Size and Value Matter, But Not The Way You Thought

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ABSTRACT

Fama and French risk premiums do not reliably estimate the magnitude of the size or book-to-market effects, inducing many researchers to inflate the number of factors. We object that controlling ex ante for noise in the estimation procedure enables to keep a parsimonious set of factors. We replace Fama and French's independent rankings with the conditional ones introduced by Lambert and Hübner (2013). This alternative framework generates much stronger "turn-of-the-year" size and "through-the-year" book-to-market effects than conventionally documented. Furthermore, the factors deliver less specification errors when used to price portfolios, especially regarding the "small angels" (low size – high BTM stocks).

Keywords: size, value, small angels, Fama and French, sequential sorting, January effects

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Pricing anomalies related to size (Banz, 1981), value (Basu, 1983), and momentum (Jegadeesh and Titman, 1993) effects on the US stock market have been documented since the early 1980s. First related to mispricing over the Capital Asset Pricing Model, these effects have been widely recognized as priced factors since the influential work of Fama and French (1993). The size premium captures the outperformance of small capitalization stocks over large capitalizations, and Fama and French (1993) associate this first market anomaly with a proxy for (lack of) liquidity. The outperformance of value stocks (i.e. stocks with high book value with regard to their market value) over growth stocks has been related by the same authors to market distress (see also, Fama and French, 1995). Their paper develops a set of heuristics enabling the inference of size and book-to-market effects in the US market. The resulting so-called "Fama and French three-factor model" has become a core version of empirical asset pricing models taught at many levels in many business schools.

While the original factor construction algorithm developed by Fama and French (1993) has become the standard method to estimate both size and value (i.e. book-to-market) premiums, there are those who suggest that the premiums obtained with the Fama and French technique could be misspecified. Using mutual fund data, Huij and Verbeek (2009) point out a strong value effect but no small firm effect. They further show that the original value factor might be overestimated under the Fama and French framework. According to Li, Brooks and Miffre (2009), the portfolios underlying the value premium are not well diversified and as a consequence, the value effect is related to idiosyncratic risk. Finally, Cremers, Petajisto and Zitzewitz (2012) reveal a failure in the Fama and French methodology which leads to overestimate the size and value effects: their original work allocates the same weight to small and large sized portfolios although value effects are stronger in smaller stock portfolios. Besides, as also shown by Horowitz, Loughran, and Savin (2000), the size effect is concentrated into microcap stocks.

Recent studies have fueled this debate by advocating that the value effect could even be insignificant in the Fama and French framework (Fama and French, 2015a, 2015b; Hou, Xue and Zhang, 2014, 2015). To cope with this criticism, Fama and French (2015a) introduce two factors that totally subsume the significance of the value factor. The investment factor CMA (Conservative minus Aggressive) defines the return spread between firms that invest the least and the most. The profitability factor RMW (Robust minus Weak) represents the return spread between firms with the highest and the lowest operating profitability. On the basis of the dividend discount model, Fama and French (2015a) show that the value factor can be meaningfully decomposed into a profitability and investment factor, leading to a five-factor (i.e. 4-1+2 by excluding the momentum factor) model specification. This evidence is further supported by Hou, Xue and Zhang (2014, 2015) with their *q*-factor model. Their profitability (ROE) and investment (I/A) factors are shown to outperform Fama and French's five-factor model.

A weak size effect has also been claimed by the literature [please refer to van Dijk (2011) and Asness et al. (2015) for a full discussion]. Asness et al. (2015) introduce a quality factor (QMJ, Quality minus Junk) that jointly controls for profitability, growth, safety, and payout and resurrects the size effects over time.

Such an inflation of the number of variables needed to explain the cross-section of stock returns can be interpreted in two very different ways. It could be the reflection of a complexity in the return generation process that had been formerly ignored, and thus represent a real advance in empirical asset pricing. The very recent work of Fama and French (2015c) shows that their new five-factor model fails to price all market anomalies and tests the significance of the small leg of each factor. Considering both the factors and their small leg, they propose ad hoc selection of factors according to the anomaly to be priced for keeping the model parsimonious. Alternatively, the need to increase the number of factors could just represent an admission of weakness in the quest for parsimony in factor models, because the right way to understand the universe of systematic risk exposures has not been adequately found. If the latter explanation is true, and this is clearly the perspective adopted in this paper, then researchers should keep on attempting to improve factor construction methodologies to show that having recourse to supplementary risk premiums become superfluous when the original ones are properly determined. Before moving to five-, six- or seven-factor models, one should first do whatever possible to reject all possible explanations of deficiencies of the original three-factor asset-pricing model. This is the major objective of our paper, and we believe that it contributes to reinforcing a parsimonious approach to asset pricing.

Our main argument relies on the fact that the Fama and French independent sorting methodology leads to an inconsistent definition of value stocks. In their framework, value stocks are tilted towards micro-capitalizations. Our paper revisits the way in which size and book-to-market effects translate onto risk factors. We show that the Fama and French premiums are contaminated by cross-effects that are not adequately neutralized by their independent sorting procedure. To achieve this objective, we follow the sequential methodology proposed by Lambert and Hübner (2013), used to isolate fundamental risks into portfolio returns. By removing contamination effects at the early stage, i.e. when constructing the empirical risk premiums, we aim to shed new light on the relative importance of the size and book-to-market effects in the US market over an extended period (1963-2014).

We demonstrate the existence of a strong value effect, albeit not in the way Fama and French measure it. Our definition of the value effect does not refer to the original interpretation of Fama and French. The value factor might capture part of default risk as distress is more likely to be found in small value stocks. However, it does not constitute a proxy for default risk (as pointed out by Vassalou and Xing, 2004). Our new factor is consistent with Zhang (2005) and associates the value effect with greater sensitivity of a firm’s earnings to the economic conditions.

We differentiate ourselves from the cited literature challenging the existence of size and value effects by controlling ex ante for external factors rather than a posteriori. This adjustment leads to a stronger “turn-of the year” (January) size effect as well as a permanent, “through-the-year” value premium over time. The seasonality of the size effect has been deeply investigated in the literature (Reinganum, 1981; Roll, 1981; Keim, 1983). We emphasize a particularly strong seasonal effect under the new sequential methodology of building the size and value risk factors. The figures are impressive: a long/short strategy of investing the long leg in the Small portfolio and a short leg in the Large portfolio only in January every year, staying out of the market for the remaining 11 months, would yield an average yearly return of 4.77% and monthly standard deviation of 4.78%, which represents a yearly Sharpe ratio of 3.48 sustained over 52 years. The seasonal January size effect is so pronounced that the mean return of the size factor from February till December each year even becomes negative, although insignificant, over the 52 years under study.

Using our sequential methodology to derive the book-to-market factor, we do not witness anymore a tilt towards small value stocks (which drives the value factor in F&F framework and its relation with a distress factor) and discover a remarkably steady and significant value effect across the year and every business cycle, and all market capitalizations. Put differently, if we correct for noise in the way we allocate stocks to the characteristic portfolios, we find a strong book-to-market effect not only across market capitalizations but also across time.

Specification tests of the sequential size and value factors reveal that, to a large extent, the change in factor building methodology largely mitigates the need for additional risk premiums to explain stock returns. The factors deliver less specification errors when used to price portfolios, especially regarding the "small angels" (low size but high book-to-market stocks) which had come out, to date, as a puzzling, unresolved residual effect.

Neither the Fama and French five-factor model, nor the *q*-factor model were able to outperform an alternative, yet equally parsimonious, version of the original Fama and French model (augmented or not with a momentum factor) defined under a sequential approach.

The rest of the paper is organized as follows. Section 1 reviews the daunting challenges about the size and market anomalies. Section 2 presents the drawbacks related to the independent sorting procedure performed in the original Fama and French methodology. Section 3 describes the sequential methodology for constructing mimicking portfolios based on size, book-to-market, and momentum. Section 4 performs a workhorse of the properties of the two competing sets of the original size and book-to-market factors. Section 5 tests the significance of the sequential factors with its three competing sets of factors (Fama and French, 1993, 2015a, 2015b; Hou, Xue and

Zhang, 2014, 2015). Section 6 compares the specification power of the four competing set of factors for pricing passive portfolios. Section 7 concludes by summarizing the main insights of this research.

1 The size and book-to-market anomalies

Mispricing with regard to the original Capital Asset Pricing Model (Sharpe, 1964; Lintner, 1965) due to factors such as the size and value effects has been documented in the US stock market since the early 1980s. The three-factor model (Fama and French, 1993) that captures these effects has been strongly challenged in the literature. Berk (1997) point out that when defining the size effect with regard to market capitalisation and thus stock price, size might display a spurious relation with stock return. Berk further documents mixed evidence about the size effect when measured with accounting indicators (like sales). Arnott, Hsu and Moore (2005) point out that noise in stock prices due to trading or microstructure might also create the size and value effects. Vassalou and Xing (2004) provide further evidence that the size and value effect only indirectly proxies for default risk as default is more likely to be found in small value stocks.

Table 1 casts some doubt about the persistence of the size and value effects. Asness et al. (2015) analyse the statistical properties of the size effect under three periods: January 1963 to December 1979, the “golden age” (the time when the size effect is strongest), January 1980 to December 1999, “embarrassment” (the time when the size effect is weakest), and the recent recovery in the size premium (January 2000 to December 2014, “resurrection”).

Table 1

Fama & French's original size and value premiums over time.

The table displays descriptive statistics for F&F size (SMB_{ff}) and book-to-market (HML_{ff}) premiums over time. Both stock factors are obtained from K. French's website. Time-series mean, standard deviation (S.D.), *t*-stat for the bilateral test of time series mean equals to 0, as well as the number of observations considered are displayed. The analysis covers the original period used in Fama and French (1993) – that is from January 1963 – up to December 2014. It performs the analysis for January and February-December separately over the same sample period, as well as over three sub-periods referenced by Asness et al. (2015) reflecting the time when the size effect is strongest (January 1963 to December 1979, the "golden age"), weakest (January 1980 to December 1999, "embarrassment"), and the recent recovery in the size premium (January 2000 to December 2014, "resurrection").

			SMB_{ff}				HML_{ff}			
			Mean (%)	S. D. (%)	T-stat	Freq	Mean (%)	S. D. (%)	T-stat	Freq
Total sample	01-63	12-14	0.24	3.09	1.93	624	0.38	2.85	3.30	624
January			1.97	3.41	4.16	52	1.38	3.57	2.79	52
Feb. - Dec.			0.08	3.02	0.64	572	0.29	2.76	2.47	572
Golden age	01-63	12-79	0.46	3.16	2.09	204	0.53	2.44	3.09	204
Embarrassement	01-80	12-99	-0.04	2.66	-0.23	240	0.19	2.80	1.04	240
Resurrection	01-00	12-14	0.36	3.52	1.36	180	0.45	3.32	1.84	180

From Table 1, the size premium appears to be inconsistent over time and only significant in January. Reinganum (1981), Roll (1981), and Keim (1983) had already identified a calendar anomaly for the size premium known as the "turn-of-the-year effect". Further evidence can be found in Jacobsen, Mamun and Visaltanachoti (2005) and Moller and Zinca (2008). Asness et al. (2015) show that after controlling ex post for quality/junk, the significance of the size effect reappeared across the whole sample period and not only concentrated during the month of January.

Hou and van Dijk (2008) reach similar conclusions after adjusting firms' returns for profitability shocks.

