*-1.50*	*1.35*	*25.56*	*11.21*	*0.78*	*-1.43*	*5.42*	*-0.90*	*1.14*
	0.91	-0.15	0.01	-0.24	-0.21	0.00	0.87	-0.02	-0.25	-0.24	0.04	-0.14	0.00
BGL	*26.97*	*-3.10*	*0.22*	*-5.46*	*-4.92*	*0.32*	*24.51*	*-0.44*	*-3.97*	*-5.79*	*1.00*	*-3.83*	*0.07*
BGM	0.90	-0.24	0.06	-0.39	-0.07	0.00	0.90	-0.19	-0.15	-0.37	0.18	-0.02	0.00

	29.56	-5.63	1.83	-9.57	-1.90	0.46	28.43	-4.06	-2.73	-10.10	5.00	-0.47	-0.13
	1.01	0.05	-0.17	-0.33	0.09	0.00	1.01	-0.02	0.02	-0.33	-0.20	0.10	0.00
BGH	26.72	1.00	-4.13	-6.46	1.75	0.27	25.01	-0.26	0.26	-7.02	-4.36	2.42	0.38
	1.08	0.04	-0.05	0.12	-0.22	0.00	1.09	0.05	-0.02	0.07	0.05	-0.17	0.00
BML	30.40	0.78	-1.28	2.59	-4.85	0.25	28.72	1.00	-0.27	1.71	1.14	-4.39	-0.20
	0.97	0.02	0.03	-0.01	0.16	0.00	0.96	0.05	-0.04	-0.01	0.05	0.16	0.00
BMM	34.44	0.59	1.05	-0.21	4.48	-1.70	32.03	1.07	-0.68	-0.19	1.36	5.15	-1.58
	1.12	0.09	-0.05	0.06	0.02	0.00	1.09	0.09	-0.12	0.05	-0.10	0.05	0.00
BMH	27.01	1.53	-1.08	1.06	0.47	-0.25	24.74	1.39	-1.52	1.05	-1.91	1.17	-0.06
	1.00	0.12	0.10	0.53	-0.18	0.00	0.96	0.27	-0.13	0.49	0.09	-0.16	0.00
BVL	28.85	2.35	2.75	11.55	-3.99	0.52	25.81	5.07	-1.88	11.41	2.05	-4.12	0.59
	1.02	0.09	0.09	0.25	-0.11	0.00	0.99	0.17	-0.09	0.24	0.13	-0.08	0.00
BVM	31.78	2.02	2.55	5.94	-2.78	1.22	29.64	3.49	-1.48	6.32	3.42	-2.34	1.03
	0.93	-0.22	-0.08	0.32	0.04	0.00	0.94	-0.25	-0.11	0.30	-0.01	0.02	0.00
BVH	25.35	-4.26	-1.96	6.62	0.80	1.62	24.25	-4.46	-1.63	6.65	-0.19	0.49	1.78
GRS	1.71						1.66						
p	0.02						0.02						
Mean R^2	0.75						0.75						

The Table reports the results of the first-stage regression tests of the returns of the 27 sequentially sorted size, book-to-market (BTM) and momentum portfolios on the Fama-French and Carhart factors, together with the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. For the portfolios, the first letter denotes size (Small, S; Medium, M; Large, L), the second the BTM category (Low or "Glamour", G; Medium, M; High, or "value", V), and the third momentum (Low, L; Medium, M; High, H) category. The factors are *rmrf*, the market risk premium, *hmls* and *hmlb*, the decompositions of the *hml* factor as in Zhang (2008), *MMB_CPZ*, the mid-cap minus large cap factor, *SMM_CPZ*, the small cap minus mid-cap factor, *BHML_CPZ* and *SHML_CPZ* the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010). For each of the portfolios the table reports two rows; with the coefficient in the top row and the corresponding t-statistic in the bottom row.

Table 8: GRS Test Results for the 25 Standard Deviation Portfolios: Panel A. Basic Models

	Basic FF				Basic Carhart				
Portfolios	rmrf	smb	hml	_cons	rmrf	smb	hml	umd	_cons
SD1	0.71	0.01	0.02	0.00	0.71	0.01	0.03	0.01	0.00
	18.46	*0.12*	*0.45*	*1.59*	*18.27*	*0.14*	*0.46*	*0.14*	*1.49*
SD2	0.76	0.01	-0.06	0.00	0.77	0.02	-0.04	0.04	0.00
	23.21	*0.21*	*-1.33*	*2.92*	*23.10*	*0.34*	*-0.67*	*0.94*	*2.55*
SD3	0.84	-0.16	0.09	0.00	0.84	-0.16	0.11	0.04	0.00
	25.58	*-3.44*	*1.94*	*1.18*	*25.43*	*-3.28*	*2.11*	*0.88*	*0.89*
SD4	0.92	-0.14	0.10	0.00	0.93	-0.13	0.14	0.06	0.00
	26.67	*-2.87*	*2.10*	*-0.84*	*26.62*	*-2.65*	*2.50*	*1.37*	*-1.19*
SD5	0.86	-0.08	0.12	0.00	0.86	-0.08	0.13	0.02	0.00
	24.82	*-1.57*	*2.58*	*1.68*	*24.59*	*-1.50*	*2.42*	*0.38*	*1.51*
SD6	0.90	0.01	0.08	0.00	0.89	-0.01	0.02	-0.10	0.00
	23.98	*0.12*	*1.57*	*0.05*	*23.55*	*-0.16*	*0.38*	*-1.94*	*0.58*
SD7	0.85	0.12	0.03	0.00	0.85	0.12	0.03	0.00	0.00
	26.57	*2.65*	*0.59*	*1.16*	*26.28*	*2.64*	*0.56*	*0.12*	*1.08*
SD8	1.08	0.14	-0.19	0.00	1.06	0.11	-0.31	-0.19	0.00
	28.68	*2.57*	*-3.63*	*-0.85*	*28.39*	*2.05*	*-5.15*	*-3.88*	*0.23*
SD9	1.02	0.10	0.09	0.00	1.02	0.10	0.09	0.00	0.00
	27.10	*1.81*	*1.68*	*-0.69*	*26.79*	*1.80*	*1.48*	*0.06*	*-0.68*
SD10	0.99	0.32	0.08	0.00	1.01	0.34	0.18	0.16	0.00
	25.39	*5.59*	*1.55*	*2.58*	*25.88*	*6.04*	*2.93*	*3.11*	*1.65*
SD11	1.00	0.08	0.12	0.00	1.01	0.09	0.17	0.08	0.00
	26.29	*1.41*	*2.34*	*0.87*	*26.29*	*1.62*	*2.80*	*1.54*	*0.41*
SD12	0.99	0.30	0.05	0.00	0.98	0.29	0.00	-0.08	0.00
	23.40	*4.93*	*0.77*	*-0.49*	*22.99*	*4.69*	*-0.05*	*-1.42*	*-0.08*
SD13	1.06	0.32	-0.13	0.00	1.06	0.32	-0.14	-0.01	0.00
	27.95	*5.83*	*-2.56*	*0.83*	*27.61*	*5.74*	*-2.28*	*-0.14*	*0.84*
SD14	1.12	0.12	0.00	0.00	1.13	0.15	0.09	0.15	0.00
	25.19	*1.92*	*-0.02*	*0.42*	*25.49*	*2.27*	*1.28*	*2.56*	*-0.31*
SD15	1.11	0.41	0.01	0.00	1.11	0.40	-0.04	-0.08	0.00
	27.32	*6.97*	*0.22*	*-0.52*	*26.87*	*6.70*	*-0.58*	*-1.52*	*-0.08*
SD16	1.06	0.47	0.26	0.00	1.07	0.47	0.26	0.01	0.00
	27.29	*8.29*	*4.75*	*-1.04*	*27.00*	*8.23*	*4.20*	*0.20*	*-1.06*
SD17	1.16	0.49	0.02	0.00	1.15	0.48	-0.04	-0.10	0.00
	24.38	*7.17*	*0.32*	*-1.27*	*23.95*	*6.90*	*-0.52*	*-1.57*	*-0.79*
SD18	1.17	0.35	-0.05	0.00	1.18	0.38	0.03	0.13	0.00
	24.65	*5.16*	*-0.71*	*-0.25*	*24.82*	*5.43*	*0.45*	*2.11*	*-0.83*
SD19	1.14	0.61	-0.08	0.00	1.12	0.58	-0.20	-0.20	0.00

