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The Determinants of Sovereign Bond Yield Spreads in the EMU: A GVAR Model

By

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RESUME

La recherche à propos des écarts de taux d'obligations souveraines a considérablement augmenté avec la crise de la dette en Europe, principalement à cause de l'inquiétude croissante concernant l'avenir de la zone euro ainsi que le scepticisme au regard des changements radicaux des taux d'intérêts des pays de l'UEM qui ne peuvent pas être expliqués par des modèles standards. Avec des niveaux de couts d'emprunts insoutenables, la Grèce, l'Irlande et le Portugal n'ont plus accès au marché et une partie de l'opinion condamne ce qu'elle appelle un comportement irrationnel de la part des marches financiers. Les académiciens essayent d'apporter de nouvelles explications à ces changements.

Notre étude contribue aux actuelles recherches sur les facteurs déterminants les différences entre les taux des obligations de la zone Euro et se différencie ainsi en de nombreuses manières des précédents travaux réalisés à ce sujet. Tout d'abord, nous utilisons de plus longues bases de données qui couvrent les récents évènements de la crise Européenne. De plus, nous utilisons une nouvelle variable d'aversion pour le risque calculée à partir de données Européennes, qui peut être décrite comme étant la différence entre les indexes Bbb et Aaa des obligations corporatives de la zone euro. Nous effectuons également une étude d'évènement : nous analysons quelles sont les prévisions fiscales publiées par la Commission Européenne qui influencent de manière significative les écarts de taux afin de nous aider à spécifier notre modèle. Enfin, ce mémoire propose une nouvelle utilisation d'un modèle GVAR pour l'analyse des écarts de taux des obligations souveraines de la zone euro. Il surperforme les modèles standards grâce à l'ajout de variables fiscales et de contagion. En effet, nous développons le modèle GVAR présenté par Favero (2013) auquel nous ajoutons des variables capturant le risque de crédit (croissance du PIB réel), l'effet de contagion et une variable dichotomique pour la crise.

Les résultats estimés à partir de notre modèle GVAR suggèrent un manque de consensus au sein des pays de la zone euro et des différences significatives entre les pays GIIPS et Core en terme de facteurs déterminants les écarts de taux. De plus, en utilisant le modèle avec des données pays par pays, l'indicateur R2 augmente de manière drastique indiquant l'importance

qu’ont les facteurs idiosyncratiques dans les mouvements des écarts de taux. De manière générale, nous trouvons que les écarts de taux des obligations souveraines étaient principalement influencés par le ratio prévision de la dette sur PIB, l’aversion au risque et les facteurs de contagion, ce qui est en adéquation avec les découvertes des précédentes recherches.

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ABSTRACT

The literature about the sovereign yield spreads grew substantially with the euro debt crisis, mainly because of the rising concerns about the Eurozone future and the skepticism regarding the radical shifts in few EMU countries' interest rates which cannot be explained by standard models. With unsustainable borrowing cost levels, Greece, Ireland and Portugal lost access to the market and part of the public opinion condemned what they called a market irrational behavior. Academics try to bring new lights to these market reactions.

Our paper aims to contribute to the growing body of literature that studies the determinants of bond yield differentials in the Eurozone and differs in many ways from the previous works. First of all, we use longer data sets, which cover the recent Eurozone crisis events. Then, we use a new risk aversion proxy based on European data, which can be described as the difference between the euro corporative bond indexes Bbb and Aaa. We also perform an event study of the European Commission fiscal forecasts publication for European countries to help specify our model with the fiscal fundamentals that significantly influence the spreads. Finally, this paper proposes a new application of a GVAR model for the sovereign bond spreads analysis in the Eurozone that outperforms standard models thanks to the inclusion of fiscal fundamental and contagion variables. Indeed we extend the Global Vector Autoregressive (GVAR) model introduced by Favero (2013) in whom we add variables capturing the credit risk (real GDP growth), the contagion effect and a dummy variable for the crisis.

The results estimated with our GVAR model suggest a lack of consensus among euro countries and significant differences between the GIIPS and the Core countries in terms of spreads determinants. Moreover by taking the model to country by country data, the R-squared drastically increase which shows the importance of idiosyncratic behavior in the spreads movements. Overall, we find that the sovereign bond yield spreads were mainly influenced by the expected debt to GDP, the risk aversion and the contagion factors, which is in line with the related literature findings.

1. Introduction

After the inception of the European Monetary Union (EMU), the sovereign bond yields across the member states converged and were almost seen as substitutes. However with the international financial crisis in 2008, fiscal imbalances increased in the euro area, reflecting the high financial costs of the banking industry bailouts and the economic slowdown. These developments lead to a sovereign debt crisis that engulfed the whole EMU and more particularly the so-called periphery economies. The government bond spreads on German Bunds are one of the main indicator used by investors, but standard models fail to explain fully the levels reached during the crisis. This paper proposes a new application of a GVAR model for the sovereign bond spreads analysis in the Eurozone that outperforms standard models thanks to the inclusion of fiscal fundamental and contagion variables.

Understanding the forces influencing the spreads is of great importance as explain Favero and Missale (2012): "If markets can stay irrational longer than a country can stay solvent, then the role of yield spreads on national bonds as a fiscal discipline device is considerably weakened, and some form of ECB intervention or the issuance of Eurobonds can be economically justified.[1]" Indeed, as our model relies heavily on expected fiscal fundamentals, we can bring some evidence about how investors perceive fiscal imbalances and to which extent these factors influence their decisions in the long run.

Our paper aims to contribute to the growing body of literature that studies the determinants of bond yield differentials in the Eurozone and differs in many ways from the previous works. First of all, we use longer data sets, which cover the recent Eurozone crisis events. Then, we use a new risk aversion proxy based on European data, which can be described as the difference between the euro corporative bond indexes Bbb and Aaa. We also perform an event study of the European Commission fiscal forecasts publication for European countries to help specify our model with the fiscal fundamentals that significantly influence the spreads. Finally, our model is inspired by the Global Vector Autoregressive (GVAR) model introduced by Favero (2013) in whom we add variables capturing the credit risk (real GDP growth), the contagion effect and a dummy variable for the crisis.

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[1] Favero, Carlo A. et Alessandro Missale (2012). « Sovereign spreads in the eurozone: which prospects for a eurobond? », *Economic Policy*, vol. 70, p. 235.

The rest of this paper is organized as follows. Section 2 gives an overview of the related literature. In Section 3 we perform data analysis to identify the possible bias in the time series and highlight the differentials within the EMU since the European crisis. Section 4 performs an event study to quantify the relationship between the expectations of fiscal variables and innovations in bond spreads that will be later used to help specify our GVAR model. In Section 5 we address the cross-sectional properties of the time series and perform unit root tests. Section 6 describes the specification of our GVAR model and compares it to the GVAR developed by Favero (2013) and the standard approach to model the euro area spreads. Section 7 contains the estimated results. In Section 8 we use our model to forecast the spreads country by country for 6 months and compare the estimates to actual figures. Section 9 offers some concluding remarks.

2. Literature Review

The literature about the sovereign yield spreads grew substantially with the euro debt crisis, mainly because of the rising concerns about the Eurozone future and the skepticism regarding the radical shifts in few EMU countries' interest rates which cannot be explained by standard models. With unsustainable borrowing cost levels, Greece, Ireland and Portugal lost access to the market and part of the public opinion condemned what they called a market irrational behavior. Academics try to bring new lights to these market reactions. For instance, Pisani-Ferry (2013) thinks that we can find some of the answers in the way the monetary union was build. He argues that most of the issues that emerged during the euro debt crisis were already previously diagnosed but were largely ignored because of too much confidence that the EMU would organically develop into an optimal currency union. Strong economic asymmetry across countries, the increase of incentives for fiscal laxity resulting from the monetary unification and the lack of institution that could act as a lender of last resort are all reasons that can help to explain the recent market behavior in regard to the European countries. Therefore, the EMU architecture, as it was imagined in the Maastricht Treaty, has proved to be incomplete with the absence of fiscal imbalances prevention mechanism which allowed the main countries (France and Germany) of the Euro area to discredit the fiscal discipline rules in force (the 60% debt/GDP and 3% deficit/GDP criteria)[2].

Most of the recent works study the sovereign bond yield spread determinants using linear regressions with proxies for liquidity, credit and international risks such as:

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 X_{it} + \beta_3 Z_t + u_{it} \qquad (2.1)$$

where Y_{it} is the sovereign bond yield spread, X_{it} a vector of country-specific variables and Z_t is a vector of variables common across countries.

To begin with this literature review, we present the proxy variables of great interest which were previously used in standard models (2.1) and discuss their respective impact on spreads. We first cover various methods to capture the default risk such as the use of fiscal fundamentals, Credit Default Swaps (CDS), domestic banking sector size and Credit Ratings data. We then talk about the influence of liquidity and international risk on the sovereign bond yield spreads. In the second part of this literature review, we present studies that identified financial contagion effect across the EMU with linear regressions, CoVar, high-frequency data or GVAR models. Finally, in a last part we discuss how the related studies account for the probable market shift behavior in the sovereign debt pricing of European countries, from linear regressions with dummy variables to more complex time-varying coefficient models.

2.1 The Proxy Variables

A common finding in the literature is evidence that the interest rates differentials among EMU countries are partly explained by the default risk premium and the influence of macroeconomic fundamentals. Attinasi et al. (2010) find for instance that during the period 2007-2009, “expected budget deficits and/or higher government debt ratios relative to Germany contributed to higher government bond yield spreads”[3]. Hallerberg and Wolff (2008),

[2] Pisani-Ferry, Jean (2013). « The known unknowns and unknown unknowns of European Monetary Union », *Journal of International Money and Finance*, vol. 34, p. 10-11.

[3] Attinasi, Maria-Grazia, Cristina Checherita et Christiane Nickel (2010). « What explains the surge in Euro area sovereign spreads during the financial crisis of 2007-09? », *Public finance and management*, vol. 10, no 4, p. 632.

Gerlach et al. (2010) have similar results based on debt and deficit levels, which are good indicators of a country's creditworthiness. There is another range of studies, such as Barrios et al. (2009), that use Credit Default Swaps (CDS) to capture the credit risk component of yield spreads and even if this variable can be potentially biased by systematic and liquidity risk premiums, they show results consistent with the related literature. Calice et al. (2014) use CDS term premium as an alternative, which is basically the difference between the 10 and the 5 year CDS spreads, to only capture the idiosyncratic risk of each country and remove the possible bias. Aizenman et al. (2013) take a different approach and develop a model to regress CDS prices on macroeconomic variables such as debt/tax and deficit/tax to estimate the key determinants of sovereign risk. Their results show that the risk of default was overpriced for Eurozone countries in comparison to other world matching countries during the crisis period.

De Grauwe and Ji (2013) find similar results and argue that the bonds of EMU members are seen as riskier investments than "stand-alone" countries with similar fiscal fundamentals which issue debt in their own currency because they cannot benefit from a lender of last resort, the central bank. The EMU periphery countries that face a liquidity crisis, and consequently high interest rates, are then forced to follow strong budget austerity programs that push them in a deeper recession. The authors talk about a self-fulfilling debt crises in the case of the Eurozone as there is a risk that the combination of high interest rates and recessions turn the liquidity crisis into a solvency crisis.

Ghosh et al. (2013) further study the question of default risk assessment in the EMU and develop an explicit concept of fiscal space, which takes account of the government's limits to raise the primary balance in response to rising public debt, investigating how CDS and bond rates are affected by currency union membership during periods of high and low uncertainty. The authors highlight three key implications of being part of a monetary union:

- Member states may expect assistance from the rest of the union in case of financial troubles.
- There is a need to keep more fiscal space than countries that issue debt in their own currency.
- The union members rely more heavily on fiscal policies (raise taxes, cut spending…) because of their lack of control over monetary policy that could help to satisfy the

budget constraints, by eroding the real value of debts with higher inflation for instance.

With the data going from the euro inception until the financial crisis, they find that the Eurozone countries were borrowing at lower interest rates than it would be expected given their fiscal space, which suggests that the first factor mentioned above dominated and that markets expected the bailouts of distressed union members if needed. However, once the crisis started the EMU countries credit risk premium were overpriced if we only rely on fiscal space. For Ghosh et al. this implies that given the EMU weak reaction to assist its distressed financial members, the constraints related to the currency union increased the uncertainty around the debt sustainability of the Eurozone countries and ultimately the default risk premium.

De Santis (2013), in contrast to the other studies cited above, not only controls for the default risk component of the sovereign bond yields with expected deficit and debt ratios but also captures the downgrade risk. Indeed, many institutional investors have strong allocation rules based on credit ratings that can prevent portfolio managers to invest in lower grade assets and can trigger a reaction on spreads. Even if rating decisions tend to lag the market and the available information, Moodys, S&P and Fitch ratings played a significant role in the Greek, Irish, Portuguese, Spanish and Italian credit risks according to De Santis' data.

Gerlach et al. (2010) try to take into account implicit liabilities related to the size of a country's banking sector in the sovereign yields analysis. They find that during periods of low global risk, the domestic banking sector size is negatively correlated with bond yield spreads and inversely in case of high market uncertainty when governments could be exposed to domestic banks' liabilities (cf. Ireland during the euro debt crisis). They estimate that during the crisis, the transfer of liabilities from the private sector to governments accounted for "almost one percentage point of euro area sovereign spreads". Attinasi et al. (2010) show similar results with a dummy variable for bank rescue packages: banking industry bailouts triggered a reassessment of the sovereign credit risk pricing according to their data. Pisani-Ferry (2013) explains that even if the correlation between fiscal and banking crisis was historically well-known, the probability that this interdependence could potentially create self-fulfilling crises in the EMU was widely underestimated. "Member States keep individual responsibility for the rescue of their national banking systems and the huge size of such systems in the euro area –

the average bank assets-to-GDP ratio is 350 percent in the EU – implies that the fiscal consequences of banking failures are potentially large enough to bring state solvency into question. In the absence of a supranational resolution framework, problems in the banking system can raise doubts about the sovereign's own creditworthiness – which in turn weakens the value of the implicit guarantee provided by the state to the banking system and threatens the solvency of banks. At the same time, however, domestic banks still hold on their balance sheets a considerable share of the debt issued by their national governments. As each euro-area member is solely responsible for the debt it has issued, any doubt about sovereign solvency has the potential to also harm the banking system"[4].

Liquidity risk is another possible determinant of sovereign yield spreads studied in the literature with mixed findings. In theory, asset illiquidity is priced in theory by the financial markets because investors face the risk of not being able to trade positions at a fair price in case of insufficient sell and buy orders volume. Market depth is then negatively correlated with the interest rate. Favero et al. (2010) find evidence with daily frequency data for the period 2002-2003 of a liquidity risk premium for just 9 countries out of a total of 16. De Santis (2013) shows that liquidity differentials are priced for every EMU countries except Netherlands and Finland but also finds the existence of a flight to liquidity premium benefiting German Bunds during the crisis. This new factor is captured by the spread between the KfW ('Kreditanstalt für Wiederaufbau') bond and the German Bund, which have the same default risk as the German government guarantees both. Inversely, Oliveira et al. (2012) find no evidence that the liquidity risk had an impact on the sovereign spreads before and during the financial crisis. Finally, Pagano (2004) indicates that the liquidity risk factor has just a minor role in yield differentials and that part of this role comes from its interaction with the credit risk. Indeed, higher supply can be associated with increasing public debt and deficits and thus a higher default risk premium. Overall, there is no consensus about the liquidity impact on Eurozone yield spreads which could be explained by the use of different data frequencies across studies, as the liquidity risk factor seems to cancel out in the long run. As we are working with low-frequency data (monthly), we decided to not include a liquidity risk variable in our model.

[4] Pisani-Ferry, Jean (2013). « The known unknowns and unknown unknowns of European Monetary Union », *Journal of International Money and Finance*, vol. 34, p.9.

