A macro-financial analysis of the euro area sovereign bond market

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Abstract

We estimate the 'fundamental' component of euro area sovereign bond yield spreads, i.e. the part of bond spreads that can be justified by country-specific economic factors, euro area economic fundamentals, and international influences. The yield spread decomposition is achieved using a multi-market, no-arbitrage affine term structure model with a unique pricing kernel. More specifically, we use the canonical representation proposed by Joslin, Singleton, and Zhu (2011) and introduce next to standard spanned factors a set of unspanned macro factors, as in Joslin, Priebsch, and Singleton (2013). The model is applied to yield curve data from Belgium, France, Germany, Italy, and Spain over the period 2005-2013. Overall, our results show that economic fundamentals are the dominant drivers behind sovereign bond spreads. Nevertheless, shocks unrelated to the fundamental component of the spread have played an important role in the dynamics of bond spreads since the intensification of the sovereign debt crisis in the summer of 2011

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1 Introduction

The creation of the European Economic and Monetary Union (EMU) in January 1999 led to an unprecedented convergence of government bond yields of eurozone countries[1], with remaining yield differentials being mainly attributed to differences in the levels of credit and liquidity risks among countries. The surge in the spreads between euro area sovereign bond yields and market risk-free rates, particularly since 2011, has raised questions about the underlying drivers of bond spreads and whether economic fundamentals (country-specific and international) alone are able to explain such dynamics. In this paper, we extend the approach proposed by Joslin et al. (2011) to a multi-market setting in order to decompose yield spreads of a set of euro area countries into a fundamental and a non-fundamental component. The fundamental component can be justified by a set of country-specific factors, euro area economic fundamentals, and international factors. The non-fundamental part incorporates liquidity and political uncertainty effects, in addition to remaining common factors which might be proxying for redenomination risk, i.e. the fear by investors that at least one country would abandon the euro area.[2]

Our paper is part of a broad literature that studies the determinants of bond yield differentials in the eurozone. Despite its various approaches, we view this literature as divided in two main strands. The first one relies mainly on regressions of yield spreads on a number of fundamental variables representing credit, liquidity, and international risks (see, for instance, Favero et al. (2010)). Although there does not seem to be a clear consensus on the relative weight of each component, most studies in this strand of the literature point to the importance of both credit and liquidity risks in explaining differences in euro area bond spreads for the period before the start of the sovereign debt crisis in late 2009. Among the most recent studies, and particularly those focused on the sovereign debt crisis in the euro area, different approaches have been used to identify the extent to which bond spreads are justified by macroeconomic and financial fundamentals. Several papers have found evidence of the importance of a country's macroeconomic situation in determining its sovereign bond yields, as these depend on its fiscal position and ability to honour its commitments. Bayoumi et al. (1995) find evidence of the impact of the debt level on bond spreads for the U.S., while later studies reach similar conclusions for euro area countries (Hallerberg and Wolff (2006), Faini (2006), and others). Thus, the fundamental part (i.e. related to a country's creditworthiness) of bond yields may be estimated using mainly

[1] See Pagano and von Thadden (2004) for a detailed description of this process.

[2] The term *mispricing* has been used to designate the non-fundamental component of sovereign bond spreads, i.e. the part of bond spreads not explained by differences in fiscal and macroeconomic fundamentals. See, for example, De Grauwe and Ji (2012) and Di Cesare et al. (2012).

country-specific indicators. Aizenman et al. (2011) develop a model of pricing of sovereign risk for a number of European and non-European countries where sovereign credit default swap (CDS) spreads are regressed on fiscal position indicators and other macroeconomic variables. According to their results, CDSs have been mispriced in euro area periphery countries, being excessively low in tranquil periods and too high during the recent sovereign debt crisis.

Nevertheless, other factors may be behind movements in sovereign bond spreads, including the level of international risk aversion and financial contagion, the latter being of particular relevance within a currency union. In the case of the euro area, market liquidity, cyclical conditions and risk appetite, which are related to the level of short-term rates, have been identified as important factors behind the level of bond spreads (Manganelli and Wolswijk (2009)). Attinasi et al. (2011), for example, control for the effect of such factors on euro area sovereign bond spreads vis-à-vis German sovereign bonds. De Santis (2013), on the other hand, considers the impact of contagion from events in Greece to other eurozone countries. He concludes that both sovereign solvency risk and contagion have played an important role in the increase of bond spreads in eurozone countries during the recent debt crisis. Giordano et al. (2013), in turn, distinguish between three types of contagion, with a 'pure contagion' not being justified by fundamentals. They do not find evidence of this kind of contagion during the debt crisis in the euro area. Finally, Caceres et al. (2010) also find evidence of contagion originating in the most affected countries in the eurozone.

A second strand of the literature includes papers that estimate multi-issuer, no-arbitrage, affine term structure models. For example, in order to analyze the dynamics of bond spreads of EMU countries, Düllmann and Windfuhr (2000) employ standard interest rate models using the short rate and the spread between risky and risk-free bonds as factors, while Geyer et al. (2004) rely on the estimation of purely latent factor models. Borgy et al. (2011), on the other hand, employ a multi-country affine term structure model making use of macroeconomic variables as factors.[3] They estimate the joint dynamics of eight euro area government bond yield curves making use of three common euro area macro factors and one latent fiscal factor for each country. They focus on the effect of fiscal policy on the perceived sovereign default probabilities for each country and conclude that fiscal factors are the main determinants in the increase of yield spreads since 2008. Ang and Longstaff (2013) use a multi-factor affine framework to disentangle the systemic and country-specific shocks on CDS spreads of government bonds for the U.S., individual U.S. states, and eleven euro area countries. Their findings point to a stronger impact of systemic risk

[3] Amato and Luisi (2006) use a combination of macroeconomic and latent variables in an affine term structure model of defaultable bonds but their model is applied to U.S. *corporate* bond spreads.

among European sovereigns than among individual U.S. states. This is interpreted by Battistini et al. (2013) as evidence of a possible breakup of the currency union. These authors estimate a dynamic latent factor model to identify the shocks driving the sovereign yields of each euro area issuer. They distinguish between a common (systemic) factor, capturing the perceived risk of a collapse of the euro system, and a country-specific factor, capturing each country's credit risk. Using euro area data from 2008 to 2012, they conclude that yield differentials are mainly driven by country risk, particularly for eurozone periphery countries.

The economic literature, therefore, finds evidence that both country-specific credit risk, contagion risk, and international risk factors are important in the determination of euro area sovereign bond spreads. Nevertheless, depending on the specific country under study, the effect of common risk factors not only is significantly different in magnitude but also has opposite effects on bond spreads.

Our model is part of the *multi-issuer*, no-arbitrage, *affine term structure model* literature and it differs from the extant papers in at least two points. First, we attempt to determine the fundamental component of bond spreads by using a relatively large set of observable macroeconomic factors. Our model therefore allows one to link the development of yield spreads with the evolution of the economic situation. Second, from an econometric setting, we adopt a relatively flexible and simple methodology that overcomes most of the drawbacks related to existing affine term structure models. These shortcomings are related to the significant amount of time necessary for the convergence of standard maximum likelihood algorithms[4] and, more importantly, to the fact that the standard formulation implies that the macroeconomic risk factors are spanned by – i.e. can be expressed as a linear combination of – bond yields. This spanning condition is however overwhelmingly rejected by standard regression analysis, which shows that there is no perfect linear relation between yields and macroeconomic variables (see Joslin et al. (2013)).

To overcome these issues, we use the approach proposed by Joslin et al. (2011) and Joslin et al. (2013), extending it to a multi-issuer setting. We propose a *multi-country*, no-arbitrage, affine term structure model in which the countries share a common currency.[5] Our goal is to identify the fundamental component of eurozone sovereign bond yield differentials. To this end, we estimate separately five *two-market* models for Belgium, France, Germany, Italy, and Spain in

[4]For a description of the usual computational challenges faced by affine term structure models, see Duffee and Stanton (2008), among others.

[5]Bauer and Diez de los Rios (2012) combine the methodology of Joslin et al. (2011) and Joslin et al. (2013) in a multi-country affine term structure model which includes unspanned macroeconomic risks. Their model, however, also includes foreign exchange risk.

which the Overnight Indexed Swap (OIS) rate is used as the reference rate, i.e. it serves as our benchmark market. We procede as follows. We estimate the dynamics of a single risk-neutral measure in order to fit the OIS yield curve and the yield curve of the respective country. This is achieved with the use of four spanned pricing factors computed as linear combinations of yields. Two of these factors are used to fit the OIS yield curve and the other two to fit the country's bond yield differentials. In order to determine the effect of specific macroeconomic and financial variables in the dynamics of bond spreads, we estimate a vector autoregressive (VAR) model combining the spanned factors with nine unspanned factors. Five of them represent country-specific fundamental factors, euro area economic measures, and other international influences. The other four factors capture the non-fundamental component of the sovereign spread, such as liquidity premia, political uncertainty, and common dynamics in the eurozone sovereign bond spreads. The VAR system allows for the assessment of the relative importance of economic fundamentals in the dynamics of the spanned factors and, hence, of yield spreads.

We apply our model to monthly data of the mentioned countries over the period between August 2005 and May 2013. In all five cases, our specification is able to fit both the OIS and the country's yield curve rather well. Our main contribution, however, is related to the assessment of the relative importance of each group of factors for the dynamics of bond spreads. This is done by means of impulse response functions (IRFs), variance decompositions, and a historical decomposition of bond yield spreads.

Our main result is clear. Both economic as well as non-fundamental risk factors are important sources of variation in bond yield spreads. *Non-fundamental risk shocks* are the main source of variation in bond spreads for short forecast horizons (up to one-month horizon), explaining between 35% (Germany, 5-year bond spread) and 82% (Belgium and France, 3-year bond spread) of such variation. This proportion decreases for longer forecast horizons. Overall, this proportion is the lowest for Belgium and the highest for France, where this group of factors accounts for most of the variation in bond spreads for all maturities and forecast horizons. Nevertheless, for all countries, such shocks are responsible for at least 20% of the bond spread variation for any maturity and forecast horizon. *Shocks to economic fundamentals*, on the other hand, gain in importance as the forecast horizon increases. For Belgium, Germany, and Italy, such shocks are the dominant source of variation in bond spreads for forecast horizons above one year. For France and Spain, those shocks also play an important role in long forecast horizons.

We also illustrate the importance of each group of factors over time with a historical decomposition of bond yield spreads. Our results show that, overall, economic fundamentals are the dominant drivers behind yield differentials. Nevertheless, non-fundamental risk shocks have had a significant impact on bond spreads since September 2011.

The remainder of the paper is organized as follows. Section 2 presents the common-currency, multi-country, affine term structure model and the VAR system used to determine the influence of macroeconomic and financial factors on bond spreads. Section 3 summarizes the data, describes the estimation method, and discusses the results. Section 4 analyses the historical decomposition of bond spreads and Section 5 concludes the paper.

2 The Model

We extend the standard affine yield curve model to a multi-market, single-pricing kernel framework. This framework is particularly useful in addressing issues related to the euro area sovereign bond market. Specifically, in the context of a common currency, it allows us to model a financially integrated market by imposing a unique pricing kernel while at the same time acknowledging the possibility of country-specific (default) risks. The model hence features a parsimonious representation of the yield spread dynamics, allowing for both common and country-specific risk factors. As shown by the empirical results, the model is able to capture the most salient features of the euro area sovereign bond market, both in the cross-sectional as well as in the time series dimension.