	22.06	*8.13*	*-1.09*	*0.13*	*21.65*	*7.72*	*-2.48*	*-3.03*	*0.97*
SD20	1.23	0.76	-0.12	0.00	1.23	0.76	-0.10	0.05	0.00
	24.00	*10.22*	*-1.76*	*1.50*	*23.83*	*10.21*	*-1.18*	*0.67*	*1.25*
SD21	1.13	0.61	-0.23	0.00	1.13	0.61	-0.21	0.03	0.00
	21.69	*8.06*	*-3.15*	*0.94*	*21.51*	*8.04*	*-2.47*	*0.49*	*0.77*
SD22	1.15	0.57	-0.06	0.00	1.15	0.57	-0.06	0.01	0.00
	18.94	*6.47*	*-0.75*	*-0.46*	*18.74*	*6.41*	*-0.59*	*0.11*	*-0.48*
SD23	1.27	0.95	-0.27	0.00	1.24	0.90	-0.43	-0.27	0.00
	17.50	*8.98*	*-2.66*	*-0.30*	*17.08*	*8.58*	*-3.76*	*-2.86*	*0.50*
SD24	1.13	0.97	-0.30	0.00	1.13	0.98	-0.27	0.04	0.00
	18.07	*10.70*	*-3.49*	*0.83*	*17.94*	*10.66*	*-2.75*	*0.52*	*0.65*
SD25	1.22	1.50	-0.70	0.00	1.22	1.51	-0.68	0.03	0.00
	13.32	*11.33*	*-5.56*	*-0.79*	*13.20*	*11.24*	*-4.67*	*0.24*	*-0.82*
GRS	1.47				1.13				
p	0.07				0.31				
Mean R^2	0.62				0.62				

The Table reports the results of the first-stage regression tests of the returns of the 25 portfolios ranked on their prior 12-month standard deviation of returns. SD1 is the portfolio with the lowest prior standard deviation, SD25 the portfolio with the highest. The portfolios are regressed on the Fama-French and Carhart factors, together with the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. The factors are *rmrf*, the market risk premium, *smb, hml* and *umd* are as defined in the text and on Ken French's website, with breakpoints formed using the largest 350 UK firms. For each of the portfolios the table reports two rows; with the coefficient in the top row and the corresponding t-statistic in the bottom row.

Table 8: GRS Test Results for the 25 Standard Deviation Portfolios:
Panel B. Value-Weighted Factor Components Models

	CPZ-FF				CPZ-Carhart				
Portfolios	rmrf	smb_CPZ	hml_CPZ	_cons	rmrf	smb_CPZ	hml_CPZ	umd_CPZ	_cons
SD1	0.72	0.01	0.00	0.00	0.72	0.01	0.00	0.00	0.00
	18.34	*0.12*	*-0.06*	*1.62*	*18.22*	*0.12*	*-0.08*	*-0.06*	*1.60*
SD2	0.77	0.03	-0.04	0.00	0.77	0.03	-0.02	0.05	0.00
	23.11	*0.74*	*-1.07*	*2.85*	*23.16*	*0.87*	*-0.48*	*1.36*	*2.51*
SD3	0.83	-0.14	0.02	0.00	0.83	-0.14	0.02	0.00	0.00
	24.99	*-3.81*	*0.45*	*1.47*	*24.84*	*-3.78*	*0.45*	*0.08*	*1.42*
SD4	0.91	-0.14	0.04	0.00	0.91	-0.14	0.05	0.02	0.00
	26.12	*-3.63*	*0.88*	*-0.56*	*26.02*	*-3.56*	*1.01*	*0.53*	*-0.66*
SD5	0.85	-0.07	0.03	0.00	0.85	-0.08	0.01	-0.03	0.00
	24.29	*-1.89*	*0.67*	*1.91*	*24.08*	*-1.96*	*0.31*	*-0.82*	*2.04*
SD6	0.90	0.01	0.13	0.00	0.89	0.00	0.10	-0.06	0.00
	23.73	*0.16*	*2.70*	*-0.06*	*23.52*	*0.01*	*1.91*	*-1.58*	*0.27*
SD7	0.86	0.07	-0.01	0.00	0.86	0.07	-0.01	-0.01	0.00
	26.44	*1.92*	*-0.15*	*1.15*	*26.25*	*1.87*	*-0.26*	*-0.34*	*1.20*
SD8	1.10	0.08	-0.15	0.00	1.09	0.07	-0.20	-0.10	0.00
	28.40	*1.77*	*-3.09*	*-0.93*	*28.24*	*1.52*	*-3.86*	*-2.56*	*-0.39*
SD9	1.03	0.04	0.06	0.00	1.02	0.03	0.05	-0.02	0.00
	26.78	*0.84*	*1.29*	*-0.67*	*26.58*	*0.79*	*1.04*	*-0.40*	*-0.57*
SD10	1.01	0.19	-0.03	0.00	1.02	0.19	0.00	0.06	0.00
	25.22	*4.18*	*-0.66*	*2.57*	*25.26*	*4.30*	*-0.09*	*1.38*	*2.23*
SD11	0.99	0.03	0.11	0.00	1.00	0.04	0.15	0.08	0.00
	25.97	*0.69*	*2.36*	*0.85*	*26.12*	*0.88*	*2.91*	*1.89*	*0.44*
SD12	1.01	0.23	0.05	0.00	1.00	0.22	0.01	-0.08	0.00
	23.58	*4.78*	*0.91*	*-0.70*	*23.37*	*4.59*	*0.16*	*-1.82*	*-0.31*
SD13	1.08	0.24	-0.07	0.00	1.08	0.24	-0.06	0.02	0.00
	27.80	*5.47*	*-1.41*	*0.49*	*27.70*	*5.49*	*-1.09*	*0.55*	*0.37*
SD14	1.12	0.06	0.06	0.00	1.13	0.08	0.12	0.13	0.00
	24.96	*1.29*	*1.08*	*0.28*	*25.32*	*1.56*	*2.03*	*2.70*	*-0.29*
SD15	1.14	0.31	-0.04	0.00	1.14	0.31	-0.07	-0.06	0.00
	27.69	*6.79*	*-0.70*	*-0.73*	*27.46*	*6.63*	*-1.18*	*-1.40*	*-0.42*
SD16	1.09	0.35	0.14	0.00	1.09	0.35	0.13	-0.02	0.00
	27.34	*7.80*	*2.87*	*-1.21*	*27.13*	*7.70*	*2.45*	*-0.53*	*-1.07*
SD17	1.18	0.35	0.04	0.00	1.18	0.34	0.02	-0.06	0.00
	24.45	*6.43*	*0.72*	*-1.55*	*24.24*	*6.29*	*0.24*	*-1.11*	*-1.29*
SD18	1.19	0.22	0.01	0.00	1.19	0.23	0.05	0.09	0.00
	24.44	*4.13*	*0.15*	*-0.48*	*24.57*	*4.29*	*0.80*	*1.76*	*-0.83*
SD19	1.18	0.47	-0.04	0.00	1.17	0.45	-0.10	-0.12	0.00