Table 1 shows the Fama and French value premium has barely subsisted for the last 25 years. The book-to-market premium only appears significant during the "golden age" period (*t*-statistics of 3.09). For the sub-sample periods of "embarrassment" and "resurrection", HML (*t*-statistics of resp. 1.04 and 1.84) is almost non-existent.

According to Fama and French (1993, 1995), the book-to-market factor proxies for market distress but this interpretation has recently been challenged in the literature. Fresh evidence has emphasized the need for a profitability factor rather than a distress factor for modeling the cross-sections of stock returns (Novy-Marx, 2013; Ball et al., 2015). Zhang (2005) propose another explanation of the value effect: value companies generate strong cash flow but might suffer during periods of recession. The rationale is that these "asset-in-place" firms have larger difficulties to scale down their investments in squeezed economic contexts and ultimately end up being forced to run their business with unproductive assets. Value stocks have to deliver a higher expected return to compensate for this risk. Several studies (e.g., Petkhova and Zhang, 2005) have confirmed this interpretation of the value effect.

Fama and French (2015a) themselves confess that the book-to-market factor might even be redundant in the US stock market as soon as a profitability and an investment factor are considered: the investment factor CMA (Conservative minus Aggressive) is the average spread return of the stocks with the lowest and the highest investment profile, and the profitability factor RMW (Robust minus Weak) is the average spread return of the stocks with the highest and the lowest operating profitability. They show that the premium captured in the value premium is explained by the remaining four factors, namely the excess market return (Rm-Rf), the size (SMB), the investment (CMA), and the profitability (RMW). When the analysis is performed on each factor, HML appears to be subsumed by the investment factor (CMA) and the profitability factor (RMW). Similar evidence is also related in Hou, Xue and Zhang (2014). In a sequel study, Hou, Xue and Zhang (2015) show that their *q*-factors subsume the Fama and French factors (both the three-factor model and its five-factor augmented with momentum) but not vice versa. Fama and French (2015c) recently extend their five-factor model by considering the small leg of each factor. This leads to further increase the number of factors to be considered for pricing one market anomaly.

Undoubtedly, Table 1 and the extant literature cast doubt on the ability of both original F&F factors to deliver a consistent risk premium over time.

2 Background: correlation bias in the Fama and French (1993) methodology

The Fama and French (1993) three-factor model and its extension for momentum (authored by Carhart, 1997) have become the benchmark in empirical asset pricing. Using a dataset from the Center for Research in Security Prices (CRSP), Fama and French consider two methods of scaling US stocks, i.e. an annual two-way sort on market equity and an annual three-way sort on book-to-market according to New York Stock Exchange (NYSE) breakpoints (quantiles). They then construct six value-weighted (two-dimensional) portfolios at the intersections of the annual rankings (performed each June of year *y* according to the fundamentals displayed in December of year *y*-1). The size or SMB factor (Small minus Big) measures the return differential between the average small cap and the average big cap portfolios, while the book-to-market or HML factor (High minus Low) measures the return differential between the average value and the average growth portfolios. In order to group together US stocks with small/large market capitalization and with low/high book-to-market ratios, Fama and French perform two independent rankings on market capitalization and on book-to-market ratios.

Under an independent sorting, the six portfolios will have approximately the same number of stocks only if size and book-to-market are unrelated characteristics; that is, if there is no significant correlation between the risk fundamentals. However, market capitalization and book-to-market are correlated. The study of Fama and French (1993) even points out that "*using independent size and book-to-market sorts of NYSE stocks to form portfolios means that the highest book-to-market/market equity quintile is tilted toward the smallest stocks*" (Fama and French, 1993, pp. 12).

Table 2 reports significant negative correlations between the independent rankings.

Table 2

Correlations between the independent rankings.

The table reports polychoric correlations between the F&F independent rankings for size (SMB_{ff}) and book-to-market (HML_{ff}) premiums among the 2x3 characteristic-sorted portfolios on size and book-to-market over January 1963-December 2014. Annual minimum and maximum correlation between the final ranking of the size and the book-to-market factors are also displayed. Tests for significance of the pair-wise correlations are performed: *, **, and *** indicate statistical significance at the 0.1, 0.05 and 0.01 levels, respectively.

	SMB_{ff} / HML_{ff}
Correlation	-28%***
95% Lower Confidence Limit	-28.44%
95% Upper Confidence Limit	-27.05%
Annual Minimum	-53%***
Annual Maximum	9%***

We use polychoric correlation between ordered-category variables. This statistic provides a way to separately quantify association and similarity of the two-way size and three-way book-to-market rankings. The analysis is performed on each portfolio rebalancing date, i.e. June of each year *y*. The independent rankings defined under the Fama and French framework show a negative correlation of about 28% over the period ranging from January 1963 to December 2014.

This correlation bias will create an imbalance between the numbers of stocks within the six portfolios composing the premiums, as shown in Table 3 and Figure 1.

Table 3

Stock distribution among the 2x3 characteristics portfolios.

The table displays the stock repartition for the F&F 2x3 characteristic-sorted portfolios on size (small and big) and book-to-market (low, medium and high) over January 1963-December 2014. The summary statistics contain the monthly average, median, minimum and maximum stock distribution among the six portfolios.

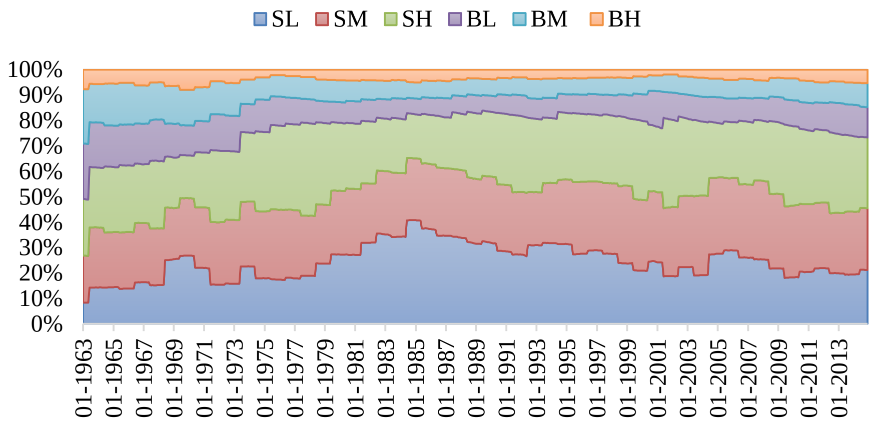
	Total	SL_{ff}	SM_{ff}	SH_{ff}	BL_{ff}	BM_{ff}	BH_{ff}	Average / (σ)
Mean	3791	975	995	1013	362	303	143	632 / 403
Median	3904	999	1016	1007	358	298	149	638 / 410
Min	1036	86	191	229	209	222	79	169 / 69
Max	6546	1825	1924	1939	774	446	216	1187 / 797

The imbalance within the distribution of stock amongst these portfolios suggests that the size effect cannot be equivalently diversified across book-to-market sorted portfolios and could therefore contaminate the value effect derived from those portfolios. The reverse is also true. Figure 1 illustrates the imbalance in the stock partitioning across portfolios over time.

Figure 1

Relative stock partitioning across the 2x3 characteristics portfolios.

The figure displays the total percentage stock repartition among the F&F 2x3 characteristic-sorted portfolios on size (small and big) and book-to-market (low, medium and high) over January 1963-December 2014.



In the working paper version of Cremers, Petajisto and Zitzewitz (2012), the authors already state that "*only the largest cap decile is clearly negatively correlated with SMB; the midcaps (size deciles 6-8) are positively correlated with SMB despite being included among big stocks, which should mechanically induce a negative correlation*". This quote would support our argument that using NYSE breakpoints, Fama and French are mixing small- with mid-caps which should have an impact on the size premium. As a consequence, the Fama and French methodology might not price accurately the incremental return of pure small cap stocks.

3 An alternative to the Fama and French procedure: the sequential sorting technique

To correct for the correlation bias described in the Fama and French original methodology, we replace the independent rankings with a sequential sorting procedure. We will demonstrate that such a technique leads to a substantial purification of risk factors by ensuring the homogeneity of each constructed portfolio on all three fundamental risk dimensions (i.e. book-to-market, momentum and size).

3.1 Factor construction approach

The modified factor construction approach differs from the original Fama and French methodology on a number of points. Firstly, our methodology comprises a comprehensive framework that analyses the three empirical risk dimensions (size, book-to-market, and momentum) altogether. Each form of risk is equally considered. Secondly, the modified methodology proposes a consistent and systematic sorting of all listed stocks, while Fama and French only perform a heuristic split according to NYSE stocks. Finally, our sequential sort avoids spurious cross-effects in risk factors due to any correlation between the rankings underlying the construction of the benchmarks. The following subsections detail the construction of the sequential premiums.

3.1.1 The sequential sorting procedure

In designing the sorting procedure, our objective is to detect whether, when controlling for two out of the three risk dimensions, there is still enough return variation related to the third risk criterion. Therefore, we substitute the Fama and French "independent sort" with a "sequential" or "conditional sort", i.e. a multi-stage sorting procedure. More specifically, we successively perform three sorts. The first two sorts operate on "control risk" dimensions, followed by the risk dimension to be priced. We use the momentum effect documented by Jegadeesh and Titman (1993) and introduced in empirical asset pricing models by Carhart (1997) as one of the control risk dimensions, and then use either size or book-to-market as the second one, depending on whether we want to isolate the book-to-market or size risk premium.

The sequential sorting produces 27 portfolios capturing the return relating to a low, medium, or a high level of the risk factor, conditional on the levels registered on the two control risk dimensions. Taking the simple average of the differences between the portfolios' highest and lowest scores on the risk dimension to be priced whilst scoring at the same level for both control risk dimensions, we are able to obtain the return variation related to the risk under consideration.

This procedure is similar to that of Lambert and Hübner (2013). To obtain the risk premium corresponding to dimension X, after sequentially controlling for dimensions Y and Z, the factor can be computed as:

$$X_{Y,Z,t} = \frac{1}{9}\left[\sum_{b=H,M,L}\sum_{c=H,M,L} R_t(HX|bY|cZ) - \sum_{b=H,M,L}\sum_{c=H,M,L} R_t(LX|bY|cZ)\right] \qquad (1)$$

where $R_t(aX|bY|cZ)$ represents the return of a portfolio of stocks ranked a on dimension X, among the basket of stocks ranked b on dimension Y, themselves among the basket of stocks ranked c on dimension Z. Dimensions X, Y and Z stand for respectively the factor to be priced and its control while H, M and L stand for high, medium and low, respectively. When dimension X corresponds to market cap, the premium is defined as LX minus HX.

In contrast to an independent sorting, this sequential one ensures the balance with regard to the number of stocks in all 27 portfolios. All portfolios provide the same level of diversification.

3.1.2 Three-way sort

We split the sample according to three levels of size, book-to-market, and momentum. Two breakpoints (1/3rd and 2/3rd percentiles) were used for all fundamentals. Instead of the original six portfolios, this method leads to a set of 27 baskets of stocks. The breakpoints are based on all US markets, not only on NYSE stocks. The finer size classification also contributes to balance the proportion between the small/value, small/growth, large/value and large/growth portfolios. It also provides a better distinction between small and large cap stocks. Sorting stocks into portfolios according to whole sample breakpoints rather than NYSE stocks might exacerbate the tilt towards NASDAQ stocks into the small cap portfolios. We acknowledge that the representation of NASDAQ is quite important among the 9 portfolios which fall under the low market capitalization. For illustrative purposes, the proportion amounts to an average of 57% for the HML factor. However, such an issue is also present in the Fama and French framework, although it uses NYSE breakpoints, with an average of 31% for the three portfolios of low market capitalisation.

