# Systematic Risk Premia in EM Bond Markets

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**Abstract**

Despite the fact, that emerging market (EM) bond investments have yielded decent returns over the last 15 years and have recently become more and more popular among risk-taking investors due to the low interest-rate environment, the academic research on this asset class is still quite meager. We address this issue by firstly developing a three-factor model that allows to systematically explain the return-generating process of EM bond investments. We find that up to 83.1% of the variation of local currency bond returns can be explained by a market, a duration and a carry factor. We use linear regressions to show the importance of the carry factor in explaining EM bond specific return dynamics, since this factor does not only capture currency risk but also sovereign credit risk - two components inherently connected to EM bond investments. In a final step, we find that the average long-term risk premia of all three factors are significantly positive, but substantially vary over time. A Fama-MacBeth framework based on EM bond fund returns is used to get monthly out-of-sample estimates of the time-varying risk premia.

**Keywords:** empirical asset pricing, emerging markets, bond funds, risk factors, risk premia, factor models, Fama MacBeth regression, carry.
**JEL Classification:** G11, G12

# 1 Motivation

Since the introduction of the Captial Asset Pricing Model (CAPM) by Sharpe (1964) and Lintner (1965) and the Arbitrage Pricing Theory (APT) by Ross (1976), the issue of empirically explaining the cross-section of expected returns has received an overwhelming interest from academics as well as practitioners. A recent study by Harvey, Liu, and Zhu (2015) shows the myriad of papers trying to explain the cross-section of expected returns by introducing hundreds of new factors[1]. They document that 316 different factors - mainly focusing on *equities* - have recently been proposed in the literature to explain the cross-section of expected returns, which they refer to as data mining and therefore argue for higher statistical criteria. The asset management industry seems to follow this "factor" trend by shifting away from classical asset-allocation funds towards strategy-allocation funds based on various risk factors. These newly incorporated funds, which mainly focus on equity risk factor strategies, are advertised as "smart beta" products.

The importance of using multiple risk factors to explain the dynamics of expected returns across various asset classes is unchallenged and is well summarized in Ang (2014). Nonetheless, while the main focus in the field of empirical asset pricing lies on explaining equity returns, the literature on bond returns in general, and on bond returns of emerging markets (EM) specifically, is less numerous. This is supported by a simple screening of the EBSCO database for specific keywords in this research field.[2] It shows up that two thirds of all papers referring to factor models and/or risk premia since the 1980s have been written on equity markets, while only one third has focused on bond returns. If we refine the screening and consider only those papers which at least use the keywords "bond" and "emerging markets", we find that only 9% of all papers written since 1980 are focusing on the analysis of EM bond investments.[3]

*Our paper* tries to close this gap by firstly, *identifying* those risk factors that are qualified to explain the dynamics of government bond returns of emerging market countries, and by secondly, *quantifying* the risk premia earned by those factors over time. Additionally, the usage of *tradeable* factors also differentiates our approach from existing ones. Since EM government bonds are in general not very liquid, we do not make use of individual bonds but use mutual funds, instead. This is similar to Elton, Gruber, and Blake (1995) who also use mutual funds to explain return dynamics, but for developed market (DM) bond investments. In the first part, we are interested in the role of a *market* and a *duration* factor and in their impact on excess returns of EM bond investments. Moreover, we evaluate to what extent these traditional factors have to be augmented by an additional factor such as a *carry* factor to get a better understanding of the return-generating process of EM bond markets. In the second part, the main focus lies on the empirical out-of-sample estimation of the time-varying risk premia for the market, the duration and the carry factor.

Since these three factors are well described in the empirical asset pricing literature, we avoid any

[1]See also Cochrane (2011) who refers to this situation as "a zoo of new factors".

[2]See table 10 in the appendix for more details.

[3]This specification tends to even overestimate the number of papers in the field, since some papers analyze stock and bonds together.

discussions concerning data mining issues. While the rational of a general market risk premium is based on the CAPM framework, the premium received for holding duration and carry risks can be explained by the empirical failure of both the Expectations Hypothesis (EH) and the Uncovered Interest Rate Parity (UIP), respectively. Fama and Bliss (1987) and Campbell and Shiller (1991) are among the first to empirically show the failure of the EH, which generally states that the long-term yield needs to be equal to the average of the expected short-term yields. They document the existence of a duration premium in the overall bond market that compensates investors for holding long-term bonds. Cochrane and Piazzesi (2005) confirm this finding by constructing a single risk factor based on one year forwards rates to explain US government bonds excess returns. Duffee (2011) argues that the single factor used by Cochrane and Piazessi is not sufficient to explain the return dynamics of government bonds and adds a hidden factor that allows to explain a large portion of excess returns. Dockner, Mayer, and Zechner (2013) introduce an additional credit risk factor derived from one year forward CDS spreads, which allows a better explanation of bond returns across countries with different credit rating.

The rationalization of the carry premium finds its origin in the failure of the UIP, which states that the expected depreciation of a currency is equal to the interest rate differential between two countries. Hansen and Hodrick (1980) and Hansen and Hodrick (1983) are the first ones to document this failure empirically and thus give rise to the so-called "forward premium puzzle" in international FX markets. A first explanation to that puzzle comes from Fama (1984) who argues that the depreciation of high-yield currencies - mostly those currencies held long in a carry factor - positively co-varies with bad times. This indicates that an investor holding that carry risk most likely faces extreme losses exactly at those times when the value of money is high and therefore demands a premium. Della Corte, Sarno, Schmeling, and Wagner (2014) relate the carry risk premium to a country's default risk. They argue that a surge in sovereign default risk is strongly related to a depreciation of a country's exchange rate. Therefore the carry premium is a compensation for global credit risk. Brunnermeier and Pedersen (2009) and Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011), however, relate the carry premium to currency crash risk. They show that currencies tend to crash in times when liquidity dries up using the global financial crises as an empirical example.

Our results show that up to 83.1% of the returns variation of local EM bond investments can be explained by using a *three-factor model* consisting of a market, a duration and a carry factor over a time period of 15 years. All three factor are robust over time and show up highly significant, which allows to rule out any data mining issues. Since we analyze both returns based on local currency EM bonds and returns based on USD-denominated EM bonds, we are also able to empirically document that the carry premium compensates investors not only for holding FX risks, but also for *credit risks*. This finding is consistent with Della Corte, Sarno, Schmeling, and Wagner (2014). Additionally, we find that the average long-term risk premia of all three factors are significantly positive, but substantially vary over time. Put differently, we are able to estimate the time-varying risk premia of all three factors *out-of-sample*, by using a data sample based on EM bond funds in combination with the two-step regression framework defined in Fama and MacBeth (1973). Besides that, we document low correlations among the three risk premia, which might be exploited for diversification purposes in a portfolio context. Finally, our findings indicate that the fund industry might have reacted too slowly, since most EM bond funds have only been incorporated when the carry premium has been already low or even negative.

We begin with a definition of our three risk factors in section 2. The empirical identification of the return-generating process of EM bond investments is discussed in section 3, while section 4 documents the estimation of the time-varying risk premia. Section 5 shows that our results are robust, while section 6 concludes the paper.

## 2 Factors

To systematically analyze the return dynamics of EM bond markets, we need to define factors that capture the risks associated with an investment in that asset class. To avoid any data mining issues, we focus on factors that are not only well documented in the academic literature but can also be economically rationalized. Following that, we hypothesize that the variation of EM bond returns can be sufficiently explained by a three-factor model using a market, a duration and a carry factor. While the first two factors - market and duration[4] - have been discussed by Fama and French (1993) and Elton, Gruber, and Blake (1995) and can be considered as traditional factors for explaining DM bond returns, the carry factor is less well established to explain return dynamics. Thus it can be considered as a new and additional factor that explicitly captures the risks of EM bond investments. We require our factors to be tradeable, i.e. they can be directly traded on the market using financial derivatives, which distinguishes our approach from prevailing literature. We use the database Bloomberg to download the relevant data for the construction of our factors.[5]

### 2.1 Methodology

Our *market factor* is supposed to measure the general market premium that is earned by investing into risky assets and can thus be viewed as a proxy of the overall global economic conditions. Since it is not trivial to define a benchmark of the global market portfolio that comprises all available assets and contains all the risks associated with them, we use a simplifying heuristical approach that is widely used in the asset management industry to overcome that short-falling. Following that, our global market factor is set up as a linear combination of a globally diversified equity index and a global bond index with focus on developed markets. This is in contrast to Elton, Gruber, and Blake (1995) who use only an equity index as a market factor to explain DM bond fund returns. Explicitly the monthly excess return of our tradeable market factor, $rx_t^M$, is given by

$$rx_t^M = p * rx_t^{\text{Equity}} + (1-p) * rx_t^{\text{Debt}}, \tag{1}$$

where $rx^{\text{Equity}}$ and $rx^{\text{Debt}}$ are the monthly excess returns of the MSCI AC World Index (equity) and the GBI Global Bond Index (debt)[6]; $p$ and $(1-p)$ represent the weights. We use the 1-month US LIBOR rate

[4]The literature also refers to this factor as "term" factor.

[5]See Appendix B for more details.

[6]The Bloomberg tickers for the equity and the debt index are "GDUEACWF" and "JHDCGBIG", respectively.

as risk-free asset[7]. The market factor used in our empirical analysis is set up by using a weighting of 60% equity and 40% debt. This is coherent with the asset management standard of a 60/40 benchmark portfolio that is documented e.g. in Perold and Sharpe (1995). We abbreviate our market factor by "BM6040".

To explicitly measure the sensitivity of EM bond returns to interest-rate changes in the US, we set up a *duration factor* using US Treasury Note futures. In contrast to Fama and French (1993), who use long-term US government bonds and T-bills for their term factor, we make use of bond futures. This allows us to construct a factor with constant maturity that is tradeable and serves as an explicit proxy of the slope of the US yield curve. Our decision for using only the US yield curve to explain EM bond returns is twofold: Firstly, we have reason to believe that the US interest rate policy, and any changes thereof, are closely watched by the central banks of emerging market countries. This leads to the assumption that the US yield curve serves as an implicit benchmark for the yield curves in EM countries and therefore helps to explain EM bond returns. Secondly, the data quality and availability of EM bond futures is quiet meager. Since we are interested in a clean measure with a long time-series and a low correlation to our carry factor, we only make use of US futures data. The monthly excess return, $rx_t^{10Y}$, of a fully collaterialized strategy based on being long 10-Year US Treasury Note futures is given by

$$rx_t^{10Y} = \frac{F_t^T}{F_{t-1}^T} - 1, \tag{2}$$

where $F_t^T$ and $F_{t-1}^T$ are the prices of the 10-Year US Treasury Note futures[8] with maturity in $T$ at time point $t-1$ and $t$ . The strategy includes roll costs/gains by rolling futures approximately one month before maturity. The term "fully collaterlized" refers to the fact that the strategy does not include any leverage, since the full futures price needs to be deposited on the margin account. Additionally, we assume that the margin account earns the risk-free rate, which makes the returns in formula 2 excess returns.

Since we are interested in the slope (and not the level) of the US yield curve, the duration factor used in our empirical analysis is set up by being long the 10-Year US Treasury Note futures and being short the 2-Year US Treasury Note futures[9], which can be explicitly shown by

$$rx_t^D = rx_t^{10Y} - rx_t^{2Y} \tag{3}$$

where $rx_t^D$ is the monthly excess return of the duration factor. $rx_t^{10Y}$ is the monthly excess return of an investment in the 10-Year US Treasury Note futures and $rx_t^{2Y}$ is the monthly excess return of an investment in the 2-Year US Treasury Notes futures, which is computed based on equation 2. We abbreviate our duration factor by "US10Ymin2Y".

