Master Thesis in Econometrics & Management Science

Quantitative Finance

Bottom Up Credit Investing

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Abstract

This paper builds on the work of Israel et al. (2015) and Houweling and Van Zundert (2015). These papers provide a framework to construct multi-factor portfolios and calculate their performance for corporate bonds. This paper contributes to the literature by testing several different implementations for a given factor, whether combining different implementations for a given factor improves performance and whether factor timing yields better returns than an equal-weighted multi-factor portfolio. This analysis is performed on an extensive data set consisting of US investment grade, US high-yield, European investment grade and European high-yield indices. This paper finds that the (multi-)factor portfolios generally improve the risk-adjusted returns compared to the benchmark.

Keywords: factor investing, value, size, defensive, carry, momentum, corporate bonds

Contents

1 An Introduction to Factor Investing

The practice of asset management changed substantially over the last several years. All professional investors used to invest in an active and fundamental way, they actively searched for securities they believed would outperform. The investment target was to perform better than their benchmark and their competitors. During the financial crisis of 2008 many active asset managers had a lower return than their benchmark, usually a broad value-weighted index (e.g. S&P500). Some agents concluded that the fees for active management were too high compared to the added performance, instead they decided to invest in a passive manner.[1] Passive investing usually consists of buying index trackers, this instrument (very) closely resembles a (broad) index. This strategy will never outperform the index, but at the same time, the strategy will never under-perform the index. Many mutual funds (e.g. Vanguard) provide these services.

Since the financial crisis a blend between active and passive investing is on the rise: factor investing. It combines features of active portfolio management such as trying to generate alpha and passive portfolio management such as investing systematically.[2] A factor can be roughly defined as 'any characteristic relating a group of securities that is important in explaining their return and risk' (Bender et al., 2013). The popularity of this strategy among professional investors is due to the research of Ang, Goetzmann and Schaefer (2009). They did research for the Norwegian Government Pension Fund - Global, this sovereign wealth fund was formed in 1990 to invest state revenues from oil and gas. During the financial crisis the performance of the actively managed fund was well below the benchmark. The three professors investigated on behalf of the Norwegian Ministry of Finance why the performance fell behind. The fund invested in different asset classes, such that it appeared the fund was well diversified. However, Ang, Goetzmann and Schaefer (2009) concluded that before, during and after the financial crisis the fund was not as diversified as expected. The two reasons why factor investing attracts so much attention are illustrated with the example above. Firstly, different asset classes (e.g. equities and bonds) were highly correlated during the financial crisis. Factor investing could construct a (more) diversified portfolio. The second reason is

[1] Verhage, J. *These Charts Show the Astounding Rise in Passive Management*, available at: Bloomberg

[2] To understand this paper the reader does not have to have a profound knowledge of finance or fixed income and more specifically of factor investing. A brief, but thorough, overview of factor investing is given in the Appendix. Therefore, I would like to suggest the reader who is not familiar with factor investing to read the Appendix before going ahead with the rest of this paper. The reader who knows the basic concepts of factor investing can immediately continue with this paper.

the cost of active management, when a fund outperforms higher costs can be justified. Trough combining aspects of both active and passive portfolio management factor investing could be able to achieve higher returns than passive management will keeping costs close to the costs of passive management. Asset managers such as AQR and Robeco have implemented (systematic) factor strategies for equities and credits into their funds portfolio.[3,4] Spence Johnson (2014) predict that the market for factor investing will grow to €287 billion by 2018 from €75 billion in 2013 (Spence Johnson, 2014).

This strategy holds positions in deviation from the index (market portfolio), however, these deviations are based on academic and empirical evidence. The increase in processing power of computers and the systematic collection of financial data makes it possible to create and maintain investment strategies based on anomalies found in the data. Although the structural implementation of factor investing was not realised until after the financial crisis, the first research was already conducted in 1934 (Graham and Dodd, 1934). The research on these anomalies or factors really took of with the work of Fama and French (1992). Since then many articles were written on this subject, mostly focusing on equities. Some widely accepted factors are the market factor, the value factor, the size factor and the momentum factor (Sharpe, 1964; Fama and French, 1992; Carhart, 1997). More recently attention has shifted to other asset classes (Houweling and Van Zundert, 2015; Israel et al., 2015). This paper focuses on factor investing in the corporate bond market.

Two important aspects of factor investing should be underscored. The first aspect is that factor investing is not an arbitrage opportunity. There will be times that the strategy will underperform. However, the literature documented that these strategies on average have a positive (excess) return. The second aspect is the explanation on why these factor premiums exist. Although some of these factors were documented more than 20 years ago there is still no uniformly accepted theory on why these factor premiums existed and why they still exist. There are two competing approaches to explain the existence of factor premiums (Koedijk, Slager and Stork, 2014; Bender et al., 2013; Asness, 2015). The first one assumes that agents are rational. The explanation is that the factor premium is a compensation for additional risk. In this case the old saying in finance that 'there is no such thing as a free lunch' holds true. Another theory that assumes rational agents tries to explain factor premiums by the

[3]Available at: funds.aqr.com/our-funds/alternative-investment-funds/style-premia-alternative-fund#qspix
[4]Available at: robeco.com/en/professionals/strategies-products/factor-investing/factor-investing-equities.jsp

constraints that some investors encounter, such that they can not take advantage of the premiums. An example is the leverage constraint that many investors have. The second main theory on the existence of factor premiums uses behavioural finance to explain the factor premiums, it assumes that not all investors all fully rational and the premiums are a result of under- or overreaction. Despite the lack of complete explanation on the existence of factor premiums, many (institutional) investors are interested in this strategy, mainly because of the diversification benefits next to their already existing portfolios.

The goal of this research is to beat a benchmark (the index) in terms of a risk-return trade-off through the allocation to factors. Outperformance (alpha) can only be achieved in two ways, either by security selection or by market timing. Factor investing is a cross-sectional strategy (security selection). At any given point in time based on a certain factor some securities are bought/over-weighted and some securities are sold/under-weighted. This is a bottom-up approach. It is also possible to do a (top-down) time-series strategy, for a given set of factors it is determined how much should be allocated to each factor through time (market timing). The panel data (cross-section times time-series data) used in this research are the constituents of several Bank of America Merrill Lynch (BofAML) corporate bond indices starting from 1998. Hence, it is possible to combine both security selection as well as market timing to construct an optimal portfolio.

Most bond indices (including the BofAML indices) use a monthly updating rule. This means that at the beginning of every month some new bonds are added to the index and some other bonds are deleted from the index. It is also possible that the constituents of the index from one month to another stay the same. The factor portfolios will be updated once a month, because the indices update their 'portfolios' also once a month. This makes it easier to compare the performance of the factor portfolios to the index. Monthly rebalancing is also in line with other research (Israel et al., 2015).

As mentioned above outperformance can only be achieved in two ways (security selection and market timing). To be able to perform better than the benchmark an efficient implementation of the factor portfolios is key, otherwise the potential benefit can turn into a loss. Three potential pitfalls of factor investing are unrewarded risk, negative exposure to other factor premiums and unnecessary trading costs.[5] First, due to the nature of momentum investing, this strategy has a high turnover. If some of the turnover could be limited the trading costs would go down, which would boost the performance of the strategy. Second, a security could have large exposure to a factor, but at the same time it could have large negative exposure to another factor. This would lower the attractiveness of this security.

There is a final potential pitfall for investors: overconfidence. This behavioural bias often 'pushes people to tinker with things they do not deeply understand, leading them to over-complicate, over-engineer and over-optimize' (Bridgewater, 2009). All in all, factor investing can be compared to chess; it is easy to learn but difficult to master.

Factor investing is quite well established for equities. There is less research for fixed income instruments. Also, there are fewer funds that invest systematically in bonds than in equities. The reason that other asset classes than equities are relatively less researched are some fundamental difficulties associated with these. This paper focuses on the (corporate) bond market. First of all bonds mature, except for a perpetual bond, while a stock does not mature assuming there is no default. This difference makes it difficult to create and maintain an index of (corporate) bonds. For example, given that a certain basket of bonds is used as an index, then this basket can not be kept simply through time, because the characteristics of the index will change (e.g. the duration will shorten). A second problem for bonds is that a bond issuer (country or company) can have many different issues (bonds with different embedded options, maturities, coupon rates, etc.). On the other hand companies usually have only one kind of stock outstanding, at most two different, class A and B shares. A third problem is the nature of investing in corporate bonds, trading is done over-the-counter (OTC). This makes it difficult to create a structured database containing all characteristics of a bond. Also, the liquidity in the OTC market is difficult to measure. Therefore investors may not take part in a transaction. Hence, liquidity plays a key role in constructing a bond portfolio. Even though these difficulties associated with fixed income investing the potential benefit for factor strategies seem to be there. The value weighted index 'over-weights' highly leveraged firms, because firms with more outstanding debt have a larger weight in the index. The index might therefore have a higher credit risk than optimal. Concluding this section, factor investing is more difficult in bonds than in equities, but enhanced indexing seems to be possible.

[5] Huij, J. *Factor investing, the flip side of following the index*, available at: Robeco

The motivation for this research serves two different purposes. First, factor investing in the equity space has been well documented in academia. However, other assets classes (e.g. bonds, commodities and currencies) have been less researched. This paper focuses on the corporate bond market, thereby adding to the knowledge about factor strategies. To give some more substance to this the following research questions are formulated:

- Do (multi-)factor portfolios improve the performance compared to the index in the corporate bond market?
- Is factor investing profitable when trading costs are taken into consideration?

The first part focuses on the performance of the factor strategies. The second part of the motivation serves the more practical side. If the performance of the factor strategies differs from the index, could this be explained by differences in the characteristics of the portfolios? The corresponding research question:

- Do the (multi-)factor portfolios load on specific characteristics (e.g. duration or sector)?

The performance of the individual factor portfolios is mixed. Some of the factors perform better than the index and some of the factors perform worse. Combining different measures leads sometimes to a better performance than the individual factors, but not uniformly over all factors and all indices. The multi-factor portfolios have a better performance than the index. Incorporating transactions costs decreases the performance substantially. Of the four indices there is only one multi-factor portfolio that outperforms the corresponding index if transaction costs are incurred.

This paper is organized as follows: section 2 provides an overview of the existing literature on factor investing. Section 3 elaborates on the data, followed by methodology in section 4. Section 5 present the results of the research and section 6 concludes this paper.

2 Literature Review

Factor investing is nowadays a hot topic (Spence Johnson, 2014). However, the first articles on factor investing were already published in the 1960s. In (very) recent years there are articles written on factor investing in other asset classes than equities. This section will provide an overview of the literature on factor investing in the corporate bond market.

2.1 Cross-Sectional Predictability of Returns

Cross-sectional predictability of returns has been subject of many (academic) articles. Three highly influential papers are Fama and French (1992), Fama and French (1993) and Fama and French (2015), these articles explain the cross-sectional differences in stock and bond returns. Fama and French (1992) show that value (book-to-market ratio) and size (market equity), market-β, earnings-to-price ratio and leverage (ratio of total book assets to book/market-equity) can explain cross-sectional differences in returns. They conclude that market-β does not predict very well, while book-to-market and size explain part of the cross-section.

Fama and French (1993) provide a framework to turn the insights of Fama and French (1992) into factors. The first step is to create portfolios. They do this by means of a double sort. The first sort is on size. There are now two portfolios, one with size smaller than the median and one portfolio with size larger than the median. Each size portfolio is sorted into three different value (measured by book-to-market ratio) portfolios (cut-offs at the 30^{th} and 70^{th} percentile). In total there are now six portfolios: small value, big value, small neutral, big neutral, small growth and big growth. The size factor is constructed as the average return on the small-firm portfolios minus the average return on the big-firm portfolios. The value factor is constructed as the average return on the value portfolio minus the average return on the growth portfolios. Both the size and value factor are zero-investment portfolio, so the returns of this portfolio are excess returns. The model with the market factor, size factor and value factor is commonly referred to as the Fama-French three factor model. The conclusion of the paper is that factors have explanatory power for stocks.

2.2 Factors, Factors Everywhere

Fama and French (1992, 1993) provide a methodology to estimate and test factor performance. Many articles used this approach to test different factors. This section will give an overview of the factors used in research.

Value

Value captures securities that have prices lower than their intrinsic value. Value is a well-known equity factor, it was introduced by Fama and French (1993). They use the book-to-market ratio as a measure for value.

Correia et al. (2012) and Maitra (2016) performed research to the value factor in credit markets. Correia et al. (2012) suggest that the value factor may be of use in credit markets. Maitra (2016) concludes that the value premium is highly significant and uncorrelated with other sources of risk premium.

Size

The size factor indicates that on average small-cap firms earn higher returns than large-cap firms. Like value, size is a well-known equity factor, it was also introduced by Fama and French (1993). They use market equity as a measure for size. Houweling and Van Zundert (2015) use size in the credit market, they conclude that size also provides significant risk-adjusted returns in the corporate bond market.

Momentum

Jegadeesh and Titman (1993) introduced the concept of momentum. Carhart (1997) created the momentum factor. Momentum reflects that securities with a strong past returns will (on average) perform better than securities with weak past performances. The momentum factor is often added to the Fama-French three factor model, creating the four-factor model.

Momentum is another well-known equity factor, there is also research for fixed income. Pospisil and Zhang (2010), Barth, Hühn and Scholz (2016) and Jostova et al. (2012) all reach the same conclusion: a momentum strategy yields a positive return in high-yield corporate bonds. Haesen, Houweling and Van Zundert (2012) conclude that 'firm-specific news is first slowly incorporated in equity prices, resulting in residual equity momentum, and subsequently in corporate bond prices, resulting in cross-asset return predictability'.

Defensive/Low Risk/Quality

A relatively new, but already established factor is the defensive (low risk, quality, low beta or low volatility) factor. There are many different names for this factor, but all use the same 'definition': on average, securities with lower than average volatility earn higher risk-adjusted returns than high volatility securities.

This factor could be quite confusing, since in the CAPM model higher returns are associated with higher risk. However, this factor states that this is not necessarily the case. Van Vliet et al. (2011) show that in practice the low volatility factor works. Frazzini and Pedersen (2014) create a 'betting against beta' (BAB) factor and conclude that this factor provides significant positive risk-adjusted returns. Houweling et al. (2012) focus on credits and conclude that the low-risk anomaly yield superior risk-adjusted returns.

Carry

The carry factor is less well-known than the four other factors. It is also less common in the equity space. Carry can be defined as: 'the benefit (or cost) of owning an asset'. For example, commodities usually have a negative carry because commodities require storage. Bonds usually have a positive carry because the bonds pay a coupon. The carry factor states that on average securities that have a high carry have higher returns than securities with a low carry. Indeed, Koijen et al. (2015) find that carry works in the bond market.

2.3 Multi-Factor Portfolio Research

The outperformance of individual factors has been proven in the literature. As mentioned before, factor investing is not an arbitrage opportunity. At some point the performance of a factor strategy will be poor. To diversify the portfolio held by the investor it seems to be a good idea to combine multiple factors into one multi-factor portfolio. This multi-factor portfolio could mitigate the drawbacks of a single factor.

The papers by Asness et al. (2015), Houweling and Van Zundert (2015) and Israel et al. (2015) provide a framework to construct multi-factor portfolios and calculate their performance for corporate bonds. This paper takes these papers as starting points, therefore each of them are introduced in the next three sections. These papers will also be used to compare methodology and results.

Israel et al. (2015)

Israel et al. (2015) use four factors for the multi-factor portfolio: carry, defensive (low-risk), momentum and value. Size is deliberately not chosen, since 'the corporate bond market is notoriously expensive to trade'. This paper focuses on large and liquid corporate bonds. Smaller bonds (in terms of total amount outstanding) in the bond market have in general lower liquidity than larger bonds. Both long-short and long-only factor portfolios are constructed. For this paper the most interesting part is the set up for the multi-factor long only portfolio.

The first step for the multi-factor long only portfolio is to rank each security based on the four factors. For example, a given bond could have a high exposure to momentum but at the same time a negative exposure to carry. The second step is to average the exposure (i.e. the rank after sorting) of the bond over all factors, this is done by simple averaging. In this way every bond has a 'multi-factor exposure'. The final step in the portfolio construction procedure is to optimize the 'multi-factor exposure'. The weights for every security are determined by a linear optimization problem. The objective is to optimize the 'multi-factor exposure', under certain restrictions such as turnover constraint and deviations from benchmark constraints. This portfolio (consisting of investment grade and high-yield bonds) earns 1% in excess of the benchmark annually.

Houweling and Van Zundert (2015)

Houweling and Van Zundert (2015) use four factors in their multi-factor portfolio with size instead of carry. A single-factor portfolio consists of the 10% corporate bonds with the highest exposure (top decile) to a given factor. The multi-factor portfolio is constructed by equal weighting of the single-factor portfolios. The portfolio is held for twelve months. Houweling and Van Zundert (2015) use US high-yield and US investment grade data and the analysis is done for both indices separately. They outperform the investment grade index by 0.8% per annum and the high-yield index by 3.3% per annum.

Asness et al. (2015)

Asness et al. (2015) do not focus on the corporate bond market, nonetheless it is very relevant for this research. Hence, the focus will be on the methodology concerning government bond indices. The methodology is similar to that of Israel et al. (2015). The difference being that Asness et al. (2015) use long-short portfolios. Also, instead of equal weighting of the factors, Asness et al. (2015) use equal volatility weighting. The results of this research are not directly relevant for this research because the portfolios consist of long and short positions.

2.4 Factor Timing

After the individual factor portfolios are created they are combined into one multi-factor portfolio. It is very reasonable that factor premiums are time-varying, therefore it could be useful to time the factor exposure. When expected returns for a certain factor are high more weight is given to this specific factor.

Factor timing done well could add performance, however, when implemented the wrong way it leads to performance degradation (Hsu, Myers and Whitby, 2016). Also, the essay of Asness (2016) states that the 'siren song [of factor timing] should be resisted'. Moskowitz, Ooi and Pedersen (2012) provide a positive outlook on factor timing. They find that over the last 25 years the time-series momentum factor is significant in 58 futures contracts and in several major asset classes.

2.5 Contributions to the Literature

As mentioned before in section 2.3, this paper uses Asness et al. (2015), Israel et al. (2015) and Houweling and Van Zundert (2015) as starting point. This paper contributes three things to the existing literature. The first contribution regards the definition of the factor. In the literature are many different measures for a given factor. A priori it is not obvious which measure is preferred. Since each measure tries to capture the same (underlying) factor return it might be worthwhile to combine the different measures. In this way the idiosyncratic noise for each measure has a smaller contribution, such that the combined measure should provide a cleaner proxy for the factor. Intuitively this can be compared to model averaging for out-of-sample forecasting, usually the average model forecast performs better than any individual forecasts (Timmermann, 2006).

Secondly, this paper contributes to the portfolio construction process for multi-factor portfolios. Many investors use the 1/N rule for the assets in their portfolio. This rule is also used at the ‘factor-level’; every factor gets an equal weight. In practice this (naive) diversification rule works well (DeMiguel et al., 2009). As mentioned before, factor investing is no arbitrage opportunity. Every factor will have periods when there is underperformance. Intuitively, reducing the exposure to the factor when there is a period of underperformance should increase the overall performance.

The last contribution is the data considered in this research. Israel et al. (2015) and Houweling and Van Zundert (2015) both use US high-yield and US investment grade indices. This paper uses four indices: US high-yield, US investment grade, European high-yield and European investment grade index. The geographical and credit rating separations make it possible to identify the periods of different performance. These periods of dispersion in the performance might shed some valuable insight on the inner workings of factor investing.

3 Data

The first step in the investment process is understanding and choosing the benchmark and a corresponding investment universe. This decision has large impacts on the results of the research (Goltz and Campani, 2011; Kidd, 2012). Mutual fund managers are usually compared to an index. This makes it easier to estimate their skill. In the corporate bond market there are two large well-known providers of indices, Bank of America Merrill Lynch (BofAML) and Barclays. In this research several indices of BofAML are considered as benchmark, the investment universe consists of the constituents of these BofAML indices. The benefit of BofAML over Barclays is entirely due to the available history of both providers. The BofAML indices have available data since 1996, while the avalaible data for Barclays is only one year. The specific indices of BofAML used in this research are: Euro Corporate Index (henceforth European investment grade), US Corporate Index (henceforth US investment grade), European Currency High Yield Index (henceforth European high-yield) and US High Yield Index (henceforth US high-yield). The data of the indices start in 1998. Daily observations for all characteristics (e.g. price and duration) of the constituents are collected. The constituents of these indices are traded over-the-counter (OTC). The prices are traded prices, when no trades are available quoted prices are used. In the next sections each of the indices is explained in more detail.

3.1 Index Rules

Bonds and especially corporate bonds can have many different features and (embedded) options. The plainest vanilla bond is a fixed-rate bond. There are also many exotic bonds, for example these bonds have pay-in-kind, callable, sinkable or fixed-to-float options. Table 1 contains an overview for the rules of inclusion.

Table 1: Overview Rules of Inclusion

	US HY	EU HY	US IG	EU IG
Currency	USD	EUR and GBP	USD	EUR
Geographical	US domestic	Eurobond, Sterling and Euro domestic	US domestic	Eurobond or Euro domestic
Time to Maturity	at least 18 months	at least 18 months	at least 18 months	at least 18 months
Remaining Time to Maturity	at least one year	at least one year	at least one year	at least one year
Coupon Schedule	fixed	fixed	fixed	fixed
Minimum Amount Outstanding	\$100 million	€100 million, £50 million	\$250 million	€250 million

Note: this table shows the rules of inclusion for the US high-yield, European high-yield, US investment grade and European investment grade indices.

For all indices the following portfolio construction rules hold:

- the index constituents are capitalization weighted.
- bond payments during the month are held until the next rebalancing date
- cash does not earn any income
- rebalancing is done on the last calendar day of the month
- no change are made to constituent holdings other than on month end rebalancing dates

The specific details of the rules of inclusion and portfolio construction rules are in the Appendix.

3.2 Important Definitions

Four important concepts for investing in fixed income are the return on a bond, spread duration, option adjusted spread (OAS) and duration times spread (DTS). All concepts are explained in detail in the next sections.

Definition of Return

Portfolio management is dealing with the interaction of risk and return. However, return does not have an unambiguous definition. The definition of BofAML will be explained in this section.

The definition of total return is the 'percentage change in the economic value of a bond resulting from the changes in the bonds price as well as the growth in value due to interest income earned during this period'. This definition applied to a fixed rate bond is the bonds price at the end of the period plus the accrued interest plus received coupon payments divided by the bonds price at the beginning of the period plus accrued interest. Corporate bonds are not risk-free. Therefore, the excess return is also of relevance. The definition for excess swap return is the total return minus the return of basket of duration matched government bonds. BofAML provides both the total and excess returns.

Option Adjusted Spread (OAS)

The option-adjusted-spread (OAS) is defined by BofAML as '[the] amount that the yield curve is shifted in order to match the present value of a bond's discounted cash flows to its price while taking into account of any embedded optionality'.[6] So, it is the difference in spread between the yield of the benchmark and the yield of the bond, adjusted for any embedded options of the bond. The benchmark is usually a government bond. Accounting for embedded options is not easy, because there is no uniform model. Hence, OAS is model dependent.

Spread Duration

Spread duration measures the sensitivity in the market price of a bond when the OAS of that specific bond changes. Spread duration is not the same as duration. This measures the price sensitivity to interest rates.

Duration Times Spread

Ben Dor et al. (2007) proposed a new measure for credit risk. Nowadays, it is the most used credit risk measure in practice. Duration times spread (DTS) multiplies the market weight with spread duration and spread. Especially in the high-yield market many bonds have embedded optionality, therefore, in this research OAS is used instead of spread.

3.3 Data Adjustments and Constraints

In theory all the constituents of the BofAML indices make up the investment universe. Unfortunately sometimes it happens that for individual bonds the data is unavailable or seem very implausible (e.g. negative price). Also, some bonds are in financial distress, market fundamentals for these securities are very different than for 'normal' investment grade or high-yield bonds. Therefore, adjustments of the data and constraints on the data are made such that the analysis is as clean as possible.

Financial assets have to be identified, for example trading a security without knowing exactly what the underlying characteristics are would lead to chaotic and illiquid financial markets. There are multiple identifiers used in practice, the data from BofAML contains the ISIN (International Securities Identification Number) and Cusip (Committee on Uniform Security Identification Procedures) identifiers.

[6] Bank of America Merrill Lynch, *Definitions*, available at: BAML Markets

For many observations the ISIN is missing, therefore, their Cusip can only identify the securities. There are 218 bonds in the four indices that have multiple Cusips, for these bonds the 'wrong' Cusip is overwritten with the 'correct' Cusip.[7]

The database of BofAML contains 99 variables in total. However, a couple of variables are not included in the database that are necessary for the analysis. These variables are obtained from Bloomberg.

Any large database is bound to have missing values. Unfortunately the BofAML database is no different. If any of the used variables is missing in the database then the bond is left out for the analysis.

As mentioned before, distress investing is a different kind of investing. It also has a different investor base. To make this research as valid as possible these securities are not taken into account. A rule of thumb from practice is that corporate bonds trading at an OAS higher than 1000 basis points (bps) are in distress. Therefore, only bonds with an OAS lower than 1000 bps are eligible for the investment universe. Corporate bonds have an additional risk compared to government bonds, namely credit risk. This implies that they should have a positive (option-adjusted-)spread. Therefore, the OAS should be larger than zero.

Finally, logic dictates the following constraint:

- issue date $\leq$ observation (analysis) date $<$ maturity date

Table 2 shows how many bonds are deleted in the analysis of this paper. The data starts in 1996, however in this period there are not enough constituents to perform a meaningful analysis. Therefore, the starting dates for the analysis for the European investment grade, US investment grade and US high-yield indices are January 1998 and for European high-yield January 2000. Figure 1 shows how many constituents there are for each index in each month.

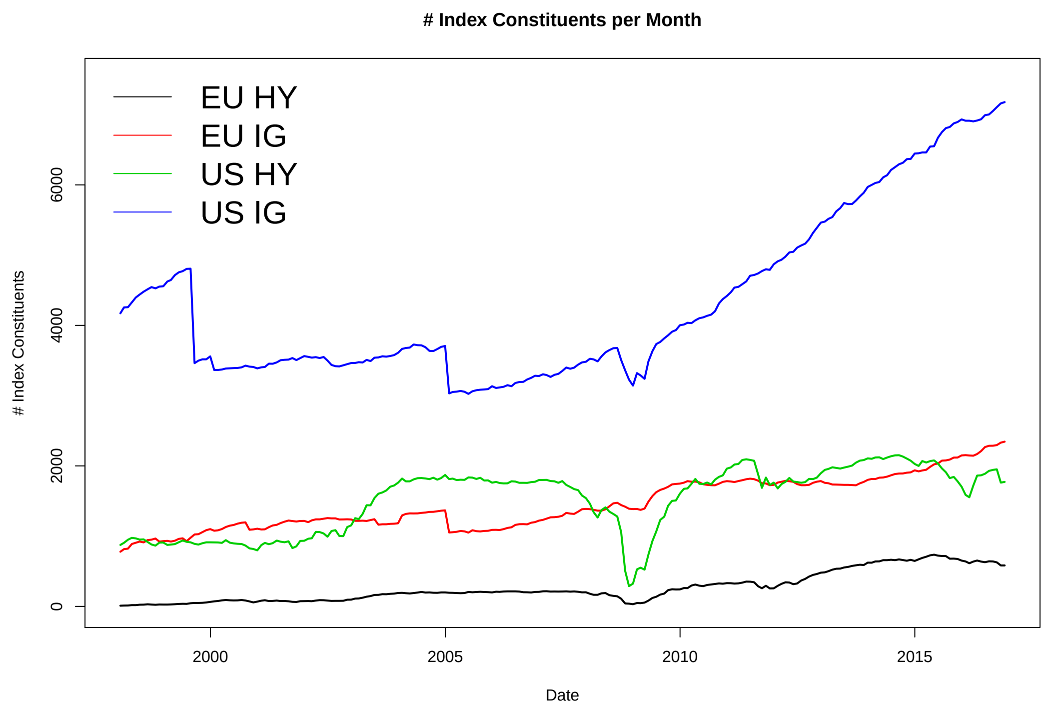
[7] The wrong Cusips were either typos or the Bloomberg identifier was used instead of the Cusip.