A parsimonious representation of the yield curve dynamics is obtained by focusing on the latent version of the affine yield curve model. This type of model imposes the no-arbitrage restriction in the context of Gaussian and linear (latent) state space dynamics under the risk-neutral measure. Following Joslin et al. (2011), we use a limited set of spanned factors – the so-called yield portfolios – to model in a consistent way the cross-sectional features of the yield curve. Subsequently, in line with Joslin et al. (2013), 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) both macroeconomic and financial 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 financial variables in the yield curve dynamics. In this analysis, we focus on the (ir)relevance of macroeconomic fundamentals in explaining the yield (spread) curve dynamics in the euro area bond market. We proceed in two steps. First, we present the common-currency, multi-country affine yield curve model. We then present the specific assumptions imposed in the VAR system.

2.1 A multi-market affine yield curve model

This section builds on Joslin et al. (2011) who introduce affine yield curve models using observable yield portfolios as factors spanning the yield curve. We discuss a multi-market version of this model.

We assume the existence of K fundamental and unobserved pricing factors for the yield curve of all markets, $X_{k,t}$, $k = 1, ..., K$, collected in the vector $X_t = [X_{1,t}, ..., X_{K,t}]'$. As explained below, these factors reflect fundamental sources of risk. They can be either common (affecting all markets) or market-specific (affecting a subset of markets) risk factors. The dynamics of these factors under the unique risk-neutral measure (Q) is modelled by means of a maximally flexible affine VAR(1) dynamics (see Dai and Singleton (2000)):

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

where Φ_X^Q is a diagonal matrix containing the distinct eigenvalues of Φ_X^Q, $\Phi_X^Q = diag(\lambda_1^Q, ..., \lambda_K^Q)$, and Σ_X is a lower-triangular matrix. We assume that the K factors determine each of the m market-specific, short-term interest rate in market m, $r_{m,t}$, with $m = 1, ..., M$. The dependence of the short-term interest rate of market m on the pricing factors is given by the $1 \times K$ vector ρ_m^1:

$$r_{m,t} = \rho_m^0 + \rho_m^1 X_t. \tag{2}$$

As such, the model allows us to introduce simultaneously 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_m^1. We use a two-market setup ($M = 2$), where market 1 is a benchmark market and market 2 is the sovereign bond market of a specific country in the euro area. 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 *common* factors, i.e. $r_{1,t} = \rho_1^0 + [1, 1, 0, 0]\, X_t$, and the *market-specific*, short-term sovereign yield of the specific bond market is given by $r_{2,t} = \rho_1^0 + \rho_2^0 + [1, 1, 1, 1]\, X_t$. The latter two factors drive the movements of the instantaneous spreads and can be interpreted as reflecting market-specific default risk or liquidity factors; see e.g. Duffie and Singleton (1999).

As mentioned in Joslin et al. (2011) and Dai and Singleton (2000), the framework consisting of eq. (1) and (2) leaves open some identification issues. To econometrically identify all parameters, additional restrictions need to be imposed. We follow one of the identification schemes proposed by Joslin et al. (2011) (see their Proposition 2). In particular, in the context of the $A_0(n)$ type of model proposed in eq. (1), we impose the following restriction on the Q-dynamics: $C_X^Q = 0$. As a result, and imposing stationarity on the Q-dynamics, the parameter ρ_m^0 becomes proportional to the unconditional average of the short rate in each market. Furthermore, due to the latent structure of the model, we also need to fix the loadings of the short-term rates on the factors X_t by setting the parameter vector ρ_m^1 to $\rho_1^1 = [1, 1, 0, 0]$ and $\rho_2^1 = [1, 1, 1, 1]$ (see also the discussion above). Conditional on this identification scheme, the Q-dynamics of the canonical multi-country yield curve model can be summarized by a parameter vector for market m consisting of $\Theta_m = \left\{C_X^Q,\ \Phi_X^Q,\ \Sigma_X,\ \rho_m^0,\ \rho_m^1\right\}$, where C_X^Q and ρ_m^1 are fixed for reasons of identification.

Given the risk-neutral dynamics (eq. (1)) and the definition of the short-term interest rate for each market (eq. (2)), zero-coupon bond yields can be written as an affine function of the state vector (see e.g. Dai and Singleton (2000)). Denoting the time-t yield in market m and maturity n by $y_{m,t}(n)$, the yield curve can be written as an affine function of the factors:

$$y_{m,t}(n) = A_{m,n}(\Theta_m) + B_{m,n}(\Theta_m)X_t, \tag{3}$$

where the functions $A_{m,n}(\Theta_m)$ and $B_{m,n}(\Theta_m)$ follow from no-arbitrage difference eq. (see Duffee (2002), Dai and Singleton (2000) and Ang and Piazzesi (2003)). Assuming there are N yields per market, we collect all market-specific yields in a vector $y_{m,t} = [y_{m,t}(1), ..., y_{m,t}(N)]'$. Defining

$$A_m(\Theta_m) = [A_{m,1}(\Theta_m), ..., A_{m,N}(\Theta_m)]'$$

and

$$B_m(\Theta_m) = \left[B_{m,1}(\Theta_m)', ..., B_{m,N}(\Theta_m)'\right]',$$

the market-specific yield curve is given by:

$$y_{m,t} = A_m(\Theta_m) + B_m(\Theta_m)X_t. \tag{4}$$

Stacking the yields and the functions $A_m(\Theta_m)$ and $B_m(\Theta_m)$ across the M markets, $Y_t = \left[y'_{1,t}, ..., y'_{M,t}\right]'$, $A(\Theta) = [A_1(\Theta_1)', ..., A_M(\Theta_M)']'$, and $B(\Theta) = [B_1(\Theta_1)', ..., B_M(\Theta_M)']'$, we obtain the multi-market, no-arbitrage yield curve representation:

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

The fundamental pricing factors, X_t, are unobserved. However, a suitable rotation based on yield portfolios can be used to identify an equivalent, observable, yield curve representation. These yield portfolios, defined as linear combinations of yields (possibly across different markets), are assumed to be perfectly priced by the no-arbitrage restrictions. Formally, the l-th yield portfolio with yield $P_{l,t}$ is defined by a time-invariant weight function w_l such that $P_{l,t} = w_l Y_t$. Assuming there are (at least) K such yield portfolios, stacked in the $K \times (NM)$ matrix W, the vector of yield portfolios is given by $P_t = WY_t$. In addition, assuming zero measurement errors on the yield portfolios allows us to re-express the fundamental affine yield curve model in terms of the observable yield portfolios P_t. It is straightforward to show that the representation in terms of observable yield portfolios becomes:

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

2.2 Decomposing yield curves

We use a standard first order Gaussian VAR representation to assess the relative importance of macroeconomic and financial shocks in the yield curve dynamics while maintaining the condition of no-arbitrage. This type of decomposition can be performed using the yield curve representation in eq. (6). Given that yields are affine functions of the observable yield portfolios, it becomes equivalent to a decomposition of the yield portfolios, P_t. Denoting the set of unspanned macroeconomic and financial 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. The identification is performed by first including the more exogenous variables, representing international and euro area conditions, then the country-specific macroeconomic factors, and, finally, the country-specific yield spread factors. This allows for an immediate impact of shocks in the macroeconomic and financial variables on sovereign bond spreads. In the next section, we detail the variables included in the vectors of unspanned and spanned factors.

2.3 Estimation method

Three main characteristics distinguish the estimation of our common-currency, two-market affine yield curve model from standard macro-finance models (see, for example, Ang and Piazzesi

(2003)). First, we select a group of observed yield portfolios (spanned factors) to fit the yield curves of the country under study and the benchmark market (the OIS rate in our case). Second, we choose a set of macroeconomic and financial variables (unspanned factors) which might (i) have predictive content for excess bond returns over and above that of the spanned factors, and (ii) help us discriminate between the relevant determinants of bond yield spreads. Finally, we focus on the dynamics of *bond yield spreads* with respect to the benchmark market.

Our estimation procedure follows the two-step procedure proposed by Joslin et al. (2011). This procedure uses an efficient factorization of the likelihood function, arising from the use of yield portfolios as pricing factors. In particular, the likelihood function for the data vector $Z_t = [M_t', P_t']'$ is factored into two components:

$$f(Y_t, Z_t \mid Z_{t-1}) = f(Z_t \mid Z_{t-1}, C^{\mathbb{P}}, \Phi^{\mathbb{P}}, \Sigma) \times f(Y_t \mid P_t, \Theta).$$

The first component, $f(Z_t \mid Z_{t-1}, C^{\mathbb{P}}, \Phi^{\mathbb{P}}, \Sigma)$, is the prediction density for the state vector, Z_t, which is implied by the VAR(1) model in Section 2.2:

$$Z_t = C^{\mathbb{P}} + \Phi^{\mathbb{P}} Z_{t-1} + \Sigma \varepsilon_{Z,t}^{\mathbb{P}} , \qquad \varepsilon_{Z,t}^{\mathbb{P}} \sim N(0, I_K). \tag{8}$$

The second component, $f(Y_t \mid P_t, \Theta)$, refers to the yield curve density and is obtained from the no-arbitrage affine yield curve model:

$$Y_t = a_p(\Theta) + b_p(\Theta) P_t + \Sigma_Y \varepsilon_{Y,t} , \qquad \varepsilon_{Y,t} \sim N(0, I_{L^Y}), \tag{9}$$

where the loadings $a_p(\Theta) = \left[I - B(\Theta)(WB(\Theta))^{-1}W\right] A(\Theta)$ and $b_p(\Theta) = B(\Theta)(WB(\Theta))^{-1}$ are obtained by rotating the loadings of eq. (5) (see eq. (9)). This factorization allows for an efficient two-step maximum likelihood estimation procedure, which can be summarized as follows.

- Step 1: We estimate the prediction equation (see eq. (8)) using standard OLS regressions. This is possible since all factors included in this VAR system are observable and because there are no restrictions in the VAR dynamics. This results in the estimation of $C^{\mathbb{P}}$ and $\Phi^{\mathbb{P}}$ and in a initial estimate for Σ which is used in step 2.

- Step 2: Using a QML procedure and fixing the parameters $C^{\mathbb{P}}$ and $\Phi^{\mathbb{P}}$ of the prediction equation, we estimate the remaining parameters in eq. (9), namely Φ_X^Q, Σ_X, ρ_m^0, in order to fit the yield curves of both markets. We use the OLS estimates of Σ as a starting value for Σ_X, as in Joslin et al. (2011). Then, we maximize the likelihood function by a mixture of simulated annealing and simplex procedures.

3 Empirical Results

3.1 Data

The model is estimated on monthly data over the period from August 2005 to May 2013 (94 observations per time series). The data used can be sorted in two groups.

Common factors. One group consists of variables used across all markets and for all countries analyzed. It includes (*i*) the Chicago Board Options Exchange (CBOE) Market Volatility Index (*VIX*), obtained from Datastream, which expresses the implied volatility of the Standard & Poor's (S&P) 500 stock market index options, as a measure of global financial volatility or uncertainty in financial markets; (*ii*) the European Commission's Economic Sentiment Indicator (*ESI*), a forward-looking variable which reflects expectations regarding the euro area economic outlook; (*iii*) the Overnight Indexed Swap (OIS) rates for maturities of 1, 2, 3, 4, and 5 years, from Bloomberg, which reflects the evolution of the risk-free interest rate for all euro area countries, and is also used as a reference rate to calculate the spreads of sovereign bonds at the respective maturities; (*iv*) the spread between the yield on the German government-guaranteed KfW ('Kreditanstalt fur Wiederaufbau', a government-owned development bank) bond and the German sovereign bond (from Bloomberg), averaged across maturities, which measures the liquidity premium, and can be interpreted as a common liquidity or flight to safety (*F2S*) factor across the euro area bond market[6] (see De Santis (2013)); (*v*) the European Economic Policy Uncertainty Index (*POL*), produced by Economic Policy Uncertainty, which measures economic uncertainty related to policies. This index, proposed by Baker et al. (2013), is constructed based on newspaper coverage of policy-related economic uncertainty and the disagreement among economic forecasters on future economic indicators for France, Germany, Italy, Spain, and the United Kingdom. In this paper, this index is used as a general measure of political risk in the euro area.