Besides the two traditional factors mentioned above, we introduce a third factor which is called

[7]We also used the risk-free interest rate provided by Fama and French. Our results remain robust irrespective of the specification of the risk-free asset.

[8]The 10-Year US Treasury Note futures entitle for the conversion of US Treasury notes maturing at least 6.5, but not more than 10 years from the first day of the delivery month.

[9]See also Koijen, Moskowitz, Pedersen, and Vrugt (2017) who use a similar definition of the slope of the yield curve.

*carry factor* and that is specifically designed to capture the risk dynamics of EM bond investments. Since EM bonds, in contrast to DM bonds, are substantially exposed to currency and credit risks, it is essential that our factor accounts for those two risk components. Using currencies in our setup ensures that the carry factor explicitly captures FX risks. Arguing that the carry factor also captures credit risk is, however, not that straight forward, but is documented in Della Corte, Sarno, Schmeling, and Wagner (2014), who show that the risk premium of a carry factor can be explained by sovereign default risks. Following Koijen, Moskowitz, Pedersen, and Vrugt (2017), we set up a tradeable *carry factor* based on sorting currencies according to their forward premium, where high-yield currencies are bought against the US-Dollar.

The monthly excess return of a long currency carry position based on forward rates is explicitly given by

$$c_{i,t}^{\text{long}} = \frac{F_{i,t-1}^{1M}}{S_{i,t}} - 1, \tag{4}$$

where $S_{i,t}$ is the spot rate (measured in numbers of foreign currency units per 1 unit of USD) of currency $i$ at time $t$, and $F_{i,t-1}^{1M}$ is the respective 1-month forward rate of currency $i$ known in $t-1$. $c_{i,t}^{\text{long}}$ corresponds to the monthly carry excess return in USD of currency $i$ in the period from $t-1$ to $t$. By assuming that the entire forward price needs to be deposited in a margin account the strategy is considered as fully collateralized.

A carry factor is then constructed by being long the $n$ highest yielding currencies out of the total universe of $N$ currencies at time $t-1$ and being short the USD, and by equally weighing these $n$ carry returns. Using the implied yield (IY) known already in $t-1$ and given by

$$IY_{i,t-1} = \frac{F_{i,t-1}^{1M}}{S_{i,t-1}} - 1 \tag{5}$$

as selection criterion allows us to finally define the excess return of our carry factor, $rx_t^C$, as follows:

$$rx_t^C = \frac{1}{n} \sum_{i=1}^{N} c_{i,t}^{\text{long}} * \mathbb{1}_{\left(\text{rank}(IY_{i,t-1}) \leq n\right)}, \tag{6}$$

$N$ is the total number of currencies available in our sample, which in our case consists of a maximum of 46 DM and EM currencies.[10] The indicator function $\mathbb{1}_{\left(\text{rank}(IY_{i,t-1}) \leq n\right)}$ equals 1 for the $n$ highest ranked currencies (i.e. 1, 2,...), and 0 otherwise. Using the fraction term ($\frac{1}{n}$) in combination with the summation guarantees the equal weighting. Our final setup of the carry factor uses $n = 5$, i.e. that only the carry returns ($c_{i,t}^{\text{long}}$) of the 5 highest-yielding currencies are taken into account, and is abbreviated by "HMU5". We also test various other specifications using e.g. $n = 1$, $n = 3$ or $n = 20\%$ (i.e. 20% of the highest-yielding currencies are bought), as well as a setup, which is abbreviated by "HML5", where also the lowest-yielding currencies (and not only the USD) are being sold. Despite this myriad of different factor specifications our results remain robust.[11]

[10] Find an overview of all currencies used for the construction of our carry factor in table 11 in the appendix.

[11] More details about the alternative factor specifications can be found in the appendix.

## 2.2 Descriptive Statistics

We illustrate the excess return performance of our three defined factors in comparison to the performance of two EM bond fund indices, where one index serves as a benchmark for EM bonds in local currency (GBI.EM) and the other one proxies EM bonds denominated in USD (EMBI)[12]. The differentiation between these two EM bond indices is essential, since the local currency index is explicitly exposed to the currency risks of EM countries, while the USD-denominated one is not. The pure fact that there even exists these two different indices is also special to EM bond investments, since many EM countries are forced - due to their high inflation and their unstable exchange rates - to issue debt in hard currency, such as USD, to attract investors and get international funding. Most EM countries therefore do not only have local currency bonds, but also USD-denominated bonds outstanding.

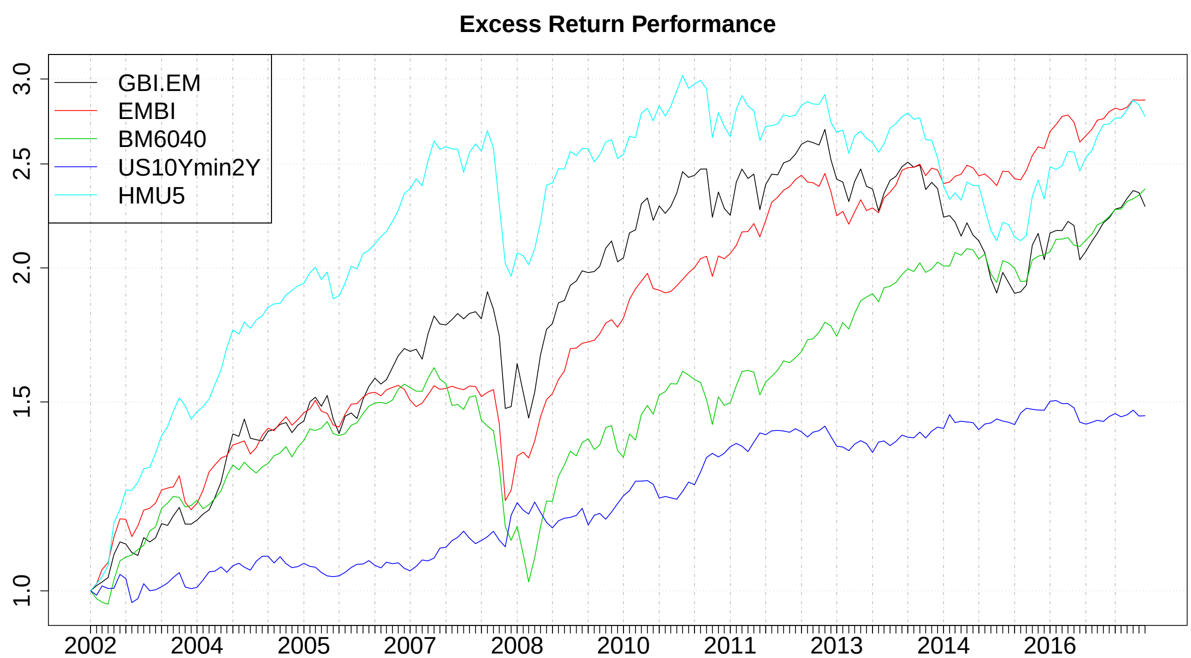


**Figure 1:** The figure shows the excess return performance of a local currency EM bond index (GBI.EM), a USD-denominated EM bond index (EMBI) and our three previously defined factors of the market (BM6040), the duration (US10Ymin2Y) and the carry (HMU5). We start at 2002-12 since there is no data available for the local currency EM bond index (GBI.EM) prior to that.

Figure 1 shows what 1 USD invested on December 31, 2002 would have grown to over a time period of approximately 15 years. It is interesting to mention that although an investment into a local currency bond index has yielded a better performance than an investment into a USD-denominated bond index over a long period of time (first 10 years), over the full period the USD-denominated bond index outperforms. This is attributable to the substantial setback of the local currency index during 2013, which might be explained by the so-called "Taper Tantrum", where the US Federal Reserve Bank was considering interest rate hikes for the first time after the financial crises of 2008. Besides the pure

[12]The Bloomberg tickers for the local currency and the USD-denominated bond index are "JGENVUUG" and "JPEIGLBL", respectively.

performance, we are also interested in risk measures such as standard deviations, higher moments and Sharpe ratios of the two EM bond indices and our three factors.

| | **EM Bond Indices** | | **Factors** | | |
|---|---|---|---|---|---|
| | GBI.EM | EMBI | BM6040 | US10Ymin2Y | HMU5 |
| Excess Return | 6.27 | 7.48 | 6.22 | 2.66 | 7.50 |
| StdDev | 11.78 | 8.31 | 8.79 | 4.94 | 11.12 |
| Skewness | −0.60 | −1.83 | −0.87 | 0.23 | −0.69 |
| ExKurtosis | 1.86 | 10.21 | 3.21 | 2.89 | 2.07 |
| SharpeRatio | 0.53 | 0.90 | 0.71 | 0.54 | 0.68 |

**Table 1:** Descriptive Statistics of the two EM bond indices, where the GBI.EM proxies local currency bond investments and the EMBI proxies USD-denominated investments and our three previously defined risk factors of the market (BM6040), the duration (US10Ymin2Y) and the carry (HMU5). We use monthly excess returns in USD from 2002-12 till 2017-10.

Table 1 shows an attractive annualized excess return of 6.27% and 7.48% for the local and the USD-denominated EM bond index, which are in a similar range to the returns of our market and carry factor. Only the duration factor yields a substantially lower return of 2.66%. The EM bond indices as well as the factors exhibit attractive Sharpe ratios of above 0.5, where especially the Sharpe ratio of 0.9 of the USD-denominated EM bond index sticks out. A possible explanation of this highly attractive ratio is that risks of higher moments, which are not negligible in the case of the the USD-denominated EM bond index (e.g. excess kurtosis of 10.21), are not taken into account when computing Sharpe ratios.

## 3 Factor Analysis

After the definition of our three factor, we are finally able to empirically address the question whether these three factors have a significant impact in explaining EM bond return dynamics. Similar to Fama and French (1992), we use the following time-series regression setup to write the return-generating-process of EM bond investments as

$$rx_t^{\text{Index}} = \alpha + \beta^M rx_t^M + \beta^D rx_t^D + \beta^C rx_t^C + \epsilon_t, \tag{7}$$

with $rx_t^{\text{Index}}$ denoting the excess returns of either (1) the local currency bond index (GBI.EM) or (2) the USD-denominated bond index (EMBI), and $rx_t^M$, $rx_t^D$ and $rx_t^C$ being the excess returns of the market, the duration and the carry factor, respectively. The $\beta$-coefficients are estimated over the full sample and represent the factor loadings.

It is worth mentioning that for this analysis we do not need the data on a fund level basis, since we are only interested in understanding the return-generating-process of EM bond investments. For that it is sufficient to only use data on an index level basis. Nonetheless, it is still essential to differentiate between local currency and USD-denominated EM bond investments, which we take care of by performing a separate factor analysis using formula 7 for the local currency index (GBI.EM) and the

USD-denominated index (EMBI). To show that our results are robust and also valid to explain the returns of EM bond funds, we perform the same factor analysis on fund level basis and show these results in section 5.