There is a clear consensus in the literature that the sovereign bond yield spreads are not just determined by country-specific risk variables but are increasingly driven by international factors and global risk aversion (Geyer et al. (2004), Favero et al. (2010), Codogno et al. (2003)). Investors' portfolios are strongly correlated despite having quite different compositions thanks to the growing international government bond market integration that increased the exposure to systematic risks (Kumar and Tatsuyoshi (2011). For instance, Longstaff et al. (2011) find that during the 2000-2010 period "sovereign credit risk appears to be much more linked to global factors than are equity returns"[5], as 64% of the spreads variations are explained by a common factor among the different countries when it only explains 46% of equity returns. This common international risk factor can be explained by the fact that in case of market turbulence, risk-averse investors will shift their portfolios towards lower risk assets. This is the so-called flight to safety effect. Market uncertainty, and subsequently a rise of risk aversion, should benefit all euro sovereign yields as they are usually seen as a low-risk asset class but only the German is traded as a "safe heaven", considered default free and highly liquid. Thus, the EMU bond spreads are positively correlated with the global risk aversion and the risk premium changes. Moreover, according to Favero and Missale (2012) global risk aversion can sometimes work as a catalyst for country-specific risks: in the case of the euro periphery countries, their poor fiscal fundamentals were only priced in their yield spreads after the financial crisis. Models able to capture such time-varying relations will be discussed later in this literature review.

2.2 The Contagion Effects

Financial contagion affected EMU sovereign yields in several ways. Giordano et al. (2013) for example distinguish between 3 types of contagion: the wake-up call contagion which occurs when new information, initially confined to one country, prompt investors to reassess the credit risk of other states, the shift-contagion which occurs when the normal cross-market

[5] Longstaff, France A., Jun Pan, Lasse Pedersen et Kenneth J. Singleton (2011). « How sovereign is sovereign credit risk? », *American economic journal*, vol. 3, no 2, p. 76.

channel intensifies after a crisis in one country, and the pure contagion when changes are unrelated to fundamentals. They modify (2.1) specifications and estimate instead:

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 X_{it} + \beta_3 Z_{it} + \beta_4 D_t + \beta_5 D_t Y_{it-1} + \beta_6 D_t X_{it} + \beta_7 D_t Z_{it} + u_{it} \qquad (2.2)$$

where D_t is a dummy variable equal to 1.0 after the start of the Greek crisis, which coincides with the revision of Greek falsified fiscal data in October 2009.

In this model, β_7 captures shift-contagion (more pronounced sensitivity to global factors), β_6 captures the wakeup-call effect (increased sensitivity to country-specific fundamentals) and β_4 represents what is left of the Greek crisis contagion as captured by the dummy variable, the pure contagion. Giordano et al. find evidence of wakeup-call contagion during the euro debt crisis but it is worth mentioning that they only control for the Greek contagion. De Santis (2013) also considers the spillover effects of the events in Greece to other EMU countries but by using S&P, Moody's and Fitch credit ratings and by studying key economic news effects. He finds evidence of spread increase for every country except Ireland, Netherlands, and Finland after these announcements. Similarly to Giordano et al. (2013), he concludes wakeup-call contagions were most important for EMU countries with weaker fiscal conditions but fails to explain a large fraction of the spillover effect across countries.

Reboredo and Ugolini (2015) studied the contagion effects thanks to the conditional value-at-risk (CoVaR) measure, using copulas. “The CoVaR is the VaR of a market conditional on the financial distress of another market, with financial distress measured as the return of the distressed market taking values less than or equal to its VaR.”[6] Their results show that the Greek crisis had spillover effects on the periphery countries, especially Portugal, but not on the rest of the EMU. Finally, Ehrmann and Fratzscher (2015) have a different approach and test for the presence of contagion and fragmentation among the euro area. To achieve such identification, they use high-frequency data (5 minutes) and employ a methodology that exploits the heteroskedasticity of changes in bond yields. They find strong evidence of euro area bond market fragmentation during the crisis, which could be partly explained by a flight to quality effect as there are instances where shocks raise yields in stressed countries - such as Italy, Portugal and Ireland - but lower yields in the core countries during the crisis. However,

[6] Reboredo, Juan C. et Andrea Ugolini (2015). « Systemic risk in European sovereign debt markets: A CoVaR-copula approach », *Journal of International Money and Finance*, vol. 51, p. 242

this phenomenon mainly disappeared after the ECB announcement of its OMT program[7]. Therefore, Ehrmann and Fratzscher find no evidence of contagion overall between 2010 and 2012 and the fragmentation effect means that the transmission of shocks was weaker during that period. Overall, their findings suggest that "financial integration strengthened within core countries and within periphery countries, whereas across these country groups there was more fragmentation."[8]

A growing literature is working with Global Vector Autoregressive models (GVAR) to capture the time-varying interdependence among financial variables across countries and thereby capture the spillover effects. Pesaran and his coauthors (Pesaran et al. (2004), Pesaran et al. (2006), Dees et al. (2007)) introduced the GVAR model where foreign variables are weighted averages of the variables of the rest of the EMU with country-specific weights based on trade shares (i.e. the proportion of a country X in the total trades of a country Y over the last years). This multivariate time series model has the advantage of explaining the changing correlation between spreads that standard linear regression models would not be able to capture while imposing a tight structure. The GVAR is a good model to capture contagion among the Eurozone, but it does not capture possible time-variation in the bond yield determinants or a market behavior shift during the financial crisis. Caporale and Girardi (2013) analyzed the spillover effects of EMU periphery countries fiscal imbalances on the Eurozone member states sovereign bond yields with the GVAR model and find strong correlations between EMU long-term interest rates. However, even if domestic factors remain modest in comparison to international factors (global risks, contagion…), there is strong evidence that the financial markets sanction the fiscal imbalances when they exceed a given threshold. Favero (2013) modified the standard GVAR model so that an increase in the spread in Country X will affect that in all EMU countries with an impact size based on the closeness with the Country X in terms of fiscal fundamental. He measures the distance in terms of fiscal fundamentals with the projections of debt to GDP and deficit to GDP ratios and explains the interdependence between EMU spreads by the expectation of an exchange rate devaluation in case of a euro

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[7] Outright Monetary Transactions is an ECB program through which they purchase in the secondary market sovereign bonds issued by the Eurozone member states under certain conditions.

[8] Ehrmann, Michael et Marcel Fratzscher (2015). *Euro Area Government Bonds: Integration and Fragmentation during the Sovereign Debt Crisis*, 2015-13, *Bank of Canada Working Paper*, p. 13

exit or break-up. Favero and Missale (2012) apply the same modified GVAR model to capture the nonlinear contagion effects in the Eurozone. These last 2 papers find strong evidence of spillover effects during the financial crisis and even stronger during the euro debt crisis, but the model fails to predict the highest levels of spreads observed during the crisis that leaves the possibility of remaining pure contagion factors.

2.3 Market Shift Behavior

By using linear regression models with separate distinct periods (the pre-crisis: 2000 to 2007 and the crisis: 2007 to 2010) Oliveira et al. (2012) find evidence of a shift in the market behavior regarding the sovereign debt pricing in the Eurozone. Bernoth et al, (2012) and Afonso et al. (2014) show similar results by using dummy variables for the defined crisis period, suggesting that markets are now pricing risks that they did not consider previously. After the start of EMU, the fiscal fundamental differences between countries only had a small impact on yield spreads as the bonds were traded at very close prices and were almost seen as substitutes by the market which potentially failed in its discipline role. However, following the 2007 financial crisis events, the market sanctioned more than before the EMU periphery countries with the weakest fiscal fundamentals.

Rather than having a discrete shift point between distinct periods, a few studies allow for coefficients that change gradually over time. Assmann and Boysen-Hogrefe (2012) use time-varying coefficients β_t that follow random walks:

$$\beta_t = \beta_{t-1} + u_t \qquad \text{with} \qquad u_t \sim (0, \textstyle\sum_t) \tag{2.3}$$

to analyze the EMU sovereign yields dynamics which respect the equation:

$$Y_{i,t} = \beta_t X_{i,t} + \varepsilon_{i,t} \tag{2.4}$$

where $X_{i,t}$ is a vector that contains the relevant determinants and risk factors. The model assumes time-varying variances with GARCH-type specifications for the error terms u_t and $\varepsilon_{i,t}$. They find that the yield spreads determinants are highly volatile across time and that the expected debt to GDP has the biggest explanatory power among the tested variables for the Eurozone countries. However, it is worth mentioning that they do not use any proxy variable to capture the international risk or global risk aversion factors which could bias the results. Pozzi and Wolswijk (2012) apply another model with latent coefficients to test the financial integration of the EMU, with full financial integration being defined as the situation where bond risk premiums are only affected by common risk factors. The risk premiums, obtained thanks to the ICAPM, are decomposed in common or idiosyncratic latent risk factors by using a linear state space approach in the following system:

$$R_{it+1} = \alpha_{it+1} + \beta_{it+1} R_{wt+1} + \eta_{it+1} \quad (2.5)$$

$$\alpha_{it+1} = \kappa_{it+1}^{\alpha} \mu_i + \pi_i \alpha_{it} + \kappa_{it+1}^{\alpha} \varepsilon_{it+1} \text{ (AR(1) process)} \quad (2.6)$$

$$\beta_{it+1} = \kappa_{it+1}^{\beta} \gamma_i + (1 - \kappa_{it+1}^{\beta}) \lambda \quad (2.7)$$

$$R_{wt+1} = \mu_w + \pi_w R_{wt} + \varepsilon_{wt+1} \quad (2.8)$$

where R_{it+1} and R_{wt+1} respectively stand for excess returns of the bonds i and the portfolio w (common component), α_{it+1} reflects the compensation for country-specific risks and β_{it+1} represents the conditional covariance of the country- specific bond and the global portfolio returns. Therefore, κ is a convergence operator and determines the weights, γ_i is the country-specific constant and λ the common constant. Pozzi and Wolswijk show that country specific risks were almost eliminated by the end of 2006 (except for Italy) and then reappeared with the start of the financial crisis. Bernoth and Erdogan (2012) with their semiparametric time-varying coefficient model show similar results and also add on the significant impact of global risk aversion on sovereign yield differentials. There is also another strand of the literature analyzing the dynamics of EMU sovereign spreads but with affine term structure models (Geyer et al. (2004)). Dewachter et al. (2014) apply the model to the whole yield curve data for Belgium, France, Germany, Italy and Spain and cover the 2005-2013 period. The whole yield curve data use brings the additional information that fundamental risk is the main source of variation for short term horizon bonds (up to 1 month), explaining between 35 and 82% of such movements, and that this proportion decreases for longer horizons. They find that overall, like in the cited above studies, the idiosyncratic risks are the main driver of sovereign bond yields even if non fundamental variables remain significant.

Few facts can be highlighted from this literature review and help us to specify our model for the study of bond yield spreads determinants.

- A contagion factor significantly influenced the European spreads, or at least part of them, during the crisis. We use a GVAR model to capture such effect because it is a very flexible framework that allows us to take into account the following points.
- There is evidence of a shift in the market behavior regarding the sovereign debt pricing in the Eurozone after the crisis. Thus, we include a crisis dummy variable in our GVAR model to account for this non-linearity in the spreads.
- A common international risk factor partly explains the spreads movements. In section 3, we present a new risk aversion variable based on European data that will capture the global risk effects in our model.
- The countries' creditworthiness, as defined by macroeconomic fundamentals, partly explain the interest rates differentials among EMU countries. Similarly to most of the related literature, we use expected fiscal balance and debt to GDP series as proxies for credit risk. Moreover, we add the expected real GDP growth variable that was surprisingly ignored so far in the analysis of sovereign yields.

3. Exploratory Data Analysis

In this 3rd section, we describe the time series that will be used later for the various analysis and we aim to identify the possible bias. Therefore, this explanatory data analysis allows us to show the differentials within the EMU in terms of fiscal fundamentals that could potentially explain the bond yield spreads divergence.

3.1 Sovereign Bond Yields

We analyze the sovereign bond yields of 10 Eurozone countries: Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal, and Spain. We also include the German bond yields in this analysis as it will be used later for the Spread on Bunds computation. The data cover the period 2001, corresponding to the euro adoption by Greece, until the end of 2014 which gives us a dataset of 1680 monthly observations in total. The 10-year bond yields of the individual countries are the averaged observations for each month, as published by the European Central Bank Statistical Data Warehouse. Figure 3.1.1 plots the yields. The European Economic and Monetary Union (EMU) creation in 1999 led to the convergence of the member states' bond yields. Such convergence remained until the start of the 2008 financial crisis. The different sovereign bonds of EMU countries were almost traded as substitutes thanks to the elimination of exchange rate risk and the near-disappearance of idiosyncratic risk as the market was confident that distressed union members would benefit from bailouts if needed and that the probability of such event was very remote. With the global financial crisis and the European debt crisis, the yield differentials among the EMU countries sharply rose which raised questions about the drivers of such dynamics.

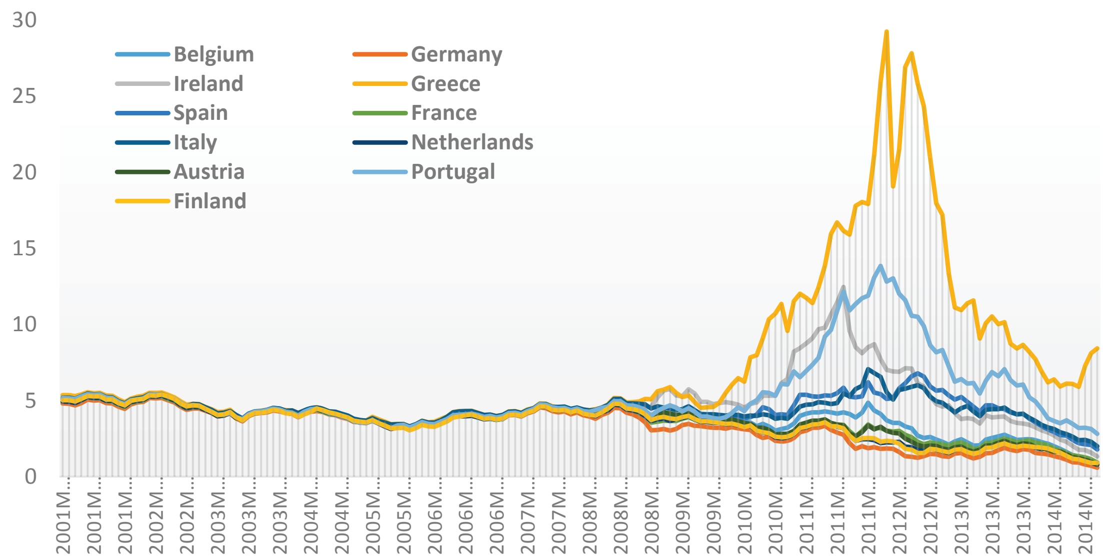
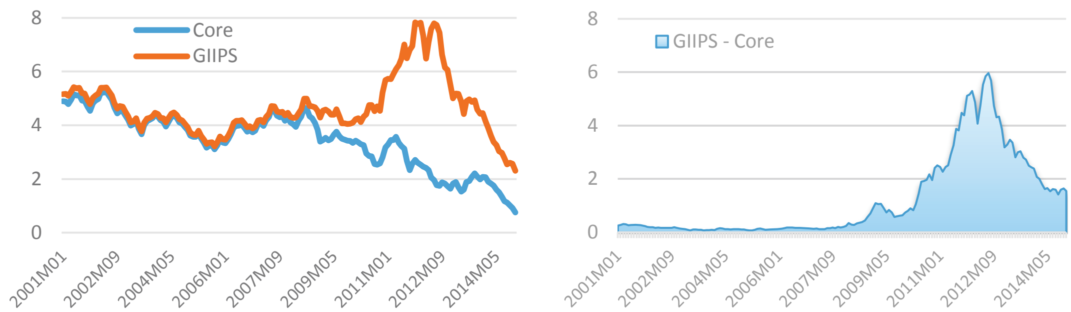


Figure 3.1.1: 10-year bond yields (%) for 11 EMU countries from 2001 until 2014[9]

The figures 3.1.2 and 3.1.3, which show the average bond yields for the GIIPS (Greece, Ireland, Italy, Portugal, and Spain) and for the rest of the EMU (the Core), highlight this radical shift. The global financial crisis, in the second half of 2007, just slightly increased the yields difference in EMU and the spread really started to kick off in late 2009 with the publications of the fiscal costs caused by the banking crisis. GIIPS interest rates were increasing while simultaneously decreasing for the rest of the EMU countries. As a consequence, the difference in borrowing costs grew substantially among the union and the GIIPS had to pay 6 percentage points more in 2011 when raising debts in the primary market. In late 2014, the situation seems to almost be back to normal with the GIIPS, on average, that are borrowing for 10 years

[9] Similar figures can be found in the Appendix with the use of the sovereign bond spreads instead of the yields (Figures 1 through 4). The countries are divided into 2 categories for a better presentation: the high and the low yielders.

cheaper than ever (2.5%) even if the difference with the rest of the Eurozone remains at 1.5 percentage points, which is significantly more than the pre-crises period.



