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ARTICLE



Measuring the effect of monetary shocks on European sovereign country risk: an application of GVAR models

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ABSTRACT

This paper investigates the effect of European monetary policies on Eurozone countries' sovereign risks. We control for interdependencies across individual variables within and across countries using a global VAR specification weighting transmission by their fiscal position. We find evidence of positive correlation between sovereign bond CDS and risk aversion for almost all countries in the Eurozone. The effects are larger after the 2012 Greek debt crisis. When the ECB increases its refinancing rate or there is a decline in money aggregates (i.e., M3), we observe an increase in sovereign bonds' risk of all countries (except Greece). In contrast, monetary policy tightening shocks have the opposite impact on Greece due to a differentiation effect.

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KEYWORDS

Global VAR; sovereign risk in the Eurozone; CDS

1. Introduction

The 2007–2008 financial turmoil urged governments of advanced economies to step in to the center of financial systems and assume the risk of privately held debt across capital markets. Consecutive bail-outs and governments' intervention to protect “too big to fail” institutions led to a stream of risk transmission from private financial sector to public sector, eventually leading to a lack of investor confidence in sovereign debt. As a result, spillover and contagion among countries attracted great attention after global financial crisis. With multiple European countries being in the center of debt troubles, the rapidly weakening situation in the Eurozone attracted a number of empirical papers covering the issues of sovereign risk in the euro area. Most importantly, the debt crisis in Greece, Ireland and Portugal (later Italy and Spain too) focused the attention of the sovereign bond spreads literature on the interdependence of countries' risks.

This paper contributes to the understanding of (i) how monetary policies affect sovereign risk, (ii) international linkages among sovereign risks and, (iii) heterogeneity among Eurozone countries, using an econometric specification of credit default swaps (CDS) as a proxy of country-specific sovereign risk.

The literature on sovereign risks and contagion is very extensive and it has recently focused on Europe. Most papers analyze the contagion mechanism and study its determinants. Dungey and Martin (2007) analyzes the linkage between countries and financial

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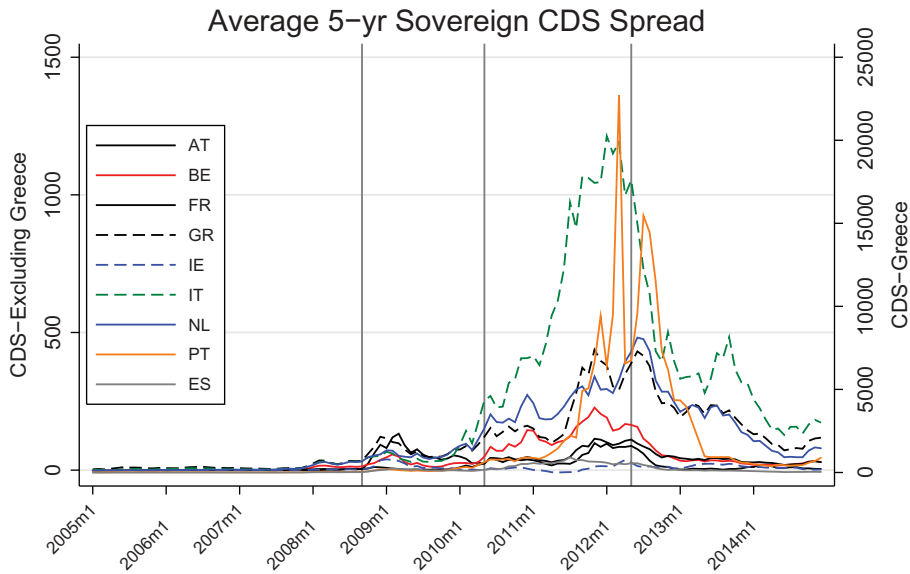


Figure 1. Monthly average 5 years sovereign CDS spread (in basis points).

Note: CDS relative to CDS of German Bunds have seen two stress periods in last 10 years. First, CDS spreads in Eurozone increased sharply in 2008/09 global financial crisis. Between mid-2009 and mid-2011, CDS spread in the zone decreases, however with the start of euro area crisis in May 2010, CDS spreads move up sharply.

markets and find significant evidence of spillovers and contagion during the East Asian financial crisis of 1997–98. Fratzscher (2009) studies the transmission channels of US shocks to foreign exchange markets and finds that macroeconomic variables and financial exposure are important elements of transmission for both advanced and emerging markets. Diebold and Yilmaz (2009) examine the spread of shocks in global equity markets using variance decomposition methods. Bekaert, Cho, and Moreno (2010) provides evidence on the importance of monetary shocks. Niehof (2014) finds that foreign shocks have a higher effect on countries with higher debts, and European bond markets are primarily driven by European shocks. There is also evidence of global interdependency and determinants of volatility of bond spread changes across countries.

There is strong evidence of co-movement of government bond spreads in the Euro area (see Figure 1). Government spreads statistical processes are generally decomposed into three main factors: risk aversion, fiscal factors and liquidity factors (see Codogno, Favero, Missale, Portes, & Thum, 2003; Geyer, Kossmeier, & Pichler, 2004; Haugh, Ollivaud, & Turner, 2009; Manganelli & Wolswijk, 2009). Appetite for risk is an important driver of the variation in sovereign bond spreads in the Euro area. US corporate bond spreads, as a proxy of global risk measure, is found statistically significant factor of European bond spreads (Codogno et al., 2003; Geyer et al., 2004; Manganelli & Wolswijk, 2009; Sgherri & Zoli, 2009). With the start of Economic and Monetary Union of the European Union (EMU) and until the middle of 2008, sovereign bond yields for EMU member countries remained relatively close to each other. However, after late 2008 with financial markets realizing the impact of the crisis, sovereign bond yield spreads between Germany and other Euro area countries started to widen significantly. Recent studies also confirm that the start of EMU and 2008–09 financial crisis change the effect of government debt and deficit on sovereign bond yields within the Euro area

and find that Germany was perceived as a “safe-haven” in international financial market after 2008–09 financial crisis (Bernoth, von Hagen, and Schuknecht (2012)).

The second common determinants are fiscal fundamentals and economic growth. Bernoth and Wolff (2008); Bernoth et al. (2012); Favero (2013) examine the effect of both debt and deficit on bond spreads. Assmann and Boysen-Hogrefe (2012) use time-varying approach and find debt to GDP ratio is the most important factor which can explain fluctuation in government bond spreads. Sovereign bond spreads become an interesting area to analyze after 2008–09 sovereign debt crisis and studies on government bond spread started to investigate whether yields co-movements differ over time. Fiscal fundamentals are time-varying factors and European co-movement differs over time (Assmann & Boysen-Hogrefe, 2012; Attinasi, Checherita, & Nickel, 2010; Barrios, Iversen, Lewandowska, & Setzer, 2009; Bernoth et al., 2012; Borgy, Laubach, Mesonnier, & Renne, 2011; Sgherri & Zoli, 2009).

The third commonly used determinant of spread yields is liquidity risk. This a very important factor as countries within the Euro area have not perfect control over monetary decisions which are taken by the central institutions, i.e., European Central Bank (ECB). We consider the effect monetary shocks by studying M3 and ECB refinancing rate in our model as the main determinants of the Eurozone liquidity. We thus study how liquidity shocks and monetary policy in general affects euro countries' CDS. There are different results on the importance of liquidity on government bonds. Favero, Pagano, and von Thadden (2010) do not find liquidity as a significant factor in sovereign bond spreads, and show that liquidity is not independent from default risk and risk aversion.