Country-specific data. Country-specific data series include three macroeconomic variables, obtained from Datastream:[7] (*i*) the annual growth rate of real gross domestic product (*GDP*); (*ii*) the annual inflation of the Harmonized Index of Consumer Prices (*CPI*); and (*iii*) the annual growth rate of the public debt to GDP ratio (*D/GDP*), which is used to estimate the impact of the change in the fiscal position of each country on government bond spreads. Both *GDP*

[6] In the remaining of the paper, we refer to the terms flight to safety and flight to liquidity interchangeably.

[7] For the series such as inflation and GDP, the releases of May 2013 were not available. We used instead the forecasts made by the International Monetary Fund.

and D/GDP are available only on a quarterly basis, so they are interpolated to obtain data at a monthly frequency. Besides these macroeconomic data series, country-specific data include the per annum zero-coupon yield for government bonds of each of the five countries analyzed for maturities of 1, 2, 3, 4, and 5 years.

3.2 Spanned and unspanned factors

We now specify the vector of spanned factors or yield portfolios, P_t, defined in Section 2.1, which is used to explain the dynamics of the yield curves in our two-market setup. As mentioned before, we estimate the model separately for each of the five countries having the OIS rate as our benchmark bond market. We then describe the unspanned factors, M_t, used to assess the driving forces behind yield spread movements.

Spanned factors. We adopt a total of four spanned factors to fit the OIS and the country-specific yield curves. The first two factors are used to explain the dynamics of the OIS yield curve. In principle, we could choose any linear combination of observed yields to form such portfolios. Nevertheless, to avoid fitting perfectly a set of specific yields and underfitting the others, we opt for extracting the first two principal components of the five OIS rates ($PC_t^{OIS,1}$ and $PC_t^{OIS,2}$). Since these yield portfolios refer to the benchmark rate, they are the same in the separate estimations for each of the countries. The last two factors are used to fit the country's bond yield spreads. We follow the same principle used for the first two factors and extract for each country the first two principal components of the yield spreads between the country's sovereign yields and the OIS rates for the five maturities considered ($PC_t^{spr,1}$ and $PC_t^{spr,2}$). As a result, we obtain the following vector of yield portfolios:

$$P_t = \left[PC_t^{OIS,1}, PC_t^{OIS,2}, PC_t^{spr,1}, PC_t^{spr,2}\right]'. \tag{10}$$

Unspanned factors. We include a total of nine unspanned factors in the assessment of the macroeconomic and financial determinants of sovereign bond yield spreads, which can be sorted in three sub-groups. The first one consists of variables capturing the global tension in the financial market and the expectation regarding the European economic situation, *VIX* and *ESI*, respectively. The second sub-group contains four factors which account for non-fundamental risks in the euro area bond market. The first one is our common liquidity factor in the eurozone bond market (*F2S*). The next two non-fundamental factors capture the common dynamics of euro area sovereign bond yield differentials. They are obtained as the first two principal components of *all* the standardized spreads between bond yields of the five countries included in our sample and the OIS yield curve ($PC_t^{Eur\_spr,1}$ and $PC_t^{Eur\_spr,2}$).[8] The last factor in this sub-group is our measure for the political uncertainty in the euro area (POL). The final sub-group includes three standard economic variables related to the overall fiscal sustainability of the country. They are the growth rate of real GDP, the growth rate of the Consumer Price Index, and the growth in the debt-to-GDP ratio, *GDP*, *CPI*, and *D/GDP*, respectively. The vector of unspanned factors can then be represented as:

$$M_t = \left[VIX_t, ESI_t,\ F2S_t, PC_t^{Eur\_spr,1}, PC_t^{Eur\_spr,2}, POL_t,\ GDP_t, CPI_t, D/GDP_t\right]'. \quad (11)$$

All 13 factors for the five countries can be seen in Figures 1 to 3. Figure 1 shows the variables which are common to all countries, i.e. the first six unspanned and the first two spanned factors. Figure 2 shows the macroeconomic data specific to each country and Figure 3 depicts the last two spanned factors, which are also specific to each country. The OIS rates and bond yield data are shown in the next section when we evaluate the yield curve fit for each country.

Insert Figure 1: Unspanned and spanned common factors

Insert Figure 2: Unspanned country-specific macroeconomic factors

Insert Figure 3: Spanned country-specific factors

3.3 Model evaluation

The model fits the yield curve of the five countries rather well. An illustration of this can be seen in Figures 4 and 5. Figure 4 shows the fit of the 5-year OIS rate resulting from the separate estimation of the model for each of the five countries and Figure 5 displays the fit of the 5-year bond yield spread for each country. Finally, Table 1 reports summary statistics concerning the bond spread fit for all maturities and countries. Except for the last column in this table, all values are expressed in basis points. The statistics for the yield fitting errors are presented in the last three columns. Although both the mean and standard deviation of the fitting errors are quite low, the first-order autocorrelation seems remarkably high in some cases, potentially indicating the presence of a missing factor. Notwithstanding this, the model fits well both the OIS yield curve and the country-specific spreads. A confirmation of the good fit of the model is found in Table 2, which reports the R^2's of the OIS rates and bond yield spreads for the

[8] We have a total of 25 series of bond yield spreads since we use five maturities for each of the five countries in the sample.

five estimated models. The R^2's of the OIS rates are equivalent across models, suggesting that, independently of the country considered, the model consistently fits the OIS yield curve. The R^2's of all bond yield spreads are well above 90%, except in three cases. These high values imply that two factors are able to capture most of the recent movements in bond spreads for all countries. Overall, we conclude that, despite the small number of spanned factors, our model is able to capture the evolution over time of OIS rates and government bond spreads across maturities.

Insert Figure 4: Fit of the 5-year OIS rate in each of the five cases

Insert Figure 5: Fit of the 5-year bond yield spread for each country

Insert Table 1: Diagnostic statistics of the estimated models

Insert Table 2: Diagnostic statistics of the estimated models – R^2

3.4 Impulse response functions

IRFs allow us to visualize the relationship between each of the 13 variables included in the model and movements in the yield curve. The ordering of the variables included in the VAR in eq. (7) is as follows:

$$
\begin{aligned}
F_t \;=\; & \Big[VIX_t, ESI_t,\ F2S_t, PC_t^{Eur\_spr,1}, PC_t^{Eur\_spr,2},\ PC_t^{OIS,1},\ PC_t^{OIS,2},\ POL_t, \\
& GDP_t,\ CPI_t,\ D/GDP_t,\ PC_t^{spr,1},\ PC_t^{spr,2}\Big]'. \qquad (12)
\end{aligned}
$$

As mentioned before, we start with the more exogenous variables, representing international and European wide variables, and then include the country-specific factors. As a result, the first eight variables are common to all countries and the last five are country specific. We therefore estimate the following VAR(1) system:

$$
F_t = C_F^{\mathbb{P}} + \Phi_F^{\mathbb{P}} F_{t-1} + \Sigma_F\ \varepsilon_{F,t}^{\mathbb{P}}, \qquad (13)
$$

where Σ_F is a lower-triangular matrix implied by the lower triangular identification of the shocks. Figures 6 to 12 illustrate the IRFs for the 5-year bond spreads of all countries for a shock of one standard deviation to some of the 13 factors. The dark and light shaded areas show the 66% and 90% confidence intervals, respectively, and the horizontal axis is expressed in months. Despite the high dimension of the VAR system, most of the IRFs are in line with economic intuition. We comment on some of the cases shown in these figures.

We start by analyzing the response of bond spreads to common economic factor shocks. We see in Figure 6 that a one-standard deviation shock to the VIX index, and therefore an increase in the uncertainty in financial markets, initially increases bond spreads for all countries, except Germany, where the spreads decrease. We find a significant initial response (below 6 months) that is particularly strong for Italy, around 10 basis points, but weaker for the other countries, being below 5 basis points in absolute value. Figure 7, on the other hand, shows that an increase in the euro area confidence (ESI) only marginally affects bond spreads, initially decreasing bond spreads for Italy and Spain but increasing for the other countries.

We now turn to the response of bond spreads to common non-fundamental factor shocks. From Figure 8, we see that flight to safety ($F2S$, or flight to liquidity) shocks increase bond spreads of all countries, with the exception of Germany, where the spreads decrease. The magnitude of this response is small for all countries, below 5 basis points, and is significant for a short horizon for France, Germany and Belgium. Innovations to the first principal component of euro area spreads ($PC_t^{Eur\_spr,1}$), shown in Figure 9, significantly increase bond spreads of all countries. This reaction is significant up to about 3 months after the shock in most cases. The magnitude of the reactions is large relative to the other shocks. For example, for Spain and Italy, we observe an initial increase of about 15 basis points. Turning to the innovations to the second principal component of euro area spreads ($PC_t^{Eur\_spr,2}$), Figure 10 shows that a positive shock to this factor increases bond spreads of Belgium, Italy, Spain and France (the latter with a lag), and decreases those of Germany. The magnitude of the reactions is large for the peripherical countries (Italy and Spain) while is small for the other three countries. Lastly, the effect of political uncertainty (POL) shocks on bond spreads can be seen in Figure 11. For short horizons, an increase in political uncertainty has a positive but marginal impact on spreads of most countries. For horizons above one quarter, the impact of a political shock is more marked for peripheral countries such as Italy and Spain, with a significant increase of bond spreads above 5 basis points.

Finally, we analyze the response of bond spreads to country-specific economic factor shocks, and in particular to D/GDP (Figure 12). In most of the cases an increase in the D/GDP ratio generates a positive and significant reaction of bond spreads over long horizons, the only exception being Italy, where positive shocks to the D/GDP ratio induce a counterintuitive negative reaction of yields' spreads.

Insert Figures 6 to 12: Impulse response functions

3.5 Variance decompositions

We now perform a variance decomposition in order to identify the main drivers behind movements in sovereign bond yield spreads. The model includes a total of 13 factors, four observable factors spanning the yield curve (P_t) of each country and other nine unspanned factors (M_t). To facilitate interpretation, these factors are divided in three groups: (i) *economic factors* summarize the information concerning the global and euro area environments and the economic situation of each country. This group includes the following variables: VIX, ESI, GDP, CPI, D/GDP, $PC^{OIS,1}$, and $PC^{OIS,2}$; (ii) *idiosyncratic factors* represent country-specific conditions that cannot be captured by the economic and financial variables included in the model, i.e. $PC^{spr,1}$ and $PC^{spr,2}$; and (iii) *non-fundamental risk factors* measure the euro area dynamics of sovereign bond spreads which should not be present in a well-functioning monetary union and include the remaining variables ($F2S$, $PC^{Eur\_spr,1}$, $PC^{Eur\_spr,2}$, and POL).

