“Debt Contagion in Europe: A Panel-VAR Analysis”

by

Florence Bouvet  
Sonoma State University

&

Ryan Brady  
U. S. Naval Academy

&

Sharmila King  
University of the Pacific
Debt Contagion in Europe: A Panel-VAR Analysis

Florence Bouvet  
Economics Department  
Sonoma State University, CA  
bouvet@sonoma.edu

Ryan Brady  
Economics Department  
US Naval Academy  
rbrady@usna.edu

Sharmila King  
Economics Department  
University of the Pacific, CA  
sking1@pacific.edu

ABSTRACT

The European sovereign-debt crisis began in Greece when the government announced in December 2009 that its debt reached 121% of GDP (or 300 billion euros) and its 2009 budget deficit was 12.7% of GDP - four times the level allowed by the Maastricht Treaty. The Greek crisis soon spread to other Economic and Monetary Union (EMU) countries, notably Ireland, Portugal, Spain and Italy. Using quarterly data for the 2000-2011 period, we implement a Panel-Vector Autoregressive (PVAR) model for 11 EMU countries to examine the extent to which a rise in a country’s bond-yield spread or debt–to-GDP ratio affects another EMU countries’ fiscal and macroeconomic outcomes. To distinguish between interdependence and contagion among EMU countries, we compare results obtained for the pre-crisis period (2000-2007) with the crisis period (2008-2011) and control for global risk aversion.

Keywords: Panel VAR, sovereign debt crisis, euro area, contagion

JEL Codes: E58, F36, F33
1. Introduction

The Euro debt crisis threatens to derail the global recovery following the financial crisis of 2008. This paper examines the transmission of a potential sovereign debt default by contagion in the Euro Area. The European sovereign-debt crisis started in Greece when the government announced in December 2009 that its debt reached 300bn euros and its budget deficit for 2009 was 12.7% - four times the level allowed by the Maastricht Treaty. The crisis soon affected other EMU countries, notably Ireland, Portugal, Spain, and Italy. Are the refinancing problems of these countries only due to changes in their own economic fundamentals? Are developments in Greece affecting the market’s assessment of other EMU members, and causing contagion?

Contagion occurs when financial or macroeconomic imbalances (shocks) create a systemic risk beyond that explained by economic fundamentals (see Constancio, 2012 and Forbes, 2012). Contagion differs from macroeconomic interdependence among countries in that transmission of risk to other countries is different under “normal economic times. Forbes (2012) defines contagion as spillovers resulting from extreme negative effects. If co-movements of markets are similarly high during non-crisis periods and crisis periods, then there is only evidence of strong economic linkages between these economies (Missio and Watzka, 2011). At the center of the Greek debt crisis is a Greek fiscal crisis stemming from corruption, an inefficient tax system, and a bloated public sector. One could argue that the Greek phenomenon is independent from the overall European fiscal situation and particular to Greece. Yet, the downgrading of the Greek credit rating was soon followed by similar downgrades for other EMU countries: Ireland, Portugal and Spain notably.

Several studies (De Santis 2012, Eickmeier and Ng 2011, Barrios et al. 2009) empirically examine the nature of credit shocks and the mechanism by which credit shocks propagate from country to another. One path of propagation of a shock is through trade linkages, another is through international capital markets. Some institutional investors (such as pension funds) or banks are required to hold a minimum rating in their portfolio. For banks, often a minimum rating is required to comply with capital requirements or collateral when borrowing from the central bank. So, if a country’s debt is downgraded, these institutions will have to reduce their holdings of the debt which could cause bond yields to rise. Moreover, euro-area banks hold euro-area government debt as a diversification strategy; however these banks are then exposed to
changes in the value of government debt. This means that banks are not only exposed to
domestic government risk but also risk emanating from other countries in the euro-area (Bolton
and Jeanne 2011). An increase in perceived global risk magnifies the importance of fiscal
imbalances such as excessive debt or budget deficits which leads investors to discriminate
between economically weaker countries (such as Greece, Spain, Portugal or Italy) and stronger
countries (such as Germany, the Netherlands or France). Consequently, sovereign yield spreads
rise (Barrios et al. 2009). Cochrane (2010) argues that the contagion effect is dependent on
whether the euro-area will shield investors from potential losses from other periphery countries,
so investors are closely watching the Greek bail-out.