Niehof (2014) also defines a fourth element which is financial market risk of spillover due to evidence in the literature of co-movement of bonds market and stocks market. This is especially relevant for countries in the EMU that have the same currency, and as such, they are connected with strong links that go to European central institutions.

We apply a global VAR (GVAR) model of Pesaran, Schuermann, and Weiner (2004), Chudik and Fratzscher (2011) and Chudik and Pesaran (2011). This is a framework for capturing interdependence and spillovers allowing for common factors and time-varying components. We model government bond CDS relative to Germany by domestic, global, monetary and weighted foreign variables where weights are calculated using their fiscal position. We include two factors that determine the fluctuation in government bond CDS similar to Favero (2013); a local factor (fiscal fundamentals and growth), and a global factor (market's appetite for risk). While the GVAR method has been widely used in regional contexts to evaluate monetary policy, this is not the only alternative model. For instance, factor-augmented models, spatial and Bayesian methods also provide alternatives to reduce the dimensionality in an inter-connected empirical model with interdependence and spillovers. A recent and extensive summary of regional models to study monetary shocks appears in Dominguez-Torres and Hierro (2019).

We find evidence of positive correlation between sovereign bond CDS and risk aversion for almost all countries in the Eurozone. Monetary shocks in the Eurozone have large and heterogeneous effects in the countries that share the Euro. When ECB increases its refinancing rate, we observe an increase in risk of sovereign bonds of all countries in the Euro area (except Greece). A decline in money aggregates (i.e., M3) leads to increasing sovereign risk. In contrast, monetary policies have the opposite impact on Greece, possibly due to a differentiation effect. That is, a general improvement (deterioration) of the Eurozone countries' risk might relatively worsen (improves) the Greek market valuation.

The remainder of this paper is organized as follows. [Section 2](#) reviews the literature on measuring monetary shocks. [Section 3](#) presents the econometric model. In [section 4](#), we describe data and study sovereign bond CDS with 5 years maturity. In [section 5](#), we provide the results. [Section 6](#) concludes.

2. Monetary shocks in the Eurozone

Financial and non-financial markets are unlikely to respond to policy actions that were already anticipated. That is, central banks actions are systematically related to economic variables (i.e., inflation, output gap) which are both observed by the national governments, international institutions and economic agents, then anticipatory responses occur before the actual change happens (i.e., a tightening of the monetary policy, increment of the interest rate). In that case it is difficult to identify the causal effect of monetary policy on financial markets. Distinguishing thus between expected and an unexpected policy action is a key fundamental challenge of the literature, and for this the definition of what is a shock and how it is constructed varies.

This has been a topic of continuous interest in the US, where the Federal Reserve Bank (Fed) actions were systematically analyzed. Since Bernanke and Blinder (1992) and Sims (1992), a considerable literature employed vector autoregressive (VAR) methods to identify and measure these shocks. The canonical methodology of Christiano, Eichenbaum, and Evans (1996) propose to measure exogenous monetary shocks using orthogonalized shocks to the Fed funds rate (FFR) in a structural VAR model. The system is identified by assuming that Fed behavior has no contemporary effect on other “real” economic variables, but it takes these into account for policy actions.

Many other alternative methodologies have been proposed in the literature. Bernanke and Kuttner (2005) follow Kuttner (2001) in using FFR futures data to construct a measure of “surprise” rate changes. They use the event study analysis of comparing the future 1-month futures contract with the actual target rate set by the Fed. The economic rationale is that *future* interest rates reflect expectations about monetary policies, and thus, deviations of the *actual* rate from the predicted one by the futures market represent a shock. Their approach overcomes some of the problems encountered by Christiano et al. (1996) VAR such as the time invariant parameter issue and omitted-variable bias. These “surprise” measures of monetary policy are based only on the actual/observed policy rate. These might not fully capture monetary policy shocks for two reasons. First, agents might be able to anticipate changes in the policy rate but might be surprised about the path of monetary policy. Second, recent changes in monetary policy, such as reaching the zero lower bound and the use of unconventional monetary policy, might make FFR-based measures superfluous.

The literature emphasizes that monetary policy is multi-dimensional. Gurkaynak, Sack, and Swanson (2005), among others, make an important distinction between measures of surprises on the target rate (*target shocks*) and surprises on the path of monetary policy (*path shocks*). While Bernanke and Kuttner (2005) and Christiano et al. (1996) shocks fall within the category of target shocks, because they capture the unanticipated variation in monetary policy that is reflected in the current reaction of the policy instrument, *path shocks* intend to capture shocks to the path of monetary policy. Path shocks correspond to the surprises about future policy that can be inferred from forward guidance and/or other communications by the Board members.

Intuitively, path shocks allow assessing agents' expectations about the evolution of monetary policy. These shocks are based on expectations about the path of the FFR controlling for forecasts about the evolution of the inflation and output gap.

Econometric models for the US have particular features that cannot be found in Euro area countries. While the ECB is the central bank of the Euro area countries, its policies may not be directly linked to individual countries performance but to more aggregate performance at the Eurozone. The primary objective of the ECB, as laid down in Article 127(1) of the Treaty on the Functioning of the European Union, is to maintain price stability within the Eurozone. The Governing Council in October 1998 defined price stability as inflation of under 2%, "a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the Euro area of below 2%" and added that price stability "was to be maintained over the medium term". The basic tasks, as defined in Article 3 of the Statute, are to define and implement the monetary policy for the Eurozone, to conduct foreign exchange operations, to take care of the foreign reserves of the European System of Central Banks and operation of the financial market infrastructure under the TARGET2 payments system and the technical platform (currently being developed) for settlement of securities in Europe (TARGET2 Securities). The ECB has, under Article 16 of its Statute, the exclusive right to authorize the issuance of Euro banknotes. Member states can issue Euro coins, but the amount must be authorized by the ECB beforehand (upon the introduction of the Euro, the ECB also had exclusive right to issue coins). The principal monetary policy tool of the European central bank is collateralized borrowing or repo agreements. These tools are also used by the US Fed, but the Fed does more direct purchasing of financial assets than its European counterpart. The collateral used by the ECB is typically high quality public and private sector debt.

Unlike the US Fed, the ECB has only one primary objective but this objective has never been defined in statutory law, and the HICP target can be termed ad-hoc. In fact, the ECB has been at the center of the recent European crisis with interventions that exceeded its original mandate. On 9 May 2010, the 27 member states of the European Union agreed to incorporate the European Financial Stability Facility (EFSF). The EFSF's mandate is to safeguard financial stability in Europe by providing financial assistance to Eurozone member states. The EFSF is authorized to use the following instruments linked to appropriate conditionality:

- (i) To provide loans to countries in financial difficulties (e.g., Greek bailout);
- (ii) To intervene in the primary and secondary debt markets. Intervention in the secondary debt market will be only on the basis of an ECB analysis recognizing the existence of exceptional financial market circumstances and risks to financial stability.
- (iii) Act on the basis of a precautionary program.
- (iv) Finance recapitalization of financial institutions through loans to governments.

Both for US and Europe, the classical tools of monetary policy (i.e., FFR for the US, managing the ECB refinancing rate for the ECB) lost its flexibility and effectiveness as it reached the zero lower bound. US monetary authorities gradually changed its policy instruments by considering forward guidance and QE (Quantitative Easing).¹ In contrast to the Fed, the ECB normally does not buy bonds outright. The normal procedure

used by the ECB for manipulating the money supply has been via the so-called refinancing facilities. In these facilities, bonds are not purchased but used in reverse transactions: repurchase agreements, or collateralized loans. These two transactions are similar, i.e., bonds are used as collateral for loans, the difference being of legal nature. In the repos the ownership of the collateral changes to the ECB until the loan is repaid.

