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Sovereign Bond Risk Premiums

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Abstract

Sovereign credit risk has become an important factor driving government bond returns. We therefore introduce an empirical asset pricing model which exploits information contained in both forward interest rates and forward CDS spreads. Our analysis covers euro-zone countries with German government bonds as credit risk-free assets. We construct a market factor from the first three principal components of the German forward curve as well as credit risk factors from the principal components of forward CDS curves. Our results show that predictability of risk premiums of sovereign euro-zone bonds improves substantially if the market risk factor is augmented by a common euro zone and an orthogonal country-specific credit risk factor, measured by an increase in the average R^2 over euro-zone sovereigns from 0.21 to 0.61. Furthermore, we find that most of the variation of sovereign bond risk premiums is attributable to the common euro-zone credit risk factor while country-specific credit risk factors play a subordinate role.

Keywords: Sovereign bond risk premiums, market and credit risk factors, euro-zone debt crisis.

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1 Introduction

Risk premiums of sovereign bonds vary substantially over time. This has been documented in several seminal studies such as Fama & Bliss (1987) and Campbell & Shiller (1991) or, more recently, by Cochrane & Piazzesi (2005) and Duffee (2011).[1] Cochrane & Piazzesi (2005), for example, find that risk premiums for U.S. government bonds can be predicted by a linear combination of one-year forward rates with an R^2 as high as 44%. These findings confirm that forward interest rates contain important information about time-varying sovereign risk premiums. A central feature of Cochrane & Piazzesi (2005) is that government bond risk premiums are explained exclusively via the cross section of essentially default-free yields. While this is an approach consistent with the majority of existing term structure models, recent sovereign debt crises have demonstrated forcefully that government bond yields can no longer be considered to be without credit risk. In past years even most developed countries' term structures of government bond yields have been driven by two factors: the term structure of default-free spot rates and the term structure of sovereign credit spreads.

In this paper we make use of data for sovereign credit default swap (CDS) contracts of eight euro-zone countries and of interest rates extracted from the German term structure to construct separate yield and credit factors. On a monthly basis we calculate one-year forward interest rates starting in one, three, five, and seven years implicit in the German term structure. As these forward rates are highly correlated, we extract the first three principal components (PCs) and use these to construct a linear riskless term-structure factor. For simplicity, we refer to this factor as the market factor which is identical for all euro-zone countries. In addition, we calculate one-year forward CDS spreads starting in one, three, five, and seven years to construct credit factors for each country, except for Germany. These credit factors are calculated in a three-step approach. First, we extract the first principal component from each country's CDS forward curve. We find that for each country the first PC explains more than 90% of the variation in CDS forward spreads. In a second step, we calculate the first principal component from the country-specific first principal components. This provides us with a credit factor that captures common euro-zone credit risk which we call the euro-zone credit factor. In a third step, we regress the country-specific PCs on the euro-zone credit factor to isolate the orthogonal component, i.e. the error term of the regression. This error term represents our country-specific credit factor.

[1] Additional references studying the time variation of bond risk premiums include Ferson & Harvey (1991), Ilmanen (1995) and Dahlquist & Hasseltoft (2013).

Using this approach to construct market and credit risk factors, we find that the use of credit risk factors substantially improves predictability of excess bond returns. We find that predicting government bond excess returns exclusively by the market risk factor, as in Cochrane & Piazzesi (2005), yields an average R^2 over our sample of euro-zone sovereigns of 0.21. However, including credit risk factors increases the average R^2 to 0.61, ranging from 0.51 for France to 0.73 for Ireland. Moreover, the decomposition of credit risk of euro-zone sovereigns into a common euro-zone component and an orthogonal country-specific component reveals that most of the variation of sovereign bond risk premiums is attributable to the common euro-zone factor while the country-specific factors play a subordinate role. In line with Longstaff et al. (2011) who document that CDS spreads are driven by a common credit factor that is highly correlated to the US stock and high-yield markets we find that the common euro-zone credit risk factor is related to the European stock market. Finally, checking the robustness of our sovereign bond pricing model we find that neither a change in the decomposition of the credit factors nor using swap rates as riskless interest rates changes our overall conclusions.

The analysis of risk premiums of sovereign bonds has become an active area of research and our paper relates to several existing empirical studies. Cochrane & Piazzesi (2005) analyze the time variation of expected excess bond returns and find that a tent-shaped lagged linear factor of one-year forward interest rates contains information about future excess bond returns. According to their findings, this factor predicts excess bond returns with differing maturities remarkably well. It is shown to be counter-cyclical and to have predictive power also for stock returns. Duffee (2011) challenges this approach and argues that yields as factors for risk premiums are neither theoretically necessary nor empirically supported. He shows that almost half of the variation of bond risk premiums cannot be detected using the cross-section of yields as in Cochrane & Piazzesi (2005). Instead, he identifies a factor that goes beyond the cross section of yields and refers to this as the hidden factor. He finds that fluctuations in this hidden component have strong forecasting power for both future short-term interest rates and excess bond returns. Our paper is consistent with these findings. In our framework the credit factors take the role of the hidden factor used in Duffee (2011). Dahlquist & Hasseltoft (2013) study international bond risk premiums and identify local and global factors that have strong forecasting power and are not spanned by the cross section of yields. It turns out that their global factor is closely related to the international business cycle and US bond risk premiums. Similarly, Ludvigson & Ng (2009) do not rely on the cross section of yields when forecasting government bond risk premiums but identify macroeconomic factors, instead. They find that real and inflation factors have important forecasting power for future excess returns on US government bonds, above and beyond the predictive power contained in forward rates and yield spreads. As a consequence, risk premiums in their model have a marked counter-cyclical component, which is consistent with existing theories that investors get compensated for the risk associated with macro-economic fluctuations. Cieslak & Povala (2011) decompose yields into long-horizon expected inflation and maturity-related cycles and study the predictability of bond excess returns. The maturity-related cycles are used to construct a forecasting factor that explains up to and above 50% of the in-sample and 30% of the out-of-sample variation of yearly excess bond returns. In contrast to our paper, none of the papers discussed above utilizes credit factors to explain government bond risk premiums.

Longstaff et al. (2011) study sovereign credit risk using CDS data. They find that a large fraction of sovereign credit risk can be attributed to global factors. During the period from 2000 to 2010 up to 64% of the variation of sovereign credit spreads is accounted for by the first principal component of CDS spreads. This value increases to 75% during the period of the financial crisis ranging from 2007 to 2010. The first principal component of CDS spreads has a negative correlation of -0.74 with the US stock market and a correlation of 0.61 with changes in the VIX index. As credit spreads are driven by a global factor, Longstaff et al. (2011) analyze whether this factor is priced and find that a third of the total CDS spread can be attributed to a global CDS risk premium. Our paper differs from Longstaff et al. (2011) by focusing on government bond risk premiums as a function of the riskless term structure of interest rates, a common euro-zone, and a country-specific credit factor. Caceres et al. (2010) also study sovereign credit spreads and explore how much of their movements are due to a shift in global risk aversion or due to country-specific risks, arising from worsening fundamentals or from spillovers originating in other sovereigns. They find that, while at the beginning of the crisis shifts in risk aversion contributed a major share to increased credit spreads, later in the crisis, country-specific factors have started to play a more important role. Bernoth et al. (2012) study bond yield differentials among EU government bonds. They show that government spreads contain a risk premium that increases with fiscal imbalances and depends negatively on the size of the issuer's bond market. Finally, Haugh et al. (2009) analyze large recently observed movements in yield spreads for sovereign bonds in the euro zone. While the increase in average risk aversion is an important factor that explains the levels of CDS spreads, it is found that fiscal performance plays an important role, too. They present evidence that incremental deteriorations in fiscal performance lead to larger increases in the spread, with the consequence that financial market reactions could become an increasingly important constraint on fiscal policy for some countries.

Overall, our results integrate well with the existing empirical literature discussed above. As in Cochrane & Piazzesi (2005), we construct a factor that is based on the cross section of risk-free yields that we identify with the German term structure. We then augment this factor with a common and a country-specific credit factor, which we derive from the forward curve of sovereign CDS spreads. As the CDS market is driven by credit fundamentals of a country, it is clear that these factors cover fundamentals that cannot be captured by the cross section of the riskless German term structure. Hence, in this way our analysis complements the results found in Duffee (2011), Ludvigson & Ng (2009), and on an international level, in Dahlquist & Hasseltoft (2013).