3.2 Data

Since the purpose of this paper is to propose a robust comparison framework to the original Fama and French approach, we strictly follow their stock selection methodology to construct our sample. The period ranges from January 1963 (as in Fama and French, 1993) to December 2014 and comprises all NYSE, AMEX, and NASDAQ stocks collected from the merge between the Center for Research in Security Prices (CRSP) and COMPUSTAT databases. The analysis covers 624 monthly observations. The market risk premium corresponds to the value-weighted return on all US stocks minus the one-month T-Bill rate from Ibbotson Associates. We consider stocks that fully match the following lists of filtering criteria: a CRSP share code (SHRCD) of 10 or 11 at the beginning of month *t*, an exchange code (EXCHCD) of 1, 2 or 3, available shares (SHROUT) and price (PRC) data at the beginning of month *t*, available return (RET) data for month *t*, at least two years of listing on COMPUSTAT to avoid the survival bias (Fama and French, 1993) and a positive book-equity value at the end of December of year *y*-1. Our sample is thus varying over time: for instance, from a total of 5,612 stocks available as of December 2014, our conditions restrict our sample to 3,271 stocks.

As in Fama and French (1993), we define the book value of equity as the COMPUSTAT book value of stockholders' equity (SEQ) plus the balance-sheet deferred taxes and investment tax credit (TXDITC). If available, we decrease this amount by the book value of preferred stock (PSTK)[1]. If

[1] If not available, we use the value of preferred stock is estimated by either the redemption (PSTKRV) or liquidation (PSTKL) value, in that particular order.

the book value of stockholders' equity (SEQ) plus the balance-sheet deferred taxes and investment tax credit (TXDITC) are not available, we use the firm total asset (AT) minus the total liabilities (LT). Book-to-market equity is then the ratio of the book common equity for the fiscal year ending in calendar year *y*-1, divided by market equity. Market equity is defined as the price (PRC) of the stock times the number of shares outstanding (SHROUT) at the end of June *y* to construct the size factor and at the end of December of year *y*-1 to construct the value factor.

Carhart (1997) completes the Fama and French three-factor model by computing a momentum (i.e. a *t*-2 until *t*-12 cumulative prior-return) or UMD (Up minus Down) factor that reflects the return differential between the highest and the lowest prior-return portfolios.

We illustrate our methodology with the HML factor construction. We start by breaking up the NYSE, AMEX, and NASDAQ stocks into three groups according to the momentum criterion (first control). We then successively scale each of the three momentum-portfolios into three classes according to their market capitalization (second control). Splitting each of these nine portfolios once again to form three new portfolios according to their book-to-market fundamentals (variable to be priced), and end up with 27 value-weighted portfolios. The rebalancing is performed on an annual basis at the end of June of year *y*. An analogy could be made to a cubic construction: each year, any stock integrates one slice, then one row, then one cell of a cube and thus enters one and only one portfolio. The stock specific value-weighted return for each month following the yearly ranking is then related to the reward gained through the risks incurred in this portfolio.

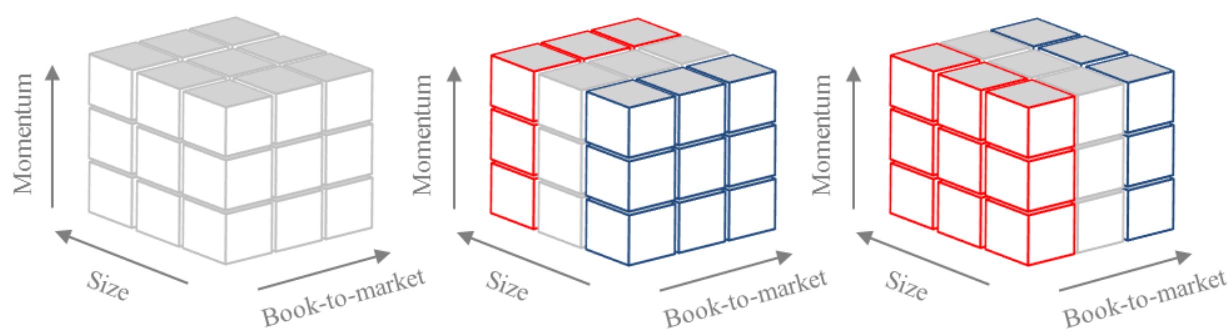
Amongst the 27 portfolios inferred from the sequentially sorted risk factors, we retrieve only the 18 that score at a high or a low level on the risk dimension (corresponding to the last sort performed), i.e. value/growth. The nine self-financing portfolios are then created from the difference between high- and low-scored portfolios displaying the same ranking on the size and momentum dimensions (used as control variables). Finally, the HML risk factor is computed as the arithmetic average of these nine portfolios. Note that each premium can be defined in two different ways within this conditional framework[2].

Illustrations of the sequential premiums constructions are displayed in Figure 2.

Figure 2

Representative sequential construction of the 3x3x3 characteristics portfolios.

The three figures display the cubic sequential methodology construction of the 3x3x3 characteristics portfolios. The left-hand figure shows the split of US stock universe when applying the sequential sorting procedure. The middle figure displays the portfolios used to construct the size premium by first sorting on the momentum, then book-to-market and finally size: blue (resp. red) squares represent small (resp. large) capitalisation stock portfolios. The right-hand figure displays the portfolios used to construct the value premium by first sorting on the momentum, then size and finally book-to-market: blue (resp. red) squares represent high (resp. low) book-to-market ratio stock portfolios.



[2] The paths for the sequential SMB and HML factors used are respectively momentum, book-to-market and size and momentum, size, book-to-market. The alternative paths were tested and lead to the same conclusion. Results are available upon request.

4 The sequential approach: curing for the correlation issue

Section II of this paper presented preliminary evidence regarding the correlation bias inherent in the Fama and French factor construction. This section examines the empirical impact of the methodological changes introduced above, the first of which was the sequential sort procedure[3].

Table 4 reports the polychoric correlation between the sequential rankings for size and book-to-market, respectively, from the SMB' premium and the HML' premium.

Table 4

Correlations between the sequential rankings.

Table 4 displays polychoric correlations between the stock rankings along the size and value dimension under the sequential methodology over January 1963-December 2014. Annual minimum and maximum correlations between the final ranking of the size and the book-to-market factors are also displayed. Tests for significance of the pair-wise correlations are performed: *, **, and *** indicate statistical significance at the 0.1, 0.05 and 0.01 levels, respectively.

	SMB' / HML'
Correlation	24%***
95% Lower Confidence Limit	23.41%
95% Upper Confidence Limit	24.52%
Annual Minimum	2%
Annual Maximum	43%***

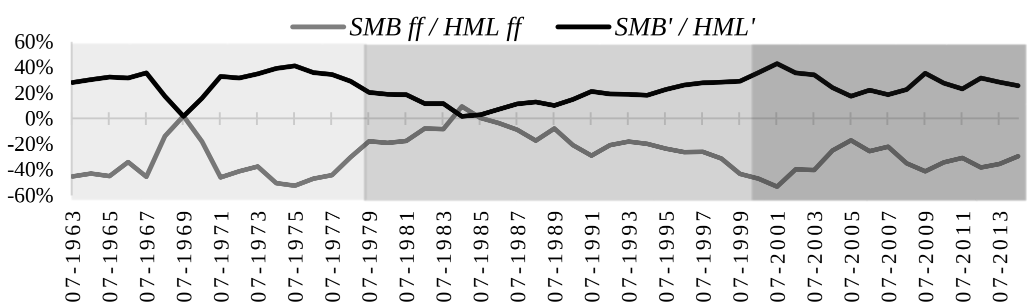
[3] One should recall that with our objective being to review the original construction of the size and value premiums while controlling for additional sources of risk, momentum has only been introduced into the analysis as an additional control variable. For consistency purposes, it has been defined using an annual rebalancing contrary to the original approach of Carhart (1997).

Contrary to Table 2, Table 4 displays a significant positive correlation of about 24% between the final sequential rankings. This reversal effect between the rankings is illustrated over the period ranging from January 1963 to December 2014 in Figure 3.

Figure 3

Correlations between the independent F&F and sequential rankings over time.

This figure shows the evolution of the polychoric correlations between the independent rankings of the sequential methodology for size (*SMB*) and book-to-market (*HML*) premiums among the 3x3x3 characteristic-sorted portfolios (black line) and the 2x3 characteristic-sorted portfolios (gray line) for size and book-to-market over January 1963-December 2014. We highlighted three sample periods as defined by Asness et al. (2015), that is, the "golden age" (light gray), the "embarrassment" (medium gray), and the "resurrection" (dark gray).



We observe a quasi-symmetrical effect between the rankings correlations produced by the original and sequential empirical risk factors. To better understand this reversal effect, Table 5 presents the historical frequencies that a low, medium or high size stock be classified either as low, medium or high book-to-market (resp. Panel A, B, and C). For the sequential procedure, the probability of a small (resp. big) capitalization to be ranked high book-to-market is the lowest (resp.

highest), i.e. 24% (resp. 47%). The results are completely opposite for the Fama and French procedure, in which a small (resp. big) capitalization have the highest (resp. lowest) likelihood to be ranked high book-to-market 38% (resp. 16%).

Table 5

Frequencies of the independent Fama and French and sequential rankings.

This table reports the frequencies of the book-to-market rankings for the different size stocks. Under the Fama and French model, only two size classifications (i.e. low or high) may be allocated either low, medium or high book-to-market. Under the sequential framework, three size classification (i.e. low, medium, and high) may be allocated either low, medium or high book-to-market. We display in this table the mean, minimum and maximum of the yearly ranking frequencies over the period ranging from January 1963 and December 2014.

	Sequential rankings			Fama and French rankings		
BM→	Low	Medium	High	Low	Medium	High
	Panel A: Low Size					
Mean	45%	31%	24%	28%	34%	38%
Min	34%	19%	16%	9%	27%	24%
Max	57%	37%	32%	44%	44%	49%
	Panel B: Medium Size					
Mean	30%	41%	30%			
Min	22%	30%	19%			
Max	34%	57%	37%			
	Panel C: High Size					
Mean	26%	27%	47%	46%	38%	16%
Min	21%	21%	34%	36%	28%	9%
Max	33%	34%	55%	62%	47%	28%

The positive correlation[4] resulting from the sequential procedure induces that an income stock is more likely to constitute a large capitalization company under the sequential framework. Such a finding is consistent with the concept of value/income generation (contrary to the evidence displayed at Table 2 under the original Fama and French framework). Our framework for pricing the value effect is close to Zhang (2005) and the concepts of cost reversibility and earnings risk. It differs from Fama and French (1993) as it does not relate the value effect to market distress which is only present in small value stocks.

The use of sequential breakpoints favors better allocations of stocks into portfolios. Stocks are homogeneously distributed with an average of 122 stocks and a standard deviation of only 4 stocks per portfolio over the whole sample period. We master the tilt of the 27 portfolios toward small stocks as the correlations between the rankings on the priced dimension and on the control variables produced by the sequential approach are independent (correlation close to 0). These results are displayed in Table 6. The average annual correlations between the sequential control rankings with the dimension to be priced are almost identical during the whole sample period. From January 1963 to December 2014, the annual ranking correlations range between -0.18% and 0.14% for the first control variable and -0.32% and 0.17% for the second control variable. It appears that the correlation among the rankings is constrained by the sequential sorting itself since the alternative construction path leads to inverting the correlations for the control rank[5].