This changed with the recent sovereign-debt crisis. The ECB always could, and through the late summer of 2011 did, purchase bonds issued by the weaker states even though it assumes, in doing so, the risk of a deteriorating balance sheet. As of 18 June 2012, the ECB in total had spent 212.1bn (equal to 2.2% of the Eurozone GDP) for bond purchases covering outright debt, as part of its Securities Markets Programme (SMP) running since May 2010. On 6 September 2012, the ECB announced a new plan for buying bonds from Eurozone countries. The duration of the previous SMP was temporary, while the Outright Monetary Transactions (OMT) program has no ex-ante time or size limit. On 4 September 2014, the bank went further by announcing it would buy bonds and other debt instruments primarily from banks in a bid to boost the availability of credit for businesses. The Emergency Lending Assistance (ELA) program was designed for financial institutions in a liquidity crisis, such as the Greek banks in the course of the 2015 Greek financial snafu, when the banks experienced massive deposit flight. On 9 March 2015 the ECB started its own Quantitative Easing program, which was designed to ease sovereign stress in its member states. Purchases are 60bn per month. The program is expected to last until at least September 2016. Though the ECB's main refinancing operations (MRO) are from repo auctions with a (bi)weekly maturity and monthly maturation, the ECB now conducts long-term refinancing operations (LTROs), maturing after 3 months, 6 months, 12 months and 36 months. In 2003, refinancing via LTROs amounted to €45bn which is about 20% of overall liquidity provided by the ECB.

There is also an extensive literature exploring monetary shocks in Europe, although the changing institutional environment makes it less conclusive. Barran, Coudert, and Mojon (1996), Ramaswamy and Slok (1998), and Dornbusch, Favero, and Giavazzi (1998) analyze the monetary transmission across countries in Europe before Euro was introduced and finds that European countries respond similarly to the monetary shocks but with different magnitude. Since the data used by these studies are before EMU was established, they only consider monetary policy effects and/or interest rate changes for each country separately. After the Eurozone was established, there has been further studies considering the effect of common Euro area monetary policy shocks. Georgiadis (2015) included ECB intervention in addition to macroeconomic variables (output growth, inflation, etc.) to analyze determinant of transmission of Euro area monetary policy and concludes that economies of the Euro area countries are affected by the ECB's monetary policy and transmission of monetary policy in the Euro area countries differs. The results of his research confirms to results of similar studies related to effect of monetary policy shock in Eurozone (also see Ciccarelli, Ortega, & Valderrama, 2012; Georgiadis, 2014).

¹Forward guidance is a change in the strategy of underpinning policy communication. The structure of FOMC statements has been modified to include: (i) an economic outlook, in January 2000; (ii) qualitative statements about future policy inclinations, in August 2003; (iii) calendar-based guidance, in August 2011; (iv) outcome-based guidance, in December 2012. Quantitative Easing policies consist of purchases, by the central bank of specified quantities of long-term financial assets. This could be separated into QE1, (late 2008–2009) and QE2 (2010 q2–2011 q2). While QE1 consisted of purchases of MBS, Treasuries and Agency securities, QE2 focused only on the purchase of long-term Treasury securities. The Fed intervened in both Treasury and mortgage securities in QE1 and QE2.

We analyze the effect of monetary shocks on sovereign risk using two monetary measures. The first one is the ECB refinancing rate and the second one is broad money aggregate (M3). M3 is the broadest measure of money supply, and Euro area M3 money supply includes following items; (i) liabilities of the money-issuing sector and central government liabilities with a monetary character held by the money-holding sector, (ii) currency in circulation, (iii) overnight deposits, (iv) deposits (v) repurchase agreements (vi) money market fund shares (vii) debt securities up to 2 years. Changes in both monetary variables are assumed to be exogenous to individual Eurozone countries' sovereign risk, once interdependence is taken into account.

3. GVAR model

We use a global vector autoregressive (GVAR) model to capture time-varying interdependence of sovereign risk (see Dees, Mauro, Pesaran, & Smith, 2007; Diebold & Yilmaz, 2009, 2009; Di Mauro & Pesaran, 2013; Favero, 2013). Our baseline specification is

$$\begin{aligned} \Delta(S_{it} - S_{gt}) = & \beta_{i0} + \beta_{i1}(S_{it} - S_{gt}) + \beta_{i2}\Delta RiskAv_{it} + \beta_{i3}(D_{it} - D_{gt}) + \beta_{i4}(B_{it} - B_{gt}) \quad (1) \\ & + \beta_{i5}\ln(ECB)_{it} + \beta_{i6}\ln(M3)_{it} + \beta_{i7}\ln(Oil)_{it} + \beta_{i8}W_{it-1}^d + \beta_{i9}W_{it-1}^b + \mathbf{u}_{it}, \\ & \mathbf{u}_t \sim i.i.d.(0, \Sigma), \end{aligned}$$

$$i = 1, 2, \dots, N, t = 1, 2, \dots, T,$$

where \mathbf{u}_t is the collection of shocks for the N countries and Σ is a $N \times N$ variance-covariance matrix of contemporaneous shocks interdependence. The dependent variable is the monthly change in the spread of country i CDS of 5 years sovereign bond with respect to German (g) Bund for a given period t , $(S_{it} - S_{gt})$. The first determinant of sovereign risk is the country's fiscal fundamentals. We use two proxies for country's macroeconomic and fiscal conditions: debt to GDP ratio (B_{it}) and deficit to GDP ratio (D_{it}). Second and third determinants are global risk aversion ($\Delta RiskAv_{it}$) and monetary policies, which are proxied by $\ln(ECB)$, the logarithm of the ECB refinancing rate and $\ln(M3)$, the logarithm of M3. Finally, we also consider oil prices (in logs) as a proxy for global shocks that might affect the sovereign risk in Euro area. These common variables are treated as exogenous.

The GVAR specification allows for time-varying interdependencies among countries. A time-varying weighting matrix captures the importance and influence of country j on country i 's economy. Following Favero (2013) we employ fiscal fundamentals as distance between countries to construct the interrelation matrix of the GVAR specification. The interdependence appears explicitly in the two variables W_{it-1}^d for debt to GDP ratio and W_{it-1}^b for deficit to GDP ratio, where other countries influence is based on Maastricht Treaty framework for time t as

$$dist_{ji,t}^B = |B_{j,t} - B_{i,t}|/0.6, \quad \text{and} \quad dist_{ji,t}^D = |D_{j,t} - D_{i,t}|/3 \quad (2)$$

$$\omega_{ji}^B = \frac{1/dist_{ij}^B}{\sum \frac{1}{dist_{ij}^B}} \quad \text{and} \quad \omega_{ji}^D = \frac{1/dist_{ij}^D}{\sum \frac{1}{dist_{ij}^D}} \quad (3)$$

$$W_{it}^b = \sum \omega_{ji}^B S_{it} \quad \text{and} \quad W_{it}^d = \sum \omega_{ji}^D S_{it} \quad (4)$$

The contemporaneous global CDS spreads (W_{it}^b and W_{it}^d) are not included in the model like a standard GVAR model, because these variables are unlikely to be exogenous due to low number of cross-section units. Therefore, we use lags of global spread in our specification.