Figures 3.1.2 & 3.1.3: 10YR bond yield differential between the GIIPS and the Core countries
The graphics are composed by the yields weighted average, computed with time-varying weights based on the GDP size of each country relative to the whole EMU. The Y axis is in percent.

In the following 3.2 and 3.3 sections, we respectively analyze the credit risk and general risk aversion proxy variables that will help us to study the sovereign yield spreads in Section 7.

3.2 Credit Risk Variables

We focus on variables measuring fiscal performance and expect that if the fiscal state of a country deteriorates relative to Germany, the bond spread increases because of the higher default risk premium required by the market. Thus, we use the expected debt to GDP, the deficit to GDP ratios and the real GDP growth[10] to capture the countries default risk but according to Cimadomo (2011) and his fiscal data literature review, such figures may not be free of bias. It emerges that for most of the euro area countries, the revisions in fiscal forecasts are large and can be partly explained by political and institutional factors. Indeed, there is evidence that the GDP growth projections tend to be overestimated during political elections whereas the deficit and debt forecasts are underestimated. The bias mentioned above will not impact our analysis as long as the European Commission's projections are strongly correlated with the market ones.

There are different international institutions, EC, IMF and OECD, that produce fiscal forecasts but Artis and Marcellino (2001), Keereman (1999) and Melander et al. (2007) argue

[10] The data come from the European Commission's fiscal forecasts. They respect the ESA 2010 set of principles for national accounts and are related to the general government sector.

that the European Commission's projections for euro area countries are the most accurate. Artis and Marcellino study short term and long term forecasts made by these 3 major institutions between 1976 and 1995 for the G7 countries and compare the Mean Absolute Error (MAE) and the Root Mean Squared Error (RMSE) for deficit to GDP projections. Keereman similarly compares the MAEs and RMSEs for the period 1969 to 1997 but for a broader range of forecasts - GDP growth rate, inflation rate, total private Investment, unemployment rate, deficit to GDP ratio, current account, growth rates of global export and import volumes of goods – and finds the absence of bias, of persistence in the errors and of overly optimistic forecasts in the EC's projections. Finally, Melander et al. updated Keerean's work by extending the observation period until 2005 and by including further tests. They find similar conclusions even if projections accuracy for Portugal, Italy, Luxembourg and Ireland have slightly deteriorated overall and are better estimated in the recent OECD's reports.

We performed a similar analysis for the 2001 to 2014 period. We compared the European Commission's forecasts made at different time horizon with the corresponding historical data and computed the average errors, mean absolute errors (MAE), Errors' mean absolute deviation (MAD) and the average forecasts in order to identify possible bias. We systematically excluded the Greek data as they were largely revised after 2009 and significantly increased the errors.

On Figure 3.2.1, we can see that the average error, the MAE and the MAD of our expected debt to GDP figures are increasing with the forecast horizon and respectively reach -4.31, 7.59 and 7.44 percentage points. The errors are high in comparison to the 70% average forecast. Moreover, the negative average error for all the forecast horizons except T means that these projections underestimated the debt to GDP ratios of the euro area countries.

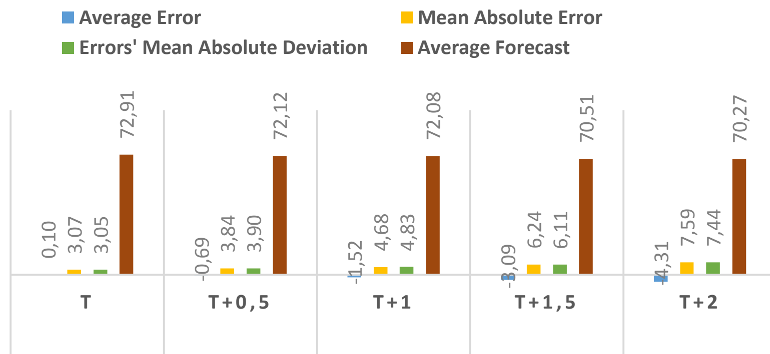


Figure 3.2.1: EC's general government gross debt (% of GDP) forecasts and the historical data, sample Q2.2001-Q4.2014

Figure 3.2.2 plots the deficit forecasts statistics and once again the average error, the MAE and the MAD are growing with the forecast horizon. The errors are very high for the T+1.5 and T+2 horizons as the MAE and MAD are almost equivalent to the Mean Absolute Forecast, which underlines the EC inability to forecast 2 years in advance the government balance, especially during the financial crisis. Therefore, the significant positive average error through all the forecast horizons means that the EC tended to underestimate the deficits during the 2001-2014 period.

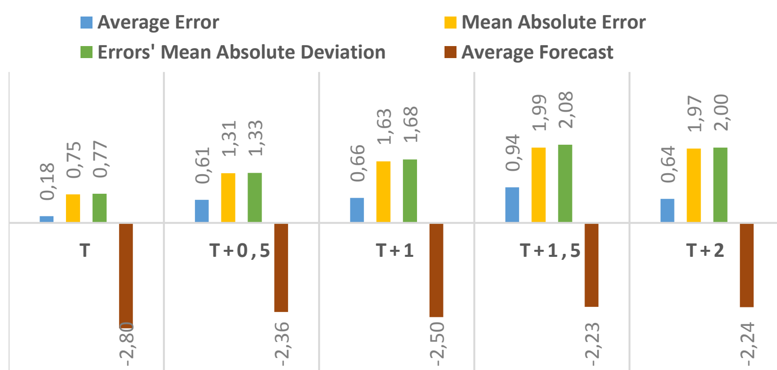


Figure 3.2.2: EC's general government balance (% of GDP) forecasts and the historical data, sample Q2.2001-Q4.2014

Figure 3.2.3 plots the real GDP growth forecasts statistics and the significantly positive average error outlines that the EC tended to overestimate the real GDP growth over the studied period for longer forecast horizon. As for the expected deficits, the EC had difficulties in forecasting the real GDP accurately in the long run if we consider the fact that the mean absolute error and the average forecast are very close.

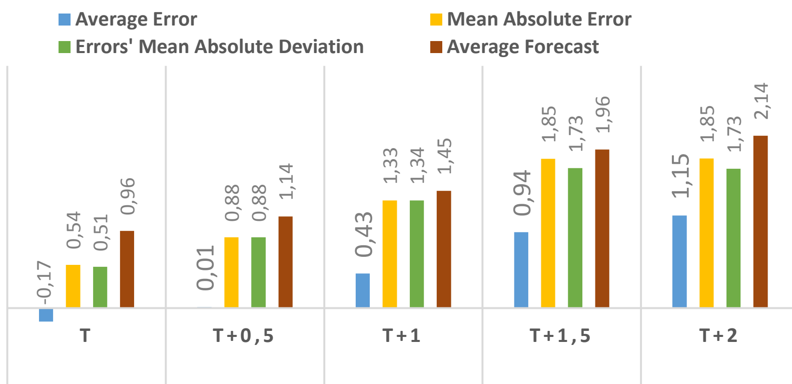


Figure 3.2.3: EC's real GDP growth (% of last period) forecasts and the historical data, sample Q2.2001-Q4.2014

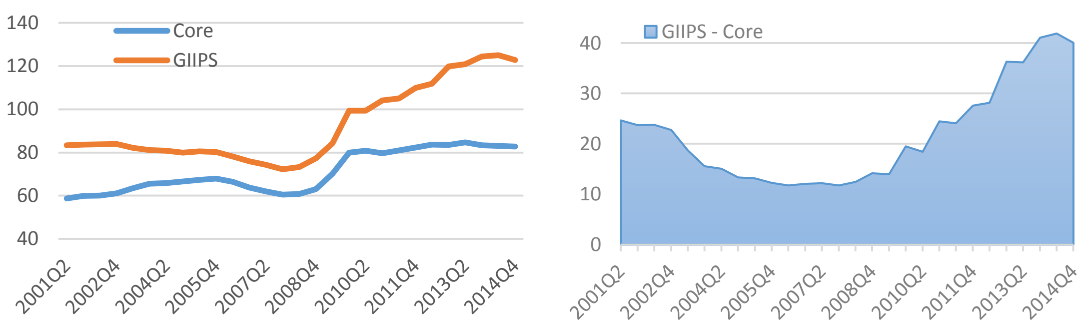
Overall, we find slightly different outcomes than Artis and Marcellino (2001), Keereman (1999) and Melander et al. (2007) for our sample period since the difference between the forecasts and the actuals are quite large. Indeed, the debt to GDP, deficit to GDP and real GDP growth forecasts are overly optimistic between 2001 and 2014. However, we think that these forecasts, even if they may not be exempt from bias, are better credit risk variables than historical data because investors value default risks on the basis of their country's fiscal projections, estimated with the data available at that time. It also avoids a potential bias that could arise from the fact that current deficit figures could include government interest payments. Moreover, as mentioned by Attinasi et al. (2010): "Given its prominent role in the application of the EU fiscal surveillance framework, we assume that investors use the European Commission's forecast as a reliable source of information to form their expectations."[11]

We continue our exploratory data analysis for the credit risk variables with the presentation of differentials between the GIIPS and Core countries in terms of expected debt to GDP, balance to GDP and real GDP growth.

Figures 3.2.4 and 3.2.5 plot our expected debt to GDP data and exhibit the indebtedness of GIIPS and the rest of the EMU (EMU – GIIPS). We can observe similar trends in

[11] Attinasi, Maria-Grazia, Cristina Checherita et Christiane Nickel (2010). « What explains the surge in Euro area sovereign spreads during the financial crisis of 2007-09? », *Public finance and management*, vol. 10, no 4, p. 605.

the figures 3.1.2 and 3.1.3, which outlines the correlation between the GIIPS expected indebtedness and the sharp rise of bond yields relative to the rest of the Eurozone. From 2001 until the start of the global financial crisis, the difference was shrinking and reached its lowest level of 10 percentage points, supporting the idea of an increasing market integration. Then, the EMU countries equally suffered from a debt increase as a consequence of the 2008 banking crisis, and this is only after, that the figure diverged across the union. The ratio kept rising for the GIIPS until 2014 where it reached more than 120% of debt when the rest of the EMU stabilized around the 80% mark. In the end, there is a differential of 40 percentage points and the evidence of correlation underlined by the plots could potentially mean that the expected debt to GDP is one of the variables driving the government bond yields in the Eurozone. However, it is worth mentioning that even if at the end of 2014 the expected debt to GDP ratio has never been as high for the GIIPS, the bond yields differential with the rest of the union is closing in. That could be explained by the fact that the market was reassured by the apparent GIIPS ability to stop the debt ratio growth at the 120% mark but most of all, this means that there are other underlying forces affecting sovereign bond yields.



Figures 3.2.4 & 3.2.5: Expected debt to GDP (%) difference between GIIPS and the rest of EMU

The graphics are composed by the weighted average of the Debt to GDP ratios, computed with time-varying weights based on the GDP size of each country relative to the whole EMU. Similarly to the related literature, we averaged the forecasts with different time horizons for each data publication.

Figure 3.2.6 clearly suggests that higher expected debt to GDP is associated with higher bond yield and according to the R-squared of 0.65, the relationship between both variables seems to be quite significant. Based on the data at the end of 2014, Greece is the only outlier value, and its bond yield appears to be overestimated based on the solely expected debt to GDP variable.

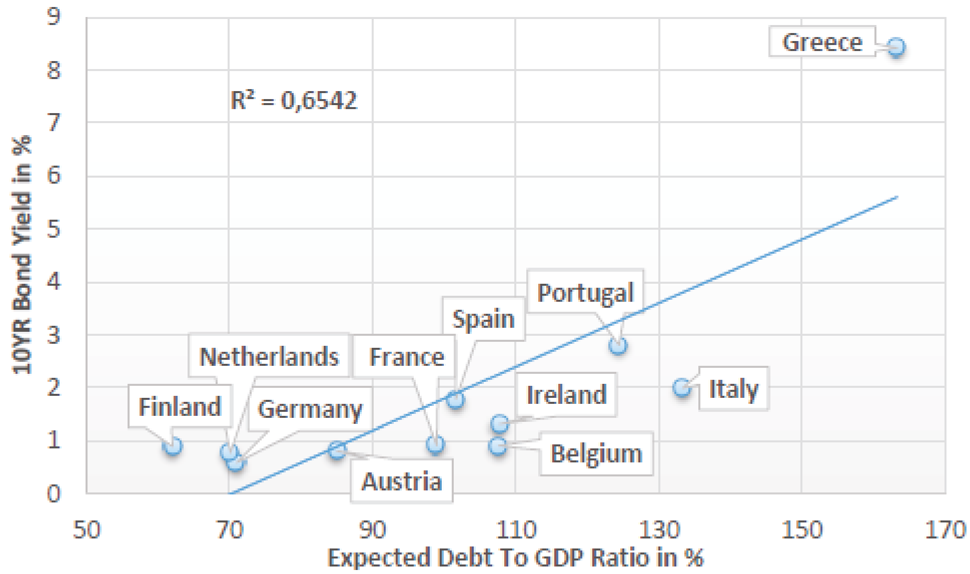
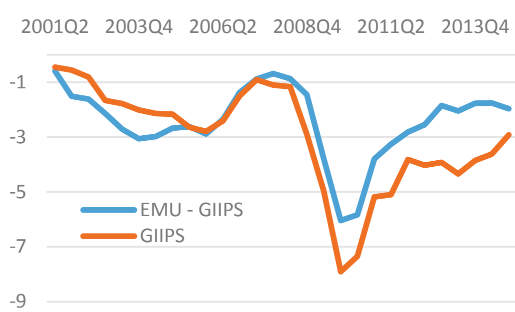
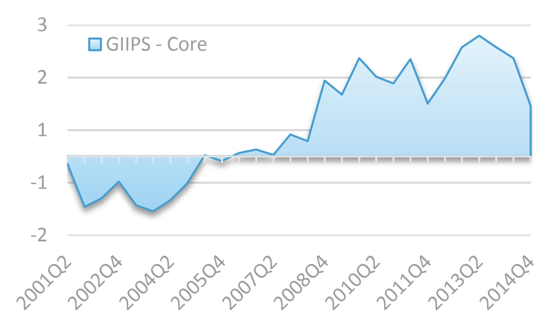


Figure 3.2.6: 10-year sovereign bond yields and expected government debt in 2014Q4
Similarly to the related literature, we averaged the forecasts with different time horizons for each data publication.

Figures 3.2.7 and 3.2.8 exhibit our second variable that proxies the credit risk, the expected general balance. Once again, the plots show the difference between the GIIPS and the Core countries from 2001 to the end of 2014. The EMU countries taken as a group never expected surplus during this period. Therefore, the results are in line with the previous findings: between 2001 and 2008 the GIIPS had smaller deficits which helped to reduce the differential in terms of debt but after 2008 and an annual deficit of -8%, the GIIPS constantly underperformed the Core countries.