Table 2: Percentage of Observations Removed

	EU HY	EU IG	US HY	US IG
Tot. num. obs. at last day of the month	70584	339986	420393	1037071
w/ Bloomberg mapping	-0%	-0%	-0%	-0%
w/ OAS 'restriction'	-14.7%	-0.01%	-15.7%	-0.01%
w/ Spread Duration 'restriction'	-0%	-0%	-0.00%	-0%
w/ Date 'restriction'	-0%	-0.00%	-0%	0.00%
Adjustment Start Period	-0%	-0.02%	-0.03%	-0.04%
Removal Missing Values	-0.06%	-0.05%	-0.04%	-0.03%

Note: this table shows the percentage of observations removed when the restrictions are applied for the EU HY, EU IG, US HY and US IG indices.

Figure 1: Number of Index Constituents per Month



Note: this figure shows the number of constituents for each index in each month.

Some measures need historical data of the bond to be available, for example momentum needs at least six months historical data to calculate the cumulative return. When a bond enters the index for the first time it does not have a history, this bond is not taken into account for the investment universe of the factors that need historical data.

3.4 Descriptive Statistics

Table 3 provides some descriptive statistics for the four indices. First, the cross-sectional average is calculated and then the average of the time-series is calculated.

Table 3: Descriptive Statistics

	US HY	US IG	EU HY	EU IG
average #obs	1515	4336	293	1453
average duration	4.95	6.41	4.11	4.36
average spread duration	4.17	6.12	4.15	4.61
average OAS	446	162	446	127
average yield-to-worst	7.40	4.75	6.05	3.61
average index weight	0.06	0.02	0.33	0.07

Note: this table shows the descriptive statistics of the US HY, US IG, EU HY and EU IG indices

4 Methods

This section explains which methods are used to construct an 'optimal' bond portfolio. First, the methodology to create a factor from a characteristic of an asset is explained. Then the factors are defined, constructed and tested for significance. Some important considerations for (multi-)factor portfolios are discussed. The last sections explain how the single- and multi-factor portfolios are constructed and how their performance is measured.

4.1 From Characteristics to Factors

First the need for factors instead of characteristics is discussed. Factors in a factor model are relevant for all assets. Hence, a firm characteristic can not be a factor, because a firm-characteristic is not relevant for other firms. However, a firm characteristic could approximate the sensitivity to a factor. For example, a firm with a large market value (size) may point at a negative exposure to the size factor.

For the creation of factors this paper will make use of a procedure similar to Fama and French (1993). The procedure consists of the following steps:

- determine the characteristic for each asset
- sort the assets based on the characteristic
- create portfolios based on portfolio rule (top and bottom buckets)
- calculate the returns of the buckets
- the difference in return between top and bottom buckets should be due to the influence of the factor

It should be noted that there is no unique portfolio rule to create portfolios. In practice there are a couple of common rules, decile portfolios, quintile portfolios and 30-40-30 portfolios, but other rules can be applied as well. Also, the portfolio returns can be calculated with an equally or value weighted methodology. The portfolios used in this research are created by equal-weighting the top and bottom 20% (quintiles) buckets.

4.2 Factor Definitions

The previous section explained how to create a factor from a characteristic. But, multiple characteristics may proxy for the same factor. The performance of the strategy could change depending on the exact definition of the factor. In this research multiple characteristics (measures) will be used for each factor. In the next sections the factors are defined, they are in line with most academic and practical definitions.

Value

The value factor is well known in the equity space. The assumption of this factor is that on average assets with prices lower than their intrinsic value earn higher returns than those with a higher price than their intrinsic value. This factor was introduced by Fama and French (1992, 1993). Also, in the bond market the value factor has been researched (Correia et al., 2012; Maitra, 2016). Fama and French define the value factor as the average return on a value portfolio minus the average return of a growth portfolio. Where the value portfolio consist of assets with a book-to-market ratio above the 70^{th} percentile, the growth portfolio consists of assets with a book-to-market ratio below the 30^{th} percentile. The measures used in this research for value are:

- residual of the cross-sectional regression of the log of OAS on the log of duration, credit rating and historical bond excess return volatility (Israel et al., 2015)
- percentage deviations between actual and fitted credit spread (Houweling and Van Zundert, 2015)

The measure of Israel et al. (2015) is implemented with the following steps. Because this measure makes use of the bonds historical excess return volatility it needs at least a couple of historical returns, therefore, it should be at least a couple of months in the index. The lower limit of to be eligible for the investment universe is six months, if the bond is longer than six months in the index all the observations are considered up to sixty months. Thus, if the bond has been in the index for more than sixty months only the most recent sixty observations are considered. The next step is to run a cross-sectional regression:

$$\log(OAS_i) = \beta_{0,i} + \beta_{1,i}\log(Dur_i) + \beta_{2,i}CR_i + \beta_{3,i}HstVol_i + \epsilon_i \quad \text{where} \quad i = 1,..,N. \quad (1)$$

Where CR denotes the credit rating converted to an ordinal variable, where the highest credit rating $AAA = 1$ and the lowest credit rating $D = 22$. $HstVol$ denotes the historical excess return volatility and N denotes the number of constituents in the investment universe. The last step is to calculate the measure:

$$e_i = \log(OAS_i) - \log(\widehat{OAS_i}) \quad \text{where} \quad i = 1,..,N. \quad (2)$$

A positive residual e_i implies that 'true' OAS (observed in the market) is higher than the fitted OAS. Therefore, the compensation for this asset is higher than it should be according to the model. Likewise, a negative residual e_i implies that compensation of the 'true' OAS is too low for this asset. Hence, positive residuals are preferred over negative residuals.

Similarly, the measure of Houweling and Van Zundert (2015) is implemented. The following cross-sectional regression is run:

$$S_i = \alpha_i + \beta_{1,i} CR_i + \beta_{2,i} M_i + \beta_{3,i} \Delta S_i + \epsilon_i \quad \text{where} \quad i = 1, .., N, \tag{3}$$

where S denotes the asset swap spread, CR denotes the credit rating, M denotes the maturity of the bond, ΔS denotes the three-month asset swap rate change and N denotes the number of constituents of the investment universe. There is a slight difference of implementation compared with Houweling and Van Zundert (2015), they dummy coded the credit ratings whereas this paper uses the credit rating as an ordinal variable. The benefit of this is that there are fewer parameters to estimate, especially for the beginning period for European high-yield index where the number of index constituents is not large. The downside is that this assumes that credit rating has a linear effect. Also, Houweling and Van Zundert (2015) uses the credit spread of an asset, because the BofAML data does not provide the credit spread this paper use the asset swap spread.

The measure is calculated by:

$$e_i = \frac{S_i - \hat{S}_i}{\hat{S}_i} \quad \text{where} \quad i = 1, .., N. \tag{4}$$

Also for this measure a positive (scaled) error implies that the compensation is higher than it should be according to the model.

Size and Liquidity

The size factor was introduced in the same paper as the value factor (Fama and French, 1992, 1993). The assumption for this factor is that on average small-cap assets earn higher returns than large-cap assets. Fama and French use market equity as measure for size, the size factor is a long-short portfolio, long the above median market equity assets and short the below median market equity values. In the bond market the liquidity of a bond is (very) dependent on its size, therefore, there is a possibility that the size factor captures (part of) the liquidity premium. The measures used in this research for size and liquidity are:

- size of the bond issue (Soe and Xie, 2016)
- age of the bond
- size of the bond issuer in the index (Houweling and Van Zundert, 2015)

The four indices of BofAML are not capped. The data provided by BofAML contains the index weight of every bond. Hence, size of the issue can easily be determined by the index weight. The third measure by Houweling and Van Zundert (2015) can be seen as the bond equivalent of the measure of Fama and French (1992, 1993). Every issuer (company) has a unique ticker, adding all the index weights for bonds with the same ticker gives the index weight of the issuer. Equivalent to the equity factor, smaller issues and smaller issuers are assumed to earn higher adjusted returns.

The age of the bond is calculated as the time between the maturity date and the analysis date divided by the time between the maturity date and issue date. It is assumed that the older bonds are less liquid and therefore bear an illiquidity premium.

Momentum

The momentum factor was introduced by Carhart (1997), it assumes that on average assets with high historical return earn higher returns than those assets with low historical returns. Carhart used the one-year price change as measure for momentum (with a one month lag). This measure can directly be used in the credit market. These are the measures considered for momentum:

- 6-month trailing bond excess return (Israel et al., 2015; Houweling and Van Zundert, 2015)
- 12-month trailing bond excess return (Asness et al., 2015)

The trailing bond excess return is calculated with the following equation:

$$R_i = \prod_{l=0}^{T}(1 + r_{i,t-l}) - 1 \quad \text{where} \quad i = 1, .., N, \tag{5}$$

where R denotes the cumulative return over the last six or twelve months, T denotes how many observations are used (either six or twelve), r denotes the excess return for a given period and N denotes the number of constituents in the investment universe.

Defensive and Quality

The defensive factor and quality factors are proven in the literature by Frazzini and Pedersen (2014), Asness, Frazzini and Pedersen (2013) and Houweling et al. (2012). There are many different names for the defensive factor. Sometimes it is refereed to as the low-risk factor or low-volatility factor. Because the quality factor definition is close to the defensive definition in the literature this paper will combine the two of them into one factor. The assumption behind this factor is that on average low volatility assets earn higher risk-adjusted returns than high volatility assets. The measures used in this research for defensive and quality are:

- duration times spread (DTS) (Soe and Xie, 2016)
- highest rating with shortest maturity (Houweling and Van Zundert, 2015)
- volatility of the change in OAS (Soe and Xie, 2016)

Equivalent to the equity definition for defensive bonds with a low DTS and/or low volatility of the change in OAS are assumed to 'safe and sound' investments that bear high risk-adjusted returns.

The measure by Houweling and Van Zundert (2015) first selects all bonds with a relatively high credit rating, that is, AAA to $A-$ and $BB+$ to $B-$ for investment grade and high-yield, respectively. Then the bonds with the shortest maturity are selected. These bonds are expected to have a high risk-adjusted return.

Carry

The carry factor is proven in the literature by Koijen et al. (2015). It is especially known as exchange rate strategy, but it can also be applied to fixed income. The measures used in this research for carry are:

- OAS
- yield-to-worst

For both measures it is expected that bonds with a high OAS and/or high-yield-to-worst have a high return.

4.3 Combination of Characteristics into a Single Factor

For every factor the different measures are combined into a single factor portfolio. First, for a given measure the individual assets are ranked, these ranks are standardized (z-scores). In theory all measures for a given factor should proxy for the same underlying factor. However, it could be that one measure seems act differently than the other measure(s). Because a priori it is not obvious which measure is best all measures are simply averaged.

Some assets are part of the investment universe of one measure but not in the investment universe of another measure, in that case the 'average' consists only of the measure that ranks this asset.

4.4 Portfolio Management Considerations

Mean-variance analysis introduced by Markowitz (1952) is only optimal under certain assumptions. In practice these assumptions usually do not hold for fixed income investing, therefore some important considerations are discussed in this section.

Long-Short vs Long-Only Portfolios

Multiple studies have empirically shown the benefits of factor investing. However, not all papers agree upon how to implement the factors, on the one hand some articles use a long-short portfolio, others use a long-only approach. It is possible to capture factor premia without taking short positions. However, if the short positions are smaller than the long positions, or even no short positions at all, the exposure to the market increases. In other words, fewer short positions lead to a higher correlation of the factors with the market. Blitz et al. (2014) empirically compare both approaches. The goal is to determine which approach is preferable under various conditions. They conclude that the long-only approach is in general a better approach when practical issues are taken into account. An example of a practical issue is a benchmark/portfolio constraint for the portfolio manager. It might be that the portfolio manager is not allowed to make large deviations from the benchmark weights. Another common portfolio constraint is that the portfolio managers are not allowed to take any short positions.

As mentioned before, liquidity is an important aspect of (fixed income) investing. Nowadays the bond market liquidity seems to be dried up.[8,9] Therefore, a portfolio consisting of only long positions seem to be more realistic.

[8]Turner, M. *A dramatic shift is taking place in bond trading*, available at: Business Insider

[9]Udland, M. *4 sentences explain why investors remain forever worried about bond market liquidity*, available at: Business Insider

Correlation across Factors

Different factors try to capture different aspects of return components. It is likely that some factors have a positive correlation and others have a negative correlation (especially in long-only portfolios, see section 4.4). This should be taken into consideration in the multi-factor portfolio construction procedure. Otherwise it might happen that some individual bonds are getting too much weight, while others are under-weighted compared to the theoretically optimal portfolio.

Deviation from Benchmark Constraints

A portfolio manager is compared to a benchmark, e.g. the (net) returns are compared. Also many portfolio managers are not allowed to take large deviations from the benchmark weight. In one of the final portfolios the investor is not allowed to deviate more 0.25% per constituent from the index.

Trading Costs

The implemented strategy determines every month a new portfolio. Therefore, transaction costs will be incurred. It is assumed that the turnover costs are 50 basis points for investment grade indices and 70 basis points for high-yield indices. For the index it is assumed that there is management fee of 25 basis points per year.

Investment Universe

Testing (factor) investing strategies is only relevant in an out-of-sample (OoS) framework. The implementations of the factor strategies for the backtest will be as follows, first determine at the end of each month the investment universe. The investment universe consists of the bonds that are this month as well as next month part of the index. The investor assumes that he knows the constituents of the index of the next month, in practice this assumption is met. The next step is to determine which bond should be held starting from the beginning of next period. This is based on the factors in the current period.

4.5 Single-Factor Portfolios

In this section the construction of a single-factor portfolio is described in detail. The construction is similar to Asness et al. (2015) and Houweling and Van Zundert (2015). This approach is based on the sorts used to create the factors in section 4.2. For every factor the corresponding investment universe is sorted based on the measure. The final portfolio is equally weighted top quintile (20%) of the investment universe.

4.6 Multi-Factor Portfolios

The ultimate goal of this research is to construct a multi-factor portfolio in an efficient way. In this section the different procedures used to construct multi-factor portfolios will be explained.

1/N Portfolios

In the previous section the methodology to construct a single-factor portfolio based on sorts is explained. Equal weighting the single-factor portfolios constructs the multi-factor portfolio. This portfolio does not take any of the portfolio management considerations in section 4.4 into account.

Historical Percentile Comparison

In asset pricing prices and expected returns are inversely related, when prices are low expected returns are high and when prices are high expected returns are low. Each factor (long-short) return is compared to its (recent) return history. The portfolio weight for a given factor is calculated as:

$$w_i = \frac{1 - \text{HistRank}_i}{\sum_{i=1}^{N}(1 - \text{HistRank}_i)}, \tag{6}$$

where N denotes the number of factors. $HistRank$ denotes the historical rank of the factor. That is the rank of the factor return at period t compared to the historical factor return over periods from $t-12$ to t. When the current factor return is higher than in the past more weight is given to this factor in period $t+1$. This method tries to time the individual factors returns. By doing this, the return of the multi-factor portfolio is expected to be higher.

Linear Optimization Problem

In the spirit of Israel et al. (2015) a linear optimization problem is set up. The objective function is to maximize the multi-factor portfolios exposures to the different factors. Some restrictions are made, such as the no shorting constraint, fully invested constraint and deviation from benchmark constraint.

The full optimization problem is:

$$\begin{aligned}
&\max \sum_{i=1}^{I} w_i \text{COMBO}_i \\
&\text{subject to} \\
&w'\iota = 1 \\
&|w_i - b_i| \leq 0.25\%, \forall i \\
&w_i \geq 0,\ i = 1, \ldots, N
\end{aligned} \tag{7}$$

Where $COMBO$ is the equal weighted exposure to all factors. Similar to Israel et al. (2015) every security is ranked for each of the five factors. Then the average 'multi-factor exposure' is calculated by simply averaging the ranks to the five individual factors. The objective function maximizes the 'multi-factor exposure' of the entire portfolio.

The scaled benchmark weight is denoted by b. The benchmark weights are scaled because they do not sum to one. Some bonds were deleted because they do not meet the restriction (e.g. OAS $>$ 1000). Another reason why some are dropped is because they are not part of the index in the next period. N is the number of constituents for a given month. The first constraint makes sure that the portfolio is fully invested. The second constraint imposes a restriction of the deviation from the benchmark weight. The last constraint imposes that it is not possible to have any short positions.

The set up of the optimization problem makes sure that the portfolio constraints of section 4.4 are met. Also, the correlation between the factors is implicitly taken into consideration trough the combination of the ranks. Because this methodology is computationally intensive this will only be applied to the European high-yield index.

1/N Decile Portfolios

This method sorts the securities based on their equal weighted exposure to all factors (i.e. COMBO of section 4.6). Then the 20% with the highest exposure (i.e. 'best' average rank) will be used in the top portfolio. The bottom portfolio is constructed in the opposite way.

4.7 Factor Performance

To be able to compare the performance of the different strategies and the benchmark some performance measures are calculated. The specific measures are explained in the next sections.

Sharpe Ratio

The Sharpe Ratio introduced by Sharpe (1994) is a well-known performance measure in the finance industry. It measures the excess return per unit of risk (volatility). The formula is:

$$S = \frac{E(R - R_b)}{\sqrt{Var(R - R_b)}} \tag{8}$$

Where S denotes the Sharpe ratio, R the return of the asset or portfolio and R_b denotes the return of the benchmark.

Depending on what the investor wants to measure different combinations of R and R_b can (should) be chosen. In this paper the return over duration matched government bond is used as excess return, both for the factor portfolios and the indices. The geometric average return will be used instead of the arithmetic average to give a more realistic estimate of the return of the strategy.

Maximum Drawdown

Another well-known performance measure in finance is the maximum drawdown. There are two aspects of the drawdown, the magnitude and the duration. The definition of the magnitude is the peak-to-trough decline of an investment, usually calculated as a percentage of the peak:

$$\text{MDD} = \frac{P - L}{P} \tag{9}$$

Where P denotes the highest value in cumulative wealth before the largest drop in cumulative wealth. L is the lowest value in cumulative wealth before a new high is encountered. The duration of a drawdown is the length of the period between when the peak is established and when a new higher value is established.

Time-Series Regression

To test the outperformance of the factors the following model will be estimated:

$$r_t = \alpha + \beta RM_t + \epsilon_t \tag{10}$$

Where r_t is the return of the multi-factor strategy and RM_t denotes the market return. An indication of outperformance is that α is positive and significantly different from zero.

Significance of Factor Risk Premium

The factor risk premium can be calculated as the mean of the factor return (top portfolio minus bottom portfolio). To test if the factor risk premium is significantly different from zero a t-test can be conducted. It is standard in practice to compare a portfolio manager to a benchmark. In this research the investment universe consists of the constituents of large (general) corporate bond index. There are restrictions on going short, duration, credit ratings, et cetera. Therefore, in this research the index itself seems a perfect benchmark.

Fraction of Positive Returns

The 'top' portfolio is expected to outperform the 'bottom' portfolio. An intuitive measure for outperformance is the percentage of time the return of the top portfolio is higher than the return of the bottom portfolio:

$$\%Pos.Rtn. = \frac{\sum_{t=1}^{T} I_{[r_{top_t} - r_{bottom_t} > 0]}}{T} \tag{11}$$

Where $I_{[A]}$ is an indicator, it returns 1 if statement A is true and T denotes the number of observations.

Tracking Error

The tracking error indicates the deviation of the investors portfolio compared to the index (benchmark). The tracking error is measured as follows:

$$TE = \sqrt{Var(r_p - r_b)} \tag{12}$$

Where $r_p - r_b$ is the difference between the portfolio return and the benchmark return.

5 Performance of Factor Portfolios

The results of the research are presented in the following sections. First, the main findings of this paper are presented. Then the results are shown per strategy. More detailed results can be found in the Appendix.

5.1 Main Results of Bottom Up Credit Investing

Value

In general value performs very well. All implementations of value perform better than the index on absolute returns as well as risk-adjusted returns for the European high-yield, US high-yield and US investment grade indices. For the European investment grade index the second implementation of value performs worse than the index.

The first implementation performs better on absolute and risk-adjusted return than the second implementation for the European investment grade, US high-yield and US investment grade indices. Combining the two measures does not improve the performance in general. Only for the European high-yield index the combination of the two measures improves the performance. The Sharpe ratio of the combination for the US high-yield index is also higher than both individual measures.

For all indices is the Sharpe ratio for the combined measure higher than for the index. The value strategy increases the Sharpe ratio with 51% for the European high-yield index, 9% for the European investment grade, 91% for the US high-yield index and 41% for the US investment grade index.

If transaction costs are incurred only the first implementation for US investment grade index is able to perform better than the index. The combined measure performs worse for all indices. For the European high-yield index is the Sharpe ratio 23% lower than the index, for the US high-yield index is the Sharpe ratio 10% lower and the Sharpe ratio is 33% lower for the US investment grade index. The return for the European investment grade turns negative due to the transaction costs.

So, concluding the performance of the value strategy: there is a lot of potential for this strategy. However, limiting the turnover is crucial if asset managers want to implement this strategy in practice.

Size

The performance of the size strategy is mixed. This strategy 'behaves' quite different for each index. For the US investment grade index is the performance good. All implementations and the combination perform better than the index on absolute as well as risk-adjusted returns. The absolute return increases by 8% for the combination and the Sharpe ratio increases by 91%. For the second implementation the Sharpe ratio increases by 164%. The second implementation and the combination are also able to perform better than the index when transaction costs are incurred. The Sharpe ratios after transaction costs are 0.18 and 0.20 for the second implementation and the combination, respectively, while the index has a Sharpe ratio of 0.15.

All implementations perform better than the index in terms of Sharpe ratio for the US high-yield index, but none of them perform better in terms of absolute returns. The Sharpe ratios for the second implementation and the combination are higher than the index for both European indices and the absolute returns are lower. The combination achieves a higher absolute return than the index (1.18 relative to 1.17) for the European investment grade index.

Some other notable results regarding the performance of size are:

- the second implementation always performs best based on risk-adjusted returns and maximum drawdown, but worst on absolute returns
- combining the measures does not add any performance
- this strategy performs bad based on absolute returns for both high-yield indices
- the decrease in performance after transaction costs is much smaller compared to the value strategy (small companies tend to remain small)
- the performance of the first (size of the bond issue) and third (size of the bond issuer) strategy are very similar

Depending on the preferences of the investor this strategy might be beneficial to include in his or hers overall portfolio. However, more care should be taken than for the value strategy. Again, limiting turnover is crucial for an implementation in the real world.

Momentum

The literature has documented that investment grade bonds do not have momentum effects, either they are insignificant or there is even a reversal effect (Jostova et al., 2012; Pospisil and Zhang, 2010; Houweling and Van Zundert, 2015). However, high-yield bonds do contain a momentum effect.

This research does confirm these results with respect to investment grade bonds. The momentum strategy can not distinguish between 'winner' and 'loser' bonds in the European investment grade index. The performances of all implementations (top and bottom portfolios) are very close to the index in terms of absolute and risk-adjusted returns. In the US investment grade index there is a small reversal effect to be noticed. For example, the bottom portfolio of the second implementation (12-month momentum) achieves cumulative return of 29%, the index achieves a return of 19% and the top portfolio achieves 8%.

The results of the literature regarding high-yield bonds can not be confirmed. Momentum does not perform well for the European as well as the US high-yield indices. None on the implementations is able to outperform the index on absolute or risk-adjusted returns. The absolute return of the momentum strategy for the European high-yield index is roughly 30% lower than the index and for the US high-yield index the return is roughly 25% lower. The decreases of the Sharpe ratios are about the same.

Obviously, the performance after transcription costs are incorporated is even worse. The returns for both investment grade indices even turn negative. An investor should not invest in the momentum strategy based on this research.

Carry

The carry strategy achieves very high absolute returns. All implementations and the combination have a higher absolute return than the corresponding index. The absolute returns for the first implementation are always higher than for the second implementation. The increase in absolute returns for the first implementation relative to the index is more than 200% for the high-yield indices, the increase for the European investment grade index is 30% and 60% for the US investment grade index.

The performance of the carry strategy is also very good based on the risk-adjusted metric. The Sharpe ratios for both implementations and the combination are higher than the index for the European high-yield, US high-yield and US investment grade indices. The Sharpe ratios for first implementation and the combination are equal to the index for the European investment grade index. Again, the first implementation performs better than the second implementation for all indices. The Sharpe ratio of the first implementation is 51% higher than the index for European high yield index and the Sharpe ratio is the same as the index for the European investment grade index. The US high-yield index has an improvement of 85% and the US investment grade index has an improvement of 132%.

The relatively low Sharpe ratio compared to the others for the European investment grade can be explained by the extremely bad performance during the financial crisis. The cumulative returns for the top portfolios drop far below the index, hence the maximum drawdown of this strategy is also very high. During the financial crisis investors sold their more risky assets and moved into more safe assets, this is known as the 'flight-to-quality'. This effect can be also be seen for the US investment grade index. The high-yield indices are much less affected by the flight-to-quality effect.

The combination of both measures marginally improves the performance for the European high-yield indices. For the other indices the first implementation performs better than the combination. So, in general a carry investor is better of with the first implementation.

The carry strategy is able to outperform the index after incorporating transaction costs for both high-yield indices. The Sharpe ratio with transaction costs for the first implementation for the European high-yield index is 1.21, while the index has a Sharpe ratio of 1.09. For the US high-yield the carry strategy achieves a Sharpe ratio 0.98, while the index has a Sharpe ratio of 0.77. The first implementation has a higher Sharpe ratio than the index for the US investment grade index and all other implementations have lower Sharpe ratios.

This research confirms the work of Koijen et al. (2015). An investor should allocate part of their portfolio to the carry strategy.

Defensive

The second implementation of defensive is doing what it is expected to be doing: low returns, but even lower risk. This implementation is therefore able to outperform the index for the European high-yield, US high-yield and US investment grade index in terms of risk-adjusted return. The increases in Sharpe ratios are 15%, 49% and 82% respectively, for the European high-yield, US high-yield and US investment grade indices. The Sharpe ratio for the European investment grade index is 26% lower than the index. This implementation is not able to outperform the index after transaction costs are incorporated. The Sharpe ratios for the high-yield indices decrease with roughly 40% and the returns for the investment grade indices turn negative. The reason for that is this strategy buys short dated bonds, therefore, a lot of reinvestments are needed.

The first and third implementations are not performing as expected. The bottom portfolios outperform the top portfolios in terms of absolute as well as risk-adjusted. This is surprising, because this strategy intends to achieve high risk-adjusted returns. Even worse, the bottom portfolio for the third implementation outperforms the index in terms of Sharpe for three out of the four indices (European investment grade: 0.38 relative to 0.34, US high yield: 1.07 relative 0.81 and US investment grade: 0.48 relative to 0.22). For the US investment grade index the outperformance is still there if transaction costs are taken into account.

The combination of the three measures does not add any performance. This is due to the bad performance of the first and third measure.