### 3.1 Model Selection

In the first step, we focus on the empirical identification of the systematic risk factors based on the local currency EM bond index. For that we use a stepwise procedure that is summarized in table 2. While models 1 - 3 only use a single market factor to explain the excess returns of the local bond index, a duration factor is added in models 4 and 5; models 6 - 9 add a carry factor using two different specifications, while model 10 excludes the market factor. Only the models 1, 4 and 6 use the exact specifications of our previously defined three factors such as "BM6040", "US10Ymin2Y" and "HMU5". All the other models use factors with slightly different specifications. We still display them to show the robustness of our results. While 51.9% of the local EM bond index returns can be explained by only using an equity index (model 2), only a meager 1.6% of the return variation can be explained by using a DM bond index (model 3). This result seems to be surprising at first sight, might however be explained by the fact, that EM bond investments - in contrast to DM bond investments - are not used as a hedge in times of economic downturn (bad times), but rather are seen as attractive investments in stable economic conditions (good times). To attribute for that we use our previously defined market factor (BM6040), which is supposed to proxy for the general economic conditions in model 1 and observe the highest explanatory power (57.9%) of all three single-factor models. Since the duration factor (US10Ymin2Y) also shows up significantly in model 4, the explanatory power can be increase to 62.0% by using a two-factor model. In a last step, we add our carry factor (HMU5) in model 6, which shows up highly significant as well. Models 8 and 9 include a carry factor (HML5) that uses a setup which goes long the highest- yielding currencies and is short the lowest-yielding currencies (instead of being short only the USD).[13] Using this kind of specification lowers the explanatory power, identifying model 6 as the best model. The *main key-take-away* here is that a maximum of 83.1% of the return variation of the local EM bond index can be explained by a three-factor-model using our previously defined market, duration and carry factors (model 6). Besides that we want to emphasize the relatively high factor loading of the carry factor of 0.721 in model 6, which - according to our previously stated assumptions - does not only measure the FX risks but also the credit risks inherent to EM bond investments.[14]

[13] Find more details on the exact setup in the appendix.

[14] We also test for autocorrelation using e.g. Durbin-Watson tests, Ljung-Box tests, etc. and do not find significant autocorrelation in the error terms. Nonetheless, we show that our results are robust by displaying heteroscedasticity and autocorrelation corrected (HAC) standard errors for the local currency and the USD-denominated bond indices in the appendix.

| GBI.EM - Index | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | **Model 6** | Model 7 | Model 8 | Model 9 | Model 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (Intercept) | $-0.000$ | 0.013 | 0.049 | $-0.016$ | $-0.010$ | $-0.026^{*}$ | $-0.024$ | $-0.032$ | $-0.028$ | $-0.018$ |
| | (0.020) | (0.022) | (0.031) | (0.020) | (0.020) | (0.013) | (0.013) | (0.018) | (0.019) | (0.014) |
| BM6040 | $1.015^{***}$ | | | $1.033^{***}$ | | $0.358^{***}$ | | $0.828^{***}$ | | |
| | (0.066) | | | (0.062) | | (0.062) | | (0.070) | | |
| MSCI.AC | | $0.570^{***}$ | | | $0.613^{***}$ | | $0.206^{***}$ | | $0.490^{***}$ | |
| | | (0.041) | | | (0.037) | | (0.037) | | (0.042) | |
| GBI.Glo.HedUSD | | | 0.546 | | | | | | | |
| | | | (0.285) | | | | | | | |
| US10Ymin2Y | | | | $0.537^{***}$ | $0.752^{***}$ | $0.462^{***}$ | $0.532^{***}$ | $0.584^{***}$ | $0.756^{***}$ | $0.422^{***}$ |
| | | | | (0.111) | (0.113) | (0.074) | (0.077) | (0.104) | (0.105) | (0.080) |
| HMU5 | | | | | | $0.721^{***}$ | $0.728^{***}$ | | | $0.930^{***}$ |
| | | | | | | (0.049) | (0.049) | | | (0.036) |
| HML5 | | | | | | | | $0.344^{***}$ | $0.350^{***}$ | |
| | | | | | | | | (0.065) | (0.065) | |
| Adj. $R^2$ | 0.571 | 0.519 | 0.015 | 0.620 | 0.614 | 0.831 | 0.828 | 0.670 | 0.667 | 0.799 |
| Num. obs. | 178 | 178 | 178 | 178 | 178 | 178 | 178 | 178 | 178 | 178 |

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

**Table 2:** This table shows the stepwise regression results based on the local currency EM bond index (GBI.EM) which is available in the period of 2002-12-31 till 2017-10-31. The following regression specification is used: $rx_t^{GBI.EM} = \alpha + \beta^M rx_t^M + \beta^D rx_t^D + \beta^C rx_t^C + \epsilon_t$. OLS standard errors are shown in parentheses.

After analyzing the local currency EM bond index, we are now focusing on the USD-denominated bond index and use the same stepwise regression procedure, summarized in table 3. Keep in mind that the returns of the USD-denominated bond index are - per definition - not exposed to FX risks, which marks a substantial difference to the local currency EM bond index. Similar to previous findings, it can be shown that up to 47.0% of the return variation of a USD-denominated investment can be explained by our general market factor (BM6040) in model 1. Compared to the results of the local currency index of table 2, it can be seen that the explanatory power of the single factor models (models 1 - 3) as well as the market factor loadings are lower (except for model 3). Despite the similarity of the results at first sight, the significantly positive alpha (intercept) of models 1-3 need to be mentioned emphasized. This is a clear indication that a single-factor model is not sufficient in explaining the return-generating-process of the USD-denominated bond index. Adding our duration factor (US10Ymin2Y), which shows up highly significant, does not only increase the explanatory power to 65.0%, but it also makes the alpha insignificant. In a last step, we augment the model by our previously defined carry factor (HMU5), which turns out to be significantly positive (model 6). Models 8 and 9 include a different specification of the carry factor that goes long the highest yielding currencies and is short the lowest-yielding currencies (HML5). These specifications result in a slightly lower explanatory power which identifies model 6 again as the best model. 74.2% of the return variation of the USD-denominated EM bond index can thus be explained by our three-factor model, which is slightly less than the 83.1% explanatory power previously observed for the local currency bond index.

| EMBI | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | **Model 6** | Model 7 | Model 8 | Model 9 | Model 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (Intercept) | 0.034* | 0.044** | 0.053* | 0.014 | 0.017 | 0.009 | 0.011 | 0.002 | 0.004 | 0.017 |
| | (0.016) | (0.017) | (0.021) | (0.013) | (0.013) | (0.011) | (0.011) | (0.012) | (0.012) | (0.013) |
| BM6040 | 0.650*** | | | 0.674*** | | 0.357*** | | 0.525*** | | |
| | (0.052) | | | (0.042) | | (0.054) | | (0.047) | | |
| MSCI.AC | | 0.350*** | | | 0.400*** | | 0.208*** | | 0.310*** | |
| | | (0.033) | | | (0.025) | | (0.032) | | (0.028) | |
| GBI.Glo.HedUSD | | | 0.862*** | | | | | | | |
| | | | (0.192) | | | | | | | |
| US10Ymin2Y | | | | 0.717*** | 0.857*** | 0.681*** | 0.754*** | 0.751*** | 0.860*** | 0.642*** |
| | | | | (0.075) | (0.077) | (0.065) | (0.067) | (0.069) | (0.070) | (0.072) |
| HMU5 | | | | | | 0.338*** | 0.343*** | | | 0.547*** |
| | | | | | | (0.042) | (0.043) | | | (0.032) |
| HML5 | | | | | | | | 0.250*** | 0.255*** | |
| | | | | | | | | (0.044) | (0.044) | |
| Adj. $R^2$ | 0.470 | 0.393 | 0.098 | 0.650 | 0.644 | 0.742 | 0.738 | 0.704 | 0.701 | 0.678 |
| Num. obs. | 178 | 178 | 178 | 178 | 178 | 178 | 178 | 178 | 178 | 178 |

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

**Table 3:** The USD-denominated EM Bond Index (EMBI) is also available in the period of 1994-01-31 till 2017-10-31. However, in this table we only use data for the period of 2002-12-31 till 2017-10-31 to make it comparable to the local currency bond index (GBI.EM). The following regression specification is used: $rx_t^{EMBI} = \alpha + \beta^M rx_t^M + \beta^D rx_t^D + \beta^C rx_t^C + \epsilon_t$. OLS standard errors are shown in parentheses.

Instead of looking at the results of tables 2 and 3 in isolation, we are especially interested in the *commonalities* as well as the *differences* that arise from the analysis of the two EM bond indices with clearly different risk dynamics. Despite these obvious differences in risk dynamics, our empirical factor analysis still shows that the *same* three-factor model - using our previously defined factor specifications of the market, the duration and the carry (BM6040, US10Ymin2Y, HMU5) - should be used to systematically explain EM bond returns, irrespective of whether local or USD-denominated investments are considered. This result might seem surprising at first sight, especially with regard to our carry factor. Remember that our carry factor explicitly measures FX risks, since it is set up by an equally weighted basket of currencies. Therefore it seems to be obvious - even *ex ante* - that the coefficient of the carry factor turns out to be positive and highly significant ($\beta^C = 0.721$) when analyzing the local currency EM bond index in table 2 (model 6). The same cannot be expected for the USD-denominated bond index, since this index is not exposed to FX risk. Nonetheless, our empirical results (see model 6 in table 3) also identify the carry factor as highly significant in explaining USD-denominated bond returns. The major difference, however, lies in the magnitude of the factor loading of the carry factor. By comparing model 6 of the tables 2 and 3, we find similar factor loadings of the market (0.358 versus 0.357) and the duration factor (0.462 versus 0.681), while the factor loading of the carry factor based on the USD-denominated bond index is only half of the one observed for the local currency index (0.721 versus 0.338). This result is striking in the sense that it shows that our carry factor does not only capture FX risks, but implicitly also captures *credit risks*, which is consistent with Della Corte, Sarno, Schmeling, and Wagner (2014). By simply comparing the magnitude of the factor loadings, one might conclude that the carry factor compensates for 50% FX risks and 50% credit risks.

### 3.2 Robustness of the three-factor model

The goal of the following analysis is to show the robustness of our three-factor model. To do so, we use the same model specification as in model 6 in tables 2 and 3. We subdivide the full time period of approximately 15 years into three 5-year periods (columns 1 - 3), and one 10-year period (column 4). Column 5 shows the regression results of the full time period and is identical to model 6 of the previous subsection. The key message from table 4 is that our three-factor model is robust throughout different time periods. This is not only shown by the statistical significance of all factors (except of the duration factor in the first 5-year period (column 1)), but also by the fact that the estimated factor loadings remain stable over time. The high explanatory power of more than 80% (except for the first 5-year period) allows to conclude that our proposed three-factor model is sufficient to explain the return-generating-process of local currency EM bond investments.

| GBI.EM | 2003/01-2007/10 | 2007/11-2012/10 | 2012/11-2017/10 | 2007/11-2017/10 | 2003/01-2017/10 |
|---|---|---|---|---|---|
| (Intercept) | $-0.042$ | $0.033$ | $-0.049^{**}$ | $-0.008$ | $-0.026^{*}$ |
| | (0.028) | (0.025) | (0.018) | (0.015) | (0.013) |
| BM6040 | $0.465^{**}$ | $0.374^{***}$ | $0.351^{***}$ | $0.304^{***}$ | $0.358^{***}$ |
| | (0.151) | (0.102) | (0.098) | (0.066) | (0.062) |
| US10Ymin2Y | 0.261 | $0.473^{***}$ | $0.560^{***}$ | $0.541^{***}$ | $0.462^{***}$ |
| | (0.141) | (0.120) | (0.118) | (0.085) | (0.074) |
| HMU5 | $0.574^{***}$ | $0.715^{***}$ | $0.827^{***}$ | $0.801^{***}$ | $0.721^{***}$ |
| | (0.109) | (0.096) | (0.058) | (0.055) | (0.049) |
| Adj. $R^2$ | 0.654 | 0.868 | 0.895 | 0.873 | 0.831 |
| Num. obs. | 58 | 60 | 60 | 120 | 178 |

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

**Table 4:** This table uses the following regression specification $rx_t^{GBI.EM} = \alpha + \beta^M rx_t^M + \beta^D rx_t^D + \beta^C rx_t^C + \epsilon_t$ to estimate the factor loadings for the local currency EM Bond Index over 3 x 5-year periods, 1 x 10-year period and the full 15-year period. OLS standard errors are shown in parentheses.