Our paper is organized as follows. In the next section we present a description of our empirical model. In section 3 we present the dataset, summarize our regression results, quantify the estimated risk premiums, and report the main findings of the paper. In section 4 we perform a number of robustness checks. First, we estimate an alternative model in which we omit the decomposition of credit risk into a common euro-zone and a country-specific component. Second, we use euro-zone swap rates instead of German yields as our riskless interest rates. Third, we estimate our model for a shorter sample period that excludes negative yields. Finally, we perform an out-of-sample analysis of our results. Section 5 concludes.

2 Model Specification

This section introduces the empirical model of sovereign bond excess returns. Our approach builds on the existing findings discussed in the introduction that forward prices contain valuable information to explain and predict risk premiums. As our focus is on decomposing sovereign bond risk premiums into market and credit risk factors, we start with the German term structure of spot rates, which we identify as riskless interest rates, as well as country-specific term structures of CDS spreads for each country in the sample. To construct the market factor we derive one-year forward rates from the German term structure of spot rates. We denote the one-year forward interest rate between dates $t+n-1$ and $t+n$ by:

$$f_t^{(n)} = \frac{P_t^{(DE,n-1)} - P_t^{(DE,n)}}{P_t^{(DE,n)}}, \tag{1}$$

where $P_t^{(DE,n)}$ denotes the German zero-coupon bond price at time t with maturity n years. The construction of the market factor is not done by employing the forward rates directly but by making use of their first three principal components, instead. To be consistent with the construction of our credit factors, we utilize one-year forward rates starting in one, three, five, and seven years, i.e. $f_t^{(2)}$, $f_t^{(4)}$, $f_t^{(6)}$, and $f_t^{(8)}$, to calculate the first three principal components denoted by:

$$\boldsymbol{MF_t} = \left(MF_t^{(1)},\ MF_t^{(2)},\ MF_t^{(3)}\right). \tag{2}$$

A linear combination of these PCs defines the market factor which is identical for each country in the euro zone.

The credit factors are obtained in the following way. First, we use the most liquid spot CDS maturities of one, three, five, seven, and ten years to derive the spreads of forward CDS contracts starting in one, three, five, and seven years with a maturity of one year, respectively. The forward CDS rates are denoted by $cf_t^{(i,n)}$, where $n \in \{2, 4, 6, 8\}$ and i captures the country. Hence, $cf_t^{(i,4)}$ denotes the forward CDS rate at time t of a contract starting in three years with a maturity of one year for country i.

From the time series of these forward CDS rates the first PCs are calculated for each country i, denoted by $PC_t^{(i)}$. Using these PCs we perform a second principal component analysis to extract the euro-zone credit factor, $CF_t^{(Euro)}$. Hence, the common euro-zone credit factor is the first PC of the individual countries' first PCs. Finally, we regress each country's first PC on the euro-zone credit factor,

$$PC_t^{(i)} = \beta^{(i)}\, CF_t^{(Euro)} + \epsilon_t^{(i)}, \tag{3}$$

and define the orthogonal error term, i.e. the residual of this regression, as the country-specific credit factor $CF_t^{(Country,i)} \equiv \epsilon_t^{(i)}$. This procedure results in a common euro-zone credit factor as well as orthogonal country-specific credit factors for all countries except Germany. Following the approach of Cochrane & Piazzesi (2005), we then regress excess bond returns on market and credit risk factors. We use $P_t^{(i,n)}$ to denote the n-year zero-coupon bond price of country i and define one-year holding period returns as:

$$r_{t+1}^{(i,n)} = \frac{P_{t+1}^{(i,n-1)} - P_t^{(i,n)}}{P_t^{(i,n)}}. \tag{4}$$

Excess holding period returns for maturity n are calculated as:

$$rx_{t+1}^{(i,n)} = r_{t+1}^{(i,n)} - r_{t+1}^{(DE,n)}, \tag{5}$$

with $r_{t+1}^{(DE,n)}$ being the one-year holding period return of a German zero-coupon bond with maturity n years. Having specified the excess returns for different maturities we next define the average excess return as the mean over maturities of 1 to 8 years:

$$\overline{rx}_{t+1}^{(i)} = \frac{1}{8}\left(rx_{t+1}^{(i,1)} + rx_{t+1}^{(i,2)} + rx_{t+1}^{(i,3)} + rx_{t+1}^{(i,4)} + rx_{t+1}^{(i,5)} + rx_{t+1}^{(i,6)} + rx_{t+1}^{(i,7)} + rx_{t+1}^{(i,8)}\right). \tag{6}$$

In our baseline model, we regress average excess holding period returns on market and credit risk factors:

$$\overline{rx}_{t+1}^{(i)} = \delta_0^{(i)} + \boldsymbol{\gamma^{(i)} MF_t} + \delta_1^{(i)} CF_t^{(Euro)} + \delta_2^{(i)} CF_t^{(Country,i)} + \varepsilon_{t+1}^{(i)}, \tag{7}$$

where $\varepsilon_{t+1}^{(i)}$ represents the error term for country i and $\boldsymbol{\gamma^{(i)}} = \left(\gamma_1^{(i)},\ \gamma_2^{(i)},\ \gamma_3^{(i)}\right)'$ is a vector of exposures of average excess bond returns to the market factor. Note that the market factor $\boldsymbol{MF_t}$ is identical among all countries, implying that there is a single market risk factor in the euro zone. Equation (7) additionally documents our modeling of a common euro-zone and country-specific credit factors. In addition to the baseline model we estimate individual-maturity regressions of the form:

$$rx_{t+1}^{(i,n)} = \delta_0^{(i)} + \boldsymbol{\gamma^{(i)} MF_t} + \delta_1^{(i)} CF_t^{(Euro)} + \delta_2^{(i)} CF_t^{(Country,i)} + \varepsilon_{t+1}^{(i)}. \tag{8}$$

Taking expectations on both sides of equations (7) or (8) we find that the total risk premium is the sum of the estimated market risk premium (MRP), the euro-zone credit risk premium (ECRP), and the country-specific credit risk premium (CCRP). The euro-zone and country-specific credit risk premiums can be added to yield the total credit risk premium (TCRP) for country i. Denoting the estimated coefficients of equations (7) and (8) by $\boldsymbol{\widehat{\gamma}^{(i)}}$, $\widehat{\delta_1}^{(i)}$, and $\widehat{\delta_2}^{(i)}$ we have:

$$
\begin{aligned}
MRP &\equiv \widehat{\gamma}^{(i)} \boldsymbol{MF_t}, \\
ECRP &\equiv \widehat{\delta_1}^{(i)} CF_t^{(Euro)}, \\
CCRP &\equiv \widehat{\delta_2}^{(i)} CF_t^{(Country,i)}, \\
TCRP &\equiv \widehat{\delta_1}^{(i)} CF_t^{(Euro)} + \widehat{\delta_2}^{(i)} CF_t^{(Country,i)}.
\end{aligned} \tag{9}
$$

3 Bond Risk Premiums

3.1 Dataset

We use monthly CDS spreads of USD-denominated contracts for eight euro-zone countries: Austria, Belgium, France, Ireland, Italy, Netherlands, Portugal, and Spain. The ninth country is Germany with its term structure being assumed to represent the risk-free curve. Out of these eight euro-zone countries we have peripheral states as well as core countries such as Austria, Belgium, France, and the Netherlands. Our data sources are Bloomberg and Datastream, with the sample period ranging from October, 2006 to March, 2017. We do not include Greece since its CDS data is available only until February 2012. The sample period covers roughly two years of pre-crisis data as well as the financial and European debt crisis period. We include CDS maturities of 1, 3, 5, 7, and 10 years since these represent the most frequently traded tenors. The restriction to euro-zone countries comes with the advantage that we need not deal with exchange-rate risk and can identify the term structure of a single country, Germany, as the risk-free term structure.

For the same sample period, we collect monthly zero-coupon yields from Bloomberg. We obtain these data for maturities of 1, 2, 3, 4, 5, 6, 7, and 8 years for all countries. Tables (10) and (11) summarize the descriptive statistics of the excess holding period returns which are computed from the zero-coupon yield data as outlined in section (2) as well as the descriptive statistics of the forward CDS spreads which are computed from the CDS data as outlined in the appendix.