There are several approaches to examine the spillover of shocks from one country or region
to another. Some studies use global vector autoregressions (GVARs) to examine the dynamic
spillover effects of sovereign debt (Caporale and Girardi 2011, Eickmeier and Ng 2011) across
countries. The GVAR approach is a multi-country VAR in which one estimates a VAR model
for each country included in the sample. In addition to the lagged values of every country’s
variables in each equation, each VAR includes global variables which are constructed as the
weighted averages of the variables of the other countries included in the analysis. Typically, the
coefficient on the foreign variables are weighted by bilateral-trade or weighted to capture
international financial exposure. Another approach uses panel VARs (Assenmacher-Wesche and
Gerlach 2008) to examine the transmission of shocks internationally. “This technique combines
the traditional VAR approach, which treats all the variables in the system as endogenous, with
the panel-data approach, which allows for unobserved individual heterogeneity.” (Love and
Zicchino, 2006; page 193). Panel VARs differ from GVARs in that the coefficients on the
foreign variables are restricted to zero, and only one set of coefficients are estimated (not one for
each country, as in the GVAR). Structural vector error-correction models (De Santis 2012) are
also used to model the propagation of such shocks. Mink and De Haan (2012) use a different
approach, an event study to examine how financial markets respond to news on developments in
Greece.

Several papers have examined the relationship of government debt on long term interest rates
(Marattin and Salotti 2010, Baldacci and Kumar 2010) and the spillover effect of rising debt on
interest rates in other countries (Caporale and Girardi 2011). These studies find a significant,
positive relationship of government debt increases on the long-term interest rate. Empirical evidence is however mixed since the effects of increases in government debt can be offset by private saving, foreign saving via international capital markets, or if the debt is considered high quality it could indicate increasing liquidity. Caporale and Girardi (2011) find asymmetries between a debt/GDP shock originating in “core” countries compared to “periphery” countries.\footnote{Core Countries are France, Germany, Belgium, Luxemburg, Italy, Austria, Finland and the Netherlands. Periphery countries are Portugal, Ireland, Greece, and Spain.} They find that a debt/shock originating from France or Germany causes the long-term interest rate to fall for other Euro Area countries suggesting a liquidity benefit to other Euro Area countries. However, the same shock originating from the “periphery” causes long-term interest rates in other Euro Area countries to rise slightly indicating that default risk in the periphery is increasing borrowing costs for most. De Grauwe and Ji (2012) find evidence of a self-fulfilling rise in sovereign risk spreads emanating from the periphery compared to core countries in the Euro Area and other “stand alone” countries that can issue debt in currencies controlled by their own central bank. Specifically the debt-to-GDP and debt-to-tax revenue ratios are significant in explaining sovereign risk spreads in the Euro Area but not “stand alone” countries such as the US or UK, which suggests that countries that do not control their own money supplies are vulnerable to rising debt levels.

Using a Panel Vector Autoregressive (PVAR) model, we assess the extent to which rising debt to GDP ratios and government-bond yield spreads\footnote{Throughout this paper we will use the terms government-bond yield spread, sovereign spread, and risk premium interchangeably.} in EMU countries are due to changes in countries’ economic fundamentals and/or contagion from other troubled EMU economies. In addition to analyzing contamination from Greece, we also assess whether contagion from other larger southern countries, notably Spain and Italy, pose a bigger risk on the remaining euro area. This study contributes to the existing literature in several ways. First, in addition to debt-to-GDP shock, we examine shocks to sovereign spreads (other papers only analyze the determinants of sovereign spreads). Second, to distinguish interdependence from contagion, we compare the IRF’s obtained from the crisis period (2008-2011), with those obtained for the pre-crisis period (2000-2007). We also control for global uncertainty (global risk aversion) in addition to other economic fundamentals to better isolate risk originating from the peripheral countries in the euro-area (Caceres, Guzzo and Segoviano 2010). Finally, we measure the sovereign risk-spread
relative to the US, so we can retain Germany in our sample and examine the response of euro area countries to an isolated shock originating in Greece and other peripheral countries using the PVAR approach.