Summarising the results of defensive yields: the second implementation is a good strategy in theory for an investor who is (mainly) concerned with capital preservation. However, the transaction costs of this strategy are too high to implement this strategy in practice.

Multi-Factor

The multi-factor portfolios yield in general a good performance. The multi-factor portfolio outperforms the index on absolute as well as risk-adjusted returns for both US indices. The Sharpe ratio for the multi-factor portfolio of the US high-yield index is 12% higher than the Sharpe ratio of the index and the increase is 13% for the US investment grade index. The absolute returns increase with 37% and 82%, respectively. The performance for the European indices is less clear-cut. The Sharpe ratio for the European high-yield index is higher (20%), but the absolute return is lower (-4%). For the European investment grade is the Sharpe ratio lower (-6%), but the absolute return is higher (4%). None of the multi-factor portfolios have a higher Sharpe ratio than the index when transaction costs are incurred.

The multi-factor decile portfolio outperforms the index on absolute and risk-adjusted returns for all indices. The absolute returns increase by 54%, 11%, 60% and 33%, respectively for the European high-yield, European investment grade, US high-yield and US investment grade indices. Furthermore, the Sharpe ratios increase by 50%, 32%, 85% and 195%, respectively for the European high-yield, European investment grade, US high-yield and US investment grade indices. The performance decreases when transaction costs are incurred. Only for the US high-yield is the risk-adjusted return still higher than the index (0.83 relative to 0.77). The Sharpe ratio for the European high-yield index is 6% lower and the Sharpe ratios for both investment grade indices turn negative.

Multi-factor investing for credits seems to be a field with a lot of potential. This strategy performs better than the index. However, implementing this strategy is real life is not easy. When transaction costs are incurred the performance drops below the level of the index. Therefore, limiting turnover is key for an investor that wants to implement this strategy in practice.

5.2 Value

Figures 6, 7, 8 and 9 show the cumulative wealth obtained for the value strategy for the different indices. Tables 8, 9, 10 and 11 show the final obtained cumulative wealth, Sharpe ratio, Sharpe ratio with transaction costs and the maximum drawdown.

The first implementation underperforms until the financial crisis for the European high-yield index in terms of absolute returns. This might also explain the relatively low maximum drawdown. This implementation starts to outperform the index after the European sovereign debt crisis of 2012. The same pattern can be seen for the US high-yield index. The first implementation lags behind the second implementation until the financial crisis of 2008, although to a lesser extent than for the European high-yield index. The first implementation performs better the second from the financial crisis onwards. For both investment grade indices the first implementation has always a higher cumulative wealth than the second implementation. Notable is the bad performance of this strategy compared to the index for both investment grade indices during the financial crisis. The cumulative wealth for second implementation for the European investment grade index is roughly 20% lower than the index. The influence of the financial crisis on the performance for the high-yield indices seems to be smaller.

The first implementation has a better performance on a risk-adjusted basis for both investment grade indices and for the US high-yield index, while the second implementation performs better for the European high-yield index. The combination of the two measures improves the performance compared to the individual implementations for both high-yield indices. The combination deteriorates the performance compared to the first implementation for the investment grade indices.

The value measures of Israel et al. (2015) and Houweling and Van Zundert (2015) seem to be quite similar, that is, both try to determine the 'correct' spread (i.e. OAS and asset swap spread) and compare it to the actual spread. The dependent variables are also quite similar, both use credit rating and maturity and duration are related. However, the performance is different. This is most likely due to the last dependent variable, Israel et al. (2015) use the historical excess return volatility, while Houweling and Van Zundert (2015) use the change in asset swap spread. The former is the second moment, while the latter can be seen as the first moment. So, for investment grade bonds the second moment is more important to determine the cheap bonds, for high-yield bonds the combination of first and second moment seems to determine the cheap bonds best. A possible explanation is that in the investment grade market investors are much more concerned with the downside, because the upside is capped. The overall economy plays a big part in the analysis for an investment grade bond. At the same time many high-yield portfolio managers think that high-yield bonds should be analysed from an equity analyst's perspective. Unlike the investment grade market the return in the high-yield market has much more upside potential. Therefore, the return might play a bigger role in determining the cheapness of a bond.

The performance of this strategy decreases drastically when transaction costs are taken into account. There is only one portfolio that is still able to outperform the index, namely the first implementation for the US investment grade index. The Sharpe ratio for this portfolio decreases by 70%. This is no exception, the Sharpe ratio for combined implementation for the US investment grade index decreases by 80%.

Tables 32 until 67 provide the additional results (such as long-short performances, tracking errors, correlation matrices and overviews of rating, industry, type, OAS, spread and modified duration exposures). The long-short value returns are significantly different from zero for the European high-yield and both US indices. Also, about three quarters of the time the returns are positive. Some of the correlations for the long-short portfolios are (quite) high in absolute terms. All correlation between the long-short value portfolio and the index are higher than 0.50, this indicates that there are possibilities to diversify the portfolio. However, the diversification benefits are limited. The correlations for the long-only portfolio are all above 0.69. The value portfolio overweighs safer bonds (better credit ratings), while at the same time overweighting bonds with a higher OAS. Indicating that that the credit spread is too high for bonds with a higher credit spread. This strategy overweighs bonds in the banking, insurance and financial services industries. This is most likely due to the financial crisis. During this period the price of the debt (and equity) of financial firms dropped substantially.

This research confirms previous work on the value factor in the corporate bond market Houweling and Van Zundert (2015) and Correia et al. (2012). The increase in performance for both US indices is in line with Houweling and Van Zundert (2015).

5.3 Size

Figures 10, 11, 12 and 13 show the cumulative wealth obtained for the size strategy, Tables 12, 13, 14 and 15 show the performance measures.

There are couple of results for the size strategy. First, the Sharpe ratios for the second implementation (and the combination) are higher than the index for all indices. However, this strategy does not achieve high absolute returns. This implementation only outperforms the index for the US investment grade index (1.21 relative to 1.19). The second implementation targets illiquid bonds, because investors tend to hold older bonds till maturity. Also, the pull-to-par effect for older bonds is stronger than for younger bonds.

Second, as mentioned before, the performances of the first and third strategy are very similar.

This is because small issuers tend to issue small bonds.

Third, the decision to combine size and liquidity is because the size factor might pick up some liquidity premium. The reason for that is that small bonds (either measured by issue or issuer) tend to have lower liquidity. Thus, the first and third implementations target different bonds than the second. This might explain why their combination does not add any performance.

Fourth, the size of a bond (either measured by issue or issuer) does not yield any return for the European indices. But, for the US indices is does yield a return. A possible explanation might be that European firms have a larger portion of their debt in bank loans (compared to bonds) than US firms. So that, even the 'larger' European bond issues (and issuers) are not large enough to warrant a size premium.

None of the long-short size returns are significantly different from zero. The t-statistics range from 0.77 to 1.72, while the fraction of positive returns range between 0.51 and 0.58. The correlations for the long-short returns show a similar pattern for the different indices. The correlations are negative for the index, carry and value, but positive for defensive and momentum. The correlations for the long-only portfolio are all above 0.78. The size strategy tends to overweight less safe bonds (lower credit ratings). It tends to overweight bonds with a lower modified and spread duration. This is most likely due to the influence of the second implementation. Interest and spread changes have less influence on bonds with a short time to maturity vis-à-vis bonds with a long time to maturity.

This research confirms the results of Houweling and Van Zundert (2015) to some extent. Indeed, the Sharpe ratios for third implementation (the measure of Houweling and Van Zundert (2015)) increase. However, the increase is much smaller, this paper finds an increase of 7% for the US high yield index and 18% for the US investment grade index. Houweling and Van Zundert (2015) report increases of 178% and 250%, respectively.

5.4 Momentum

The momentum strategy does not perform well for the high-yield indices, as can be seen in Figures 14 and 16 and in Tables 16 and 18. Already before the financial crisis this strategy lags behind the corresponding index. After the financial crisis the difference in performance increases further. This result is surprising and can not be easily explained. A possible explanation is that the momentum strategy picks up the pull-to-par effect of older bonds. So, it mixes positive (negative) returns due to the 'expected' appreciations (depreciations) in the price of a bond and the 'true' momentum effect. A possible solution is to consider the momentum strategy only for young bonds with a long time to maturity. Another less likely possible explanation is that due to the need of historical data for this strategy the investment universe becomes too small to make meaningful distinctions between the bonds. This is especially relevant for the European high-yield index, since the number of constituents is relatively small (see Figure 1). Also, the number of constituents of the US high-yield index dropped substantially during the financial crisis.

Table 17 provides the performance measures of the momentum strategy for the European investment grade index. Most notable is that the difference between the different top and bottom portfolios are practically negligible. This indicates that the momentum factor is not relevant in explaining returns in the cross-section. The only time that there is a difference between the top and bottom portfolios is during the height of the financial crisis. All bottom portfolios experience a sharp decline in returns. This can be seen in Figure 15. The bottom portfolios recover quite quickly and it is again hard to distinguish between the top and bottom portfolios.

The momentum strategy for the US investment grade index contains a reversal effect. Figure 17 and Table 19 shows that the bottom portfolio outperforms the top portfolio. Similar as to the European investment grade index the bottom portfolios experience large decreases in performance during the financial crisis. The cumulative wealth for the bottom portfolios are lower than for the top portfolios, again the bottom portfolios recover quickly after the crisis.

There is no indication that combining six and twelve-month momentum improves performance. Transaction costs decrease the bad performance of momentum even further. The Sharpe ratios for the investment grade indices decrease with roughly 50% to 60%.

The bad performance of momentum is also reflected in the long-short portfolios. None of the long-short returns are significantly different from zero for the European indices and the

US high yield index. The fractions of positive returns are all very close to 50%. The US investment grade index only has 37% of the time a positive return. This is another indication for the reversal effect. The correlations for the long-only portfolio are all close to one. The momentum strategy tends to overweight low and high credit ratings and underweight the 'middle' ratings for the high-yield indices. For the investment grade indices it tends to overweight riskier bonds (lower credit ratings). The strategy tends to overweight higher modified and spread durations. Bonds with higher modified and spread durations show larger outcomes and hence have a tendency for the extremes (either positive or negative returns).

The literature documents potential for this strategy for high-yield bonds. This paper does not confirm this potential. Therefore, based on this research an investor should not invest in the momentum strategy.

5.5 Carry

As mentioned before, the carry strategy performs very well based on absolute (see Figures 18, 19, 20 and 21) as well as risk-adjusted returns (see Tables 20, 21, 22 and 23). The performance of this strategy is still better than the index after transaction costs are incurred.

Two notable observations can be made about the performance of the carry strategy. First, the flight-to-quality effect during the global financial crisis can easily be observed for both investment grade indices. But, the flight-to-quality effect is much smaller for the high-yield indices. Also, the European sovereign debt crisis is clearly visible for the European investment grade index, but only a small 'glitch' for the European high-yield index. A possible explanation is that carry investors in high-yield markets plainly accepted the risks involved. This could be either by choice or they were forced to, because there were no counterparties to sell to.

The second notable observation is the very similar performance of the two different implementations until the financial crisis. The first implementation starts outperforming the second implementation only after the financial crisis. This surprising result can not be explained. It is left for further research to determine why the performance of the two implementations are similar before the financial crisis, but different after the crisis. This likely influences the performance of the combination of the two measures. But, without an explanation it is impossible to analyse why the combination adds performance for the European high-yield, but it does not add performance for the other indices.

The returns of the long-short portfolios are all significantly different from zero. The t-statistics for both high-yield indices are larger than 9. The high-yield indices have at least 81% of the time a positive return, while the investment grade indices have at least 65% of the time a positive return. The correlations for the long-short portfolio show a similar pattern for the all indices. The long-short carry strategy has a positive correlation with value strategy, but a negative correlation with defensive, size and momentum. The long-only correlations are all quite high. Obviously, the carry strategy overweighs bonds with a higher OAS. Also, it overweighs riskier (lower credit ratings) bonds. The strategy is fairly neutral with respect to industry, type, modified and spread durations. Concluding this section, this is a useful strategy for investors to add to their portfolio.

5.6 Defensive

Figures 22, 23, 24 and 25 show the cumulative wealth for the different indices for the defensive strategy. The bottom portfolios of the first and third implementations have higher a final cumulative wealth than the corresponding top portfolios for all indices. However, these portfolios endure large drawdowns during the financial crisis of 2008. The top portfolios of the second implementation are barely impacted by the crisis.

Tables 24, 25, 26 and 27 show the performance measures. As mentioned above, the bottom portfolios of the first and third implementation perform well on the basis of absolute returns. The absolute return for the bottom portfolio of the first implementation for the European high yield index is almost double that of the index. However, adjusting the returns for their risk deteriorates the performance. This implementation only outperforms the US high-yield index based on Sharpe ratios, but the margin by which it outperforms is small (0.82 relative to 0.81). The similarity of the first measure of defensive (DTS) and the first measure of carry (OAS) can be noted. However, for defensive the top portfolios are the bonds with a low DTS, while for carry the top portfolios consists of bonds with a high OAS. Therefore, the performance of the bottom portfolio of the first measure of defensive can be compared to the top portfolio of the first implementation of carry. For all indices the top portfolio of carry performs better on risk-adjusted and absolute returns. Hence, DTS can be seen as a worse proxy for carry than OAS.

A possible explanation why the third implementation does not yield the expected performance is that not all changes in OAS are the same. For example, negative changes (current OAS is lower than previous OAS) imply a lower credit risk, while positive changes imply a higher credit risk. Therefore, it might be beneficial for the defensive strategy to apply the volatility of the change of OAS only for negative changes in OAS. This can be compared to the use of lower partial moments in equities.

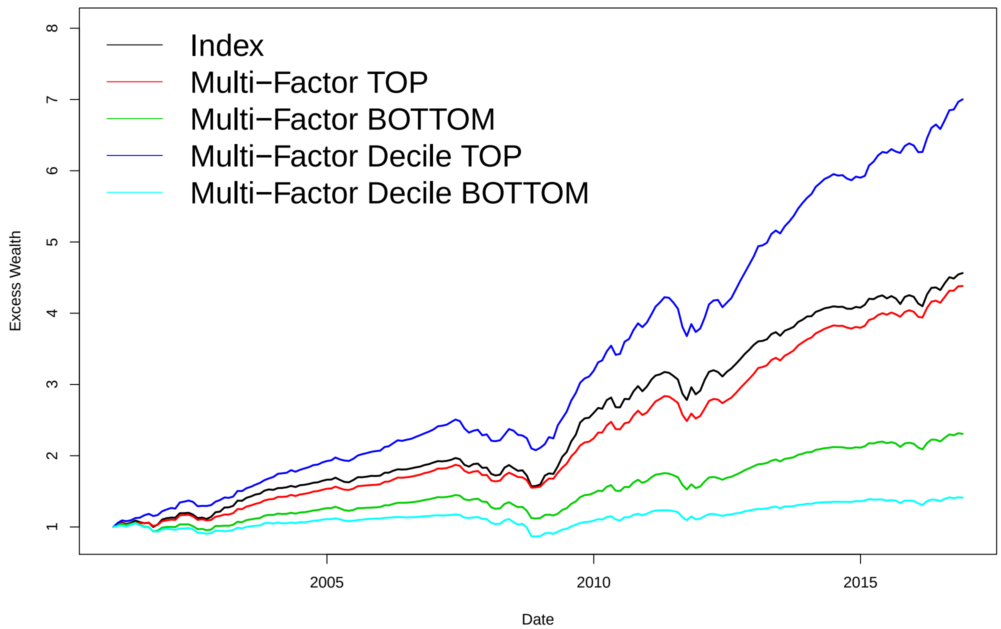
The bad performance of the top portfolio can also be seen in the long-short returns. The top portfolio has roughly 40% of the time a higher return than the bottom portfolio. The long-short correlations are similar for all indices, defensive has a negative correlation with value and carry and defensive has a positive correlation with size and momentum. The defensive strategy overweighs safer bonds (better credit ratings). Also, it is overweight on more senior debt. This is more pronounced for the European indices than for the US indices. Finally, it overweighs bonds with a low OAS, low spread duration and low modified duration.

This research confirms that the defensive measure of Houweling and Van Zundert (2015) has a better risk-adjusted return than the index for the US indices. However, the increase in performance of this paper is much smaller than the increase in performance of Houweling and Van Zundert (2015).

5.7 Multi-Factor

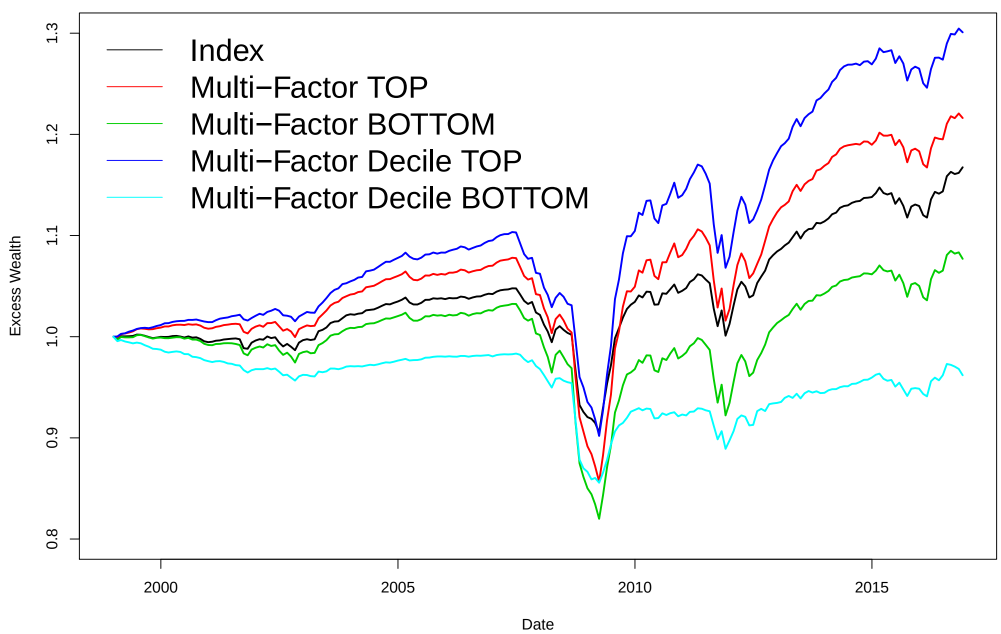
Figures 2, 3, 4 and 5 show the cumulative wealth obtained form the multi-factor and multi-factor decile strategies, Figures 26, 27, 28, 29 and 30 show the cumulative obtained from the other multi-factor strategies. Tables 4, 5, 6 and 7 show the performance measures.

Figure 2: Cumulative Wealth Multi-Factor Strategies EU HY



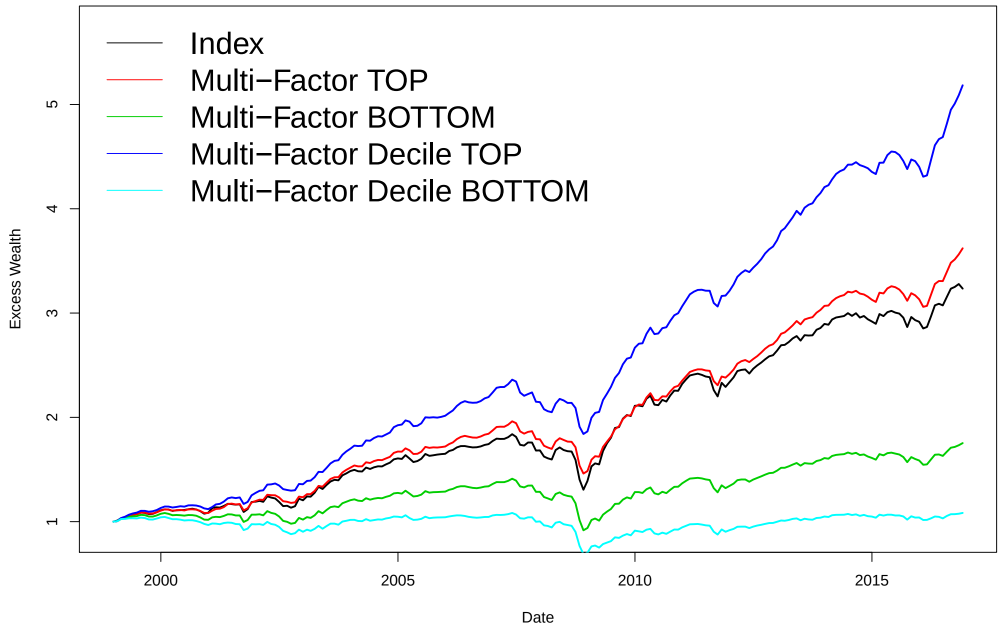
Note: this figure shows the cumulative wealth obtained from the multi-factor strategies in the EU HY space.

Figure 3: Cumulative Wealth Multi-Factor Strategies EU IG



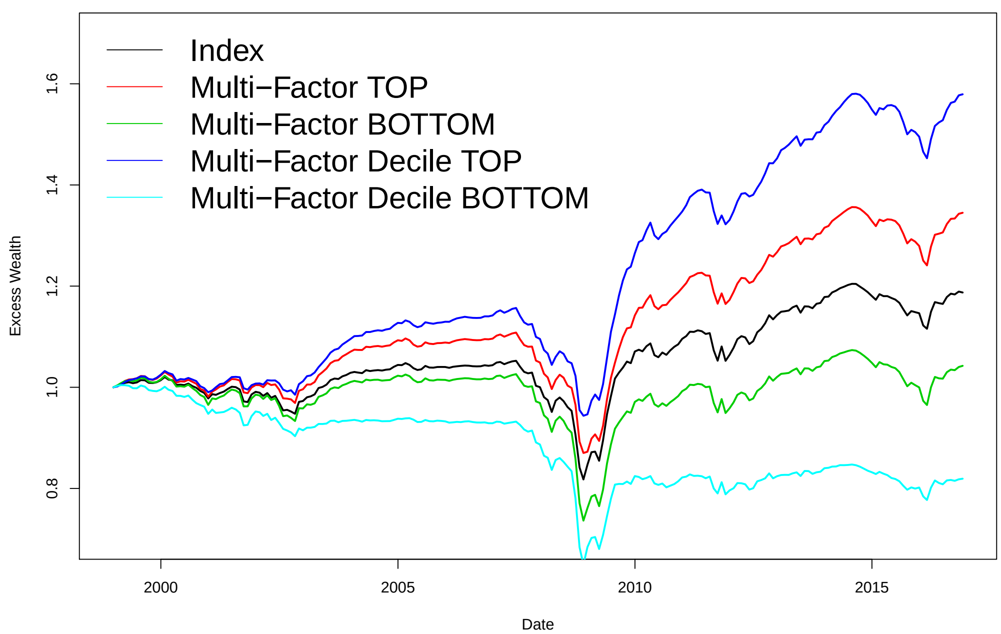
Note: this figure shows the cumulative wealth obtained from the multi-factor strategies in the EU IG space.

Figure 4: Cumulative Wealth Multi-Factor Strategies US HY



Note: this figure shows the cumulative wealth obtained from the multi-factor strategies in the US HY space.

Figure 5: Cumulative Wealth Multi-Factor Strategies US IG



Note: this figure shows the cumulative wealth obtained from the multi-factor strategies in the US IG space.

Table 4: Performance Multi-Factor Strategies EU HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	4.56	1.13	1.09	20.36
Multi-Factor TOP	4.38	1.36	0.82	12.41
Multi-Factor BOTTOM	2.31	0.72	0.23	22.90
Multi-Factor Decile TOP	7.00	1.69	1.03	12.97
Multi-Factor Decile BOTTOM	1.41	0.31	-0.28	26.42
Multi-Factor HPC TOP	4.01	1.29	0.47	14.80
Multi-Factor HPC BOTTOM	2.31	0.75	-0.03	24.59
Multi-Factor LOP TOP	3.30	0.99	0.67	26.68

Note: this table contains the performance measures for the multi-factor strategies in the EU HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'. The Sharpe ratio of the equal weighted index is 1.10. The HPC strategy starts investing later than the other strategies due to the need of more historical data. The corresponding Sharpe ratio for the index is 1.15.

Table 5: Performance Multi-Factor Strategies EU IG

	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.17	0.34	0.22	13.60
Multi-Factor TOP	1.22	0.32	-0.15	20.54
Multi-Factor BOTTOM	1.08	0.13	-0.43	20.57
Multi-Factor Decile TOP	1.30	0.45	-0.32	18.27
Multi-Factor Decile BOTTOM	0.96	-0.10	-1.35	14.50
Multi-Factor HPC TOP	1.21	0.30	-0.75	20.81
Multi-Factor HPC BOTTOM	1.08	0.12	-1.02	20.81

Note: this table contains the performance measures for the multi-factor strategies in the EU IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'. The Sharpe ratio of the equal weighted index is 0.29. The HPC strategy starts investing later than the other strategies due to the need of more historical data. The corresponding Sharpe ratio for the index is 0.36.

Table 6: Performance Multi-Factor Strategies US HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	3.23	0.81	0.77	29.37
Multi-Factor TOP	3.62	1.11	0.61	25.76
Multi-Factor BOTTOM	1.75	0.40	-0.04	35.49
Multi-Factor Decile TOP	5.18	1.50	0.83	22.23
Multi-Factor Decile BOTTOM	1.08	0.06	-0.46	36.87
Multi-Factor HPC TOP	3.28	1.00	0.19	27.61
Multi-Factor HPC BOTTOM	1.63	0.34	-0.34	37.15

Note: this table contains the performance measures for the multi-factor strategies in the US HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'. The Sharpe ratio of the equal weighted index is 0.82. The HPC strategy starts investing later than the other strategies due to the need of more historical data. The corresponding Sharpe ratio for the index is 0.76.

Table 7: Performance Multi-Factor Strategies US IG

	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.19	0.22	0.15	22.54
Multi-Factor TOP	1.35	0.40	0.02	21.75
Multi-Factor BOTTOM	1.04	0.05	-0.29	28.55
Multi-Factor Decile TOP	1.58	0.65	0.01	18.68
Multi-Factor Decile BOTTOM	0.82	-0.21	-0.74	35.34
Multi-Factor HPC TOP	1.31	0.36	-0.43	21.77
Multi-Factor HPC BOTTOM	1.03	0.03	-0.66	28.49

Note: this table contains the performance measures for the multi-factor strategies in the US IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'. The Sharpe ratio of the equal weighted index is 0.18. The HPC strategy starts investing later than the other strategies due to the need of more historical data. The corresponding Sharpe ratio for the index is 0.21.

As mentioned before, the multi-factor and multi-factor decile portfolios perform generally very well for all indices. The cumulative return of the multi-factor decile portfolio is at all times higher than the multi-factor portfolio. Also, the Sharpe ratios of all multi-factor decile portfolios are higher than the multi-factor portfolios.

Factor timing seems not to be possible, for all indices the absolute returns as well as the Sharpe ratios decrease compared to the 'normal' multi-factor portfolio. Transaction costs lower the performance even further due to the high turnover of this strategy. These results confirm that factor timing is (very) difficult in practice. The linear optimization problem by Israel et al. (2015) does not work very well for the European high-yield index. The absolute return and the risk-adjusted return are lower than the 'normal' multi-factor portfolio.