Figures 3.2.7 & 3.2.8: Expected general balance (%) difference between GIIPS and the rest of the EMU
The graphics are composed by the weighted average of the Expected General Balance, computed with time-varying weights based on the GDP size of each country relative to the whole EMU. Similarly to the related literature, we averaged the forecasts with different time horizons for each data publication.

Finally, the figures 3.2.9 and 3.2.10 exhibit our last variable that captures the credit risk, the expected GDP growth. From 2001 until 2007, the GIIPS had higher expected GDP growth than the rest of the monetary union which can help to explain the shrinking difference

3.3 General Risk Aversion Variable

We call risk aversion the factor measuring the market appetite for risk. We surveyed the main risk aversion variables in the literature related to the bond yields determinants and displayed in Figure 5 of the Appendix the various time-series: VIX, VSTOXX, the spread between the US corporative bond indexes rated Baa and Aaa, and the spread between the US Government bonds and the Aaa US corporative bond index. Except for the VSTOXX index, which is derived from the EURO STOXX 50 Index options traded on Eurex and measures the implied volatility, the other mentioned variables are not based on European data. This is why we constructed a euro corporative bond index Bbb-Aaa similarly to the US corporative Baa-Aaa spread, which is one of the most popular global risk variable in the literature. The data come from BofA Merrill Lynch indexes on Bloomberg and to our knowledge, such variable was not previously considered for bond yields analysis. We can see in Figure 3.3.1 that the euro based variable is slightly more volatile as it remains at lower levels than the US one during the low uncertainty period 2001-2007 and higher levels during the European crisis. In particular, the EUR Corp Bbb-Aaa seems to capture better the European debt crisis in 2012 than the US Corp Baa- Aaa. We think that, as our risk aversion variable is based on European data, it should consequently be more correlated to the Eurozone sovereign yields.

Please note that we also considered the use of Euro Swap Spreads, which is the difference between the 10-year (or 5-year) EUR swap and the 10-year (5-year) German Bund, but we only had limited access to European swap data.

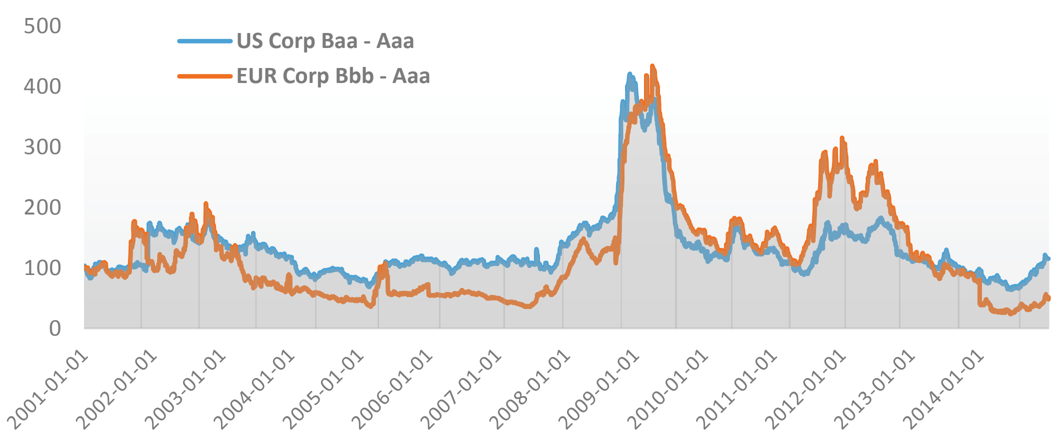


Figure 3.3.1: Comparison between the US and the EUR corporate bond yield spreads

4. Event Study

The European Commission forecasts for the euro area fiscal fundamentals are roughly published every 6 months and projected at different time horizons. As previously mentioned, we are going to use the expected debt to GDP, the general government balance and the real GDP growth to capture the credit risk in our analysis of the sovereign bond spreads and we need to perform an event study in order to identify the best use of the different forecast horizons. Indeed, the EC releases forecasts in spring with T+0.5 and T+1.5 years horizons whereas they release T, T+1 and T+2 forecasts in fall. In the related literature most of the studies, to our knowledge, average the forecasts at different horizons and do not consider alternatives such as the short and long-term forecasts, but also the difference between these 2 projections that could potentially better capture the credit risk.

We study the spreads on Bunds movements around the EC's forecasts publication, identified as being the press release date, with a 1 week time window (2 days before and 3 days after the event). More specifically, we analyze the difference in spreads before and after the publication in order to identify which variables (forecasts and time horizons) are driving the fixed income market when the EC releases its projections. This event study helps us to specify our GVAR model in section 7 with adequate time horizons for the variables based on fiscal fundamentals and to determine which macroeconomic fundamentals significantly influence the European spreads. Regarding our independent variables, the fiscal fundamentals, we use the difference between the new and the previous EC forecast as well as the differential with the German fiscal data[12]. With data from 2001 until the end of 2014 for 10 euro area countries, we have a total of 280 observations for each variable. Table 4.1 shows some key statistics for each variable that will be further used in regressions.

	Spreads	Debt AVG	Balance AVG	Growth AVG	Debt LT-ST	Balance LT-ST	Growth LT-ST	Debt ST	Balance ST	Growth ST	Debt LT	Balance LT	Growth LT
Average	0,006	0,907	-0,134	-0,040	0,246	-0,068	0,035	-0,001	-0,098	-0,061	0,998	-0,165	-0,026
Median	-0,003	0,100	-0,100	0,000	0,150	0,000	0,100	0,000	-0,200	-0,050	0,100	-0,100	0,000
Std Dev	0,339	6,252	1,744	0,640	4,744	2,333	1,328	2,066	2,445	1,177	6,304	1,223	0,648
Min	-1,44	-35,00	-16,30	-3,62	-28,60	-20,40	-4,90	-8,20	-21,90	-6,40	-31,30	-8,20	-4,30
Max	4,90	37,70	15,75	2,85	27,80	22,00	6,50	6,70	20,10	3,40	33,60	3,10	3,80

Table 4.1: Descriptive statistics of the event study data (%), sample 01.2001-12.2014

[12] $X_t^{i*} = \left(X_t^i - X_t^{bd}\right) - (X_{t-1}^i - X_{t-1}^{bd})$, with X_t^i being the forecast for the fiscal data matrix X of country i and X_t^{bd} being the German forecasts, t stands for the last forecasts publication date.

The variables "AVG" mean that we averaged the forecasts with different horizons at each publication whereas the variables "LT-ST"[13] mean that we computed the difference between long term and short term forecasts. In this case, the short-term forecasts are less than 6 months horizons while the long-term forecasts are approximately 2 years horizon. The approximation comes from the fact that the EC does not publish its forecasts at fixed dates, and the release can sometimes be delayed by a month. We can observe that, on average the spreads did not have a clear upward or downward tendency after the forecasts publication (average of 0.006 and a median of -0.003 percentage points) while the debt and the deficit increased relative to Germany.

We excluded one outlier corresponding to the period[14] where the Greek government defaulted on part of its private obligations (consequently, the debt largely decreased) and Greek political parties failed to form a government after the legislative elections which resulted in an increase in Greek government bond spreads of 490 basis points during the week in which the EC fiscal forecasts happened to be published. This one outlier value was solely responsible for an apparent negative relationship between debt and spread. Figure 4.1 clearly outlines the presence of this value, in the lower right side of the graphic, as this scatter plot shows the relationship between the change in the averaged horizon forecasts for debt and the change in the spreads on Bunds.

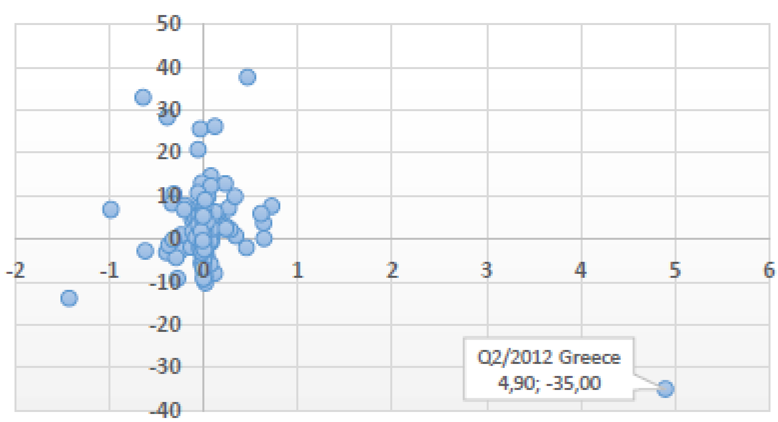


Figure 4.1: Relationship between Debt AVG (vertical axis) and Spreads (horizontal axis)

[13] The LT-ST variable allows us to capture whether it is the difference between long term and short term forecasts that matters the most in describing the spreads movements.

[14] May 2012

We perform several panel regressions with robust standard errors to identify which variables can best explain the changes in spreads after the EC forecast announcements. The results can be found in Table 4.2. The numbers in brackets are the t-statistics whereas the others represent the estimated coefficients. We highlighted in yellow the coefficients significantly different than 0 at a 5% level.

	Average across horizons				Long Minus Short Term Forecasts				Short Term Forecasts				Long Term Forecasts			
Constant	-0,014	-0,013	-0,010	-0,013	-0,015	-0,012	-0,012	-0,015	-0,012	-0,012	-0,012	-0,011	-0,014	-0,015	-0,011	-0,015
	(-1,34)	(-1,26)	(-1,00)	(-1,24)	(-1,44)	(-1,16)	(-1,16)	(-1,49)	(-1,19)	(-1,16)	(-1,13)	(-1,04)	(-1,37)	(-1,43)	(-1,10)	(-1,44)
Debt to GDP	0,002			0,002	0,008			0,010	0,014			0,022	0,002			0,001
	(0.60)			(0,44)	(1.74)			(2.12)	(1.71)			(2.42)	(0.59)			(0,14)
Fiscal Balance		-0,009		-0,011		-0,003		-0,006		-0,002		-0,001		-0,019		-0,018
		(-1,50)		(-1,50)		(-0,27)		(-0.6)		(-0,23)		(-0,10)		(-1.68)		(-1.33)
GDP Growth			0,045	0,051			0,003	-0,008			0,001	0,025			0,018	0,021
			(1.79)	(2.01)			(0,22)	(-0,66)			(0,06)	(1.44)			(0.84)	(0.34)
Adj. R-squared	0,007	0,009	0,025	0,048	0,043	0,001	0,001	0,053	0,026	0,001	0,000	0,044	0,006	0,018	0,004	0,025

Table 4.2: OLS regressions results with Spreads as dependent variable, sample 01.2001-12.2014

The positive coefficients found for the debt to GDP variable, even if the size of their impact seems to be rather small, are consistent with the findings in the related literature. For instance, a debt to GDP increase (short-term) of 1 percentage point relative to Germany would result in a 2.2 basis points rise of the spread on Bunds. Afonso et al. (2014) with the same panel of countries and a sample over the period 1999.02-2010.11 found even smaller expected GDP coefficients, inferior to 1 basis point. However, even if the debt to GDP factor is statistically significant when we use the short-term horizon and the long minus short-term forecasts, in bivariate regressions it only explains respectively 2.6% and 4.3% of the variance of the spreads' changes after the EC publications.

Similarly, the negative coefficients for the fiscal balance are in line with the conclusions found in the literature and support the negative correlation with the spreads. However, the fiscal balance impact remains quite small and is only significant at a 10% in the case of long-term forecasts. Indeed, 1 percentage point increase in the surplus (long-term) relative to Germany would translate into a 1.9 basis points reduction of the spread on Bunds. Nevertheless, it is worth mentioning that Afonso et al. (2014) find similar results for the expected fiscal balances with a -0.07 basis point coefficient significant at a 10% level. The fiscal balance long-term forecasts explain only 1.8% of the variance of the spreads movements around the EC projections releases in our analysis.

Finally, the real GDP growth coefficients are quite puzzling as they underline a positive correlation with the spreads. The average across horizons variable is significant at a 5% level in our multivariate regression and a 1 percentage point (pp) raise of the real GDP relative to Germany would increase the spreads by 4.8 basis points. In a bivariate regression, the GDP growth factor (averaged horizons) has a 10% level of significance and can explain 2.5% of the spreads variations. Please note that we cannot compare these results with the related literature ones because to our knowledge, previous bond yield spreads studies did not use the real GDP growth variable.

The correlation matrix in Table 4.3 helps us to understand the above-estimated coefficients. The correlation is low across our different variables and only the significant negative correlation of -0.61 between short-term change in debt and the change in growth stands out from the rest. This correlation could have an impact on the estimated coefficients for our short-term variables in the previous regressions as our variables have to be independent. However, as we get the same result regardless of whether we include both variables or just one, we conclude that this correlation does not impact our estimates.

	Average			**Long-Short Term**			**Short Term**			**Long Term**		
	Debt	Deficit	Growth	Debt	Deficit	Growth	Debt	Deficit	Growth	Debt	Deficit	Growth
Debt	1			1			1			1		
Deficit	-0,243	1		0,203	1		-0,200	1		-0,438	1	
Growth	-0,031	0,179	1	0,371	0,083	1	-0,610	0,204	1	-0,015	0,096	1

Table 4.3: Correlation matrix of our variables, sample 01.2001-12.2014
We highlighted in yellow the result significantly different from zero.

We made other regressions, not shown here, with just the short and the long horizon forecasts for each variable. They confirm that once we include the short-term debt forecast, the long-term variable has no impact and vice versa in the case of the fiscal balance. Regarding the growth variable, similarly to what we saw in Table 4.2, neither the short nor the long horizon forecast is significant.

We mix the most significant independent variables according to our analysis and perform a new regression. Table 4.4 exhibits the results, and we can notice that the explicative power of our model increased giving an 8.4% adjusted R-squared. The long-term fiscal balance and the averaged horizon forecasts for GDP growth are significant at a 5% level whereas the short horizon debt has an estimated coefficient significantly different than 0 at a level of 13%. The coefficients signs are similar to the outcomes in Table 4.3, and it is worth mentioning that the growth forecasts have an even bigger impact on the spreads changes than above.

Spreads	Coefficients	t-stat	p-value
Constant	-0,014	-1,33	0,183
DebtST	0,011	1,52	0,129
BalanceLT	-0,027	-2,34	0,02
GrowthAVG	0,061	2,28	0,024
Adj. R-squared	0,084		

Table 4.4: OLS regression with a combination of the most significant independent variables

Figure 4.2 plots the relationships between our independent variables and the spreads on Bunds. A solid trend line illustrates in each case the linear relationship. Based on our tests, these 3 variables seem to be the best pick to capture the credit risk accurately in our spreads sample.

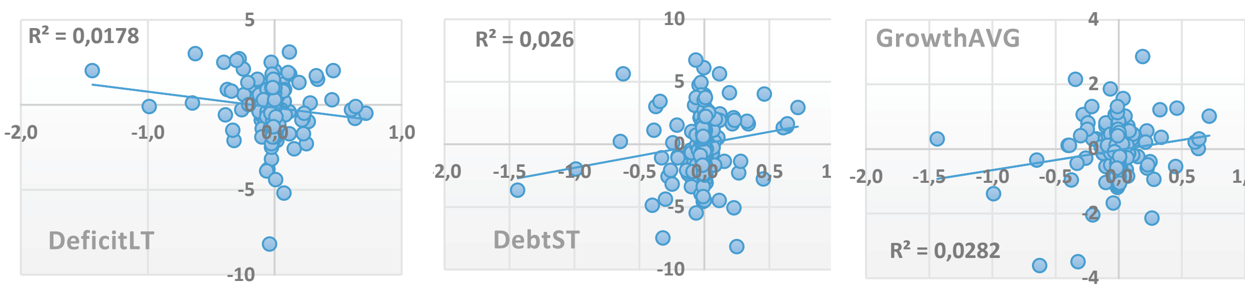


Figure 4.2: Relationship between DeficitLT, DebtST & GrowthAVG (Y-axis) and Spreads (X-axis)

We push a little bit further the event study with the inclusion of a dummy variable to capture the European debt crisis. The dummy variable sets the start of the European debt crisis in March 2009 onwards. We choose the starting date similar to Afonso et al. (2014) for 2 main reasons: first, "the most intense period of the credit crisis was over by the spring 2009 with major stock market indices experiencing their lowest levels in early March 2009 and since then recording significant gains[15]" and second because this is when the EC published public debt to GDP ratio forecasts with an average increase of 19% across the euro area.