4. Data

4.1. CDS and other variables

A credit default swap (CDS) is a swap contract in which the protection buyer of the CDS makes a series of premium payments to the protection seller and, in exchange, receives a payoff if the bond goes into default. CDS is a direct measure of the default risk but not of the probability of default, as the price of a CDS depends both on the probability of default and on the expected recovery value of the defaulted bond. Moreover, such measure is not perfect; CDS differentials might also reflect the different liquidity of different sovereign CDSs, as well as counterparty risk (i.e., the risk that the protection seller of the CDS is not able to honor her obligation when the bond goes into default).

Data on daily CDS with maturities between 1 and 10 years are provided by Bloomberg and S&P Capital-IQ starting from 2006. In particular, we consider the monthly mean of 5 years CDS on sovereign bonds. The primary goal of this paper is to analyze the effect of monetary policy on Euro area countries sovereign risks, as measured by 5 years CDS bonds. We focus on 10 countries: Austria, Belgium, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain. The sample has monthly frequency and runs from January 2006 to December 2014.

Considering the findings of Bernoth et al. (2012) on Germany's "safe-haven" status in Euro area, the CDS relative to German Bund reveals the risk that an investor takes by buying a specific sovereign bond. Therefore, CDS data used in our study is the spread to CDS of German Bund.

If the country's fiscal position degrades in comparison to the benchmark country (Germany in our case), the CDS of government bond spread increases due to demand of higher default risk premium. Debt to GDP and fiscal deficit to GDP ratios are the most common fiscal variables used as a proxy of country-specific credit risk.² We use both variables constructed from Eurostat. Since these variables have quarterly frequency, we interpolate data from quarterly to monthly using cubic splines.

We also include US corporate long-term Baa-Aaa spread (as per Moody's rating scale) in our analysis in order to control for time-varying global risk aversion which is a conventional measure in the related literature (Bernoth & Erdogan, 2012; Bernoth et al., 2012; Codogno

²Some studies that use debt to GDP ratio as credit risk indicator are Favero and Missale (2012); Favero (2013); Manganelli and Wolswijk (2009); Beirne and Fratzscher (2013); Bernoth and Erdogan (2012); Bernoth et al. (2012); Aizenman, Hutchison, and Jinjara (2013). Credit risk is proxied by deficit to GDP in Bernoth and Erdogan (2012); Bernoth et al. (2012). Beirne and Fratzscher (2013); Lane (2012); de Grauwe and Ji (2012) use current account deficit or fiscal balance in their studies.

et al., 2003; Favero, 2013; Geyer et al., 2004). When there is high uncertainty in the market, the investors prefer safer bonds to riskier corporate bonds. Therefore, the difference between low-grade bond (Baa) and high-grade bond (Aaa) increases.

4.2. Unit root and structural break tests

We present the results of unit root tests in Table 1. The t-statistics reported in the table are for Augmented Dickey–Fuller (ADF) and Philips-Perron unit root tests that correspond to the statistics with the longest significant lag and four lags, respectively. The lag length used in ADF unit root test is selected by the Akaike Information Criterion (AIC) based on the standard ADF regressions. In addition to the result of unit root test for individual countries, we also include results for panel data. We run the unit root tests using time trend and a constant.

Our results point out that CDS of 5 years government bonds has unit root for all countries apart from Netherlands according to ADF. However, the version of CDS that we use in our model, CDS of sovereign bond relative to CDS of German Bund, are stationary for all countries and also for the pooled panel. Unit root test of all explanatory variables, that we include in our baseline mode, are also reported in Table 1. Debt/GDP ratio relative to Debt/GDP ratio of Germany is the only variable in our model that has unit root. Favero (2013) states that non-stationary exogenous variables can be used in GVAR models, and therefore we employ Debt/GDP ratio relative to Germany.

Structural breaks are likely to be observed in economies that are subject to significant political, social and economic events. The fact that country-specific GVAR models are specified conditional on foreign and global variables should somewhat eliminate the structural break issue. Since the GVAR framework is vulnerable to this problem (Dees et al., 2007), we run three tests: (i) possible breaks in our dependent variable, (ii) possible breaks in the regression, (iii) confirmation of on whether break dates apply to all countries.

We apply Quandt Likelihood Ratio (QLR) structural break tests in CDS of sovereign bonds over CDS of German Bund for nine countries in the Eurozone in order to determine the periods where trend of CDS statistically changes at 5% significance level. Figure 2 shows QLR statistics of the structural breaks in CDS from 2006 to 2014 for each country. Apart from Belgium and France, sovereign risk trends of all other countries is affected by 2007–2008 financial crisis. Almost all countries' risks show structural change for the Greece debt crisis in 2012, only the trend of sovereign risk for Netherlands is not affected by 2012 debt crisis.

We also run the QLR test for unknown dates to determine structural breaks in country-specific models and report our result in Figure 3. There is statistically significant variation in the structure of the model for almost all countries. In line with the QLR results in variable level, only Netherlands has no structural changes in the model.

Finally, we apply Chow tests for each possible break point that we got using QLR tests, September 08, April 10 and April 12, and present results in Table 2. We run regressions for each country separately and the only possible break that affects all countries is Apr'12, which is the closest period to the Greece debt crisis.

Overall, not surprisingly, there is strong evidence of structural instability and almost all countries are affected by recent financial and debt crisis. Therefore, we also run our

Table 1. Unit root tests.

| Variable | | ADF at level | ADF at first difference | PP at level | PP at first difference |
|--|-------|--------------|-------------------------|-------------|------------------------|
| <i>CDS of 5 years bond relative to CDS of German Bund with same maturity</i> | | | | | |
| Austria | AT | -2.280 | -6.432*** | -2.341 | -8.924*** |
| Belgium | BE | -1.723 | -6.475*** | -1.529 | -7.677*** |
| France | FR | -1.639 | -6.158*** | -1.618 | -7.974*** |
| Greece | GR | -2.820 | -11.853*** | -3.335* | -16.550*** |
| Ireland | IE | -0.868 | -4.906*** | -1.047 | -9.252*** |
| Italy | IT | -1.936 | -5.473*** | -1.812 | -8.108*** |
| Netherlands | NL | -3.576** | -6.710*** | -2.968 | -7.224*** |
| Portugal | PT | -0.889 | -5.378*** | -1.285 | -10.530*** |
| Spain | ES | -1.360 | -6.492*** | -1.187 | -8.142*** |
| CDS | Panel | 1.136 | -18.254*** | 2.247 | -24.017*** |
| Variable | | ADF at level | ADF relative to GR | PP at level | PP relative to GR |
| <i>Debt/GDP Ratio</i> | | | | | |
| Austria | AT | -3.326* | -2.221 | -2.405 | -3.555** |
| Belgium | BE | -1.735 | -1.807 | -2.117 | -2.316 |
| France | FR | -1.970 | -1.203 | -2.058 | -2.009 |
| Greece | GR | -1.730 | -1.976 | -2.325 | -2.666 |
| Ireland | IE | -0.282 | -0.921 | -0.928 | -1.352 |
| Italy | IT | -1.213 | -0.336 | -1.799 | -1.120 |
| Netherlands | NL | -1.717 | -1.497 | -2.132 | -2.311 |
| Portugal | PT | -1.538 | -1.708 | -1.649 | -1.860 |
| Spain | ES | -4.250*** | -2.518 | -2.683 | -1.950 |
| Debt/GDP | Panel | -5.311*** | -7.222*** | 1.770 | 1.043 |
| Variable | | ADF at level | ADF relative to GR | PP at level | PP relative to GR |
| <i>Deficit/GDP_{it} Ratio</i> | | | | | |
| Austria | AT | -3.719* | -3.427* | -4.012** | -4.452*** |
| Belgium | BE | -4.968*** | -4.810*** | -4.199*** | -4.200*** |
| France | FR | -3.735** | -3.195* | -3.426* | -3.942** |
| Greece | GR | -2.523 | -2.985 | -3.388* | -3.757** |
| Ireland | IE | -1.943 | -2.090 | -2.621 | -2.839 |
| Italy | IT | -3.302* | -2.829 | -4.157*** | -4.197*** |
| Netherlands | NL | -1.995 | -2.779 | -3.446* | -4.191** |
| Portugal | PT | -2.608 | -3.990** | -3.101 | -4.101** |
| Spain | ES | -3.260* | -4.228*** | -2.871 | -3.755** |
| Debt/GDP | Panel | -21.035*** | -23.140*** | -6.789*** | -7.844*** |
| Variable | | ADF at level | ADF at first difference | PP at level | PP at first difference |
| <i>Other Variables</i> | | | | | |
| In(Oil) | | -1.606 | -7.624*** | -2.682 | -7.760 *** |
| In(ECB rate) | | -1.784 | -9.274*** | -1.953 | -9.403*** |
| In(M3) | | -3.572** | -8.502*** | -3.674** | -9.025*** |
| Baa-Aaa(Risk) | | -1.732 | -6.025*** | -2.348 | -5.882*** |