Tables 28, 29, 30 and 31 show the results of the time-series regressions. The results confirm the results of the performance measures. The long-only (and long-short) multi-factor (decile) portfolios show in general an outperformance compared to the index. All intercepts (alphas) are significantly positive, except for the long-only multi-factor portfolio for the European investment grade index. The market returns (betas) have a significant positive influence on the return for the long-only portfolios. Notable are the high values of R^2. So, although active choices are made to deviate from the index, by far most of the variation in the multi-factor (decile) portfolio returns are due to the variation of returns of the index itself. Also notable are the large exposures to the market for the long-only multi-factor and multi-factor decile portfolio for the European investment grade index. This explains why the outperformance in terms of Sharpe ratios of the multi-factor portfolios compared to the index is relatively small for the European investment grade index. Basically, the multi-factor portfolios are leveraging the index with roughly 30%. All betas for the US indices are significantly negative. Theoretically, this influence should be zero. Hence, the multi-factor portfolio is not completely market neutral. The market return has a small, but significantly, positive influence of the long-short multi-factor portfolio for the European high-yield index, but the market return is not significantly different from zero for the long-short multi-factor decile portfolio. The market return has no significantly influence on the long-short multi-factor portfolio return for the European investment grade index, while it has a significant positive impact for the long-short multi-factor decile portfolio. The last notable observation regarding the time-series regressions is the similar numbers (in terms of magnitude) for the long-only multi-factor and multi-factor decile portfolios for both high-yield indices. So although, there might be slight differences in the performance of individual factors, but on the multi-factor level the performances are very similar.

All multi-factor long-short returns are significantly different from zero. Also, at least 73% of the time the return is positive. The multi-factor portfolio is neutral with respect to credit rating, industry, type and OAS. It slightly overweighs bonds with a lower spread and modified durations. The multi-factor decile portfolio overweighs bonds that have a lower credit rating (riskier bonds), higher OAS, lower spread duration and lower modified duration.

These results confirm previous work on multi-factor investing in the corporate bond market. Similar as to Houweling and Van Zundert (2015) and Israel et al. (2015) this paper finds that multi-factor portfolios generally improve the risk-adjusted returns compared to the benchmark. However, when transaction costs are incurred the outperformance vanishes. Therefore, is it important for an investor to lower the turnover of this strategy to make it feasible in practice.

6 Conclusion

This paper builds on the work of Houweling and Van Zundert (2015), Israel et al. (2015) and Asness et al. (2015). Each of these papers describes a method to obtain a multi-factor credit portfolio. All portfolio construction procedures use one measure per factor. The next step is to combine the multiple factors into one multi-factor portfolio. This is usually done by simple averaging.

The first obtained result of this paper is that different implementations of the same factor lead sometimes to very different performance. Also, the same implementation for a factor for a different index could sometimes yield different results. Combining different measures for a given factor could be beneficial, however, the investor should be wary which measures to combine. Hence, investment solutions should be tailored for each investor.

Secondly, this paper provides results that multi-factor decile portfolio and the 'normal' multi-factor portfolio outperform the index. The multi-factor decile portfolios are more 'concentrated' than the 'normal' multi-factor portfolio. The portfolio construction procedure of the decile portfolio makes sure that proven factors do not work against each other in the multi-factor portfolio. Also, there are fewer bonds in the multi-factor decile portfolio compared to the 'normal' multi-factor portfolio.

Finally, this paper provides results for the European market next to the US market. The correlations between factor returns can sometimes differ for the different indices. Therefore, optimizing the factor definitions as well as the portfolio construction procedure should be done for the individual indices. This is probably due to the segregation of the markets. Also, they have a different investor base, both between investment grade and high-yield and for the US and Europe.

To conclude, allocating to factors instead of a market capitalization weighted index improves the performance of the portfolio before transaction costs. This research implies that asset managers (and all other investors) in theory should allocate some part of their portfolio to factors.

6.1 Discussion of Research

This report shows that the performance of investing in the corporate bond market can be improved. There are a couple of things further research could take into account.

Inherent to factor investing are the higher transaction costs than for following an index. In this research no restrictions are made for the turnover of a portfolio. There are two potential solutions for lowering the turnover for future research. First, the overlapping portfolio methodology of Jegadeesh and Titman (1993) could be used. Second, this research immediately sells a bond when it is no longer part of the top quintile. This hard 'rule' can be relaxed, for example, only sell the bond when if it has been of out of the top quintile for three months.

The second possible extension is on the fundamental side. This paper takes a long-only position in the corporate bond market, because of the restrictions and difficulties of short shelling. If the investor would like to be market neutral one could think of implementing positions in the credit default swap (CDS) market. For example, by selling a protection (CDS) with a five-year maturity. The CDS market is a liquid alternative to investing in credit markets.

Another possible extension is in the used data. In this research fairly general information is used. Adding (more) accounting and equity data could improve the measurements for the factors. Also, daily data is available for the indices, including this information might improve the estimates of the factors. Also, it is possible to select only one per issuer with the methodology of Houweling and Van Zundert (2015). In the credit market an important risk is the interest rate risk, hence adding an interest rate factor could improve performance.

Sometimes all of the quintiles perform worse than the index. Further research is required to understand why this is the case. Possible explanations could be a bad implementation, some theoretical argument on why this should happen or because of the use of equal weighting.

A last possible extension is to model market impact. It may not be realistic for some issues that a large trade can easily be executed.

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7 Appendix

7.1 Historical Overview of Factor Investing (in the Corporate Bond Market)

Markowitz (1952) made a major breakthrough with his paper on portfolio selection. It is often thought that modern finance theory has started with this article. In this paper Markowitz demonstrates how an investor should allocate his wealth based on the first and second moment of the individual securities. Up until this day his mean-variances analysis is a cornerstone of portfolio theory. After this paper many researchers tried to estimate the inputs of the individual assets for the mean-variance framework. The Capital Asset Pricing Model (CAPM) introduced by Sharpe (1964) and Lintner (1965) relates the expected return of a security to its correlation with the market, measured as a value-weighted index of a large index. Often, the S&P500 is used as a proxy for the market. In an efficient market the investors' expected return depends on taken risk, there is no free lunch. This means that the alpha (excess return) of a security and the alpha of a portfolio of securities must be zero. Tests performed in the 1960s and 1970s concluded that the CAPM works fine.

In one of the most cited papers in economics and finance Fama and French (1992) show that the market factor is not able to completely explain returns on its own. Some equities with specific company characteristics have higher returns for a given level of the market factor. Hence, alpha can be achieved, sometimes this is also refereed to as 'beta is dead'. These characteristics (factors) are size and value. The model with these three factors is called three factor Fama-French model. The fourth widely accepted factor is the momentum factor (Carhart, 1997), this states that stocks that performed well in the recent past are likely to perform well in the recent future.

Factor portfolios are held in deviation from the market portfolio, therefore, not everybody can hold a factor portfolio in equilibrium. If, for instance, all investors decided to invest in the value factor the price of these securities would go up, until the level where no excess return is made. The risk that such an event will eventually happen, that is, factor premiums will disappear is not likely (Koedijk, Slager and Stork, 2014), but it is present.

How to Proceed from CAPM

In the literature are three approaches to improve the theory:

- extend the consumption-based framework (e.g. time-dependent or kinked utility functions)
- extend the CAPM (e.g. time-varying, higher order moments or incorporation of wealth)
- investigate popular trading strategies, for which assets does the CAPM fail? (e.g. size, value and momentum)

This paper will focus on the third approach. Since the 1990s there is structured investigation to these problems.

The next step is to determine the factors. There are three ways to choose a factor: economic theory, empirical work and statistical work.

Economic theory: factors can be chosen on economic theories such as the CAPM or the Intertemporal Capital Asset Pricing Model (ICAPM), zero-beta CAPM or Consumption Capital Asset Pricing Model.

Empirical work: factors can also be chosen on empirical work. A famous example is the three factor model by Fama and French (1992, 1993). Industry or macroeconomic factors are also possible.

Statistical work: principal components can also be used as factors.

Terminology

In the industry, in the literature and on the internet are many different terms for factor investing, such as, smart beta, alpha investing, alternative beta and exotic beta. Following Ang (2014) this paper will use the term 'factor (investing)'. The reason is that beta is the measuring the exposure to a risk factor and alpha is the excess return in asset pricing theory.

Bond Definitions

- duration: sensitivity measure of the price of a bond to changes in interest rate
- high-yield bond: bond with low rating and high default risk
- investment grade bond: bond with high rating and low default risk
- par value: amount to be paid at maturity by the issuer
- yield-to-maturity (YTM): expected annual return assuming no default

- yield-to-worst (YTM): the lowest potential yield that can be received without an actual default of the issuer

7.2 Additional Rules of Inclusion and Portfolio Construction

Additional Rules for US HY

- below investment grade (average of Moody's, Standard and Poor's and Fitch)
- qualifying securities must have risk exposure to countries that are member of the FX-G10 (all Euro members, US, Japan, UK, Canada, Australia, New Zealand, Switzerland, Norway and Sweden), Western Europe or territories of the US and Western Europe
- original issue zero coupon, 144A securities (both with and without registration rights and pay-in-kind securities (including toggle notes)) are included
- callable perpetual securities are included provided they are at least one year from the fist call date
- fixed-to-floating rate securities are included provided they are callable within the fixed rate period and are at least one year from the last call prior to the date the transitions from a fixed to a floating rate security
- capital securities where conversion can be mandated by a regulatory authority, but which have no specified trigger are included
- hybrid capital securities, such as those issues that potentially convert into preference shares, those with both cumulative and non-cumulative coupon deferral provision and those with alternative coupon satisfaction mechanisms are included
- contingent capital securities (CoCos) are excluded
- securities issued or marketed primarily to retail investors, equity-linked securities, securities in legal default, hybrid securitized corporates, Eurodollar bonds (USD securities not issued in the US domestic market, taxable and tax-exempt US municipal securities and DRD-eligible securities are excluded
- accrued interest is calculated assuming next-day settlement

Additional Rules for EU HY

- below investment grade (average of Moody's, Standard and Poor's and Fitch)
- original issue zero coupon, 'global' securities (debt issued simultaneously in the Eurobond and domestic markets), 144A securities (both with and without registration

rights and pay-in-kind securities (including toggle notes)) are included

- callable perpetual securities are included provided they are at least one year from the fist call date
- fixed-to-floating rate securities are included provided they are callable within the fixed rate period and are at least one year from the last call prior to the date the transitions from a fixed to a floating rate security
- capital securities where conversion can be mandated by a regulatory authority, but which have no specified trigger are included
- hybrid capital securities, such as those issues that potentially convert into preference shares, those with both cumulative and non-cumulative coupon deferral provision and those with alternative coupon satisfaction mechanisms are included
- contingent capital securities (CoCos) are excluded
- securities in legal default, equity-linked securities, euro legacy currency securities and hybrid securitized corporate securities are excluded
- accrued interest is calculated assuming next-day settlement

Additional Rules for US IG

- investment grade (average of Moody's, Standard and Poor's and Fitch)
- original issue zero coupon, 144A securities (both with and without registration rights and pay-in-kind securities (including toggle notes)) are included
- callable perpetual securities are included provided they are at least one year from the fist call date
- fixed-to-floating rate securities are included provided they are callable within the fixed rate period and are at least one year from the last call prior to the date the transitions from a fixed to a floating rate security
- capital securities where conversion can be mandated by a regulatory authority, but which have no specified trigger are included
- hybrid capital securities, such as those issues that potentially convert into preference shares, those with both cumulative and non-cumulative coupon deferral provision and those with alternative coupon satisfaction mechanisms are included
- contingent capital securities (CoCos) are excluded
- securities in legal default, equity-linked securities, Eurodollar bonds (USD securities not issued in the US domestic market), taxable and tax-exempt US municipal securities and

DRD-eligible securities are excluded

- accrued interest is calculated assuming next-day settlement

Additional Rules for EU HY

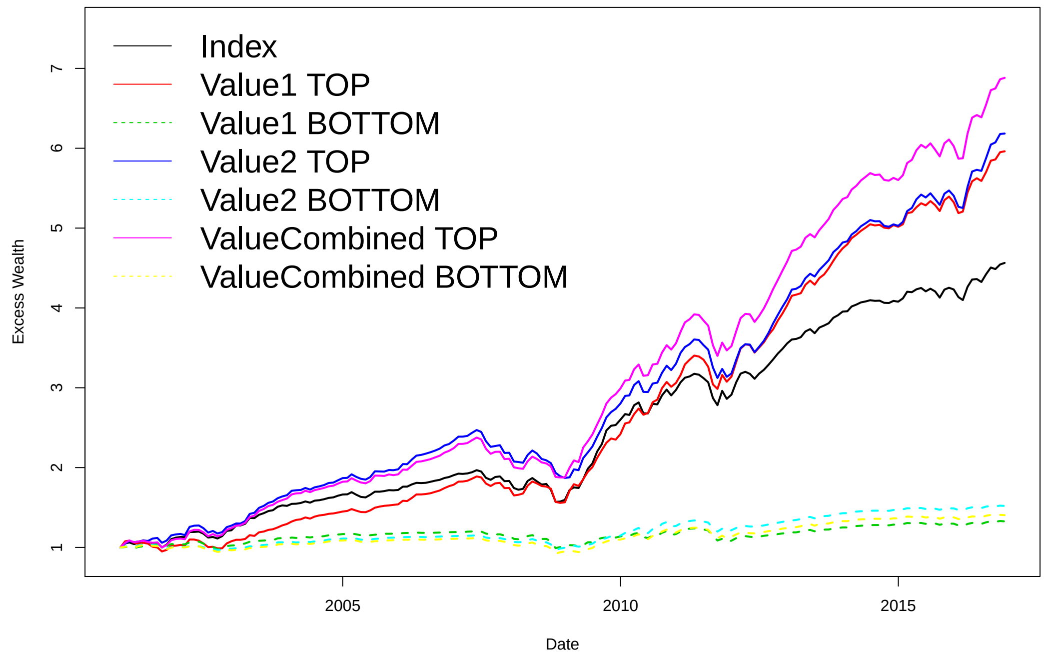
- investment grade (average of Moody's, Standard and Poor's and Fitch)
- original issue zero coupon, pay-in-kind securities (including toggle notes) are included
- fixed-to-floating rate securities are included provided they are callable within the fixed rate period and are at least one year from the last call prior to the date the transitions from a fixed to a floating rate security
- capital securities where conversion can be mandated by a regulatory authority, but which have no specified trigger are included
- hybrid capital securities, such as those issues that potentially convert into preference shares, those with both cumulative and non-cumulative coupon deferral provision and those with alternative coupon satisfaction mechanisms are included
- contingent capital securities (CoCos) are excluded
- euro legacy currency, equity-linked securities, securities in legal default and securities issued marketed primarily to retail investors are excluded
- accrued interest is calculated assuming next-day settlement

7.3 Additional Results

Additional Results Value

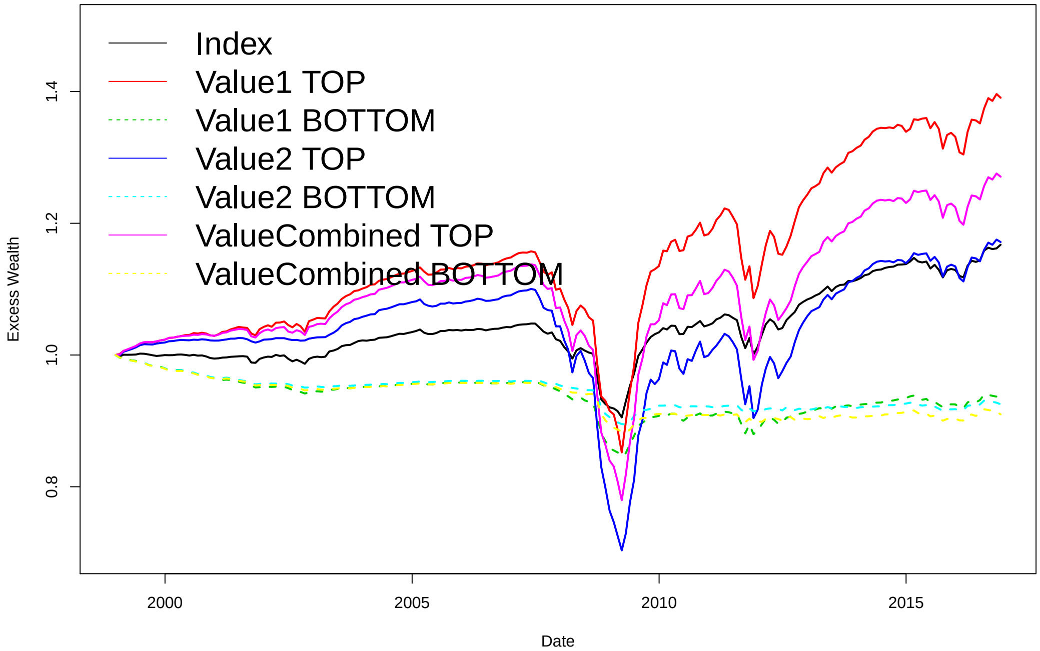
Cumulative Wealth Value Strategies

Figure 6: Cumulative Wealth Value Strategies EU HY



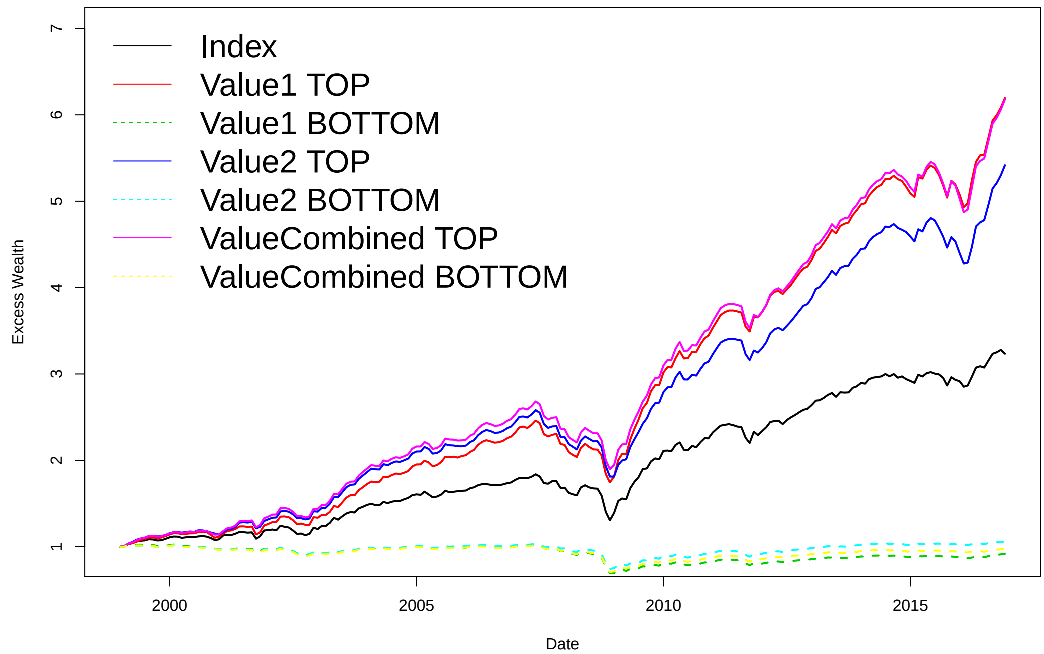
Note: this figure shows the cumulative wealth obtained from the different value strategies in the EU HY space.

Figure 7: Cumulative Wealth Value EU IG



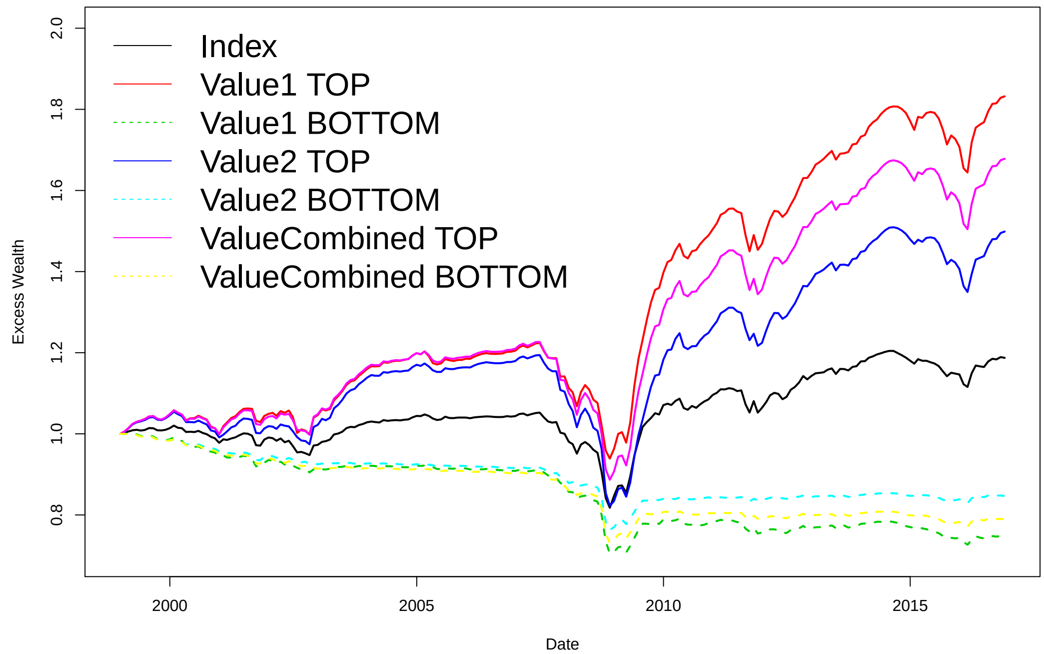
Note: this figure shows the cumulative wealth obtained from the different value strategies in the EU IG space.

Figure 8: Cumulative Wealth Value Strategy US HY



Note: this figure shows the cumulative wealth obtained from the different value strategies in the US HY space.

Figure 9: Cumulative Wealth Value Strategy US IG



Note: this figure shows the cumulative wealth obtained from the different value strategies in the US IG space.

Performance Measures Value Strategies

Table 8: Performance Value Strategy EU HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	4.56	1.13	1.09	20.36
M. 1 TOP	5.96	1.31	0.69	12.31
M. 1 BOTTOM	1.33	0.34	-0.56	17.83
M. 2 TOP	6.18	1.38	0.73	24.56
M. 2 BOTTOM	1.52	0.53	-0.33	16.04
M. COMBINED TOP	6.88	1.44	0.83	13.32
M. COMBINED BOTTOM	1.40	0.42	-0.47	17.71

Note: this table contains the performance measures for the differerent value strategies in the EU HY space. ‘Final Cum. W.’ indicates ‘final cumulative wealth’, ‘SR’ indicates ‘Sharpe ratio’, ‘SR w/ TC’ indicates ‘Sharpe ratio with transaction costs’ and ‘MDD’ indicates ‘maximum drawdown’.

Table 9: Performance Value Strategy EU IG

	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.17	0.34	0.22	13.60
M. 1 TOP	1.39	0.39	-0.10	26.41
M. 1 BOTTOM	0.93	-0.24	-1.71	15.41
M. 2 TOP	1.17	0.16	-0.34	36.12
M. 2 BOTTOM	0.93	-0.48	-3.16	10.57
M. COMBINED TOP	1.27	0.26	-0.20	31.52
M. COMBINED BOTTOM	0.91	-0.53	-2.86	11.80

Note: this table contains the performance measures for the differerent value strategies in the EU IG space. ‘Final Cum. W.’ indicates ‘final cumulative wealth’, ‘SR’ indicates ‘Sharpe ratio’, ‘SR w/ TC’ indicates ‘Sharpe ratio with transaction costs’ and ‘MDD’ indicates ‘maximum drawdown’.

Table 10: Performance Value Strategy US HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	3.23	0.81	0.77	29.37
M. 1 TOP	6.19	1.23	0.65	29.41
M. 1 BOTTOM	0.92	-0.08	-0.93	32.81
M. 2 TOP	5.42	1.22	0.62	30.15
M. 2 BOTTOM	1.06	0.06	-0.73	28.38
M. COMBINED TOP	6.18	1.26	0.69	29.56
M. COMBINED BOTTOM	0.98	-0.02	-0.79	30.87

Note: this table contains the performance measures for the differerent value strategies in the US HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 11: Performance Value Strategy US IG

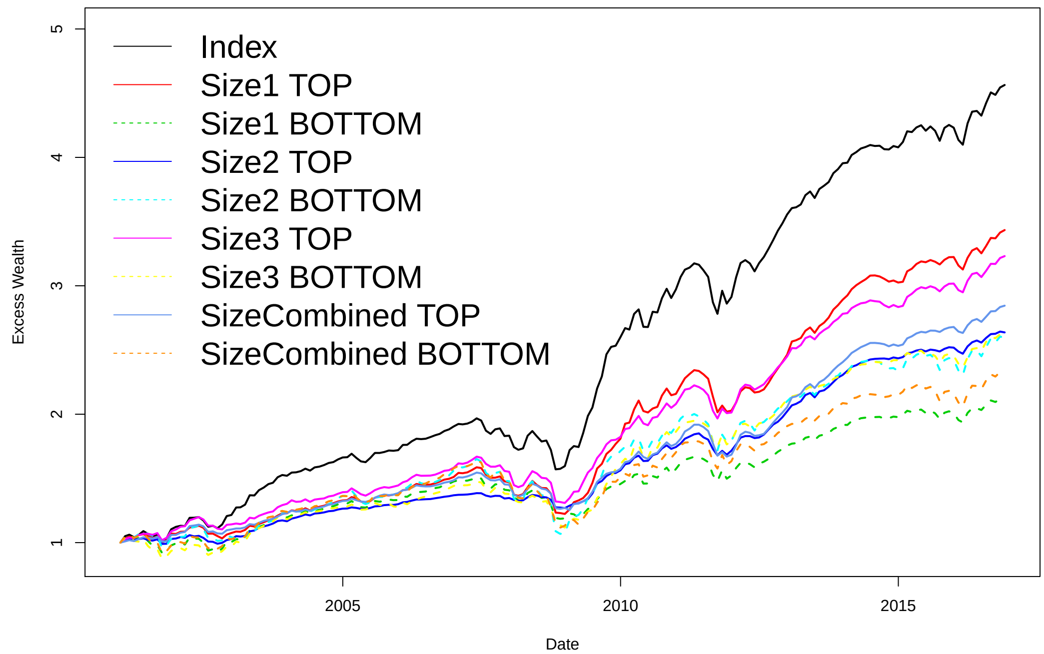
	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.19	0.22	0.15	22.54
M. 1 TOP	1.83	0.60	0.18	23.68
M. 1 BOTTOM	0.75	-0.50	-1.34	29.58
M. 2 TOP	1.50	0.39	-0.09	31.61
M. 2 BOTTOM	0.85	-0.38	-1.41	23.68
M. COMBINED TOP	1.68	0.50	0.10	28.19
M. COMBINED BOTTOM	0.79	-0.48	-1.42	26.96

Note: this table contains the performance measures for the differerent value strategies in the US IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Additional Results Size

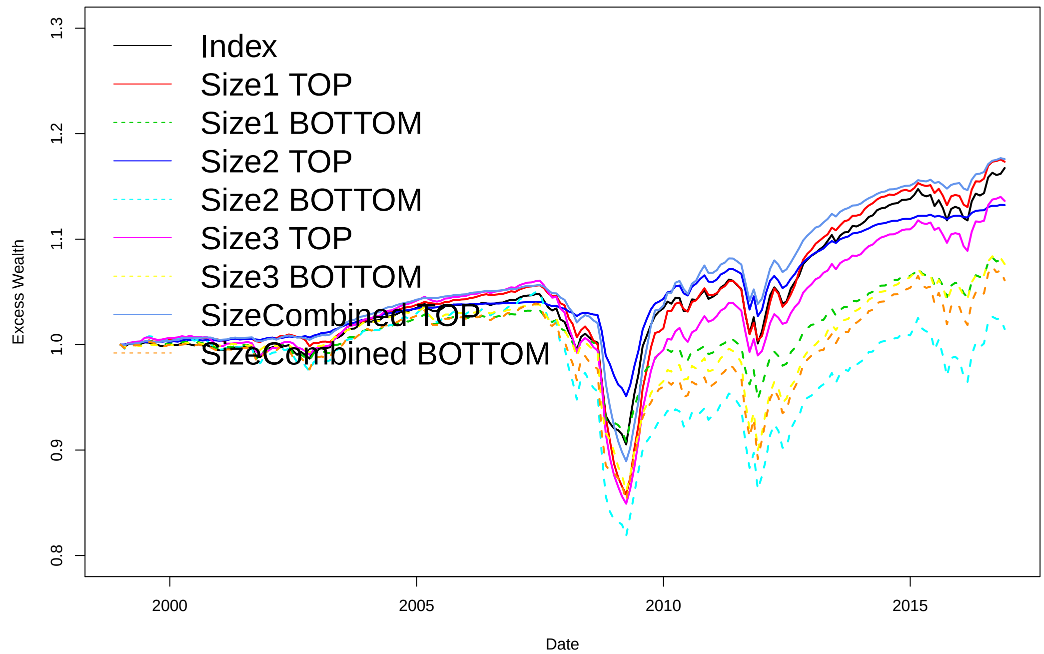
Cumulative Wealth Value Strategies

Figure 10: Cumulative Wealth Size Strategies EU HY



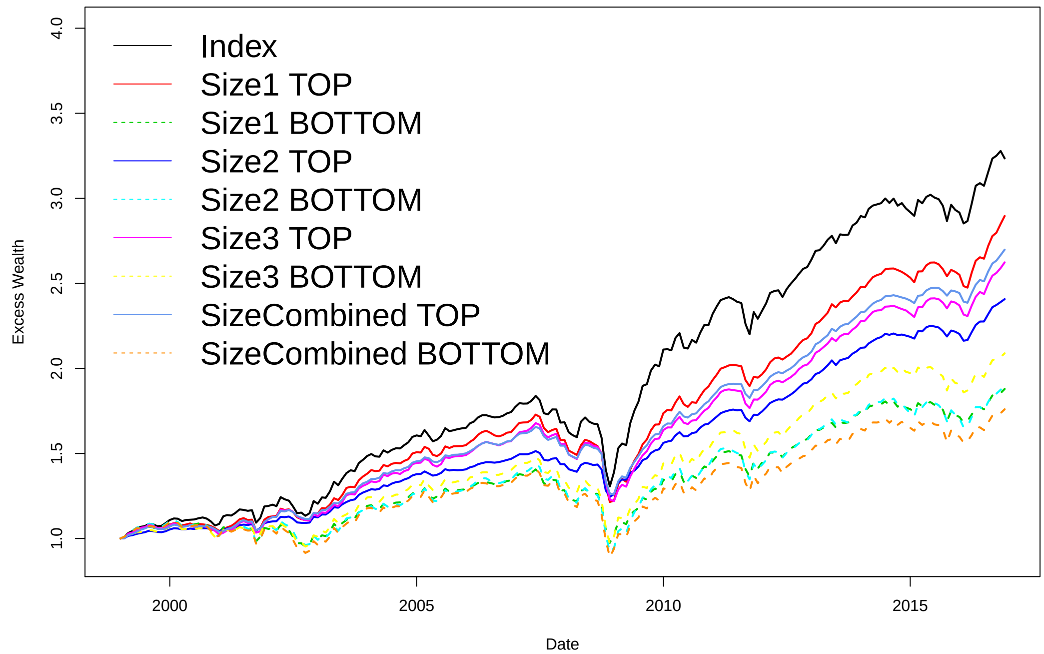
Note: this figure shows the cumulative wealth obtained from the different size strategies in the EU HY space.