The results are displayed in Table 4.5, and we can observe that each variable seems to have a bigger impact and is slightly more significant during the crisis than before. Indeed, none

[15] Afonso, Antonio, Michael G. Arghyrou et Alexandros Kontonikas (2014). « Pricing Sovereign Bond Risk in the European Monetary Union Area: An Empirical Investigation », *International Journal of Finance and Economics*, vol. 19, no 1, p. 51

of the coefficients is significantly different from 0 for the pre-crisis period whereas the growth variable is significant during the crisis. Thus, we test the hypothesis that the precrisis variables are jointly significantly different from 0. With an F-test of 2.93 and a p-value equals to 3.4%, we can conclude with a 5% significance level that our 3 variables have a joint influence on the precrisis spreads on Bunds. Then, we test the joint hypothesis that the variables before and during the crisis are equals in order to make sure that the crisis has a significant impact: for the debt we have an F-test equals to 1.60 (p-value=20.7%), for the fiscal balance we have 2.24 (p-value=13.5%) and finally 5.61 (p-value=1.9%) for the growth. Thus, the growth is the only variable that has a significantly different impact on spreads at the 5% level before and during the crisis. To sum up, we find that even if our precrisis coefficients are individually not significantly different from 0, they jointly had an effect on the spreads changes after the EC forecasts releases. Moreover, we find some evidence that at least the growth variable had a significantly bigger impact on spreads during the crisis, which supports the idea that during periods of high uncertainty, the market is more sensitive to fiscal imbalances and is closely monitoring fiscal forecasts. These results comfort our idea to include a crisis dummy variable in our latter spreads determinants analysis.

Spreads	Coefficients	t-stat	p-value
Constant	-0,007	-0,48	0,629
DebtST	0,000	-0,25	0,801
DebtST crisis	0,012	1,26	0,210
BalanceLT	-0,004	-1,13	0,260
BalanceLT crisis	-0,029	-1,81	0,072
GrowthAVG	-0,007	-0,75	0,454
GrowthAVG crisis	0,080	2,43	0,016
Dummy crisis	-0,014	-0,61	0,543
Adj. R-squared	0,101		

Table 4.5: OLS regression with a combination of the most significant independent variables and dummy variables for the euro debt crisis[16]

Overall, 2 main outcomes can be highlighted from this event study and help us to improve our model:

- We identified the best use of the different time horizons for the forecast of fiscal fundamentals: the short-term debt, the long-term fiscal balance and the average GDP

[16] We highlighted in yellow the estimate significantly different from zero.

growth are the most significant variables for our spreads analysis. For the rest of the paper, we will only use these particular credit risk proxy variables.

- We find evidence that the crisis has a significant impact on our estimated coefficients. Thus, we will include a crisis dummy variable in our model that aims to identify the bond yield spreads determinants.

5. Unit Root Tests

In estimating error-correction models for the yield spreads, we found that coefficients on the lagged spread where typically very close to 1.0, suggesting that the spread may be non-stationary. In the case of a non-stationary series, a shock would have a permanent effect on the process as it would not come back to its trend in the long run. We are concerned with the presence of unit root in our data because the use of OLS regressions relies on the stochastic process being stationary given that the presence of a unit root can produce invalid inference. Thus in this section, we perform unit root tests in order determine if our time series are stationary and can be used in our GVAR model without any further transformation.

Data stationarity is a topic largely ignored in most of the related literature and of the studies that performed the tests, only Reboredo and Ugolini (2015)[17] could reject the null hypothesis of a unit root in bonds or CDS spreads. Favero (2013), Oliveira et al. (2012), Arghyrou and Kontonikas (2012), Kumar and Okimoto (2011) analyze all their variables in first difference in order to avoid the non-stationarity related issues. In the other hand, De Grauwe and Ji (2013) and Giordano et al. (2013) find evidence of cointegration among their variables.

We perform for each country the augmented Dickey-Fuller test for a unit root. The test involves fitting by OLS the model:

$$\Delta y_t = \alpha + \beta y_{t-1} + \delta t + \theta_1 \Delta y_{t-1} + \theta_2 \Delta y_{t-2} + \cdots + \theta_k \Delta y_{t-k} + u_t \qquad (5.1)$$

where δ_t is a coefficient on a time trend. The intuition is that the lagged value y_{t-1} will not provide any information in predicting the change in Δy_t if a unit root is present in the series.

[17] They perform the augmented Dickey-Fuller and Phillips-Perron tests on European sovereign bond price returns (8 countries) and are able to reject for each country the null hypothesis, with a 5% significance level. Their sample is composed by weekly data going from January 14. 2000 until October 26. 2012.

We specified 12 lags in our augmented Dickey-Fuller regressions, as we are dealing with monthly data, and the results can be found in Table 5.1. The p-values vary from 0.219 to 0.607. Thus, we cannot reject the null hypothesis of a unit root in the spreads. We used different lags and also performed the Phillips-Perron unit root tests and found similar outcomes. These results suggest that our spreads time series are potentially nonstationary. Alternatively, it is also possible that our unit root tests lack power as we are only working with 168 observations.

	t-stat	p-value		t-stat	p-value
Belgium	-1,713	0,424	**Italy**	-1,590	0,488
Ireland	-1,815	0,373	**Netherlands**	-1,918	0,323
Greece	-1,348	0,607	**Austria**	-1,871	0,346
Spain	-2,165	0,219	**Portugal**	-1,511	0,528
France	-1,402	0,582	**Finland**	-1,814	0,374

Table 5.1: Results of the augmented Dickey-Fuller test for the spreads on Bund

Because of the lack of power with individual unit root tests we decide to perform further tests with panel data. Indeed, the pooling approach of the following tests gives higher test power than the separate unit root tests above as it enables to work with more observations (1660 versus 168). Moreover, due to the mixed outcomes we will perform and discuss several panel tests.

According to Breitung and Pesaran (2008), the panel unit root tests can be divided into 2 distinct generations. A 1st generation that assumes series independence and a 2nd generation that was introduced, in particular, to avoid the size distortion in the case of violation of the independence assumption. The LLC and the IPS tests belong to the 1st generation and even though they were not initially designed to test dependent series, some adjustments can be made. In the other hand, the Breitung and the Pesaran CADF are among the most popular tests of the 2nd generation.

Levin et al. (2002) developed the Levin-Lin-Chu (LLC) test for panel data which allows for individual-specific intercepts and time trends. Their model is derived from the Augmented Dickey-Fuller test detailed in equation 5.1 and can be written as follows:

$$\Delta y_{it} = \alpha_i d_t + \beta_i y_{it-1} + \sum_{L=1}^{Pi} \theta_{iL} \Delta y_{it-L} + u_{it} \qquad \text{for each unit i = 1, …,N} \qquad (5.2)$$

d_t indicates the vector of deterministic variables, α_i indicates the corresponding vector of coefficients and P_i is the appropriate lag order. The error variance and the serial correlation of higher-order vary freely across individuals. However, this model assumes that all panels have the same autoregressive parameter. We test the integration of all series:

$\beta_1 = \cdots = \beta_N = \rho$ with $H_0: \rho = 1$ or $H_1: |\rho| < 1$

This test could seem rigid as it requires that the series are either all stationary or all non-stationary but it is commonly used in the related literature (i.e. De Grauwe and Ji (2013)). In order to mitigate the impact of cross-correlation among the countries, as the test assumes independent series, the authors suggest that we first subtract the cross-sectional averages from the series. The cross-sectional means are simply:

$$\overline{y_t} = \frac{1}{N}\sum_{i=1}^{N} y_{i,t} \tag{5.3}$$

Im et al. (2003) developed the Im-Pesaran-Shin (IPS) test that relaxes the assumption of a common autoregressive parameter (β in equation 5.2) across the panels. Here, we test:

$H_0: \beta_1 = \cdots = \beta_N = 1$ or $H_1: |\rho_1| < 1, \cdots, |\rho_L| < 1$ where $L = l$N, 0 < l < 1

With the IPS test, only a large fraction of individuals has to be stationary to reject the null hypothesis. This test is based on the mean of individual unit root statistics (cf. ADF, equation 5.1). More particularly, the test t-statistic is based on the ADF statistics averaged across the panels.

Breitung and Das (2005) describe the Breitung test which performs Generalized Least Squares (GLS) estimation of equation 5.1, allowing standard t-stat testing for $\beta_1 = 1$ as T and N tend to infinity and enable a standard normal limiting distribution. This test requires a larger T than N and performs better than the other tests in case of large sample size according to the authors. Moreover, the Breitung test is robust to cross-sectional dependence in the series.

Finally, Pesaran (2007) developed another robust model for strong cross-sectional dependence that is driven by an unobserved common factor f_t such as the error term $u_{i,t}$ has the following structure:

$$u_{i,t} = \omega_i f_t + \varepsilon_{i,t}$$

where $\varepsilon_{i,t}$ is an individual-specific error which is independently distributed across the series and time. With the inclusion of the cross-sectional means $\overline{y_t}$ (cf. equation 5.3) on the right side of the ADF regression (cf. equation 5.1), we obtain the cross-sectionally augmented Dickey-Fuller (CADF) regressions:

$$\Delta y_{i,t} = \alpha_{i,t} + (\beta_i - 1) y_{i,t-1} + c_i \bar{y}_{t-1} + \sum_{j=1}^{k_i} \theta_{i,j} \Delta y_{i,t-j} + \sum_{j=0}^{k_i} \Psi_{i,j} \Delta \bar{y}_{t-j} + \varepsilon_{i,t}$$

Similarly to the IPS test, Pesaran's CADF is consistent under the alternative that only a fraction of the series are stationary.

The results of the different tests can be found in Table 5.2. We can reject the null hypothesis of a unit root in all of the spreads with 3 of the 4 tests at a 5% significance level. The LLC test is the only one that fails to reject it, but as we previously mentioned it is a more rigid test where all the series have to be stationary in order to reject H_0. Thus, we find strong evidences that at least some of the spreads are stationary. Table 5.2 also exhibits the results for the independent variables, the fiscal fundamentals, and we only find significant evidence of stationarity for the GDP growth forecasts. Additional tests were made with the risk aversion series and we were not able to reject the non-stationarity hypothesis.

Variable	IPS Test	LLC test	Breitung test	Pesaran CADF
Spreads	0,019*	0,173	0,043*	0**
Debt to GDP	0,999	0,931	0,956	1
Fiscal Balance	0,502	0,634	0,316	0,093
GDP Growth	0,016*	0,175	0,051*	0,035*

Table 5.2: Panel unit root tests, p-values, sample 01.2001-12.2014[18]

** and * mean that the tests results are respectively significant at 1 and 5% levels

We cannot perform cointegration tests because we only find evidence of non-stationarity for debt to GDP and fiscal balance time series. Thus, as the estimation requires stationarity, all the data are entered in 6-period difference for the rest of the study. The non-stationarity of our initial data will no longer impact our estimates because further tests allowed us to reject the null hypothesis of unit roots in the differenced series. In the following section, we describe the econometric framework and will come back to the implications of non-stationary series for our GVAR model.

6. The Econometric Framework

To analyze the long-term determinants of the EMU sovereign bond yield spread, we adopt 2 different econometric models. Specification 6.1 is representative of most of the research previously made on the subject (Favero et al. (2010), Attinasi et al. (2010), Gerlach et

[18] For each test, we apply the Akaike Information Criterion (AIC) to select the accurate number of lags for each panel.

al. (2010) etc…) and models the sovereign spreads as persistent processes moving around a time-varying mean that is determined by fiscal fundamental factors and a global risk aversion factor.

$$\Delta(Y_t^i - Y_t^{bd}) = \beta_{i0} + \beta_{i1}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right) + \beta_{i2}\Delta\left(b_t^i - b_t^{bd}\right) + \beta_{i3}\Delta\left(d_t^i - d_t^{bd}\right) + \beta_{i4}\Delta\left(g_t^i - g_t^{bd}\right) + \beta_{i5}\Delta(Bbb_t - Aaa_t) + \beta_{i6}D_t + u_{it} \quad (6.1)$$

with $u_{it} \sim i.i.d.(0, \sum)$

The dynamic of the differential between the 10 year yields to maturity of EMU country i, Y_t^i, and the 10 year yields of German Bunds, Y_t^{bd}, are determined here by a common world factor, country specific factors and the dummy variable $D_t$capturing the global financial/euro debt crises (after March 2009). Indeed, d_t^i, b_t^i and g_t^i represent respectively the short term expected debt to GDP ratio, the long term expected budget balance and the average across horizons expected real GDP growth. $Bbb_t - Aaa_t$ stands for our risk aversion proxy and $Y_{t-1}^i - Y_{t-1}^{bd}$ is the spread the year before and aims to capture the persistence in the data such as that caused by the slow adjustment of yield spreads to persistent changes in the explanatory variables. However, model (6.1) does not control for the potential contagion within the euro area. Please remember that in the context of a GVAR model, the contagion of the spreads is based on the fiscal fundamental closeness with the other union members.

Our second model is based on the Global Vector Auto Regressive (GVAR) methodology proposed by Pesaran et al. (2004) and is able to capture the time-varying co-movements across domestic variables. We can describe the general GVAR specification as follows:

$$x_{it} = A_{i1}d_t + B_i x_{i,t-1} + \varphi_{i0}x_{i,t}^* + \varphi_{i1}x_{i,t-1}^* + u_{it} \quad (6.2)$$

where $d_t$is a vector of common exogenous variables, x_{it} is a vector of domestic variables specific to country i. Then, $x_{i,t}^*$is a vector of foreign variables specific to country i with $x_{i,t=}^* \sum_{j\neq i} w_{ij}x_{jt}$where $w_{ij}$is the share of country j in the trades (exports and imports) of country i and weights the influence of the x_{jt} variable on country i. We assume that u_{it} is a vector of country-specific idiosyncratic shocks which are serially uncorrelated with a zero mean: $u_{it} \sim i.i.d.(0, \sum)$

Model (6.2) allows the computation of foreign variables that are time-varying combinations of domestic variables and is very useful to simulate the interdependencies across countries of an integrated economic area. Pesaran et al. (2004) for instance simulate the impact on other regions of a positive shock on German real GDP and equity prices. In that case, the impact size for the different countries would be based on the size of their trades with Germany relative to the total German trades. "This approach aggregates regional cointegrated systems into a unified global system."[19]

In our analysis of the euro area spreads, we consider a GVAR specification inspired by Favero (2013) and Favero and Missale (2012) that allows for a time-varying relation between fiscal fundamentals and sovereign bond spreads. The model can be written as follows:

$$\Delta\left(Y_t^i - Y_t^{bd}\right) = \beta_{i0} + \beta_{i1}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right) + \beta_{i2}\Delta\left(b_t^i - b_t^{bd}\right) + \beta_{i3}\Delta\left(d_t^i - d_t^{bd}\right) + \beta_{i4}\Delta\left(g_t^i - g_t^{bd}\right) + \beta_{i5}\Delta(Bbb_t - Aaa_t) + \beta_{i6}D_t + \beta_{i7}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^b + \beta_{i8}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^d + \beta_{i9}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^g + u_{it} \quad (6.3)$$

with $u_{it} \sim i.i.d.(0, \sum)$

$\left(Y_t^i - Y_t^{bd}\right)^k = \sum_{j\neq i} w_{ji}^k \left(Y_t^j - Y_t^{bd}\right)$ k = b, d, g

$w_{ji}^k = \frac{w_{ji}^{*,k}}{\sum_{j\neq i} w_{ji}^{*,k}}$ $w_{ji}^{*,k} = \frac{1}{\mathrm{dist}_{ji}^k}$

$\mathrm{dist}_{ji}^b = E_t\left(\left|b_t^j - b_t^i\right|\right)/0.6$

$\mathrm{dist}_{ji}^d = E_t\left(\left|d_t^j - d_t^i\right|\right)/3$

$\mathrm{dist}_{ji}^g = E_t\left(\left|g_t^j - g_t^i\right|\right)$

The standard model specification (6.1) is here augmented by 3 distinct weighted averages of spreads among the euro area that are designed to capture the contagion in the Eurozone. In contrast to the model (6.2) proposed by Pesaran et al. (2004), the weights are not based on the trades but are computed as a function of the level of debt, fiscal balance and growth. Indeed, the closer a country J is in terms of fiscal fundamentals with a country I, the bigger a change of its spread will impact the spreads of country I. As our fiscal data are based on the European Commission forecasts, the weights are changing approximately every 6 months. Moreover, the distance in terms of debt and fiscal balance is rescaled by the

[19] Pesaran, Hashem, Til Schuermann et Scott M. Weiner (2004). « Modeling Regional Interdepencies using a Global Error-Correcting Macroeconomic Model », *Journal of Business and Economic Statistics*, vol. 22, no 2, p. 159.

respective values specified in the Maastricht Treaty, 60% and 3% of GDP. According to Favero (2013): "This re-scaling allows to measure the two distances in the same metric of percentage deviation from the Maastricht reference point, and it makes them comparable.[20]"

With our GVAR model (6.3), we can capture the contagion effects of fiscal imbalances in the EMU in determining the sovereign bond yields as the introduction of the weighted global variables makes the spreads of each country dependent on fiscal and macroeconomic fundamentals of the whole euro area.