Notes: ADF: Augmented Dickey–Fuller with number of lags selected by AIC. PP: Philips–Perron test results based on four lags.

* significant at 10%, ** significant at 5%, *** significant at 10%.

baseline GVAR model before and after the 2012 Greece debt crisis in order to detect the changes in the effect of domestic and foreign variable on sovereign risk.

5. GVAR results

In this section, we present and interpret the result of seemingly unrelated regression (SUR) using GVAR models and impulse response functions (IRF) for country-specific shocks and monetary shocks.

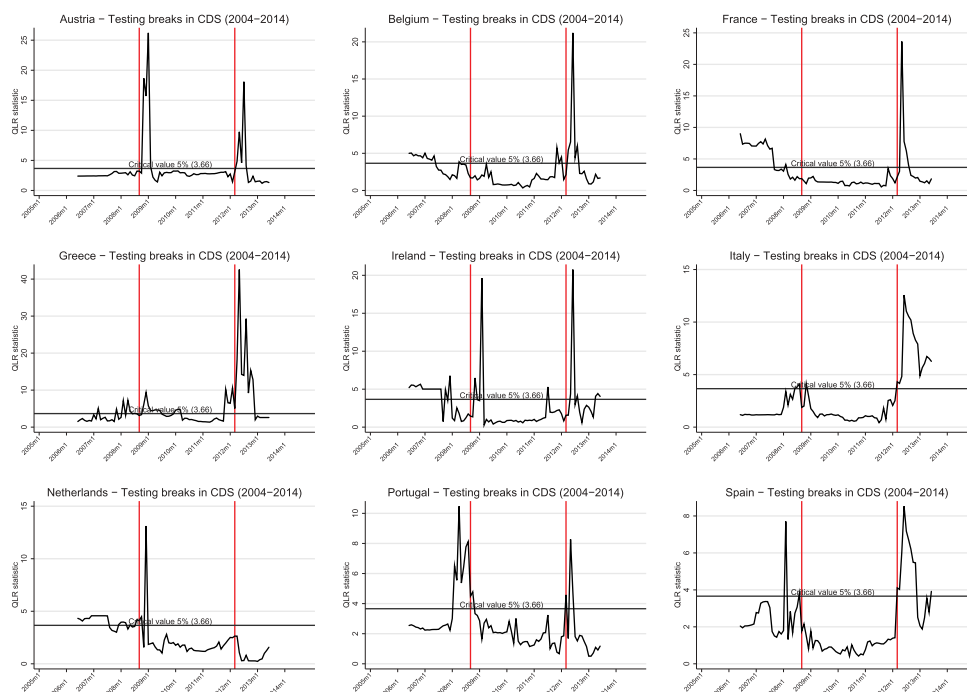


Figure 2. Quandt Likelihood Ratio (QLR) structural break in CDS relative to German Bund.

Note: We check structural break in CDS for four lags. Vertical red lines represent August 08 for 2007–2008 financial crisis and March 12 for 2012 Greece debt crisis, respectively. Horizontal black line is for critical value of F-test at 5% significance level.

5.1. *Seemingly unrelated regression model*

We present the results of the SUR model for nine countries using the GVAR model in order to analyze interdependence of countries in Euro area and other the factors that affect country risks.

Table 3 covers all periods from the beginning of 2006 to the end of 2014. In order to compare the changes before and after 2012 Greece debt crisis, we also run the same regression for a sub-sample between January 2006 to March 2012, and another for April 2012 to December 2014. The results for before and after 2012 Greece debt crisis are provided in Tables 4 and 5, respectively.

CDS spreads in differences are negatively affected by its lag for all countries, which is in line with the findings of Favero (2013). However, Portugal presents a positive effect when we include all periods in our analysis. When taking into account the subsample before the 2012 Greece debt crisis, Portugal is also negatively affected by its CDS lag.

When M3 increases in the Eurozone, the government risk of almost all countries decreases, except for Greece that is affected in the opposite direction. Similar results are obtained for the effect of ECB refinancing rate. An increase in ECB refinancing rate increases sovereign risk of all countries except Greece. Thus, we can conclude that a tightening of the monetary policy (i.e., either M3 decreases or ECB increases) is thus associated with an increase of the Eurozone countries' CDS. The case of Greece

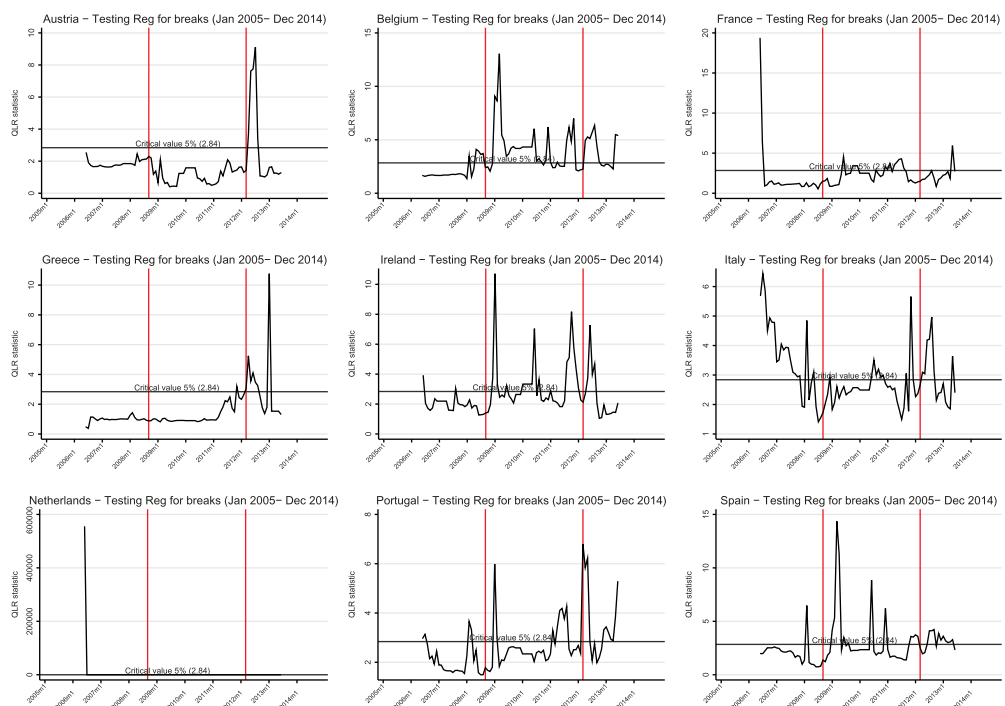


Figure 3. Quandt Likelihood Ratio (QLR) structural break in regression.