The same approach is also used for the USD-denominated EM bond index. Performing regressions for the same 15-year period (column 5), as well as for the same three 5-year (column 1 - 3) and the same 10-year period (column 4), confirm the robustness of our results. While the explanatory power of our three-factor model for USD-denominated bond investments is slightly lower with approximately 75% over the full sample, it shows up very stable throughout all time periods. All the factors show up highly significant and the factor loadings are extremely robust over time. Again, we want to highlight that the $\beta$-coefficients of the carry factor for the USD-denominated bonds are approximately half of the ones for the local currency EM bond index shown in table 5. This can again be explained by the fact that in the case of the USD-denominated bond index the carry factor only measures credit risk, while in the case of the local currency bond index the carry factor is a proxy for FX *and* credit risks.

| EMBI | 2003/01-2007/10 | 2007/11-2012/10 | 2012/11-2017/10 | 2007/11-2017/10 | 2003/01-2017/10 |
|---|---|---|---|---|---|
| (Intercept) | −0.011 | 0.048 | 0.003 | 0.027 | 0.009 |
| | (0.021) | (0.025) | (0.015) | (0.014) | (0.011) |
| BM6040 | 0.252* | 0.320** | 0.384*** | 0.349*** | 0.357*** |
| | (0.114) | (0.102) | (0.085) | (0.062) | (0.054) |
| US10Ymin2Y | 0.882*** | 0.575*** | 0.641*** | 0.602*** | 0.681*** |
| | (0.106) | (0.119) | (0.102) | (0.079) | (0.065) |
| HMU5 | 0.318*** | 0.412*** | 0.311*** | 0.368*** | 0.338*** |
| | (0.082) | (0.095) | (0.050) | (0.051) | (0.042) |
| Adj. $R^2$ | 0.714 | 0.755 | 0.778 | 0.762 | 0.742 |
| Num. obs. | 58 | 60 | 60 | 120 | 178 |

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

**Table 5:** This table uses the following regression specification $rx_t^{EMBI} = \alpha + \beta^M rx_t^M + \beta^D rx_t^D + \beta^C rx_t^C + \epsilon_t$ to estimate the factor loadings for the USD-denominated EM Bond Index over 3 x 5-year periods, 1 x 10-year period and the full 15-year period. OLS standard errors are shown in parentheses.

# 4 Risk Premia

Previously we have focused on the factor definition and the analysis of the return-generating-process of EM bond investments. Now we are able to empirically address the question of whether an investor is compensated over the long run for being exposed to our three (risk) factors, and if so, how this compensation varies over time. Put differently, we are interested in estimating the time-varying risk premia using an approach firstly described in Fama and MacBeth (1973). This approach allows to quantify the risk premia - sometimes also referred to as "price of risk" - over time, since it does not only use the time-series but also the *cross-section* of data. Due to the necessity of cross-sectional data in the Fama-MacBeth approach, we need to turn to a more detailed dataset that is based on EM bond funds instead of the granular dataset previously used, which is based on EM bond indices only. The following analyses are therefore based on this more detailed EM bond fund dataset.

The Fama-MacBeth approach is a two-step procedure that exploits the time-series of data in the first step and uses the cross-section of all available EM bond funds in the second step. Formally, the first step, using *time-series regressions*, is given by

$$rx_{i,t} = \alpha_{i,t} + \beta_{i,t}^M rx_t^M + \beta_{i,t}^D rx_t^D + \beta_{i,t}^C rx_t^C + \epsilon_{i,t}, \tag{8}$$

with $rx_{i,t}$ denoting the excess return of bond fund $i$ from period $t-1$ to $t$, and $rx_t^M$, $rx_t^D$ and $rx_t^C$ are the excess returns of the market, the duration and the carry factor from period $t-1$ to $t$, respectively. The coefficients $\beta_{i,t}^M$, $\beta_{i,t}^D$ and $\beta_{i,t}^C$ represent the time-varying factor loadings of each bond fund $i$ to the market, the duration and the carry factor, respectively. The subscript $t$ indicates that the $\beta_{i,t}$-coefficients change over time, since they are estimated using expanding window regressions with at least 24 months of data for the first estimation. This expanding window procedure, which is similar to the one used in Fama and MacBeth (1973), ensures that the $\beta$-coefficients are estimated without a *forward-looking* bias, i.e. the $\beta$-coefficients are estimated out-of-sample. Since the inception dates of the EM bond funds in our sample are not the same, the time point $t$ of the first estimated $\beta_{i,t}$ varies across funds.

After this first step (time-series regressions), we end up with a time-series of three estimated $\beta_{i,t}$'s for each fund $i$. These $\beta$-coefficients are then used as explanatory variables in the second step - the *cross-sectional regressions* - to estimate the time-varying risk premia of the market, the duration and the carry factor. Formally, this cross-sectional step is given by

$$rx_{i,t} = \beta^M_{i,t-1}\gamma^M_t + \beta^D_{i,t-1}\gamma^D_t + \beta^C_{i,t-1}\gamma^C_t + a_{i,t}, \tag{9}$$

where $\gamma^M_t$, $\gamma^D_t$, $\gamma^C_t$ represent the estimated factor premia of the market, the duration and the carry at each time point $t$. Our special focus is devoted to the subscript $t-1$ for the $\beta$-coefficients. This means that only the return info up to time point $t-1$ is used to estimate the $\beta$-coefficients in the first step regressions (equation 8), which guarantees an *out-of-sample* estimation of the risk premia ($\gamma$) in the second step (equation 9). On the left-hand-side of the cross-sectional regression, we use the excess returns ($rx_{i,t}$) of all available EM bond funds $i$ (at least 15 funds) at each time point $t$. Since we have an unbalanced panel due to different inception dates, we require the cross-section to consist of at least 15 EM bond funds to estimate the three $\gamma$-coefficients. The pricing errors are given by $a_{i,t}$. It might be noted that we do not use a general intercept in our cross-sectional regression setup in equation 9 to estimate the risk premia.[15]

## 4.1 Data

Since the Fama-MacBeth approach does not only require a time-series, but also a cross-sectional analysis, our previously used dataset, which only included the local currency and the USD-denominated EM bond index is not sufficient anymore. Therefore, we turn to a more detailed dataset that is based on the single fund level. We use the database Morningstar to download all available mutual funds as well as ETFs that are categorized as "EM fixed income" with "USD" as their base currency. Additionally, we differentiate between funds investing in local currency EM bonds and those funds investing in USD-denominated EM bonds. This is in analogy to our previous differentiation of the two indices. Besides that, we explicitly want to emphasize that our dataset includes all funds that have been closed or annihilated over time to avoid any kind of survivorship bias.

Using this screening process, the Morningstar database gives us 617 funds. Unfortunately, we cannot make use of all of these funds, since the same fund within one fund-family is listed several times. The only difference being is the total expense ratio depending on whether this fund is set up for retail or institutional investors. Put differently, out of those 617 funds the large majority of funds only differs by their cost structure but not by their asset allocation. Therefore we decided to go through the full list of 617 funds by hand to choose *the* one fund of each fund-family, which cost structure is designed for institutional investors. Additionally, we also exclude all funds that are explicitly named "corporate

[15]We also computed the time-varying risk premia using a cross-sectional regression setup including a general intercept, which are not displayed here. The results remain robust.

bond funds", since our main focus is on sovereign EM bond investments. Doing that we end up with a total of *128 funds*.

For the classification into local currency or USD-denominated funds, we use the Morningstar category "Emerging-Markets Local-Currency Bond" in a first step. This categorization, however, is not fully correct for all bond funds and therefore we use our own selection procedure as follows: We download the top 10 holdings of each EM bond fund via Bloomberg[16] and additionally get the respective currencies of these positions. We define a threshold of 4, saying that each EM bond fund is categorized as local currency bond fund if at least 4 bonds, out of the top 10 holdings, are denominated in other currencies than USD. Doing that, we finally end up with *55 local currency* EM bond funds and *73 USD-denominated* EM bonds funds.

To avoid major estimation errors due to small sample sizes, we additionally set up the following two constraints: Firstly, we require the *time-series* of each EM bond fund to be greater than 24 months. Each fund that does not fulfill that criteria is excluded from the sample. Secondly, we look at the *cross-section* of EM bond funds and only take those time points into consideration, where at least 15 different funds (local currency and USD-denominated funds together) are available. This criteria is firstly fulfilled in 1997/07, which therefore also marks the starting point of our data sample.

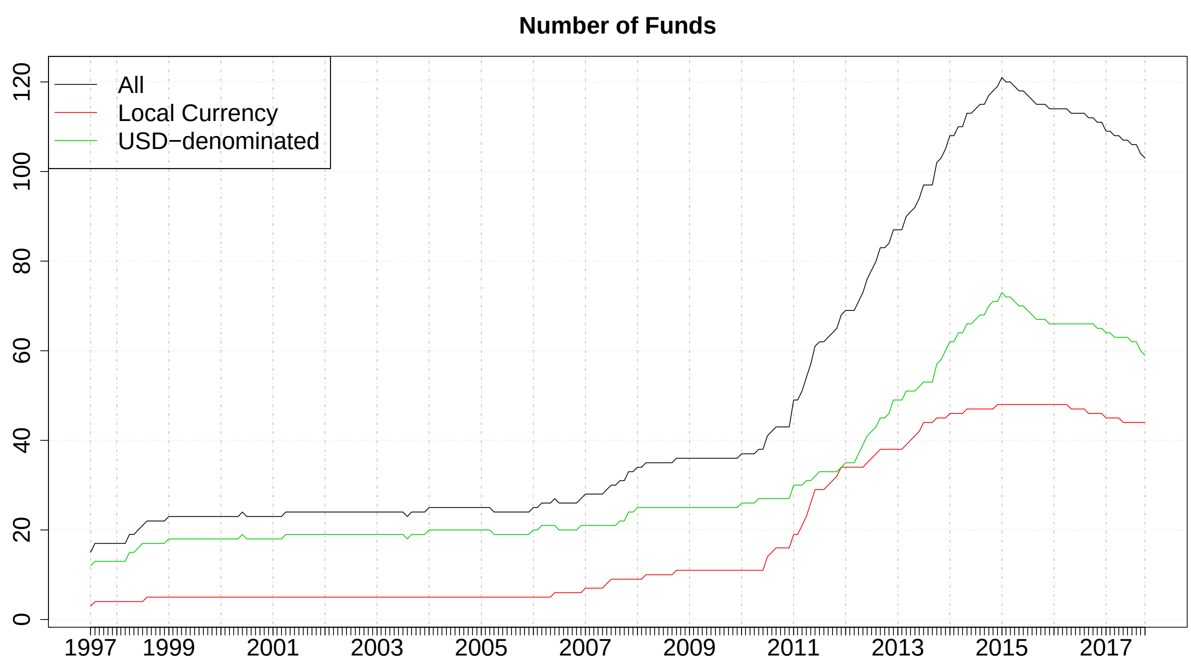


**Figure 2:** The graphic shows the amount of funds that are in the sample over time. The following selection criteria need to be fulfilled such that funds get included into the sample: 1) The return *time-series* is greater than 24 months. 2) The *cross-section* of funds needs to be greater or equal than 15, i.e. at each month there need to be at least 15 funds available. 3) We use local and USD-denominated funds to get a larger cross-section that varies between 15 and 121 funds over time - with a maximum of 48 local currency funds.