[4] Almost nil correlations between the rankings (i.e. July, 1969 and 1985) are due to a reduction of the market equity for the overall market which lowers the tilts for the classification. Results are available on request.
[5] Results are available upon request

Table 6

Correlations between the sequential control rankings.

The table reports polychoric correlations between the sequential control rankings for size (*SMB'*) and book-to-market (*HML'*)[6] premiums among the 3x3x3 characteristic-sorted portfolios on size and book-to-market over January 1963-December 2014. Yearly mean, minimum and maximum correlations between the control rankings of the size and the book-to-market factors are displayed.

	Size		Book-to-market	
	Momentum (first control)	Book-to-market (second control)	Momentum (first control)	Size (second control)
Annual Mean	-0,01%	-0,01%	-0,01%	-0,01%
Annual Minimum	-0,32%	-0,18%	-0,32%	-0,18%
Annual Maximum	0,17%	0,14%	0,17%	0,14%

Table 7 analyzes how these ranking correlations condition the final correlation between the size and value factors. The bottom-left corner displays the cross-correlations between the two sets of premiums. The SMB' and HML' factors are correlated at 81% and 88% with their Fama and French counterparts, respectively. These levels indicate that, although the original and the modified size and value premiums are intended to price the same risk, approximately 19% to 11% of their

[6] The construction of one factor under the 3x3x3 characteristic-sorted portfolios always provides two outcomes for the factor. The table displays the *SMB'* factor by first sorting the sample on the momentum then the book-to-market and finally the size. The construction of one factor under the 3x3x3 characteristic-sorted portfolios always provides two outcomes for the factor. The table displays the *HML'* factor by first sorting the sample on the momentum then the size and finally the book-to-market. When we control first for momentum before the value or size dimension, the correlations are not significantly affected.

variation provides different information. We related those differences to the purification effect of the sequential sort shown in Table 6.

Table 7

Correlation matrix of the empirical risk premiums.

The table reports the paired correlations (in %) among the modified (sequential) and the original F&F empirical risk premiums over the period ranging from January 1963 to December 2014, as well as across these two sets of factors. Tests for significance of the pair-wise correlations are performed: *, **, and *** indicate statistical significance at the 0.1, 0.05 and 0.01 levels, respectively.

	SMB'	*HML'*	*UMD'*	*SMB$_{ff}$*	*HML$_{ff}$*	*UMD$_{ff}$*
SMB'	1					
HML'	-0.34***	1				
UMD'	-0.08**	-0.13**	1			
SMB$_{ff}$	0.81***	-0.33***	-0.08**	1		
HML$_{ff}$	-0.21***	0.88***	-0.30***	-0.23***	1	
UMD$_{ff}$	0.06	-0.06	0.63***	0.00	-0.16***	1

The momentum premium displays a lower correlation with the UMD$_{ff}$ factor. Contrary to the SMB$_{ff}$ and HML$_{ff}$ factors, French's momentum premium does not follow the Fama and French (1993) methodology exactly: the premium is rebalanced monthly rather than annually. It differs from our momentum premium with regard to the breakpoints used for the rankings and the annual rebalancing scheme used in the sequential sorting procedure.

In Table 7, the bottom-right corner presents the intra-correlations between the Fama and French premiums. The SMB$_{ff}$ and HML$_{ff}$ factors are negatively correlated over the period (-23%). The top-left corner presents the intra-correlations among the sequential premiums: the signs are the same as those displayed by the Fama and French premiums, but the correlation levels are slightly higher. The SMB' and HML' factors are more negatively correlated over the period (-34%). The sequential size effect is confined to a January effect and negative although not significant over the rest of the year while the sequential value is positive and persistent all over the year. This induces the negative correlation, which is not related to the construction method. Table 8 shows that the correlation between the original F&F size and value factors are significantly positive (resp. negative) during January (resp. February-December). This further supports the tilt of the value stocks to small caps which outperform in January.

Table 8

Correlation matrix of the empirical risk premiums: January effect.

The table reports the paired correlations (in %) among the modified (sequential) and the original F&F empirical risk premiums over the period ranging from January 1963 to December 2014, as well as across these two sets of factors. Tests for significance of the pair-wise correlations are performed: *, **, and *** indicate statistical significance at the 0.1, 0.05 and 0.01 levels, respectively. Panel A reports the correlations only in January and Panel B displays the correlations between February and December.

	Panel A : Only January				Panel B : February to December			
	SMB'	*HML'*	SMB_{ff}	HML_{ff}	*SMB'*	*HML'*	SMB_{ff}	HML_{ff}
SMB'	1				1			
HML'	-0.09	1			-0.40***	1		
SMB_{ff}	0.78***	0.02	1		0.83***	-0.28***	1	
HML_{ff}	0.23	0.88***	0.27*	1	-0.39***	0.88***	-0.32***	1

5 Factor consistency, significance and seasonality: the sequential vs independent framework

Inconsistency and seasonality of the Fama and French size factor have already been documented in Section 1. Yet, the absence of the value effect during the "embarrassment" period (from January 1980 to December 1999) revealed by Table 1 has not been examined in the literature. Table 1 also showed a strong Fama and French value premium during the month of January (1.38%). However, when considering the sequential premiums over the same subsample periods, the value effect reappears consistent and stable over time with significant average return at a 99% confidence level (Panel B of Table 9). From Table 9, no particular effect can be reported during January. The rationale is that in the F&F framework, HML_{ff} is contaminated by the size "turn-of-the-year" effect. Curing for correlation among rankings mitigates this contamination.

Table 9

Sequential size and value premiums over time.

The table displays descriptive statistics for F&F size (SMB_{ff}) and book-to-market (HML_{ff}) premiums as well as the sequential size (*SMB')* and book-to-market (*HML')* premiums over four periods of time. Both SMB_{ff} and HML_{ff} are obtained from K. French's website. Time-series mean, standard deviation, *t*-stat for the bilateral test of time series mean equals to 0, as well as the number of observations considered are displayed as well as the percentage of positive return over the sample periods (Pos. Obs.). The analysis covers the original period used in Fama and French (1993) – that is from January 1963 – up to December 2014. We consider the periods January and February-December separately over the same sample period, as well as three sub-periods referenced in Asness et al. (2015) reflecting the time when the size effect is strongest (January 1963 to December 1979, "golden age"), weakest (January 1980 to December 1999, "embarrassment"), and the recent recovery in the size premium (January 2000 to December 2014, "resurrection").

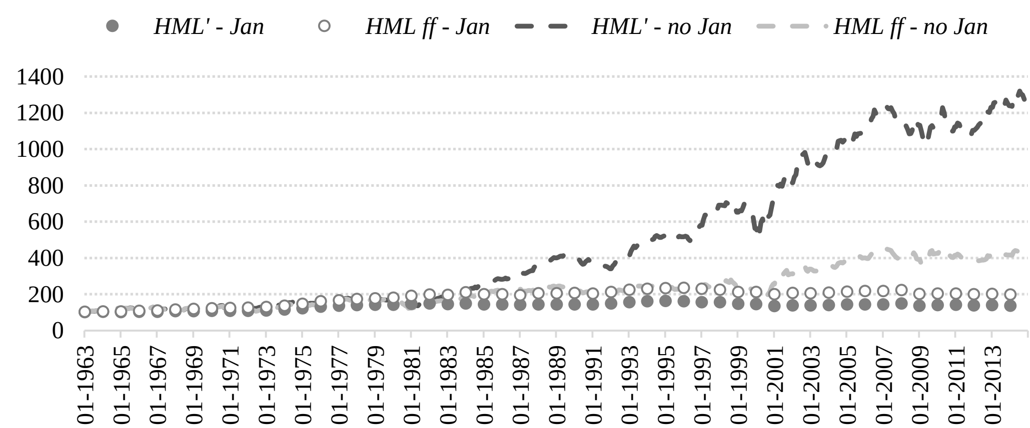
Panel A: Fama and French Factors													
			SMB_{ff}					HML_{ff}					
			Mean (%)	S. D. (%)	*t*-stat	Freq	Pos. Obs. (%)	Mean (%)	S. D. (%)	*t*-stat	Freq	Pos. Obs. (%)
Total sample	01-63	12-14	0.24	3.09	1.93	624	51	0.38	2.85	3.30	624	57
January			1.97	3.41	4.16	52	67	1.38	3.57	2.79	52	75
Feb. - Dec.			0.08	3.02	0.64	572	50	0.29	2.76	2.47	572	56
Golden age	01-63	12-79	0.46	3.16	2.09	204	54	0.53	2.44	3.09	204	63
Embarassement	01-80	12-99	-0.04	2.66	-0.23	240	54	0.19	2.80	1.04	240	63
Resurrection	01-00	12-14	0.36	3.52	1.36	180	52	0.45	3.32	1.84	180	54
Panel B : Sequential Factors													
			SMB'					*HML'*					
			Mean (%)	S. D. (%)	*t*-stat	Freq	Pos. Obs. (%)	Mean (%)	S. D. (%)	*t*-stat	Freq	Pos. Obs. (%)
Total sample	01-63	12-14	0.23	4.18	1.40	624	47	0.48	2.33	5.16	624	60
January			4.77	4.78	7.20	52	87	0.63	2.97	1.54	52	62
Feb. - Dec.			-0.18	3.88	-1.10	572	44	0.47	2.27	4.93	572	60
Golden age	01-63	12-79	0.52	4.08	1.83	204	48	0.42	2.06	2.89	204	64
Embarassement	01-80	12-99	-0.11	3.80	-0.44	240	46	0.57	2.27	3.90	240	60
Resurrection	01-00	12-14	0.36	4.74	1.03	180	49	0.43	2.69	2.17	180	58

In Figure 4, we illustrate the evolution of the value premium over the sample period and demonstrate that no "turn-of-the-year" effect applies under the sequential framework.

Figure 4

Value calendar effect.

This figure shows respectively the evolution of $100 invested from January 1963 to December 2014 in which the full capital is invested in the sequential or Fama and French value premium only in January (dotted lines) and if the initial $100 are invested in the value premium excluding the month of January (dashed lines).

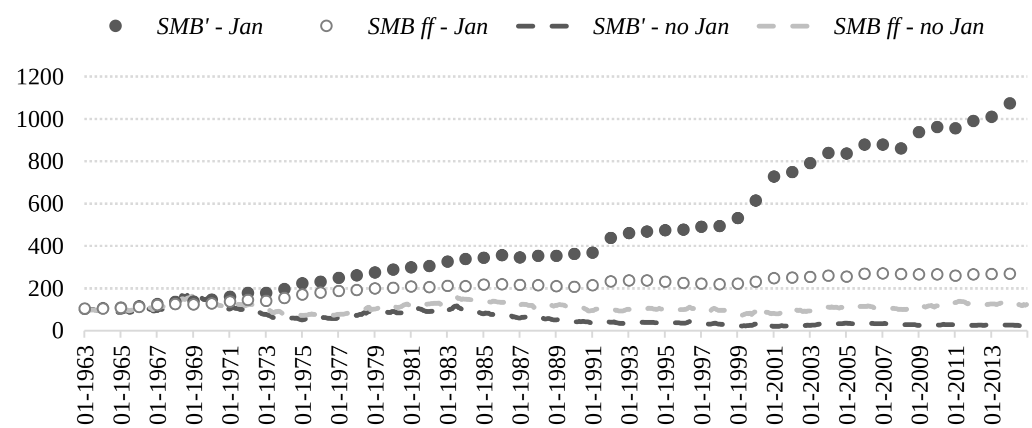


Echoing Cremers, Petajisto and Zitzewitz (2012) on the overestimation of the size effect under the Fama and French framework, our sequential framework reduces the size factor (SMB'*)* to a January effect (which more than doubles compared to SMB_{ff} with a 4.77% monthly average return versus 1.97% for the latter). Controlling ex ante for the momentum and value effect, the size factor does not reveal to be significant outside the month of January. It is even found to be negative, although not significant, over the 52 years of the sample period when only the remaining 11 months of the year are considered. Figure 5 shows the evolution of the size premium over the sample period and reports the significant “turn-of-the-year” effect under both frameworks, the effect being even more pronounced under the sequential framework.