3.2 Principal Components as Risk Factors

The German term structure as well as the country-specific CDS curves are the basis for the construction of our market and credit risk factors. As outlined in section 2, we do not use forward rates directly to measure the market risk factor but extract principal components, instead. In section 4.1 we take an alternative approach and use forward interest rates and forward CDS spreads directly to construct the market and credit risk factors. The first three PCs for the German spot rates are reported in table (1) Panel A. The results confirm previous findings that the first three PCs explain almost all variation contained in the spot rates, with the first factor being a level, the second a slope, and the third a curvature factor (see Litterman & Scheinkman (1991)).

Next we extract PCs from the term structure of forward CDS spreads for each country separately. Tables (1) to (3) present the corresponding results. We find that the first PC explains at least 90% of each individual country's variation in forward CDS spreads and in the analysis below we represent the information in the entire CDS forward curve exclusively by its first PC. For completeness we also report the second and third PCs in tables (1) to (3). Analogous to the case of the German term structure, the first PC of the forward CDS spreads represents a level factor, with loadings across countries and across maturities being close to 0.5. Also, for most countries, the second PC represents a slope and the third a curvature factor.

The PC analysis reveals that the loadings across countries are quantitatively very similar and that they share identical patterns. We therefore investigate whether the country-specific PCs are driven by a common underlying factor. To extract this common euro-zone factor we apply a principal components analysis to the first PC of each country. The results of this approach are presented in table (4). The common credit factor explains 89% of the variation of country components. Given that the loadings of the common factor are quantitatively very similar and range from 0.33 for Austria to 0.37 for France, the common euro-zone credit factor can be interpreted as a level factor.

3.3 Estimation Results

We first estimate the baseline model as given by equation (7). As discussed above, the estimation is done under the assumption that the market factor, capturing variations in the risk-free term structure, is identical for each euro-zone country. As in Cochrane & Piazzesi (2005) we use yearly holding period returns and estimate the model based on a monthly frequency. Hence, we face an overlapping data problem and use Newey-West (HAC) covariance estimators in all estimations. As argued by Cochrane & Piazzesi (2005) we use 18 lags for the Newey-West correction to increase the chance that it corrects for the MA(12) structure induced by the overlapping data.

Table (5) summarizes the main results for the baseline model. We first turn to the results on the credit risk factors. They reveal a highly significant and positive effect of the common euro-zone credit factor on future excess returns. The p-values of the coefficients $\delta_1^{(i)}$ do not exceed 0.01 with the exception of Spain with a p-value of 0.06. Thus, increased euro-zone wide sovereign risk levels are significantly and positively associated with risk premiums in government bond markets of all countries covered.

We next turn to the effects of the country-specific credit factors, captured by the coefficients $\delta_2^{(i)}$. Table (5) reveals that for Austria, Italy, and Netherlands country-specific credit factors have a highly significant and positive effect on future risk premiums, while for Belgium, France, Portugal, Ireland, and Spain the estimates are insignificant. The latter result may reflect the fact that these countries are important sources of systemic risk within the euro zone, so that there are no significant orthogonal country-specific factors in their bond markets.

Regarding the coefficients of the market factors, denoted by $\gamma_1^{(i)}$, $\gamma_2^{(i)}$, and $\gamma_3^{(i)}$, we find that for each country except France, and marginally Italy and Spain, at least one of the market risk factors is significant. While the coefficients of the level and curvature factor exhibit opposite signs for different countries, we find that the slope of the German term structure is negatively related to future excess returns for all countries. While also previous studies, such as Harvey (1988), Estrella & Hardouvelis (1991), Estrella & Mishkin (1997), Fama & French (1989), Siegel (1991), Fama & Bliss (1987), or Nyberg (2013), have highlighted that the slope of the term structure is related to risk premiums, our findings differ in that it is the negative of the slope that predicts risk premiums. We attribute this finding to the fact that a significant part of our dataset represents the period of the financial and European debt crisis.

Overall, the model seems to exhibit substantial explanatory power. The average R^2 of the baseline model amounts to 0.61 ranging from 0.51 for France to 0.73 for Ireland. By contrast, estimating the baseline model without the common euro-zone and the country-specific credit factors yields an average R^2 of only 0.21. Hence, including credit risk factors substantially increases the explanatory power of the model.

The standard deviation of the excess returns in comparison to the standard deviations of the estimated market risk premiums (MRP), the common euro-zone credit risk premiums ($ECRP$), and the country-specific risk premiums ($CCRP$) reveal the relative contributions of risk factors and corresponding risk premiums to the total variation of expected excess returns of sovereigns. A comparison of these standard deviations is given in table (12). Focusing on the bottom line of this table which displays average values, we find that the estimated euro-zone credit risk premium exhibits the highest volatility with a standard deviation of almost 0.05, followed by the market and country-specific credit risk premiums with standard deviations of 0.03 and 0.02, respectively. Hence, it appears that over the sample period most of the variation of expected excess bond returns of euro-zone countries is attributable to the common euro-zone credit risk factor, whereas country-specific credit risk premiums seem to play a subordinate role. The dominance of the common euro-zone factor suggests that investors cannot eliminate these risks through diversification. Hence, government bonds exposed to common euro-zone credit risk will only be attractive for investors if they offer a positive risk premium.

Table (6) reports the R^2 of the individual-maturity regressions as given by equation (8). For the one-year maturity the average R^2 amounts to 0.64. It slightly increases to 0.65 for the two-year maturity and then monotonically decreases to 0.55 for the eight-year maturity.

Finally comparing our results to Longstaff et al. (2011) who find that CDS spreads are driven by a common credit factor that is highly correlated with the US stock and high-yield markets we look at the correlation between the common euro-zone credit factor and the STOXX Europe 50 index and find a correlation of -0.78.

4 Robustness

In this section we perform a number of robustness checks for our findings. First, we specify an alternative model in which we do not use principal components to construct market and credit factors, but instead, directly use forward interest rates and forward CDS spreads in our regressions. Second, we use euro-zone swap rates instead of the German term structure as our riskless benchmark as one might argue that even Germany is exposed to some sovereign risk. We then proceed to re-estimate the model for a shorter period, excluding subperiods in which yields of euro-zone sovereigns turn negative. Finally, we conduct an out-of-sample analysis and check the robustness of our results over a number of subperiods.

4.1 Forward Rates as Risk Factors

The approach introduced in the preceding section makes use of information contained in forward rates extracted through principal components. While principal components allow us to construct a common euro-zone and orthogonal country-specific credit factors, these are latent factors and, hence, do not directly represent economic variables. In this section we choose an alternative route and construct market and credit risk factors, using forward rates directly. Hence, with this approach it is not possible to differentiate between a common euro-zone and country-specific credit factors. We denote the alternative market and credit risk factors by:

$$\begin{aligned} \boldsymbol{MF_t^{(A)}} &= \left(f_t^{(2)},\ f_t^{(4)},\ f_t^{(6)},\ f_t^{(8)}\right), \\ \boldsymbol{CF_t^{(i,A)}} &= \left(cf_t^{(i,2)},\ cf_t^{(i,4)},\ cf_t^{(i,6)},\ cf_t^{(i,8)}\right). \end{aligned}$$

These factors are translated into an estimated market and credit risk premium by estimating the alternative model:

$$\overline{rx}_{t+1}^{(i)} = \delta_0^{(i)} + \boldsymbol{\gamma^{(i)} MF_t^{(A)}} + \boldsymbol{\delta^{(i)} CF_t^{(i,A)}} + \varepsilon_{t+1}^{(i)}, \tag{10}$$

where the parameter vectors are given by:

$$\begin{aligned} \boldsymbol{\gamma^{(i)}} &= \left(\gamma_1^{(i)},\ \gamma_2^{(i)},\ \gamma_3^{(i)},\ \gamma_4^{(i)}\right)', \\ \boldsymbol{\delta^{(i)}} &= \left(\delta_1^{(i)},\ \delta_2^{(i)},\ \delta_3^{(i)},\ \delta_4^{(i)}\right)'. \end{aligned}$$

In line with section 2 we define the estimated market and credit risk premium as:

$$\begin{aligned} MRP^{(A)} &\equiv \boldsymbol{\hat{\gamma}^{(i)} MF_t^{(A)}}, \\ TCRP^{(A)} &\equiv \boldsymbol{\hat{\delta}^{(i)} CF_t^{(i,A)}}. \end{aligned} \tag{11}$$

Table (7) reports the results for the model given by equation (10). Comparing these results with those from the standard model reported in table (5) reveals two important findings. First, using forward rates directly instead of PCs increases the average R^2 from 0.61 to 0.65. This increase in the R^2 reflects the fact that the representation of the market risk factor by the first three principal components of the German forward interest rates, the representation of the common euro-zone risk factor by the first PC of the individual country's first PCs, and the representation of the country-specific risk factors by the orthogonal part to the common euro-zone risk factor are associated with a loss of information that results in a lower R^2. Second, we find that while the majority of forward CDS spreads is significant for most countries, forward interest rates are significant in notably fewer cases and typically at the short maturities.