The variance decomposition is performed for bond spreads with maturities of 1, 3, and 5 years and for a forecast horizon of up to 10 years. The results can be seen in Table 3. As an illustration, we also present the results for the 5-year bond spread decomposition in Figure 13. A number of observations emerge from these results. First, both economic and non-fundamental risk shocks are significant sources of variation in bond yield spreads. *Non-fundamental risk shocks* are the main source of yield spread variation for short forecast horizons (up to one-month horizon), where this type of shock explains between 35% (Germany, 5-year bond spread) and 82% (Belgium and France, 3-year bond spread) of the bond spread variation. The effect of this type of shock is, however, also significant for long forecast horizons. For all countries, non-fundamental risk shocks are responsible for at least 20% of the bond spread variation for any maturity and forecast horizon. This proportion is the lowest for Belgium and the highest for France, where this group of factors accounts for most of the variation in bond spreads for all maturities and forecast horizons. Among the four non-fundamental risk factors, the first principal component of euro area bond spreads ($PC^{Eur\_spr,1}$) plays a dominant role, suggesting the presence of spillover (contagion) effects across countries. The political uncertainty factor (POL) seems to have a minor influence in the variation of bond yield spreads.[9] *Economic shocks*, on the other hand, gain in importance as the forecast horizon increases. For Belgium, Germany, and Italy, such shocks are the dominant source of variation in bond spreads for forecast horizons above one year. For France and Spain, those shocks also play an important role in long forecast horizons. Finally, in most cases, *country-specific shocks* play a minor role in the variance decomposition

[9] The specific contribution of each factor to the forecast variance is available upon request.

of bond yield spreads. One notable exception is the case of Belgium, where this type of shock is responsible for 20% or more of the bond spread variation for any maturity.

Insert Figure 13: Variance decomposition of 5-year bond yield spreads

Insert Table 3: Variance decomposition of bond yield spreads

4 Historical decomposition of bond yield spreads

The variance decompositions discussed above point to the importance of both economic as well as non-fundamental risk factors in the forecast variances of bond yield spreads. To visualize the contribution over time of each group of factors to the total bond yield spread, we perform a historical decomposition of bond spreads. Figures 14 to 18 show the historical decomposition of 5-year bond yield spreads for each country over our sample period.[10] Each panel shows the contribution of one group of shocks to the total yield spread.

We find that, in all cases, *economic shocks* are responsible for a substantial part of bond yield spreads. This can be seen, for example, for the cases of Italy and Spain, shown in Figures 17 and 18, respectively. *Non-fundamental risk shocks* also had a significant impact on government bond spreads especially after the intensification of the debt crisis in September 2011. This corroborates the findings of previous studies which report evidence that yield spreads of EMU countries are not justified based only on fiscal and macroeconomic fundamentals (see De Grauwe and Ji (2012) and Di Cesare et al. (2012)). For example, in September 2011 the non-fundamental component explains 283 basis points of the 5-year Italian bond spread (Figure 17, bottom panel), which represents about 46% of the total spread. We observe similar patterns for Belgium, France, and Spain. As mentioned in the analysis of the variance decomposition, the two principal components capturing the common dynamics of euro area sovereign bond yield differentials ($PC_t^{Eur\_spr,1}$ and $PC_t^{Eur\_spr,2}$) are the two most important non-fundamental factors.[11] Finally, *country-specific shocks* had overall a smaller impact on bond spreads, with the exception of Italy and Spain around the middle of 2011 and 2012. In summary, although we identify an increase in bond spreads due to non-fundamental risk shocks after the intensification of the debt crisis in September 2011, our results show that, in general, economic fundamentals are the dominant

[10] The results for 1- and 3-year bond yield spreads are qualitatively similar and are available upon request.

[11] This can be seen in a decomposition of the non-fundamental component of bond yield spreads, which is available upon request.

drivers behind bond yield spreads.

Insert Figures 14 to 18: Historical decomposition of bond spreads

As an illustration of the contribution of non-fundamental shocks to sovereign bond spreads, Table 4 presents a decomposition of 1-, 3-, and 5-year bond yields for each country as of May 2013. Columns 2 to 4 show the contribution of each spread component to the total bond spread, column 5 shows the level of the OIS rate, and columns 6 and 7 display the observed and fundamental levels of bond yields at that date, respectively. The fundamental level is computed as the observed level minus the non-fundamental component. Notice that the sum of the three spread components (columns 2 to 4) plus the OIS rate (column 5) differs slightly from the observed bond yield (column 6) due to fitting errors. The table shows, for example, that at the end of May 2013, while the observed level of the Italian 5-year bond yield was 3.13%, its fundamental level was only 2.18%.

Insert Table 4: Bond yield decomposition − May 2013

5 Conclusion

We present an empirical approach to identify the component of euro area sovereign bond yield spreads due to non-fundamental risks. Put differently, we assess the effect on government bond yields due to the probability of a country leaving the euro area. The yield spread decomposition is achieved with the use of a common-currency, two-market, no-arbitrage affine term structure model. The model is based on the methods proposed by Joslin et al. (2011) and Joslin et al. (2013), which are computationally faster than standard likelihood-based methods and allow the inclusion of unspanned macro factors. This avoids the likely misspecification of standard formulations which only incorporate spanned macro factors. The model is applied to yield curve data from Belgium, France, Germany, Italy, and Spain over the period 2005-2013. Bond spreads are computed with respect to the OIS rate.

The model includes a total of 13 factors, four observable factors spanning the OIS rates and the yield curve of each country and nine unspanned factors. To simplify interpretation, these factors are classified as economic, idiosyncratic, and related to non-fundamental risk. Overall, we find that economic fundamentals remain the dominant drivers behind euro area sovereign bond spreads. Nevertheless, non-fundamental risk shocks have played an important role in the dynamics of yield spreads for all countries and maturities analyzed following the intensification of the debt crisis since the summer of 2011. More specifically, between July 2011 and August 2012, the impact of non-fundamental risk shocks resulted in a strong widening of sovereign bond spreads relative to the OIS rate which cannot be associated with macroeconomic and financial conditions in the euro area as a whole or in the country under study.

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Table 1: Diagnostic statistics of the estimated models

	Mean		Std		Fitting error		
	data (bp)	emp (bp)	data (bp)	emp (bp)	mean (bp)	std (bp)	auto
Belgium							
spread_{1yr}	17	18	38	43	0	8	0.754
spread_{2yr}	31	30	56	52	1	6	0.683
spread_{3yr}	41	40	61	59	0	6	0.741
spread_{4yr}	48	49	62	64	-1	3	0.650
spread_{5yr}	57	56	66	66	1	4	0.777
France							
spread_{1yr}	-1	-1	18	17	1	3	0.755
spread_{2yr}	8	10	18	17	-2	4	0.728
spread_{3yr}	13	11	22	21	2	4	0.721
spread_{4yr}	17	15	26	26	2	1	0.446
spread_{5yr}	21	23	28	31	-2	4	0.826
Germany							
spread_{1yr}	-8	-9	11	10	1	4	0.375
spread_{2yr}	-11	-9	12	11	-1	4	0.443
spread_{3yr}	-11	-9	11	11	-2	4	0.442
spread_{4yr}	-7	-9	13	12	2	3	0.699
spread_{5yr}	-7	-7	13	14	0	3	0.557
Italy							
spread_{1yr}	76	76	113	115	0	7	0.486
spread_{2yr}	104	104	135	132	1	7	0.413
spread_{3yr}	119	120	143	143	0	7	0.719
spread_{4yr}	127	128	147	148	-1	3	0.641
spread_{5yr}	131	131	150	149	0	6	0.654
Spain							
spread_{1yr}	86	86	120	121	0	5	0.504
spread_{2yr}	108	107	139	137	1	7	0.522
spread_{3yr}	119	120	147	148	-1	8	0.702
spread_{4yr}	129	129	159	157	-1	5	0.801
spread_{5yr}	137	136	164	165	0	6	0.522

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.

Table 2: Diagnostic statistics of the estimated models - R-squared

	OIS rate				
Mat. (years)	1	2	3	4	5
Belgium	0.9996	0.9993	0.9995	0.9999	0.9994
France	0.9996	0.9994	0.9995	0.9999	0.9994
Germany	0.9996	0.9994	0.9994	0.9999	0.9994
Italy	0.9996	0.9993	0.9995	0.9999	0.9994
Spain	0.9996	0.9994	0.9995	0.9999	0.9994

	Bond yield spreads				
Mat. (years)	1	2	3	4	5
Belgium	0.9506	0.9889	0.9914	0.9978	0.9957
France	0.8773	0.9679	0.9712	0.9921	0.9924
Germany	0.8643	0.8841	0.8539	0.9321	0.9535
Italy	0.9967	0.9971	0.9979	0.9994	0.9984
Spain	0.9982	0.9973	0.9971	0.9990	0.9988

Note: The table shows the R^2 of the OIS rates and bond yield spreads for each of the estimated models.

Table 3: Variance decomposition of bond yield spreads

	1-yr bond spread			3-yr bond spread			5-yr bond spread		
Belgium									
Horizon	Eco	Idios	Non-f	Eco	Idios	Non-f	Eco	Idios	Non-f
1 m	0.09	0.29	0.62	0.06	0.12	0.82	0.06	0.17	0.77
1 yr	0.35	0.34	0.31	0.47	0.25	0.28	0.50	0.24	0.26
3 yr	0.40	0.31	0.29	0.57	0.21	0.22	0.61	0.20	0.19
5 yr	0.40	0.30	0.30	0.57	0.21	0.22	0.61	0.19	0.20
7 yr	0.40	0.30	0.30	0.57	0.21	0.22	0.61	0.19	0.20
10 yr	0.40	0.30	0.30	0.57	0.21	0.22	0.61	0.19	0.20
France									
Horizon	Eco	Idios	Non-f	Eco	Idios	Non-f	Eco	Idios	Non-f
1 m	0.01	0.32	0.67	0.03	0.14	0.82	0.09	0.33	0.58
1 yr	0.34	0.18	0.48	0.30	0.07	0.64	0.27	0.07	0.66
3 yr	0.37	0.16	0.47	0.38	0.05	0.57	0.38	0.05	0.57
5 yr	0.38	0.14	0.48	0.39	0.05	0.57	0.39	0.05	0.57
7 yr	0.38	0.14	0.48	0.39	0.05	0.56	0.39	0.05	0.56
10 yr	0.38	0.14	0.48	0.39	0.05	0.56	0.40	0.05	0.56
Germany									
Horizon	Eco	Idios	Non-f	Eco	Idios	Non-f	Eco	Idios	Non-f
1 m	0.26	0.27	0.48	0.22	0.16	0.62	0.26	0.39	0.35
1 yr	0.40	0.17	0.43	0.40	0.10	0.50	0.37	0.25	0.38
3 yr	0.53	0.13	0.34	0.56	0.07	0.37	0.50	0.17	0.33
5 yr	0.54	0.11	0.35	0.56	0.06	0.38	0.51	0.13	0.36
7 yr	0.54	0.11	0.35	0.56	0.06	0.38	0.52	0.13	0.35
10 yr	0.55	0.11	0.35	0.56	0.06	0.38	0.52	0.13	0.35
Italy									
Horizon	Eco	Idios	Non-f	Eco	Idios	Non-f	Eco	Idios	Non-f
1 m	0.16	0.26	0.58	0.18	0.27	0.55	0.19	0.30	0.51
1 yr	0.39	0.18	0.43	0.42	0.14	0.44	0.43	0.13	0.44
3 yr	0.50	0.17	0.33	0.54	0.16	0.31	0.55	0.15	0.30
5 yr	0.51	0.17	0.32	0.56	0.16	0.28	0.57	0.16	0.27
7 yr	0.51	0.17	0.32	0.56	0.16	0.29	0.57	0.16	0.27
10 yr	0.52	0.17	0.31	0.56	0.16	0.28	0.57	0.16	0.27
Spain									
Horizon	Eco	Idios	Non-f	Eco	Idios	Non-f	Eco	Idios	Non-f
1 m	0.12	0.34	0.53	0.13	0.31	0.56	0.14	0.32	0.54
1 yr	0.21	0.20	0.59	0.25	0.18	0.58	0.27	0.18	0.55
3 yr	0.28	0.17	0.54	0.37	0.13	0.50	0.40	0.13	0.47
5 yr	0.36	0.15	0.49	0.45	0.11	0.43	0.48	0.11	0.41
7 yr	0.37	0.15	0.48	0.46	0.11	0.42	0.49	0.11	0.40
10 yr	0.37	0.15	0.48	0.46	0.11	0.42	0.49	0.11	0.40