Figure 5

Size calendar effect.

This figure shows respectively the evolution of $100 invested from January 1963 to December 2014 in which the full capital is invested in the sequential or Fama and French size premium only in January (dot lines) and if the initial $100 are invested in the size premium excluding the month of January (dash lines).



We perform six regression models in which the value (or resp. size) premium is first regressed on RM_{ff}, SMB (or resp. HML), and a combination of recent factors that have recently shown to compete with the Fama and French (1993) model, i.e. the Fama and French (2015a) factors, the quality factor of Asness et al. (2015) as well as the Hou, Xue and Zhang *q*-factors (2014).

Results for the original Fama and French and sequential value premium are displayed in Table 10, Panel A and B respectively. Considering that this paper aims at reviewing the misspecification of the three-factor model, we do not redefine the momentum factor[7]. The profitability (RMW) and the investment (CMA) factors are available on French's website. For the quality factor (Quality minus Junk), we refer to the Asness et al. (2015) library.

Panel A of Table 10 confirms Fama and French's evidence. The value factor is not proved significant (*t*-stat=0.97) when the profitability (RMW) and the investment (CMA) factors are introduced in the regression model. Yet, the HML_{ff} factor reappears significant (*t*-stat=3.44) when we control ex post for quality/junk stocks. Panel B of Table 10 substitutes the original Fama and French size and book-to-market factors with our new set of sequential premiums. Strikingly, the HML' factor is persistent in any method of factor construction, suggesting that our methodology is able to control ex ante for quality (and not ex post such as in the Asness et al.'s framework). Correcting for correlation bias among rankings is thus a catalyst to retrieve the pure value effect.

We assess the persistence of the value anomaly in the presence of Hou, Xue and Zhang (2014) profitability (ROE) and investment (I/A) factors. In their paper, they demonstrate the outperformance of their *q*-factor model against the recent F&F five-factor model. Panel A supports this evidence as their *q*-factor model fully explains the original F&F value risk premium, delivering an insignificant alpha of 0.08 (*p*-value=0.39). Yet, the sequential value factor persists against the *q*-factors with an alpha of 0.28 (*t*-stat=3.52).

To conclude, contrary to the original Fama and French value factor, the sequential HML factor is not redundant under the *q*-factor model or the Fama and French five-factor model.

[7] Tests substituting the original momentum factor (Carhart, 1997) with the sequential premium, which includes annual portfolio rebalancing (June of each year), provide similar results. Results are available upon request.

Table 10

Robustness tests on HML (High minus Low) factor.

The table reports regression results for the Fama and French value premium (Panel A) and the sequential value premium (Panel B) on the factors, that is RM_{ff}, the size factor (SMB_{ff}), the momentum (UMD_{ff}), the profitability (*RMW*), and the investment (*CMA*). We also add *QMJ* (Quality minus Junk) factor from Asness, et al. (2015), and the profitability (*ROE*) and investment (*I/A*) from Hou, Xue, Zhang (2014). The period used to perform the regressions ranges from January 1963 to December 2014. Figures underlined in light grey are regressed from July 1967 to December 2014 since the *ROE* and *I/A* factors are only made available for this time period.

Panel A : Regression on HML_{ff}											
	Int	RM_{ff}	SMB_{ff}	*HML'*	UMD_{ff}	*RMW*	*CMA*	*QMJ*	*ROE*	*I/A*	R^2
Coef	-0.11			1.01							0.77
t-statistic	-1.97			45.28							
p-value	**0.05**			0.00							
Coef	0.59	-0.18	-0.14		-0.13						0.15
t-statistic	5.43	-7.00	-3.76		-5.13						
p-value	0.00	0.00	0.00		0.00						
Coef	0.58	-0.18	-0.14		-0.13	-0.02					0.15
t-statistic	5.25	-7.03	-3.60		-5.05	-0.36					
p-value	0.00	0.00	0.00		0.00	0.72					
Coef	0.08	0.00	-0.04		-0.12	0.20	1.00				0.54
t-statistic	0.97	-0.04	-1.46		-6.20	4.72	23.09				
p-value	**0.33**	0.97	0.15		0.00	0.00	0.00				
Coef	0.27	-0.13	-0.15		-0.06	0.63	0.97	-0.68			0.62
t-statistic	3.44	-5.90	-5.33		-3.54	11.68	24.58	-11.30			
p-value	0.00	0.00	0.00		0.00	0.00	0.00	0.00			
Coef	0.08	-0.05	-0.09		-0.09				-0.13	1.02	0.53
t-statistic	0.86	-2.35	-2.82		-4.00				-3.03	20.44	
p-value	**0.39**	0.02	0.00		0.00				0.00	0.00	

Table 10-(*continued)*

Panel B : Regression on *HML'*											
	Int	RM_{ff}	*SMB'*	HML_{ff}	UMD_{ff}	*RMW*	*CMA*	*QMJ*	*ROE*	*I/A*	R^2
Coef	0.20			0.76							0.77
t-statistic	4.07			45.28							
p-value	0.00			0.00							
Coef	0.68	-0.17	-0.16		-0.09						0.21
t-statistic	7.49	-8.23	-8.10		-4.30						
p-value	0.00	0.00	0.00		0.00						
Coef	0.65	-0.17	-0.15		-0.09	0.04					0.22
t-statistic	7.07	-8.05	-6.73		-4.35	0.80					
p-value	0.00	0.00	0.00		0.00	0.43					
Coef	0.25	-0.01	-0.10		-0.08	0.22	0.80				0.55
t-statistic	3.47	-0.76	-5.74		-5.14	5.88	21.26				
p-value	0.00	0.45	0.00		0.00	0.00	0.00				
Coef	0.38	-0.10	-0.16		-0.05	0.48	0.78	-0.43			0.59
t-statistic	5.32	-5.12	-8.54		-2.97	9.81	21.67	-7.81			
p-value	0.00	0.00	0.00		0.00	0.00	0.00	0.00			
Coef	0.28	-0.06	-0.16		-0.06				-0.10	0.80	0.53
t-statistic	3.52	-3.34	-8.15		-3.11				-2.53	18.62	
p-value	0.00	0.00	0.00		0.00				0.01	0.00	

We perform a similar analysis for the size factor. Table 11 displays the intercepts and factor betas as well as their *t*-statistics and *p*-values of a multifactor model performed on the original size factor (Panel A) and on the sequential size factor (Panel B). As pointed out by Asness et al. (2015), SMB_{ff} is only significant – at a confidence level of 99% – when controlling for profitability or quality. However, the sequential size factor appears to be consistently significant in any method of factors construction, whether or not controlling ex post for profitability or quality. Relative to the F&F model, a sequential methodology proves to control ex ante rather than ex post for spurious noise (*t*-stats always significant).

Table 11

Robustness tests on SMB (Small minus Big) factor.

The table reports regression results for the Fama and French size premium (Panel A) and the sequential size premium (Panel B) on the factors that is RM_{ff}, the value factor (HML_{ff}), the momentum (UMD_{ff}), the profitability (*RMW*), and the investment (*CMA*). We also add the *QMJ* (Quality minus Junk) factor from Asness et al. (2015), and the profitability (*ROE*) and investment (*I/A*) from Hou, Xue, Zhang (2014). The period used to perform the regressions ranges from January 1963 to December 2014. Figures underlined in light grey are regressed from July 1967 to December 2014 since the *ROE* and *I/A* factors are only made available for this time period.

Panel A : Regression on SMB_{ff}											
	Int	RM_{ff}	*SMB'*	HML_{ff}	UMD_{ff}	*RMW*	*CMA*	*QMJ*	*ROE*	*I/A*	R^2
Coef	0.08		0.57								0.67
t-statistic	1.12		35.67								
p-value	**0.26**		0.00								
Coef	0.21	0.18		-0.17							0.12
t-statistic	1.73	6.63		-3.88							
p-value	**0.08**	0.00		0.00							
Coef	0.20	0.18		-0.16	0.01						0.12
t-statistic	1.65	6.54		-3.76	0.18						
p-value	**0.10**	0.00		0.00	0.86						
Coef	0.33	0.14		-0.15	0.03	-0.52					0.24
t-statistic	2.88	5.23		-3.60	1.01	-9.80					
p-value	0.00	0.00		0.00	0.31	0.00					
Coef	0.36	0.13		-0.08	0.03	-0.54	-0.14				0.24
t-statistic	3.11	4.50		-1.46	1.24	-9.89	-1.68				
p-value	0.00	0.00		0.15	0.22	0.00	0.09				
Coef	0.57	-0.06		-0.30	0.07	0.15	0.07	-0.90			0.35
t-statistic	5.25	-1.95		-5.33	2.88	1.84	0.92	-10.42			
p-value	0.00	0.05		0.00	0.00	0.07	0.36	0.00			
Coef	0.48	0.11		-0.16	0.16				-0.59	-0.14	0.29
t-statistic	3.92	4.10		-2.82	5.11				-11.38	-1.61	
p-value	0.00	0.00		0.00	0.00				0.00	0.11	

(continued)

Table 11-*(continued)*

Panel B : Regression on *SMB'*											
	Int	RM_{ff}	SMB_{ff}	*HML'*	UMD_{ff}	*RMW*	*CMA*	*QMJ*	*ROE*	*I/A*	R^2
Coef	0.00		1.17								0.67
t-statistic	-0.02		35.67								
p-value	**0.98**		0.00								
Coef	0.54	0.04		-0.58							0.12
t-statistic	3.12	0.90		-8.18							
p-value	0.00	0.37		0.00							
Coef	0.55	0.03		-0.58	-0.01						0.12
t-statistic	3.10	0.84		-8.10	-0.27						
p-value	0.00	0.40		0.00	0.78						
Coef	0.70	-0.02		-0.45	0.04	-0.91					0.29
t-statistic	4.39	-0.64		-6.73	0.99	-12.33					
p-value	0.00	0.52		0.00	0.32	0.00					
Coef	0.68	-0.01		-0.51	0.03	-0.88	0.11				0.29
t-statistic	4.24	-0.31		-5.74	0.86	-11.08	1.03				
p-value	0.00	0.76		0.00	0.39	0.00	0.30				
Coef	1.01	-0.29		-0.69	0.11	0.15	0.25	-1.33			0.43
t-statistic	6.86	-6.98		-8.54	3.29	1.32	2.55	-12.17			
p-value	0.00	0.00		0.00	0.00	0.19	0.01	0.00			
Coef	0.86	-0.04		-0.67	0.24				-0.98	0.21	0.35
t-statistic	5.18	-1.01		-8.15	5.72				-13.94	1.84	
p-value	0.00	0.31		0.00	0.00				0.00	0.07	

We carry out the same analysis on the competing factors from the Fama and French five-factor model as well as on the *q*-factors or Hou, Xue, Zhang (2014). We test whether exposures to the recent F&F factors of profitability (RMW) and investment (CMA) still provide explanatory power under the new sequential framework. We run the test twice, first with the original size and value factors (Panel A), and secondly with the sequential version of the factors (Panel B). Results for RMW are displayed in Table 12. The profitability factor appears significant under all regression constructions (F&F and sequential) with a confidence of 99%, except when the quality factor is included. This suggests that RMW and QMJ share a similar source of risk. Once performed on

CMA, results show that under the F&F framework (Panel A of Table 13), the investment factor is significant when combined with any additional factor. This is, however, not true once implemented with the sequential factors. Under the sequential framework, CMA is subsumed by HML' and RMW (last regression of Panel B). The t-statistics of the intercept are not significant when we control ex ante and/or ex post for quality. This suggests that controlling ex post for quality/junk (QMJ) just appears to be an additional layer of control for profitability (RMW) and vice versa.