	22.46	*7.94*	*-0.67*	*-0.24*	*22.26*	*7.73*	*-1.45*	*-2.17*	*0.21*
SD20	1.28	0.56	-0.10	0.00	1.28	0.56	-0.07	0.08	0.00
	24.15	*9.39*	*-1.55*	*1.06*	*24.19*	*9.48*	*-0.93*	*1.34*	*0.76*
SD21	1.17	0.48	-0.11	0.00	1.18	0.49	-0.06	0.10	0.00
	21.89	*8.01*	*-1.64*	*0.46*	*22.03*	*8.17*	*-0.85*	*1.78*	*0.08*
SD22	1.18	0.43	0.09	0.00	1.19	0.44	0.15	0.12	0.00
	19.17	*6.26*	*1.20*	*-0.90*	*19.32*	*6.43*	*1.80*	*1.82*	*-1.26*
SD23	1.34	0.75	-0.16	0.00	1.32	0.73	-0.23	-0.15	0.00
	18.03	*9.05*	*-1.71*	*-0.76*	*17.83*	*8.85*	*-2.32*	*-1.93*	*-0.35*
SD24	1.19	0.77	-0.10	0.00	1.20	0.78	-0.03	0.14	0.00
	18.49	*10.66*	*-1.27*	*0.16*	*18.68*	*10.86*	*-0.40*	*2.07*	*-0.27*
SD25	1.32	1.12	-0.40	-0.01	1.33	1.14	-0.32	0.17	-0.01
	13.45	*10.22*	*-3.22*	*-1.34*	*13.57*	*10.35*	*-2.37*	*1.62*	*-1.65*
GRS	1.43				1.18				
p	0.09				0.26				
Mean R^2	0.61				0.61				

The Table reports the results of the first-stage regression tests of the returns of the 25 portfolios ranked on their prior 12-month standard deviation of returns. SD1 is the portfolio with the lowest prior standard deviation, SD25 the portfolio with the highest. The portfolios are regressed on the Fama-French and Carhart factors, together with the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. The factors are *rmrf*, the market risk premium, *smb_CPZ*, *hml_CPZ* and *umd_CPZ*, formed using the market capitalisations of the intersecting size and book-to-market, and size and momentum portfolios as described in Cremers et al. (2010). For each of the portfolios the table reports two rows; with the coefficient in the top row and the corresponding t-statistic in the bottom row.

Table 8: GRS Test Results for the 25 Standard Deviation Portfolios: Panel C, Decomposed Factor Models