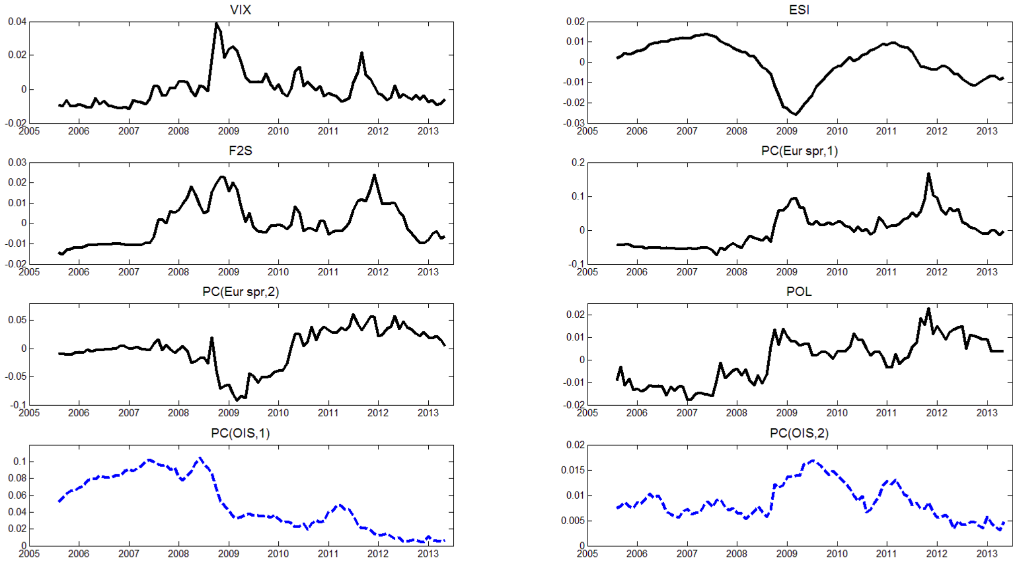
Note: *Eco*, *Idios*, and *Non-f* denote the component due to economic, idiosyncratic, and non-fundamental shocks, respectively.

Table 4: Bond yield decomposition - May 2013

	Spread component			Level		
Mat.	Eco	Idios	Non-f	OIS	Obs	Fund
Belgium (% p.a.)						
1 yr	-0.046	0.004	0.007	0.074	0.095	0.088
3 yr	0.088	0.035	0.091	0.302	0.462	0.370
5 yr	0.185	0.058	0.149	0.631	1.049	0.900
France (% p.a.)						
1 yr	-0.063	0.010	0.044	0.074	0.079	0.036
3 yr	-0.043	0.054	0.116	0.302	0.391	0.275
5 yr	-0.011	0.100	0.193	0.631	0.930	0.736
Germany (% p.a.)						
1 yr	-0.050	0.000	0.001	0.074	0.044	0.043
3 yr	-0.060	-0.013	-0.013	0.302	0.193	0.206
5 yr	-0.060	-0.040	-0.039	0.631	0.511	0.550
Italy (% p.a.)						
1 yr	0.602	-0.406	0.518	0.074	0.839	0.321
3 yr	1.255	-0.106	0.853	0.302	2.215	1.363
5 yr	1.471	0.041	0.948	0.631	3.131	2.182
Spain (% p.a.)						
1 yr	0.822	0.109	0.202	0.074	1.099	0.897
3 yr	1.453	0.223	0.633	0.302	2.675	2.042
5 yr	1.736	0.273	0.818	0.631	3.341	2.523

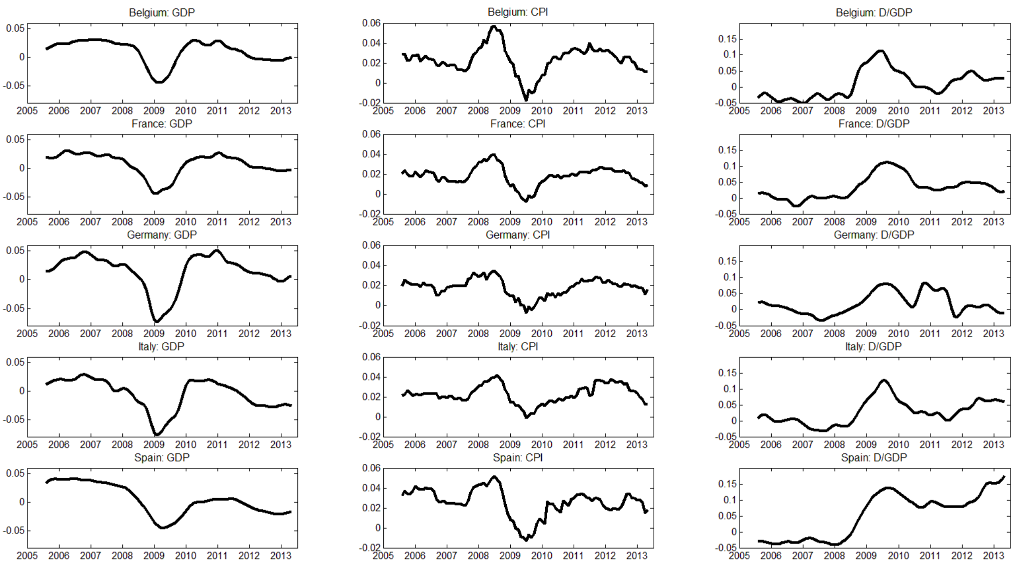
Note: *Eco*, *Idios*, and *Non-f* denote the component due to economic, idiosyncratic, and non-fundamental shocks, respectively. *Obs* denotes the observed level of bond yields and *Fund* its fundamental value, computed as the observed level (*Obs*) minus the non-fundamental component of bond spreads.

Figure 1: Unspanned and spanned common factors



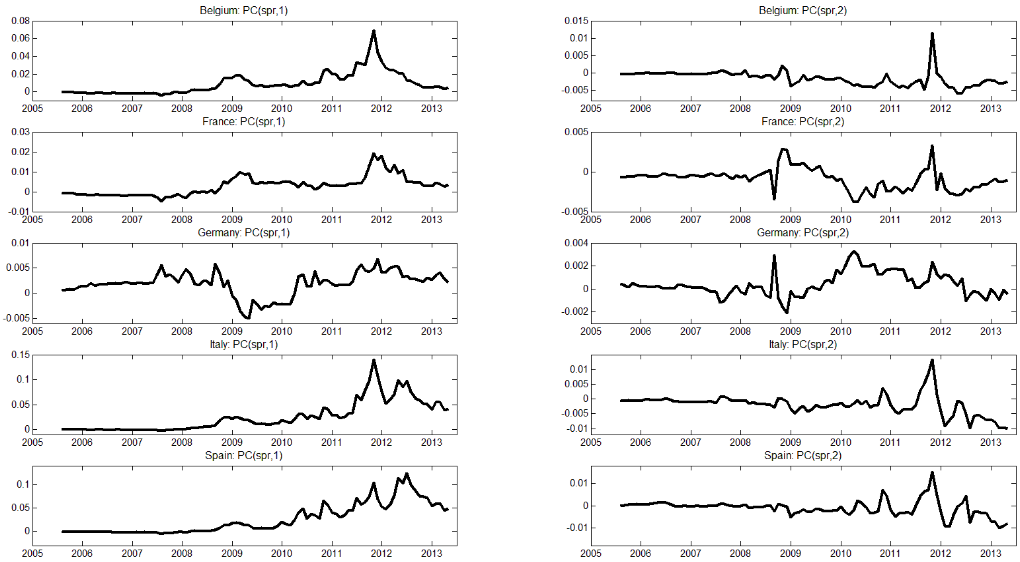
Note: *VIX* is the Chicago Board Options Exchange (CBOE) Market Volatility Index; *ESI* is the European Commission's Economic Sentiment Indicator; *F2S* is the spread between the yield on the German government guaranteed bond (KfW) and the German sovereign bond, averaged across maturities; *POL* is the European Economic Policy Uncertainty Index; *PC(Eur_ spr,1)* and *PC(Eur_ spr,2)* are the first two principal components of the standardized spreads between bond yields of the five countries included in our sample and the OIS yield curve; finally, *PC(OIS,1)* and *PC(OIS,2)* are the first two principal components of the five OIS rates. For all series, the sample period goes from August 2005 to May 2013.

Figure 2: Unspanned country-specific macroeconomic factors



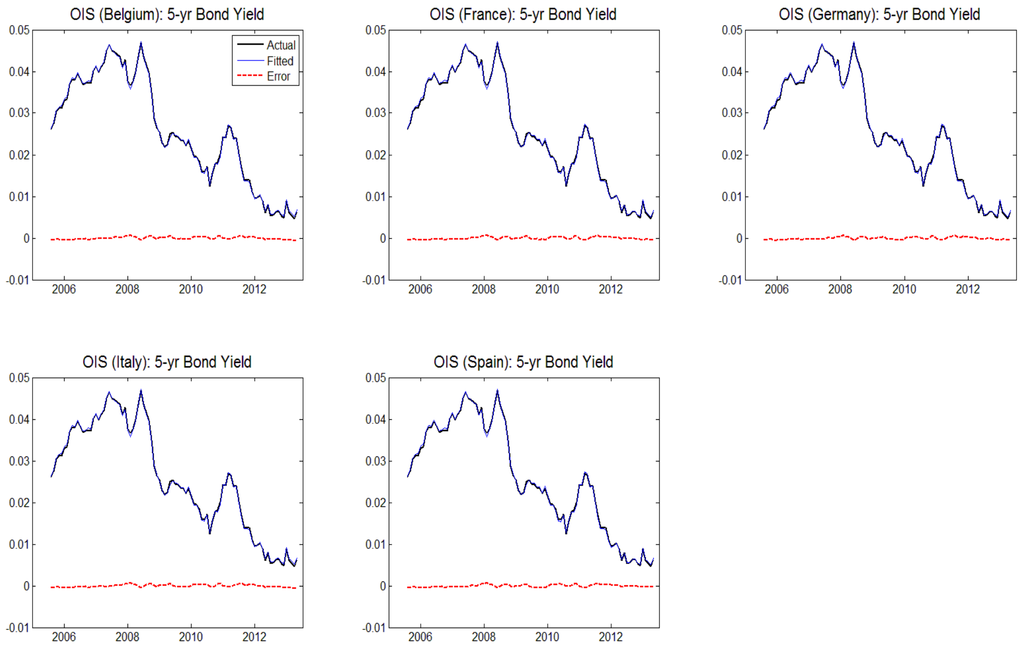
Note: For every country, *GDP* is the year-on-year growth rate of the real GDP index, *CPI* is the year-on-year growth rate of the Consumer Price Index, and *D/GDP* is year-on-year change in the debt-to-GDP ratio. For all series, the sample period goes from August 2005 to May 2013. Quarterly data are interpolated in order to obtain monthly series.