This section demonstrates the outperformance of the sequential factors over the original Fama and French (1993) size and value factor and over the Fama and French (2015a) investment factor. RMW still persists after controlling for the sequential value factor but it does not under Hou, Xue, Zhang (2015) framework or once the QMJ factor has been added to the sequential model. Showing that the *q*-factors of Hou, Xue, Zhang (2014) do not explain our size and value factors, we need further tests of complementarity that will be performed in the next section[8].

[8] None of our multi-factor combinations were able to fully explain the *ROE* and *I/A* factors. Results available on request.

Table 12

Robustness tests on RMW (Robust minus Weak) factor.

The table reports regression results for the profitability factor *RMW* on the set of factors comprising the Fama and French premiums (Panel A), i.e. the market (RM_{ff}), the size (SMB_{ff}), the value (HML_{ff}), the momentum (UMD_{ff}), and the investment (*CMA*). In Panel B, we substitute the original size and value factors with their respective sequential versions. We also add the *QMJ* (Quality minus Junk) factor from Asness et al. (2015), and the profitability (*ROE*) and investment (*I/A*) from Hou, Xue, Zhang (2014). The period used to perform the regressions ranges from January 1963 to December 2014. Figures underlined in light grey are regressed from July 1967 to December 2014 since the *ROE* and *I/A* factors are only made available for this time period.

Panel A : Regressions with FF factors

	Int	RM_{ff}	SMB_{ff}	HML_{ff}	UMD_{ff}	*CMA*	*QMJ*	*ROE*	*I/A*	R^2
Coef	0.31		-0.28							0.16
t-statistic	3.97		-10.95							
p-value	0.00		0.00							
Coef	0.22			0.06						0.01
t-statistic	2.59			2.13						
p-value	0.01			0.03						
Coef	0.30	-0.04	-0.26	-0.01	0.04					0.18
t-statistic	3.71	-1.99	-9.80	-0.36	2.23					
p-value	0.00	0.05	0.00	0.72	0.03					
Coef	0.37	-0.07	-0.25	0.18	0.06	-0.41				0.25
t-statistic	4.71	-3.87	-9.89	4.72	3.16	-7.47				
p-value	0.00	0.00	0.00	0.00	0.00	0.00				
Coef	-0.10	0.13	0.04	0.29	-0.02	-0.35	0.85			0.68
t-statistic	-1.77	8.94	1.84	11.68	-1.43	-9.93	29.07			
p-value	**0.08**	0.00	0.07	0.00	0.15	0.00	0.00			
Coef	0.04	-0.03	-0.08	0.16	-0.13			0.67	-0.21	0.57
t-statistic	0.64	-1.89	-3.52	5.61	-7.90			22.12	-4.50	
p-value	**0.52**	0.06	0.00	0.00	0.00			0.00	0.00	

Panel B : Regressions with sequential factors

	Int	RM_{ff}	*SMB'*	*HML'*	UMD_{ff}	*CMA*	*QMJ*	*ROE*	*I/A*	R^2
Coef	0.31		-0.23							0.23
t-statistic	4.13		-13.60							
p-value	0.00		0.00							
Coef	0.16			0.18						0.04
t-statistic	1.89			5.36						
p-value	**0.06**			0.00						
Coef	0.29	-0.06	-0.22	0.03	0.05					0.26
t-statistic	3.67	-3.15	-12.33	0.80	2.76					
p-value	0.00	0.00	0.00	0.43	0.01					
Coef	0.32	-0.09	-0.19	0.24	0.06	-0.41				0.33
t-statistic	4.31	-5.28	-11.08	5.88	3.49	-8.33				
p-value	0.00	0.00	0.00	0.00	0.00	0.00				
Coef	-0.11	0.12	0.02	0.29	-0.02	-0.30	0.78			0.67
t-statistic	-1.95	7.85	1.32	9.81	-1.65	-8.57	24.75			
p-value	**0.05**	0.00	0.19	0.00	0.10	0.00	0.00			
Coef	0.02	-0.03	-0.06	0.22	-0.12			0.63	-0.22	0.59
t-statistic	0.29	-2.38	-3.57	6.57	-7.34			20.46	-5.10	
p-value	**0.77**	0.02	0.00	0.00	0.00			0.00	0.00	

Table 13

Robustness tests on CMA (Conservative minus Aggressive) factor.

The table reports regression results for the investment factor *CMA* on the set of factors composed of the Fama and French premiums (Panel A), i.e. the market (RM_{ff}), the size (SMB_{ff}), the value (HML_{ff}), the momentum (UMD_{ff}), and the profitability (*RMW*). In Panel B, we substitute the original size and value factors with their respective sequential versions. We also add the *QMJ* (Quality minus Junk) factor from Asness et al. (2015), and the profitability (*ROE*) and investment (*I/A*) from Hou, Xue, Zhang (2014). The period used to perform the regressions ranges from January 1963 to December 2014. Figures underlined in light grey are regressed from July 1967 to December 2014 since the *ROE* and *I/A* factors are only made available for this time period.

Panel A : Regressions with FF factors

	Int	RM_{ff}	SMB_{ff}	HML_{ff}	UMD_{ff}	*RMW*	*QMJ*	*ROE*	*I/A*	R^2
Coef	0.35		-0.12							0.03
t-statistic	4.37		-4.57							
p-value	0.00		0.00							
Coef	0.14			0.49						0.49
t-statistic	2.46			24.38						
p-value	**0.01**			0.00						
Coef	0.17	-0.09	0.02	0.47	0.04					0.53
t-statistic	2.85	-6.33	1.10	22.22	2.83					
p-value	0.00	0.00	0.27	0.00	0.00					
Coef	0.23	-0.10	-0.03	0.47	0.05	-0.21				0.57
t-statistic	4.05	-7.19	-1.68	23.09	3.61	-7.47				
p-value	0.00	0.00	0.09	0.00	0.00	0.00				
Coef	0.13	-0.03	0.02	0.51	0.03	-0.40	0.30			0.60
t-statistic	2.22	-2.10	0.92	24.58	2.28	-9.93	6.42			
p-value	**0.03**	0.04	0.36	0.00	0.02	0.00	0.00			
Coef	-0.01	-0.04	0.03	0.10	0.03			-0.11	0.86	0.86
t-statistic	-0.38	-4.77	2.96	6.27	3.67			-6.82	35.64	
p-value	**0.71**	0.00	0.00	0.00	0.00			0.00	0.00	

Panel B : Regressions with sequential factors

	Int	RM_{ff}	*SMB'*	*HML'*	UMD_{ff}	*RMW*	*QMJ*	*ROE*	*I/A*	R^2
Coef	0.33		-0.04							0.01
t-statistic	4.12		-2.28							
p-value	0.00		0.02							
Coef	0.07			0.53						0.43
t-statistic	1.16			21.48						
p-value	**0.25**			0.00						
Coef	0.08	-0.09	0.07	0.53	0.03					0.49
t-statistic	1.32	-6.33	5.03	19.92	1.78					
p-value	**0.19**	0.00	0.00	0.00	0.08					
Coef	0.16	-0.10	0.02	0.53	0.04	-0.25				0.54
t-statistic	2.60	-7.67	1.03	21.26	2.78	-8.33				
p-value	0.01	0.00	0.30	0.00	0.01	0.00				
Coef	0.09	-0.06	0.04	0.56	0.03	-0.36	0.18			0.55
t-statistic	1.45	-3.68	2.55	21.67	1.82	-8.57	3.70			
p-value	**0.15**	0.00	0.01	0.00	0.07	0.00	0.00			
Coef	-0.02	-0.03	0.02	0.09	0.03			-0.12	0.88	0.86
t-statistic	-0.58	-4.26	2.16	4.98	3.52			-7.23	37.32	
p-value	**0.56**	0.00	0.03	0.00	0.00			0.00	0.00	

6 Specification tests: the small angel effect

In this final section, we examine the pricing properties for the four competing sets of factors – namely, the Fama and French (1993) size and value factors, the Fama and French (2015a) investment and profitability factors, the q-factors of Hou, Xue and Zhang (2014), the sequential factors as well as the quality factor of Asness et al. (2015) – by implementing an efficiency test similar to Cremers, Petajisto and Zitzewitz (2012) and Fama and French (2012, 2015a). We evaluate the specification errors displayed by both the modified and the original size and value factors in seven regression models on the set of 5x5 Fama and French portfolios formed on size and book-to-market. Fama and French (2012, 2015a) show that the original size and value premiums provide significant positive misspecification for small/value stocks. We refer to these stocks as the "small angels" effect. Our objective is to assess whether the sequential specification of the factors is able to price passive investment portfolios without specification errors.

6.1 The 5x5 specification error matrix

The 5x5 portfolios are constructed on the basis of a 5x5 sort into size and book-to-market[9]. Table 15 displays the specification errors (α_p) of the 25 portfolios as well as their t-statistics and p-values produced by the original F&F 3-factor model (Panel A), the four-factor Carhart model (Panel B) and its extensions to Fama and French (2015a) – with and without the QMJ factor of

[9] Downloaded from K. French's library in January 2015.

Asness et al. (2015) – and Hou, Xue and Zhang (2014) (Panel C to G). Results for the sequential approach are shown in Table 15.

Table 14 demonstrates that the Fama and French original model is misspecified for each of the four corners (Panel A), namely: the small growth stocks, the large growth stocks, the small value stocks and the large value stocks. Yet, using the new set of (sequential) premiums helps to cure part of the mispricing on low growth stocks (Table 15, Panel A). We might relate this residual significant alpha in growth stocks to the work of Campbell, Giglio, Polk, and Turley (2015) who show that growth stocks display hedging properties against declining stock returns and volatility, the large growth stocks being the least risky. Large growth stocks offer indeed a residual positive alpha under the sequential mode as shown in Table 15 Panel B.

More importantly, the "small angels" effect, which is distinguishable in the top right corner, totally vanishes under the sequential approach (Table 15, Panel A). The abnormal performance of these extreme risk portfolios in the F&F framework suggests misspecified risk factors rather than simply missing factors. Besides, controlling Fama and French model (1993) ex post for quality/junk [i.e. adding any new factor from Fama and French five-factor model, the *q*-factor model of Hou, Xue and Zhang (2014) or adding the QMJ factor of Asness et al. (2015)] never cures the "small angels" effect in the F&F framework: there is always one intercept of the upper right corner remaining significant (*t*-stat=2.29 and *p*-value=0.02) at a confidence interval of 95% (Table 14, Panel E). Results are displayed in Table 14 from Panel B to E. Only a control ex ante (as performed by the sequential approach) manages to control for noise.