	Zhang Decomposition						CPZ-Decomposition						
Portfolios	**rmrf**	**smb**	**hmls**	**hmlb**	**umd**	**_cons**	**rmrf**	**MMB**	**SMM**	**BHML**	**SHML**	**umd_CPZ**	**_cons**
	0.71	0.00	-0.01	0.01	0.00	0.00	0.72	0.03	-0.01	-0.02	0.07	0.02	0.00
SD1	*17.94*	*0.09*	*-0.18*	*0.26*	*-0.08*	*1.57*	*16.99*	*0.52*	*-0.10*	*-0.48*	*1.56*	*0.45*	*1.38*
	0.77	0.02	-0.01	0.00	0.05	0.00	0.74	0.08	-0.06	0.00	-0.06	0.05	0.00
SD2	*22.72*	*0.41*	*-0.34*	*-0.10*	*1.08*	*2.49*	*20.78*	*1.46*	*-0.89*	*-0.09*	*-1.60*	*1.27*	*2.76*
	0.85	-0.17	0.10	-0.07	0.02	0.00	0.85	-0.10	-0.13	-0.07	0.20	0.04	0.00
SD3	*25.62*	*-3.60*	*2.82*	*-1.65*	*0.50*	*1.10*	*24.43*	*-2.00*	*-2.04*	*-1.88*	*5.00*	*1.15*	*0.90*
	0.93	-0.15	0.05	0.01	0.04	0.00	0.94	-0.15	-0.07	0.00	0.13	0.04	0.00
SD4	*26.14*	*-2.92*	*1.17*	*0.31*	*0.77*	*-0.92*	*25.20*	*-2.82*	*-0.99*	*0.03*	*3.14*	*1.02*	*-1.09*
	0.88	-0.09	0.14	-0.08	0.01	0.00	0.86	-0.01	-0.11	-0.07	0.19	0.01	0.00
SD5	*24.96*	*-1.82*	*3.51*	*-1.69*	*0.16*	*1.67*	*23.19*	*-0.10*	*-1.72*	*-1.69*	*4.44*	*0.38*	*1.60*
	0.88	0.00	-0.02	0.11	-0.08	0.00	0.86	0.05	-0.09	0.12	-0.08	-0.07	0.00
SD6	*23.15*	*-0.09*	*-0.48*	*2.16*	*-1.55*	*0.39*	*21.22*	*0.89*	*-1.19*	*2.68*	*-1.76*	*-1.72*	*0.57*
	0.86	0.12	0.04	-0.05	-0.01	0.00	0.84	0.15	-0.03	-0.06	0.04	0.01	0.00
SD7	*26.15*	*2.55*	*1.08*	*-1.24*	*-0.13*	*1.21*	*23.94*	*2.89*	*-0.52*	*-1.41*	*1.00*	*0.18*	*1.22*
	1.05	0.13	-0.19	-0.07	-0.19	0.00	1.06	0.05	0.00	-0.10	-0.16	-0.12	0.00
SD8	*27.66*	*2.50*	*-4.47*	*-1.38*	*-3.91*	*0.20*	*25.58*	*0.82*	*-0.02*	*-2.16*	*-3.48*	*-2.80*	*-0.07*
	1.02	0.09	0.03	0.03	-0.01	0.00	1.00	0.12	-0.08	0.02	0.04	0.01	0.00
SD9	*26.36*	*1.67*	*0.62*	*0.62*	*-0.16*	*-0.59*	*24.18*	*2.09*	*-1.02*	*0.52*	*0.82*	*0.13*	*-0.56*
	1.03	0.32	0.16	-0.08	0.14	0.00	0.97	0.40	-0.06	-0.08	0.15	0.13	0.00
SD10	*26.19*	*5.78*	*3.72*	*-1.46*	*2.84*	*1.85*	*23.26*	*6.66*	*-0.78*	*-1.67*	*3.09*	*3.04*	*2.09*
	1.01	0.08	0.09	0.09	0.09	0.00	0.99	0.16	-0.07	0.07	0.13	0.11	0.00
SD11	*26.10*	*1.45*	*2.07*	*1.71*	*1.75*	*0.34*	*24.17*	*2.74*	*-0.99*	*1.54*	*2.74*	*2.72*	*0.28*
	0.98	0.29	0.02	0.04	-0.05	0.00	1.00	0.21	0.23	0.05	-0.03	-0.08	0.00
SD12	*22.69*	*4.79*	*0.35*	*0.74*	*-0.96*	*-0.28*	*21.58*	*3.12*	*2.75*	*0.87*	*-0.58*	*-1.79*	*-0.30*
	1.04	0.33	-0.11	0.06	0.01	0.00	1.02	0.33	0.05	0.01	-0.14	0.03	0.00
SD13	*26.91*	*6.07*	*-2.67*	*1.13*	*0.19*	*0.66*	*24.70*	*5.49*	*0.70*	*0.20*	*-2.99*	*0.61*	*0.78*
	1.11	0.15	-0.10	0.21	0.14	0.00	1.09	0.17	-0.06	0.15	-0.06	0.14	0.00
SD14	*25.01*	*2.30*	*-1.98*	*3.62*	*2.39*	*-0.28*	*22.84*	*2.47*	*-0.64*	*2.79*	*-1.04*	*2.81*	*-0.10*
	1.12	0.40	0.08	-0.10	-0.06	0.00	1.12	0.41	0.20	-0.11	0.14	-0.01	0.00
SD15	*27.02*	*6.82*	*1.81*	*-1.81*	*-1.07*	*-0.23*	*25.51*	*6.43*	*2.49*	*-2.11*	*2.73*	*-0.15*	*-0.75*
	1.08	0.45	0.18	0.04	0.01	0.00	1.05	0.57	0.11	0.01	0.17	0.04	0.00
SD16	*27.13*	*7.96*	*4.08*	*0.77*	*0.29*	*-1.05*	*25.20*	*9.43*	*1.43*	*0.15*	*3.71*	*0.92*	*-1.26*
	1.13	0.48	-0.11	0.10	-0.11	0.00	1.15	0.43	0.23	0.02	0.03	-0.03	0.00
SD17	*23.40*	*7.07*	*-2.07*	*1.56*	*-1.70*	*-0.79*	*22.01*	*5.73*	*2.40*	*0.28*	*0.55*	*-0.51*	*-1.33*
	1.17	0.38	-0.03	0.12	0.14	0.00	1.14	0.33	0.06	0.09	-0.13	0.08	0.00
SD18	*24.36*	*5.52*	*-0.58*	*1.88*	*2.34*	*-0.95*	*21.97*	*4.35*	*0.66*	*1.59*	*-2.27*	*1.60*	*-0.46*
	1.11	0.60	-0.11	-0.01	-0.18	0.00	1.13	0.58	0.27	-0.08	0.02	-0.08	0.00
SD19	*21.09*	*7.99*	*-1.93*	*-0.14*	*-2.73*	*0.82*	*19.93*	*7.06*	*2.65*	*-1.31*	*0.33*	*-1.32*	*0.17*
SD20	1.23	0.78	-0.05	0.02	0.07	0.00	1.23	0.63	0.39	0.02	-0.16	0.07	0.00

	23.36	*10.40*	*-0.83*	*0.26*	*0.98*	*1.11*	*21.61*	*7.73*	*3.87*	*0.30*	*-2.48*	*1.28*	*1.06*
	1.11	0.64	-0.20	0.11	0.05	0.00	1.13	0.50	0.38	0.06	-0.22	0.08	0.00
SD21	*20.87*	*8.45*	*-3.40*	*1.58*	*0.75*	*0.61*	*19.84*	*6.11*	*3.76*	*0.95*	*-3.41*	*1.36*	*0.45*
	1.13	0.59	-0.13	0.24	0.05	0.00	1.15	0.48	0.36	0.19	-0.15	0.09	0.00
SD22	*18.28*	*6.72*	*-1.97*	*2.87*	*0.58*	*-0.73*	*17.45*	*5.07*	*3.00*	*2.45*	*-2.00*	*1.33*	*-0.93*
	1.24	0.95	-0.12	-0.08	-0.19	0.00	1.26	0.78	0.55	-0.11	-0.21	-0.15	0.00
SD23	*16.55*	*8.90*	*-1.47*	*-0.81*	*-1.95*	*0.12*	*15.77*	*6.79*	*3.87*	*-1.20*	*-2.30*	*-1.89*	*-0.11*
	1.10	1.01	-0.23	0.17	0.09	0.00	1.10	0.84	0.54	0.14	-0.41	0.09	0.00
SD24	*17.29*	*11.15*	*-3.26*	*1.97*	*1.13*	*0.34*	*16.56*	*8.77*	*4.54*	*1.82*	*-5.45*	*1.33*	*0.44*
	1.17	1.57	-0.46	0.13	0.11	-0.01	1.17	1.16	0.77	0.03	-0.79	0.06	0.00
SD25	*12.44*	*11.79*	*-4.41*	*1.04*	*0.91*	*-1.17*	*11.69*	*8.05*	*4.33*	*0.28*	*-7.01*	*0.61*	*-0.88*
GRS	1.11						1.27						
p	0.32						0.18						
Mean R^2	0.63						0.63						

The Table reports the results of the first-stage regression tests of the returns of the 25 portfolios ranked on their prior 12-month standard deviation of returns. SD1 is the portfolio with the lowest prior standard deviation, SD25 the portfolio with the highest. The portfolios are regressed on the Fama-French and Carhart factors, together with the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. The factors are *rmrf* , the market risk premium, *hmls* and *hmlb*, the decompositions of the *hml* factor as in Zhang (2008), *MMB_CPZ*, the mid-cap minus large cap factor, *SMM_CPZ*, the small cap minus mid-cap factor, *BHML_CPZ* and *SHML_CPZ* the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010). For each of the portfolios the table reports two rows; with the coefficient in the top row and the corresponding t-statistic in the bottom row.

