A Macro-Financial Analysis of the Corporate Bond Market*

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PRELIMINARY VERSION

Abstract

We assess the contribution of economic and risk-related factors in the determination of euro area corporate bond spreads over the period 2005-2015. We combine the methods proposed by Joslin, Singleton, and Zhu (2011) and Joslin, Priebsch, and Singleton (2014). The proposed multi-market, no-arbitrage affine term structure model is based on the methodology proposed by Dewachter, Iania, Lyrio, and Perea (2015). Our model uses the OIS rate as the benchmark risk-free rate and the corporate yield curves for two rating classes. The model includes four spanned and six unspanned factors. The latter include economic and risk-related factors. Overall, both economic and risk-related factors play a significant role in the determination of the OIS rate and corporate bond spreads. This becomes clear in the historical decomposition of such rates throughout the global financial crisis. Our results emphasize the importance of including both macroeconomic and risk-related factors in the analysis of corporate bond yields.

JEL classifications: E43; E44

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*The views expressed are those of the authors and do not necessarily reflect those of the European Central Bank or the National Bank of Belgium. All remaining errors are our own.

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1 Introduction

The global financial crisis starting in late 2008 had a significant impact on a number of markets. For example, it affected significantly the levels of sovereign and corporate bond spreads with respect to market risk-free rates. It also affected the overall bank lending capacity and ultimately led to a significant impact on the real economy of most countries. Since then, one observes a renewed interest in the study of the underlying driving forces behind movements in the yield curve of both sovereign and corporate bonds. This paper presents an empirical approach to identify the contribution of a number of macroeconomic and risk-related factors in the determination of corporate bond spreads.

Our model is part of the still growing literature on affine term structure models, initiated by Duffie and Kan (1996) with the use of latent factors and summarized by Dai and Singleton (2000). Ang and Piazzesi (2003) provided new stimulus to this line of research with the inclusion of macroeconomic variables together with unobservable factors. A number of studies followed their lead with the implementation of models that either gave latent factors a clear macroeconomic interpretation of were structural in nature (e.g. Bekaert et al. (2010), Dewachter and Lyrio (2006), Hördahl et al. (2008), and Rudebusch and Wu (2008)). This strand of models has also been applied to corporate bonds. Amato and Luisi (2006), for example, use a combination of macroeconomic and latent variables in an affine term structure model of defaultable bonds to study the U.S. corporate bond market. Further developments in this area also led to the inclusion of financial factors, next to the standard macroeconomic factors (e.g. Dewachter and Iania (2011)).

The above models, however, suffer from two important shortcomings. The first is well-known and refers to the difficulty in estimating such models. Standard maximum likelihood algorithms usually demand a significant amount of time for its convergence.[1] This first difficulty is overcome by the method proposed by Joslin et al. (2011). The second shortcoming was recently emphasized by Joslin et al. (2014). Standard formulations of affine yield curve models imply that the macroeconomic (and financial) risk factors are spanned by – i.e. can be expressed as a linear combination of – bond yields. This condition is however overwhelmingly rejected by standard regression analysis, which shows that there is no perfect linear relation between yields and such variables. These authors, therefore, propose the inclusion of a number of unspanned factors.

[1] The usual computational challenges faced by affine term structure models are well described by Duffee and Stanton (2008).

Such factors have predictive content for excess returns over and above the information contained in bond yields. Therefore, these factors do not affect the shape of the yield curve but carry relevant information to forecast excess bond returns.

Our methodology combines the methods proposed by Joslin et al. (2011) and Joslin et al. (2014) and can be seen as a reduced-form approach of the models proposed by Duffie and Singleton (1999). Such combination has been used previously by Dewachter et al. (2015) in the context of euro area sovereign bonds. These authors propose a two-market model composed by the OIS rate, seen as their benchmark market, and the sovereign bond market for a specific country of the euro zone. Our focus is, however, on the corporate bond market. In our case, our first market is also composed by our benchmark risk-free rate, the OIS yield curve. Our second market, however, is composed by the yield curve for corporate bonds of the highest rating class in our sample (A, in our case). Our third market is then composed by the yield curve for corporate bonds of the second highest rating class in our sample (BBB, in our case). Due to the availability of data, we only use these two rating classes. The model, however, allows the inclusion of as many rating classes as necessary. The proposed methodology is applied to the euro area corporate bond market using monthly data for the period from July 2005 to April 2015.

Our model includes a total of ten factors, six unspanned factors and four observable factors spanning the OIS rates and the yield curves of corporate bonds of the two rating classes (A and BBB). The unspanned factors include standard macroeconomic factors (economic activity and inflation) and risk-related factors, which capture global tensions, systemic risk, and liquidity concerns in the financial market and the cost of borrowing for non-financial corporations. To simplify interpretation, these factors are divided in three groups: economic, risk-related, and idiosyncratic factors.

Our results show that, overall, both economic and risk-related factors play a significant role in the determination of the OIS rate and corporate bond spreads. For the OIS rate, economic shocks are the most important source of variation only for short-term maturities (up to two years) and short forecasting horizons (one month). For longer forecasting horizons, economic and risk-related shocks have approximately the same influence on the OIS rate dynamics. For corporate bond spreads, risk-related shocks are the dominant drivers for all maturities and forecasting horizons. The historical decomposition of the OIS yield curve and the corporate bond spreads show the important contribution of these two groups of factors during the global financial crisis. It also shows that the decrease in corporate bond spreads observed in 2014 is mainly attributed to a decrease in the contribution of risk-related factors. In short, our results emphasize the importance of including also risk-related factors in the analysis of corporate bond yields.

The remainder of this paper is organized as follows. Section 2 presents the multi-market, affine term structure model and the VAR system used to determine the influence of macroeconomic and risk-related factors on corporate bond spreads. Section 3 summarizes the data, describes briefly the estimation method, and discusses the results. This includes the analysis of Impulse Response Functions (IRFs), variance decompositions and the historical decomposition of the OIS rates and corporate bond spreads. Section 4 concludes the paper.

2 The Modelling Framework

Dewachter et al. (2015) combine the methods proposed by Joslin et al. (2011) and Joslin et al. (2014) and extend the standard affine yield curve model to a multi-market, single-pricing kernel framework. Their framework is applied to sovereign bond yields. In their set-up, one of the markets represents the risk-free yield curve and the other the sovereign bond market of a specific country.

In our set-up, the first market also represents the risk-free benchmark (the OIS rate). Nevertheless, since our focus is on the corporate bond market, our second and third markets are represented by the yield curves on corporate bond indices of different rating classes (A and BBB).

The framework adopted by Dewachter et al. (2015) is particularly useful since it allows us to fit the three yield curves with a reasonable precision and also to choose the relevant set of unspanned factors in order to forecast excess bond returns. Since the methodology is explained in detail in Dewachter et al. (2015), we restrict ourselves to the modifications made in the original framework to fit our purpose.

As is usual in this literature, this type of model imposes the no-arbitrage restriction in the context of Gaussian and linear state space dynamics under the risk-neutral measure. As suggested by Joslin et al. (2011), we adopt a limited set of spanned factors – yield portfolios – to model the cross-sectional of the yield curve. And as suggested by Joslin et al. (2014), we model the dynamics of the yield portfolios under the historical measure by means of a standard VAR, including next to the yield curve portfolios a number of macroeconomic and risk-related variables. Based on the VAR dynamics, and the affine yield curve representation implied by the risk-neutral dynamics, we assess the relative contribution of the respective macroeconomic and risk-related variables in the yield curve dynamics. Below, we describe briefly the multi-market affine yield curve model proposed by Dewachter et al. (2015) and present the assumptions imposed in the VAR system.