We find that, in the pre-crisis period, an increase in one country’s sovereign spread increases other countries’ sovereign spreads, but does not affect their debt-to-GDP ratios, thus indicating economic interdependence among EMU countries. Following 2008, the same shock to sovereign spreads has a large effect on countries’ debt-to-GDP ratios, if the shock stems from Greece or Spain suggesting contagion. When the shocks affect debt-to-GDP ratios, we do not find evidence of contagion. However, whether the shock improves or worsens the other EMU economies depends on the debt level of the country “shocked”.

The remainder of the paper is organized as follows. In Section 2 we describe the Panel VAR model and the data that we use to analyze whether a shock to an EMU country’s sovereign spread or debt-to-GDP ratio affects the other EMU countries. We discuss in section 3 the impulse response functions obtained from aforementioned shocks. In Section 4 we make concluding remarks.

2. Data and Estimation methodology

We estimate our impulse response functions from a six-variable PVAR in log-levels. Estimating the VAR in levels has a few advantages including the ease of interpreting the impulse response coefficients as well as avoiding some misspecification issues related to estimating a VAR in first differences or taking into account issues of cointegration (see Ramaswamy and Sløk (1998), Holden (1995), and Ibrahim (2006) for discussion on these points). For example, Ludvigson (1998) notes that even in the case where some variables may be nonstationary, a VAR in levels will have standard asymptotic distributions (as shown by Sims, Stock, and Watson (1990)). Similarly, Ramaswamy and Sløk (1998) measure the effects of monetary policy on European Union countries in addition to the United Kingdom using a VAR estimated in levels (they also provide discussion on the benefits of estimating the VAR in levels—see Ramaswamy and Sløk (1998), page 379-380, in particular). Ashley and Verbrugge (2009) show that even in the presence of non-stationarity and cointegration, estimating a VAR in levels provides impulse
response functions that are robust to those specification issues (see also Naka and Tufte (1997) for Monte Carlo evidence related to this point).

The PVAR approach has several advantages over individual country VARs. First, we gain degrees of freedom by analyzing a panel of countries. Further, we can better model the spillovers from one country to another since the panel approach captures country-level heterogeneity.

The PVAR model is given by:

$$Z_{it} = A(L)Z_{it-1} + e_{it}$$

Where $Z_{it}$ is a matrix of endogenous variables, $A(L)$ is a matrix polynomial in the lag operator $L$, with country $i = 1,...,11$.

In the baseline specification, the vector $Z$ includes the following variables:

- the Debt-to-GDP ratio
- the rate of GDP growth
- the rate of inflation (measured as the percentage change in Harmonized Consumer Price indices)
- the countries’ bond-yield spread measured as the difference between a country’s ten-year bond rate and the rate on the ten-year U.S. Treasury note
- the Global Risk Aversion index
- and the Country of Interest Sovereign Risk Spread/or Debt-to-GDP ratio.

While several papers measure the sovereign spread as the difference between an EMU country’s ten-year bond rate and the rate on the ten-year German bonds (Missio and Watzka, 2011; De Grauwe and Ji, 2012; Caggiano and Greco, 2012), we choose to use the U.S. Treasury note as the risk-free asset benchmark in order to keep Germany in our analysis. Our sample consists of 11 EMU countries (Austria, Belgium, Finland, France, Ireland, Italy, Germany, Greece, the

---

3 We ran the same VAR with the debt-to-GDP ratio in first differences and the IRFs were similar to those presented below. We discuss more sensitivity analysis later in this section.
Netherlands, Portugal and Spain\textsuperscript{4}). We use quarterly data over the period 1999Q1-2011Q4, which are obtained from the OECD Economic Outlook and Eurostat.