Table 15 shows that adding F&F profitability factor to the three-factor sequential model augmented with the Carhart momentum does not improve the specification. Besides, introducing the investment factor (CMA) leads to more significant specification errors. Only four intercepts are significant at a 90% confidence interval in Panel D, whereas in Panel E the amount of significant coefficients reaches six. The investing factor (CMA) thus brings a greater amount of noise to the model. This remains in line with our previous observation, highlighted in Section 5, where CMA is subsumed by HML' and RMW. We find this result consistent with the extant literature. Indeed, as pointed out by Campbell and Vuolteenaho (2004), value stocks displayed post-1963 very low "good beta" (i.e. sensitivity to equity risk premium) but very high bad beta which measures the impact of variation in market cash flows. This evidence explains why value stocks are more affected by economic downturns. In bad times, value stocks suffer from costly reversibility as they cannot easily reduce their unproductive capital. However, in good times they have low investment rate as they benefit from the capacity of their previously unproductive equipment (Campbell, Polk and Vuolteenaho, 2010). This does not only confirm the risk definition of value stocks embedded in our construction method but also provides an explanation to the low significance displayed by the investment factors of Fama and French (2015a). The superior return offered by low investment firms are fully captured under our framework into the HML factor. One additional evidence supports this: under both the five-factor Fama and French model and the *q*-

factor model, the other investment premium (I/A) of Hou, Xue and Zhang (2014) is only partly significant across the 5x5 portfolios[10].

We also perform a horse race between the *q*-factor model of Hou, Xue and Zhang (2014) and our sequential empirical model. Table 14 first displays the 5x5 regression results for the original *q*-factor model with the size (ME), profitability (ROE) and investment (I/A). Using the Hou, Xue and Zhang (2014) factor model still leaves 8 out 25 significant alphas (at a confidence level of 95%) in which we find the "small angels" effect. By comparison, the sequential three-factor model augmented with the momentum only deliver 3 significant alphas at the 5% level.

We further test the joint pricing power of the *q*-factors and our sequential factors. Panel F of Table 15 introduces the *q*-factors into the three-factor sequential model and Panel G augments the model with the momentum Carhart factor. Contrary to Hou, Xue and Zhang (2015), the HML factor keeps significant in the *q*-factor model for all but one portfolios when defined under the sequential framework[11]. Under both models, we observe not less than 7 out of 25 portfolios with significant alphas (at a confidence level of 95%). Joining our sequential sorting procedure to the *q*-factor model does not prove to improve the simple four-factor model we advocate in this paper. We reject the hypothesis of moving to a five-, or six-factor model.

[10] Results are available upon request.
[11] Results on factors are available upon request.

Table 14

Specification errors (α) of the 25 portfolios under the original F&F framework.

This table exhibits specification errors (α) for the 25 portfolios produced by the extended empirical CAPM models. Panels A to F display the specification errors (α) for the 25 portfolios using the Fama and French (1993) approach as well as the respective *t*-statistics and *p*-values for the different factor model combinations over the sample period (from January 1963 to December 2014). RM_{ff}, SMB_{ff}, HML_{ff}, UMD_{ff}, *RMW* and *CMA* time-series are available on K. French's library. *QMJ* (Quality minus Junk) is obtained from Asness et al. (2015). As for the size (ME), profitability (*ROE*) and investment (*I/A*) from Hou, Xue, Zhang (2014) are only made available for a sample period ranging from July 1967 to December 2014.

$$R(t) - R_F(t) = \alpha + b[R_M(t) - R_F(t)] + \sum_i k_i\, F_i(t) + e(t)$$

B/M→	Low	2	3	4	High	Low	2	3	4	High	Low	2	3	4	High
Panel A: Three-factor intercepts: RM_{ff}. SMB_{ff}. *and* HML_{ff}															
			α					*t(α)*					*P-value*		
Small	-0.48	-0.01	-0.01	0.14	0.13	-5.10	-0.11	-0.10	2.59	2.23	**0.00**	0.91	0.92	**0.01**	**0.03**
2	-0.18	-0.05	0.10	0.06	-0.05	-2.76	-0.87	1.80	1.14	-0.87	**0.01**	0.38	0.07	0.25	0.38
3	-0.06	0.05	0.00	0.05	0.11	-1.01	0.69	0.03	0.82	1.53	0.31	0.49	0.98	0.42	0.13
4	0.13	-0.10	-0.04	0.06	-0.08	2.17	-1.47	-0.58	0.92	-1.05	**0.03**	0.14	0.56	0.36	0.30
Big	0.17	0.03	-0.06	-0.11	-0.16	3.64	0.57	-0.84	-1.94	-1.75	**0.00**	0.57	0.40	**0.05**	0.08
Panel B: Four-factor intercepts: RM_{ff}. SMB_{ff}. HML_{ff}. *and* UMD_{ff}															
			α					*t(α)*					*P-value*		
Small	-0.43	0.00	-0.01	0.13	0.16	-4.48	0.01	-0.13	2.25	2.71	**0.00**	1.00	0.90	**0.02**	**0.01**
2	-0.14	0.00	0.11	0.06	-0.04	-2.04	-0.08	1.96	1.09	-0.77	**0.04**	0.93	**0.05**	0.28	0.44
3	-0.03	0.07	0.03	0.06	0.14	-0.41	1.10	0.38	0.87	1.93	0.68	0.27	0.70	0.38	**0.05**
4	0.13	-0.06	0.01	0.07	-0.03	2.05	-0.84	0.10	1.06	-0.43	**0.04**	0.40	0.92	0.29	0.67
Big	0.18	0.02	-0.06	-0.09	-0.12	3.77	0.38	-0.83	-1.50	-1.32	**0.00**	0.70	0.41	0.13	0.19
Panel C: Five-factor intercepts: RM_{ff}. SMB_{ff}. HML_{ff}. UMD_{ff}. and *RMW*															
			α					*t(α)*					*P-value*		
Small	-0.34	0.08	-0.02	0.10	0.13	-3.78	1.13	-0.30	1.73	2.18	**0.00**	0.26	0.76	0.08	**0.03**
2	-0.13	-0.06	0.05	0.00	-0.08	-1.89	-1.08	0.86	0.01	-1.41	0.06	0.28	0.39	0.99	0.16
3	-0.02	0.01	-0.05	0.01	0.08	-0.33	0.10	-0.72	0.19	1.08	0.74	0.92	0.47	0.85	0.28
4	0.15	-0.12	-0.04	0.06	-0.06	2.30	-1.71	-0.61	0.88	-0.76	**0.02**	0.09	0.54	0.38	0.45
Big	0.12	-0.02	-0.05	-0.11	-0.08	2.55	-0.42	-0.64	-1.79	-0.87	**0.01**	0.68	0.52	0.07	0.38

(continued)

Table 14-*(continued)*

Panel D: Six-factor intercepts: RM_{ff}. SMB_{ff}. HML_{ff}. UMD_{ff}. *RMW*. and *CMA*															
	α					*t(α)*					*P-value*				
Small	-0.31	0.08	-0.03	0.08	0.11	-3.39	1.14	-0.60	1.34	1.81	**0.00**	0.25	0.55	0.18	0.07
2	-0.10	-0.08	0.05	-0.02	-0.08	-1.43	-1.34	0.85	-0.41	-1.37	0.15	0.18	0.39	0.68	0.17
3	0.03	0.00	-0.05	-0.01	0.06	0.51	0.07	-0.81	-0.11	0.80	0.61	0.94	0.42	0.91	0.42
4	0.16	-0.18	-0.07	0.05	-0.05	2.42	-2.49	-1.02	0.67	-0.61	**0.02**	**0.01**	0.31	0.51	0.54
Big	0.13	-0.08	-0.08	-0.11	-0.05	2.79	-1.33	-1.11	-1.82	-0.49	**0.01**	0.18	0.27	0.07	0.62
Panel E: Seven-factor intercepts: RM_{ff}. SMB_{ff}. HML_{ff}. UMD_{ff}. *RMW*. *CMA*. and *QMJ*															
	α					*t(α)*					*P-value*				
Small	-0.17	0.10	-0.05	0.07	0.14	-1.84	1.43	-0.86	1.13	2.29	0.07	0.15	0.39	0.26	**0.02**
2	-0.05	-0.12	0.03	-0.07	-0.10	-0.76	-1.93	0.54	-1.27	-1.58	0.45	**0.05**	0.59	0.21	0.11
3	0.05	0.01	-0.04	-0.02	0.04	0.73	0.09	-0.66	-0.34	0.57	0.46	0.93	0.51	0.73	0.57
4	0.18	-0.14	-0.04	0.04	0.00	2.72	-1.92	-0.49	0.61	0.00	**0.01**	0.06	0.62	0.54	1.00
Big	0.06	-0.05	-0.03	-0.12	0.00	1.21	-0.78	-0.40	-1.84	-0.04	0.22	0.44	0.69	0.07	0.97
Panel F: Five-factor intercepts: RM_{ff}. *ME*. HML_{ff}. *ROE and I/A*															
	α					*t(α)*					*P-value*				
Small	-0.22	0.25	0.06	0.18	0.22	-2.19	3.37	0.99	2.71	2.90	**0.03**	**0.00**	0.32	**0.01**	**0.00**
2	-0.07	-0.03	0.04	0.01	-0.01	-0.93	-0.41	0.58	0.15	-0.21	0.35	0.68	0.56	0.88	0.83
3	0.06	-0.04	-0.11	-0.04	0.14	0.93	-0.50	-1.50	-0.54	1.65	0.35	0.62	0.14	0.59	0.10
4	0.18	-0.23	-0.14	0.00	-0.08	2.63	-2.90	-1.70	-0.06	-0.90	**0.01**	**0.00**	**0.09**	0.95	0.37
Big	0.10	-0.09	-0.14	-0.19	-0.01	2.00	-1.40	-1.73	-2.83	-0.08	**0.05**	0.16	**0.08**	**0.00**	0.94
Panel G: Six-factor intercepts: RM_{ff}. *ME*. HML_{ff}. UMD_{ff}. *ROE and I/A*															
	α					*t(α)*					*P-value*				
Small	-0.23	0.24	0.06	0.18	0.22	-2.24	3.29	0.97	2.68	2.92	**0.03**	**0.00**	0.33	**0.01**	**0.00**
2	-0.06	-0.02	0.04	0.01	-0.01	-0.85	-0.27	0.72	0.24	-0.20	0.40	0.79	0.47	0.81	0.84
3	0.07	-0.02	-0.10	-0.03	0.15	0.99	-0.34	-1.37	-0.45	1.74	0.32	0.73	0.17	0.65	**0.08**
4	0.18	-0.21	-0.12	0.00	-0.07	2.61	-2.81	-1.57	0.00	-0.80	**0.01**	**0.01**	0.12	1.00	0.42
Big	0.11	-0.09	-0.13	-0.19	-0.01	2.14	-1.34	-1.71	-2.75	-0.08	**0.03**	0.18	**0.09**	**0.01**	0.93

Table 15

Specification errors (α) of the 25 portfolios under the sequential framework.