Figure 2 illustrates the total number of funds, as well as the number of local currency funds and funds investing in USD-denominated bonds over time. While the number EM bond funds was quite

[16] We use the Bloomberg Ticker "Top Mutual Fund Holdings" to get the top 10 holdings of each fund.

stable over a long period of time, many new funds were incorporated starting in 2011 reaching a maximum of more than 120 funds in 2015. Since then, however, the number of EM bond funds has been slightly decreasing.

### 4.2 Empirical quantification of risk premia

After the definition of the Fama-MacBeth framework and the setup our EM bond fund dataset, we are able to empirically estimate the time-varying risk premia of our three factors. In a first step, we perform time-series regressions based on equation 8 using expanding window regressions (with at least 24 months of data) to estimate the three $\beta_{i,t}$-coefficients of the market, the duration and the carry factor for each fund $i$ in each time point $t$. After that we use these three $\beta$-coefficients of time point $t-1$ to get monthly *out-of-sample* estimaties of the time-varying risk premia ($\gamma_t$) at time point $t$ for each of the three factors using equation 9. Since the estimated monthly risk premia vary substantially (see figure 6 in the appendix) making an interpretation of long-term patterns impossible, we choose to display the cumulative risk premia instead.

Figure 3 shows how much 1 USD invested in 1999/07 in each of the three risk premia would have grown to over the last 18 years. Due to the two-step Fama-MacBeth procedure, it is straight forward to compare the cumulative performance of these three risk premia since they all exhibit the same risk loading. In other words, the cross-sectional analysis ensures that the estimated risk premia shown here are normalized to a risk loading of $\beta = 1$ for all three factors. While the cumulative performance of all three risk premia is positive over the long run, there seems to be a strong variation over time. While the estimated market premium was substantially negative in the time period of the financial crisis, the duration and the carry premia were considerably less negatively effected in 2009. The carry premium, which is less documented in the literature than the market and the duration premium, seems to be most volatile, especially since 2013. While the carry premium was constant and substantially positive from 2003 till 2011, with a slight negative premium in 2009, the extremely high positive premium from 2009-2011 is striking. Since then, however, the carry premium has been fluctuating around zero, turning substantially negative starting in 2014. Only recently (since 2016), the carry premium has become positive again.

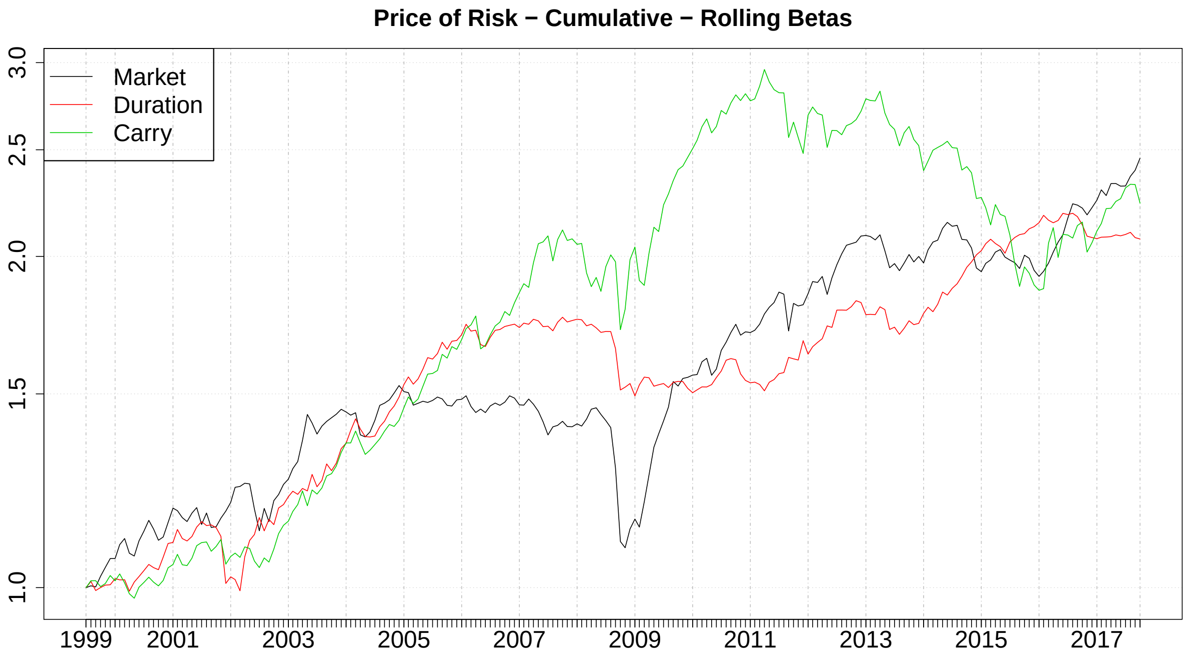


**Figure 3:** A Fama-MacBeth regression setup (without intercept) is used to compute the risk premia of the market, the duration and the carry factor, which is explicitly given by: $rx_{i,t} = \beta^M_{i,t-1}\gamma^M_t + \beta^D_{i,t-1}\gamma^D_t + \beta^C_{i,t-1}\gamma^C_t + a_{i,t}$. The table shows the cumulative return of the three risk premia ($\gamma$). We use regressions based on an expanding window (of at least 24 months) for each fund $i$ to estimate time-varying $\beta_{i,t}$-coefficients.

The trajectory of the carry premium might also explain the evolution of the number of EM bond funds seen in figure 2. Remember that starting in 2011 the number of EM bond funds was tripling, reaching its maximum in 2015 and gradually decreasing ever since. Assuming that fund companies base their decisions on whether to incorporate a fund (or not) on backtests using historical data, they could have been attracted by the appealing carry premium up until 2011, explaining the rising number of EM bond funds thereafter. Also the recent decrease (since 2015) in the number of funds can potentially be explained by the carry premium, which has been low and even negative since 2011. A question that inevitably arises in this context is, whether the fund industry was too slow in recognizing the attractive carry premium of the period 2003-2011, and has reacted too late by only incorporating EM bond funds when the carry premium has already become unattractive (2011-2016).

| Risk Premia | Market | Duration | Carry |
|---|---|---|---|
| **Panel A: Full and 15-year period** | | | |
| 1999/07-2017/10 | | | |
| $\overline{\gamma}$ | 0.053 | 0.042 | 0.049 |
| $t(\overline{\gamma})$ | 2.743 | 2.908 | 2.061 |
| 2002/10-2017/10 | | | |
| $\overline{\gamma}$ | 0.054 | 0.040 | 0.056 |
| $t(\overline{\gamma})$ | 2.539 | 2.881 | 1.985 |
| **Panel B: 1 x 8-year and 1 x 10-year period** | | | |
| 1999/07-2007/10 | | | |
| $\overline{\gamma}$ | 0.044 | 0.070 | 0.093 |
| $t(\overline{\gamma})$ | 1.855 | 2.966 | 3.857 |
| 2007/11-2017/10 | | | |
| $\overline{\gamma}$ | 0.060 | 0.018 | 0.013 |
| $t(\overline{\gamma})$ | 2.049 | 1.041 | 0.338 |
| **Panel C: 1 x 3-year and 3 x 5-year periods** | | | |
| 1999/07-2002/10 | | | |
| $\overline{\gamma}$ | 0.058 | 0.043 | 0.026 |
| $t(\overline{\gamma})$ | 1.286 | 0.910 | 0.790 |
| 2002/11-2007/10 | | | |
| $\overline{\gamma}$ | 0.035 | 0.088 | 0.137 |
| $t(\overline{\gamma})$ | 1.334 | 3.731 | 4.227 |
| 2007/11-2012/10 | | | |
| $\overline{\gamma}$ | 0.081 | 0.006 | 0.054 |
| $t(\overline{\gamma})$ | 1.580 | 0.228 | 0.882 |
| 2012/11-2017/10 | | | |
| $\overline{\gamma}$ | 0.038 | 0.029 | −0.028 |
| $t(\overline{\gamma})$ | 1.389 | 1.502 | −0.584 |

**Table 6:** This table shows the mean ($\overline{\gamma}$) and the t-statistics ($t(\overline{\gamma})$) of the estimated monthly risk premia of the market, the duration and the carry factor for the full data sample of 18- and 15-years in Panel A, for a 8- and a 10-year period in Panel B and for one 3- and three 5-year periods in Panel C. The results are comparable to the findings of table 3 in Fama and MacBeth (1973). We use regressions based on an expanding window with at least 24 months of data for each fund $i$ to estimate the three out-of-sample $\beta_{i,t}$-coefficients. See figure 6 for the monthly fluctuations of the estimated risk premia.

In addition to the graphical illustration, table 6 shows the mean and the t-statistics of the monthly estimated risk premia of the market, the duration and the carry factor. There are two main key-take-aways we want to emphasize: Firstly, the risk premia of all three risk factors are *significantly positive* over the long-run (see Panel A). This is crucial since it shows that our results are consistent with the efficient market hypothesis which stipulates that an investor should earn a premium over the long-run for holding systematic risks. The average risk compensation an investor would have earned over the last 18 years for holding the market, the duration and the carry risk (factors) are 5.3%, 4.2% and 4.9%, respectively. The second key-take-away is that the risk premia substantially *vary over time*. This is best seen by comparing the average risk premia of the 3-year period and the three 5-year period with each other. While most of the premia are still positive (but not significant), the carry premium shows up to be even negative with -2.8% (but not significant) in the last 5-year period. Comparing this with the extremely high compensation of 13.7% in the period 2002/11-2007/10 shows how volatile the carry premium is.

| Correlations | Market | Duration | Carry |
|---|---|---|---|
| *1*999/07-2017/10 | | | |
| Market | 1.00 | - | - |
| Duration | 0.16 | 1.00 | - |
| Carry | 0.49 | 0.19 | 1.00 |

**Table 7:** This table shows correlations of the estimated monthly risk premia ($\gamma$) of the market, the duration and the carry factor over the sample period of 1999/07-2017/10 based on estimated $\beta_{i,t}$ using expanding window regressions.

While the duration premium exhibits a very low correlation towards the market and the carry premia of 0.16 and 0.19 respectively, the co-movement of the general market and the carry premium is stronger with about 0.49. The low correlations might be exploited for diversification purposes in a portfolio context. Table 7 shows the full correlation table of the monthly out-of-sample estimates for the three risk premia.

# 5 Robustness

In the following section, we display additional regression results as well as another illustration of the time-varying risk premia to show that our findings are robust and to support our previous argumentation.