Our model differs in many points with the one developed by Favero (2013) and Favero and Missale (2012)[21]. First of all, we remove the risk aversion lagged variable because it was not significant in our estimations, and there was no obvious economic motivation for its inclusion. Then, we added the expected growth, and subsequently the growth weighted contagion variable because it explained spreads changes significantly in our event study. We also included a dummy variable in the spirit of equation (6.1) to capture the financial crisis effects that the other variables were not able to explain. Finally, when Favero and Missale used the first difference for the spreads on Bunds and the risk aversion factor, we work with 6-period difference data because of the bi-annual fiscal forecasts presence in our analysis[22]. Indeed, because of the results of the unit root tests, above, all the variables are entered in 6th difference (indicated by Δ) as the estimation requires stationarity.

[20] Page 347

[21] $\Delta\left(Y_t^i - Y_t^{bd}\right) = \beta_{i0} + \beta_{i1}\left(Y_{t-1}^i - Y_{t-1}^{bd}\right) + \beta_{i2}(Baa_{t-1} - Aaa_{t-1}) + \beta_{i3}\left(b_t^i - b_t^{bd}\right) + \beta_{i4}\left(d_t^i - d_t^{bd}\right) + \beta_{i5}\Delta(Baa_t - Aaa_t) + \beta_{i6}\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^b + \beta_{i7}\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^d + u_{it}$ with $u_{it} \sim i.i.d.(0, \sum)$

$\left(Y_t^i - Y_t^{bd}\right)^k = \sum_{j\neq i} w_{ji}^k \left(Y_t^j - Y_t^{bd}\right)$ k = b, d

$w_{ji}^k = \frac{w_{ji}^{*,k}}{\sum_{j\neq i} w_{ji}^{*,k}}$ $w_{ji}^{*,k} = \frac{1}{\text{dist}_{ji}^k}$

$\text{dist}_{ji}^b = E_t\left(\left|b_t^j - b_t^i\right|\right)/0.6$

$\text{dist}_{ji}^d = E_t\left(\left|d_t^j - d_t^i\right|\right)/3$

[22] Similar analysis were performed with 1st difference data but the estimated coefficients were non-significant (cf. Appendix Table 1). Given that we are working with monthly observations but that fiscal forecasts only change twice per year, the first differences of the fiscal variables are therefore equal to zero in five out of six months. The use of six-period differences avoids this.

7. Estimation Results

In this section, we apply our models to describe the European sovereign bond yield spreads' components. We begin with a panel data estimation to show how the GVAR model dominates the standard one in modeling the response of European spreads to the debt crisis. Moreover, this analysis gives us a first outlook of the factors influencing the spreads with the estimation of fixed coefficients across the Eurozone countries. In a second part, we estimate more detailed results with the use of country by country data.

7.1 Panel Data Analysis

The results of the estimation of the GVAR (6.3) and of the standard model (6.1), implemented in panel data via pooled OLS regression with Driscoll and Kraay standard errors[23], are reported in Table 7.1. The full panel is composed of the 10 euro area countries for a total number of 1620 observations. Moreover, the GIIPS (Greece, Ireland, Italy, Portugal and Spain) and the Core countries (Belgium, France, Netherland, Austria and Finland) each represent 810 observations.

The independent variables are barely significant when we estimate fixed coefficients across the Eurozone countries: the contagion effect based on growth (β_9) and on debt (β_7) are significant at a 5% level whereas the risk aversion (β_5) and the expected growth have a 10% significance. According to this first analysis, the global risk aversion and contagion effects can partly explain the Eurozone spreads increase during the sample period. This is consistent with the related literature findings that the spreads are mainly driven by an international factor but the weak influence of country specific variables is quite surprising. However, these results have to be mitigated because of the small explanatory power of our independent variables outlined by the 29% R-squared. There seems to be a lack of consensus across euro countries in terms of spreads determinants.

When we previously described the data, we documented how the spreads and the fiscal fundamentals differed since 2009 between the GIIPS and the rest of the Eurozone

[23] Driscoll and Kraay (1998) introduced a nonparametric covariance matrix estimator that produces robust standard errors to heteroscedasticity and cross-sectional correlation in the case of panel data. Therefore, the use of Newey-West estimators (Newey and West (1987)) for this analysis gave similar results.

which is why we decided to reestimate the GVAR model with 2 distinct panels: Core and GIIPS. The model explicative power improved and it now explains respectively 56% and 37% of the spreads movements for the Core countries and the GIIPS. The Core's and the GIIPS' spreads seem to be driven by different factors: the risk aversion is only significant for the Core countries while the GIIPS' spreads were significantly impacted by the contagion variables based on debt and growth. It implies that spreads for Core countries will tend to move together since the risk aversion proxy is common while those for the GIIPS will vary more across countries to the extent that their fiscal variables differ.

	β0	β1	β2	β3	β4	β5	β6	β7	β8	β9	Adj. R-squared	Prob>F
Full Panel	-0,040	-0,134	0,001	-0,066	-0,235	0,175	0,109	0,361	-0,080	0,311	0,29	0.000
	(0,0668)	(0,1767)	(0,0538)	(0,1213)	(0,1136)	(0,0872)	(0,1562)	(0,0936)	(0,1062)	(0,049)		
	[0,57]	[0,47]	[0,99]	[0,60]	[0,07]	[0,08]	[0,50]	[0,00]	[0,47]	[0,00]		
	-0,075	-0,140	-0,010	-0,064	-0,330	0,424	0,274				0,14	0,120
	(0,0853)	(0,2235)	(0,0597)	(0,1222)	(0,1779)	(0,1389)	(0,1319)					
	[0,40]	[0,55]	[0,87]	[0,61]	[0,10]	[0,01]	[0,40]					
Core	-0,012	-0,124	-0,009	-0,021	0,012	0,126	0,034	0,081	0,030	0,009	0,56	0.001
	(0,0123)	(0,1212)	(0,0045)	(0,0165)	(0,0221)	(0,0145)	(0,0286)	(0,0346)	(0,0191)	(0,0144)		
	[0,37]	[0,37]	[0,11]	[0,28]	[0,60]	[0,00]	[0,30]	[0,08]	[0,20]	[0,56]		
	-0,019	-0,187	-0,013	-0,031	0,015	0,160	0,057				0,50	0,003
	(0,0149)	(0,1374)	(0,0051)	(0,0181)	(0,0256)	(0,0202)	(0,0380)					
	[0,26]	[0,25]	[0,06]	[0,16]	[0,64]	[0,00]	[0,21]					
GIIPS	-0,086	-0,176	-0,011	-0,131	-0,272	0,271	0,321	0,600	0,138	0,343	0,37	0.000
	(0,0927)	(0,1626)	(0,0663)	(0,1566)	(0,1239)	(0,1624)	(0,2969)	(0,1411)	(0,1329)	(0,0507)		
	[0,41]	[0,34]	[0,88]	[0,45]	[0,09]	[0,17]	[0,34]	[0,01]	[0,36]	[0,00]		
	-0,142	-0,165	-0,022	-0,079	-0,462	0,687	0,594				0,19	0,237
	(0,1316)	(0,2154)	(0,0727)	(0,1653)	(0,2077)	(0,2526)	(0,3226)					
	[0,34]	[0,49]	[0,78]	[0,66]	[0,09]	[0,05]	[0,14]					

Table 7.1: Spreads on Bunds, regressions with Driscoll and Kraay standard errors and a maximum of 12 lags, monthly data (6^{th} difference) GVAR model, sample 01.2001-12.2014

The numbers in brackets ( ) are the standard errors for each estimated coefficients and the figures in square brackets [ ] stand for the pvalues. Prob>F gives the probability with which we can reject the null hypothesis that all the estimated coefficients are 0.

$$\Delta\left(Y_t^i - Y_t^{bd}\right) = \beta_{i0} + \beta_{i1}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right) + \beta_{i2}\Delta\left(d_t^i - d_t^{bd}\right) + \beta_{i3}\Delta\left(b_t^i - b_t^{bd}\right) + \beta_{i4}\Delta\left(g_t^i - g_t^{bd}\right) + \beta_{i5}\Delta(Bbb_t - Aaa_t) + \beta_{i6}D_t + \beta_{i7}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^d + \beta_{i8}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^b + \beta_{i9}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^g + u_{it}$$

Then, we test the hypothesis that the contagion variables β_7, β_8, β_9, are jointly significantly different from 0 in order to validate the inclusion of such factors into the standard model. With a 59.6 F-statistic and a p-value of 0, we can fairly say that the GVAR contagion variables should remain in our model and support the assumption of contagion effects in the euro area during the sample period. This conclusion is confirmed by the differences in R-squared between the estimates in Table 7.1, with and without contagion variables. It is interesting to note that the removal of the contagion variables mostly affected the global risk aversion and the crisis dummy coefficients which more than doubled with the full panel and the GIIPS data estimations. Therefore, the coefficients estimated without the GVAR contagion variables, are systematically smaller than the ones from the GVAR model. More importantly, the F-statistic for GIIPS panel suggests that there is no evidence that any of the non-GVAR variables has a significant impact on the spreads movements. The risk aversion is the only variable significant at 5% and these results show that the surge of spreads for the GIIPS cannot be explained by our non-GVAR fiscal fundamental factors. Overall, we find that the inclusion of the GVAR contagion variables significantly improves the model goodness of fit. We find evidence that our GVAR model dominates the standard one in modelling the sovereign bond yield spreads movements during our sample period.

We performed similar estimations of the GVAR model but with the data in first difference and in level (cf. respectively Tables 1 and 2 of the Appendix). Even if the outcomes are slightly different, the conclusions remain the same: the euro spreads were significantly affected by a global risk aversion factor, in particular Core countries, and by contagion factors (especially the GIIPS).

7.2 Country by Country Analysis

Further to our findings suggesting a lack of consensus across Euro countries in terms of spreads determinants, we perform country by country analysis with our GVAR model. The estimated results implemented via the SUR method with robust standard errors can be found in Table 7.2.

Few comments can be made based on the Table 7.2 estimates:

- The R-squared vary from 57%, in the case of Ireland, to 84% for Portugal which is a vast improvement from the 37% found with the GIIPS panel. It shows the importance of idiosyncratic behavior in the spreads movements.

- The risk aversion coefficient is significant for every country except Greece, which is consistent with the outcomes displayed in Tables 7.1 and 7.2 and shows the importance of international risk regarding spreads dynamics.

	β0	β1	β2	β3	β4	β5	β6	β7	β8	β9	R-squared	Prob>F
BE	-0,061	-0,134	-0,029	-0,005	0,018	0,203	0,104	0,153	0,018	0,028	0,71	0.000
	(0,0140)	(0,0621)	(0,0055)	(0,0236)	(0,0427)	(0,0278)	(0,0427)	(0,0524)	(0,0486)	(0,0440)		
	[0,00]	[0,03]	[0,00]	[0,83]	[0,67]	[0,00]	[0,01]	[0,00]	[0,71]	[0,53]		
IR	0,084	-0,499	0,097	-0,083	0,220	0,222	-0,643	0,171	0,304	0,07	0,57	0.000
	(0,0424)	(0,1435)	(0,0187)	(0,0553)	(0,0444)	(0,0922)	(0,2339)	(0,1378)	(0,0747)	(0,1901)		
	[0,05]	[0,00]	[0,00]	[0,13]	[0,00]	[0,02]	[0,01]	[0,22]	[0,00]	[0,70]		
GR	-0,232	-0,172	-0,176	-0,204	-0,884	0,145	1,508	5,440	-0,951	-0,427	0,72	0.000
	(0,0895)	(0,0374)	(0,0374)	(0,0664)	(0,2110)	(0,1729)	(0,4521)	(1,2819)	(0,6485)	(0,3153)		
	[0,10]	[0,01]	[0,00]	[0,00]	[0,00]	[0,40]	[0,00]	[0,00]	[0,14]	[0,18]		
SP	-0,030	0,163	-0,015	0,052	-0,086	0,147	0,167	-0,105	-0,559	-0,145	0,69	0.000
	(0,0280)	(0,0758)	(0,0133)	(0,0274)	(0,0909)	(0,0481)	(0,1080)	(0,1935)	(0,1161)	(0,0477)		
	[0,29]	[0,03]	[0,25]	[0,06]	[0,34]	[0,00]	[0,12]	[0,59]	[0,00]	[0.00]		
FR	0,005	-0,114	-0,026	-0,002	0,041	0,076	0,061	0,022	0,026	0,138	0,65	0.000
	(0,0060)	(0,0987)	(0,0075)	(0,0140)	(0,0316)	(0,0178)	(0,0301)	(0,0323)	(0,0323)	(0,0483)		
	[0,39]	[0,25]	[0,00]	[0,86]	[0,20]	[0,00]	[0,04]	[0,49]	[0,43]	[0,00]		
ITA	-0,045	0,045	-0,056	0,057	-0,167	0,360	0,244	0,307	0,026	-0,154	0,66	0.000
	(0,0246)	(0,0588)	(0,0150)	(0,0338)	(0,0997)	(0,0667)	(0,1010)	(0,0928)	(0,0261)	(0,1095)		
	[0,07]	[0,45]	[0,00]	[0,09]	[0,09]	[0,00]	[0,02]	[0,00]	[0,32]	[0,16]		
ND	0,005	0,011	0,002	-0,008	0,006	0,097	-0,004	-0,029	-0,048	-0,010	0,58	0.000
	(0,0074)	(0,0641)	(0,0046)	(0,0085)	(0,0214)	(0,0090)	(0,0193)	(0,0274)	(0,0283)	(0,0339)		
	[0,47]	[0,87]	[0,74]	[0,33]	[0,79]	[0,00]	[0,83]	[0,29]	[0,09]	[0,77]		
AT	-0,002	-0,117	0,010	-0,004	0,086	0,162	0,003	-0,106	0,225	-0,008	0,75	0.000
	(0,0082)	(0,0649)	(0,0044)	(0.0103)	(0,0373)	(0,0141)	(0,0237)	(0,0532)	(0,0459)	(0,0232)		
	[0,81]	[0,07]	[0,02]	[0,67]	[0,02]	[0,00]	[0,92]	[0,05]	[0,00]	[0,74]		
PT	-0,024	-0,101	-0,011	-0,041	-0,369	0,117	0,189	0,864	0,430	0,308	0,84	0.000
	(0,0265)	(0,0525)	(0,0244)	(0,0502)	(0,0773)	(0,0636)	(0,1216)	(0,1394)	(0,2603)	(0,0394)		
	[0,37]	[0,05]	[0,65]	[0,42]	[0,00]	[0,07]	[0,12]	[0,00]	[0,10]	[0,00]		
FIN	-0,010	-0,178	-0,009	0,006	-0,029	0,132	0,032	-0,026	-0,046	0,065	0,70	0.000
	(0,0082)	(0,0488)	(0,0040)	(0,0073)	(0,0067)	(0,0092)	(0,0151)	(0,0392)	(0,0440)	(0,0235)		
	[0.22]	[0,00]	[0,02]	[0,42]	[0,00]	[0,00]	[0,03]	[0,50]	[0,30]	[0,01]		

Table 7.2: Spreads on Bunds, SUR method, monthly data GVAR model, sample 01.2001-12.2014

The numbers in brackets ( ) are the standard errors for each estimated coefficients and the figures in square brackets [ ] stand for the pvalues. Therefore, the Prob>F represents the probability that all the estimated coefficients are not significantly different from 0.

$$\Delta\left(Y_t^i - Y_t^{bd}\right) = \beta_{i0} + \beta_{i1}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right) + \beta_{i2}\Delta\left(d_t^i - d_t^{bd}\right) + \beta_{i3}\Delta\left(b_t^i - b_t^{bd}\right) + \beta_{i4}\Delta\left(g_t^i - g_t^{bd}\right) + \beta_{i5}\Delta\left(Bbb_t - Aaa_t\right) + \beta_{i6}D_t + \beta_{i7}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^d + \beta_{i8}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^b + \beta_{i9}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^g + u_{it}$$

- Concerning the expected debt, the significant coefficients of France, Italy, Greece, Finland and Belgium are surprisingly negative which means that a debt increase relative to Germany should lower the spreads. Ireland and Austria are the only countries with a significant positive estimate.