2.1 A multi-market affine yield curve model for corporate bonds

Joslin et al. (2011) introduce affine yield curve models using observable yield portfolios as factors spanning the yield curve. This section is based on Dewachter et al. (2015), who propose a multi-market version of their model.

It is assumed the existence of K fundamental and unobserved pricing factors for the yield curve of all markets ($X_{k,t}$) collected in the vector $X_t = [X_{1,t}, ..., X_{K,t}]'$. These factors reflect fundamental sources of risk and their dynamics under the risk-neutral measure (Q) is given by a VAR(1):

$$X_t = C_X^Q + \Phi_X^Q X_{t-1} + \Sigma_X \varepsilon_t^Q, \qquad \varepsilon_t^Q \sim N(0, I_K), \tag{1}$$

where Φ_X^Q is a diagonal matrix containing the distinct eigenvalues of Φ_X^Q and Σ_X is a lower-triangular matrix. We assume that the K factors determine the risk-free interest rate ($r_{0,t}$) and each of the market-specific, short-term interest rates in market m ($r_{m,t}$), with $m = 1, ..., M$, as follows:

$$r_{m,t} = \underbrace{\rho_0^0 + \rho_1^0 X_t}_{\text{Risk-free rate}} + \underbrace{\sum_{j=1}^{m} s_{j,t}}_{\text{Spread wrt risk-free rate}} \tag{2}$$

where the first two terms, $\rho_0^0 + \rho_1^0 X_t$, represent the risk-free rate and $s_{j,t} = \rho_0^j + \rho_1^j X_t$ represents the spread with respect to the risk-free rate. In this way, the model allows the introduction of several bond markets, all conditioned on the same risk-neutral probability measure. The differences across bond markets depend on the market-specific factor sensitivities to the respective fundamental factors, ρ_1^j, $j = 1, ..., M$. We use a three-market setup (risk-free rate plus two corporate bond markets, $M = 2$). Market 0 is therefore the benchmark risk-free rate, market 1 represents corporate bonds of the highest rating class in our sample (A, in our case), and market 2 represents corporate bonds of the second highest rating class (BBB, in our case).

In this setting, we assume that the benchmark (risk-free) short-term interest rate is given by a constant and the sum of the first two spanned factors. Each of the other two spanned factors determines the dynamics of the spreads between bond yields of each rating class and the next rating class with a higher rating. We have therefore that:

$$\begin{array}{lll} \text{Risk-free interest rate} & r_{0,t} = \rho_0^0 + \rho_1^0 X_t, & \rho_1^0 = [1,1,0,0] \\ 1^{st} \text{ rating class} & s_{1,t} = r_{1,t} - r_{0,t} = \rho_0^1 + \rho_1^1 X_t, & \rho_1^1 = [0,0,1,0] \\ 2^{nd} \text{ rating class} & s_{2,t} = r_{2,t} - r_{1,t} = \rho_0^2 + \rho_1^2 X_t, & \rho_1^2 = [0,0,0,1] \end{array} \tag{3}$$

Dewachter et al. (2015) also detail the necessary identification restrictions to be imposed in the model. For that reason, we make $C_X^Q = 0$ and the parameter ρ_0^0 becomes proportional to the unconditional average of the short-term interest rate.

Given the above structure, Dai and Singleton (2000) show that zero-coupon bond yields can be written as an affine function of the state vector. Denoting the time-t yield in market m ($m = 0, 1, 2$) and maturity n by $y_{m,t}(n)$, we have that:

$$y_{m,t}(n) = A_{m,n}(\Theta_m) + B_{m,n}(\Theta_m) X_t, \tag{4}$$

where the functions $A_{m,n}(\Theta_m)$ and $B_{m,n}(\Theta_m)$ follow from the no-arbitrage condition (see e.g. Ang and Piazzesi (2003)). Dewachter et al. (2015) show that once you collect the N yields per market and stack all yields for all markets, one can obtain the following yield curve representation:

$$Y_t = A(\Theta) + B(\Theta) X_t. \tag{5}$$

with appropriate components for $A(\Theta)$ and $B(\Theta)$. It can also be shown that a suitable rotation of the pricing factors X_t based on yield portfolios (P_t) allows an equivalent yield curve representation. These yield portfolios are linear combinations of yields and are assumed to be perfectly priced by the no-arbitrage restrictions and observed without any measurement error. Assuming the yield portfolios are constructed based on a certain matrix W, $P_t = WY_t$, one can express the yield curve as:

$$Y_t = \left[I - B(\Theta)(WB(\Theta))^{-1} W\right] A(\Theta) + B(\Theta)(WB(\Theta))^{-1} P_t. \tag{6}$$

2.2 Decomposing the yield curve dynamics

We keep the framework in Dewachter et al. (2015) and adopt a first order Gaussian VAR model to assess the relative importance of macroeconomic and risk-related shocks in the yield curve dynamics. Denoting the set of unspanned factors by M_t, our VAR(1) model can be written as:

$$\begin{bmatrix} M_t \\ P_t \end{bmatrix} = C^{\mathbb{P}} + \Phi^{\mathbb{P}} \begin{bmatrix} M_{t-1} \\ P_{t-1} \end{bmatrix} + \Sigma \begin{bmatrix} \varepsilon^{\mathbb{P}}_{M,t} \\ \varepsilon^{\mathbb{P}}_{P,t} \end{bmatrix} \tag{7}$$

where Σ is a lower-triangular matrix implied by the Cholesky identification of structural shocks. Below, we describe the variables included in the unspanned and spanned factors.

2.3 Estimation method

Our estimation procedure follows the methodology proposed by Joslin et al. (2011), which is adopted and described in detail by Dewachter et al. (2015). This methodology uses an efficient factorization of the likelihood function, arising from the use of yield portfolios as pricing factors. It also allows for an efficient two-step maximum likelihood estimation procedure, which involves: (*i*) the estimation of the VAR system in eq. (7) using standard OLS regressions; and (*ii*) the estimation of the the remaining parameters to fit the OIS curve and the bond spread curves for each rating class using a maximum likelihood procedure.

3 Empirical Results

3.1 Data

We estimate the model on monthly data over the period from July 2005 to April 2015 (118 observations). The data used can be sorted in two groups: macro and risk-related data and yield curve data.

Macro and risk-related data. These data are used to construct the six unspanned factors included in the model. They are: (*i*) the Purchasing Managers' Index (*PMI*), which is based on surveys of business conditions in manufacturing and in services industries. This index is used directly as our proxy for economic activity in the euro area and is obtained from Markit Financial Information Services (markit.com); (*ii*) the year-on-year growth rate of the Euro area Harmonized Consumer Price Index (*INFL*) is our measure for inflation in the euro area. We collect the data from Datastream; (*iii*) a market volatility index based on EURO STOXX 50 realtime options prices (*VSTOXX*). This is our measure for the global tension in financial markets. The data are collected from STOXX Ltd. (stoxx.com); (*iv*) the Composite Indicator of Systemic Stress (*CISS*) in the financial system. This index incorporates a total of 15 financial stress measures and was proposed by Holló et al. (2012). The data are from the European Central Bank; (*v*) the spread between the yield on the German government-guaranteed bond ('Kreditanstalt fur Wiederaufbau', KfW, a government-owned development bank) and the German sovereign bond, averaged across maturities of 1, 2, 3, 4, 5, 7, and 10 years. This represents our liquidity or flight-to-safety factor (*F2S*). The data for both series are from Bloomberg; (*vi*) the spread between the cost of borrowing for corporations and the average of OIS rates. This is our cost of borrowing factor (*COST*) and the data are from the European Central Bank.