## 5.1 Factor Analysis

Firstly, we want to show that our proposed three-factor-model is not only sufficient in explaining the return-generating-process based on index returns as seen in section 3, but also based on fund returns. For that, we divide the full EM bond fund dataset into two groups. The first one contains 55 funds that invest into local currency EM bonds, while the second group consists of 73 funds investing into USD-denominated bonds. Due to the fact that the first group is explicitly exposed to FX risk, while the second is not, we are able to correctly estimate the factor loadings, which is especially true for the carry factor, since this factor captures both FX and credit risk. This can be nicely seen by comparing the $\beta$-coefficients of the carry factor of models 8 of table 8 (local currency EM bond funds), and table 9 (USD-denominated EM bond funds) with each. While the carry factor loading is 0.671 in the first case, it is more than cut into half (0.316) when EM bond funds without explicit FX risk are analyzed. This clearly indicates that the carry premium compensates investors not only for holding FX risks but also for credit risks. The usage of the more detailed bond fund dataset (instead of index dataset) confirms the robustness of our previous results.

| LCL - EM Funds | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | **Model 8 - FE** | Model 9 - FE |
|---|---|---|---|---|---|---|---|---|---|
| (Intercept) | $-0.019^{***}$ | $-0.004$ | $0.025^{***}$ | $-0.036^{***}$ | $-0.014^{**}$ | $-0.046^{***}$ | 0.005 | $-0.016$ | $-0.001$ |
| | (0.005) | (0.006) | (0.007) | (0.005) | (0.004) | (0.005) | (0.005) | (0.026) | (0.027) |
| BM6040 | $0.968^{***}$ | | | $1.004^{***}$ | $0.371^{***}$ | $0.713^{***}$ | | $0.382^{***}$ | |
| | (0.019) | | | (0.019) | (0.021) | (0.021) | | (0.022) | |
| MSCI.AC | | $0.540^{***}$ | | | | | | | |
| | | (0.012) | | | | | | | |
| GBI.Glo.HedUSD | | | $0.479^{***}$ | | | | | | |
| | | | (0.062) | | | | | | |
| US10Ymin2Y | | | | $0.639^{***}$ | $0.517^{***}$ | $0.668^{***}$ | $0.448^{***}$ | $0.516^{***}$ | $0.447^{***}$ |
| | | | | (0.033) | (0.028) | (0.031) | (0.029) | (0.028) | (0.029) |
| HMU5 | | | | | $0.680^{***}$ | | $0.865^{***}$ | $0.671^{***}$ | $0.864^{***}$ |
| | | | | | (0.016) | | (0.012) | (0.016) | (0.012) |
| HML5 | | | | | | $0.479^{***}$ | | | |
| | | | | | | (0.019) | | | |
| TickerAEDIX | | | | | | | | $-0.025$ | $-0.010$ |
| | | | | | | | | (0.045) | (0.046) |
| TickerEBNAX | | | | | | | | $-0.014$ | $-0.011$ |
| ... | | | | | | | | (0.074) | (0.076) |
| Adj. $R^2$ | 0.355 | 0.320 | 0.013 | 0.402 | 0.575 | 0.476 | 0.548 | 0.578 | 0.549 |
| Num. obs. | 4615 | 4615 | 4615 | 4615 | 4615 | 4615 | 4615 | 4615 | 4615 |
| Fixed-Effects | No | No | No | No | No | No | No | Yes | Yes |

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

**Table 8:** This table shows the regression results based on the 55 local currency EM bond funds. The following (fixed-effects) panel regression specification is used with fund-specific fixed effects: $rx_{i,t} = \alpha_i + \beta_i^M rx_t^M + \beta_i^D rx_t^D + \beta_i^C rx_t^C + \epsilon_{i,t}$. OLS standard errors are shown in parentheses.

Table 8 shows a step-wise regression analysis based on funds investing into local currency EM bonds similar to one used in table 2. The major difference is that models 8 - 9 use fund specific fixed-effects, while models 1 - 7 do not. While models 1 - 3 only use different specifications of the general market factor, model 4 adds our duration factor (US10Ymins2Y) and model 5 shows our previously proposed three-factor model by adding our carry factor (HMU5). Model 6 - 7 only test other factor specifications. The key message here is, that model 5 as well as model 8 (including fixed-effects) are comparable to our previously proposed three-factor-model (model 6) of table 2 confirming the robustness of our results. The factor loadings of the market, the duration and the carry factor based on local currency EM bond fund returns are with 0.382, 0.516 and 0.671 (model 8) very similar to the loadings based on index returns (0.358, 0.462, 0.721). Our three-factor-model explains up to 57.8% (slightly less than the 83.1% for index returns) of the return variation of all local currency EM bond funds.

| USD - EM Funds | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | **Model 8 - FE** | Model 9 - FE |
|---|---|---|---|---|---|---|---|---|---|
| (Intercept) | 0.013*** | 0.025*** | 0.047*** | 0.000 | −0.002 | −0.019*** | 0.017*** | −0.020 | 0.030 |
| | (0.004) | (0.004) | (0.005) | (0.004) | (0.004) | (0.004) | (0.004) | (0.040) | (0.045) |
| BM6040 | 0.909*** | | | 0.931*** | 0.671*** | 0.728*** | | 0.679*** | |
| | (0.013) | | | (0.013) | (0.016) | (0.014) | | (0.016) | |
| MSCI.AC | | 0.513*** | | | | | | | |
| | | (0.008) | | | | | | | |
| GBI.Glo.HedUSD | | | 0.390*** | | | | | | |
| | | | (0.046) | | | | | | |
| US10Ymin2Y | | | | 0.485*** | 0.456*** | 0.544*** | 0.365*** | 0.453*** | 0.364*** |
| | | | | (0.023) | (0.023) | (0.022) | (0.025) | (0.023) | (0.025) |
| HMU5 | | | | | 0.323*** | | 0.675*** | 0.316*** | 0.677*** |
| | | | | | (0.013) | | (0.011) | (0.013) | (0.011) |
| HML5 | | | | | | 0.378*** | | | |
| | | | | | | (0.013) | | | |
| TickerAEOVX | | | | | | | | −0.048 | −0.045 |
| | | | | | | | | (0.106) | (0.117) |
| TickerAEMDX | | | | | | | | −0.042 | −0.031 |
| ... | | | | | | | | (0.057) | (0.063) |
| Adj. $R^2$ | 0.393 | 0.361 | 0.010 | 0.426 | 0.469 | 0.481 | 0.346 | 0.470 | 0.346 |
| Num. obs. | 7461 | 7461 | 7456 | 7461 | 7461 | 7461 | 7461 | 7461 | 7461 |
| Fixed-Effects | No | No | No | No | No | No | No | Yes | Yes |

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

**Table 9:** This table shows the regression results based on the 73 USD-denominated EM bond funds. The following (fixed-effects) panel regression specification is used with fund-specific fixed effects: $rx_{i,t} = \alpha_i + \beta_i^M rx_t^M + \beta_i^D rx_t^D + \beta_i^C rx_t^C + \epsilon_{i,t}$. OLS standard errors are shown in parentheses.

Table 9 uses the same step-wise regression framework to explain the returns of funds investing into USD-denominated EM bonds and confirms the robustness of our previous results based on the index level (compare with table 3). Our proposed three-factor model is shown in model 5 and in model 8, which again includes fund specific fixed-effect. Comparing the factor loadings based on fund returns of 0.679, 0.453 and 0.316 (model 8) with the ones based on index returns shown in model 6 in table 3 (0.357, 0.681, 0.338), we find that especially the carry factor is very robust. We are able to explain up to 47.0% of the cross-sectional return variation of USD-denominated EM bond funds by using our three-factor-model (model 8).

## 5.2 Illustration of time-varying risk premia

Since the estimated risk-premia exhibit a substantial monthly variation (see figure 6 in the appendix) making the understanding of long-term variation patterns difficult, we previously used the cumulative returns of the three premia to overcome this issue. Here, we introduce another illustration that also allows to interpret the long-term trends of the market, the duration and the carry premium.

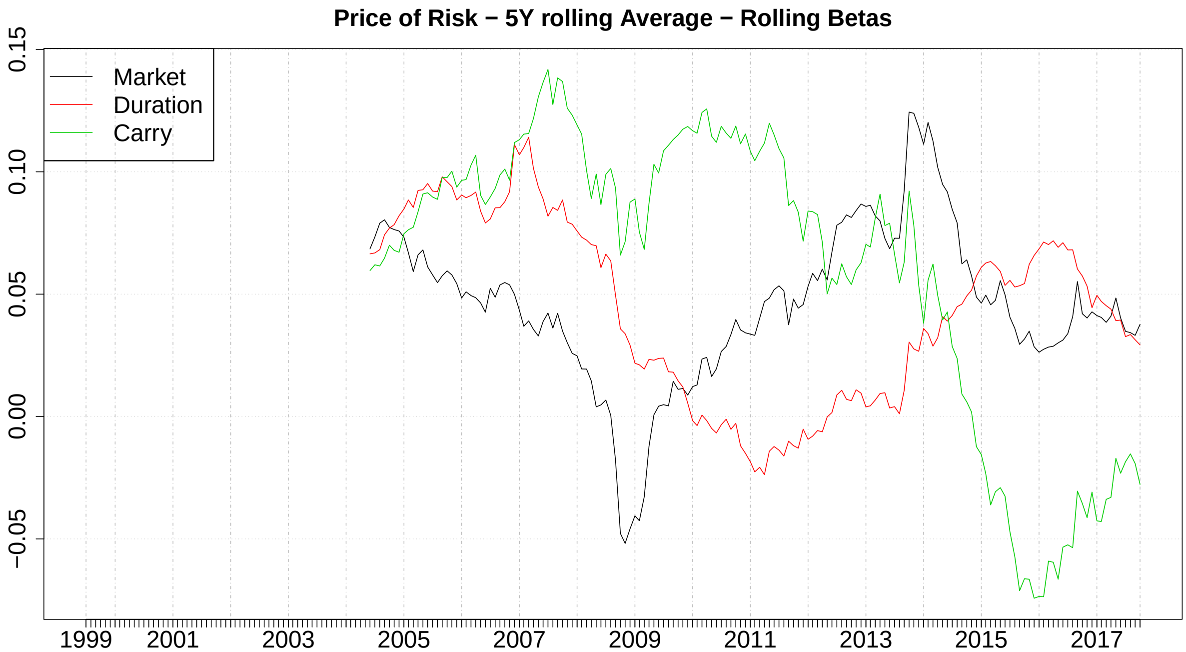


**Figure 4:** A Fama-MacBeth regression setup (without intercept) is used to compute the risk premia of the market, the duration and the carry factor, which is explicitly given by: $rx_{i,t} = \beta^M_{i,t-1}\gamma^M_t + \beta^D_{i,t-1}\gamma^D_t + \beta^C_{i,t-1}\gamma^C_t + a_{i,t}$. The table shows the 5Y moving average of $\gamma_t$, which can be interpreted as the risk premium (price of rick) per 1 unit of risk. We use regressions based on an expanding window (of at least 24 months) for each fund $i$ to estimate time-varying $\beta_{i,t}$-coefficients.

Figure 4 shows the 5-year moving average based on the monthly out-of-sample estimates for the three risk premia. The first five years are empty since the data of this period is needed to compute the first data point for 2004/07. This illustration confirms our previous results by showing that the carry premium has been especially high until 2011 (> 5% p.a.) and still positive until 2015, but has become substantially negative since then reaching its low in 2016. Recently the premium has been recovering, but is still negative. Keep in mind that the usage of 5-year moving averages results in a substantial time decay, which might influence on the interpretation. This is not true in the case of using cumulative returns.

## 6 Conclusion

Despite the attractive returns of EM bond investments over the last 15 years and the increasing interest in this investment class by risk-taking investors, who have recently been struggling to meet their (guaranteed) return targets due to the low interest-rate environment, the academic research on this asset class is still relatively meager. Our paper addresses this issue and contributes as follows: Firstly, we have developed a three-factor model that allows to systematically analyze the return-generating-process of EM bond investments; and secondly, we have quantified the risk premia of those three factors over time by exploiting the cross-sectional information provided by EM bond funds.

We find that up to 83.1% of the return variation of local EM bond investments can be explained by a *three-factor-model* using a market, a duration and a carry factor. This supports the argument that the traditional factors - market and duration - are not sufficient and thus an additional factor is needed to systematically explain the dynamics of EM bond investments. This additional factor is called carry and serves as a proxy for currency and credit risks. All three factors are robust over time and show up highly significant, which allows us to rule out any data mining issues. Besides that, we are able empirically document that the carry premium compensates an investor not only for holding currency risk, but also for being exposed to *credit risk*. This can only be shown since both, returns based on local currency bond investments and based on USD-denominated bond investments, are analyzed, which allows us to disentangle the credit risk and the FX risk component of the carry factor. Another key-take-away of our analysis is that the average long-term *risk premia* of all three factors are significantly positive, but substantially vary over time. We use the cross-sectional information provided by EM bond funds in combination with the two-step regression framework of Fama-MacBeth, to get *out-of-sample* estimates of the time-varying risk premia for the market, the duration and the carry factor. The low correlations among these three risk premia might be exploited for diversification purposes in a portfolio context. Besides that, our results support the statement that the fund industry tends to react to trends too late, since most EM bond funds have only been incorporated in the years after the carry premium has peaked.