The results for 2 particular countries caught our attention:

- In the case of Ireland, the growth coefficient (5% significant) is positive. Thus a 1 percentage point growth increase relative to Germany would increase the Irish spread by 22 basis points. Moreover, its estimated coefficient for the dummy variable is negative, which means that the start of the financial crisis decreased the Irish spread by 64 basis points. This outcome is quite puzzling and suggests that our model has difficulties in predicting accurately the Irish spreads as it represents more than likely the spreads changes that the independent variables were not able to capture during the financial crisis. Nevertheless, the significant Debt, Growth and contagion (based on debt and growth) factors partly explain the recent Irish spread rise.
- Greece is the only country with all 3 fiscal fundamentals coefficients significant. Nonetheless, the negative sign for the expected debt coefficient, which would translate into an 18 basis point spread decrease for a 1 percentage point (pp) rise of the debt relative to Germany, is counter-intuitive and differs from the related literature findings. We also note the sizeable influence of the crisis dummy variable and the contagion effect based on debt closeness, as they are 10 times larger than for other Eurozone countries with respectively 1.51pp and 5.44pp spread increases.

Overall, based on this analysis, most countries look like a special case, and we barely find a clear consensus in the coefficients as Tables 7.1 and 7.2 suggested. The expected debt to GDP and the global risk aversion variables are significant (at least 5% level) for respectively 7 and 8 countries and seem to be the main drivers of the euro area spreads. We also find evidence of significant contagion effect for 9 out of the 10 countries, Netherland being the exception, and the coefficient estimates show particularly strong influence on the Greek and Portuguese bonds. In the following section, we use the coefficients estimated above for out-of-sample forecasting of the spreads. The comparison between our forecasts and actual figures allows us to test the accuracy of our GVAR model in projecting the Eurozone spreads in the medium-term.

8. Simulation Forecast

We use the country by country coefficient estimates displayed in Table 7.2 to forecast the first 6 months spreads in 2015 which allows us to observe a concrete application of our GVAR model. We can see in Figure 8.1 the comparison between the forecasts and the actual data published by the European Central Bank[24].

Moreover, we displayed in Table 8.1 the difference between the actual figures and the estimated forecasts for each month, the Mean Error (ME), the Mean Absolute Error (MAE) and the Mean Absolute Percentage Error (MAPE[25]) for each country in order to analyze the model accuracy.

	Belgium	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
2015/01	-0,08	0,27	5,64	-0,68	-0,20	-0,78	-0,21	-0,38	-0,46	-0,09
2015/02	0,01	0,56	4,90	-0,58	-0,19	-0,74	-0,15	-0,29	-0,64	-0,07
2015/03	0,01	0,49	5,85	-0,63	-0,18	-0,76	-0,15	-0,27	-0,90	-0,07
2015/04	0,04	0,44	5,91	-0,45	-0,19	-0,73	-0,07	-0,25	-0,85	-0,09
2015/05	0,07	0,33	0,94	0,08	-0,12	-0,28	0,02	-0,41	-2,55	-0,02
2015/06	0,16	0,34	0,49	0,84	0,08	-0,17	0,16	-0,56	-3,29	-0,07
ME	0,04	0,41	3,95	-0,24	-0,13	-0,57	-0,07	-0,36	-1,45	-0,07
MAE	0,06	0,43	3,67	0,47	0,15	0,54	0,10	0,36	1,61	0,07
MAPE	0,18	0,58	0,39	0,46	0,53	0,47	0,91	2,08	0,75	0,38

Table 8.1: Difference between the actual figures and the estimated forecasts, 01.2015-06.2015

[24] Please note that when we compute the GVAR contagion variables ($\beta_{i7}\Delta\left(Y_{t-1}^{i} - Y_{t-1}^{bd}\right)^{d}$, $\beta_{i8}\Delta\left(Y_{t-1}^{i} - Y_{t-1}^{bd}\right)^{b}$, $\beta_{i9}\Delta\left(Y_{t-1}^{i} - Y_{t-1}^{bd}\right)^{g}$) we use our estimates as the weighted lagged spreads instead of the actual figures which can potentially increase the forecast errors but is consistent with 6 months spreads forecast. In other words, we use our previous spreads forecasts (Y_{t-1}^{i}) in order to get the impact of the contagion variables and ultimately the new spread forecasts (Y_{t}^{i}).

[25] MAPE = $\frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|$, with A_t being the actual value and F_t the forecast value

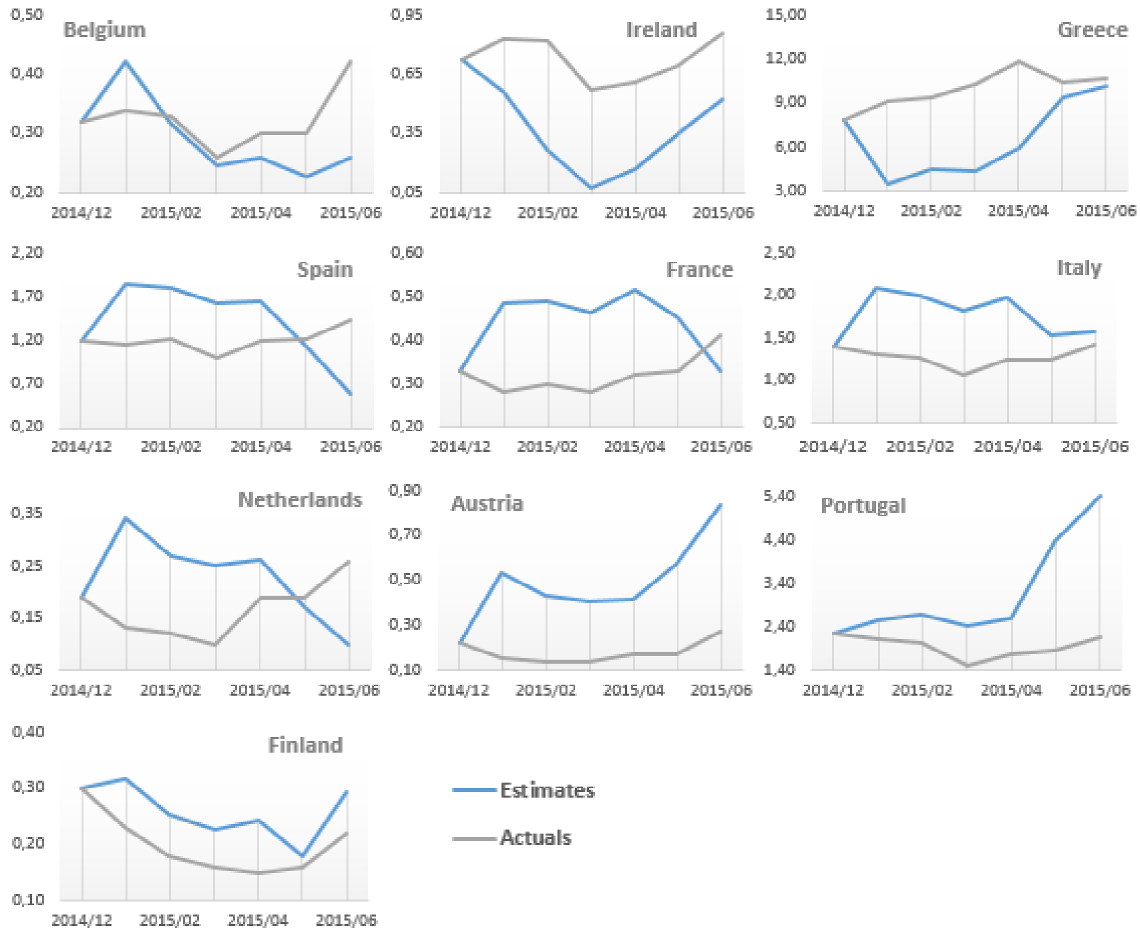


Figure 8.1: Comparison between the estimated forecasts and the actual figures, 01.2015 - 06.2015

Thanks to the MAPE we can compare the forecasting errors even if the level of the series is different across countries. On average, the errors are quite large as half of the countries have a mean absolute error 50% bigger than the actual figures and with the exception of Greece and Ireland, the model tends to overestimate the spreads, as confirmed by the negative mean errors (ME). This is especially true for Austria, with a MAPE of 2.08, as the estimates are systematically 2 times higher than the actuals during the sample period. This outcome is a little bit surprising because, with a 0.75 R-squared and 5 significant coefficients at a 5% level the model seems to fit well the Austria spread data. It can be explained by the fact that in the Austrian case, the spread forecasts have been driven up by the contagion variable because of the proximity to Greece in terms of fiscal balance expectations.

However, when we look at the MAEs we can mitigate the size of these forecasting errors: it only represents 36bp in the case of Austria and respectively 0.10 and 0.15bp for Netherlands and France. Therefore, the forecasts for Belgium, Greece and Finland are fairly accurate with respective MAPEs of 0.18, 0.39 and 0.38.

The Greek, Italian, French and Finnish cases are interesting because even if the first few estimates are significantly different from the actuals, they end up very close in the long run at the 6th month. This is a tendency that is confirmed for all the countries when we average the MAPE across countries for each month as we can observe the highest errors in January (MAPE=0.79) and the lowest for the last 3 months, with respective MAPEs of 0.59, 0.54 and 0.63. The model seems to be more accurate when forecasting spreads for longer horizons.

8.1 Greek Bailout Simulation

With the recent discussions about a new bailout program for Greece and its possible debt restructuration, we simulated 2 scenarios inspired by the information given by the IMF in its “Preliminary Draft Debt Sustainability Analysis” (2015). The 1st scenario assumes a debt to GDP reaching 200%, while all the other factors remain constant and are equal to the values at the end of June 2015, and the 2nd scenario differs only in assuming a 30% decrease in the debt ratio that would ultimately reach 142%. We find that in the case of a 3rd bailout program and the absence of debt restructuring (scenario 1), the Greek spread would reach 8.65%. Moreover, the GVAR model forecasts a 10.37% spread with the scenario 2 and 9.23% if the variables stay the same as in the end June. The negative sign associated with the debt to GDP coefficient in our model and the unrealistic assumption that all the other variables remain constant can explain these puzzling outcomes. Indeed, the fiscal balance would more than likely decrease in the event of the large debt rise described in the 1st scenario and one can also assume that a change of the global risk factor would significantly influence the spread.

9. Conclusions

In this paper, we studied the determinants of long-term government bond yield spreads against Germany in 10 Eurozone countries using a set of potential factors over the period 01.2001-12.2014. Contagion effect among bond spreads in the euro area is an important pattern in the data which is not captured by standard models (2.1). Thus, this paper has proposed to extend the GVAR model described by Favero (2013), which allows for changing interdependence among spreads, with the inclusion of a new risk aversion proxy based on European data, real GDP growth forecasts capturing the credit risk and a dummy variable for the crisis. In order to specify our model and identify the possible bias in our data, we did various analysis: we compared the EC forecasts with historical data in Section 3, we performed an event study in Section 4 and unit root tests in Section 5.

The results estimated in Section 7 with our GVAR model suggest a lack of consensus among euro countries and significant differences between the GIIPS and the Core countries in terms of spreads determinants. Moreover by taking the model to country by country data, the R-squared drastically increase which shows the importance of idiosyncratic behavior in the spreads movements. Overall, we find that the sovereign bond yield spreads were mainly influenced by the expected debt to GDP, the risk aversion and the contagion factors, which is in line with the related literature findings.

The evidence of significant contagion effect for 9 out of the 10 countries suggests that the euro area countries might benefit from a reduction of the crisis propagation risk. This has been part of the motivation for the proposed creation of a Eurobond[26] or of "a lender of last resort", similar to the European Stability Mechanism but with much higher authorized capitals, which could help to prevent crises. A lender of last resort or a Eurobond can potentially remove the default risk differentials in the EMU, and the different European bond yields would be seen as substitutes similarly to the precrisis period. However, such measures could negatively affect fiscal discipline by removing incentives for budgetary policies and would imply a risk transfer, away from the Member States with the weakest fiscal fundamentals. The increasing differentials in terms of fiscal performance among the EMU increase the cost of the above crisis prevention measures for the safest countries and ultimately weakens the unity of the EMU. As this cost increases, the inception of a Eurobond or a lender of last resort becomes less likely, and the euro area countries will remain exposed to potential irrational market behaviors and spillover effects.

In future research, it would be interesting to quantify the EMU breakeven point where the crisis prevention costs for the safest countries would offset the benefits coming from the risk reduction of crisis propagation. Therefore, we think that our GVAR model specification

[26] We call Eurobond a single debt instrument issued by EMU Member States, backed by joint guarantees.

could be improved with additional credit risk and common variables that could better explain the spreads during the European debt crisis. The European Central Bank, for example, publishes its global risk aversion indicator and could be considered. It is "constructed as the first principal component of five currently available risk aversion indicators, namely Commerzbank Global Risk Perception, UBS FX Risk Index, Westpac's Risk Appetite Index, BoA ML Risk Aversion Indicator and Credit Suisse Risk Appetite Index."[27] Finally, future research should address the issues related to the presence of a unit root in some of the spreads and fiscal fundamental time series.