Figure 11: Cumulative Wealth Size Strategy EU IG



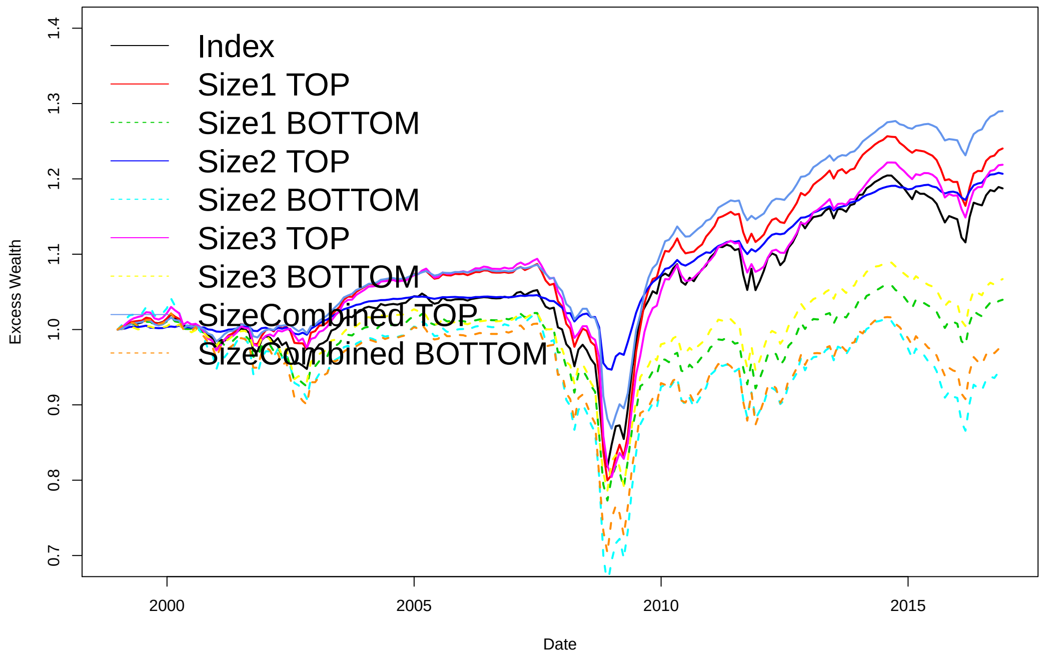
Note: this figure shows the cumulative wealth obtained from the different size strategies in the EU IG space.

Figure 12: Cumulative Wealth Size Strategy US HY



Note: this figure shows the cumulative wealth obtained from the different size strategies in the US HY space.

Figure 13: Cumulative Wealth Size Strategy US IG



Note: this figure shows the cumulative wealth obtained from the different size strategies in the US IG space.

Performance Measures Size Strategies

Table 12: Performance Size Strategy EU HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	4.56	1.13	1.09	20.36
M. 1 TOP	3.43	1.04	0.73	22.99
M. 1 BOTTOM	2.10	0.63	0.34	21.78
M. 2 TOP	2.64	1.34	0.87	9.40
M. 2 BOTTOM	2.59	0.59	0.30	35.73
M. 3 TOP	3.23	1.08	0.72	21.71
M. 3 BOTTOM	2.60	0.76	0.45	24.29
M. COMBINED TOP	2.85	1.10	0.71	18.91
M. COMBINED BOTTOM	2.31	0.58	0.30	32.38

Note: this table contains the performance measures for the differerent value strategies in the EU HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 13: Performance Size Strategy EU IG

	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.17	0.34	0.22	13.60
M. 1 TOP	1.17	0.33	0.06	18.84
M. 1 BOTTOM	1.07	0.18	-0.10	12.17
M. 2 TOP	1.13	0.44	-0.13	8.59
M. 2 BOTTOM	1.01	0.02	-0.34	22.29
M. 3 TOP	1.14	0.26	-0.01	20.03
M. 3 BOTTOM	1.08	0.14	-0.12	17.20
M. COMBINED TOP	1.18	0.40	0.06	15.84
M. COMBINED BOTTOM	1.06	0.10	-0.15	18.01

Note: this table contains the performance measures for the differerent value strategies in the EU IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 14: Performance Size Strategy US HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	3.23	0.81	0.77	29.37
M. 1 TOP	2.90	0.88	0.60	29.95
M. 1 BOTTOM	1.88	0.45	0.24	31.25
M. 2 TOP	2.41	1.14	0.74	17.91
M. 2 BOTTOM	1.90	0.39	0.08	36.66
M. 3 TOP	2.62	0.87	0.53	27.48
M. 3 BOTTOM	2.09	0.49	0.30	34.92
M. COMBINED TOP	2.70	1.03	0.66	24.04
M. COMBINED BOTTOM	1.76	0.34	0.13	37.47

Note: this table contains the performance measures for the differerent value strategies in the US HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 15: Performance Size Strategy US IG

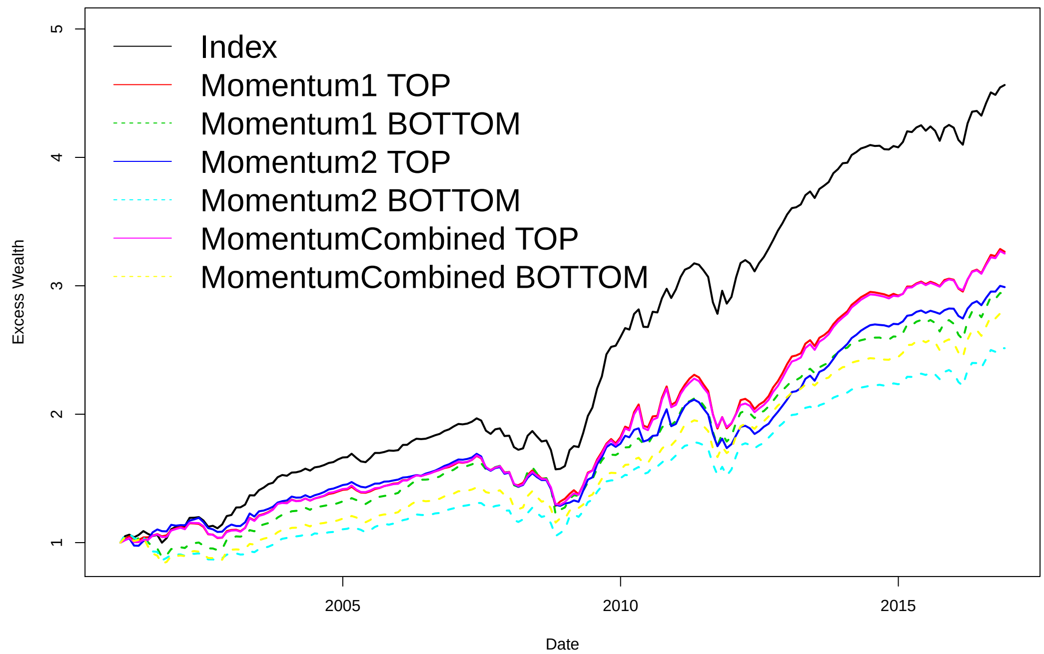
	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.19	0.22	0.15	22.54
M. 1 TOP	1.24	0.26	0.08	26.66
M. 1 BOTTOM	1.04	0.05	-0.08	24.67
M. 2 TOP	1.21	0.58	0.18	9.49
M. 2 BOTTOM	0.95	-0.05	-0.21	36.96
M. 3 TOP	1.22	0.26	0.10	26.69
M. 3 BOTTOM	1.07	0.08	-0.07	23.53
M. COMBINED TOP	1.29	0.42	0.20	20.15
M. COMBINED BOTTOM	0.98	-0.02	-0.15	31.37

Note: this table contains the performance measures for the differerent value strategies in the US IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Additional Results Momentum

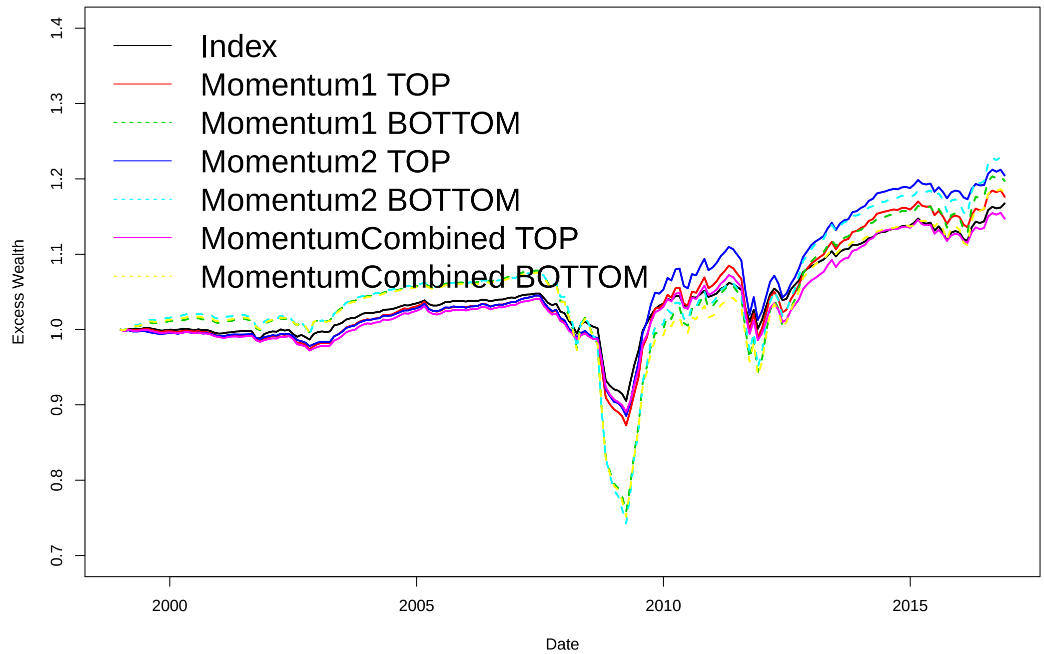
Cumulative Wealth Momentum Strategies

Figure 14: Cumulative Wealth Momentum Strategies EU HY



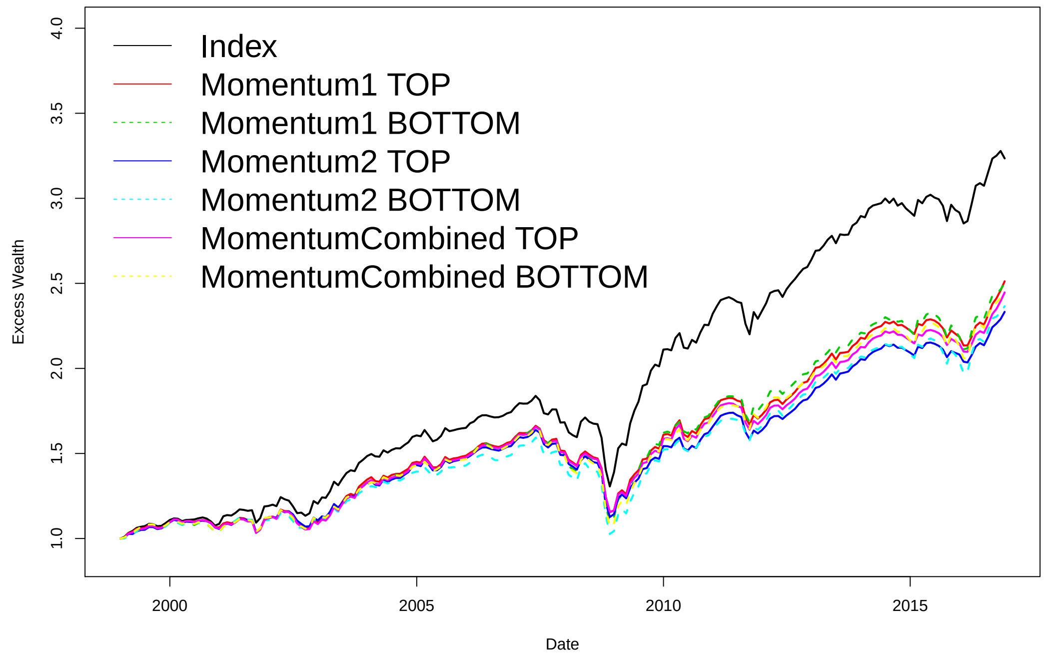
Note: this figure shows the cumulative wealth obtained from the different momentum strategies in the EU HY space.

Figure 15: Cumulative Wealth Momentum Strategy EU IG



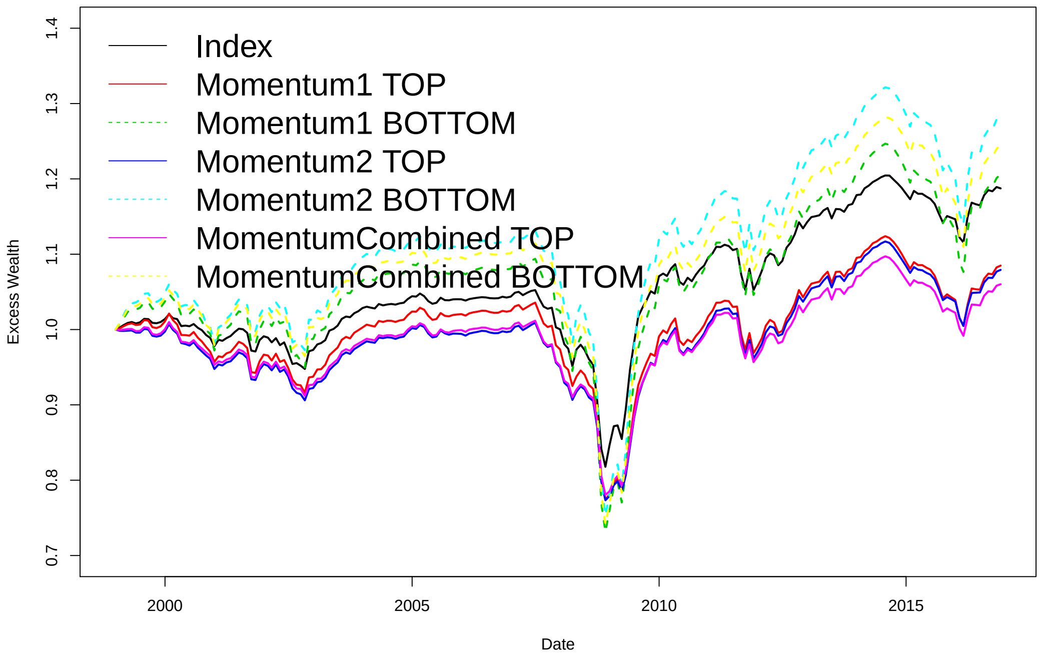
Note: this figure shows the cumulative wealth obtained from the different momentum strategies in the EU IG space.

Figure 16: Cumulative Wealth Momentum Strategy US HY



Note: this figure shows the cumulative wealth obtained from the different momentum strategies in the US HY space.

Figure 17: Cumulative Wealth Momentum Strategy US IG



Note: this figure shows the cumulative wealth obtained from the different momentum strategies in the US IG space.

Performance Measures Momentum Strategies

Table 16: Performance Momentum Strategy EU HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	4.56	1.13	1.09	20.36
M. 1 TOP	3.26	0.85	0.44	18.32
M. 1 BOTTOM	2.94	0.78	0.37	25.16
M. 2 TOP	2.99	0.85	0.41	24.26
M. 2 BOTTOM	2.51	0.73	0.28	14.73
M. COMBINED TOP	3.25	0.88	0.43	23.15
M. COMBINED BOTTOM	2.78	0.79	0.30	14.73

Note: this table contains the performance measures for the differerent value strategies in the EU HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 17: Performance Momentum Strategy EU IG

	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.17	0.34	0.22	13.60
M. 1 TOP	1.18	0.28	-0.16	16.63
M. 1 BOTTOM	1.20	0.19	-0.09	29.73
M. 2 TOP	1.20	0.33	-0.14	15.31
M. 2 BOTTOM	1.22	0.21	-0.07	30.93
M. COMBINED TOP	1.15	0.28	-0.31	14.44
M. COMBINED BOTTOM	1.18	0.18	-0.14	30.09

Note: this table contains the performance measures for the differerent value strategies in the EU IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 18: Performance Momentum Strategy US HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	3.23	0.81	0.77	29.37
M. 1 TOP	2.51	0.68	0.29	30.87
M. 1 BOTTOM	2.50	0.63	0.24	34.47
M. 2 TOP	2.33	0.66	0.26	31.53
M. 2 BOTTOM	2.37	0.59	0.20	36.09
M. COMBINED TOP	2.45	0.68	0.24	30.46
M. COMBINED BOTTOM	2.45	0.61	0.18	35.85

Note: this table contains the performance measures for the differerent value strategies in the US HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 19: Performance Momentum Strategy US IG

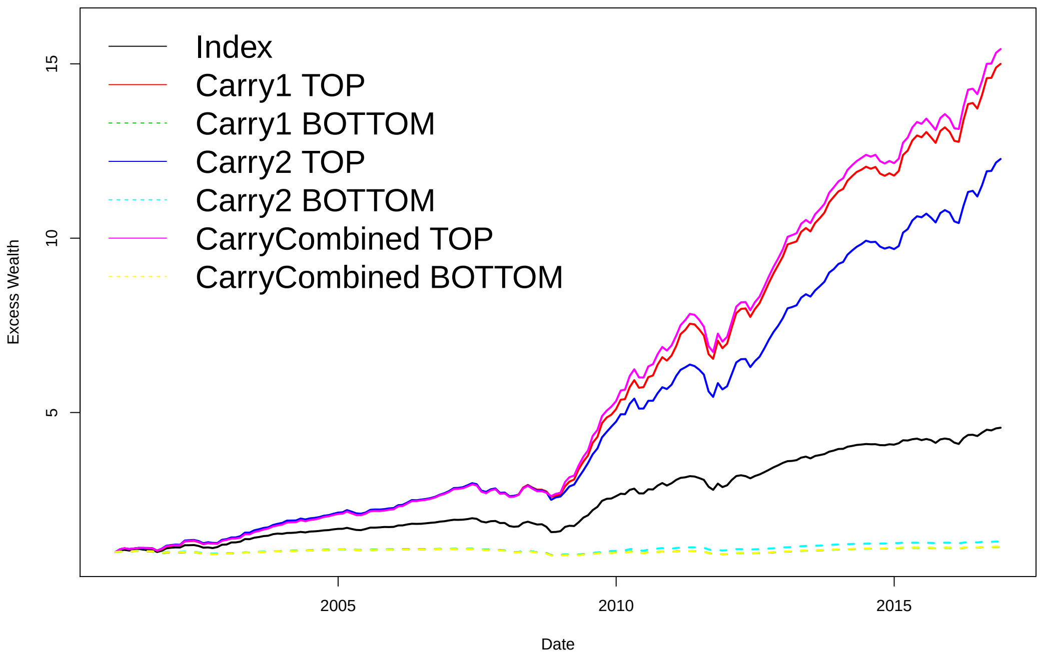
	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.19	0.22	0.15	22.54
M. 1 TOP	1.08	0.10	-0.17	25.56
M. 1 BOTTOM	1.21	0.16	-0.04	33.56
M. 2 TOP	1.08	0.10	-0.21	23.67
M. 2 BOTTOM	1.29	0.21	0.00	33.82
M. COMBINED TOP	1.06	0.08	-0.27	23.19
M. COMBINED BOTTOM	1.25	0.18	-0.05	33.88

Note: this table contains the performance measures for the differerent value strategies in the US IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Additional Results Carry

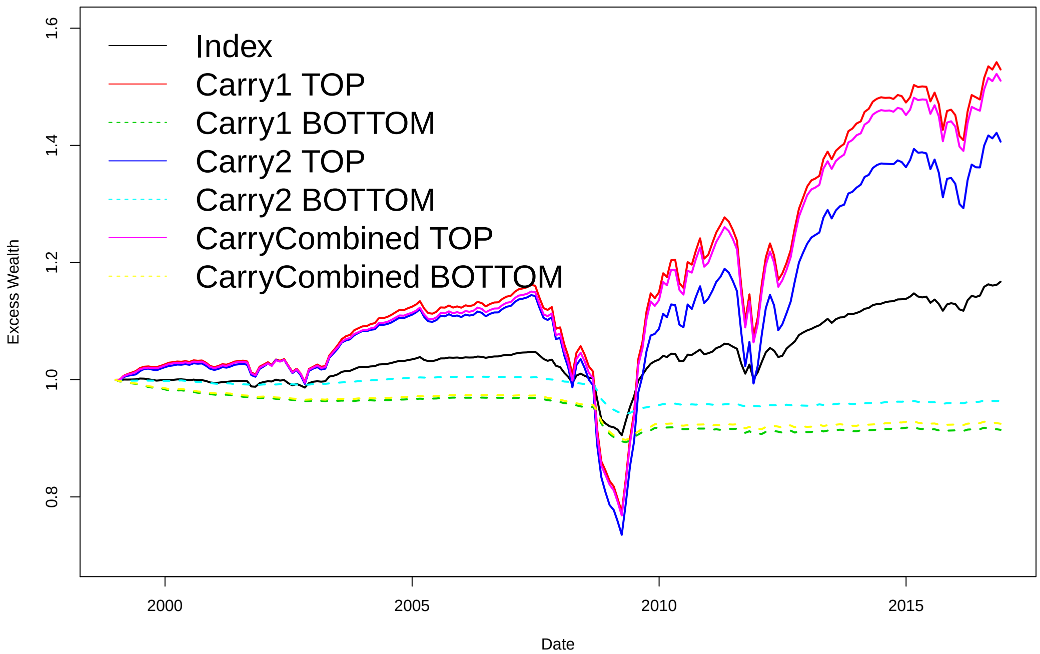
Cumulative Wealth Carry Strategies

Figure 18: Cumulative Wealth Carry Strategies EU HY



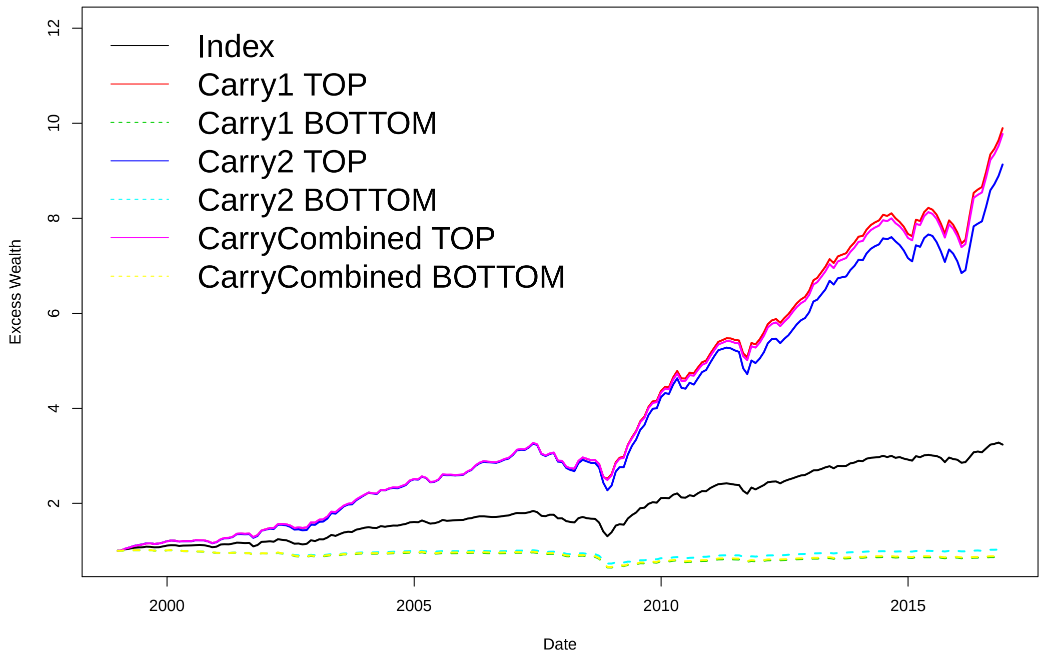
Note: this figure shows the cumulative wealth obtained from the different carry strategies in the EU HY space.