Figure 3: Spanned country-specific factors



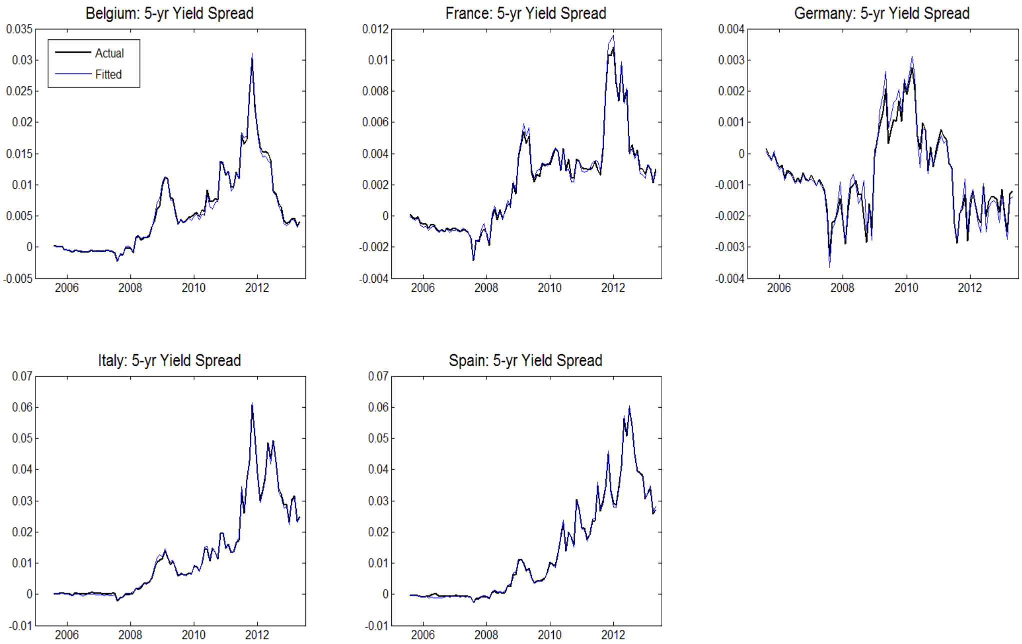
Note: For every country, *PC(spr,1)* and *PC(spr,2)* are the first two principal components of the yield spreads between the sovereign bond yields and the OIS rates for the five maturities considered. For all series, the sample period goes from August 2005 to May 2013.

Figure 4: Fit of the 5-year OIS rate in each of the five cases



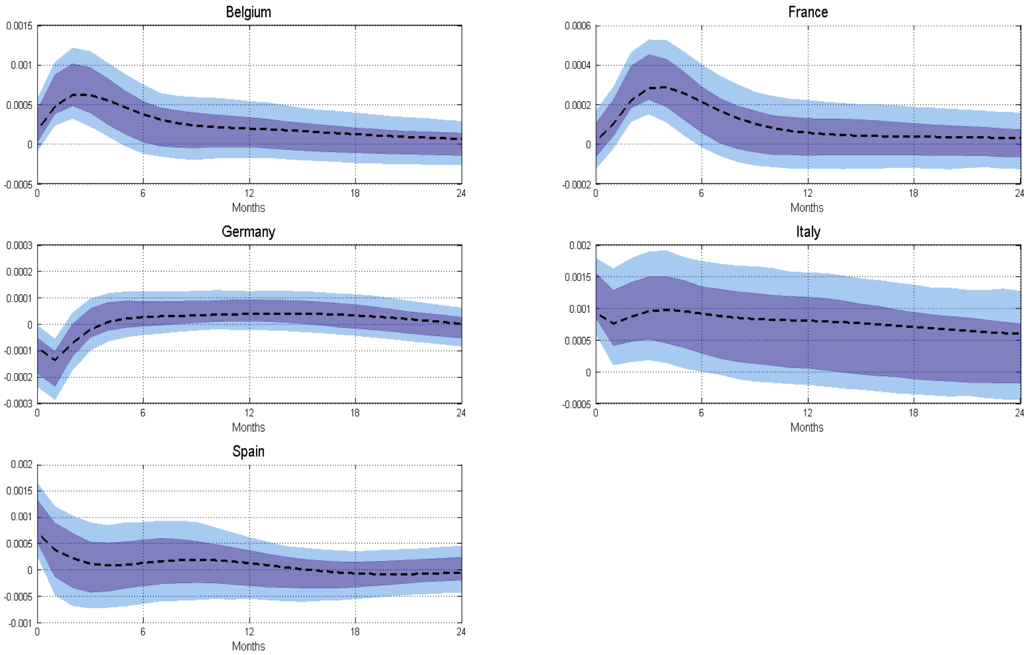
Note: The figure shows the fit of the 5-year OIS rate resulting from the separate estimation of the model for each country. For all series, the sample period goes from August 2005 to May 2013.

Figure 5: Fit of the 5-year bond yield spread for each country



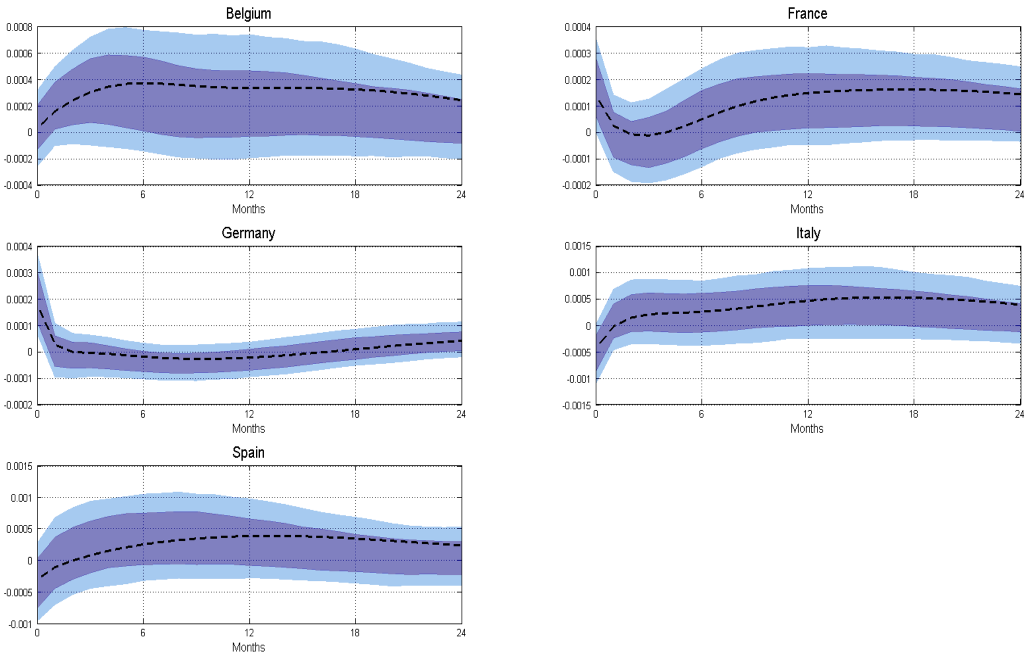
Note: The figure shows the fit of the spread between each country 5-year bond yield and the 5-year OIS rate. For all series, the sample period goes from August 2005 to May 2013.

Figure 6: Impulse response function: Response of 5-yr yield spreads to a VIX shock



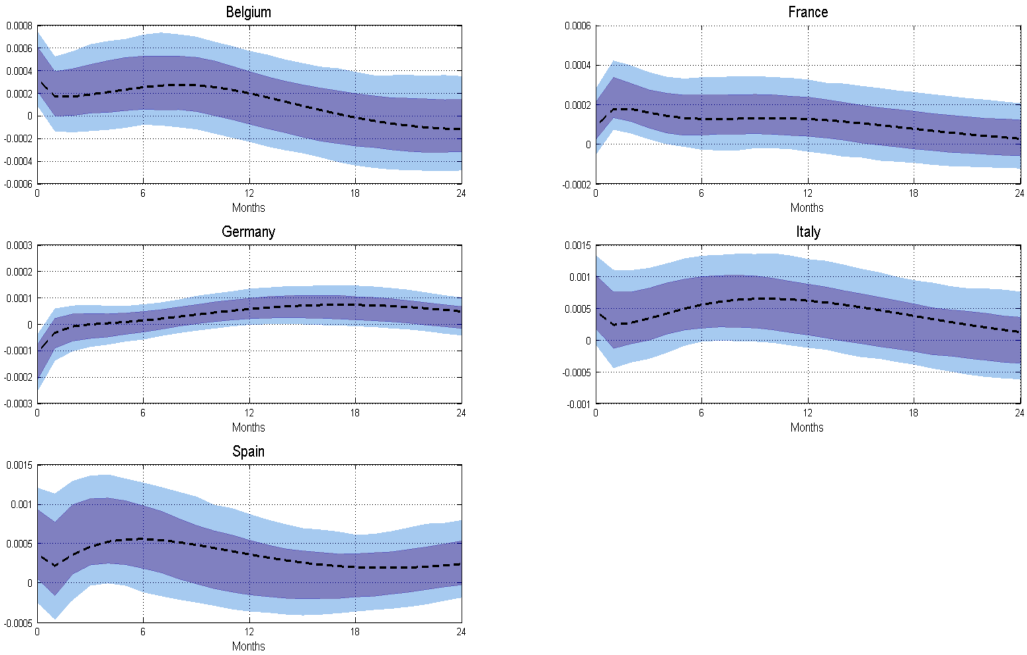
Note: The figure shows the impulse responses of 5-year bond yield spreads to a one standard deviation VIX shock. The dark and light shaded areas show the 66% and 90% confidence intervals, respectively. Error bands are obtained by standard bootstrapping procedure.

Figure 7: Impulse response function: Response of 5-yr yield spreads to an ESI shock



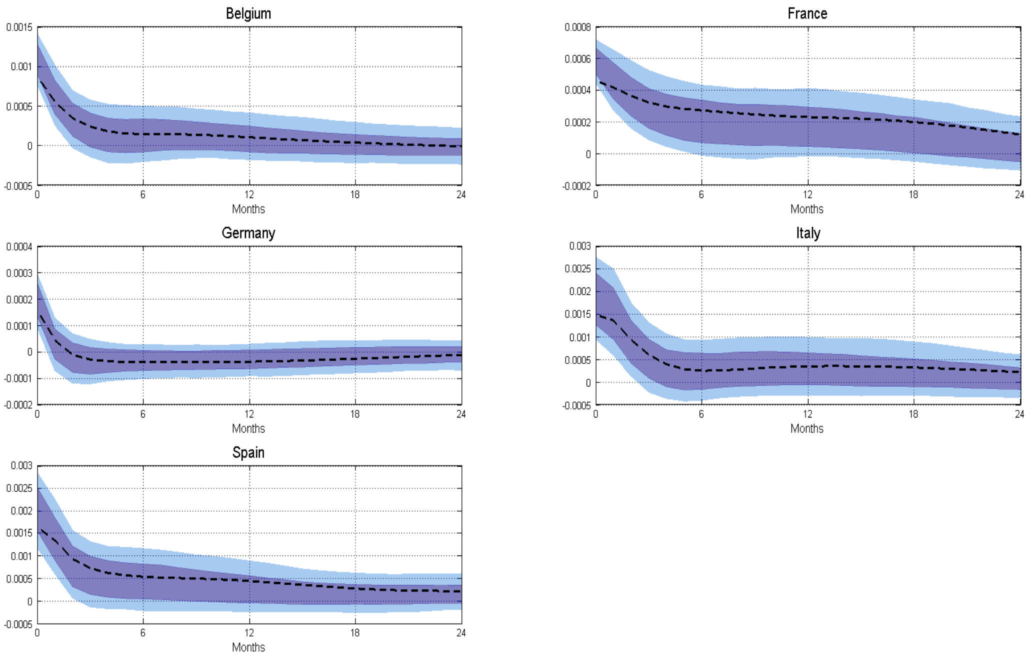
Note: The figure shows the impulse responses of 5-year bond yield spreads to a one standard deviation ESI shock. The dark and light shaded areas show the 66% and 90% confidence intervals, respectively. Error bands are obtained by standard bootstrapping procedure.