Yield curve data. We use the Overnight Indexed Swap (OIS) rate for maturities of 1, 2, 3, 4, 5, 7, and 10 years, representing the risk-free interest rate for the euro area countries. This is our risk-free benchmark rate. Finally, we collect data for two indices of corporate bond yields relative to the rating classes A and BBB. These indices are computed by and collected from Bloomberg. We use the same maturities as for the OIS rate.

3.2 Unspanned and spanned factors

We now formally specify the vectors of unspanned (M_t) and spanned (P_t) factors. The first are used to evaluate the macroeconomic and financial forces behind corporate yield spread movements. The latter are yield portfolios used to explain the dynamics of our benchmark yield curve (OIS) and the yield curves of the two corporate bond indices representing the rating classes A and BBB.

Unspanned factors. As mentioned before, we include a total of six unspanned factors. The first two factors reflect standard macroeconomic conditions of the region and include an indicator of economic activity (*PMI*) and a measure of inflation (*INFL*). The last four factors are generally risk-related factors expressing the global tension in financial markets (*VSTOXX*), the presence of a regional systemic risk (*CISS*), the existence of liquidity concerns (*F2S*), and the cost of borrowing faced by non-financial corporations (*COST*). We therefore have the following vector of unspanned factors:

$$M_t = [PMI_t,\ INFL_t,\ VSTOXX_t,\ CISS_t,\ F2S_t,\ COST_t]'. \tag{8}$$

Spanned factors. We adopt a total of four spanned factors. The first two factors are used to explain the dynamics of the OIS yield curve. They are computed as the first two principal components of the OIS rates for the seven maturities included in the sample ($PC_t^{rf,1}$ and $PC_t^{rf,2}$). Although we could choose any linear combination of observed yields to form such portfolios, this choice avoids fitting perfectly a set of specific yields and underfitting the others. The last two factors are used to explain the dynamics of corporate bond spreads. They are computed as the first two principal components of the yield spreads between a specific rating class and the rating class one level higher ($PC_t^{spr,1}$ and $PC_t^{spr,2}$). In other words, the first two principal components of the spread between A bond yields and the OIS rate and the spread between BBB bond yields and A bond yields. Since we have seven maturites, these are the first two principal components of 14 yield spread series. The vector of yield portfolios can then be expressed as:

$$P_t = \left[PC_t^{rf,1}, PC_t^{rf,2}, PC_t^{spr,1}, PC_t^{spr,2}\right]'. \tag{9}$$

All 10 unspanned and spanned factors can be seen in Figure 1, where the unspanned factors are standardized. The yield curves for the OIS rate and for the two corporate bond rating classes are shown in the next section where we evaluate the yield curve fit for each case.

Insert Figure 1: Unspanned and spanned factors

3.3 Model evaluation

The model fits the OIS and the two corporate bond yield curves rather well.[2] This can be seen in Figures 2-7. Figure 2 shows the fit of the OIS yield curve. Since the observed data (continuous line) is almost indistinguishable from the fitted values (dashed line), we display the fitting errors separately in Figure 3. We do the same for the A and BBB bond spread curves in Figures 4-7. A summary statistics of these fitting errors is provided in the last three columns of Table 1. Overall, we find that these fitting errors are quite low, as usually found in the literature for affine term structure models (see e.g. Ang and Piazzesi (2003)). The standard deviation of the fitting errors are mostly below 10 bp, reaching a maximum of 18 bp for the 10-yr BBB bond yield spread. Such fit for all yield curves is achieved with a relatively small number of spanned factors.

We also compare the risk premium for the A and BBB yield curve for a one-year holding period with the realized excess return for the same holding period (Figures 8 and 9). In both cases, we

[2] The parameter estimates of the model are available upon request and should be later included in the Appendix.

see a reasonably good fit, deteriorating somehow for long-term maturities.

Insert Figures 2-7: Yield curve fit and fitting errors

Insert Table 1: Summary statistics of OIS rates and corporate bond spreads

Insert Figures 8-9: Fit of the risk premium

Next, we focus on the dynamics of corporate bond yield spreads as a function of our ten unspanned and spanned factors. This is done through the analysis of IRFs, variance decompositions and historical decompositions. In order to facilitate interpretation, for the last two exercises, we divide the ten factors in three groups, as explained below.

3.4 Impulse response functions

We now present IRFs in order to visualize the response of corporate bond yield spreads to a one standard deviation shock to each of the 10 variables included in the model. The ordering of such variables in the VAR system defined above (eq. (7)) is as follows:

$$\begin{aligned} F_t &= [PMI_t,\ INFL_t,\ VSTOXX_t,\ CISS_t,\ F2S_t,\ COST_t \\ &\quad PC_t^{rf,1},\ PC_t^{rf,2},\ PC_t^{spr,1},\ PC_t^{spr,2}\Big]'. \end{aligned} \tag{10}$$

We start with the unspanned factors followed by the spanned factors. The unspanned factors include first the variables representing the macroeconomic situation of the euro area and then the risk-related factors. The estimated VAR(1) system is as follows:

$$F_t = C_F^{\mathbb{P}} + \Phi_F^{\mathbb{P}} F_{t-1} + \Sigma_F\ \varepsilon_{F,t}^{\mathbb{P}}, \tag{11}$$

where Σ_F is a lower-triangular matrix implied by the lower triangular identification of the shocks.

Figures 10 and 11 show the IRFs for the 5-year corporate bond yield spreads for the A and BBB rating classes, respectively. The horizontal axis is expressed in months.[3] Despite the high dimension of the VAR system, most of the IRFs are in line with economic intuition. First, we analyze the impact of shocks to the macroeconomic condition in the euro area. We see that in both cases (A and BBB bonds) a one-standard deviation shock to the *PMI* index, representing an improvement in the economic activity, initially decreases corporate bond spreads. The quantitative impact is, however, rather low, reaching a maximum of 10 basis points in the

[3] Confidence intervals should still be added to each graph.

case of BBB bonds. In the case of an inflation shock (*INFL*), although the initial reaction of bond spreads is negative, its magnitude is very small.

We now analyze the effect of shocks to the risk-related factors. As expected, in both cases (A and BBB bonds) a one-standard deviation shock to the *VSTOXX* index, and therefore an increase in the uncertainty in financial markets, initially increases corporate bond spreads. For BBB bonds, this has an initial impact of 15 basis points. The initial effect of a shock to our systemic risk measure (*CISS*) is, however, negative and therefore counterintuitive. The effect on bond spreads only becomes positive after approximately six months. Shocks to our proxy for liquidity concerns in the financial market (*F2S*) do not seem to have an immediate impact on bond spreads. Its effect is more pronounced only after approximately 10 months. Finally, shocks to the cost of borrowing (*COST*) seem to have a marginal effect on bond spreads.

Insert Figures 10-11: Impulse response functions

3.5 Variance decompositions

One constructs variance decompositions in order to assess the relative contribution of each factor to forecast variances. Since we have a total of 10 factors in the model, in order to facilitate interpretation, we divide these factors in three groups: (*i*) *economic factors* summarize the overall economic condition of the euro area and the dynamics of the risk-free rate (PMI, $INFL, PC_t^{rf,1}, PC_t^{rf,2}$); (*ii*) *risk-related factors* capture global tensions, systemic risk, and liquidity concerns in the financial market and the cost of borrowing for non-financial corporations ($VSTOXX$, $CISS, F2S, COST$); and (*iii*) *idiosyncratic factors* include the residual dynamics not explaing by economic or risk-related factors ($PC^{spr,1}$ and $PC^{spr,2}$).

Figure 12 shows the variance decomposition of the OIS yield curve. Economic shocks are the most important source of variation for short-term maturities (up to two years) and for short forecasting horizons (one month). For longer maturities, but still short forecasting horizons, risk-related factors become the dominant driver behind the OIS rate dynamics. For longer forecasting horizons, both groups of shocks (economic and risk-related) have roughly the same impact on the OIS rate.