[27] http://sdw.ecb.europa.eu/reports.do?node=1000003391

APPENDIX

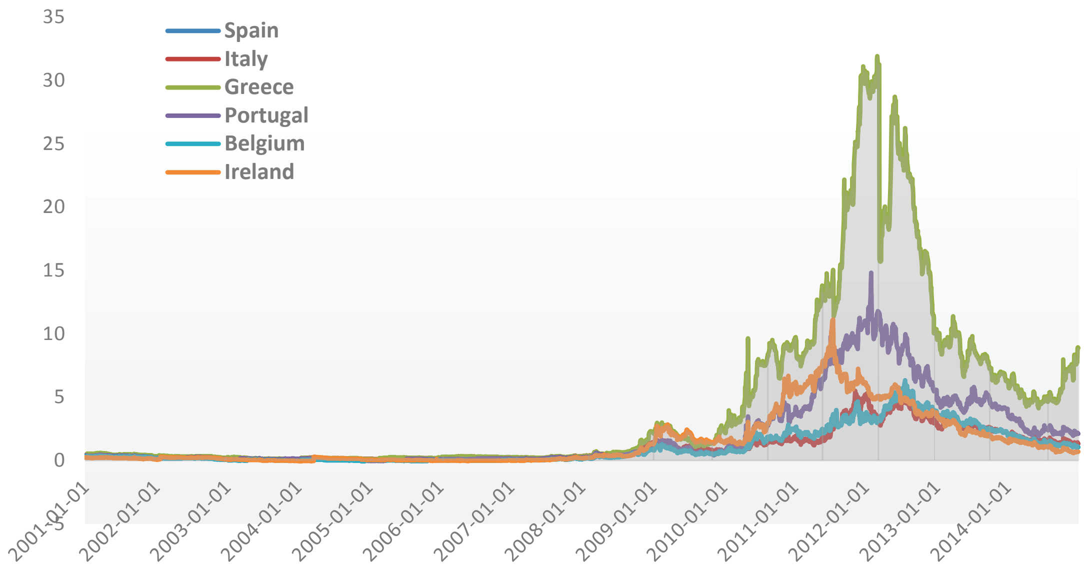


Figure 1: Government 10YR Bond Spreads for the High Yielders, sample 01.2001-12.2014

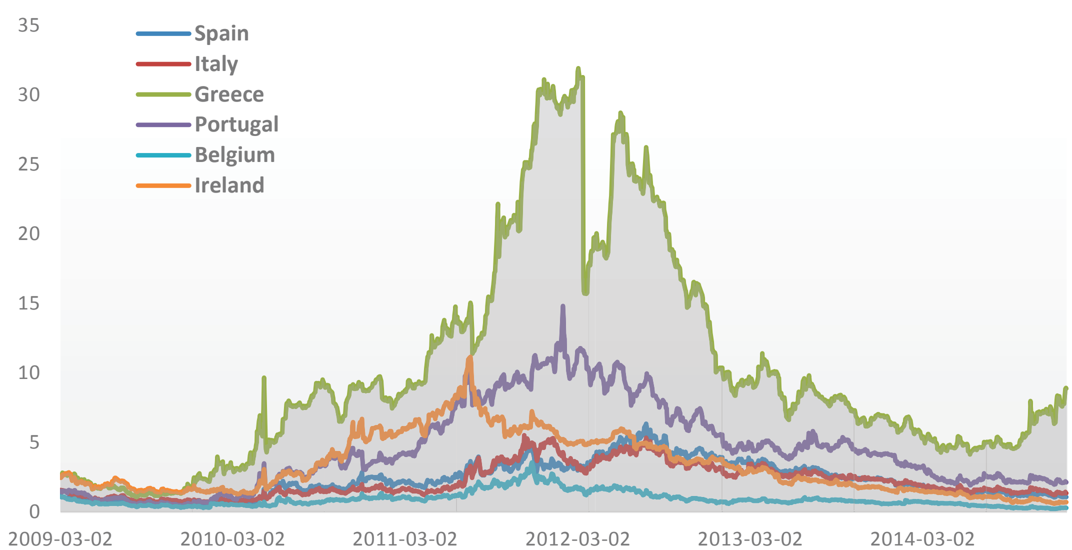


Figure 2: Government 10YR Bond Spreads for the High Yielders, Crisis Period sample

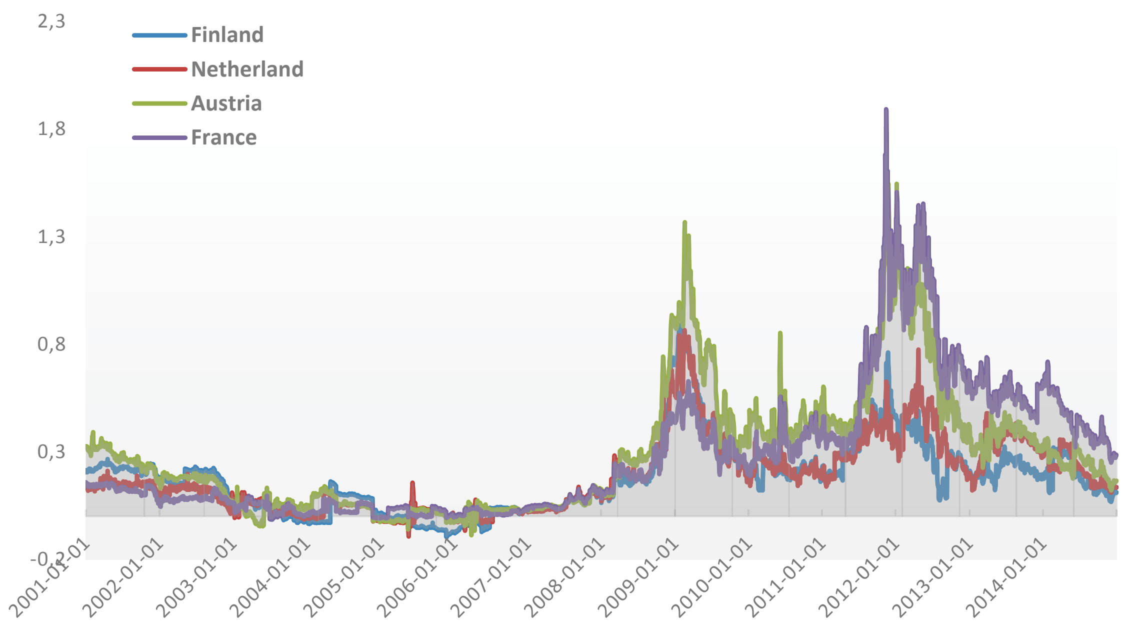


Figure 3: Government 10YR Bond Spreads for the Low Yielders, sample 01.2001-12.2014

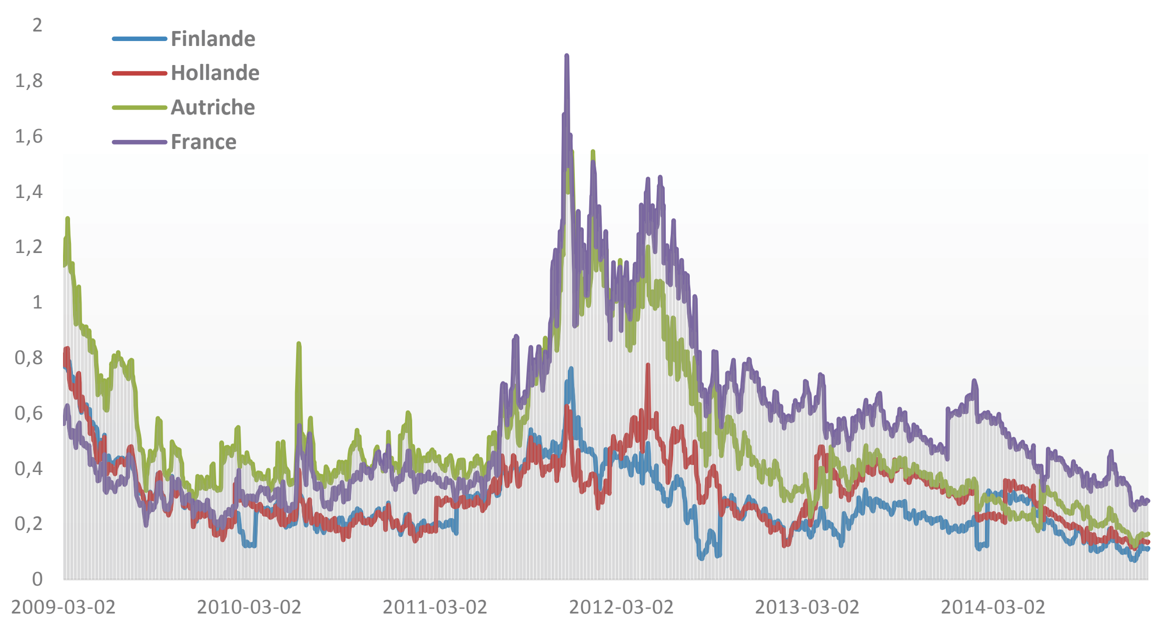


Figure 4: Government 10YR Bond Spreads for the Low Yielders, Crisis Period sample

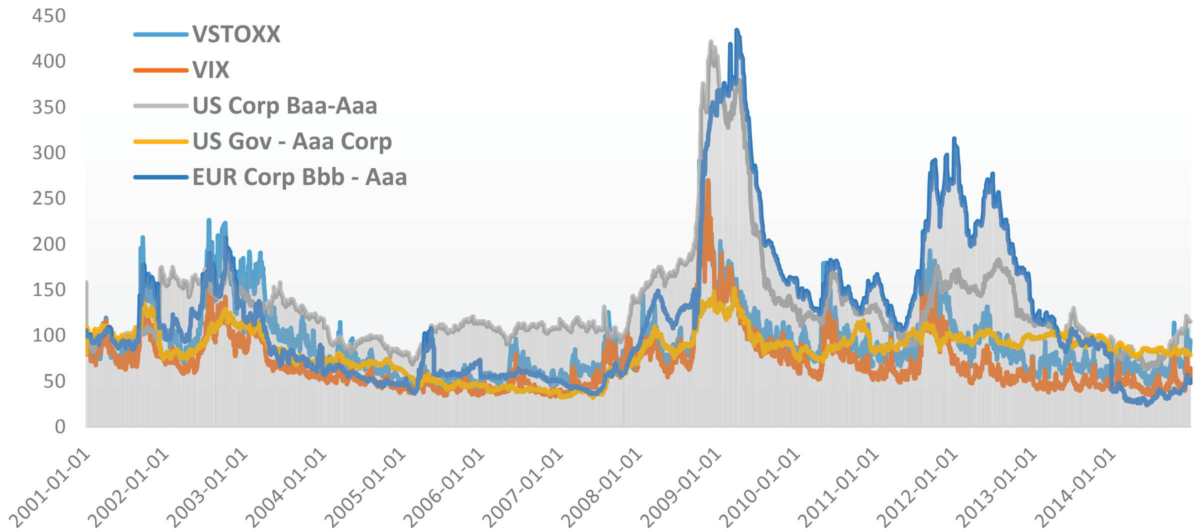


Figure 5: Comparison of the main Risk Aversion Proxies used in the related literature

	β0	β1	β2	β3	β4	β5	β6	β7	β8	β9	R-squared	Prob>F
Full Panel	-0,003	-0,138	-0,003	-0,030	-0,026	0,236	0,025	0,201	0,054	-0,011	0,06	0,077
	(0,0054)	(0,0641)	(0,0090)	(0,0193)	(0,0505)	(0,0802)	(0,0388)	(0,0875)	(0,0453)	(0,0293)		
	[0,62]	[0,06]	[0,73]	[0,15]	[0,63]	[0,02]	[0,53]	[0,05]	[0,26]	[0,71]		
Core Countries	0,002	0,021	-0,005	-0,016	0,015	0,100	-0,003	-0,002	-0,040	0,016	0,15	0,030
	(0,0037)	(0,0513)	(0,0023)	(0,0118)	(0,0136)	(0,0199)	(0,0125)	(0,0146)	(0,0409)	(0,0177)		
	[0,68]	[0,70]	[0,09]	[0,24]	[0,33]	[0,01]	[0,84]	[0,88]	[0,38]	[0,54]		
GIIPS	-0,007	-0,151	-0,007	-0,045	-0,018	0,366	0,055	0,398	0,079	-0,005	0,08	0,067
	(0,0087)	(0,0634)	(0,0139)	(0,0299)	(0,0631)	(0,1421)	(0,0748)	(0,1219)	(0,0477)	(0,0316)		
	[0,46]	[0,08]	[0,66]	[0,21]	[0,79]	[0,06]	[0,50]	[0,03]	[0,18]	[0,88]		

Table 1: Spreads on bunds, Regressions with Driscoll and Kraay standard errors and a maximum of 12 lags, Monthly data (in 1st difference) GVAR model, sample 01.2001-12.2014

The numbers into brackets ( ) are the standard errors for each estimated coefficients and the figures into square brackets [ ] stand for the pvalues. Therefore, the Prob>F represents the probability that all the estimated coefficients are not significantly different from 0.

$$\Delta\left(Y_t^i - Y_t^{bd}\right) = \beta_{i0} + \beta_{i1}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right) + \beta_{i2}\Delta\left(d_t^i - d_t^{bd}\right) + \beta_{i3}\Delta\left(b_t^i - b_t^{bd}\right) + \beta_{i4}\Delta\left(g_t^i - g_t^{bd}\right) + \beta_{i5}\Delta(Bbb_t - Aaa_t) + \beta_{i6}D_t + \beta_{i7}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^d + \beta_{i8}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^b + \beta_{i9}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^g + u_{it}$$

	β0	β1	β2	β3	β4	β5	β6	β7	β8	β9	R-squared	Prob>F
Full Panel	-0,229	0,498	0,012	-0,095	-0,101	0,312	-0,947	-0,196	0,149	0,725	0,73	0,000
	(0,1192)	(0,1434)	(0,0061)	(0,0382)	(0,1061)	(0,1259)	(0,4154)	(0,1411)	(0,1659)	(0,0521)		
	[0,09]	[0,01]	[0,01]	[0,04]	[0,37]	[0,04]	[0,05]	[0,20]	[0,39]	[0,00]		
Core Countries	-0,039	0,215	0,002	-0,009	0,023	0,101	-0,077	0,210	-0,053	0,039	0,81	0,000
	(0,0321)	(0,0777)	(0,0009)	(0,0069)	(0,0246)	(0,0203)	(0,0612)	(0,0514)	(0,0437)	(0,0269)		
	[0,29]	[0,05]	[0,07]	[0,27]	[0,41]	[0,01]	[0,27]	[0,02]	[0,29]	[0,23]		
GIIPS	-0,475	0,416	0,015	-0,133	-0,059	0,435	-0,749	-0,241	0,294	0,775	0,74	0,000
	(0,2576)	(0,1293)	(0,0076)	(0,0816)	(0,1032)	(0,2315)	(0,5874)	(0,1229)	(0,1903)	(0,0569)		
	[0,14]	[0,03]	[0,12]	[0,18]	[0,60]	[0,13]	[0,27]	[0,12]	[0,20]	[0,00]		

Table 2: Spreads on bunds, Regressions with Driscoll and Kraay standard errors and a maximum of 12 lags, Monthly data GVAR model, sample 01.2001-12.2014

The numbers into brackets ( ) are the standard errors for each estimated coefficients and the figures into square brackets [ ] stand for the pvalues. Therefore, the Prob>F represents the probability that all the estimated coefficients are not significantly different from 0.

$$\Delta\left(Y_t^i - Y_t^{bd}\right) = \beta_{i0} + \beta_{i1}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right) + \beta_{i2}\Delta\left(d_t^i - d_t^{bd}\right) + \beta_{i3}\Delta\left(b_t^i - b_t^{bd}\right) + \beta_{i4}\Delta\left(g_t^i - g_t^{bd}\right) + \beta_{i5}\Delta(Bbb_t - Aaa_t) + \beta_{i6}D_t + \beta_{i7}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^d + \beta_{i8}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^b + \beta_{i9}\Delta\left(Y_{t-1}^i - Y_{t-1}^{bd}\right)^g + u_{it}$$

Variable	Description	Frequency	Source
Spread	10yr government bond yield (differential vs. Germany)	monthly	ECB
Debt	Expected debt/GDP (vs. Germany), Short Term horizon	bi-annual	European Commission
Balance	Expected budget balance/GDP (vs. Germany), Long Term horizon	bi-annual	European Commission
Growth	Expected growth/GDP (vs. Germany), Averaged horizons	bi-annual	European Commission
Risk Aversion	Differential between euro corporative bond indexes Aaa and Bbb	monthly	Bloomberg
Crisis Dummy	Dummy variable: 1 from 03,2009 onwards, zero otherwise	monthly	Own calculation

Table 3: Data definition and sources, samples from 01.2001-12.2014

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