Before we discuss the GRA and country of interest variables included in our PVAR and performing a more rigorous econometric analysis, it is useful to look at the evolution of EMU countries’ debt-to-GDP ratios and bond-yield-spreads over time. Figure 1 displays the debt-to-GDP ratios of the original 11 EMU countries. To make the graph easier to read, we split the countries between the periphery (Greece, Ireland, Portugal, and Spain) and the core (the other seven countries). The red line captures the Stability and Growth Pact limit on government debt set at 60\% of GDP. First, it is worth noting that, even before the financial and economic crisis of 2008, only four countries maintained debt-to-GDP ratios below the 60\%-threshold: Finland, the Netherlands, Ireland, and Spain. Greece, Italy, and Belgium all had ratios well above the 60\% threshold, averaging respectively 104\%, 108\%, and 99\%. While several countries saw their debt ratios fall before the financial crisis, these ratios increased in every country after 2008. The increase is particularly striking in the periphery countries. Between the last quarter of 2008 and early 2011, the debt-to-GDP ratio increased 57.6 percentage points in Ireland, 41.3 percentage points in Greece, 32.9 percentage points in Portugal, and 25.9 percentage points in Spain. Unlike Greece whose debt troubles stemmed from fiscal indiscipline, the rapid rise in Spanish and Irish debts originated from the private sector (see Gomez-Puig and Sosvilla-Rivero 2011). Following the U.S. subprime mortgage crisis, these two countries’ governments were forced to bail-out the private sector (banking systems). Portugal's debt crisis is caused by much the same problems as Greece—decades-long overspending by the government and an overly large and bureaucratic civil service. Consequently, as shown in figure 1, the debt-to-GDP ratios of Greece and Portugal had been rising long before the economic crisis of 2008 (especially in Portugal), whereas Spain and Ireland had been able to reduce their debt-to-GDP ratios and keep them below the 60\%-threshold before they had to rescue their banking sectors.

Figure 1 here

Turning now to the government-bond yield spread (figure 2), most EMU countries enjoyed sovereign spreads with U.S. Treasury bonds close to zero, and even negative (between

\textsuperscript{4} Luxembourg is excluded from our sample because too many series were missing.
2005 and 2007) until the financial and economic crisis. While many countries experienced a slight increase in their sovereign spreads in 2008, the rapid increase in the risk-premia of periphery countries was initiated by the sovereign debt crisis in Greece late 2009. These premia have continued to escalate, and reached, in the first quarter of 2012, 22.7% in Greece, 11.18% in Portugal, 3.2% in Spain. Caggiano and Greco (2012) find that the correlation between sovereign spreads and debt-to-GDP ratios (especially for countries where the ratio is >100%) has increased since the financial crisis. Barrios et al. (2009) find that an increase in general risk perception is more important in explaining rises in sovereign risk spreads than domestic factors. However, increases in perceived risk heighten the effect of domestic imbalances on risk-spreads during times of financial stress. The situation in Ireland is slightly different in so far as its risk premium peaked during the second quarter of 2011. The Irish government’s commitment to public-debt reduction and the ratification by Ireland of the Treaty on Stability, Coordination and Governance in the Economic and Monetary Union by referendum in May 2012 eased Ireland’s access to funds.

In order to assess whether the sovereign debt crisis of one particular country, such as Greece, has affected other countries’ sovereign spreads and economic outcomes, we include the Greek risk premium or its debt-to-GDP ratio in our PVAR. While several papers in the literature assume contagion would stem from Greece alone (Constancio, 2012; Missio and Watzka, 2011), we also check the impact of shocks to larger economies which have seen their sovereign spreads rise more recently, namely Italy and Spain. For comparison purposes, we also examine whether shocks to Germany—the largest economy in the EMU—induce the same type of contagion. Consequently, while our sample includes 11 EMU members, in practice the PVARs discussed in the next section are estimated with only ten members each that are defined by exclusion of country defining the “Country-of-Interest” Risk Premium.

Because the surge to global risk aversion is a significant factor affecting a sovereign spread (Barrios et al., 2009; Bernoth and Erdogan, 2010; Carceres et al., 2010), our model also includes a measure of global risk aversion (GRA). At times of high financial market risks, investors tend to sell high-risk government bonds and buy less risky ones, leading to higher
sovereign spreads in more risky economies. Our GRA measure is based on the method proposed by Espinoza and Segoviano (2011) and used by Carceres et al. (2010). The price of an asset reflects both this asset’s returns and the price that “investors are willing to pay for receiving income in “distressed” states of nature.” (Carceres et al, 2010, page 6) The index of Global Risk Aversion measures the market price of risk. The GRA measure is constructed using the following formula:

\[ GRA_t = -(1 - PoR_t) \]  

(1)