Figure 19: Cumulative Wealth Carry Strategy EU IG



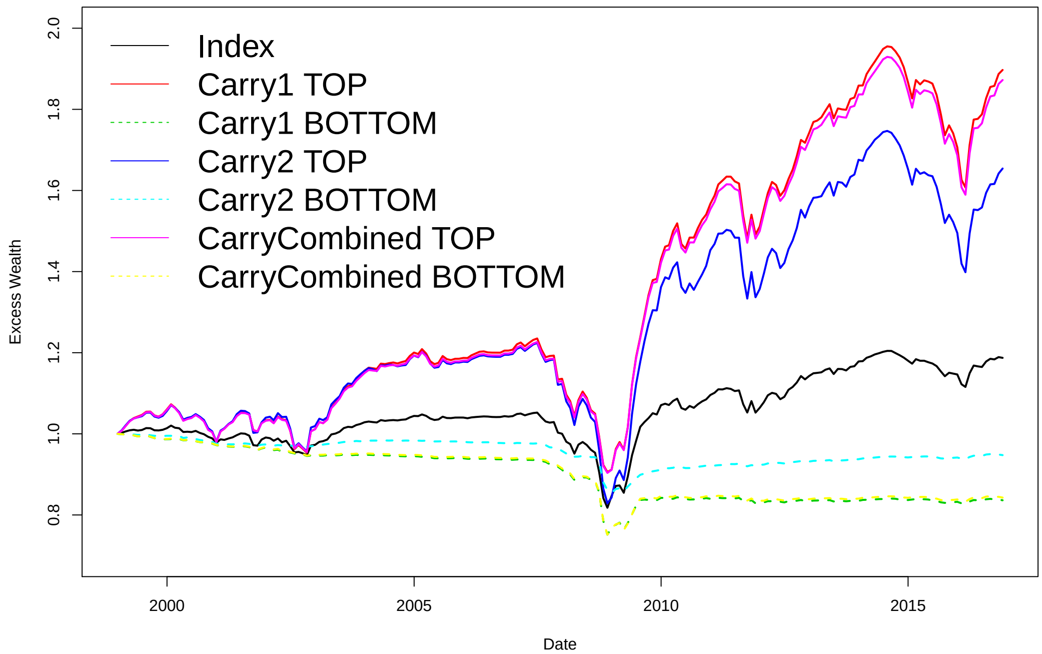
Note: this figure shows the cumulative wealth obtained from the different carry strategies in the EU IG space.

Figure 20: Cumulative Wealth Carry Strategy US HY



Note: this figure shows the cumulative wealth obtained from the different carry strategies in the US HY space.

Figure 21: Cumulative Wealth Carry Strategy US IG



Note: this figure shows the cumulative wealth obtained from the different carry strategies in the US IG space.

Performance Measures Carry Strategies

Table 20: Performance Carry Strategy EU HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	4.56	1.13	1.09	20.36
M. 1 TOP	15.00	1.71	1.21	13.37
M. 1 BOTTOM	1.14	0.21	-0.68	17.83
M. 2 TOP	12.27	1.62	1.11	14.68
M. 2 BOTTOM	1.29	0.38	-0.44	17.44
M. COMBINED TOP	15.42	1.72	1.14	14.03
M. COMBINED BOTTOM	1.14	0.21	-0.85	18.19

Note: this table contains the performance measures for the differerent value strategies in the EU HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 21: Performance Carry Strategy EU IG

	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.17	0.34	0.22	13.60
M. 1 TOP	1.53	0.34	0.11	33.40
M. 1 BOTTOM	0.91	-0.63	-2.82	10.69
M. 2 TOP	1.41	0.27	0.06	35.79
M. 2 BOTTOM	0.96	-0.34	-2.47	6.34
M. COMBINED TOP	1.51	0.34	-0.08	33.26
M. COMBINED BOTTOM	0.92	-0.54	-4.53	10.28

Note: this table contains the performance measures for the differerent value strategies in the EU IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 22: Performance Carry Strategy US HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	3.23	0.81	0.77	29.37
M. 1 TOP	9.90	1.50	0.98	29.18
M. 1 BOTTOM	0.87	-0.13	-0.79	36.54
M. 2 TOP	9.13	1.27	0.82	30.50
M. 2 BOTTOM	1.03	0.03	-0.75	28.29
M. COMBINED TOP	9.77	1.48	0.89	24.20
M. COMBINED BOTTOM	0.89	-0.11	-1.02	35.41

Note: this table contains the performance measures for the differerent value strategies in the US HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 23: Performance Carry Strategy US IG

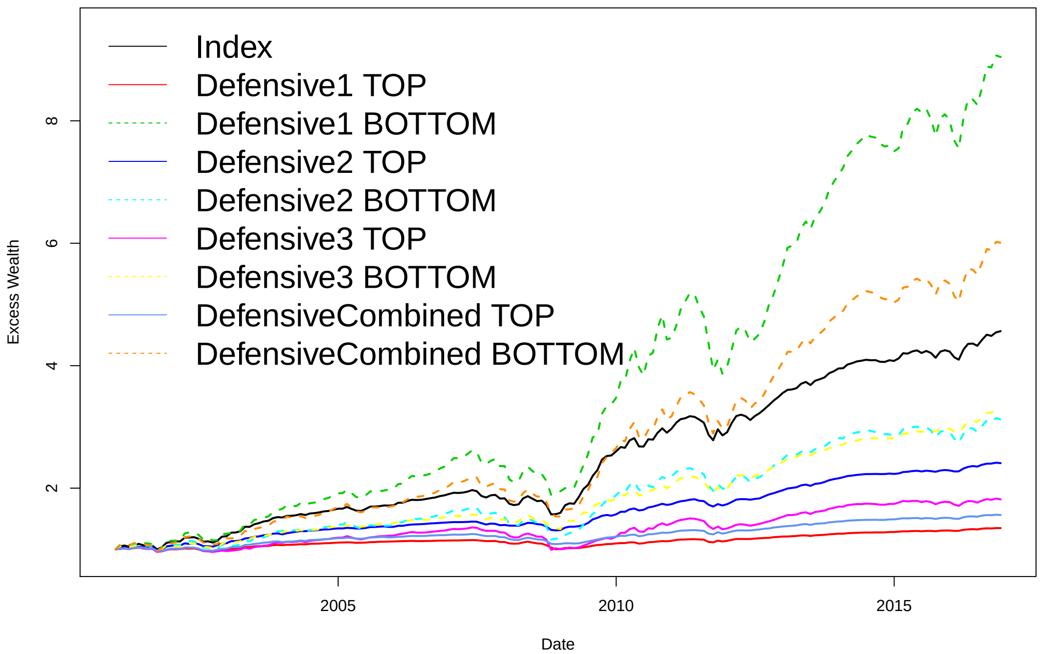
	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.19	0.22	0.15	22.54
M. 1 TOP	1.90	0.51	0.26	17.81
M. 1 BOTTOM	0.84	-0.35	-1.00	24.88
M. 2 TOP	1.65	0.35	0.15	33.01
M. 2 BOTTOM	0.95	-0.18	-1.00	14.52
M. COMBINED TOP	1.87	0.51	0.06	17.64
M. COMBINED BOTTOM	0.84	-0.33	-1.45	24.86

Note: this table contains the performance measures for the differerent value strategies in the US IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Additional Results Defensive

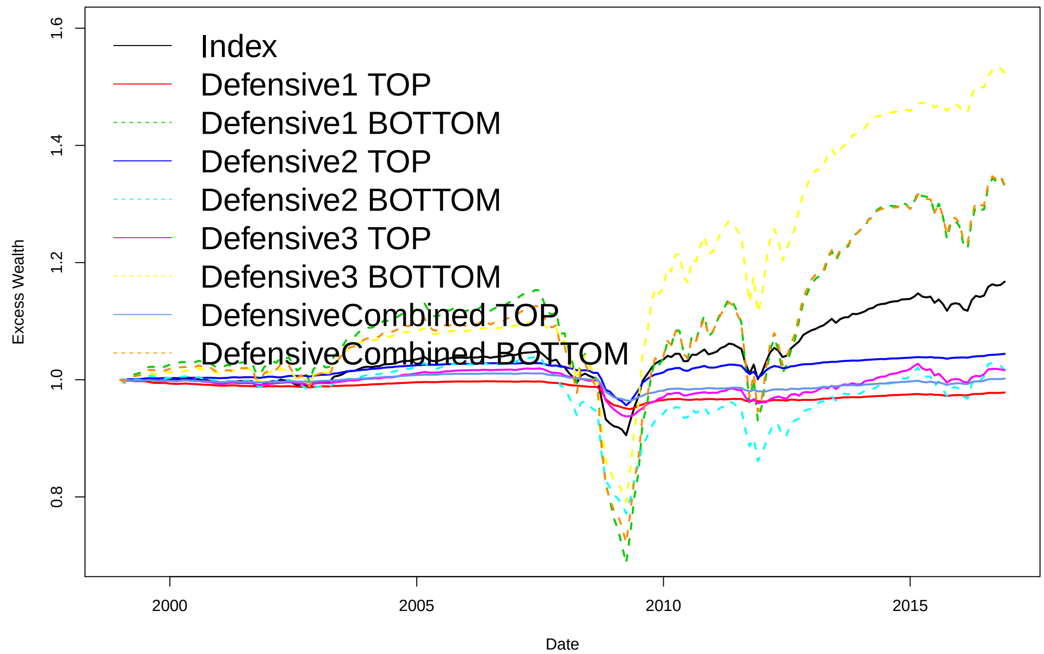
Cumulative Wealth Defensive Strategies

Figure 22: Cumulative Wealth Defensive Strategies EU HY



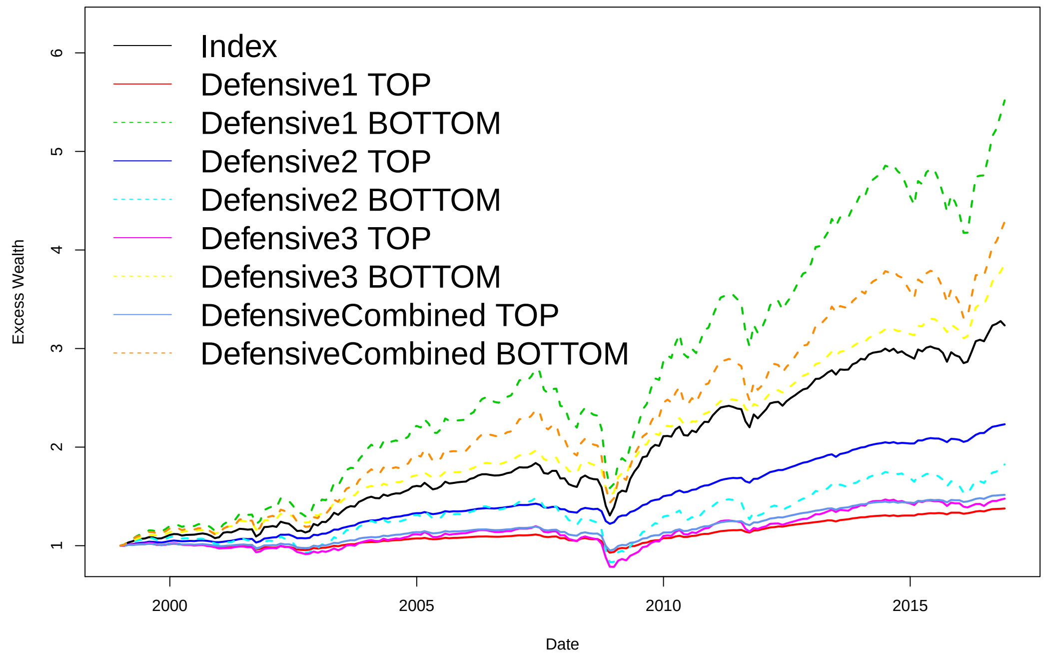
Note: this figure shows the cumulative wealth obtained from the different defensive strategies in the EU HY space.

Figure 23: Cumulative Wealth Defensive Strategy EU IG



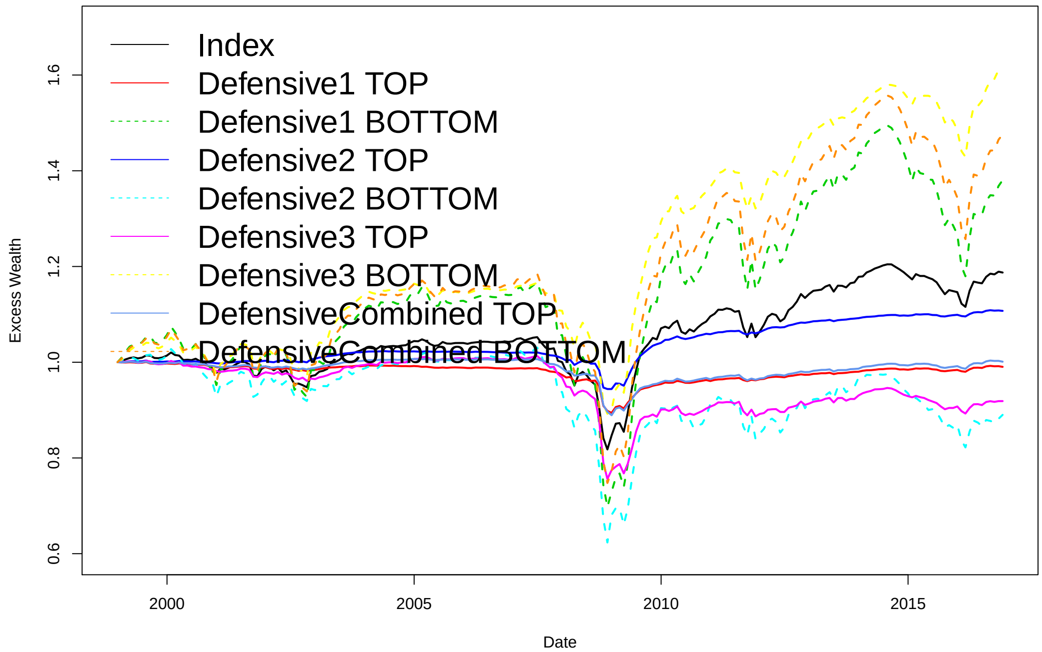
Note: this figure shows the cumulative wealth obtained from the different defensive strategies in the EU IG space.

Figure 24: Cumulative Wealth Defensive Strategy US HY



Note: this figure shows the cumulative wealth obtained from the different defensive strategies in the US HY space.

Figure 25: Cumulative Wealth Defensive Strategy US IG



Note: this figure shows the cumulative wealth obtained from the different defensive strategies in the US IG space.

Performance Measures Defensive Strategies

Table 24: Performance Defensive Strategy EU HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	4.56	1.13	1.09	20.36
M. 1 TOP	1.35	0.62	-0.55	13.10
M. 1 BOTTOM	9.04	1.06	0.77	25.50
M. 2 TOP	2.41	1.30	0.80	9.87
M. 2 BOTTOM	3.12	0.71	0.50	31.79
M. 3 TOP	1.82	0.54	0.04	27.05
M. 3 BOTTOM	3.27	1.01	0.59	12.64
M. COMBINED TOP	1.56	0.80	-0.03	13.14
M. COMBINED BOTTOM	6.01	0.97	0.62	19.17

Note: this table contains the performance measures for the differerent value strategies in the EU HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 25: Performance Defensive Strategy EU IG

	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.17	0.34	0.22	13.60
M. 1 TOP	0.98	-0.25	-2.68	5.03
M. 1 BOTTOM	1.33	0.21	0.04	40.48
M. 2 TOP	1.04	0.25	-0.80	7.00
M. 2 BOTTOM	1.02	0.02	-0.13	26.10
M. 3 TOP	1.02	0.08	-1.06	8.04
M. 3 BOTTOM	1.52	0.38	0.23	28.09
M. COMBINED TOP	1.00	0.02	-1.86	4.66
M. COMBINED BOTTOM	1.33	0.23	0.03	35.93

Note: this table contains the performance measures for the different value strategies in the EU IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 26: Performance Defensive Strategy US HY

	Final Cum. W.	SR	SR w/ TC	MDD
Index	3.23	0.81	0.77	29.37
M. 1 TOP	1.38	0.55	-0.41	16.63
M. 1 BOTTOM	5.52	0.82	0.53	43.83
M. 2 TOP	2.23	1.21	0.75	14.43
M. 2 BOTTOM	1.82	0.33	0.17	44.36
M. 3 TOP	1.48	0.31	-0.11	34.92
M. 3 BOTTOM	3.86	1.07	0.71	24.03
M. COMBINED TOP	1.52	0.59	-0.07	20.52
M. COMBINED BOTTOM	4.29	0.74	0.43	40.03

Note: this table contains the performance measures for the differerent value strategies in the US HY space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Table 27: Performance Defensive Strategy US IG

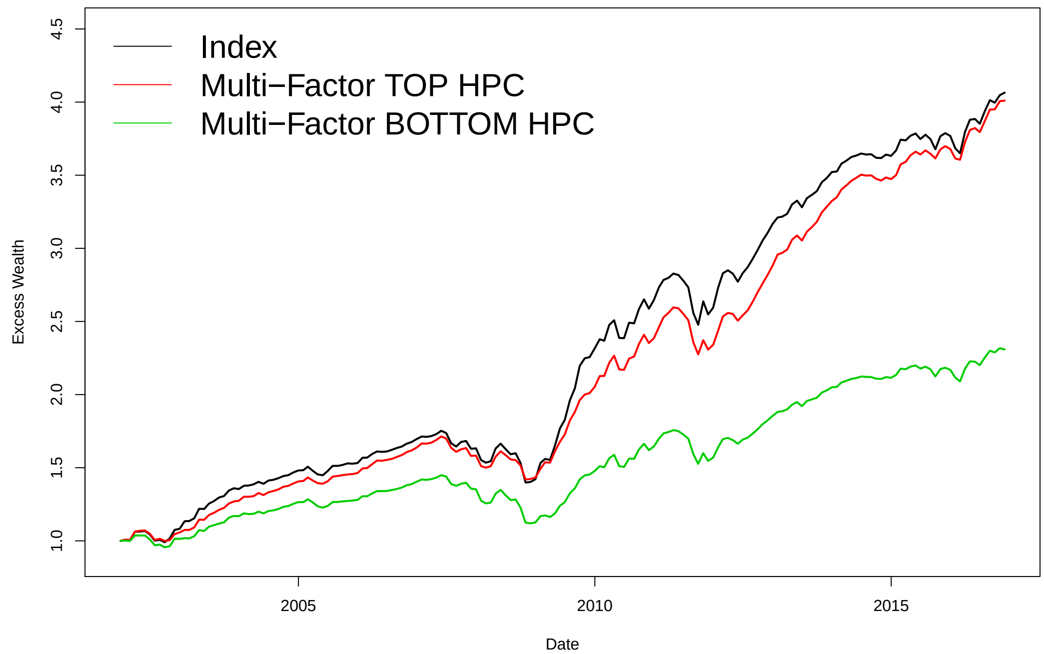
	Final Cum. W.	SR	SR w/ TC	MDD
Index	1.19	0.22	0.15	22.54
M. 1 TOP	0.99	-0.04	-0.90	10.67
M. 1 BOTTOM	1.38	0.20	0.08	41.12
M. 2 TOP	1.11	0.40	-0.18	7.73
M. 2 BOTTOM	0.89	-0.08	-0.14	40.16
M. 3 TOP	0.92	-0.12	-0.47	25.54
M. 3 BOTTOM	1.62	0.48	0.32	23.68
M. COMBINED TOP	1.00	0.00	-0.60	11.67
M. COMBINED BOTTOM	1.48	0.26	0.12	37.67

Note: this table contains the performance measures for the differerent value strategies in the US IG space. 'Final Cum. W.' indicates 'final cumulative wealth', 'SR' indicates 'Sharpe ratio', 'SR w/ TC' indicates 'Sharpe ratio with transaction costs' and 'MDD' indicates 'maximum drawdown'.

Additional Results Multi-Factor

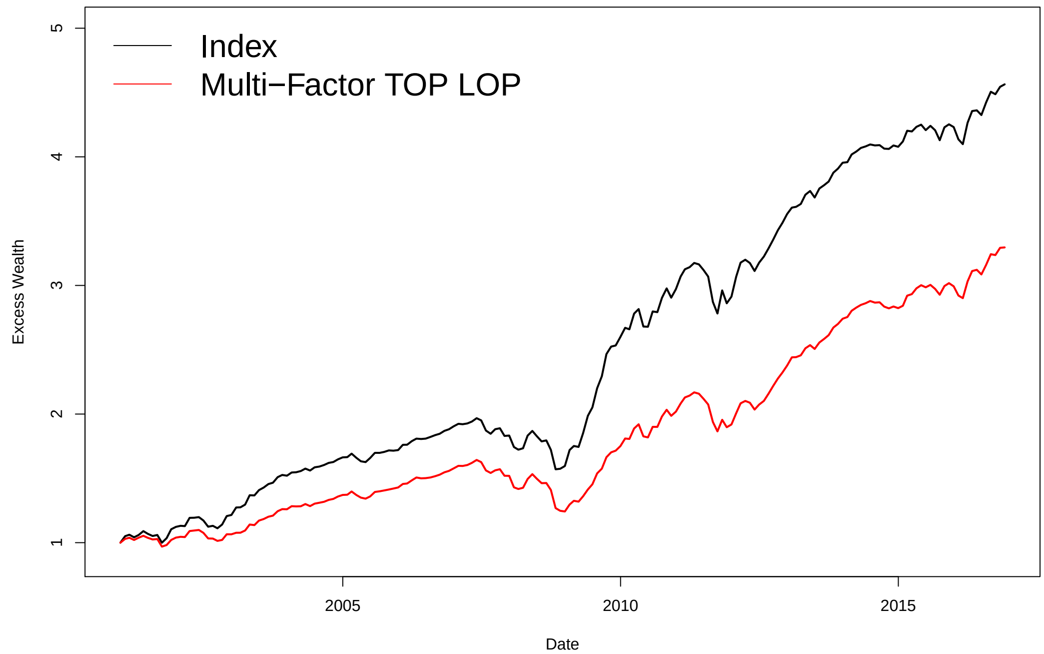
Cumulative Wealth Multi-Factor Strategies

Figure 26: Cumulative Wealth Multi-Factor HPC Strategy EU HY



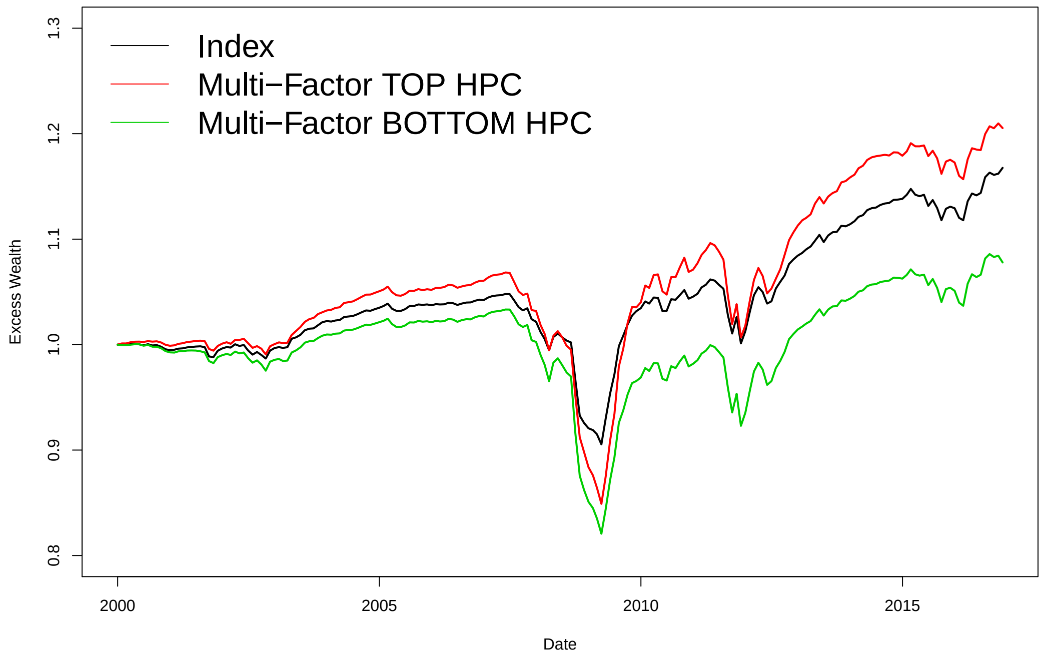
Note: this figure shows the cumulative wealth obtained from the 'historical percentile comparison' multi-factor strategy in the EU HY space.

Figure 27: Cumulative Wealth Multi-Factor LOP Strategy EU HY



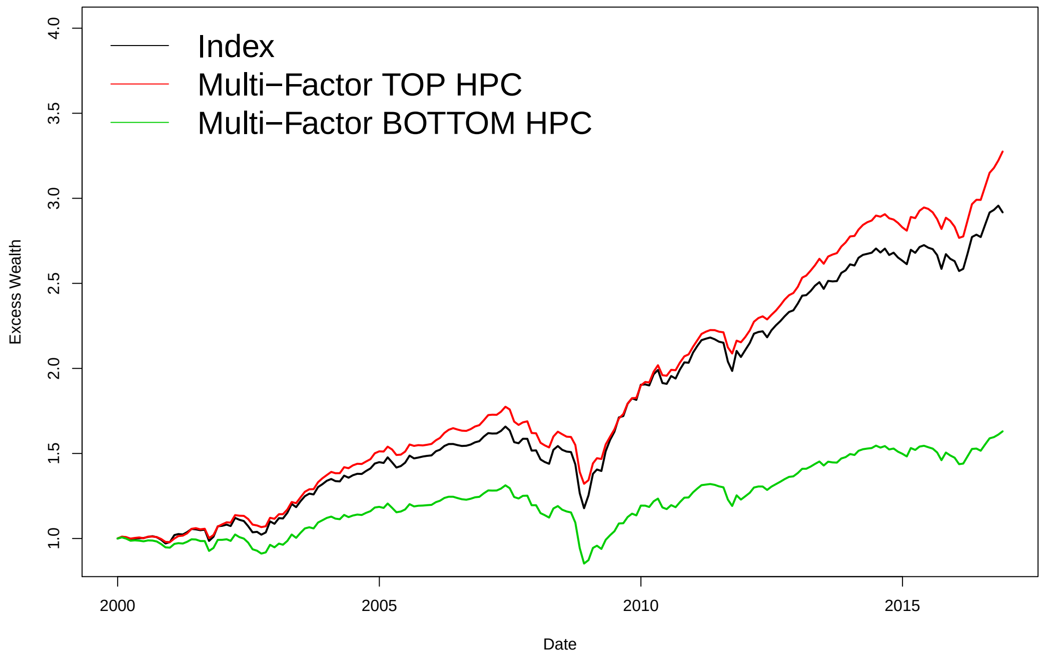
Note: this figure shows the cumulative wealth obtained from the 'linear optimization problem' multi-factor strategy in the EU HY space.