Regarding corporate bond spreads, Figures 13 and 14 show for all maturities the variance decompositions of A and BBB bond spreads, respectively. First, we note that both economic and risk-related shocks are significant sources of variation in corporate bond yield spreads. Nevertheless, in both cases (A and BBB bonds), we note that movements in corporate bond spreads are mostly attributed to risk-related shocks. For all maturities and long forecasting horizons (ten years), risk related shocks are responsible for approximately 50% of the forecast variance of corporate bond spreads. These results emphasize the importance of including such factors in the analysis of corporate bond yields. Economic factors, on the other hand, have a slightly increasing role in the forecast variance as the forecast horizon increases. Such factors are responsible for approximately 30% of the variation in bond spreads at long forecasting horizons.

Insert Figure 12-14: Variance decompositions

3.6 Historical decomposition of bond yield spreads

The variance decompositions discussed above show the importance of both economic and risk-related factors in the forecast variances of corporate bond spreads. We would like, however, to visualize the contribution over time of each group of factors to the OIS rate and corporate bond spreads. Figures 15 to 17 show the historical decomposition over our sample period of the 5-year OIS rate and the 5-year A and BBB corporate bond spreads, respectively. Each panel shows the contribution of one group of shocks (economic, risk-related, and idiosyncratic) to the total yield or yield spread.

First, we analyze the evolution of the 5-yr OIS rate, our benchmark risk-free rate (Figure 15). It is striking the importance of both economic and risk-related factors in the determination of such rate. We also observe that the recent decrease in the risk-free rate (after 2014), can be mainly attributed to the economic situation in the euro area. During this period, risk-related factors had a somehow stable influence on the OIS rate.

Looking at the corporate bond spreads (Figures 16 and 17), we see the importance of risk-related shocks, especially around the end of 2008 under the influence of the global financial crisis. Interestingly, we see that the decrease in corporate bond spreads observed during 2014 can be mainly attributed to such factors. Around April 2015, the end of our sample period, risk-related factors are responsible for a substantial part of corporate bond spreads. In summary, although economic factors have a significant impact on bond spreads during most of our sample period, our results show that, in general, risk-related factors play a very important role in the dynamics of corporate bond spreads.

Insert Figures 15-17: Historical decompositions

4 Conclusion

This paper presents an empirical approach to identify the contribution of economic and risk-related factors in the determination of corporate bond spreads. The yield spread decomposition is achieved with the use of a three-market, no-arbitrage affine term structure model. The model is based on methods proposed by Joslin et al. (2011), Joslin et al. (2014), and Dewachter et al. (2015).

Our multi-market setting includes three markets. Our first market is composed by our benchmark risk-free rate, the OIS yield curve. Our second market encompasses the yield curve for corporate bonds of the highest rating class in our sample (A, in our case) and our third market includes the yield curve for corporate bonds of the second highest rating class in our sample (BBB, in our case). The model is applied to euro area corporate bonds over the period 2005-2015.

The model includes a total of 10 factors, six unspanned factors and four observable factors spanning the OIS rates and the yield curves of corporate bonds of the two rating classes (A and BBB). To simplify interpretation, these factors are divided in three groups: economic, risk-related, and idiosyncratic factors. Overall, both economic and risk-related factors play a significant role in the determination of the OIS rate and corporate bond spreads. For the OIS rate, economic shocks are the most important source of variation only for short-term maturities and very short forecasting horizons. For longer forecasting horizons, economic and risk-related shocks have approximately the same influence on the OIS rate dynamics. For corporate bond spreads, risk-related shocks are the dominant drivers for all maturities and forecasting horizons. The historical decomposition of the OIS yield curve and the corporate bond spreads show the important contribution of these two groups of factors during the global financial crisis. It also shows that the decrease in corporate bond spreads observed in 2014 is mainly attributed to a decrease in the contribution of risk-related factors. Overall, our results emphasize the importance of including also risk-related factors in the analysis of corporate bond yields.

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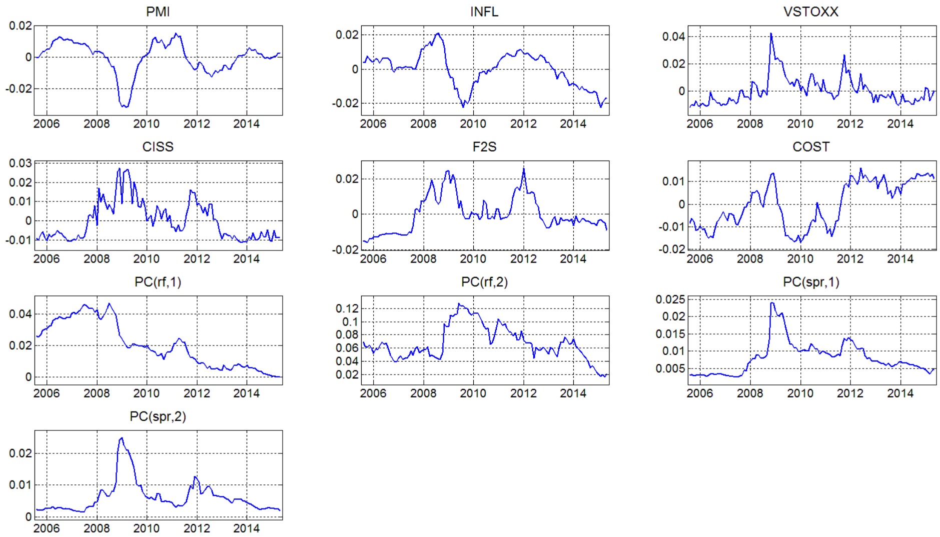
Table 1: SUMMARY STATISTICS OF OIS RATES AND CORPORATE BOND SPREADS

		Mean		Std		Fitting error	
		data (%)	emp. (%)	data (%)	emp. (%)	mean (bp)	std (bp)
OIS	yield_{1yr}	2,37	2,33	2,11	2,13	4	10
	yield_{2yr}	2,59	2,61	1,98	1,97	-2	6
	yield_{3yr}	2,84	2,87	1,87	1,85	-3	8
	yield_{4yr}	3,09	3,11	1,75	1,73	-2	7
	yield_{5yr}	3,31	3,32	1,62	1,63	-1	5
	yield_{7yr}	3,73	3,68	1,45	1,44	5	6
	yield_{10yr}	4,08	4,08	1,18	1,20	1	10
A	spread_{1yr}	0,70	0,75	0,55	0,52	-5	13
	spread_{2yr}	0,74	0,80	0,51	0,52	-5	8
	spread_{3yr}	0,87	0,85	0,57	0,52	2	8
	spread_{4yr}	0,97	0,90	0,57	0,53	7	8
	spread_{5yr}	0,98	0,96	0,54	0,53	3	7
	spread_{7yr}	1,08	1,06	0,54	0,54	2	10
	spread_{10yr}	1,19	1,23	0,50	0,55	-4	15
BBB	spread_{1yr}	1,25	1,29	0,78	0,75	-3	17
	spread_{2yr}	1,33	1,36	0,71	0,73	-3	10
	spread_{3yr}	1,47	1,43	0,74	0,72	3	6
	spread_{4yr}	1,58	1,51	0,75	0,71	7	9
	spread_{5yr}	1,61	1,58	0,71	0,70	3	7
	spread_{7yr}	1,70	1,71	0,70	0,68	-1	13
	spread_{10yr}	1,81	1,91	0,64	0,67	-10	18