Finally, we compare the relative contributions of risk factors and corresponding risk premiums to the total variation of excess returns. Table (13) reports the standard deviations of excess holding period returns, market risk premiums, and credit risk premiums. The average standard deviation amounts to 0.04 for the estimated credit risk premium and to 0.03 for the estimated market risk premium. Hence, in line with the baseline model the results suggest that for our sample period the majority of the variation of excess bond returns can be attributed to variations in the credit risk factors.

4.2 Swap Rates as Riskless Interest Rates

In section 2 we used the German term structure of interest rates to calculate the market risk factor and the excess holding period returns. One might argue, however, that even Germany is exposed to some sovereign risk. Hence, using the German term structure may not be appropriate when modeling default free interest rates. In this section we therefore follow an alternative approach and use euro-zone swap rates obtained from Datastream as riskless interest rates. Comparing swap rates with German zero-coupon yields shows that over the sample period the average swap rates are higher than the German zero-coupon yields. The differences range from 52 basis points for a three-year maturity to 34 basis points for an eight-year maturity.

In line with section 2 we use the term structure of swap rates to compute one-year forward rates starting in one, three, five, and seven years, denoted by $f_t^{(2,s)}$, $f_t^{(4,s)}$, $f_t^{(6,s)}$, and $f_t^{(8,s)}$. Again we extract the first three principal components from these forward rates which together constitute the market risk factor:

$$\boldsymbol{MF_t^{(s)}} = \left(MF_t^{(1,s)},\ MF_t^{(2,s)},\ MF_t^{(3,s)}\right). \tag{12}$$

We then redefine excess holding period returns on the basis of swap rates. Hence, we replace equation (5) by:

$$rx_{t+1}^{(i,n,s)} = r_{t+1}^{(i,n)} - r_{t+1}^{(n,s)}, \tag{13}$$

where $r_{t+1}^{(n,s)}$ denotes the swap rate with maturity n. Finally, we define average excess holding period returns:

$$\begin{aligned}\overline{rx}_{t+1}^{(i,s)} &= \frac{1}{8}\Big(rx_{t+1}^{(i,1,s)} + rx_{t+1}^{(i,2,s)} + rx_{t+1}^{(i,3,s)} + rx_{t+1}^{(i,4,s)} \\ &\quad + rx_{t+1}^{(i,5,s)} + rx_{t+1}^{(i,6,s)} + rx_{t+1}^{(i,7,s)} + rx_{t+1}^{(i,8,s)}\Big).\end{aligned} \tag{14}$$

With these definitions we can specify the model using swap rates as:

$$\overline{rx}_{t+1}^{(i,s)} = \delta_0^{(i)} + \boldsymbol{\gamma^{(i)} MF_t^{(s)}} + \delta_1^{(i)} CF_t^{(Euro)} + \delta_2^{(i)} CF_t^{(Country,i)} + \varepsilon_{t+1}^{(i)}. \tag{15}$$

Table (8) reports the estimation results for equation (15). Overall, the results from this specification are similar but weaker than those obtained for the baseline specification using the German term structure. None of the coefficients of the forward swap rates is consistent in sign across all countries and several coefficients are insignificant. The common euro-zone factor is not significant for Austria and France, while the country-specific credit risk factor is not significant for Belgium, Ireland, and Portugal. A comparison of tables (5) and (8) shows that the average R^2 drops from 0.61 to 0.48 when using swap rates to proxy for the riskless term structure. Hence, in our analysis swap rates seem to be a less suitable proxy for risk-free interest rates than German zero-coupon yields. One possible explanation for this result is that swap rates are exposed to counter party risk.[2] Especially during the financial crisis such a credit risk component implicit in the swap rates might have been substantial and also correlated with sovereign risk.

4.3 Excluding Negative Yields

One important feature of the euro-zone zero-coupon yield data used in this paper is that beginning in the second half of 2014, yields, especially with shorter maturities, become negative. In order to check whether and how negative yields affect our

[2] See, for example, Feldhütter & Lando (2008).

estimation results, we re-estimate the model for a shorter sample period ending in March 2014, thereby excluding negative yields in our sample.

The results of estimating equation (7) for this shorter sample period are reported in table (9). It turns out that while the average R^2 increases only slightly from 0.61 to 0.63, the average R_M^2, i.e. the R^2 of a model including only market factors, increases from 0.21 to 0.36. This value is close to the value of 0.35 that Cochrane & Piazzesi (2005) find in their specification. Hence, the market risk factor explains future excess returns much better during the shortened period than over the full sample including negative yields.

Table (9) also shows that while the coefficients of the level and curvature factor, $\gamma_1^{(i)}$ and $\gamma_3^{(i)}$, are largely insignificant, the slope of the German term structure, $\gamma_2^{(i)}$, is significantly and negatively related to future excess returns for most countries in the sample. We thus conclude that when excluding negative yields it is, among the market factors, mainly the slope component that drives future excess returns.

4.4 Out-of-sample Analysis

In this section we perform an out-of-sample analysis in which we randomly (by drawing without replacement) split our sample into a training set consisting of 75% of the data and a test set consisting of the remaining 25%. We then estimate the model for the training set and compute the predicted values and the pseudo R^2 for the test set. We repeat this procedure 100.000 times and report the median as well as the 5% and 95% quantiles of the pseudo R^2 for the test set for each country. We perform this out-of-sample analysis for the alternative model specification discussed in section 4.1 and hence we do not rely on a principal components analysis of our forward interest rates and forward CDS spreads.

The results are presented in table (14) in the appendix and show that the average of the median R^2 over the different countries amounts to 0.60, close to the average R^2 of 0.65 of the alternative model presented in table (7). The averages of the 5% and 95% quantiles of the R^2 over the different countries amount to 0.36 and 0.75, respectively. The average of the median R_M^2 amounts to 0.28, again close to the average R_M^2 of 0.30 of the alternative model. The corresponding average 5% and 95% quantiles of the R_M^2 equal 0.11 and 0.48, respectively.

5 Conclusion

This paper explores risk premiums in euro-zone government bond markets. In the spirit of Fama & Bliss (1987) and Cochrane & Piazzesi (2005) we use the term structure of forward interest rates as explanatory variables for subsequent risk premiums. Since Germany was considered a safe haven by investors throughout recent episodes of European sovereign risk, we use the yield curve of German zero-coupon government bonds as a proxy for the term structure of riskless interest rates in the euro zone. In the baseline specification of our econometric model we extract the first three principal components, representing a level, slope, and curvature factor, from the term structure of German forward interest rates and use these factors to construct a market risk factor.

The main contribution of the paper is to augment this market risk factor by factors accounting for sovereign credit risk in the euro zone. To this end we collect CDS spreads for a set of eight euro-zone countries and calculate for each country the corresponding one-year forward CDS spreads one year, three years, five years, and seven years out. For each of the eight countries we find that the first principal component of the term structure of forward CDS spreads explains at least 90% of their variation. In our baseline model we therefore focus exclusively on the first principal component of the term structure of forward CDS spreads for each country. In a second principal component analysis we extract the first principal component from these eight countries' first principal components and define it as our common euro-zone credit factor. Finally, country-specific credit risk factors are defined by the error term of a simple linear regression of each country's first principal component on the common euro-zone credit factor.

We demonstrate that the market risk factor, the common euro-zone credit risk factor, and the country-specific credit factors provide a robust model of risk premiums in euro-zone government bond markets. Specifically, we find that the common euro-zone credit factor turns out to be a significant predictor of bond risk premiums for all countries while the country-specific credit factors are significant for only a subset of the countries in our sample.

Furthermore, we find that augmenting the market risk factor with our common euro-zone and country-specific credit factors increases the average R^2 across countries from 0.21 to 0.61, ranging from 0.51 for France to 0.73 for Ireland. The importance of the common euro-zone credit factor is supported by the volatility of the component of risk premiums which is due to this factor. This volatility amounts to 0.05 on average across countries whereas the average volatility of the component of risk premiums that is due to the market and country-specific credit factors amounts to 0.03 and 0.02, respectively. This suggests that over our sample period most of the variation of risk premiums of euro-zone countries is attributable to the common euro-zone credit factor, whereas country-specific credit risk premiums seem to play a subordinate role.