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Table 9: Fama-Macbeth regression tests with the 25 (5x5) size and book-to-market portfolios:
Panel A: Basic FF and Carhart models, and Value-Weighted Factor Components Models.

	Basic FF						Basic Carhart					
Basic FF & Carhart Models	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	0.43	1.11	0.26	0.62	1.90	0.00	0.27	0.65	0.51	0.27	0.74	0.45
rmrf	0.10	0.22	0.82	-0.21	-0.60	0.55	0.28	0.61	0.54	0.20	0.580	0.564
smb	0.07	0.45	0.65	0.03	0.17	0.86	0.08	0.49	0.62	0.01	0.100	0.921
hml	0.42	2.10	0.03	0.36	1.78	0.07	0.50	2.53	0.01	0.47	2.450	0.015
umd							0.56	0.86	0.39	0.58	1.670	0.096
Cross-sect ional R^2	0.60			0.59			0.61			0.60		
chi-squared	19.22			26.72			15.21			24.50		
p-value	0.63			0.22			0.81			0.27		
	CPZ-FF						**CPZ-Carhart**					
Value -Weighted Factor Components Models	**Single**			**Rolling**			**Single**			**Rolling**		
cons	0.42	1.07	0.28	0.71	2.21	0.02	0.43	1.09	0.27	0.47	1.400	0.163
rmrf	0.10	0.22	0.82	-0.30	-0.86	0.39	0.08	0.19	0.85	-0.01	-0.050	0.962
smb_CPZ	0.16	0.72	0.47	0.11	0.48	0.63	0.16	0.71	0.47	0.09	0.390	0.696
hml_CPZ	0.57	2.30	0.02	0.46	2.09	0.03	0.55	2.54	0.01	0.59	2.860	0.005
umd_CPZ							-0.39	-0.56	0.57	0.57	1.420	0.156
Cross-sect ional R^2	0.60			0.58			0.61			0.59		
chi-squared	22.28			27.46			22.10			27.05		
p-value	0.44			0.19			0.39			0.16		

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. The factors are *rmrf*-the market risk premium, *smb*, *hml* and *umd* are as defined in the text and on Ken French's website, with breakpoints formed using the largest 350 UK firms, *smb_CPZ*, *hml_CPZ* and *umd_CPZ* , formed using the market capitalisations of the intersecting size and book-to-market (BTM), and size and momentum portfolios as described in Cremers et al. (2010).

Panel B: Decomposed Factor Models

Decomposed Models	Zhang decomposition Single			Rolling			CPZ-decomposition Single			Rolling		
Variable	Mean	sh-t	sh-p	Mean	sh-t	sh-p	Mean	sh-t	sh-p	Mean	sh-t	sh-p
cons	0.24	0.53	0.59	0.23	0.64	0.52	-0.40	-0.56	0.57	0.24	0.63	0.53
rmrf	0.30	0.65	0.51	0.28	0.76	0.44	0.97	1.33	0.18	0.27	0.79	0.43
smb	0.09	0.54	0.58	0.02	0.14	0.88						
hmls	0.89	2.58	0.01	0.45	1.53	0.12						
hmlb	0.55	2.42	0.01	0.46	2.20	0.02						
umd	0.79	1.20	0.22	0.55	1.70	0.08						
MMB_CPZ							0.08	0.45	0.65	0.12	0.63	0.53
SMM_CPZ							0.15	0.92	0.35	0.03	0.20	0.84
BHML_CPZ							0.50	2.14	0.03	0.42	1.89	0.05
SHML_CPZ							0.59	2.06	0.04	0.51	1.79	0.07
umd_CPZ							-0.34	-0.44	0.66	0.79	1.97	0.04
Cross-sect ional R^2	0.62			0.61			0.63			0.62		
chi-squared	12.66			22.77			18.65			20.45		
p-value	0.89			0.30			0.47			0.36		

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. The factors are *rmrf*, the market risk premium, *hmls* and *hmlb*, the decompositions of the *hml* factor as in Zhang (2008), *MMB_CPZ*, the mid-cap minus large cap factor, *SMM_CPZ*, the small cap minus mid-cap factor, *BHML_CPZ* and *SHML_CPZ* the decompositions of the *hml_CPZ* portfolio, are as described in Cremers et al. (2010).

Table 10: Fama-Macbeth regression tests with the 27 sequential size, book-to-market and momentum portfolios:
Panel A: Basic FF and Carhart models and Value -Weighted Factor Components Models.

	Basic FF						Basic Cremers					
Basic FF & Carhart Models	**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	0.87	2.29	0.02	0.71	2.09	0.03	0.40	0.99	0.32	0.53	1.53	0.12
rmrf	-0.36	-0.85	0.39	-0.34	-1.03	0.30	0.13	0.31	0.75	-0.09	-0.28	0.77
smb	0.05	0.28	0.78	0.08	0.43	0.67	0.11	0.62	0.53	0.08	0.42	0.67
hml	0.48	2.33	0.02	0.35	1.62	0.10	0.62	3.13	0.00	0.39	1.83	0.06
umd							0.56	1.50	0.13	0.24	0.78	0.43
Cross-sect ional R^2	0.57			0.57			0.59			0.57		
chi-squared	43.35			49.41			37.41			47.01		
p-value	0.00			0.00			0.02			0.00		
	CPZ-FF						**CPZ-Carhart**					
Value -Weighted Factor Components Models	**Single**			**Rolling**			**Single**			**Rolling**		
cons	0.96	2.49	0.01	0.72	2.11	0.03	0.73	1.77	0.07	0.59	1.67	0.09
rmrf	-0.45	-1.04	0.29	-0.32	-0.97	0.33	-0.20	-0.45	0.65	-0.15	-0.44	0.65
smb_CPZ	0.17	0.74	0.45	0.17	0.69	0.49	0.23	0.99	0.32	0.17	0.68	0.49
hml_CPZ	0.58	2.29	0.02	0.33	1.33	0.18	0.81	3.44	0.00	0.38	1.65	0.10
umd_CPZ							0.39	0.89	0.37	0.23	0.63	0.53
Cross-sect ional R^2	0.57			0.56			0.58			0.57		
chi-squared	44.09			44.35			45.10			40.90		
p-value	0.00			0.00			0.00			0.01		

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. The factors are *rmrf*-the market risk premium, *smb*, *hml* and *umd* are as defined in the text and on Ken French's website, with breakpoints formed using the largest 350 UK firms, *smb_CPZ*, *hml_CPZ* and *umd_CPZ* , formed using the market capitalisations of the intersecting size and book-to-market, and size and momentum portfolios as described in Cremers et al. (2010).