Table 2. Structural break test for baseline regression for known dates: September 08, April 10, April 12.

| Country | Code | F(9, n) | | F(9, n) | | F(9, n) | |
|-------------|------|--------------|-------|----------|-------|----------|-------|
| | | September 08 | Prob | April 10 | Prob | April 12 | Prob |
| Austria | AT | 3.40*** | 0.002 | 0.69 | 0.717 | 3.72*** | 0.001 |
| Belgium | BE | 2.90*** | 0.006 | 3.50*** | 0.001 | 4.98*** | 0.000 |
| France | FR | 1.51 | 0.167 | 3.04*** | 0.005 | 1.72* | 0.096 |
| Greece | GR | 0.64 | 0.761 | 1.10 | 0.380 | 5.25*** | 0.000 |
| Ireland | IE | 1.37 | 0.224 | 1.71 | 0.109 | 2.72*** | 0.008 |
| Italy | IT | 1.36 | 0.226 | 2.80*** | 0.008 | 3.12*** | 0.002 |
| Netherlands | NL | 1.30 | 0.262 | 3.82*** | 0.001 | 11.57*** | 0.000 |
| Portugal | PT | 2.18** | 0.035 | 2.01* | 0.052 | 5.86*** | 0.000 |
| Spain | ES | 1.09 | 0.385 | 1.96 | 1.38 | 0.218 | 0.053 |

Notes: We apply the Chow test for each break separately. After confirming that April 2012 is break point for all countries, we drop observations which date is greater than April 2012 in order to test break for September 2008 and April 2010. Therefore, we were able to test if there is a second common break in the dataset.

* significant at 10%, ** significant at 5%, *** significant at 10%.

deserves special attention. The results suggest that a monetary shock in the Euro area, which increases the risk of government bonds of all countries, decreases sovereign risk of Greece. This could be due to the fact that markets valueate Greek bonds in relative terms to other countries in the Eurozone, and then, a tightening of the monetary policy in the Euro-zone is perceived as positive for Greece as the rest of the countries will be negatively affected. These effects are further studied in terms of IRF when we study the effect of a monetary shock taking into account all interdependencies.

Table 3. CDS spreads on bunds, SUR – sample: January 06 to December 14.

| Variable | AT | BE | FR | GR | IE | IT | NL | PT | ES |
|--|---------------------|-----------------------|----------------------|------------------------|---------------------|----------------------|----------------------|----------------------|----------------------|
| Spread _{<i>t</i>-1} | -0.016 (0.033) | -0.101*** (0.029) | -0.052* (0.03) | -0.56*** (0.075) | -0.025 (0.03) | -0.131*** (0.029) | -0.286*** (0.044) | 0.16*** (0.048) | -0.095*** (0.028) |
| Weight Debt/GDP _{<i>t</i>-1} | -0.03 (0.019) | -0.009 (0.007) | -0.007 (0.007) | 1.649 (4.01) | -0.005 (0.028) | 0.058*** (0.015) | 0.012*** (0.003) | -0.267*** (0.062) | 0.079*** (0.027) |
| Weight Deficit/GDP _{<i>t</i>-1} | 0.008 (0.008) | 0.007*** (0.003) | 0.002*** (0.001) | 12.439*** (1.65) | -0.015** (0.007) | -0.037** (0.016) | 0 (0.002) | -0.012*** (0.006) | 0 (0.004) |
| Debt/GDPIERO_A_1665511 | 0.18 (0.367) | -0.805** (0.38) | 0.025 (0.188) | -37.457* (22.394) | 0.073 (0.395) | 0.175 (0.697) | 1.142*** (0.163) | -0.178 (0.918) | -0.017 (0.345) |
| Deficit/GDP _{<i>t</i>} | 0.242 (0.354) | -0.077 (0.248) | 0.129 (0.21) | 16.01 (30.869) | -0.596 (0.514) | 0.716 (0.76) | 0.433*** (0.12) | 0.046 (1.608) | -0.451 (0.353) |
| ln(M3)IERO_A_1665511 | -2.226 (1.435) | -6.573*** (1.655) | -2.693*** (0.831) | 522.742** (222.277) | -11.079* (6.395) | -4.961 (3.202) | -0.666 (0.464) | -7.988 (9.477) | -7.229** (3.522) |
| ln(ECB rate) _{<i>t</i>} | 2.923* (1.646) | 3.361 (2.051) | 1.701 (1.651) | -999.307* (563.47) | 14.607 (14.15) | 4.576 (7.071) | 5.331*** (0.881) | 7.915 (22.655) | 6.579 (8.169) |
| ln(Oil) _{<i>t</i>} | -22.182* (13.05) | -9.804 (14.907) | -2.519 (7.623) | 898.454 (1930.516) | -82.292 (53.088) | -50.132* (26.661) | -3.856 (4.262) | -40.841 (72.9) | -21.973 (28.832) |
| Δ Risk Aversion _{<i>t</i>} | 13.951* (7.492) | 12.724 (8.415) | 6.894 (4.433) | 552.459 (1150.172) | -7.192 (30.921) | 27.155* (15.482) | -0.039 (2.408) | 2.405 (43.767) | 18.764 (17.072) |
| Constant | 3.25 (2.891) | 33.951*** (11.189) | 4.878** (1.884) | 1435.151 (1405.506) | 16.712 (10.484) | 6.649 (30.389) | 18.947*** (2.712) | 15.946 (23.222) | 10.589 (7.268) |
| Obs. | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 | 93 |
| R ² | 0.203 | 0.213 | 0.190 | 0.607 | 0.170 | 0.344 | 0.478 | 0.211 | 0.187 |

* significant at 10%, ** significant at 5%, *** significant at 10%.

Table 4. CDS spreads on bunds, SUR – sample: January 06 to March 12.