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# A Motivation

| | Asset Class | 1980-2012 | 2013-2017 | Total | Total in % |
|---|---|---|---|---|---|
| **ALL** | | | | | |
| | Equity | 755 | 416 | 1171 | 66% |
| | Bond | 414 | 179 | 593 | 34% |
| **EM** | | | | | |
| | Equity | 287 | 193 | 480 | 27% |
| | Bond | 99 | 66 | 165 | 9% |

**Table 10:** This table shows the number of academic papers in the EBSCO database with specific keywords in the abstract until 2017-11. For stock papers the following keywords were used: factor models, risk premia, stock or equity, (emerging markets). For bond papers the keywords were adapted to: factor models, risk premia, bond or debt, (emerging markets).

# B Data

## B.1 Duration

To construct the duration factor based on futures we download the full time-series of the first and the second generic futures contracts of the 10-Year and the 2-Year US Treasury Notes from Bloomberg. The respective Bloomberg tickers for the 10-Year US Treasury Note futures are "TY1 Comdty" and "TY2 Comdty", and "TU1 Comdty" and "TU2 Comdty" for the 2-Year US Treasury Note futures. Besides the fact that Koijen, Moskowitz, Pedersen, and Vrugt (2017) also uses 2-Year and 10-Year futures contracts, the main argument to use exactly this data is also based on data quality and data availability, since the time-series dates back into the 1990s.

## B.2 Carry

Our sample consists of a maximum 46 DM and EM currencies. The spot exchange rate, quoted in terms of foreign currency units per 1 USD, as well as the 1-month Forward rate, using the same quotation, are downloaded from Bloomberg. Since not all currencies are available at each point in time, we set up an unbalanced panel, where we allow currencies to be added as well as dropped (e.g. due to the introduction of the EUR in 1999) resulting in a varying number of currencies over time.

| | Ticker | Region | Name | Market | Spot Ticker | Forward Ticker |
|---|---|---|---|---|---|---|
| 1 | GBP | Europe | British Pound Spot | DM | USDGBP | GBP |
| 2 | CZK | Europe | Czech Koruna Spot | EM | USDCZK | CZK |
| 3 | DKK | Europe | Danish Krone Spot | DM | USDDKK | DKK |
| 4 | EUR | Europe | Euro Spot | DM | USDEUR | EUR |
| 5 | HUF | Europe | Hungarian Forint Spot | EM | USDHUF | HUF |
| 6 | ISK | Europe | Iceland Krona Spot | DM | USDISK | ISK |
| 7 | NOK | Europe | Norwegian Krone Spot | DM | USDNOK | NOK |
| 8 | PLN | Europe | Polish Zloty Spot | EM | USDPLN | PLN |
| 9 | RUB | Europe | Russian Ruble SPOT (TOM) | EM | USDRUB | RUB |
| 10 | SEK | Europe | Swedish Krona Spot | DM | USDSEK | SEK |
| 11 | CHF | Europe | Swiss Franc Spot | DM | USDCHF | CHF |
| 12 | TRY | Europe | Turkish Lira Spot | EM | USDTRY | TRY |
| 13 | BRL | America | Brazilian Real Spot | EM | USDBRL | BCN |
| 14 | CAD | America | Canadian Dollar Spot | DM | USDCAD | CAD |
| 15 | CLP | America | Chilean Peso Spot | EM | USDCLP | CHN+ |
| 16 | COP | America | Colombian Peso Spot | EM | USDCOP | CLN+ |
| 17 | MXN | America | Mexican Peso Spot | EM | USDMXN | MXN |
| 18 | USD | America | US Dollar Spot | DM | USDUSD | USD |
| 19 | AUD | Asia | Australian Dollar Spot | DM | USDAUD | AUD |
| 20 | INR | Asia | Indian Rupee Spot | EM | USDINR | IRN+ |
| 21 | IDR | Asia | Indonesian Rupiah Spot | EM | USDIDR | IHN+ |
| 22 | JPY | Asia | Japanese Yen Spot | DM | USDJPY | JPY |
| 23 | MYR | Asia | Malaysian Ringgit Spot | EM | USDMYR | MRN+ |
| 24 | NZD | Asia | New Zealand Dollar Spot | DM | USDNZD | NZD |
| 25 | PHP | Asia | Philippines Peso Spot | EM | USDPHP | PPN+ |
| 26 | SGD | Asia | Singapore Dollar Spot | DM | USDSGD | SGD |
| 27 | KRW | Asia | South Korean Won Spot | EM | USDKRW | KWN+ |
| 28 | TWD | Asia | Taiwan Dollar Spot | EM | USDTWD | NTN |
| 29 | THB | Asia | Thai Baht Spot | EM | USDTHB | THB |
| 30 | ZAR | Africa | S. African Rand Spot | EM | USDZAR | ZAR |
| 31 | ILS | Asia | Israeli Shekel Spot | DM | USDILS | ILS |
| 32 | ATS | EURO | Austrian Schilling Spot | DM | USDATS | ATS |
| 33 | BEF | EURO | Belgian Franc Spot | DM | USDBEF | BEF |
| 34 | FIM | EURO | Finnish Markka Spot | DM | USDFIM | FIM |
| 35 | FRF | EURO | French Franc Spot | DM | USDFRF | FRF |
| 36 | DEM | EURO | German Mark Spot | DM | USDDEM | DEM |
| 37 | GRD | EURO | Greek Drachma Spot | EM | USDGRD | GRD |
| 38 | IEP | EURO | Irish Punt Spot | DM | USDIEP | IEP |
| 39 | ITL | EURO | Italian Lira Spot | DM | USDITL | ITL |
| 40 | LUF | EURO | Luxembourg Franc Spot | DM | USDLUF | LUF |
| 41 | NLG | EURO | Dutch Guilder Spot | DM | USDNLG | NLG |
| 42 | PTE | EURO | Portuguese Escudo Spot | DM | USDPTE | PTE |
| 43 | SKK | EURO | Slovakia Koruna Spot | EM | USDSKK | SKK |
| 44 | SIT | EURO | Slovenia Tolar Spot | EM | USDSIT | SIT |
| 45 | ESP | EURO | Spanish Peseta Spot | DM | USDESP | ESP |
| 46 | HKD | Asia | Hong Kong Dollar Spot | EM | USDHKD | HKD |

**Table 11:** This table shows the 46 currencies used for the construction of the carry factor. Besides the name and the region of each currency, we also display whether a currency is categorized as "DM" or "EM" currency. The last two columns show the Bloomberg ticker to download spot exchange rates and 1-month forward rates, respectively.

# C Performance Statistics

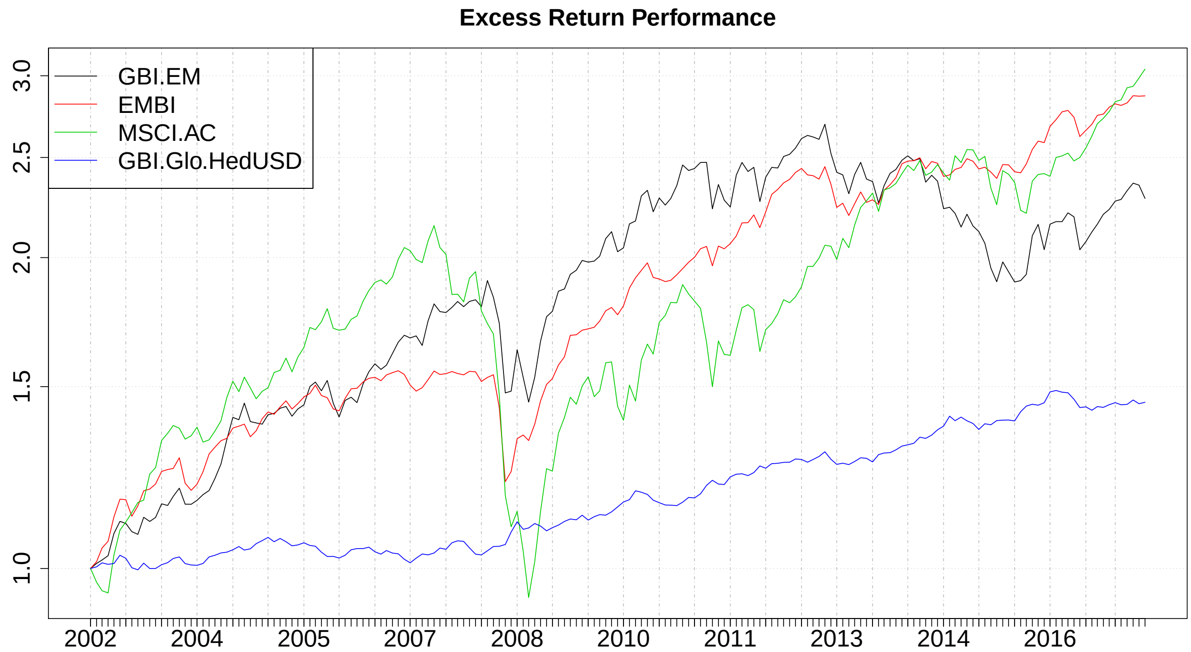


**Figure 5:** The figure shows the excess return performance of a local currency EM bond index (GBI.EM), a USD-denominated EM bond index (EMBI)in comparison to the MSCI AC World Index (equity) and the GBI Global Bond Index (debt) since 2002-12. We start with this date since there is no data available for the local currency EM bond index (GBI.EM) prior to that.

| | **EM Bond Indices** | | **Benchmarks** | | **Factors** | | |
|---|---|---|---|---|---|---|---|
| | GBI.EM | EMBI | MSCI.AC | GBI.Glo.HedUSD | BM6040 | US10Ymin2Y | HMU5 |
| ExcessReturn | 6.27 | 7.48 | 8.66 | 2.55 | 6.22 | 2.66 | 7.50 |
| StdDev | 11.78 | 8.31 | 14.94 | 3.09 | 8.79 | 4.94 | 11.12 |
| Skewness | −0.60 | −1.83 | −0.85 | 0.03 | −0.87 | 0.23 | −0.69 |
| ExKurtosis | 1.86 | 10.21 | 3.05 | −0.01 | 3.21 | 2.89 | 2.07 |
| SharpeRatio | 0.53 | 0.90 | 0.58 | 0.82 | 0.71 | 0.54 | 0.68 |

**Table 12:** Descriptive Statistics of two EM Bond indices, where GBI proxies local currency bond investments and the EMBI proxies USD-denominated investments. Additionally, there are a global equity (MSCI AC) and a global debt benchmark and three risk factors - market, duration and carry, respectively.

# D Factor Analysis

## D.1 Alternative Factor Setup

*Alternative Setup - Duration:* We only use the only 10-Year US Treasury futures to construct a long only duration factor, which is abbreviated by "US10Y" (instead of the long/short setup):

$$rx_t^D = rx_t^{10Y} \tag{10}$$

*Alternative Setup - Carry*: The monthly return of a short currency carry position based on forward rates is given by

$$c_{i,t}^{\text{short}} = -\left(\frac{F_{i,t-1}^{1M}}{S_{i,t}} - 1\right), \tag{11}$$

where $S_{i,t}$ is the spot rate of currency $i$ at $t$ and $F_{i,t-1}^{1M}$ the respective 1-month forward rate of currency $i$ known in $t-1$.