Panel B: Decomposed Factor Models

	Zhang decomposition						CPZ-decomposition					
Decomposed Models	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	0.54	1.20	0.23	0.53	1.50	0.13	-0.57	-0.94	0.34	0.20	0.49	0.62
rmrf	0.00	0.01	0.98	-0.10	-0.30	0.76	1.13	1.92	0.05	0.28	0.72	0.47
smb	0.10	0.59	0.55	0.07	0.36	0.71						
hmls	0.89	2.53	0.01	0.46	1.66	0.09						
hmlb	0.72	2.87	0.00	0.31	1.27	0.20						
umd	0.65	1.63	0.10	0.17	0.59	0.55						
MMB_CPZ							-0.02	-0.12	0.90	0.00	0.03	0.97
SMM_CPZ							0.25	1.37	0.17	0.25	1.40	0.16
BHML_CPZ							0.58	2.27	0.02	0.13	0.55	0.58
SHML_CPZ							1.09	3.56	0.00	0.77	2.70	0.00
umd_CPZ							0.89	1.92	0.05	0.29	0.78	0.43
Cross-sect ional R^2	0.59			0.58			0.60			0.59		
chi-squared	36.42			39.61			30.41			32.03		
p-value	0.02			0.01			0.08			0.05		

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. The factors are *rmrf*, the market risk premium, *hmls* and *hmlb*, the decompositions of the *hml* factor as in Zhang (2008), *MMB_CPZ*, the mid-cap minus large cap factor, *SMM_CPZ*, the small cap minus mid-cap factor, *BHML_CPZ* and *SHML_CPZ* the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010).

Table 11: Fama-Macbeth regression tests for the models with the 25 Standard Deviation portfolios:
Panel A: Basic FF and Carhart models and Value -Weighted Factor Components Models.

	Basic FF						Basic Carhart					
Basic FF & Carhart Models	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	0.93	1.80	0.07	1.06	2.54	0.01	0.83	1.51	0.13	1.02	2.44	0.01
rmrf	-0.36	-0.63	0.52	-0.67	-1.64	0.10	-0.25	-0.45	0.65	-0.64	-1.57	0.11
smb	0.16	0.57	0.57	0.26	1.13	0.25	0.16	0.54	0.58	0.34	1.46	0.14
hml	0.28	0.64	0.52	0.38	1.47	0.14	0.25	0.55	0.58	0.44	1.68	0.09
umd							0.56	0.91	0.36	-0.35	-1.07	0.28
Cross-sect ional R^2	0.48			0.47			0.48			0.48		
chi-squared	27.26			25.27			20.48			23.57		
p-value	0.20			0.28			0.49			0.31		
	CPZ-FF						CPZ-Carhart					
Value -Weighted Factor Components Models.	Single			Rolling			Single			Rolling		
cons	0.89	1.85	0.06	1.07	2.62	0.00	0.83	1.66	0.09	0.99	2.45	0.01
rmrf	-0.29	-0.54	0.59	-0.67	-1.66	0.09	-0.23	-0.42	0.67	-0.63	-1.58	0.11
smb_CPZ	0.09	0.25	0.80	0.38	1.26	0.20	0.02	0.05	0.95	0.41	1.35	0.17
hml_CPZ	0.06	0.11	0.91	0.30	1.05	0.29	0.06	0.10	0.92	0.44	1.49	0.13
umd_CPZ							0.67	0.91	0.36	-0.41	-1.05	0.29
Cross-sect ional R^2	0.48			0.47			0.49			0.49		
chi-squared	27.88			21.91			22.91			23.10		
p-value	0.18			0.46			0.34			0.33		

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. The factors are *rmrf*-the market risk premium, *smb*, *hml* and *umd* are as defined in the text and on Ken French’s website, with breakpoints formed using the largest 350 UK firms, *smb_CPZ*, *hml_CPZ* and *umd_CPZ* , formed using the market capitalisations of the intersecting size and book-to-market, and size and momentum portfolios as described in Cremers et al. (2010).

Panel B: Decomposed Factor Models

	Zhang decomposition						CPZ-decomposition					
Decomposed Factor Models	**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	0.63	1.12	0.26	0.87	1.91	0.05	0.81	1.45	0.14	0.81	1.74	0.08
rmrf	-0.02	-0.04	0.96	-0.47	-1.11	0.26	-0.28	-0.52	0.60	-0.42	-0.98	0.32
smb	0.07	0.25	0.79	0.32	1.35	0.17						
hmls	0.32	0.52	0.60	0.37	0.87	0.38						
hmlb	-0.62	-0.91	0.36	0.46	1.47	0.14						
umd	1.01	1.57	0.11	-0.17	-0.54	0.59						
MMB_CPZ							0.22	0.60	0.55	0.22	0.83	0.40
SMM_CPZ							-0.01	-0.03	0.97	0.31	1.08	0.28
BHML_CPZ							-0.46	-0.66	0.50	0.58	1.70	0.09
SHML_CPZ							0.26	0.57	0.56	0.28	0.78	0.43
umd_CPZ							1.37	1.81	0.07	-0.25	-0.61	0.54
Cross-sect ional R^2	0.49			0.49			0.49			0.50		
chi-squared	16.79			20.63			15.70			16.56		
p-value	0.66			0.41			0.67			0.61		

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. The factors are *rmrf*, the market risk premium, *hmls* and *hmlb*, the decompositions of the *hml* factor as in Zhang (2008), *MMB_CPZ*, the mid-cap minus large cap factor, *SMM_CPZ*, the small cap minus mid-cap factor, *BHML_CPZ* and *SHML_CPZ* the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010).