Where \( PoR_t \) is the share of the market price due to idiosyncratic risk as a fraction of the actual probability of a negative event. The GRA index captures the market’s perception of risk at every point in time. The GRA measure is exogenously given and common to all the countries included in the sample and the market price of risk is estimated using the US Libor-OIS and the VIX (the Chicago Board Options Exchange Volatility Index). A rise in the index of global risk aversion implies an increase in global risk aversion. As shown in figure 3, the GRA index captures the rise in global aversion observed after August 2008, and peaking in October 2008, after Lehman Brothers’ bankruptcy. After a gradual reduction in 2009, the index spikes again in December 2009 when the Greek government announced that its debts had reached 300bn euros and its budget deficit for 2009 was 12.7% - four times the level allowed by the Maastricht Treaty. The more recent increase in the last quarter of 2010 corresponds to the spread of the sovereign debt crisis to other EMU countries.

- Figure 3 here –

We again follow common practice and identify structural impulse response functions using recursive identification (through the Cholesky decomposition), with the variables ordered as follows: Global Risk Aversion (GRA), “Country-of-Interest” Risk Premium, the Debt-to-GDP ratio, the rate of real GDP growth, the rate of inflation, and the other countries’ Risk Premium. The recursive order dictates that the other countries’ risk premium responds to changes in the other variables in time \( t \). In contrast, GRA only responds to itself in time \( t \), and only with a lag to the other EMU-specific variables. The system is estimated with four lags.
Before we discuss the results, we briefly comment on the robustness of the results we report below to alternative specification choices. For example, in our analysis we order Debt-to-GDP ahead of GDP growth based on the logic that the level of Debt is not likely to respond immediately to a shock to the growth rate of GDP but with a lag as government budgets respond sluggishly to such changes. However, one could argue the other way if automatic stabilizers immediately change the ratio. We considered this alternative ordering, but the change in ordering does not greatly affect our analysis and conclusions. We attach figures for the alternative options we estimated as an appendix to our main analysis. For brevity we include the extra results only for Greece. However, a full set of alternative results are available for Spain, Italy and Germany. Given the appendix with figures just for Greece runs eight pages, the figures for the other three countries are available upon request but not included here for some semblance of brevity.

Other options we considered included varying the lag length, adding a long term interest rate for each country (in addition to the risk premium), and different transformations of some of the included variables. With respect to lag length we considered a lag length of five but the results did not change to a large degree. Obviously our short sample that covers the crisis period (defined to include 2008 to 2011, which we discuss more below) is likely to be most sensitive to changes in the available degrees of freedom and that is indeed the case. While the impulse response functions in this period do not change that much with the extra lag in the system, the statistical significance of the responses becomes weaker (stretching the lag length beyond five made estimation in the short sample impossible). Changes to the statistical significance of the responses in the longer time period were negligible with the inclusion of the extra lag.

We also estimated with the debt to GDP ratio in first differences and with GDP in log levels (instead of as a growth rate). These alternatives did not change the results substantially, nor did adding the ten year rate for each country (which might be included if one thinks the level of a country’s long term rate has a distinct effect in the system from the risk premium). Lastly, while below we focus on the pre-crisis versus crisis comparison, in the appendix we also report the results for the full sample period. Overall, changes to the VAR model along these various lines did not affect our inference to a large degree, especially when comparing the pre-crisis period to the crisis period. Of course, as more data become available over time, a researcher will be less
bound by the restrictions we face here in analyzing the crisis period, but we feel the analysis below offers a useful understanding of the spread of financial pressure across the EU, one that is relatively robust to typical variations in VAR estimation.

3. Results

3.1 Shock to a country’s risk premium

In the first set of impulse response functions below in Figure 4, we report results from a VAR estimated with Greece’s Risk Premium to gauge the effect of a one positive standard deviation shock to that country’s risk premium on the remaining ten countries in the sample (so Greek data are excluded from the remaining variables). The motivation for such a strategy is to isolate the effect of a change in one country’s risk premium on the other members of the EMU. We estimate the PVAR system in turn for shocks originating in Spain, Italy and Germany as we do for Greece (reported in Figures 5 through 7). Finally, since we estimate with a long panel (\( n = 10 \) and \( t = 39 \)), we control for country fixed-effects using dummy variables.\(^5\) Based on limitations to the Global Risk Aversion variable, the sample spans the first-quarter of 2001 through the second-quarter of 2011. We compute the responses over a 10-quarter horizon. For inference, we report standard asymptotic standard errors for the impulse response functions.