A carry factor is then constructed by buying the $n$ highest and selling the $n$ lowest yielding currencies, and by equally weighing their returns. The excess return of this long and short carry factor is explicitly given by

$$rx_t^C = \frac{1}{n}\sum_{i=1}^{N}\left(c_{i,t}^{\text{long}} * \mathbb{1}_{(\text{rank}(IY_{i,t-1})\leq n)} + c_{i,t}^{\text{short}} * \mathbb{1}_{(\text{rank}(IY_{i,t-1})<(N-n))}\right), \tag{12}$$

where $N$ is the total number of currencies available in our sample, which in our case consists of a maximum of 46 DM and EM currencies. The indicator function $\mathbb{1}_{(\text{rank}(IY_{i,t-1})\leq n)}$ equals 1 for the $n$ highest ranked currencies and 0 otherwise, while the indicator function $\mathbb{1}_{(\text{rank}(IY_{i,t-1})<(N-n))}$ equals 1 for the $n$ lowest ranked ranked (i.e. N, N-1,...) currencies and 0 otherwise. We use $n = 5$ for the construction of a long/short carry factor, abbreviated by "HML5" (HighMinusLow5).

## D.2 Correlation table of EM bond index returns and factors

| **Correlations** | **EM Index** | | **Market** | | **Duration** | | **Carry** | |
|---|---|---|---|---|---|---|---|---|
| | GBI.EM | EMBI | BM6040 | MSCI.AC | US10Y | US10Ymin2Y | HMU5 | HML5 |
| GBI.EM | 1.00 | 0.80 | 0.76 | 0.72 | 0.18 | 0.18 | 0.88 | 0.60 |
| EMBI | 0.80 | 1.00 | 0.59 | 0.56 | 0.20 | 0.22 | 0.45 | 0.45 |
| BM6040 | 0.76 | 0.59 | 1.00 | 0.99 | 0.00 | 0.00 | 0.57 | 0.44 |
| MSCI.AC | 0.72 | 0.56 | 0.99 | 1.00 | −0.11 | −0.11 | 0.58 | 0.45 |
| US10Y | 0.18 | 0.20 | 0.00 | −0.11 | 1.00 | 0.98 | 0.01 | −0.14 |
| US10Ymin2Y | 0.18 | 0.22 | 0.00 | −0.11 | 0.98 | 1.00 | 0.00 | −0.12 |
| HMU5 | 0.88 | 0.45 | 0.57 | 0.58 | 0.01 | 0.00 | 1.00 | 0.73 |
| HML5 | 0.60 | 0.45 | 0.44 | 0.45 | −0.14 | −0.12 | 0.73 | 1.00 |

**Table 13:** This table shows the correlation of the two EM bond indices and the three factors - market, duration and carry - using two different setup specification for each factor.

## D.3 Robustness based on full sample for USD-denominated index returns

| EMBI (Full sample) | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 | Model 7 | Model 8 | Model 9 | Model 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (Intercept) | 0.031 | 0.042* | 0.046 | 0.014 | 0.018 | 0.009 | 0.013 | −0.011 | −0.007 | 0.015 |
| | (0.021) | (0.021) | (0.025) | (0.020) | (0.020) | (0.020) | (0.020) | (0.020) | (0.020) | (0.023) |
| BM6040 | 0.831*** | | | 0.851*** | | 0.742*** | | 0.683*** | | |
| | (0.067) | | | (0.064) | | (0.082) | | (0.070) | | |
| MSCI.AC | | 0.459*** | | | 0.506*** | | 0.440*** | | 0.404*** | |
| | | (0.041) | | | (0.038) | | (0.050) | | (0.042) | |
| GBI.Glo.HedUSD | | | 0.868*** | | | | | | | |
| | | | (0.230) | | | | | | | |
| US10Ymin2Y | | | | 0.663*** | 0.853*** | 0.667*** | 0.831*** | 0.745*** | 0.897*** | 0.630*** |
| | | | | (0.119) | (0.122) | (0.119) | (0.121) | (0.116) | (0.117) | (0.135) |
| HMU5 | | | | | | 0.153* | 0.154* | | | 0.572*** |
| | | | | | | (0.073) | (0.074) | | | (0.064) |
| HML5 | | | | | | | | 0.348*** | 0.353*** | |
| | | | | | | | | (0.071) | (0.071) | |
| Adj. $R^2$ | 0.351 | 0.306 | 0.045 | 0.412 | 0.406 | 0.420 | 0.413 | 0.457 | 0.452 | 0.252 |
| Num. obs. | 286 | 286 | 286 | 286 | 286 | 286 | 286 | 286 | 286 | 286 |

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

**Table 14:** The USD-denominated EM Bond Index (EMBI Index) is also available for a longer time period starting from 1994-01-31 till 2017-10-31. This table shows the regression results of using the full data sample, instead of the shorter one previously displayed. The findings here, however, confirm the robustness of the previous results. The following regression specification is used: $rx_t^{EMBI} = \alpha + \beta^M rx_t^M + \beta^D rx_t^D + \beta^C rx_t^C + \epsilon_t$. OLS standard errors are shown in parentheses.

## D.4 Robustness using HAC standard errors

To make sure that our results are not driven by autocorrelation, we display heteroscedasticity and autocorrelation corrected (HAC) standard errors for our factor analysis of the local currency and the USD-denominated bond index. The results (significance levels) remain robust.

| GBI.EM - Index | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | **Model 6** | Model 7 | Model 8 | Model 9 | Model 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (Intercept) | −0.000 | 0.013 | 0.049 | −0.016 | −0.010 | −0.026 | −0.024 | −0.032 | −0.028 | −0.018 |
| | (0.022) | (0.023) | (0.032) | (0.020) | (0.020) | (0.014) | (0.015) | (0.020) | (0.020) | (0.014) |
| BM6040 | 1.015*** | | | 1.033*** | | 0.358*** | | 0.828*** | | |
| | (0.062) | | | (0.066) | | (0.068) | | (0.073) | | |
| MSCI.AC | | 0.570*** | | | 0.613*** | | 0.206*** | | 0.490*** | |
| | | (0.039) | | | (0.041) | | (0.041) | | (0.044) | |
| GBI.Glo.HedUSD | | | 0.546 | | | | | | | |
| | | | (0.323) | | | | | | | |
| US10Ymin2Y | | | | 0.537*** | 0.752*** | 0.462*** | 0.532*** | 0.584*** | 0.756*** | 0.422*** |
| | | | | (0.104) | (0.110) | (0.081) | (0.085) | (0.109) | (0.112) | (0.087) |
| HMU5 | | | | | | 0.721*** | 0.728*** | | | 0.930*** |
| | | | | | | (0.061) | (0.062) | | | (0.051) |
| HML5 | | | | | | | | 0.344*** | 0.350*** | |
| | | | | | | | | (0.085) | (0.085) | |

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

**Table 15:** This table shows the stepwise regression results based on the local currency EM bond index (GBI.EM) which is available in the period of 2002-12-31 till 2017-10-31. The following regression specification is used: $rx_t^{GBI.EM} = \alpha + \beta^M rx_t^M + \beta^D rx_t^D + \beta^C rx_t^C + \epsilon_t$. HAC standard errors are shown in parentheses.

| EMBI - Index | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | **Model 6** | Model 7 | Model 8 | Model 9 | Model 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (Intercept) | 0.034 | 0.044* | 0.053* | 0.014 | 0.017 | 0.009 | 0.011 | 0.002 | 0.004 | 0.017 |
| | (0.020) | (0.020) | (0.024) | (0.019) | (0.019) | (0.015) | (0.014) | (0.015) | (0.015) | (0.016) |
| BM6040 | 0.650*** | | | 0.674*** | | 0.357*** | | 0.525*** | | |
| | (0.100) | | | (0.099) | | (0.093) | | (0.092) | | |
| MSCI.AC | | 0.350*** | | | 0.400*** | | 0.208*** | | 0.310*** | |
| | | (0.063) | | | (0.058) | | (0.056) | | (0.054) | |
| GBI.Glo.HedUSD | | | 0.862*** | | | | | | | |
| | | | (0.196) | | | | | | | |
| US10Ymin2Y | | | | 0.717*** | 0.857*** | 0.681*** | 0.754*** | 0.751*** | 0.860*** | 0.642*** |
| | | | | (0.091) | (0.104) | (0.071) | (0.089) | (0.075) | (0.096) | (0.074) |
| HMU5 | | | | | | 0.338*** | 0.343*** | | | 0.547*** |
| | | | | | | (0.044) | (0.041) | | | (0.061) |
| HML5 | | | | | | | | 0.250*** | 0.255*** | |
| | | | | | | | | (0.044) | (0.041) | |

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

**Table 16:** This table shows the stepwise regression results based on the USD-denominated EM Bond Index (EMBI) for the period of 2002-12-31 till 2017-10-31. The following regression specification is used: $rx_t^{EMBI} = \alpha + \beta^M rx_t^M + \beta^D rx_t^D + \beta^C rx_t^C + \epsilon_t$. HAC standard errors are shown in parentheses.

# E Quantification of Risk Premia

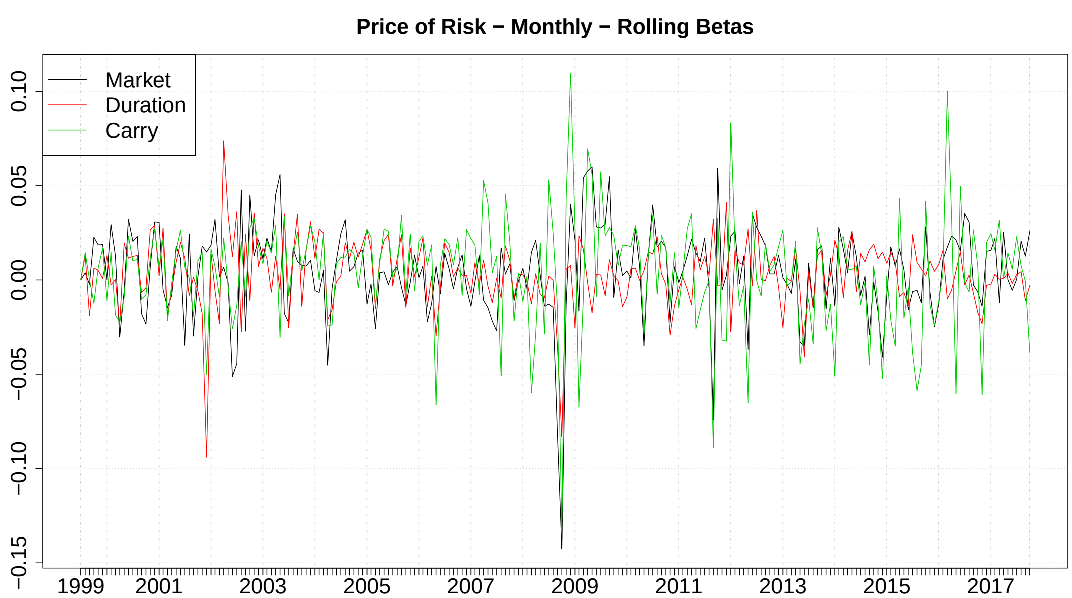


**Figure 6:** A Fama-MacBeth regression setup (without intercept) is used to compute the price of risk for the market, the duration and the carry factor, which is explicitly given by: $rx_{i,t} = \beta_{i,t-1}^M \gamma_t^M + \beta_{i,t-1}^D \gamma_t^D + \beta_{i,t-1}^C \gamma_t^C + a_{i,t}$. The table shows the monthly risk premia ($\gamma_t$). We use regressions based on an expanding window (of at least 24 months) for each fund $i$ to estimate time-varying $\beta_{i,t}$-coefficients.