Figure 28: Cumulative Wealth Multi-Factor HPC Strategy EU IG



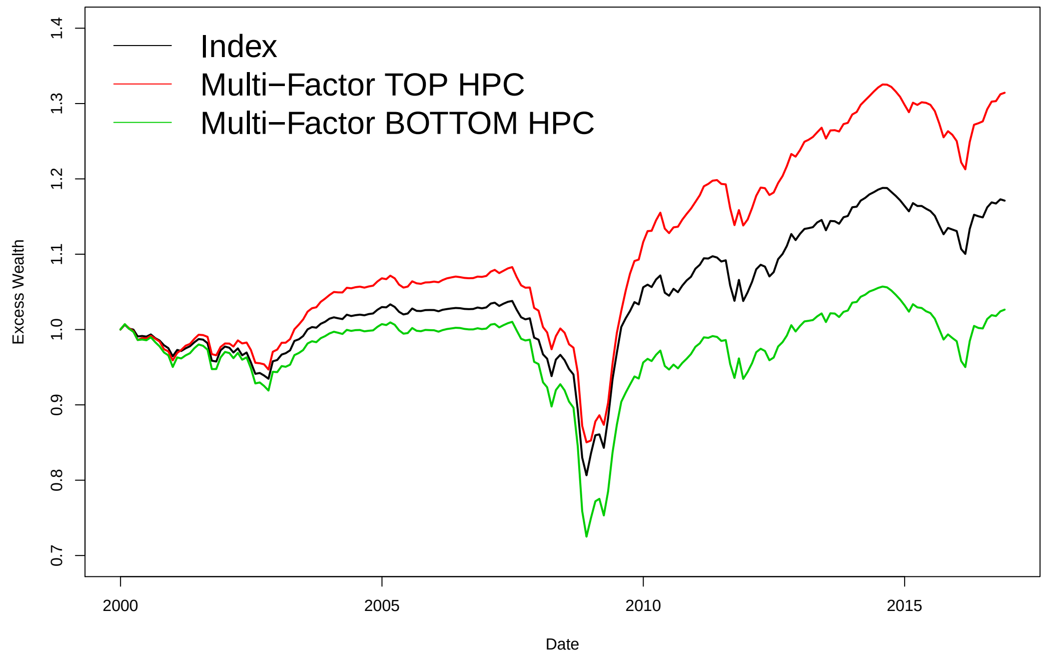
Note: this figure shows the cumulative wealth obtained from the 'historical percentile comparison' multi-factor strategy in the EU IG space.

Figure 29: Cumulative Wealth Multi-Factor HPC Strategy US HY



Note: this figure shows the cumulative wealth obtained from the 'historical percentile comparison' multi-factor strategy in the US HY space.

Figure 30: Cumulative Wealth Multi-Factor HPC Strategy US IG



Note: this figure shows the cumulative wealth obtained from the 'historical percentile comparison' multi-factor strategy in the US IG space.

Time-Series Regressions

Table 28: Time-Series Regressions EU HY

	MF Estimate (S.E.)	MF Decile Estimate (S.E.)	MF Long-Short Estimate (S.E.)	MF Decile Long-Short Estimate (S.E.)
Intercept	0.158***	0.406***	0.375***	0.821***
	(0.043)	(0.068)	(0.043)	(0.092)
Market Return	0.775***	0.778***	-0.048**	0.029
	(0.017)	(0.026)	(0.017)	(0.036)
N	191	191	191	191
RMSE	0.566	0.887	0.570	1.199
R^2	0.918	0.822	0.041	0.003

$*p \leq 0.05** \ p \leq 0.01***p \leq 0.001$

Note: this table shows the time-series regressions of the factor returns on an intercept and the market return for the EU HY space. 'MF' denotes 'Multi-Factor'.

Table 29: Time-Series Regressions EU IG

	MF Estimate (S.E.)	MF Decile Estimate (S.E.)	MF Long-Short Estimate (S.E.)	MF Decile Long-Short Estimate (S.E.)
Intercept	0.003	0.039*	0.055***	0.110***
	(0.016)	(0.019)	(0.012)	(0.030)
Market Return	1.318***	1.246***	0.019	0.468***
	(0.023)	(0.027)	(0.017)	(0.041)
N	215	215	215	215
RMSE	0.239	0.284	0.182	0.437
R^2	0.941	0.910	0.006	0.377

$*p \leq 0.05** \ p \leq 0.01***p \leq 0.001$

Note: this table shows the time-series regressions of the factor returns on an intercept and the market return for the EU IG space. 'MF' denotes 'Multi-Factor'.

Table 30: Time-Series Regressions US HY

	MF	MF Decile	MF Long-Short	MF Decile Long-Short
	Estimate	Estimate	Estimate	Estimate
	(S.E.)	(S.E.)	(S.E.)	(S.E.)
Intercept	0.164***	0.366***	0.430***	0.839***
	(0.034)	(0.043)	(0.031)	(0.062)
Market Return	0.772***	0.712***	-0.169***	-0.201***
	(0.014)	(0.018)	(0.013)	(0.026)
N	215	215	215	215
RMSE	0.481	0.605	0.443	0.881
R^2	0.934	0.884	0.447	0.224

$*p \leq 0.05 ** \ p \leq 0.01 *** p \leq 0.001$

Note: this table shows the time-series regressions of the factor returns on an intercept and the market return for the US HY space. ‘MF’ denotes ‘Multi-Factor’.

Table 31: Time-Series Regressions US IG

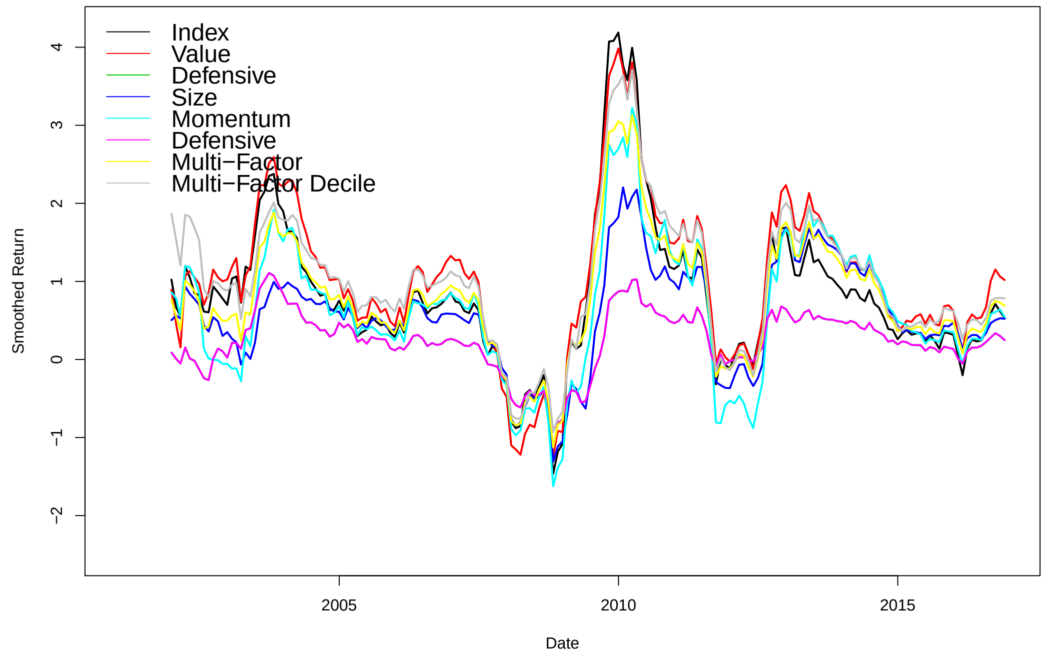
	MF	MF Decile	MF Long-Short	MF Decile Long-Short
	Estimate	Estimate	Estimate	Estimate
	(S.E.)	(S.E.)	(S.E.)	(S.E.)
Intercept	0.064*	0.145***	0.137***	0.328***
	(0.025)	(0.031)	(0.022)	(0.050)
Market Return	0.909***	0.828***	-0.244***	-0.307***
	(0.019)	(0.024)	(0.017)	(0.040)
N	215	215	215	215
RMSE	0.360	0.452	0.321	0.736
R^2	0.911	0.844	0.481	0.219

$*p \leq 0.05 ** \ p \leq 0.01 *** p \leq 0.001$

Note: this table shows the time-series regressions of the factor returns on an intercept and the market return for the US IG space. ‘MF’ denotes ‘Multi-Factor’.

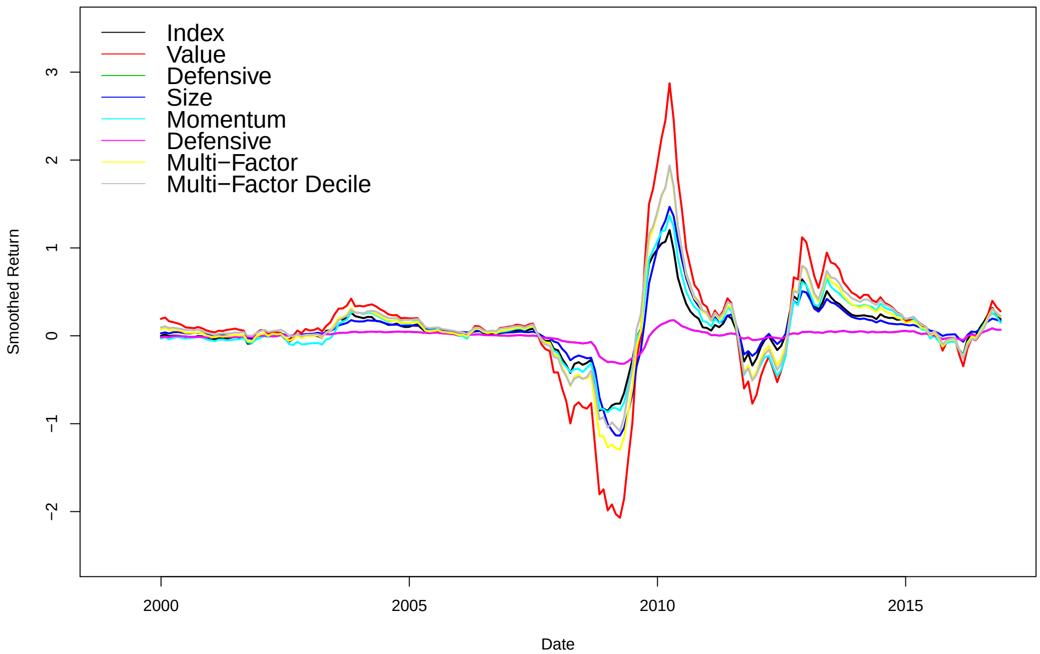
Smoothed Factor Returns

Figure 31: Smoothed Factor Return EU HY



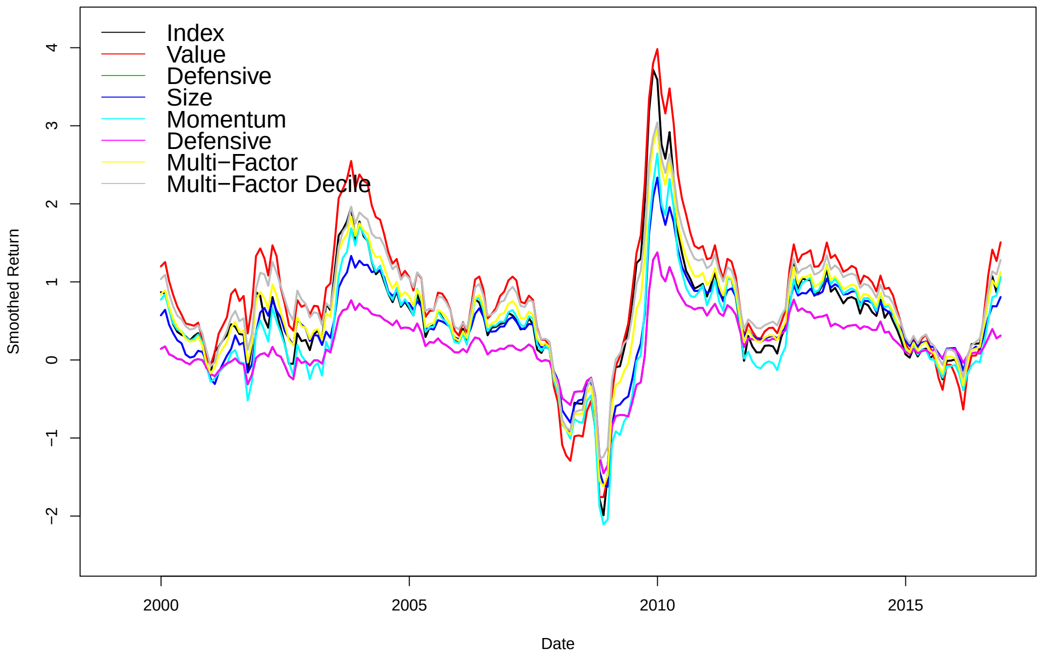
Note: this figure shows the smoothed (over a 12-month period) factor (long-short) factor returns.

Figure 32: Smoothed Factor Return EU IG



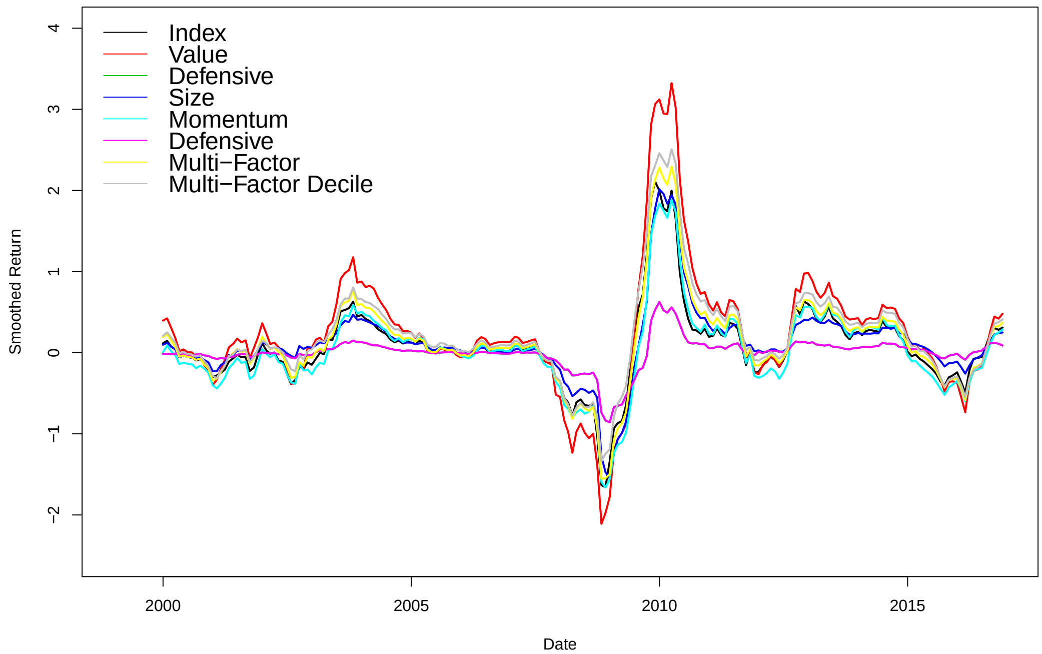
Note: this figure shows the smoothed (over a 12-month period) factor (long-short) factor returns.

Figure 33: Smoothed Factor Return US HY



Note: this figure shows the smoothed (over a 12-month period) factor (long-short) returns.

Figure 34: Smoothed Factor Return US IG



Note: this figure shows the smoothed (over a 12-month period) factor (long-short) factor returns.

Additional Results Factor Performance

Table 32: Factor Performance EU HY

	T-statistic	Fraction Pos. Rtn.	Tracking Error
Multi-Factor	7.99	0.76	0.79
Multi-Factor Decile	9.75	0.76	1.04
Value	7.58	0.74	0.86
Carry	9.06	0.81	1.04
Momentum	0.75	0.49	1.18
Size	0.77	0.55	1.45
Defensive	-4.08	0.35	1.62

Note: this table shows the results for the different performance measures in the EU HY space. The t-statistic and fraction of positive returns are calculated for the long-short portfolios. The tracking error is calculated for the long-only portfolios.

Table 33: Factor Performance EU IG

	T-statistic	Fraction Pos. Rtn.	Tracking Error
Multi-Factor	4.59	0.73	0.33
Multi-Factor Decile	3.80	0.74	0.33
Value	1.88	0.73	0.81
Carry	1.96	0.65	1.30
Momentum	-0.39	0.48	0.23
Size	1.10	0.51	0.35
Defensive	-1.17	0.40	0.62

Note: this table shows the results for the different performance measures in the EU IG space. The t-statistic and fraction of positive returns are calculated for the long-short portfolios. The tracking error is calculated for the long-only portfolios.

Table 34: Factor Performance US HY

	T-statistic	Fraction Pos. Rtn.	Tracking Error
Multi-Factor	8.16	0.78	0.72
Multi-Factor Decile	10.59	0.83	0.91
Value	10.49	0.83	0.73
Carry	10.76	0.83	0.80
Momentum	-0.13	0.52	0.70
Size	1.72	0.58	1.16
Defensive	-3.53	0.42	1.37

Note: this table shows the results for the different performance measures in the US HY space. The t-statistic and fraction of positive returns are calculated for the long-short portfolios. The tracking error is calculated for the long-only portfolios.

Table 35: Factor Performance US IG

	T-statistic	Fraction Pos. Rtn.	Tracking Error
Multi-Factor	3.79	0.73	0.38
Multi-Factor Decile	5.30	0.76	0.50
Value	4.74	0.72	0.60
Carry	3.59	0.66	0.95
Momentum	-1.49	0.37	0.38
Size	1.40	0.56	0.74
Defensive	-1.50	0.41	0.94

Note: this table shows the results for the different performance measures in the US IG space. The t-statistic and fraction of positive returns are calculated for the long-short portfolios. The tracking error is calculated for the long-only portfolios.

Additional Results Correlation Matrices

Table 36: Correlation Matrix Factor Returns EU HY

	Index	Multi-Factor	Multi-Factor Decile	Value	Carry	Defensive	Size	Momentum
Index	1.00	-0.20	0.06	0.66	0.79	-0.88	-0.67	0.03
Multi-Factor	-0.20	1.00	0.81	0.26	0.18	0.22	0.49	0.47
Multi-Factor Decile	0.06	0.81	1.00	0.46	0.40	-0.10	0.21	0.44
Value	0.66	0.26	0.46	1.00	0.79	-0.62	-0.45	-0.10
Carry	0.79	0.18	0.40	0.79	1.00	-0.80	-0.49	-0.01
Defensive	-0.88	0.22	-0.10	-0.62	-0.80	1.00	0.53	-0.08
Size	-0.67	0.49	0.21	-0.45	-0.49	0.53	1.00	0.12
Momentum	0.03	0.47	0.44	-0.10	-0.01	-0.08	0.12	1.00

Note: this table shows the correlation for the long-short factor returns.

Table 37: Correlation Matrix Long Factor Returns EU HY

	Index	Multi-Factor	Multi-Factor Decile	Value	Carry	Defensive	Size	Momentum
Index	1.00	0.96	0.91	0.94	0.94	0.89	0.81	0.88
Multi Factor	0.96	1.00	0.96	0.97	0.95	0.88	0.90	0.94
Multi-Factor Decile	0.91	0.96	1.00	0.94	0.91	0.82	0.87	0.91
Value	0.94	0.97	0.94	1.00	0.95	0.85	0.84	0.87
Carry	0.94	0.95	0.91	0.95	1.00	0.78	0.78	0.84
Defensive	0.89	0.88	0.82	0.85	0.78	1.00	0.81	0.80
Size	0.81	0.90	0.87	0.84	0.78	0.81	1.00	0.85
Momentum	0.88	0.94	0.91	0.87	0.84	0.80	0.85	1.00

Note: this table shows the correlation for the long-only factor returns.

Table 38: Correlation Matrix Factor Returns EU IG

	Index	Multi-Factor	Multi-Factor Decile	Value	Carry	Defensive	Size	Momentum
Index	1.00	0.08	0.61	0.92	0.94	-0.97	-0.57	-0.83
Multi-Factor	0.08	1.00	0.77	0.35	0.27	-0.20	0.50	0.04
Multi-Factor Decile	0.61	0.77	1.00	0.82	0.78	-0.73	-0.08	-0.45
Value	0.92	0.35	0.82	1.00	0.97	-0.97	-0.41	-0.85
Carry	0.94	0.27	0.78	0.97	1.00	-0.99	-0.51	-0.82
Defensive	-0.97	-0.20	-0.73	-0.97	-0.99	1.00	0.52	0.84
Size	-0.57	0.50	-0.08	-0.41	-0.51	0.52	1.00	0.40
Momentum	-0.83	0.04	-0.45	-0.85	-0.82	0.84	0.40	1.00

Note: this table shows the correlation for the long-short factor returns.

Table 39: Correlation Matrix Long Factor Returns EU IG

	Index	Multi-Factor	Multi-Factor Decile	Value	Carry	Defensive	Size	Momentum
Index	1.00	0.97	0.95	0.96	0.96	0.75	0.88	0.96
Multi Factor	0.97	1.00	0.99	0.99	0.99	0.73	0.94	0.97
Multi-Factor Decile	0.95	0.99	1.00	0.98	0.98	0.71	0.93	0.97
Value	0.96	0.99	0.98	1.00	0.98	0.71	0.93	0.93
Carry	0.96	0.99	0.98	0.98	1.00	0.64	0.89	0.94
Defensive	0.75	0.73	0.71	0.71	0.64	1.00	0.79	0.73
Size	0.88	0.94	0.93	0.93	0.89	0.79	1.00	0.90
Momentum	0.96	0.97	0.97	0.93	0.94	0.73	0.90	1.00

Note: this table shows the correlation for the long-only factor returns.

Table 40: Correlation Matrix Factor Returns US HY

	Index	Multi-Factor	Multi-Factor Decile	Value	Carry	Defensive	Size	Momentum
Index	1.00	-0.67	-0.47	0.54	0.55	-0.92	-0.80	-0.41
Multi-Factor	-0.67	1.00	0.94	0.17	0.14	0.52	0.78	0.34
Multi-Factor Decile	-0.47	0.94	1.00	0.42	0.37	0.29	0.62	0.22
Value	0.54	0.17	0.42	1.00	0.91	-0.69	-0.25	-0.34
Carry	0.55	0.14	0.37	0.91	1.00	-0.69	-0.36	-0.28
Defensive	-0.92	0.52	0.29	-0.69	-0.69	1.00	0.68	0.36
Size	-0.80	0.78	0.62	-0.25	-0.36	0.68	1.00	0.27
Momentum	-0.41	0.34	0.22	-0.34	-0.28	0.36	0.27	1.00

Note: this table shows the correlation for the long-short factor returns.

Table 41: Correlation Matrix Long Factor Returns US HY

	Index	Multi-Factor	Multi-Factor Decile	Value	Carry	Defensive	Size	Momentum
Index	1.00	0.97	0.94	0.95	0.95	0.92	0.90	0.96
Multi Factor	0.97	1.00	0.99	0.99	0.97	0.94	0.97	0.98
Multi-Factor Decile	0.94	0.99	1.00	0.99	0.97	0.91	0.96	0.96
Value	0.95	0.99	0.99	1.00	0.98	0.89	0.93	0.95
Carry	0.95	0.97	0.97	0.98	1.00	0.85	0.90	0.93
Defensive	0.92	0.94	0.91	0.89	0.85	1.00	0.94	0.93
Size	0.90	0.97	0.96	0.93	0.90	0.94	1.00	0.95
Momentum	0.96	0.98	0.96	0.95	0.93	0.93	0.95	1.00

Note: this table shows the correlation for the long-only factor returns.

Table 42: Correlation Matrix Factor Returns US IG

	Index	Multi-Factor	Multi-Factor Decile	Value	Carry	Defensive	Size	Momentum
Index	1.00	-0.69	-0.47	0.79	0.73	-0.95	-0.74	-0.86
Multi-Factor	-0.69	1.00	0.94	-0.23	-0.15	0.56	0.79	0.72
Multi-Factor Decile	-0.47	0.94	1.00	0.07	0.15	0.29	0.58	0.53
Value	0.79	-0.23	0.07	1.00	0.92	-0.90	-0.54	-0.71
Carry	0.73	-0.15	0.15	0.92	1.00	-0.87	-0.54	-0.61
Defensive	-0.95	0.56	0.29	-0.90	-0.87	1.00	0.70	0.84
Size	-0.74	0.79	0.58	-0.54	-0.54	0.70	1.00	0.64
Momentum	-0.86	0.72	0.53	-0.71	-0.61	0.84	0.64	1.00

Note: this table shows the correlation for the long-short factor returns.

Table 43: Correlation Matrix Long Factor Returns US IG

	Index	Multi-Factor	Multi-Factor Decile	Value	Carry	Defensive	Size	Momentum
Index	1.00	0.95	0.92	0.95	0.93	0.79	0.81	0.95
Multi Factor	0.95	1.00	0.99	0.99	0.96	0.84	0.91	0.97
Multi-Factor Decile	0.92	0.99	1.00	0.97	0.95	0.81	0.91	0.96
Value	0.95	0.99	0.97	1.00	0.97	0.77	0.86	0.94
Carry	0.93	0.96	0.95	0.97	1.00	0.69	0.79	0.92
Defensive	0.79	0.84	0.81	0.77	0.69	1.00	0.92	0.84
Size	0.81	0.91	0.91	0.86	0.79	0.92	1.00	0.89
Momentum	0.95	0.97	0.96	0.94	0.92	0.84	0.89	1.00

Note: this table shows the correlation for the long-only factor returns.

Additional Results Rating Overview

Table 44: Rating Overview per Strategy EU HY

	11	12	13	14	15	16	17	18	19	20	21	22
Index	0.22	0.16	0.13	0.13	0.15	0.13	0.06	0.01	0.01	0.00	0.00	0.00
Value	0.26	0.16	0.13	0.13	0.14	0.11	0.05	0.01	0.00	0.00	0.00	0.00
Carry	0.08	0.08	0.07	0.12	0.19	0.23	0.16	0.03	0.02	0.01	0.00	0.00
Size	0.14	0.11	0.13	0.15	0.18	0.16	0.09	0.01	0.02	0.01	0.00	0.00
Momentum	0.16	0.16	0.14	0.14	0.11	0.18	0.08	0.01	0.02	0.00	0.00	0.00
Defensive	0.40	0.25	0.15	0.10	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.00
Multi-Factor	0.22	0.16	0.13	0.13	0.13	0.13	0.07	0.01	0.01	0.00	0.00	0.00
Multi-Factor Decile	0.14	0.12	0.12	0.14	0.18	0.18	0.10	0.02	0.01	0.00	0.00	0.00

Note: this table shows the average exposure to the different ratings for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed. A rating of '11' corresponds to 'BB+' in the S&P corporate credit ratings, '12' corresponds to 'BB' until '22' which corresponds to 'D' (default).

Table 45: Rating Overview per Strategy EU IG

	1	2	3	4	5	6	7	8	9	10
Index	0.11	0.04	0.07	0.12	0.14	0.14	0.13	0.11	0.09	0.05
Value	0.18	0.05	0.07	0.12	0.13	0.13	0.09	0.09	0.09	0.06
Carry	0.01	0.01	0.01	0.05	0.10	0.15	0.14	0.20	0.20	0.13
Size	0.07	0.04	0.06	0.09	0.13	0.14	0.14	0.12	0.13	0.07
Momentum	0.06	0.02	0.05	0.10	0.12	0.13	0.15	0.15	0.15	0.07
Defensive	0.21	0.07	0.11	0.14	0.15	0.12	0.11	0.05	0.02	0.01
Multi-Factor	0.11	0.04	0.06	0.11	0.13	0.14	0.13	0.12	0.11	0.06
Multi-Factor Decile	0.09	0.03	0.05	0.09	0.12	0.14	0.12	0.12	0.14	0.09

Note: this table shows the average exposure to the different ratings for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed. A rating of '1' corresponds to 'AAA' in the S&P corporate credit ratings, '2' corresponds to 'AA+', etc.