Below we discuss first the responses displayed in Figures 4 through 7 for the pre-crisis period (2001-2007). Then we conduct the same exercise, but for the crisis period (2008-2011) to check for evidence of contagion effects. Later, we also analyze the response of the system variables to a shock to the Debt-to-GDP ratio, again for the pre-crisis and crisis periods.\(^6\)

Splitting the sample with the beginning of 2008 is motivated primarily by the notable change in Greece’s risk premium at some point in 2008 (displayed in Figure 2). In addition, as the

\(^5\) Using dummy variables to control for country-fixed effects is equivalent to the Within Estimator commonly employed when estimating with panel data (since most applications have large \( n \) but small \( t \)). Also, given we estimate with a long panel, the fixed effects estimator is consistent. See Arellano (2003) for discussion. Of course, one could use a “traditional” method and remove the country-fixed effects via transformation, but as noted earlier, doing so in the context of a VAR introduces potential mis-specification related to cointegration. See Love and Zicchino (2006) for an example using a short panel. In the appendix we provide results for the VAR estimated without fixed effects for comparison.

\(^6\) In the interest of brevity, we eschew reporting the results for shocks to the other variables. Those results are available upon request.
discussion surrounding Figures 1 through 3 suggest, anecdotally the “crisis” began in full earnest in 2008. To check that notion statistically we applied the structural break methodology of Bai and Perron (1998, 2003) to the risk premium for each country in our sample. Bai and Perron (1998, 2003) provide a method for estimating the existence of unknown \( (a\text{ priori}) \) breaks and significance tests for judging the statistical significance of any found break date. We find evidence of a statistically significant break date in Greece’s risk premium in the fourth quarter of 2008 (with a confidence interval spanning the first quarter of 2008 through the first quarter of 2009). For Spain and Italy, we find a statistically significant break in the fourth quarter of 2007. For the eight other countries in our sample, a break occurs in seven of them at some point in late 2007 or 2008.\(^7\) Hence, we feel 2008 is an appropriate point to split our sample into the pre-crisis and crisis periods.

a. **Pre-crisis period (2001-2007)**

As shown in figure 2, EMU countries enjoyed similar, low sovereign spreads (the standard deviation for this period is 0.5% or 50 basis-points). Consequently, shocks\(^8\) to different countries’ sovereign spreads yield quite similar response from the rest of the EMU. First, as shown in figures 4 to 7, debt-to-GDP ratios in other EMU countries are not significantly affected by a shock to sovereign spreads. We only observe an economic slowdown between the fifth and eight quarters following the shock. Shocks to Greece, Spain, Italy and Germany’s risk premia trigger a similar response from the risk premia of other EMU countries. A worsening of these four countries’ risk premium increases remaining EMU countries’ sovereign spreads by 8-9 basis-points the first quarter, and up to 10 basis-points at the end of the first year. Then, the effect progressively diminishes until it becomes statistically insignificant by the end of the 10-quarter time horizon. We also find a similar response from the GRA index which rises 0.2 basis-points after the risk premium shock.

\(^7\) Table A1 in the appendix lists the dates for each country in addition to Bai and Perron’s (1998, 2003) asymmetric confidence intervals. Only for Germany did we not find a statistically significant break around the crisis period. There are numerous applications of Bai and Perron’s (1998, 2003) methodology in various economic studies. In the interest of brevity we refer readers to Bai and Perron (1998, 2003) for details of their method. For an explanation of the method for the practitioner see Brady and Greenfield (2010). Here we use their techniques to support the visual evidence that something obviously changed with Greece’s risk premium, in particular, around 2008. A detailed and lengthy analysis of the structural breaks with respect to the Euro area is beyond the scope of this paper though would certainly make for an interesting extension of our current study.

\(^8\) Over the 2001-2007 period, one standard deviation in the sovereign spread equals 49 basis-points for Greece, 52 basis-points for Spain, 48 basis-points for Italy, and 47 basis-points for Germany.
b. Crisis period (2008-2011)

Unlike in the pre-crisis period, the EMU economies respond differently to risks premium shocks from the four countries studied in this paper. This is partly due to differences in the magnitude of the shocks (i.e. standard deviations in the risk premium variable): the standard deviation for Greece’s sovereign spread (659 basis-points) is more than 20 times larger than the standard deviation of the German sovereign spread (33 basis-points).