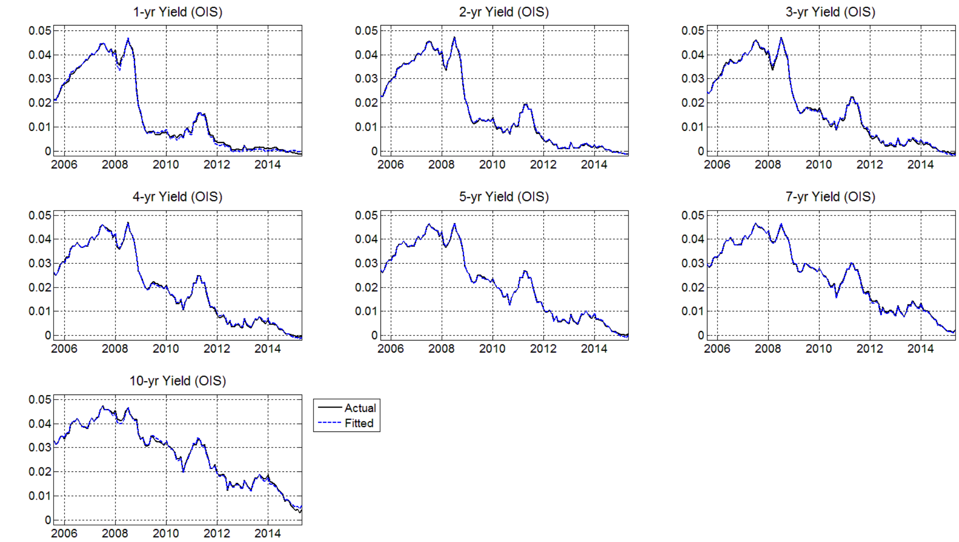
Note: *Mean* denotes the sample arithmetic average and *Std* the standard deviation, all expressed in basis points. *auto* denotes the first-order monthly autocorrelation and *emp* the empirical result from the model.

Figure 1: Unspanned and spanned factors



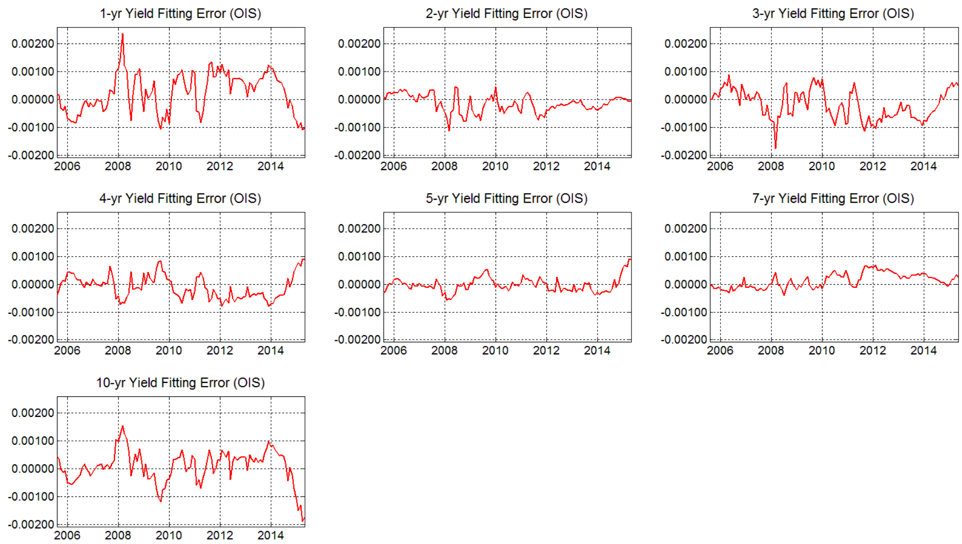
Note: The figure shows the 6 unspanned and 4 spanned factors. The unspanned factors are standardized: *PMI* is the Purchasing Managers' Index, which is based on surveys of business conditions in manufacturing and in services industries (source: markit.com); *INFL* is the year-on-year growth rate of the Euro area Consumer Price Index (source: Datastream); *VSTOXX* is a market volatility index based on EURO STOXX 50 realtime options prices (source: stoxx.com); *CISS* is the Composite Indicator of Systemic Stress in the financial system which incorporates 15 financial stress measures (source: Holló, Kremer, and Lo Duca (2012)); *F2S* is the spread between the yield on the German government guaranteed bond (KfW) and the German sovereign bond, averaged across maturities (source: Bloomberg); and *COST* is the spread between the cost of borrowing for corporations and the average of OIS rates (source: European Central Bank). The spanned factors are the following: *PC(rf,1)* and *PC(rf,2)* are the first two principal components of the OIS rates for the seven maturities included in the sample (1, 2, 3, 4, 5, 7, 10 years); and *PC(spr,1)* and *PC(spr,2)* are the first two principal components of the yield spreads between a specific rating class and the rating class one level higher. Since we have two rating classes and seven maturites these are the principal components of 14 spread series. For all series, the sample period goes from July 2005 to April 2015 (monthly, 118 obs.).

Figure 2: Fit of the OIS yield curve



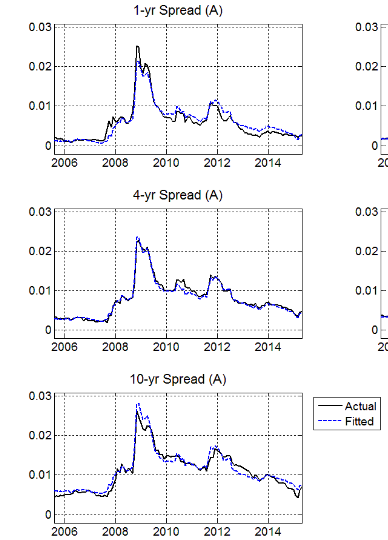
Note: The figure shows the fit of the OIS yield curve for the maturities of 1, 2, 3, 4, 5, 7, 10 years. The continuous line shows the observed (actual) data while the dashed line shows the fitted values. The sample period goes from July 2005 to April 2015 (monthly, 118 obs.).

Figure 3: Fitting errors for the OIS yield curve



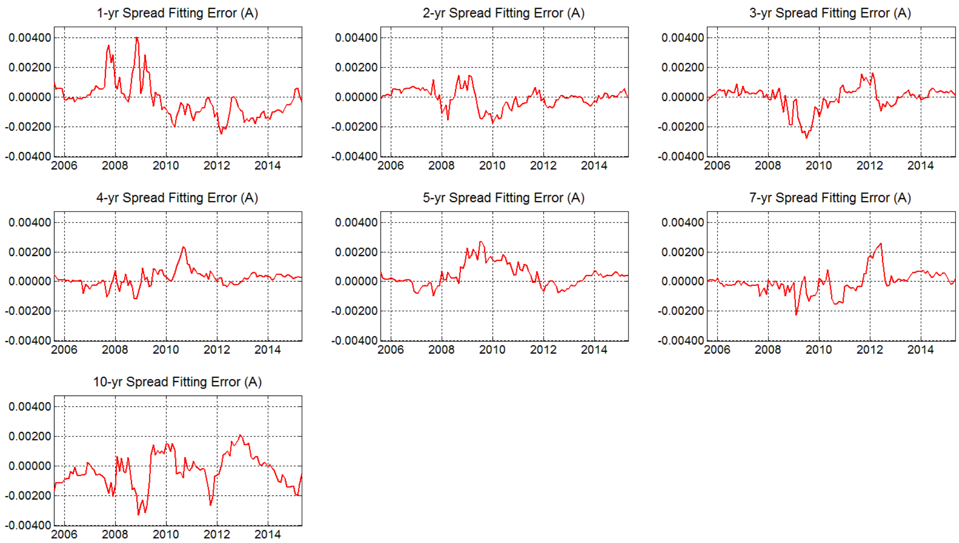
Note: The figure shows the fitting errors for the OIS yield curve for the maturities of 1, 2, 3, 4, 5, 7, 10 years. The sample period goes from July 2005 to April 2015 (monthly, 118 obs.).