| Variable | AT | BE | FR | GR | IE | IT | NL | PT | ES |
|------------------------------------|---------------------|-----------------------|----------------------|---------------------------|------------------------|-----------------------|----------------------|----------------------|------------------------|
| Spread _{it-1} | 0.018 (0.057) | -0.182*** (0.044) | -0.108** (0.046) | -0.356** (0.167) | -0.214*** (0.062) | -0.217*** (0.059) | -0.431*** (0.063) | -0.317*** (0.092) | -0.242*** (0.05) |
| Weight Debt/GDP _{it-1} | 0.001 (0.036) | 0.008 (0.012) | 0.052*** (0.016) | 14.622*** (4.988) | -0.078 (0.05) | 0.128*** (0.029) | 0.038*** (0.006) | 0.296** (0.124) | -0.045 (0.055) |
| Weight Deficit/GDP _{it-1} | 0.009 (0.015) | 0.023*** (0.004) | -0.001 (0.005) | 9.85*** (1.706) | -0.024*** (0.009) | -0.138*** (0.031) | -0.014*** (0.004) | -0.006 (0.005) | 0.011 (0.008) |
| Debt/GDP _{it} | -0.047 (0.47) | -0.996** (0.43) | -0.647* (0.351) | -143.708*** (26.731) | 3.555*** (1.104) | 0.503 (1.207) | 1.518*** (0.19) | 8.224*** (2.113) | 3.374*** (1.066) |
| Deficit/GDP _{it} | -0.394 (0.626) | -0.006 (0.257) | -0.056 (0.291) | 40.278 (31.219) | 0.702 (0.594) | 0.05 (0.731) | 0.51*** (0.129) | 1.575 (1.259) | -0.721* (0.383) |
| ln(M3) _{it} | -3.656 (2.694) | -5.182** (2.443) | -4.432*** (1.413) | -243.248 (245.316) | 13.225 (10.401) | -5.056 (4.245) | 0.138 (0.637) | 5.882 (9.241) | -3.382 (4.219) |
| ln(ECB rate) _{it} | 9.759 (7.154) | 0.587 (6.137) | 5.379* (3.1) | -322.869 (590.806) | 2.873 (23.909) | 0.839 (10.314) | 6.161*** (1.718) | 11.508 (22.65) | 4.696 (9.906) |
| ln(Oil) _{it} | -27.946 (17.482) | -10.71 (17.755) | -2.943 (8.637) | -251.481 (1710.933) | -38.428 (67.068) | -59.897** (29.966) | -9.895** (4.33) | -52.074 (63.887) | -15.206 (27.672) |
| Δ Risk Aversion _{it} | 9.457 (10.32) | 9.207 (10.492) | 3.933 (5.138) | -516.536 (1017.74) | 1.422 (38.588) | 16.916 (17.932) | -2.625 (2.551) | 10.113 (36.941) | 13.447 (16.583) |
| Constant | -2.195 (5.031) | 39.023*** (13.226) | 3.774 (2.299) | 6643.809*** (1340.961) | 108.144*** (28.659) | -1.301 (47.731) | 24.009*** (3.486) | -44.477* (24.486) | 101.653*** (26.991) |
| Obs. | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| R ² | 0.178 | 0.261 | 0.220 | 0.583 | 0.180 | 0.356 | 0.621 | 0.307 | 0.139 |

* significant at 10%, ** significant at 5%, *** significant at 10%.

Table 5. CDS spreads on bunds, SUR – sample: April 12 to December 14.

| Variable | AT | BE | FR | GR | IE | IT | NL | PT | ES |
|--|----------------------|-----------------------|-----------------------|--------------------------|-----------------------|-----------------------|----------------------|-----------------------|------------------------|
| Spread _{<i>t</i>-1} | -0.062 (0.054) | -0.283*** (0.061) | -0.377*** (0.074) | -0.846*** (0.125) | -0.439*** (0.044) | -0.318*** (0.049) | -0.12* (0.061) | -0.123 (0.103) | -0.311*** (0.061) |
| Weight Debt/GDP _{<i>t</i>-1} | -0.05*** (0.016) | 0.006 (0.009) | -0.014 (0.011) | 14.314* (8.56) | 0.013 (0.025) | 0.06*** (0.011) | 0.019*** (0.003) | -0.135 (0.092) | 0.065** (0.031) |
| Weight Deficit/GDP _{<i>t</i>-1} | 0.014*** (0.004) | 0.007*** (0.002) | 0.004*** (0.001) | 8.412*** (2.863) | -0.005 (0.003) | -0.044*** (0.011) | 0.004*** (0.001) | -0.042*** (0.009) | 0 (0.002) |
| Debt/GDP _{<i>t</i>} | -0.171 (0.513) | 1.505** (0.636) | -0.444 (0.591) | -115.453 (104.204) | -0.297 (0.989) | -0.812 (1.051) | 3.41*** (0.376) | -5.318 (4.598) | -2.283** (1.148) |
| Deficit/GDP _{<i>t</i>} | 0.19 (0.205) | 0.414 (0.352) | -0.068 (0.439) | 52.881 (40.862) | -29.253*** (3.572) | 0.229 (1.487) | 0.851*** (0.147) | -3.184 (3.22) | -0.325 (0.503) |
| ln(M3) _{<i>t</i>} | -5.161* (2.887) | -9.87*** (3.763) | -1.67 (2.753) | 3719.907*** (1173.31) | 11.482 (11.828) | -6.754 (9.289) | -2.701* (1.571) | -0.496 (38.012) | -9.871 (11.704) |
| ln(ECB rate) _{<i>t</i>} | 4.98 (3.216) | 17.301*** (4.945) | 8.472* (4.678) | -4087.824* (2144.684) | 10.122 (13.456) | 39.174*** (13.27) | 12.038*** (2.276) | 57.433 (45.341) | 34.556** (15.598) |
| ln(Oil) _{<i>t</i>} | -25.04** (12.693) | -40.182** (16.894) | -13.841 (10.735) | 10223.61** (4973.402) | -93.229** (39.049) | -21.196 (36.669) | 14.013** (6.188) | -9.284 (148.865) | -12.775 (52) |
| Δ Risk Aversion _{<i>t</i>} | 8.433 (12.624) | 56.291*** (19.137) | 35.235*** (12.063) | -4882.74 (5162.694) | 85.032** (39.539) | 190.14*** (38.378) | -2.44 (5.812) | 397.01** (161.461) | 260.56*** (50.13) |
| Constant | 10.407** (4.933) | -15.296 (18.135) | 28.335*** (7.862) | 3536.907 (8978.168) | -112.792* (67.074) | 126.732** (57.273) | 47.284*** (5.899) | 386.817 (263.16) | 110.325*** (31.272) |
| Obs. | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| R ² | 0.563 | 0.659 | 0.667 | 0.709 | 0.851 | 0.765 | 0.719 | 0.529 | 0.648 |

* significant at 10%, ** significant at 5%, *** significant at 10%.

As anticipated, there is a positive relationship between risk aversion and sovereign bonds' CDS for almost all countries, but this is statistically significant only for Austria and Italy (an increase in uncertainty for the corporate bond market leads to a rise in sovereign risk). When looking at the differences between the two subsamples, we observe that while risk aversion is not statistically significant for all countries in the 2006–2012 sample, it is positive and statistically significant for most of the countries in 2012. Thus, this reveals that the European market association to global risk changed with the deterioration of the European economy post 2012.

The effect of fiscal fundamentals is rather heterogeneous. The complete sample do not have the expected results: the projected deviations of local government debt with respect to the German government debt is negative and significant in the cases of Belgium and Greece, and positive in the case of Netherlands, while the projected deviations of local government deficits from German deficits are positive and significant only for the Netherlands. This lack of significance and incorrect sign is certainly due to the structural breaks considered above. When we consider the pre-Greek crisis subsample, however, Ireland, Netherlands, Portugal and Spain have the a positive and significant effect. This effect is in general not statistically significant for the post-Greek crisis subsample.

Given the strong heterogeneity in the CDS regression models, a pooled panel data regression model would not be recommended. Although not reported Swamy tests for slope heterogeneity rejects the null hypothesis of parameter stability across countries.

5.2. Impulse response function analysis

The SUR analysis reveals great heterogeneity among countries. In order to study the dynamic effects taking into account the interdependencies, we compute the IRF of different shocks. In each case, they correspond to a standard deviation of the variable for which we compute the shock.

Figures 4 and 5 show IRF of country-specific shocks. The first set of graphs present how countries are affected by a shock in other countries (excluding Greece and a shock of the country itself). The second set of graphs shows the effect of a shock in Greece and the country itself. The largest effects are given by shocks from Greece, Italy, Spain and Portugal. A shock in Greece, Italy and Spain have in general a positive initial shock in all countries. The Greek shock however generates large variation across time, as the initial positive shock is followed by a negative one of smaller magnitude. The aggregated effect is positive. Portugal, on the contrary, produces a large negative effect on other countries' CDS. Overall this suggests that shocks in the countries that were the most affected by the European crisis have a large effect in the rest of European countries.