Table 15 exhibits specification errors (α) for the 25 portfolios produced by the extended empirical CAPM models. Panels A to F display the specification errors (α) for the 25 portfolios as well as the respective *t*-statistics and *p*-values using the modified Fama and French (1993) size and value factors in the different factor model combinations over the sample period (from January 1963 to December 2014). The paths for the sequential *SMB* and *HML* factors used are respectively momentum, book-to-market and size, and momentum, size, book-to-market. The alternative paths were tested and lead to the same conclusions. Results are available upon request. RM_{ff}, UMD_{ff}, *RMW* and *CMA* are available on K. French's library. *QMJ* (Quality minus Junk) is obtained from Asness et al. (2015). As for the profitability (*ROE*) and investment (*I/A*) from Hou, Xue, Zhang (2014) are only made available for a sample period ranging from July 1967 to December 2014.

$$R(t) - R_F(t) = \alpha + b[R_M(t) - R_F(t)] + \sum_i k_i \, F_i(t) + e(t)$$

B/M→	Low	2	3	4	High	Low	2	3	4	High	Low	2	3	4	High
Panel A: Three-factor intercepts: RM_{ff}. *SMB'. and HML'*															
	α					*t(α)*					*P-value*				
Small	-0.36	0.01	-0.06	0.00	-0.08	-4.30	0.08	-0.80	0.04	-1.10	**0.00**	0.94	0.43	0.97	0.27
2	-0.04	-0.02	0.05	-0.04	-0.16	-0.38	-0.18	0.58	-0.51	-1.57	0.71	0.86	0.56	0.61	0.12
3	0.06	0.03	-0.05	-0.03	0.01	0.69	0.38	-0.64	-0.39	0.15	0.49	0.71	0.53	0.70	0.88
4	0.23	-0.11	-0.10	-0.02	-0.18	3.03	-1.37	-1.23	-0.32	-1.79	**0.00**	0.17	0.22	0.75	0.07
Big	0.24	-0.01	-0.13	-0.19	-0.22	4.43	-0.09	-1.81	-2.59	-1.94	**0.00**	0.93	0.07	**0.01**	0.05
Panel B: Four-factor intercepts: RM_{ff}. *SMB'. HML'. and* UMD_{ff}															
	α					*t(α)*					*P-value*				
Small	-0.31	0.03	-0.04	0.02	0.00	-3.62	0.38	-0.45	0.32	-0.03	**0.00**	0.71	0.65	0.75	0.98
2	-0.01	0.04	0.09	-0.01	-0.10	-0.09	0.41	0.97	-0.12	-0.99	0.93	0.68	0.33	0.91	0.32
3	0.08	0.07	0.00	0.01	0.09	0.79	0.79	-0.06	0.12	0.93	0.43	0.43	0.96	0.91	0.35
4	0.20	-0.05	-0.03	0.02	-0.08	2.60	-0.69	-0.33	0.26	-0.81	**0.01**	0.49	0.74	0.80	0.42
Big	0.23	-0.01	-0.12	-0.13	-0.13	4.09	-0.22	-1.59	-1.76	-1.15	**0.00**	0.83	0.11	0.08	0.25

(continued)

Table 15-*(continued)*

Panel C: Five-factor intercepts: RM_{ff}. *SMB'*. *HML'*. UMD_{ff}. and *RMW*															
	α					*t(α)*					*P-value*				
Small	-0.29	0.07	-0.07	-0.02	-0.05	-3.45	0.83	-0.80	-0.25	-0.71	**0.00**	0.41	0.42	0.80	0.48
2	0.00	0.00	0.05	-0.04	-0.11	-0.03	0.01	0.55	-0.42	-0.99	0.98	0.99	0.58	0.68	0.32
3	0.09	0.03	-0.04	0.00	0.06	0.95	0.38	-0.51	0.01	0.61	0.34	0.71	0.61	0.99	0.54
4	0.23	-0.09	-0.05	0.04	-0.08	2.87	-1.15	-0.58	0.49	-0.81	**0.00**	0.25	0.56	0.62	0.42
Big	0.15	-0.05	-0.09	-0.13	-0.07	2.86	-0.86	-1.24	-1.73	-0.66	**0.00**	0.39	0.21	0.08	0.51
Panel D: Six-factor intercepts: RM_{ff}. *SMB'*. *HML'*. UMD_{ff}, *RMW. and CMA*															
	α					*t(α)*					*P-value*				
Small	-0.29	0.06	-0.09	-0.04	-0.08	-3.41	0.71	-1.08	-0.51	-1.03	**0.00**	0.48	0.28	0.61	0.31
2	0.03	-0.01	0.05	-0.06	-0.14	0.28	-0.15	0.48	-0.65	-1.26	0.78	0.88	0.63	0.52	0.21
3	0.15	0.04	-0.06	-0.03	0.02	1.64	0.45	-0.68	-0.39	0.15	0.10	0.65	0.50	0.70	0.88
4	0.26	-0.13	-0.08	0.01	-0.12	3.31	-1.71	-1.01	0.12	-1.20	**0.00**	0.09	0.31	0.91	0.23
Big	0.17	-0.08	-0.12	-0.17	-0.12	3.24	-1.41	-1.65	-2.33	-1.05	**0.00**	0.16	0.10	**0.02**	0.29
Panel E: Seven-factor intercepts: RM_{ff}. *SMB'*. *HML'*. UMD_{ff}., *RMW*, *CMA* and *QMJ*															
	α					*t(α)*					*P-value*				
Small	-0.14	0.14	-0.04	0.01	0.02	-1.67	1.45	-0.50	0.13	0.31	0.10	0.15	0.62	0.89	0.76
2	0.13	0.05	0.15	0.02	0.03	1.20	0.49	1.60	0.21	0.28	0.23	0.63	0.11	0.83	0.78
3	0.21	0.13	0.06	0.08	0.15	2.17	1.44	0.74	0.93	1.46	**0.03**	0.15	0.46	0.36	0.14
4	0.28	-0.03	0.05	0.11	0.07	3.51	-0.41	0.59	1.38	0.72	**0.00**	0.68	0.55	0.17	0.47
Big	0.04	-0.06	-0.06	-0.09	0.05	0.72	-0.99	-0.76	-1.25	0.41	0.47	0.32	0.45	0.21	0.68
Panel F: Five-factor coefficients: RM_{ff}. *SMB'*. *HML'*. *ROE and I/A*															
	α					*t(α)*					*P-value*				
Small	-0.32	0.14	-0.09	-0.02	-0.08	-3.33	1.39	-1.05	-0.26	-1.03	**0.00**	0.17	0.30	0.80	0.31
2	0.00	-0.03	-0.02	-0.08	-0.12	-0.01	-0.30	-0.23	-0.82	-1.05	0.99	0.77	0.82	0.41	0.29
3	0.13	-0.04	-0.14	-0.10	0.06	1.26	-0.41	-1.55	-1.16	0.51	0.21	0.68	0.12	0.25	0.61
4	0.26	-0.22	-0.17	-0.05	-0.16	3.02	-2.63	-2.03	-0.68	-1.47	**0.00**	**0.01**	**0.04**	0.50	0.14
Big	0.16	-0.10	-0.16	-0.23	-0.06	2.71	-1.49	-2.01	-2.97	-0.52	**0.01**	0.14	**0.04**	**0.00**	0.60
Panel G: Six-factor intercepts: RM_{ff}. *SMB'*. *HML'*. UMD_{ff}, *ROE and I/A*															
	α					*t(α)*					*P-value*				
Small	-0.32	0.13	-0.09	-0.02	-0.07	-3.31	1.36	-1.02	-0.24	-0.97	**0.00**	0.17	0.31	0.81	0.33
2	0.00	-0.03	-0.02	-0.07	-0.12	0.02	-0.25	-0.19	-0.79	-1.04	0.99	0.81	0.85	0.43	0.30
3	0.13	-0.03	-0.13	-0.10	0.06	1.26	-0.35	-1.49	-1.13	0.56	0.21	0.72	0.14	0.26	0.58
4	0.25	-0.22	-0.16	-0.05	-0.15	2.99	-2.59	-1.97	-0.66	-1.42	**0.00**	**0.01**	**0.05**	0.51	0.16
Big	0.16	-0.09	-0.16	-0.22	-0.06	2.79	-1.47	-2.01	-2.94	-0.51	**0.01**	0.14	**0.05**	**0.00**	0.61

7 Conclusion

Arnott (2005, p. 14) indicates that "*when we separate the size effect from the value-versus-growth effect, we find that size as measured by market capitalization is far less powerful than is generally believed. And, reciprocally, the value effect — because some of its efficacy has been siphoned off by the mislabeled size effect — is far more powerful and more consistent than is generally believed.*" This paper presents a factor construction methodology that is able to capture this empirical evidence pointed out by the professional community.

We revisit the size and book-to-market effects in the US market over the 1963-2014 sample period using the sequential approach to factor construction of Lambert and Hübner (2013). Our alternative way to construct the empirical risk factors avoids the contamination of the premiums from the correlation structure of the data. Indeed, this paper aims to address some of the drawbacks identified in this heuristic approach to the construction of risk factors. The main innovations of our methodology involve a finer size classification and a conditional sorting of stocks into portfolios. We consider three risk dimensions (size, value and momentum). The conditional sorting procedure addresses the question of whether return variation related to the third risk criterion still exists even after having controlled for two other risk dimensions. The sorting procedure involves performing a sequential sort in three stages: the first two sorts are performed on control risks, followed by the risk dimension to be priced.

Compared to the Fama and French method, our factor construction method captures more accurately the return spread associated with the source of risk to be priced. It maximizes the dispersion in related sources of risk while minimizing dispersion in correlated sources of risk. The conditional sorting and the finer size classification both contribute to better balancing the weightings placed on the small/large value/growth portfolios. The most significant improvement of the new method lies in the reduction of specification errors when pricing passive benchmark investment portfolios. Overall, the use of this modified Fama and French methodology enables us to deliver a new set of risk premiums that better price the extreme risks involved in the portfolios displaying small market capitalization but strong book-to-market characteristics. The Fama and French (1993) model with and without the Carhart (1997) momentum, the five-factor Fama and French (2015a) model as well as the *q*-factor model of Hou, Xue and Zhang (2015) all fail to price these extreme portfolios.

Results presented here challenge evidence previously presented by Fama and French (2015a) suggesting that the book-to-market factor becomes redundant in a multivariate framework. Using our sequential methodology to derive the book-to-market factor, we do not witness anymore a tilt towards small value stocks (which drives the value factor in F&F framework and its relation with a distress factor) and discover a remarkably steady and significant value effect across the year and every business cycle, and all market capitalizations. Our value factor indeed associates the value effect with greater sensitivity of a firm's earnings to the economic conditions. In bad times, value stocks suffer from costly reversibility as they cannot easily reduce their unproductive capital. However, in good times they have low investment rate as they benefit from the capacity of their previously unproductive equipment (Campbell, Polk and Vuolteenaho, 2010). The superior return offered by low investment firms are fully captured under our framework into the HML factor. It therefore absorbs the information driven by the risk factor CMA, but not the other way around.

Our findings are close to those of Asness et al. (2015) where the size factor resurrects after controlling for noise. Contrary to Asness et al. (2015) however, in which controls for noise are made ex post, we control ex ante for noise in the estimation of the factor itself. It appears that using our methodology, both the size and book-to-market factors remain significant across various model specifications. Our study documents a strong "through-the-year" value effect and only a "turn-of-the-year" size effect.

Given the critical stance of our paper, it has been necessary to explore the potential improvements offered by the new sequential procedure over the original Fama and French (1993) method but also over the new sets of competing factors that have recently florished in the literature. These robustness checks deliver clear insights with regards to the key drivers of the alternative approach's pricing performance. A conditional sorting procedure purifies the size and value risk factors so that a reviewed version of the traditional Carhart model outperforms an extended empirical model (such as a five-, or six- or seven-factor model) to explain market anomalies.

Our future research agenda will investigate the relevance of implementing a sequential approach under more frequent rebalancing and will test the relevance under the sequential framework of the profitability factors *à la* Novy-Marx (2013).

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