Figure 4: Fit of the A bond yield spread



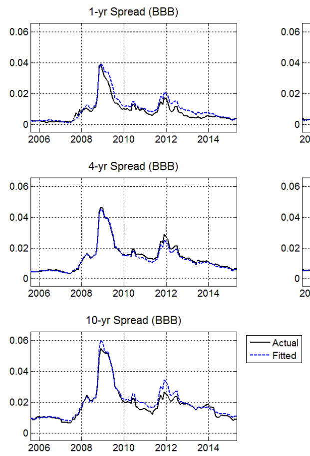
Note: The figure shows the fit of the spread between the A bond yield and the OIS rate for the maturities of 1, 2, 3, 4, 5, 7, 10 years. The continuous line shows the observed (actual) data while the dashed line shows the fitted values. The sample period goes from July 2005 to April 2015 (monthly, 118 obs.).

Figure 5: Fitting errors for the A bond yield spreads



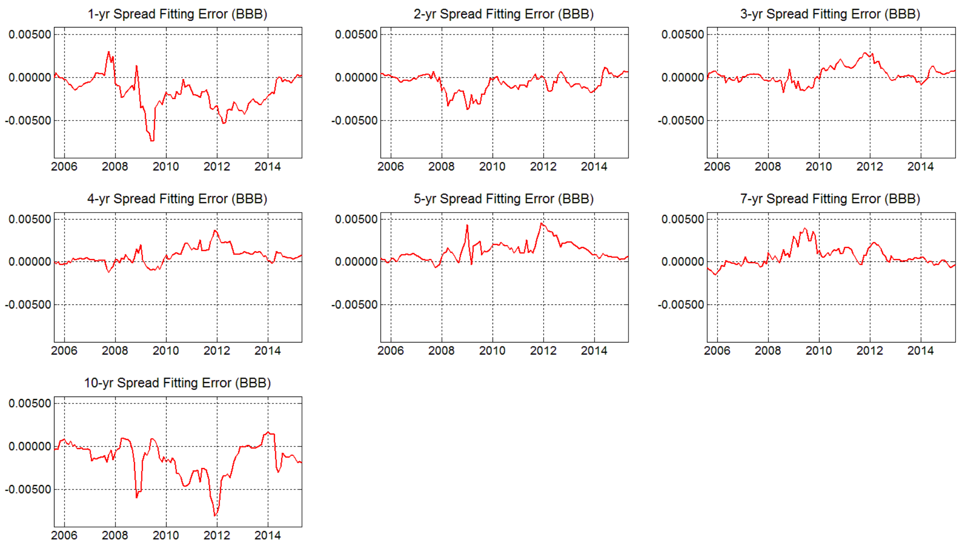
Note: The figure shows the fitting errors for the spread between the A bond yield and the OIS rate.for the maturities of 1, 2, 3, 4, 5, 7, 10 years. The sample period goes from July 2005 to April 2015 (monthly, 118 obs.).

Figure 6: Fit of the BBB bond yield spread



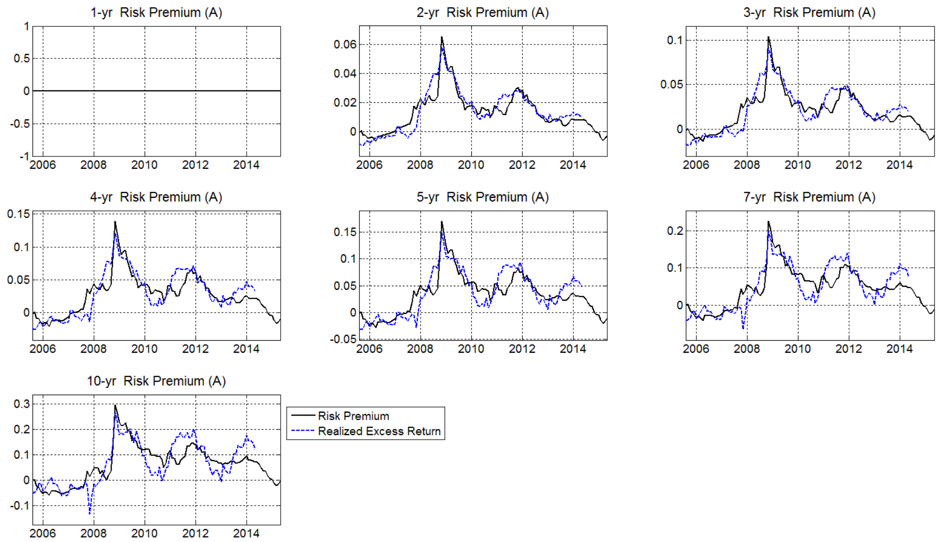
Note: The figure shows the fit of the spread between the BBB bond yield and the OIS rate for the maturities of 1, 2, 3, 4, 5, 7, 10 years. The continuous line shows the observed (actual) data while the dashed line shows the fitted values. The sample period goes from July 2005 to April 2015 (monthly, 118 obs.).

Figure 7: Fitting errors for the BBB bond yield spreads



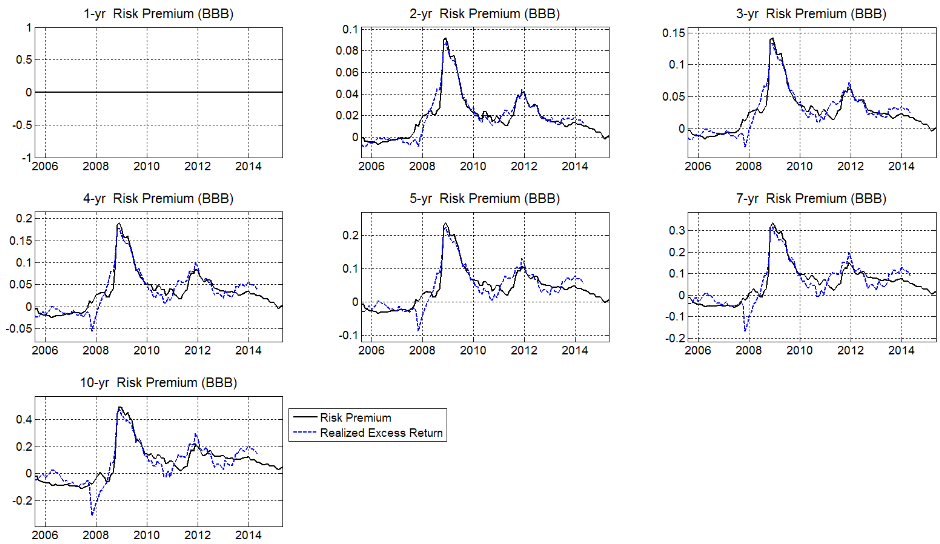
Note: The figure shows the fitting errors for the spread between the BBB bond yield and the OIS rate.for the maturities of 1, 2, 3, 4, 5, 7, 10 years. The sample period goes from July 2005 to April 2015 (monthly, 118 obs.).