Table 12: GRS Test results for models based on the largest 350 firms only

Portfolios	**25 Size and BTM**			**12 Size, B/M and Momentum**			**12 Standard Deviation**		
Models	GRS-F stat	p	Mean R^2	GRS-F stat	p	Mean R^2	GRS-F stat	P	Mean R^2
Basic Models									
Basic FF	0.69	0.86	0.73	1.39	0.16	0.79	1.47	0.13	0.70
Basic Carhart	0.87	0.64	0.73	1.25	0.24	0.79	1.05	0.40	0.70
Value-Weighted Factor Components model									
CPZ-FF	0.66	0.88	0.73	1.51	0.11	0.78	1.59	0.09	0.70
CPZ-Carhart	0.77	0.77	0.74	1.31	0.20	0.78	1.27	0.23	0.70
Decomposed Factor Models									
Zhang decomposition	0.75	0.80	0.75	0.95	0.49	0.81	1.04	0.41	0.70
CPZ-decomposition	0.65	0.90	0.76	1.09	0.36	0.80	1.08	0.37	0.71

The Table reports the results of the first-stage GRS tests of the returns of the 5x5 size and book-to-market (BTM) portfolios, 2x2x3 sequentially sorted size, BTM and momentum portfolios and 12 portfolios ranked on their prior 12-month standard deviation of returns, all formed from the largest 350 firms only. The portfolios are regressed on the Fama-French and Carhart factors, formed on the basis of only the largest 350 firms. "GRS" shows the result of the GRS F-test and the p-value for the rejection of the null hypothesis that all the intercept (_cons) terms are jointly zero. The mean adjusted R-squared for each model is also shown.

Table 13: Fama-Macbeth regression tests with the 25 (5x5) size and book-to-market portfolios formed from the largest 350 firms.
Panel A: Basic FF and Carhart Models, and Value-Weighted Factor Components model

	Basic FF						Basic Carhart					
Basic Models	**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	-0.23	-0.44	0.65	0.14	0.41	0.68	-0.24	-0.45	0.65	0.06	0.17	0.86
rmrf	0.78	1.36	0.17	0.31	0.89	0.37	0.79	1.38	0.16	0.45	1.26	0.21
smb	0.11	0.60	0.55	0.05	0.30	0.76	0.12	0.65	0.51	0.09	0.46	0.64
hml	0.56	2.22	0.02	0.54	2.32	0.02	0.60	2.29	0.02	0.65	2.75	0.00
umd							-0.15	-0.23	0.82	0.17	0.52	0.60
Cross-sect ional R^2	0.56			0.55			0.56			0.55		
chi-squared	10.6			16.7			10.5			16.8		
p-value	0.97			0.77			0.97			0.72		
	CPZ-FF						**CPZ-Carhart**					
Value-Weighted Factor Components model	**Single**			**Rolling**			**Single**			**Rolling**		
cons	-0.18	-0.31	0.75	0.18	0.50	0.62	-0.25	-0.41	0.68	0.11	0.30	0.76
rmrf	0.71	1.17	0.24	0.26	0.72	0.47	0.80	1.30	0.19	0.36	0.98	0.32
smb_CPZ	0.13	0.77	0.44	0.02	0.15	0.88	0.11	0.67	0.50	0.02	0.15	0.87
hml_CPZ	0.60	2.40	0.01	0.51	2.19	0.02	0.48	2.23	0.02	0.54	2.50	0.01
umd_CPZ							-0.94	-1.23	0.22	0.24	0.61	0.54
Cross-sect ional R^2	0.55			0.54			0.56			0.55		
chi-squared	19.3			20.0			13.5			21.6		
p-value	0.62			0.58			0.88			0.41		

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. The factors are *rmrf*-the market risk premium, *smb*, *hml* and *umd* are as defined in the text and on Ken French's website, formed using only the largest 350 UK firms, *smb_CPZ*, *hml_CPZ* and *umd_CPZ* , formed using the market capitalisations of the intersecting size and book-to-market, and size and momentum portfolios as described in Cremers et al. (2010).

Panel B: Decomposed Factor Models

	Zhang Decomposition						CPZ-decomposition					
Decomposed Factor Models	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	-0.25	-0.45	0.65	0.00	0.02	0.98	-0.22	-0.38	0.70	-0.23	-0.62	0.53
rmrf	0.79	1.37	0.17	0.52	1.42	0.15	0.77	1.25	0.21	0.76	2.13	0.03
smb	0.07	0.40	0.68	0.07	0.37	0.70						
hmls	0.44	1.57	0.11	0.37	1.33	0.18						
hmlb	0.48	2.12	0.03	0.46	2.18	0.03						
umd	-0.46	-0.70	0.48	0.02	0.08	0.93						
smb_CPZ							0.11	0.67	0.50	0.03	0.16	0.87
BHML_CPZ							0.44	1.83	0.06	0.46	2.07	0.03
SHML_CPZ							0.53	1.99	0.04	0.43	1.50	0.13
umd_CPZ							-0.14	-0.16	0.87	0.03	0.10	0.91
Cross-sect ional R^2	0.57			0.56			0.57			0.56		
chi-squared	11.81			19.15			10.93			15.96		
p-value	0.92			0.51			0.94			0.71		

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. The factors are *rmrf*, the market risk premium, *hmls* and *hmlb*, the decompositions of the *hml* factor as in Zhang (2008), *MMB_CPZ*, the mid-cap minus large cap factor, *smb_CPZ*, here the mid-cap minus the large-cap return (small firms being excluded from this largest firms portfolio), *BHML_CPZ* and *SHML_CPZ* the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010).

Table 14: Fama-Macbeth regression tests with the 12 size, book-to-market and momentum portfolios formed from the largest 350 firms
Panel A: Basic FF and Carhart Models, and Value-Weighted Factor Components model

	Basic FF						Basic Carhart					
Basic FF & Carhart Models	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	-0.64	-0.80	0.42	0.28	0.49	0.62	-0.77	-0.90	0.36	-0.16	-0.24	0.80
rmrf	1.18	1.45	0.14	0.11	0.19	0.84	1.35	1.65	0.10	0.71	1.10	0.27
smb	0.01	0.08	0.93	-0.06	-0.30	0.76	0.15	0.78	0.43	-0.03	-0.17	0.86
hml	0.39	1.32	0.18	0.28	1.04	0.30	0.74	2.69	0.00	0.38	1.40	0.16
umd							1.02	2.06	0.04	0.56	1.14	0.25
Cross-sect ional R^2	0.61			0.61			0.62			0.63		
chi-squared	14.21			17.32			3.58			14.52		
p-value	0.11			0.04			0.89			0.06		
	CPZ-FF						CPZ-Carhart					
Value-Weighted Factor Components model	Single			Running			Single			Running		
cons	-0.35	-0.40	0.68	0.63	1.08	0.28	-0.18	-0.21	0.83	0.24	0.37	0.71
rmrf	0.87	0.98	0.32	-0.26	-0.47	0.64	0.71	0.81	0.41	0.28	0.48	0.63
smb_CPZ	0.06	0.33	0.73	-0.05	-0.26	0.79	0.14	0.76	0.44	-0.03	-0.14	0.89
hml_CPZ	0.43	1.61	0.10	0.24	0.89	0.37	0.69	2.76	0.00	0.41	1.59	0.11
umd_CPZ							0.56	1.04	0.30	1.05	1.71	0.08
Cross-sect ional R^2	0.60			0.61			0.62			0.63		
chi-squared	14.21			17.40			11.32			12.03		
p-value	0.11			0.04			0.18			0.15		

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. The factors are *rmrf*-the market risk premium, *smb, hml* and *umd* are as defined in the text and on Ken French's website, formed using only the largest 350 UK firms, *smb_CPZ, hml_CPZ* and *umd_CPZ* , formed using the market capitalisations of the intersecting size and book-to-market, and size and momentum portfolios as described in Cremers et al. (2010).