We perform four main robustness tests. First, we use forward interest rates and forward CDS spreads directly as explanatory variables, rather than their principal components. For this alternative model specification we confirm the main results of our baseline model. Second, we re-estimate the model using swap rates as a proxy for riskless interest rates, rather than German zero-coupon yields. We find that over our sample period swap rates were substantially higher than German zero-coupon yields, indicating that the latter represent a better proxy for riskless interest rates. Consistent with this observation we find that the results based on swap rates are weaker than those for the baseline model. Third, we re-estimate the model for a shorter sample period, excluding the time period in which negative yields occur. We confirm our main results and find that when excluding negative yields, the average predictive power of the market risk factor rises from 0.21 to 0.36 and that among the individual market risk factors, the slope of the term structure of German forward interest rates represents the most significant factor. Fourth, we conduct an out-of-sample analysis in which we repeatedly and randomly split our dataset into training and test sets, estimate our model for the training sets, and compute the predicted values and the pseudo R^2 for the test sets. Comparing the quantiles of these R^2 with those from our baseline model, we confirm our main results.

Overall we find that the term-structures of forward interest rates and forward CDS spreads contain important information about future risk premiums for euro-zone government bonds. Furthermore, risk premiums that are due to a credit risk component can be decomposed into a common euro-zone as well as country-specific components, where the former contributes the largest share of the time-variation of total euro-zone bond risk premiums.

6 Appendix

6.1 CDS Valuation & Forward CDS Spreads

This section summarizes the extraction of forward CDS spreads from the term structure of spot CDS spreads. The methodology applied follows standard CDS valuation techniques as presented for example in O'Kane (2008). The fair spread of a CDS contract denoted by c_t^T equates the premium and protection leg of the contract. The premium leg V_t^{prem} represents the expected present value of premium payments made by the protection buyer to the protection seller until the contract matures or a credit event occurs:

$$V_t^{prem} = c_t^T RPV_t^T, \tag{16}$$

$$\begin{aligned} RPV_t^T &= \sum_{n=1}^{N} \delta(t_{n-1}, t_n) Z(t, t_n) Q(t, t_n) \\ &+ \sum_{n=1}^{N} \int_{t_{n-1}}^{t_n} \delta(t_{n-1}, u) Z(t, u)(-dQ(t, u)), \end{aligned} \tag{17}$$

where t_n for $n = 1, ..., N$ denote the premium payment dates, $t_0 = t$, $T = t_N$ denotes the maturity date of the contract, and $\delta(t_{n-1}, t_n)$ refers to the day count fraction between two consecutive premium payment dates t_{n-1} and t_n. The variable $Z(t, u)$ denotes the price of a risk-free zero-coupon bond at time t maturing at time u and $Q(t, u)$ refers to the risk-neutral survival probability until time u. Hence, the first term on the right-hand side of equation (17) is the expected present value of premium payments made by the protection buyer to the protection seller assuming that a credit event can occur only at payment dates while the second term captures the effect of premium accrued if a credit event occurs between payment dates.

The protection leg V_t^{prot} is the expected present value of the protection payment made by the protection seller to the protection buyer if a credit event occurs:

$$V_t^{prot} = (1 - R) \int_t^T Z(t, u)(-dQ(t, u)), \tag{18}$$

where R denotes the recovery rate. Equating the premium and protection leg yields:

$$c_t^T = \frac{(1-R)\int_t^T Z(t,u)(-dQ(t,u))}{RPV_t^T}. \tag{19}$$

Given observed CDS spreads we bootstrap the survival curve $Q(t,t_i)$ for various maturities t_i, setting the recovery rate R to the market convention of 40% and computing risk-free zero-coupon bond prices $Z(t,u)$ based on the German zero-coupon yield curve.

A forward CDS contract is a contract that provides protection against default of a reference obligation for a future time period starting at a forward date τ, $\tau > 0$, until a maturity date T. The premium to be paid over this future protection period is determined today at contract inception. For such a forward CDS contract, market participants should be indifferent between trading a spot CDS contract with maturity date T or a combination of spot and forward contracts covering the same period of time:

$$c_t^T RPV_t^T = c_t^\tau RPV_t^\tau + cf_t^{\tau,T} RPV_t^{\tau,T}, \tag{20}$$

where $RPV_t^{\tau,T} = RPV_t^T - RPV_t^\tau$ and $cf_t^{\tau,T}$ is the spread of a forward CDS contract with forward date τ and maturity date T. Hence, forward CDS spreads can be computed by:

$$cf_t^{\tau,T} = \frac{c_t^T RPV_t^T - c_t^\tau RPV_t^\tau}{RPV_t^T - RPV_t^\tau}. \tag{21}$$

Note that in section 2 we denote one-year forward CDS spreads starting in one, three, five, and seven years by $cf_t^{(i,n)}$, where $n \in \{2,4,6,8\}$, for simplicity. Hence, the notation $cf_t^{(i,n)}$ in section 2 corresponds to $cf_t^{t+n-1,t+n}$ as used in equation (21) above.

Table 1: Principal Components Analysis (1)

Panel A – Forward Interest Rates			
Principal Component	**Percent explained**	**Total**	
First	0.9359	0.9359	
Second	0.0558	0.9916	
Third	0.0069	0.9986	
Loadings	**First**	**Second**	**Third**
$f^{(2)}$	0.4809	-0.7632	0.3776
$f^{(4)}$	0.5137	-0.1106	-0.4943
$f^{(6)}$	0.5103	0.2735	-0.4672
$f^{(8)}$	0.4944	0.5750	0.6284

Panel B – Forward CDS Austria			
Principal Component	**Percent explained**	**Total**	
First	0.9437	0.9437	
Second	0.0509	0.9947	
Third	0.0046	0.9993	
Loadings	**First**	**Second**	**Third**
$cf^{(2)}$	0.4843	-0.7368	0.4705
$cf^{(4)}$	0.5092	-0.2007	-0.8364
$cf^{(6)}$	0.5024	0.4713	0.1680
$cf^{(8)}$	0.5038	0.4412	0.2257

Panel C – Forward CDS Belgium			
Principal Component	**Percent explained**	**Total**	
First	0.9413	0.9413	
Second	0.0532	0.9946	
Third	0.0042	0.9988	
Loadings	**First**	**Second**	**Third**
$cf^{(2)}$	0.4834	0.7405	-0.4485
$cf^{(4)}$	0.5105	0.1932	0.7821
$cf^{(6)}$	0.5047	-0.4226	0.0633
$cf^{(8)}$	0.5010	-0.4855	-0.4280

Table 2: Principal Components Analysis (2)

Panel A – Forward CDS France			
Principal Component	**Percent explained**	**Total**	
First	0.9193	0.9193	
Second	0.0731	0.9923	
Third	0.0067	0.9991	
Loadings	**First**	**Second**	**Third**
$cf^{(2)}$	0.4725	-0.7726	0.4044
$cf^{(4)}$	0.5153	-0.1478	-0.7964
$cf^{(6)}$	0.5069	0.4258	-0.0146
$cf^{(8)}$	0.5042	0.4471	0.4495

Panel B – Forward CDS Ireland			
Principal Component	**Percent explained**	**Total**	
First	0.9629	0.9629	
Second	0.0336	0.9965	
Third	0.0027	0.9993	
Loadings	**First**	**Second**	**Third**
$cf^{(2)}$	0.4862	-0.8118	0.2282
$cf^{(4)}$	0.5074	0.0412	-0.8573
$cf^{(6)}$	0.5074	0.1987	0.3773
$cf^{(8)}$	0.4987	0.5475	0.2659

Panel C – Forward CDS Italy			
Principal Component	**Percent explained**	**Total**	
First	0.9628	0.9628	
Second	0.0322	0.9950	
Third	0.0042	0.9992	
Loadings	**First**	**Second**	**Third**
$cf^{(2)}$	0.4896	-0.7569	0.4159
$cf^{(4)}$	0.5061	-0.1534	-0.7764
$cf^{(6)}$	0.5038	0.3987	-0.0865
$cf^{(8)}$	0.5003	0.4945	0.4655

Table 3: Principal Components Analysis (3)