Figure 8: Fit of the risk premium for the A bond yield curve



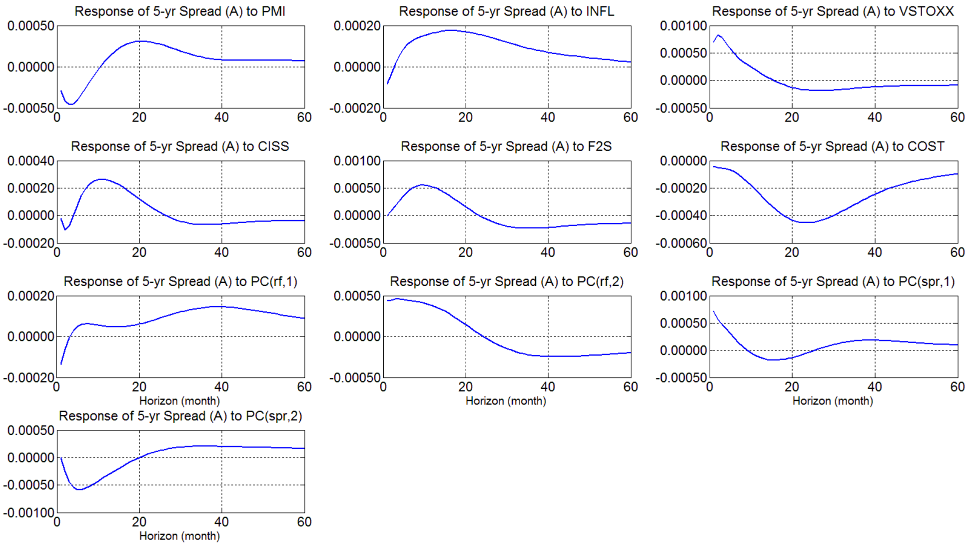
Note: The figure considers a one-year holding period. It shows the risk premium (continuous line) and the realized excess return (dashed line) for the A bond yields with maturities of 1, 2, 3, 4, 5, 7, 10 years. The sample period goes from July 2005 to April 2015 (monthly, 118 obs.).

Figure 9: Fit of the risk premium for the BBB bond yield curve



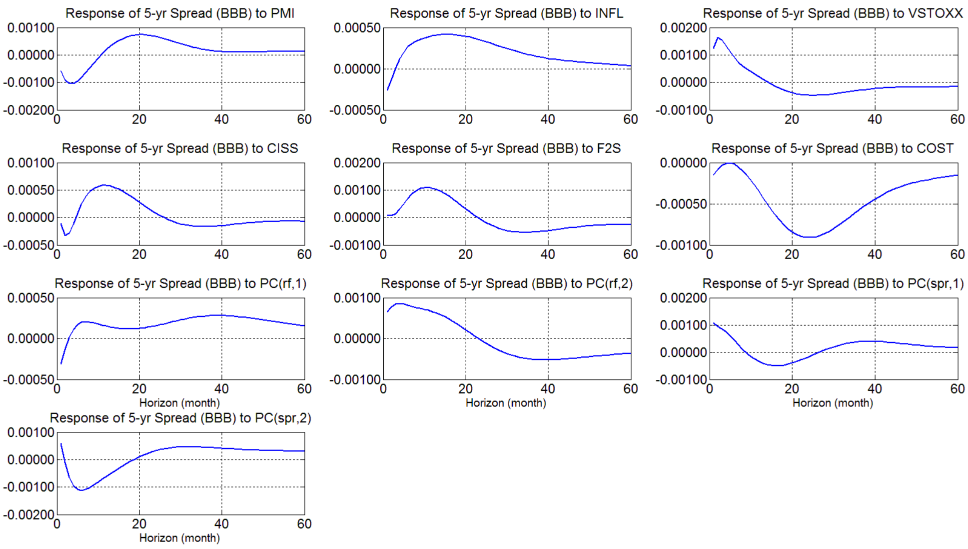
Note: The figure considers a one-year holding period. It shows the risk premium (continuous line) and the realized excess return (dashed line) for the BBB bond yields with maturities of 1, 2, 3, 4, 5, 7, 10 years. The sample period goes from July 2005 to April 2015 (monthly, 118 obs.).

Figure 10: Impulse response function: Response of the 5-yr A bond yield spread to factor shocks



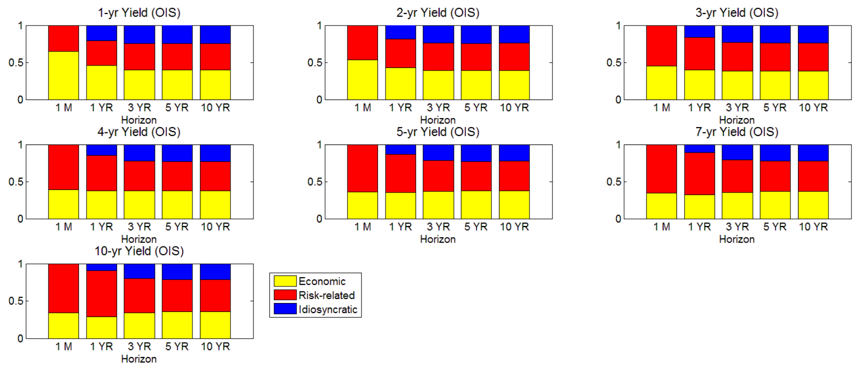
Note: The figure shows the impulse responses of 5-year BBB bond yield spreads for the maturities of 1, 2, 3, 4, 5, 7, 10 years to a one standard deviation shock in each of the 10 factos (6 unspanned and 4 spanned). Error bands should still be added.

Figure 11: Impulse response function: Response of the 5-yr BBB bond yield spread to factor shocks



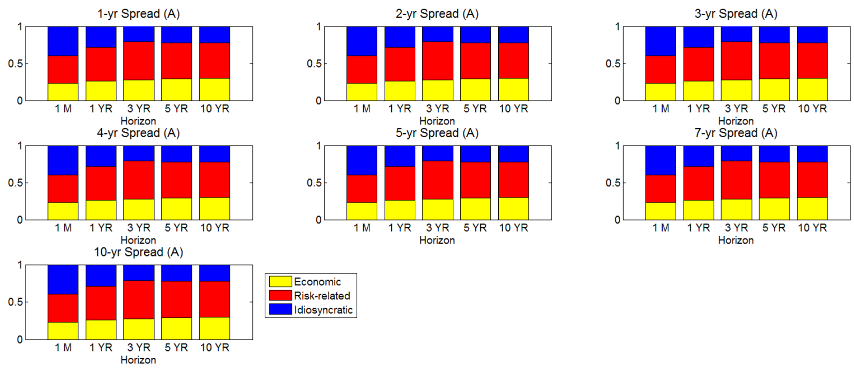
Note: The figure shows the impulse responses of 5-year A bond yield spreads for the maturities of 1, 2, 3, 4, 5, 7, 10 years to a one standard deviation shock in each of the 10 factos (6 unspanned and 4 spanned). Error bands should still be added.

Figure 12: Variance decomposition of OIS yield curve



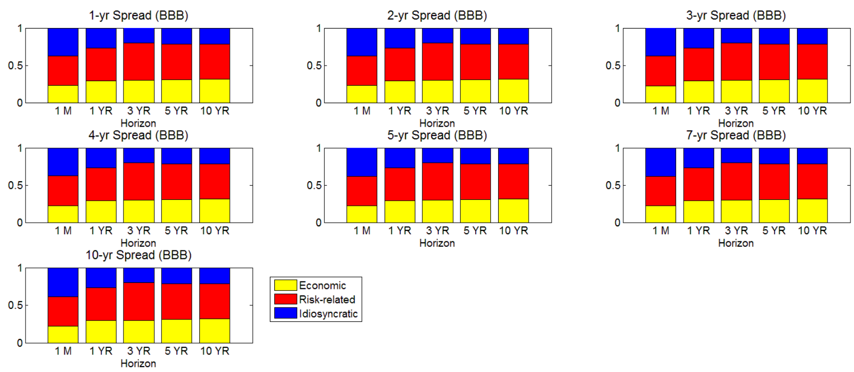
Note: The figure shows the variance decomposition of the OIS rates for the maturities of 1, 2, 3, 4, 5, 7, 10 years. Each graph shows the contribution of three groups of factors. The *economic* group includes the shocks to PMI, $INFL, PC_t^{rf,1}, PC_t^{rf,2}$; the *risk-related* group shocks to $VSTOXX$, $CISS, F2S, COST$; and the *idiosyncratic* group shocks to $PC^{spr,1}$ and $PC^{spr,2}$.