Figure 6 presents IRF for monetary shocks on countries' CDS. The graphs on the left show the monetary shocks in terms of money aggregate (M3) and those on the right hand side the effect of a shock in the ECB refinancing rate.

An increase in the M3 money aggregate reduces sovereign risk for all countries except Greece and Italy. Thus increasing liquidity in the Eurozone is considered a positive signal for the CDS market. The largest effects are observed for Ireland, Portugal and Spain. When ECB increases M3, there is an initial positive effect on Greece (i.e., CDS of 5 years government bond relative to CDS of Germany increases), which becomes negative the next period. The overall accumulated effect is positive. Increasing the ECB rate increases risks for all except (again) Greece and Italy. The largest effects are observed for Ireland and Portugal.

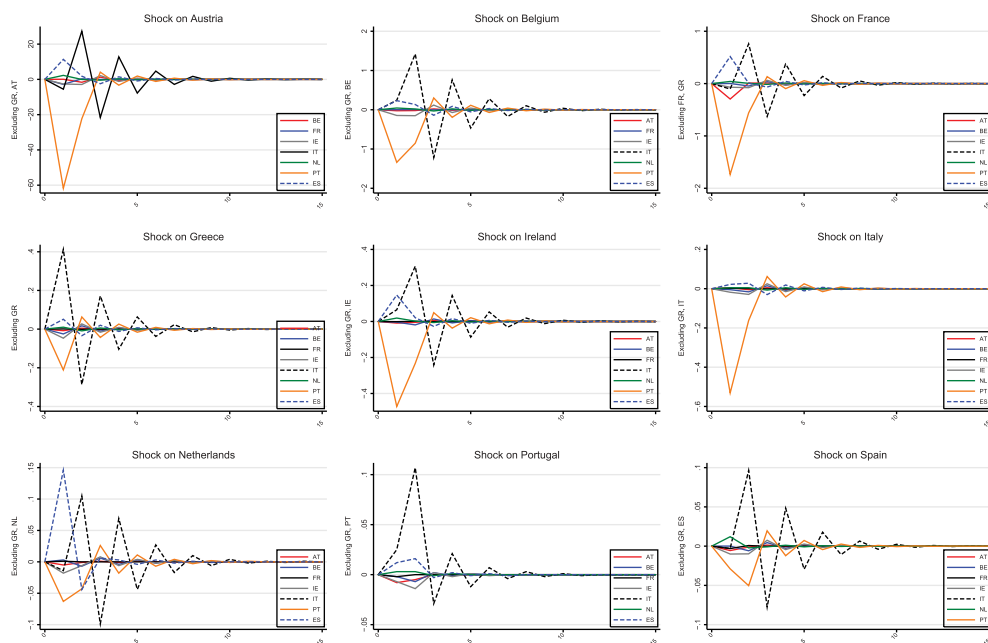


Figure 4. Impulse response functions – all shocks except Greece and the same country.

Note: Shock of a standard deviation in $\Delta(S_{it} - S_{gt})$.

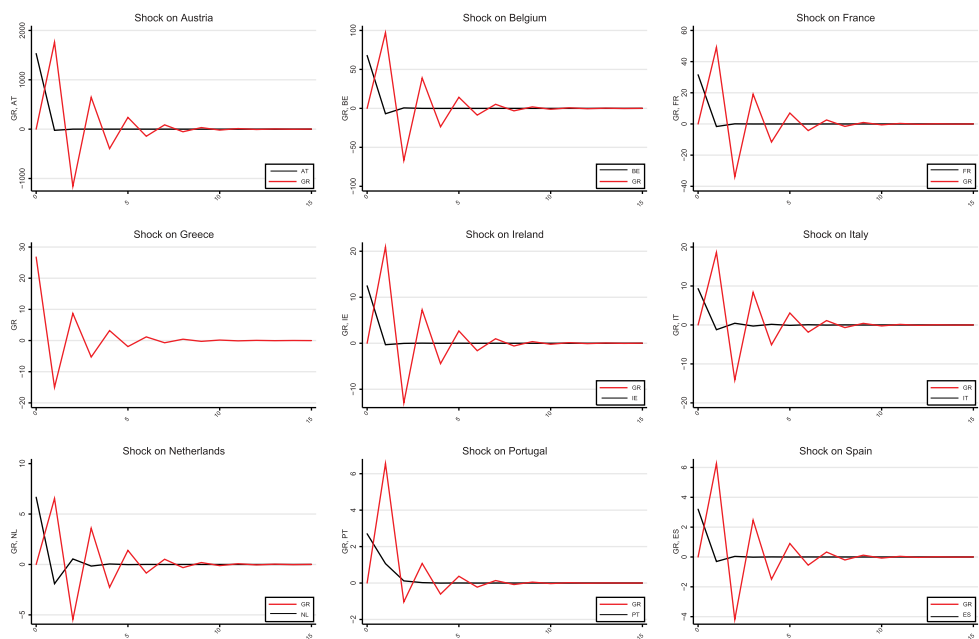


Figure 5. Impulse response functions – shocks of Greece and the same country.

Note: Shock of a standard deviation in $\Delta(S_{it} - S_{gt})$.

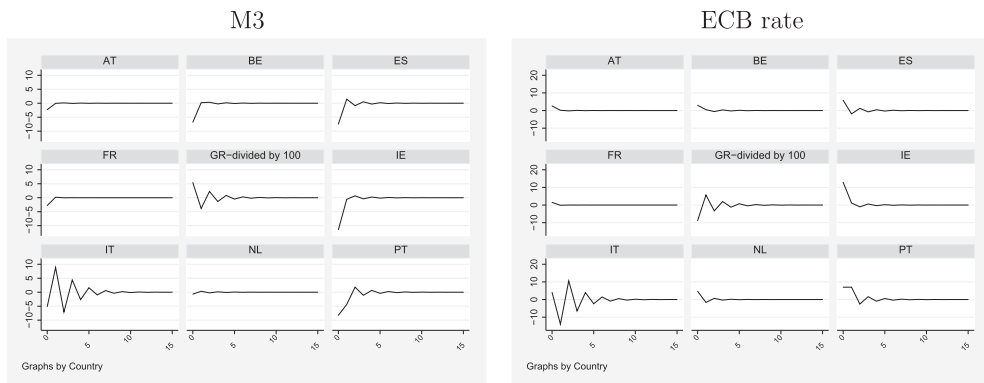


Figure 6. Impulse response functions – monetary shocks.

Note: Shock of a standard deviation in M3 and ECB refinancing rate.

The results above show that the CDS market is thus significantly affected by ECB monetary policy, but there is also large heterogeneity in the effects. A tightening of the monetary policy (i.e., reducing M3 or increasing ECB financing rate) increases sovereign risks for all countries except Greece (not clear for Italy). Note however, that there is heterogeneity in the magnitude of the shock. In particular, Ireland, Portugal and Spain (also Greece) show the largest effects.

The opposite effect on Greece could be interpreted as a differentiation effect. The Greek performance has been very weak for many years, and there has been a strong campaign to isolate Greek shocks from other countries. Our results suggest that this campaign has been successful.

6. Conclusion

This paper draws attention to the Eurozone debt crisis and the sovereign bond spreads using the CDS market. There is a positive relationship between risk aversion and sovereign bond CDS for almost all countries, which becomes larger after the 2012 Greek debt crisis. An increase in ECB refinancing rate or a decrease in money aggregates (M3) increase risk of government bond of all countries, except Greece that has the opposite effect. Greece is affected by monetary policies in a different way compared to all other European countries in our sample.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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