Panel A – Forward CDS Netherlands			
Principal Component	**Percent explained**	**Total**	
First	0.9015	0.9015	
Second	0.0892	0.9907	
Third	0.0076	0.9984	
Loadings	**First**	**Second**	**Third**
$cf^{(2)}$	0.4648	-0.777	0.4215
$cf^{(4)}$	0.5188	-0.1495	-0.8373
$cf^{(6)}$	0.5071	0.4381	0.1615
$cf^{(8)}$	0.5076	0.4266	0.3085

Panel B – Forward CDS Portugal			
Principal Component	**Percent explained**	**Total**	
First	0.9209	0.9209	
Second	0.0651	0.9859	
Third	0.0116	0.9976	
Loadings	**First**	**Second**	**Third**
$cf^{(2)}$	0.4684	-0.8533	0.2205
$cf^{(4)}$	0.5126	0.1050	-0.7791
$cf^{(6)}$	0.5159	0.2244	0.0031
$cf^{(8)}$	0.5018	0.4587	0.5868

Panel C – Forward CDS Spain			
Principal Component	**Percent explained**	**Total**	
First	0.9677	0.9677	
Second	0.0294	0.9971	
Third	0.0023	0.9994	
Loadings	**First**	**Second**	**Third**
$cf^{(2)}$	0.4911	0.7413	-0.4527
$cf^{(4)}$	0.5060	0.1415	0.8158
$cf^{(6)}$	0.5056	-0.2767	-0.0236
$cf^{(8)}$	0.4971	-0.5949	-0.3592

Table 4: Principal Components Analysis (4)

Country Components

Principal Component	**Percent explained**	**Total**	
First	0.8875	0.8875	
Second	0.0575	0.9450	
Third	0.0362	0.9812	
Loadings	**First**	**Second**	**Third**
Austria	0.3266	-0.7130	-0.0489
Belgium	0.3664	-0.0429	0.2567
France	0.3693	0.1192	-0.1771
Ireland	0.3399	-0.0973	0.7593
Italy	0.3609	0.2157	-0.3912
Netherlands	0.3531	-0.3235	-0.4010
Portugal	0.3499	0.4742	0.0864
Spain	0.3603	0.3002	-0.0505

Table (1) Panel A shows the results of a principal components analysis of German one-year forward interest rates starting in one, three, five, and seven years (denoted by $f_t^{(2)}$, $f_t^{(4)}$, $f_t^{(6)}$, and $f_t^{(8)}$) as outlined in section 2. The upper part shows the proportion of total variance explained by each of the first three principal components as well as the cumulative proportion. The lower panel presents the loadings of the first three principal components. Table (1) Panels B and C as well as tables (2) and (3) show the results of a principal components analysis of one-year forward CDS spreads starting in one, three, five, and seven years (denoted by $cf_t^{(i,2)}$, $cf_t^{(i,4)}$, $cf_t^{(i,6)}$, and $cf_t^{(i,8)}$) for Austria, Belgium, France, Ireland, Italy, the Netherlands, Portugal, and Spain as outlined in section 2. Table (4) presents the results of a principal components analysis of the individual countries' first principal components.

Table 5: Baseline Regression

Model: $\overline{rx}_{t+1}^{(i)} = \delta_0^{(i)} + \boldsymbol{\gamma}^{(i)} \boldsymbol{MF_t} + \delta_1^{(i)} CF_t^{(Euro)} + \delta_2^{(i)} CF_t^{(Country,i)} + \varepsilon_{t+1}^{(i)}$

	Austria	**Belgium**	**France**	**Ireland**	**Italy**	**Netherl.**	**Portugal**	**Spain**
$\delta_0^{(i)}$	0.0034	0.0063	0.0028	0.0276	0.0138	0.0022	0.0441	0.0145
	(0.07)	(0.2)	(0.49)	(0.03)	(0.08)	(0)	(0.11)	(0.18)
$\gamma_1^{(i)}$	-0.0025	0.0011	0.001	4e-04	0.0063	-7e-04	-8e-04	-0.0068
	(0.05)	(0.47)	(0.34)	(0.93)	(0.07)	(0.01)	(0.96)	(0.17)
$\gamma_2^{(i)}$	-0.0072	-0.0226	-3e-04	-0.1113	-0.0143	-0.0017	-0.1701	-0.0184
	(0.16)	(0.04)	(0.87)	(0.02)	(0.19)	(0.32)	(0)	(0.13)
$\gamma_3^{(i)}$	0.0315	0.0147	-0.0103	0.1689	-0.0051	0.0011	0.4043	0.0915
	(0.03)	(0.49)	(0.38)	(0.06)	(0.91)	(0.71)	(0)	(0.06)
$\delta_1^{(i)}$	0.0034	0.0096	0.0031	0.0377	0.0136	0.0013	0.0626	0.0092
	(0)	(0)	(0.01)	(0)	(0)	(0)	(0)	(0.06)
$\delta_2^{(i)}$	0.0118	-0.0052	0.0234	0.0235	0.0749	0.0084	-0.0403	0.0309
	(0)	(0.77)	(0.13)	(0.15)	(0)	(0)	(0.2)	(0.13)
$\boldsymbol{R^2}$	0.61	0.51	0.51	0.73	0.68	0.69	0.54	0.57
$\boldsymbol{R_M^2}$	0.18	0.13	0.17	0.15	0.30	0.20	0.18	0.40

This table reports the results of estimating equation (7). The sample period ranges from October 2006 to March 2017 and the estimation is based on monthly data covering 114 observations. Numbers in parentheses represent p-values based on Newey-West (HAC) covariance estimators. $\boldsymbol{R_M^2}$ denotes the R^2 of a regression without credit risk factors.

Table 6: Individual-Maturity Regressions

	Austria	**Belgium**	**France**	**Ireland**	**Italy**	**Netherl.**	**Portugal**	**Spain**	**Mean**
$\boldsymbol{R^2}$ **– 1Y**	0.47	0.68	0.48	0.86	0.82	0.22	0.77	0.84	**0.64**
$\boldsymbol{R^2_M}$ **– 1Y**	0.34	0.17	0.20	0.22	0.28	0.06	0.18	0.30	**0.22**
$\boldsymbol{R^2}$ **– 2Y**	0.64	0.61	0.60	0.73	0.78	0.39	0.63	0.78	**0.65**
$\boldsymbol{R^2_M}$ **– 2Y**	0.20	0.09	0.13	0.09	0.25	0.15	0.13	0.36	**0.18**
$\boldsymbol{R^2}$ **– 3Y**	0.64	0.55	0.64	0.69	0.73	0.69	0.55	0.67	**0.65**
$\boldsymbol{R^2_M}$ **– 3Y**	0.21	0.08	0.17	0.08	0.27	0.24	0.15	0.38	**0.20**
$\boldsymbol{R^2}$ **– 4Y**	0.63	0.55	0.64	0.68	0.69	0.71	0.51	0.62	**0.63**
$\boldsymbol{R^2_M}$ **– 4Y**	0.22	0.12	0.20	0.11	0.31	0.24	0.16	0.4	**0.22**
$\boldsymbol{R^2}$ **– 5Y**	0.61	0.52	0.51	0.70	0.66	0.68	0.51	0.54	**0.59**
$\boldsymbol{R^2_M}$ **– 5Y**	0.14	0.10	0.15	0.12	0.29	0.16	0.18	0.37	**0.19**
$\boldsymbol{R^2}$ **– 6Y**	0.60	0.51	0.50	0.72	0.65	0.69	0.53	0.53	**0.59**
$\boldsymbol{R^2_M}$ **– 6Y**	0.20	0.16	0.2	0.17	0.31	0.25	0.18	0.39	**0.23**
$\boldsymbol{R^2}$ **– 7Y**	0.57	0.50	0.48	0.73	0.66	0.65	0.54	0.52	**0.58**
$\boldsymbol{R^2_M}$ **– 7Y**	0.20	0.17	0.20	0.21	0.33	0.24	0.19	0.41	**0.24**
$\boldsymbol{R^2}$ **– 8Y**	0.54	0.47	0.40	0.72	0.63	0.64	0.54	0.49	**0.55**
$\boldsymbol{R^2_M}$ **– 8Y**	0.14	0.16	0.15	0.22	0.28	0.13	0.20	0.39	**0.21**

This table reports the R^2 of estimating equation (8) for maturities 1Y to 8Y. The sample period ranges from October 2006 to March 2017 and the estimation is based on monthly data covering 114 observations. $\boldsymbol{R^2_M}$ denotes the R^2 of a regression without credit risk factors.