Figure 13: Variance decomposition of A bond yield spreads



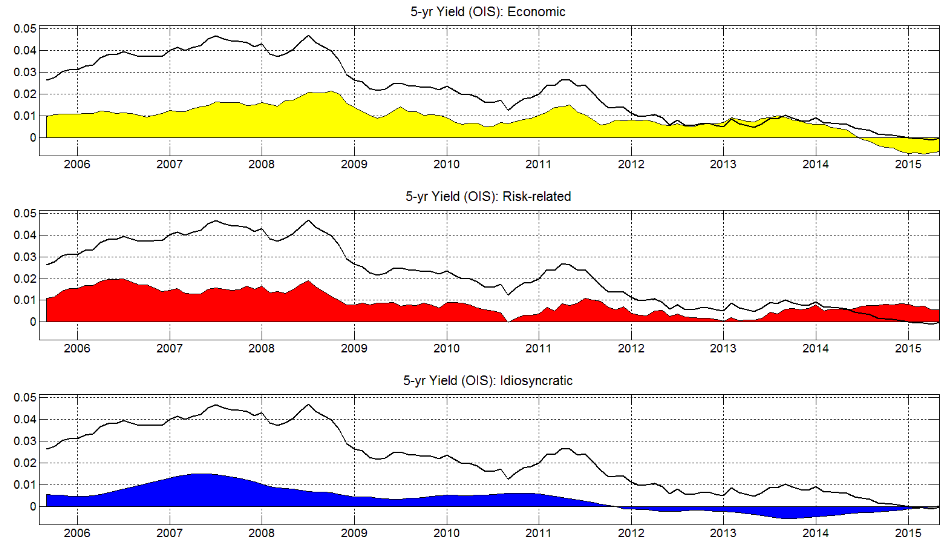
Note: The figure shows the variance decomposition of A bond yield spreads for the maturities of 1, 2, 3, 4, 5, 7, 10 years. Each graph shows the contribution of three groups of factors. The *economic* group includes the shocks to PMI, $INFL, PC_t^{rf,1}, PC_t^{rf,2}$; the *risk-related* group shocks to $VSTOXX$, $CISS, F2S, COST$; and the *idiosyncratic* group shocks to $PC^{spr,1}$ and $PC^{spr,2}$.

Figure 14: Variance decomposition of BBB bond yield spreads



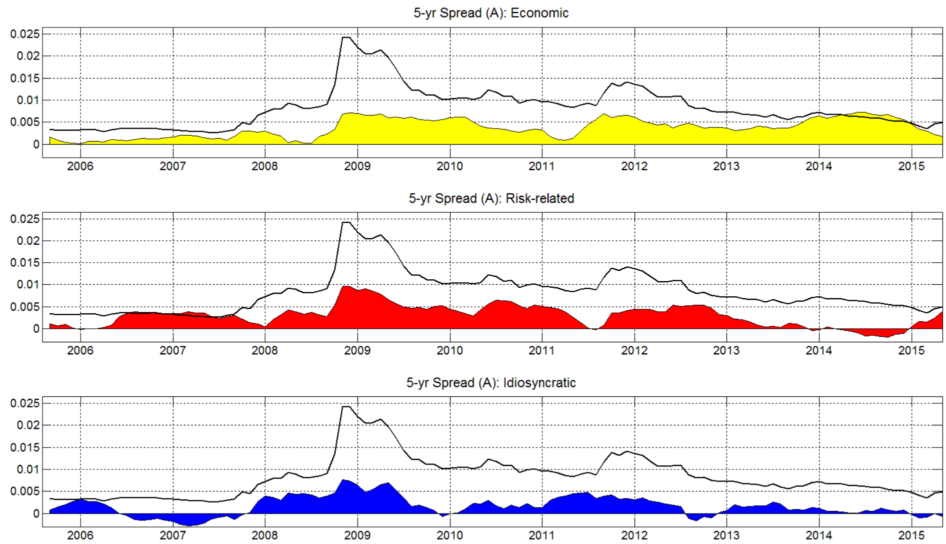
Note: The figure shows the variance decomposition of BBB bond yield spreads for the maturities of 1, 2, 3, 4, 5, 7, 10 years. Each graph shows the contribution of three groups of factors. The *economic* group includes the shocks to PMI, $INFL, PC_t^{rf,1}, PC_t^{rf,2}$; the *risk-related* group shocks to $VSTOXX$, $CISS, F2S, COST$; and the *idiosyncratic* group shocks to $PC^{spr,1}$ and $PC^{spr,2}$.

Figure 15: Historical decomposition of 5-yr OIS rate



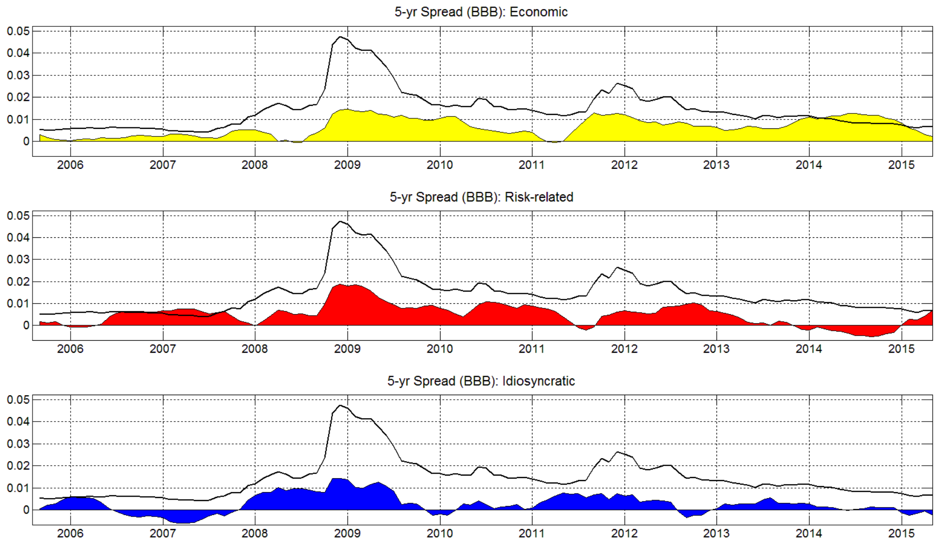
Note: The figure shows the historical decomposition of the 5-year OIS rate with the shocks grouped as follows: *Economic Component* – PMI, $INFL, PC_t^{rf,1}, PC_t^{rf,2}$; *Risk-related Component* – $VSTOXX$, $CISS, F2S, COST$; and *Idiosyncratic Component* – $PC^{spr,1}$ and $PC^{spr,2}$.

Figure 16: Historical decomposition of 5-yr A bond yield spread



Note: The figure shows the historical decomposition of the 5-year A bond yield spread with the shocks grouped as follows: *Economic Component* – PMI, $INFL, PC_t^{rf,1}, PC_t^{rf,2}$; *Risk-related Component* – $VSTOXX$, $CISS, F2S, COST$; and *Idiosyncratic Component* – $PC^{spr,1}$ and $PC^{spr,2}$.

Figure 17: Historical decomposition of 5-yr BBB bond yield spread



Note: The figure shows the historical decomposition of the 5-year BBB bond yield spread with the shocks grouped as follows: *Economic Component* – PMI, $INFL, PC_t^{rf,1}, PC_t^{rf,2}$; *Risk-related Component* – $VSTOXX$, $CISS, F2S, COST$; and *Idiosyncratic Component* – $PC^{spr,1}$ and $PC^{spr,2}$.