Panel B: Decomposed Factor Models

	Zhang decomposition						CPZ-decomposition					
Decomposed Factor Models	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	-1.02	-1.13	0.26	0.79	0.66	0.51	-1.62	-1.58	0.11	-0.04	-0.06	0.95
rmrf	1.60	1.82	0.07	-0.38	-0.34	0.73	2.18	2.31	0.02	0.65	0.87	0.38
smb	0.02	0.11	0.91	-0.06	-0.32	0.74						
hmls	0.64	2.19	0.03	0.69	2.29	0.02						
hmlb	0.53	2.00	0.04	0.38	1.33	0.18						
umd	0.76	1.67	0.09	0.62	1.21	0.22						
smb_CPZ							0.21	1.10	0.27	-0.02	-0.12	0.90
BHML_CPZ							0.44	1.52	0.13	0.22	0.71	0.47
SHML_CPZ							0.68	2.23	0.02	0.83	2.38	0.01
umd_CPZ							1.37	2.13	0.03	1.51	2.49	0.01
Cross-sect ional R^2	0.64			0.63			0.64			0.64		
chi-squared	3.29			7.21			4.11			9.96		
p-value	0.85			0.40			0.76			0.19		

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. The factors are *rmrf*, the market risk premium, *hmls* and *hmlb*, the decompositions of the *hml* factor as in Zhang (2008), *MMB_CPZ*, the mid-cap minus large cap factor, *smb_CPZ*, here the mid-cap minus the large-cap return (small firms being excluded from this largest firms portfolio), *BHML_CPZ* and *SHML_CPZ* the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010).

Table 15: Fama-Macbeth regression tests with the 12 standard deviation portfolios formed from the largest 350 firms.
Panel A: Basic FF and Carhart Models, and Value-Weighted Factor Components model

	Basic FF						Basic Carhart					
Basic FF & Carhart Models	**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	0.61	0.68	0.50	0.78	1.68	0.09	0.72	0.68	0.49	0.89	1.74	0.08
rmrf	0.00	0.00	0.99	-0.28	-0.62	0.53	0.15	-0.18	0.86	-0.39	-0.77	0.44
smb	-0.55	-1.01	0.31	-0.34	-1.07	0.28	-0.11	-0.19	0.84	-0.17	-0.52	0.60
hml	-0.75	-1.27	0.20	0.11	0.26	0.79	-0.26	-0.41	0.68	0.15	0.34	0.73
umd							1.51	2.17	0.03	-0.01	-0.04	0.97
Cross-sect ional R^2	0.50			0.49			0.50			0.49		
chi-squared	10.27			13.93			7.12			13.03		
p-value	0.59			0.30			0.78			0.29		
	CPZ-FF						**CPZ-Carhart**					
Value-Weighted Factor Components model	**Single**			**Running**			**Single**			**Running**		
cons	0.76	0.83	0.40	0.79	1.61	0.10	1.05	0.80	0.42	0.81	1.57	0.11
rmrf	-0.17	-0.18	0.85	-0.32	-0.70	0.48	-0.52	-0.54	0.59	-0.34	-0.66	0.50
smb_CPZ	-0.12	-0.27	0.78	0.00	0.03	0.97	0.01	0.04	0.96	0.02	0.10	0.92
hml_CPZ	0.22	0.34	0.73	0.40	1.08	0.28	0.80	1.17	0.24	0.36	0.95	0.34
umd_CPZ							1.82	2.45	0.01	0.01	0.03	0.97
Cross-sect ional R^2	0.49			0.47			0.49			0.48		
chi-squared	11.54			13.70			2.91			10.49		
p-value	0.48			0.32			0.99			0.48		

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. The factors are *rmrf*-the market risk premium, *smb*, *hml* and *umd* are as defined in the text and on Ken French's website, formed using only the largest 350 UK firms, *smb_CPZ*, *hml_CPZ* and *umd_CPZ* , formed using the market capitalisations of the intersecting size and book-to-market, and size and momentum portfolios as described in Cremers et al. (2010).

Panel B: Decomposed Factor Models

Decomposed Factor Models	Zhang decomposition Single			Zhang decomposition Rolling			CPZ-decomposition Single			CPZ-decomposition Rolling		
Variable	**Mean**	**sh-t**	**sh-p**	**Mean**	**sh-t**	**sh-p**	**Mean**	**sh-t**	**sh-p**	**Mean**	**sh-t**	**sh-p**
cons	0.92	0.90	0.37	0.58	1.09	0.27	1.21	0.87	0.38	0.52	0.99	0.32
rmrf	-0.36	-0.40	0.68	-0.03	-0.07	0.94	-0.68	-0.66	0.50	-0.01	-0.02	0.98
smb	-0.23	-0.38	0.70	-0.17	-0.51	0.60						
hmls	-0.26	-0.43	0.66	0.50	1.03	0.30						
hmlb	0.78	1.16	0.24	-0.11	-0.27	0.78						
umd	1.31	1.92	0.05	-0.01	-0.04	0.97						
smb_CPZ							-0.02	-0.06	0.95	0.02	0.09	0.93
BHML_CPZ							0.98	1.35	0.17	-0.07	-0.16	0.87
SHML_CPZ							-0.19	-0.33	0.74	0.48	0.99	0.32
umd_CPZ							1.61	2.06	0.04	0.20	0.40	0.69
Cross-sect ional R^2	0.51			0.50			0.51			0.49		
chi-squared	4.13			14.51			2.69			11.59		
p-value	0.94			0.15			0.98			0.31		

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. The factors are *rmrf*, the market risk premium, *hmls* and *hmlb*, the decompositions of the *hml* factor as in Zhang (2008), *MMB_CPZ*, the mid-cap minus large cap factor, *smb_CPZ*, here the mid-cap minus the large-cap return (small firms being excluded from this largest firms portfolio), *BHML_CPZ* and *SHML_CPZ* the decompositions of the *hml_CPZ* portfolio, all as described in Cremers et al. (2010).