Table 7: Baseline Regression – Alternative Model

Model: $\overline{rx}_{t+1}^{(i)} = \delta_0^{(i)} + \boldsymbol{\gamma}^{(i)} \boldsymbol{MF}_t^{(A)} + \boldsymbol{\delta}^{(i)} \boldsymbol{CF}_t^{(i,A)} + \varepsilon_{t+1}^{(i)}$

	Austria	**Belgium**	**France**	**Ireland**	**Italy**	**Netherl.**	**Portugal**	**Spain**
$\delta_0^{(i)}$	-0.0108	0.0344	0.0198	0.0575	0.0224	-0.0038	-0.0064	0.0488
	(0.05)	(0.43)	(0.44)	(0.26)	(0.8)	(0.27)	(0.96)	(0.1)
$\gamma_1^{(i)}$	0.8633	0.9421	0.6826	8.9405	3.2835	0.0615	15.6858	4.39
	(0.12)	(0.1)	(0.22)	(0)	(0.01)	(0.82)	(0)	(0)
$\gamma_2^{(i)}$	-1.2459	-0.4397	-1.6581	-7.902	-4.1385	-0.1642	-31.1887	-9.7784
	(0.2)	(0.77)	(0.21)	(0)	(0.13)	(0.79)	(0)	(0)
$\gamma_3^{(i)}$	0.6477	0.0726	1.0636	-6.3797	0.4293	0.4365	3.7967	3.4069
	(0.46)	(0.97)	(0.33)	(0.37)	(0.89)	(0.33)	(0.65)	(0.11)
$\gamma_4^{(i)}$	-0.1912	-1.4376	-0.5866	4.4366	0.1057	-0.3696	12.6236	0.9291
	(0.77)	(0.1)	(0.16)	(0.34)	(0.96)	(0.31)	(0.1)	(0.55)
$\delta_1^{(i)}$	3e-04	5e-04	5e-04	-2e-04	3e-04	4e-04	7e-04	-7e-04
	(0.09)	(0.02)	(0.01)	(0.34)	(0.25)	(0)	(0)	(0)
$\delta_2^{(i)}$	-3e-04	-5e-04	-3e-04	0.001	-5e-04	-4e-04	0	9e-04
	(0.22)	(0.01)	(0.09)	(0.06)	(0.23)	(0)	(0.9)	(0.01)
$\delta_3^{(i)}$	6e-04	0.0019	0.0011	0.0012	0.0019	4e-04	-0.0016	0.0015
	(0.39)	(0.04)	(0.06)	(0.14)	(0.07)	(0.03)	(0)	(0)
$\delta_4^{(i)}$	-2e-04	-0.0015	-0.001	-0.0018	-0.0016	-1e-04	9e-04	-0.0018
	(0.7)	(0.15)	(0.08)	(0.04)	(0.22)	(0.62)	(0.01)	(0)
$\boldsymbol{R^2}$	0.61	0.60	0.57	0.76	0.65	0.63	0.69	0.71
$\boldsymbol{R_M^2}$	0.27	0.19	0.31	0.21	0.39	0.25	0.27	0.53

This table reports the results of estimating equation (10). The sample period ranges from October 2006 to March 2017 and the estimation is based on monthly data covering 114 observations. Numbers in parentheses represent p-values based on Newey-West (HAC) covariance estimators. $\boldsymbol{R_M^2}$ denotes the R^2 when including only forward interest rates.

Table 8: Baseline Regression – Swap Rates

Model: $\overline{rx}_{t+1}^{(i,s)} = \delta_0^{(i)} + \boldsymbol{\gamma^{(i)} MF_t^{(s)}} + \delta_1^{(i)} CF_t^{(Euro)} + \delta_2^{(i)} CF_t^{(Country,i)} + \varepsilon_{t+1}^{(i)}$

	Austria	**Belgium**	**France**	**Ireland**	**Italy**	**Netherl.**	**Portugal**	**Spain**
$\delta_0^{(i)}$	0.001	0.0039	4e-04	0.0252	0.0114	-2e-04	0.0417	0.012
	(0.71)	(0.29)	(0.82)	(0.22)	(0.08)	(0.88)	(0.31)	(0.23)
$\gamma_1^{(i)}$	-0.0021	4e-04	-4e-04	-5e-04	0.0037	-0.0015	0.0052	-0.0067
	(0.18)	(0.77)	(0.65)	(0.95)	(0.13)	(0.07)	(0.72)	(0.08)
$\gamma_2^{(i)}$	-0.0044	0.0165	-0.0092	0.1133	0.0036	-0.0115	0.1997	0.0151
	(0.6)	(0.2)	(0.07)	(0.12)	(0.77)	(0.01)	(0.05)	(0.49)
$\gamma_3^{(i)}$	0.0225	0.0419	0.0166	0.0136	0.0154	0.0395	-0.4713	-0.1428
	(0.46)	(0.27)	(0.51)	(0.91)	(0.75)	(0.05)	(0.18)	(0.03)
$\delta_1^{(i)}$	0.0011	0.0065	6e-04	0.031	0.0099	-0.0012	0.0567	0.0069
	(0.18)	(0)	(0.41)	(0)	(0)	(0)	(0)	(0.01)
$\delta_2^{(i)}$	0.0057	-0.0055	0.0137	0.0182	0.0655	0.002	0.0042	0.0375
	(0.01)	(0.67)	(0)	(0.44)	(0)	(0)	(0.9)	(0.03)
$\boldsymbol{R^2}$	0.41	0.46	0.30	0.59	0.66	0.38	0.49	0.56
$\boldsymbol{R^2_M}$	0.25	0.11	0.16	0.06	0.23	0.25	0.09	0.34

This table reports the results of estimating equation (15) where excess holding period returns are based on swap rates. The sample period ranges from October 2006 to March 2017 and the estimation is based on monthly data covering 114 observations. Numbers in parentheses represent p-values based on Newey-West (HAC) covariance estimators. $\boldsymbol{R^2_M}$ denotes the R^2 of a regression without credit risk factors.

Table 9: Baseline Regression – Excluding Negative Yields

Model: $\overline{rx}_{t+1}^{(i)} = \delta_0^{(i)} + \boldsymbol{\gamma^{(i)}} \boldsymbol{MF_t} + \delta_1^{(i)} CF_t^{(Euro)} + \delta_2^{(i)} CF_t^{(Country,i)} + \varepsilon_{t+1}^{(i)}$

	Austria	**Belgium**	**France**	**Ireland**	**Italy**	**Netherl.**	**Portugal**	**Spain**
$\delta_0^{(i)}$	0.0038	0.0072	0.0033	0.032	0.0148	0.0022	0.0538	0.0154
	(0.11)	(0.22)	(0.42)	(0.05)	(0.09)	(0.01)	(0.09)	(0.37)
$\gamma_1^{(i)}$	-0.0034	0.0028	-4e-04	0.0048	0.0035	-5e-04	-1e-04	-0.0147
	(0.2)	(0.46)	(0.8)	(0.64)	(0.51)	(0.3)	(1)	(0.66)
$\gamma_2^{(i)}$	-0.0109	-0.022	-0.0013	-0.1209	-0.0166	-0.0017	-0.2028	-0.0356
	(0.06)	(0.02)	(0.61)	(0.01)	(0.07)	(0.3)	(0)	(0.02)
$\gamma_3^{(i)}$	-0.0165	-0.0108	0.0179	-0.1167	0.0176	-6e-04	-0.2563	-0.0279
	(0.11)	(0.46)	(0.06)	(0.14)	(0.57)	(0.87)	(0)	(0.39)
$\delta_1^{(i)}$	0.0028	0.0103	0.0027	0.0383	0.0136	0.0014	0.062	0.0047
	(0.15)	(0)	(0.05)	(0)	(0)	(0)	(0.01)	(0.82)
$\delta_2^{(i)}$	0.0125	-0.0051	0.0268	0.0272	0.078	0.009	-0.0413	0.0281
	(0)	(0.8)	(0.08)	(0.13)	(0)	(0)	(0.2)	(0.4)
$\boldsymbol{R^2}$	0.63	0.51	0.57	0.73	0.69	0.70	0.54	0.64
$\boldsymbol{R_M^2}$	0.31	0.25	0.34	0.29	0.45	0.31	0.31	0.58

This table reports the results of estimating equation (7). The sample period ranges from October 2006 to March 2014 and the estimation is based on monthly data covering 90 observations. Numbers in parentheses represent p-values based on Newey-West (HAC) covariance estimators. $\boldsymbol{R_M^2}$ denotes the R^2 of a regression without credit risk factors.