Table 46: Rating Overview per Strategy US HY

	11	12	13	14	15	16	17	18	19	20	21	22
Index	0.16	0.15	0.14	0.13	0.15	0.15	0.08	0.03	0.01	0.00	0.00	0.00
Value	0.19	0.16	0.12	0.11	0.14	0.16	0.09	0.03	0.01	0.00	0.00	0.00
Carry	0.04	0.05	0.07	0.08	0.17	0.26	0.20	0.10	0.02	0.01	0.00	0.00
Size	0.14	0.11	0.12	0.13	0.15	0.18	0.10	0.05	0.01	0.01	0.00	0.00
Momentum	0.13	0.13	0.12	0.12	0.15	0.17	0.11	0.05	0.01	0.01	0.00	0.00
Defensive	0.25	0.21	0.17	0.13	0.12	0.08	0.03	0.01	0.00	0.00	0.00	0.00
Multi-Factor	0.16	0.15	0.13	0.12	0.14	0.15	0.09	0.04	0.01	0.00	0.00	0.00
Multi-Factor Decile	0.09	0.09	0.10	0.12	0.17	0.23	0.13	0.06	0.01	0.01	0.00	0.00

Note: this table shows the average exposure to the different ratings for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed. A rating of '11' corresponds to 'BB+' in the S&P corporate credit ratings, '12' corresponds to 'BB' until '22' which corresponds to 'D' (default).

Table 47: Rating Overview per Strategy US IG

	1	2	3	4	5	6	7	8	9	10
Index	0.02	0.01	0.03	0.07	0.11	0.17	0.14	0.15	0.18	0.12
Value	0.06	0.02	0.06	0.10	0.11	0.12	0.09	0.12	0.17	0.16
Carry	0.00	0.00	0.00	0.01	0.03	0.07	0.09	0.17	0.30	0.32
Size	0.02	0.01	0.01	0.04	0.07	0.13	0.14	0.17	0.24	0.18
Momentum	0.02	0.00	0.02	0.05	0.08	0.16	0.14	0.17	0.21	0.16
Defensive	0.05	0.02	0.07	0.14	0.17	0.22	0.13	0.10	0.08	0.03
Multi-Factor	0.03	0.01	0.04	0.08	0.10	0.15	0.12	0.14	0.19	0.14
Multi-Factor Decile	0.02	0.01	0.02	0.04	0.07	0.10	0.11	0.16	0.24	0.23

Note: this table shows the average exposure to the different ratings for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed. A rating of '1' corresponds to 'AAA' in the S&P corporate credit ratings, '2' corresponds to 'AA+', etc.

Additional Results Industry Overview

Table 48: Industry Overview per Strategy EU HY

	Index	Value	Carry	Size	Momentum	Defensive	Multi-Factor	Multi-Factor Decile
Capital Goods	0.11	0.07	0.10	0.12	0.10	0.08	0.10	0.09
Utility	0.03	0.04	0.02	0.02	0.03	0.02	0.03	0.02
Media	0.09	0.06	0.10	0.06	0.09	0.04	0.07	0.07
Insurance	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.01
Telecommunications	0.06	0.07	0.06	0.05	0.06	0.05	0.06	0.05
Banking	0.11	0.15	0.12	0.16	0.19	0.09	0.13	0.15
Basic Industry	0.15	0.12	0.14	0.11	0.10	0.18	0.14	0.12
Consumer Goods	0.07	0.05	0.06	0.10	0.03	0.09	0.07	0.08
Technology & Electronics	0.03	0.02	0.03	0.02	0.05	0.02	0.03	0.02
Leisure	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.03
Transportation	0.03	0.05	0.05	0.07	0.03	0.02	0.04	0.06
Automotive	0.09	0.12	0.08	0.06	0.05	0.13	0.09	0.09
Healthcare	0.04	0.02	0.03	0.05	0.04	0.07	0.04	0.03
Retail	0.05	0.04	0.06	0.05	0.08	0.03	0.05	0.06
Services	0.05	0.04	0.06	0.05	0.04	0.03	0.04	0.05
Real Estate	0.01	0.02	0.01	0.01	0.00	0.05	0.02	0.01
Financial Services	0.02	0.03	0.03	0.03	0.02	0.03	0.02	0.03
Energy	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03

Note: this table shows the average exposure to the different industries for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 49: Industry Overview per Strategy EU IG

	Index	Value	Carry	Size	Momentum	Defensive	Multi-Factor	Multi-Factor Decile
Insurance	0.05	0.11	0.10	0.07	0.07	0.03	0.06	0.10
Telecommunications	0.06	0.03	0.08	0.03	0.09	0.03	0.06	0.03
Basic Industry	0.05	0.02	0.06	0.07	0.06	0.03	0.05	0.04
Technology & Electronics	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Consumer Goods	0.04	0.02	0.03	0.05	0.04	0.05	0.04	0.03
Banking	0.42	0.56	0.38	0.35	0.36	0.54	0.43	0.46
Automotive	0.05	0.03	0.05	0.04	0.05	0.06	0.05	0.04
Asset Backed	0.01	0.02	0.00	0.00	0.01	0.00	0.01	0.01
Media	0.01	0.01	0.02	0.02	0.01	0.00	0.01	0.01
Capital Goods	0.03	0.01	0.03	0.04	0.03	0.02	0.03	0.03
Healthcare	0.01	0.00	0.00	0.01	0.01	0.02	0.01	0.00
Services	0.01	0.00	0.01	0.02	0.01	0.00	0.01	0.01
Financial Services	0.06	0.09	0.06	0.05	0.06	0.06	0.06	0.07
Energy	0.03	0.03	0.03	0.04	0.03	0.04	0.03	0.03
Real Estate	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02
Transportation	0.02	0.01	0.02	0.03	0.02	0.02	0.02	0.01
Retail	0.02	0.00	0.02	0.03	0.02	0.02	0.02	0.01
Local-Authority	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Utility	0.09	0.04	0.07	0.09	0.11	0.06	0.08	0.05
Agency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mortgage Backed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Supranational	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Covered Bonds	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00
Leisure	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Foreign Sovereign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Government Guaranteed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: this table shows the average exposure to the different industries for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 50: Industry Overview per Strategy US HY

	Index	Value	Carry	Size	Momentum	Defensive	Multi-Factor	Multi-Factor Decile
Consumer Goods	0.05	0.05	0.06	0.08	0.04	0.06	0.05	0.06
Capital Goods	0.06	0.05	0.07	0.07	0.06	0.07	0.06	0.06
Banking	0.03	0.03	0.02	0.03	0.04	0.03	0.03	0.03
Energy	0.12	0.09	0.10	0.09	0.12	0.09	0.10	0.09
Telecommunications	0.07	0.08	0.08	0.02	0.09	0.05	0.07	0.06
Basic Industry	0.15	0.19	0.15	0.18	0.14	0.14	0.16	0.17
Transportation	0.02	0.05	0.04	0.04	0.02	0.02	0.03	0.04
Utility	0.05	0.06	0.04	0.04	0.06	0.06	0.05	0.04
Services	0.04	0.03	0.04	0.04	0.03	0.04	0.03	0.04
Financial Services	0.02	0.04	0.03	0.02	0.02	0.03	0.03	0.03
Insurance	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.02
Retail	0.07	0.07	0.09	0.11	0.09	0.07	0.08	0.09
Healthcare	0.07	0.04	0.06	0.06	0.05	0.08	0.06	0.05
Media	0.09	0.06	0.08	0.06	0.08	0.09	0.08	0.07
Leisure	0.06	0.05	0.05	0.05	0.05	0.08	0.06	0.06
Technology & Electronics	0.04	0.03	0.04	0.03	0.04	0.04	0.04	0.04
Automotive	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.04
Real Estate	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02
Government Guaranteed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: this table shows the average exposure to the different industries for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 51: Industry Overview per Strategy US IG

	Index	Value	Carry	Size	Momentum	Defensive	Multi-Factor	Multi-Factor Decile
Financial Services	0.07	0.11	0.05	0.04	0.05	0.12	0.08	0.06
Capital Goods	0.05	0.02	0.02	0.05	0.05	0.06	0.04	0.03
Banking	0.16	0.24	0.14	0.11	0.14	0.22	0.17	0.17
Consumer Goods	0.06	0.02	0.03	0.08	0.05	0.08	0.06	0.04
Services	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.02
Insurance	0.06	0.11	0.08	0.08	0.07	0.05	0.07	0.10
Utility	0.11	0.05	0.07	0.11	0.10	0.08	0.09	0.08
Energy	0.11	0.09	0.13	0.12	0.13	0.07	0.11	0.11
Real Estate	0.03	0.03	0.05	0.08	0.04	0.01	0.04	0.07
Transportation	0.03	0.04	0.04	0.03	0.04	0.02	0.03	0.03
Media	0.04	0.02	0.06	0.02	0.05	0.02	0.04	0.03
Basic Industry	0.06	0.07	0.11	0.10	0.07	0.04	0.07	0.10
Telecommunications	0.05	0.06	0.06	0.02	0.06	0.04	0.05	0.04
Healthcare	0.04	0.02	0.02	0.04	0.03	0.06	0.04	0.02
Technology & Electronics	0.03	0.03	0.03	0.04	0.03	0.04	0.03	0.03
Retail	0.04	0.02	0.04	0.04	0.04	0.04	0.04	0.03
Supranational	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Government Guaranteed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Local-Authority	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Automotive	0.02	0.03	0.04	0.01	0.02	0.03	0.03	0.02
Foreign Sovereign	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Leisure	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01
Agency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: this table shows the average exposure to the different industries for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Additional Results Type Overview

Table 52: Type Overview per Strategy EU HY

	SUB	SENR	SECR	JSUB	T1	T2	UT2	AT1
Index	0.09	0.62	0.18	0.03	0.05	0.02	0.02	0.00
Value	0.08	0.56	0.21	0.04	0.06	0.03	0.01	0.00
Carry	0.11	0.51	0.28	0.02	0.05	0.02	0.01	0.00
Size	0.13	0.50	0.20	0.02	0.09	0.03	0.03	0.00
Momentum	0.09	0.54	0.15	0.04	0.13	0.03	0.02	0.00
Defensive	0.05	0.81	0.09	0.01	0.02	0.02	0.01	0.00
Multi-Factor	0.09	0.61	0.17	0.03	0.06	0.02	0.02	0.00
Multi-Factor Decile	0.10	0.52	0.25	0.01	0.06	0.03	0.02	0.00

Note: this table shows the average exposure to the different bond types for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed. 'SUB' corresponds to 'subordinated', 'SENR' corresponds to 'senior', 'SECR' corresponds to 'secured', 'T2' corresponds to 'Tier 2', 'UT2' corresponds to 'upper Tier 2', 'T1' corresponds to 'Tier 1', 'JSUB' corresponds to 'junior' or 'subordinated' and 'AT1' corresponds to 'additional Tier 1'.

Table 53: Type Overview per Strategy EU IG

	SENR	JSUB	SUB	T2	SECR	T1	UT2	ASEN	PFD
Index	0.82	0.02	0.02	0.10	0.02	0.03	0.01	0.00	0.00
Value	0.57	0.05	0.05	0.18	0.04	0.08	0.02	0.00	0.00
Carry	0.57	0.07	0.06	0.16	0.02	0.09	0.02	0.00	0.00
Size	0.82	0.02	0.03	0.07	0.03	0.02	0.01	0.00	0.00
Momentum	0.75	0.03	0.03	0.12	0.02	0.04	0.01	0.00	0.00
Defensive	0.95	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00
Multi-Factor	0.78	0.02	0.02	0.10	0.02	0.04	0.01	0.00	0.00
Multi-Factor Decile	0.66	0.04	0.05	0.14	0.03	0.06	0.02	0.00	0.00

Note: this table shows the average exposure to the different bond types for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed. 'SENR' corresponds to 'senior', 'T2' corresponds to 'Tier 2', 'SUB' corresponds to 'subordinated', 'SECR' corresponds to 'secured', 'T1' corresponds to 'Tier 1', 'UT2' corresponds to 'upper Tier 2', 'JSUB' corresponds to 'junior' or 'subordinated and 'PFD' corresponds to 'preferred'.

Table 54: Type Overview per Strategy US HY

	SENR	T2	SUB	SECR	T1	UT2	JSUB	PFD	AT1
Index	0.67	0.00	0.18	0.13	0.01	0.00	0.01	0.00	0.00
Value	0.65	0.01	0.12	0.21	0.01	0.00	0.01	0.00	0.00
Carry	0.60	0.00	0.21	0.18	0.00	0.00	0.01	0.00	0.00
Size	0.58	0.01	0.25	0.14	0.01	0.00	0.01	0.00	0.00
Momentum	0.68	0.00	0.15	0.12	0.02	0.00	0.01	0.00	0.00
Defensive	0.71	0.01	0.15	0.13	0.00	0.00	0.00	0.00	0.00
Multi-Factor	0.66	0.00	0.17	0.14	0.01	0.00	0.01	0.00	0.00
Multi-Factor Decile	0.59	0.00	0.19	0.20	0.00	0.00	0.01	0.00	0.00

Note: this table shows the average exposure to the different bond types for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed. 'SENR' corresponds to 'senior', 'JSUB' corresponds to 'junior' or 'subordinated', 'SECR' corresponds to 'secured', 'SUB' corresponds to 'subordinated', 'T2' corresponds to 'Tier 2', 'T1' corresponds to 'Tier 1', 'UT2' corresponds to 'upper Tier 2', 'AT1' corresponds to 'additional Tier 1' and 'PFD' corresponds to 'preferred'.

Table 55: Type Overview per Strategy US IG

	SUB	SENR	JSUB	T2	SECR	T1	UT2	PFD
Index	0.05	0.82	0.01	0.04	0.07	0.02	0.00	0.00
Value	0.05	0.74	0.02	0.07	0.08	0.04	0.01	0.00
Carry	0.03	0.80	0.02	0.05	0.06	0.04	0.00	0.00
Size	0.05	0.83	0.01	0.02	0.08	0.01	0.00	0.00
Momentum	0.05	0.82	0.01	0.04	0.06	0.02	0.00	0.00
Defensive	0.05	0.88	0.00	0.01	0.06	0.00	0.00	0.00
Multi-Factor	0.04	0.83	0.01	0.03	0.06	0.02	0.00	0.00
Multi-Factor Decile	0.05	0.80	0.01	0.04	0.07	0.02	0.00	0.00

Note: this table shows the average exposure to the different bond types for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed. 'SENR' corresponds to 'senior', 'T2' corresponds to 'Tier 2', 'JSUB' corresponds to 'junior' or 'subordinated', 'SECR' corresponds to 'secured', 'SUB' corresponds to 'subordinated', 'T1' corresponds to 'Tier 1', 'UT2' corresponds to 'upper Tier 2' and 'PFD' corresponds to 'preferred'.

Additional Results OAS Overview

Table 56: OAS Overview per Strategy EU HY

	0-100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000
Index	0.03	0.09	0.14	0.17	0.16	0.13	0.10	0.07	0.06	0.04
Value	0.00	0.02	0.04	0.09	0.11	0.14	0.17	0.17	0.15	0.11
Carry	0.00	0.00	0.00	0.02	0.07	0.13	0.20	0.22	0.21	0.15
Size	0.02	0.08	0.13	0.15	0.14	0.14	0.12	0.11	0.08	0.04
Momentum	0.03	0.09	0.13	0.16	0.17	0.15	0.11	0.09	0.05	0.03
Defensive	0.07	0.21	0.25	0.21	0.11	0.07	0.04	0.02	0.01	0.01
Multi-Factor	0.03	0.10	0.13	0.14	0.13	0.13	0.12	0.10	0.07	0.04
Multi-Factor Decile	0.00	0.02	0.05	0.09	0.13	0.17	0.18	0.16	0.13	0.07

Note: this table shows the average exposure to different levels of OAS for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 57: OAS Overview per Strategy EU IG

	0-100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000
Index	0.59	0.25	0.08	0.04	0.02	0.01	0.00	0.00	0.00	0.00
Value	0.40	0.23	0.16	0.09	0.05	0.03	0.02	0.01	0.01	0.00
Carry	0.21	0.32	0.19	0.11	0.07	0.04	0.02	0.01	0.01	0.00
Size	0.61	0.22	0.08	0.04	0.02	0.01	0.01	0.00	0.00	0.00
Momentum	0.52	0.29	0.10	0.04	0.02	0.01	0.01	0.00	0.00	0.00
Defensive	0.81	0.16	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Multi-Factor	0.56	0.24	0.09	0.05	0.03	0.01	0.01	0.00	0.00	0.00
Multi-Factor Decile	0.41	0.29	0.14	0.08	0.04	0.02	0.01	0.01	0.00	0.00

Note: this table shows the average exposure to different levels of OAS for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 58: OAS Overview per Strategy US HY

	0-100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000
Index	0.01	0.07	0.17	0.20	0.17	0.13	0.09	0.07	0.05	0.04
Value	0.00	0.00	0.04	0.08	0.11	0.15	0.17	0.18	0.15	0.12
Carry	0.00	0.00	0.00	0.01	0.07	0.14	0.20	0.24	0.20	0.14
Size	0.01	0.06	0.12	0.15	0.16	0.14	0.12	0.10	0.08	0.05
Momentum	0.01	0.05	0.15	0.19	0.18	0.14	0.11	0.08	0.05	0.03
Defensive	0.02	0.17	0.26	0.21	0.14	0.08	0.05	0.03	0.02	0.01
Multi-Factor	0.01	0.08	0.14	0.16	0.15	0.13	0.12	0.10	0.07	0.05
Multi-Factor Decile	0.00	0.01	0.04	0.09	0.14	0.17	0.17	0.16	0.13	0.09

Note: this table shows the average exposure to different levels of OAS for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 59: OAS Overview per Strategy US IG

	0-100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000
Index	0.33	0.41	0.15	0.06	0.03	0.01	0.01	0.00	0.00	0.00
Value	0.14	0.31	0.25	0.14	0.07	0.04	0.02	0.01	0.01	0.01
Carry	0.00	0.28	0.34	0.19	0.08	0.04	0.02	0.02	0.01	0.01
Size	0.32	0.38	0.17	0.07	0.03	0.02	0.01	0.01	0.00	0.00
Momentum	0.22	0.47	0.18	0.06	0.03	0.01	0.01	0.00	0.00	0.00
Defensive	0.69	0.24	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Multi-Factor	0.33	0.36	0.17	0.07	0.03	0.02	0.01	0.01	0.00	0.00
Multi-Factor Decile	0.12	0.40	0.26	0.11	0.05	0.03	0.02	0.01	0.01	0.00

Note: this table shows the average exposure to different levels of OAS for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Additional Results Spread Duration Overview

Table 60: Spread Duration Overview per Strategy EU HY

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-15	15+
Index	0.06	0.13	0.15	0.19	0.20	0.12	0.04	0.03	0.02	0.02	0.04	0.00
Value	0.02	0.13	0.16	0.21	0.23	0.12	0.04	0.03	0.02	0.02	0.01	0.00
Carry	0.03	0.09	0.14	0.21	0.27	0.14	0.03	0.04	0.03	0.02	0.01	0.00
Size	0.11	0.20	0.20	0.18	0.12	0.05	0.01	0.02	0.03	0.02	0.06	0.00
Momentum	0.05	0.11	0.14	0.16	0.19	0.10	0.04	0.03	0.05	0.05	0.08	0.00
Defensive	0.09	0.35	0.26	0.20	0.07	0.02	0.00	0.00	0.00	0.00	0.01	0.00
Multi-Factor	0.07	0.18	0.18	0.19	0.17	0.08	0.03	0.02	0.02	0.02	0.04	0.00
Multi-Factor Decile	0.09	0.19	0.21	0.22	0.16	0.05	0.01	0.02	0.02	0.02	0.02	0.00

Note: this table shows the average exposure to different levels of spread duration for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 61: Spread Duration Overview per Strategy EU IG

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-15	15+
Index	0.02	0.15	0.15	0.16	0.14	0.12	0.10	0.07	0.03	0.02	0.03	0.00
Value	0.01	0.15	0.15	0.15	0.13	0.13	0.12	0.08	0.03	0.01	0.04	0.00
Carry	0.01	0.07	0.09	0.13	0.13	0.15	0.15	0.10	0.04	0.03	0.09	0.00
Size	0.02	0.32	0.23	0.17	0.11	0.06	0.03	0.02	0.01	0.01	0.02	0.00
Momentum	0.01	0.13	0.15	0.16	0.14	0.14	0.12	0.06	0.03	0.02	0.04	0.00
Defensive	0.03	0.48	0.31	0.14	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Multi-Factor	0.03	0.22	0.19	0.15	0.11	0.10	0.08	0.05	0.02	0.01	0.03	0.00
Multi-Factor Decile	0.04	0.23	0.19	0.16	0.11	0.10	0.07	0.04	0.01	0.01	0.03	0.00

Note: this table shows the average exposure to different levels of spread duration for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 62: Spread Duration Overview per Strategy US HY

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-15	15+
Index	0.05	0.10	0.14	0.20	0.22	0.13	0.05	0.03	0.03	0.02	0.02	0.00
Value	0.02	0.08	0.15	0.23	0.24	0.12	0.05	0.04	0.03	0.02	0.01	0.00
Carry	0.03	0.08	0.15	0.24	0.28	0.12	0.04	0.04	0.02	0.01	0.00	0.00
Size	0.10	0.19	0.22	0.23	0.14	0.04	0.02	0.03	0.02	0.01	0.01	0.00
Momentum	0.05	0.11	0.15	0.20	0.18	0.09	0.04	0.03	0.05	0.04	0.05	0.00
Defensive	0.13	0.29	0.28	0.21	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Multi-Factor	0.08	0.15	0.18	0.21	0.18	0.08	0.03	0.03	0.03	0.02	0.02	0.00
Multi-Factor Decile	0.08	0.16	0.23	0.27	0.17	0.04	0.02	0.02	0.01	0.00	0.00	0.00

Note: this table shows the average exposure to different levels of spread duration for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 63: Spread Duration Overview per Strategy US IG

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-15	15+
Index	0.02	0.11	0.12	0.13	0.11	0.11	0.11	0.06	0.03	0.03	0.17	0.01
Value	0.01	0.08	0.10	0.13	0.12	0.15	0.13	0.07	0.04	0.05	0.12	0.00
Carry	0.01	0.04	0.06	0.09	0.10	0.14	0.12	0.06	0.05	0.06	0.26	0.01
Size	0.02	0.20	0.18	0.16	0.13	0.12	0.07	0.03	0.02	0.02	0.05	0.00
Momentum	0.01	0.07	0.10	0.11	0.11	0.13	0.11	0.04	0.03	0.04	0.24	0.01
Defensive	0.02	0.34	0.30	0.22	0.06	0.02	0.02	0.01	0.00	0.00	0.00	0.00
Multi-Factor	0.02	0.15	0.15	0.14	0.10	0.10	0.09	0.04	0.03	0.03	0.14	0.01
Multi-Factor Decile	0.02	0.12	0.14	0.16	0.13	0.14	0.11	0.04	0.03	0.03	0.09	0.00

Note: this table shows the average exposure to different levels of spread duration for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Additional Results Modified Duration Overview

Table 64: Modified Duration Overview per Strategy EU HY

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-15	15+
Index	0.02	0.10	0.13	0.19	0.25	0.20	0.06	0.02	0.01	0.01	0.00	0.00
Value	0.01	0.12	0.16	0.23	0.28	0.14	0.03	0.01	0.00	0.01	0.00	0.00
Carry	0.01	0.07	0.12	0.21	0.33	0.19	0.04	0.02	0.01	0.01	0.00	0.00
Size	0.02	0.15	0.23	0.25	0.23	0.10	0.01	0.01	0.00	0.00	0.00	0.00
Momentum	0.01	0.11	0.13	0.19	0.26	0.18	0.05	0.02	0.02	0.02	0.01	0.00
Defensive	0.03	0.33	0.27	0.24	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Multi-Factor	0.03	0.15	0.17	0.23	0.24	0.13	0.03	0.01	0.01	0.01	0.00	0.00
Multi-Factor Decile	0.03	0.16	0.20	0.25	0.24	0.09	0.02	0.00	0.00	0.00	0.00	0.00

Note: this table shows the average exposure to different levels of modified duration for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 65: Modified Duration Overview per Strategy EU IG

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-15	15+
Index	0.02	0.16	0.16	0.17	0.14	0.12	0.10	0.06	0.02	0.01	0.02	0.00
Value	0.01	0.17	0.17	0.17	0.15	0.13	0.12	0.05	0.01	0.00	0.01	0.00
Carry	0.01	0.09	0.12	0.16	0.16	0.16	0.16	0.08	0.02	0.01	0.03	0.00
Size	0.03	0.34	0.25	0.18	0.12	0.05	0.02	0.01	0.00	0.00	0.00	0.00
Momentum	0.01	0.14	0.16	0.17	0.16	0.14	0.12	0.05	0.02	0.01	0.02	0.00
Defensive	0.04	0.48	0.30	0.13	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Multi-Factor	0.03	0.23	0.20	0.17	0.12	0.10	0.08	0.04	0.01	0.01	0.01	0.00
Multi-Factor Decile	0.04	0.25	0.21	0.18	0.13	0.09	0.07	0.02	0.00	0.00	0.00	0.00

Note: this table shows the average exposure to different levels of modified duration for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 66: Modified Duration Overview per Strategy US HY

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-15	15+
Index	0.01	0.05	0.10	0.17	0.24	0.20	0.09	0.04	0.03	0.03	0.04	0.00
Value	0.00	0.05	0.12	0.22	0.27	0.14	0.06	0.05	0.04	0.02	0.02	0.00
Carry	0.00	0.04	0.12	0.23	0.31	0.17	0.04	0.05	0.03	0.01	0.01	0.00
Size	0.01	0.11	0.19	0.28	0.24	0.08	0.02	0.03	0.03	0.01	0.01	0.00
Momentum	0.00	0.06	0.11	0.18	0.23	0.16	0.06	0.04	0.05	0.04	0.07	0.00
Defensive	0.01	0.18	0.24	0.30	0.22	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Multi-Factor	0.01	0.08	0.14	0.23	0.26	0.13	0.04	0.03	0.03	0.02	0.03	0.00
Multi-Factor Decile	0.01	0.09	0.20	0.31	0.26	0.07	0.02	0.02	0.02	0.01	0.01	0.00

Note: this table shows the average exposure to different levels of modified duration for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.

Table 67: Modified Duration Overview per Strategy US IG

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-15	15+
Index	0.01	0.10	0.11	0.12	0.10	0.10	0.11	0.06	0.03	0.03	0.20	0.02
Value	0.01	0.08	0.10	0.13	0.12	0.14	0.12	0.05	0.04	0.05	0.16	0.00
Carry	0.00	0.04	0.06	0.09	0.09	0.13	0.12	0.05	0.04	0.06	0.30	0.01
Size	0.01	0.20	0.18	0.16	0.13	0.11	0.07	0.03	0.02	0.03	0.06	0.00
Momentum	0.00	0.07	0.09	0.11	0.11	0.12	0.10	0.04	0.03	0.04	0.27	0.02
Defensive	0.02	0.34	0.30	0.22	0.07	0.02	0.02	0.01	0.00	0.00	0.00	0.00
Multi-Factor	0.02	0.14	0.15	0.14	0.10	0.10	0.08	0.04	0.02	0.03	0.16	0.01
Multi-Factor Decile	0.02	0.12	0.14	0.15	0.12	0.14	0.11	0.04	0.02	0.03	0.11	0.00

Note: this table shows the average exposure to different levels of modified duration for the different strategies. First the cross-sectional average is calculated, then these time-series average is computed.