Figure 8: Impulse response function: Response of 5-yr yield spreads to a F2S shock



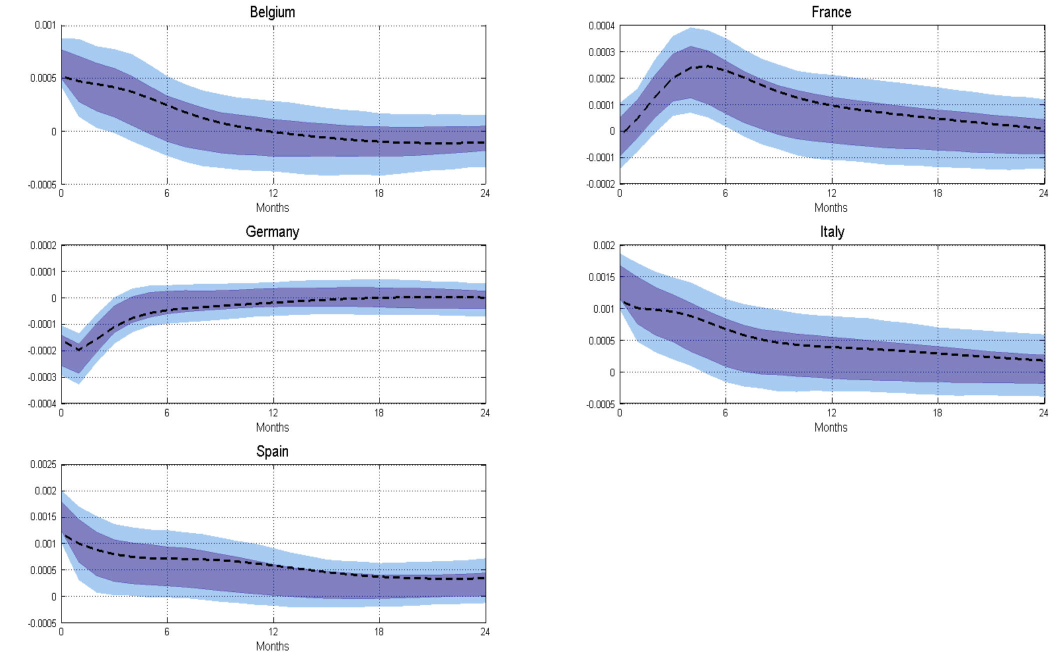
Note: The figure shows the impulse responses of 5-year bond yield spreads to a one standard deviation $F2S$ shock. The dark and light shaded areas show the 66% and 90% confidence intervals, respectively. Error bands are obtained by standard bootstrapping procedure.

Figure 9: Impulse response function: Response of 5-yr yield spreads to a PC(Eur spr, 1) shock



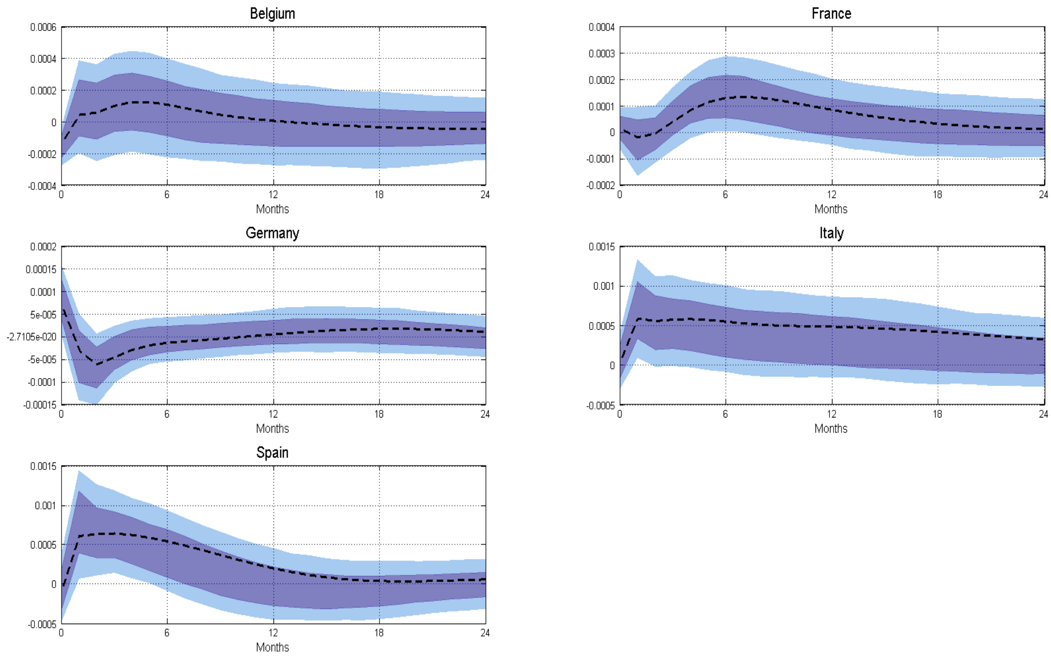
Note: The figure shows the impulse responses of 5-year bond yield spreads to a one standard deviation $PC_t^{Eur\_spr,1}$ shock. The dark and light shaded areas show the 66% and 90% confidence intervals, respectively. Error bands are obtained by standard bootstrapping procedure.

Figure 10: Impulse response function: Response of 5-yr yield spreads to a PC(Eur spr, 2) shock



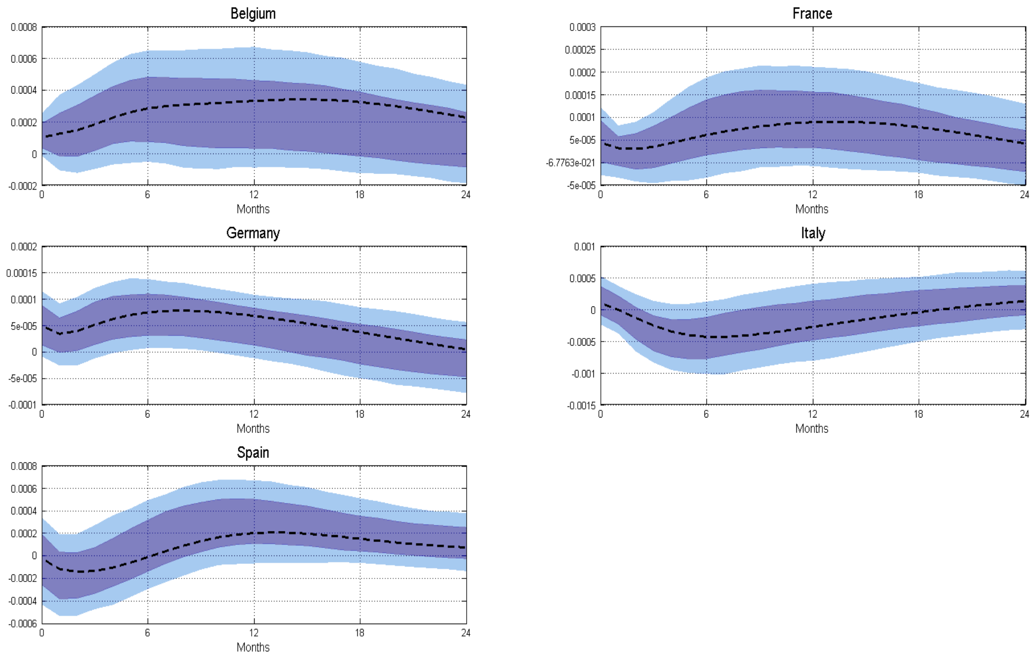
Note: The figure shows the impulse responses of 5-year bond yield spreads to a one standard deviation $PC_t^{Eur\_spr,2}$ shock. The dark and light shaded areas show the 66% and 90% confidence intervals, respectively. Error bands are obtained by standard bootstrapping procedure.

Figure 11: Impulse response function: Response of 5-yr yield spreads to a Pol. Risk shock



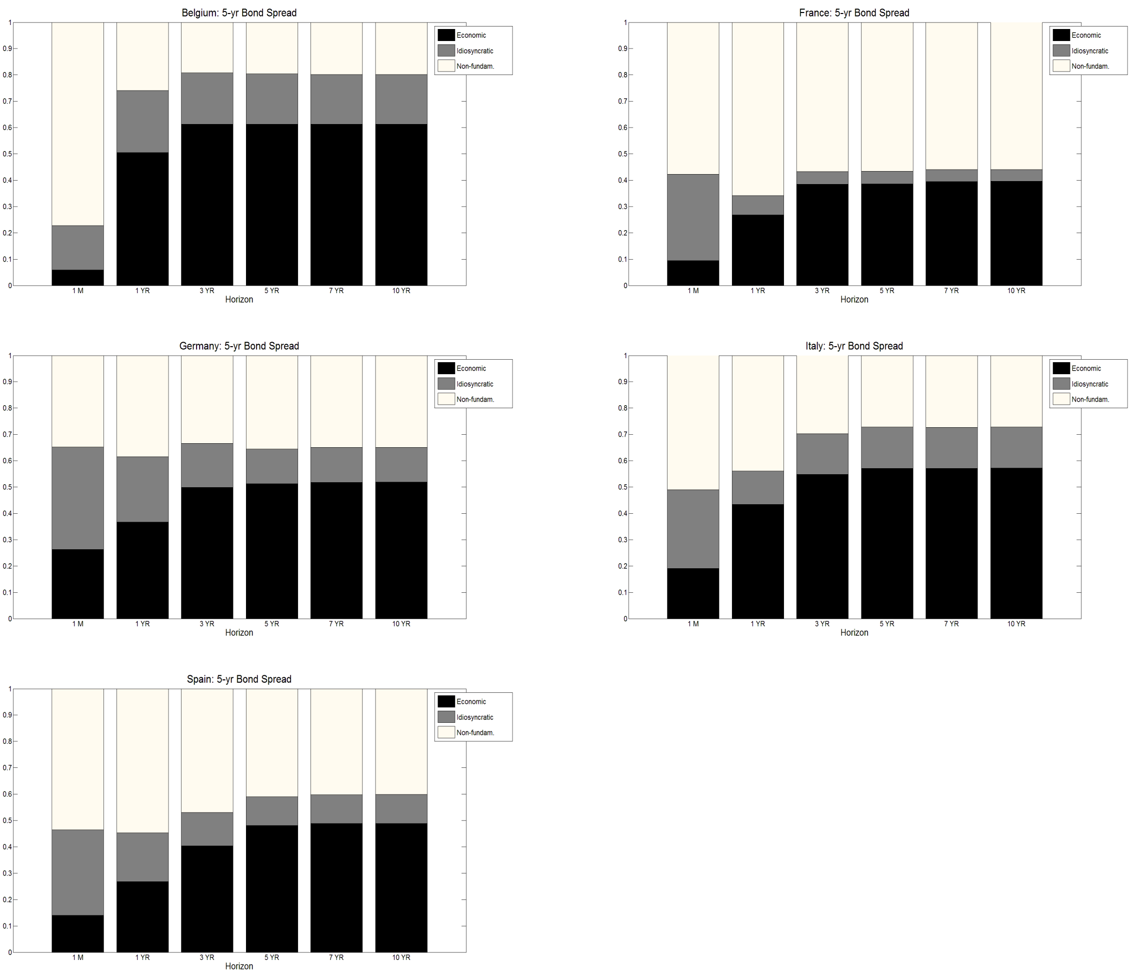
Note: The figure shows the impulse responses of 5-year bond yield spreads to a one standard deviation POL shock. The dark and light shaded areas show the 66% and 90% confidence intervals, respectively. Error bands are obtained by standard bootstrapping procedure.