Table 10: Descriptive Statistics (1)

Country	$\boldsymbol{\mu_{\overline{rx}}}$	$\boldsymbol{\sigma_{\overline{rx}}}$	$\boldsymbol{Min}$	$\boldsymbol{Max}$
Austria	0.0026	0.0122	-0.0359	0.0649
Belgium	0.0042	0.0215	-0.0557	0.1335
France	0.0014	0.0107	-0.033	0.0442
Ireland	0.0157	0.0753	-0.2048	0.3139
Italy	0.0086	0.0413	-0.1198	0.1893
Netherlands	0.0015	0.006	-0.0167	0.021
Portugal	0.025	0.1499	-0.3968	0.9956
Spain	0.0087	0.0409	-0.0968	0.1766

This table shows the mean ($\mu_{\overline{rx}}$), standard deviation ($\sigma_{\overline{rx}}$), minimum (Min), and maximum (Max) of the average excess holding period returns as defined in (6) over the sample period ranging from October 2006 to March 2017.

Table 11: Descriptive Statistics (2)

Country	$\boldsymbol{\mu_{\overline{cf}}}$	$\boldsymbol{\sigma_{\overline{cf}}}$	$\boldsymbol{Min}$	$\boldsymbol{Max}$
Austria	70.225	51.6394	2.2028	235.833
Belgium	93.4146	70.8945	3.0394	304.9969
France	76.3719	55.5126	2.17	235.504
Ireland	197.2205	184.5893	2.8713	659.8413
Italy	180.1136	120.4724	12.3825	539.4172
Netherlands	52.1336	33.9358	2.0711	147.6018
Portugal	284.289	221.8849	6.5634	788.9795
Spain	168.1994	126.105	5.007	553.3372
$\boldsymbol{\overline{cf}^{(i)}} = \frac{1}{4}\left(cf^{(i,2)} + cf^{(i,4)} + cf^{(i,6)} + cf^{(i,8)}\right)$				

This table shows the mean ($\mu_{\overline{cf}}$), standard deviation ($\sigma_{\overline{cf}}$), minimum (Min), and maximum (Max) of the average forward CDS spreads as defined at the bottom of the table as well as in section 2 for the sample period ranging from October 2006 to March 2017.

Table 12: Risk Premium Volatility

Country	$\sigma_{\overline{rx}}$	σ_{MRP}	σ_{ECRP}	σ_{CCRP}	σ_{TCRP}
Austria	0.0122	0.0079	0.0091	0.0113	0.0145
Belgium	0.0215	0.0112	0.0258	0.0022	0.0258
France	0.0107	0.0025	0.0084	0.0080	0.0116
Ireland	0.0753	0.0599	0.1010	0.0196	0.1029
Italy	0.0413	0.0141	0.0364	0.0404	0.0544
Netherl.	0.0060	0.0017	0.0035	0.0054	0.0065
Portugal	0.1499	0.1053	0.1674	0.0281	0.1698
Spain	0.0409	0.0220	0.0247	0.0171	0.0300
Average	0.0447	0.0281	0.0470	0.0165	0.0519

This table shows the standard deviations of average excess holding period returns as well as the standard deviations of the estimated market risk premium (MRP), euro-zone credit risk premium ($ECRP$), country-specific credit risk premium ($CCRP$), and total credit risk premium ($TCRP$) of the baseline model given by equation (7).

Table 13: Risk Premium Volatility – Alternative Model

Country	$\sigma_{\overline{rx}}$	$\sigma_{MRP^{(A)}}$	$\sigma_{TCRP^{(A)}}$
Austria	0.0122	0.004	0.0134
Belgium	0.0215	0.0132	0.0241
France	0.0107	0.0094	0.0099
Ireland	0.0753	0.0619	0.0917
Italy	0.0413	0.0203	0.0395
Netherlands	0.006	0.0011	0.0064
Portugal	0.1499	0.1053	0.1397
Spain	0.0409	0.0401	0.0298
Average	0.0447	0.0319	0.0443

This table shows the standard deviations of average excess holding period returns as well as the standard deviations of the estimated market risk premium ($MRP^{(A)}$) and total credit risk premium ($TCRP^{(A)}$) of the alternative model given by equation (10).

Table 14: Out-of-sample analysis

	Austria	Belgium	France	Ireland	Italy	Netherl.	Portugal	Spain
M - R^2	0.56	0.53	0.50	0.71	0.59	0.58	0.65	0.68
M - R^2_M	0.25	0.16	0.28	0.18	0.37	0.20	0.25	0.52
q05 - R^2	0.33	0.17	0.27	0.56	0.40	0.40	0.28	0.45
q05 - R^2_M	0.07	0.03	0.10	0.03	0.16	0.05	0.09	0.34
q95 - R^2	0.72	0.75	0.66	0.82	0.74	0.72	0.80	0.81
q95 - R^2_M	0.45	0.35	0.48	0.42	0.60	0.39	0.44	0.67

This table reports the results of performing the out-of-sample analysis described in section (4.4). **M - R^2** and **M - R^2_M** denote the median pseudo R^2 of the full model and the model including only forward interest rates, while **q05** and **q95** denote the corresponding 5% and 95% quantiles.

References

Bernoth, K., von Hagen, J., & Schuknecht, L. (2012). Sovereign risk premiums in the european government bond market. Journal of International Money and Finance 31(5), 975-995.

Caceres, C., Guzzo, V., & Segoviano, M. (2010). Sovereign spreads: Global risk aversion, contagion or fundamentals? IMF Working Paper 10/120.

Campbell, J. Y. & Shiller, R. J. (1991). Yield spreads and interest rate movements: A bird's eye view. Review of Economic Studies 58, 495-514.

Cieslak, A. & Povala, P. (2011). Understanding bond risk premia. Working Paper.

Cochrane, J. H. & Piazzesi, M. (2005). Bond risk premia. American Economic Review 95(1), 138-160.

Dahlquist, M. & Hasseltoft, H. (2013). International bond risk premia. Journal of International Economics 90, 17-32.

Duffee, G. R. (2011). Information in (and not in) the term structure. Review of Financial Studies 24, 2895-2934.

Estrella, A. & Hardouvelis, G. A. (1991). The term structure as a predictor of real economic activity. The Journal of Finance 46, 555-576.

Estrella, A. & Mishkin, F. S. (1997). The predictive power of the term structure of interest rates in europe and the united states: Implications for the european central bank. European Economic Review 41, 1375-1401.

Fama, E. & Bliss, R. R. (1987). The information in long-maturity forward rates. American Economic Review 77, 680-692.

Fama, E. F. & French, K. R. (1989). Business conditions and expected returns on stocks and bonds. Journal of Financial Economics 25, 23-49.

Feldhütter, P. & Lando, D. (2008). Decomposing swap spreads. Journal of Financial Economics 88, 375-405.

Ferson, W. E. & Harvey, C. R. (1991). The variation of economic risk premiums. Journal of Political Economy 99, 385-415.

Harvey, C. R. (1988). The real term structure and consumption growth. Journal of Financial Economics 22, 305-333.

Haugh, D., Ollivaud, P., & Turner, D. (2009). What drives sovereign risk premiums? OECD Economics Department Working Papers, No. 718, OECD Publishing.

Ilmanen, A. (1995). Time-varying expected returns in international bond markets. Journal of Finance 50, 481-506.

Litterman, R. B. & Scheinkman, J. (1991). Common factors affecting bond returns. Journal of Fixed Income 1, 54-61.

Longstaff, F. A., Pan, J., Pedersen, L. H., & Singleton, K. J. (2011). How sovereign is sovereign credit risk. American Economic Journal: Macroeconomics 3(2), 75-103.

Ludvigson, S. C. & Ng, S. (2009). Macro factors in bond risk premia. Review of Financial Studies 22, 5027-5067.

Nyberg, H. (2013). Predicting bear and bull stock markets with dynamic binary time series models. Journal of Banking and Finance 37, 3351-3363.

O'Kane, D. (2008). *Modelling Single-name and Multi-name Credit Derivatives*. John Wiley & Sons.

Siegel, J. J. (1991). The shrinking equity premium. The Journal of Portfolio Management 26, 10-17.

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