Figure 12: Impulse response function: Response of 5-yr yield spreads to a D/GDP shock



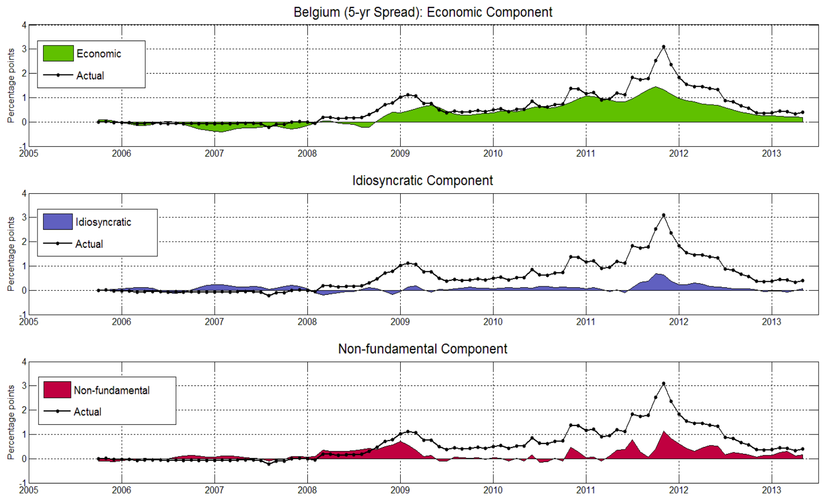
Note: The figure shows the impulse responses of 5-year bond yield spreads to a one standard deviation D/GDP shock. The dark and light shaded areas show the 66% and 90% confidence intervals, respectively. Error bands are obtained by standard bootstrapping procedure.

Figure 13: Variance decomposition of 5-year bond yield spreads



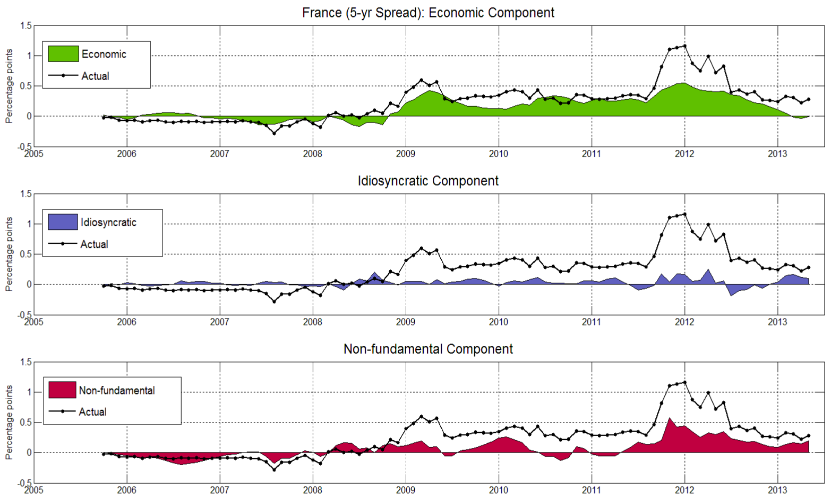
Note: The figure reports the variance decomposition of the 5-yr yield spreads for the five countries in our dataset. The forecasting horizon considered is 1-m, 1-yr, 3-yr, 5-yr, 7-yr and 10-yr. Economic groups the following shocks: VIX, ESI, GDP, CPI, D/GDP, $PC^{OIS,1}$, and $PC^{OIS,2}$; idiosyncratic groups the following shocks: $PC^{spr,1}$ and $PC^{spr,2}$; Non-fundam. groups the following shocks: $F2S, PC^{Eur\_spr,1}, PC^{Eur\_spr,2}$, and POL.

Figure 14: Historical decomposition of bond spreads - Belgium



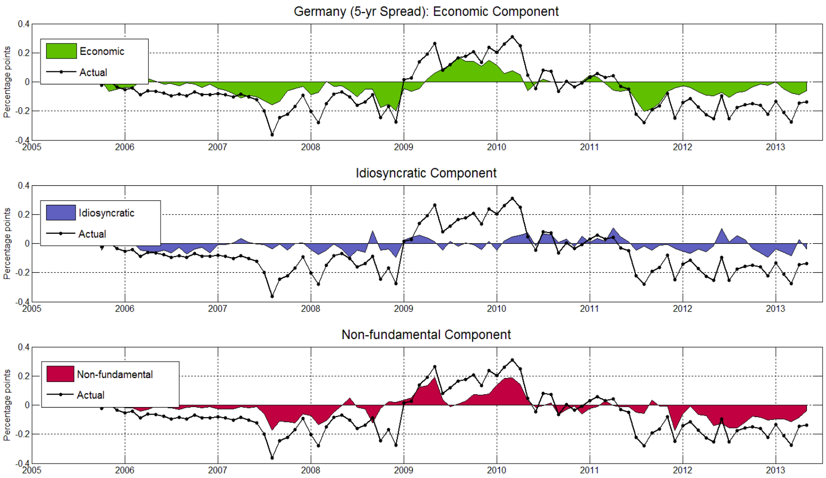
Note: The figure shows the historical decomposition of 5-year Belgian bond yield spreads with the shocks grouped as follows: *Economic Component* – VIX, ESI, GDP, CPI, D/GDP, $PC^{OIS,1}$, and $PC^{OIS,2}$; *Idiosyncratic Component* – $PC^{spr,1}$ and $PC^{spr,2}$; and *Non-fundamental Component* – $F2S, PC^{Eur\_spr,1}, PC^{Eur\_spr,2}$, and POL.

Figure 15: Historical decomposition of bond spreads - France



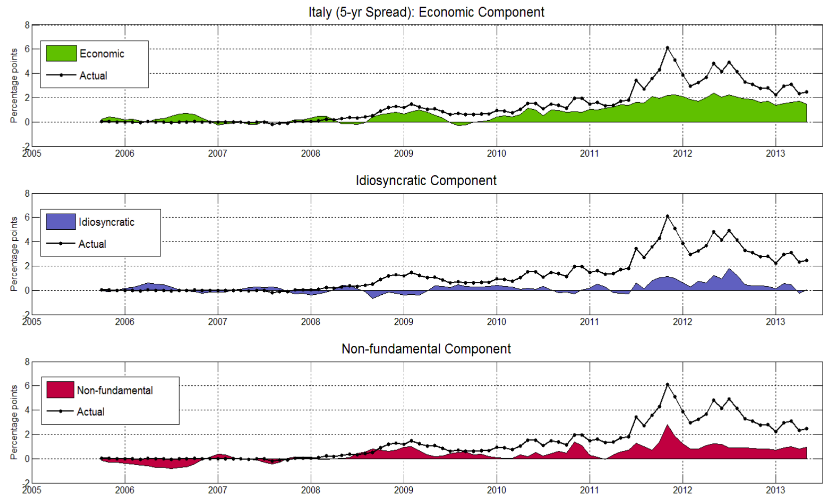
Note: The figure shows the historical decomposition of 5-year French bond yield spreads with the shocks grouped as follows: *Economic Component* – VIX, ESI, GDP, CPI, D/GDP, $PC^{OIS,1}$, and $PC^{OIS,2}$; *Idiosyncratic Component* – $PC^{spr,1}$ and $PC^{spr,2}$; and *Non-fundamental Component* – $F2S, PC^{Eur\_spr,1}, PC^{Eur\_spr,2}$, and POL.

Figure 16: Historical decomposition of bond spreads - Germany



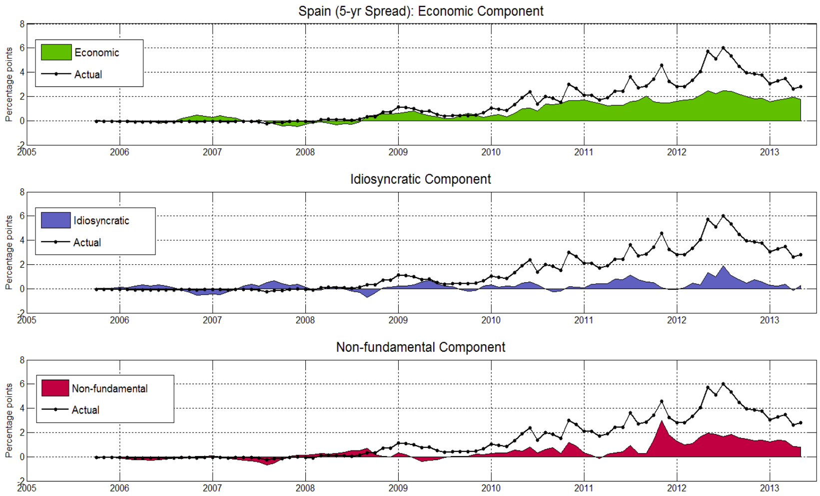
Note: The figure shows the historical decomposition of 5-year German bond yield spreads with the shocks grouped as follows: *Economic Component* – VIX, ESI, GDP, CPI, D/GDP, $PC^{OIS,1}$, and $PC^{OIS,2}$; *Idiosyncratic Component* – $PC^{spr,1}$ and $PC^{spr,2}$; and *Non-fundamental Component* – $F2S, PC^{Eur\_spr,1}, PC^{Eur\_spr,2}$, and POL.

Figure 17: Historical decomposition of bond spreads - Italy



Note: The figure shows the historical decomposition of 5-year Italian bond yield spreads with the shocks grouped as follows: *Economic Component* – VIX, ESI, GDP, CPI, D/GDP, $PC^{OIS,1}$, and $PC^{OIS,2}$; *Idiosyncratic Component* – $PC^{spr,1}$ and $PC^{spr,2}$; and *Non-fundamental Component* – $F2S, PC^{Eur\_spr,1}, PC^{Eur\_spr,2}$, and POL.

Figure 18: Historical decomposition of bond spreads - Spain



Note: The figure shows the historical decomposition of 5-year Spanish bond yield spreads with the shocks grouped as follows: *Economic Component* – VIX, ESI, GDP, CPI, D/GDP, $PC^{OIS,1}$, and $PC^{OIS,2}$; *Idiosyncratic Component* – $PC^{spr,1}$ and $PC^{spr,2}$; and *Non-fundamental Component* – $F2S, PC^{Eur\_spr,1}, PC^{Eur\_spr,2}$, and POL.

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