Figure 8 shows the responses of the six variables included in our PVAR model to a one positive standard deviation shock to the risk premium of Greece (equal to 659 basis-points). A worsening of the Greek risk premium increases the other EMU countries’ sovereign spreads by 10 basis-points in the first two quarters. This slight rise in risk premia can be explained by a comparable rise in global risk aversion in the first two quarters after the shock to Greece’s sovereign spread. The initial negative impact of the Greek risk premium shock on economic growth is consistent with rising debt-financing costs, as well as the rising debt-to-GDP ratio which increases by 50 basis-points after one year, up to 200 basis-points by the end of the simulation span.

Figure 9 illustrates that if the sovereign debt crisis originates in a larger economy such as Spain, the impacts on the other EMU countries are more severe. A one positive standard deviation shock to Spain’s risk premium (+ 107 basis-points, i.e. less than a fifth of the Greek
risk premium shock) decreases the risk premium of other countries by 10 basis-points in the first year. Unlike Greece which accounts for less than 2% of the European Union (EU) GDP, Spain’s economy represents close to 9% of the EU GDP. Consequently, if the risk premium of the larger economy rises, investors might move assets to other EMU countries that enjoy easier access to funds, and lower interest rates. Despite this fall in borrowing costs, Debt-to-GDP ratios would also increase by almost 100 basis-points after five quarters. The response then becomes statistically insignificant.

- Figure 9 here –

A slightly different picture emerges when a positive one standard deviation shock to Italy’s risk premium (+ 117 basis-points, i.e. similar to the shock to Spain’s risk premium) is considered. Now the risk premium of other countries increases by more than 15 basis-points initially, and the effect dissipates very quickly. GDP growth rates initially fall by 20 basis-points by the third quarter. A shock to the Italian risk premium also induces a larger increase in debt-to-GDP ratios, progressively increasing 120 basis-points by the sixth quarter.

- Figure 10 here –

What if the shock (again one positive standard deviation, + 33 basis-points) originated from the largest EMU economy, which also offers AAA-rated assets, namely Germany? This scenario is investigated in Figure 11. We find that other EMU countries see their risk premia increase by 10 basis-points over the first year, as Germany loses some of its appeal as a safe haven for investors, and this effect spills over to other EMU economies. Debt-to-GDP ratios in other EMU countries do not increase as in the other scenarios considered earlier. However, because Germany is a bigger player in the world economy, the shock to Germany’s risk premium – a twentieth of the shock to Greece’s risk premium- induces a larger and slightly more persistent drop in the other countries’ economic growth, and increase in the Global Risk Aversion index.

---

9 The response of other countries’ risk premia becomes statistically insignificant after the 4th quarter.
10 One still needs to keep in mind that the magnitude of this shock is much smaller than the shock to the other three countries’ risk premia.
This phenomenon might explain why other EMU countries would see their risk premia initially rise, as investors’ seek refuge in US Treasury notes.

- Figure 11 here –

Overall, these simulations provide some evidence of contagion within the EMU, as shocks to sovereign spreads from periphery countries trigger large increases in debt-to-GDP ratios in other countries. There is, however, no clear sign of contagion to other countries’ risk premia as these spreads do not respond differently during the crisis period, despite much larger shocks to the spreads of Greece, Spain, and Italy.

3.2 Shock to country’s debt-to-GDP ratio

To investigate further the presence of contagion of fiscal imbalances among EMU countries, we show in Figures 12 to 15 the responses to a one positive-standard-deviation shock to the debt-to-GDP ratio of Greece, Spain, Italy, and Germany in the pre-crisis period (2001-2007). We then contrast these responses with those obtained for the crisis period (2008-2011).

a. Pre-crisis period (2001-2007)

Because shocks to countries’ debt-to-GDP ratios trigger different responses, we discuss them individually.

Starting with a shock to Greece (Figure 12), a 390-basis-points increase in the Greek debt-to-GDP ratio does not affect other EMU countries’ debt-to-GDP ratios. However, as a result of the rise in global risk aversion, sovereign spreads rise initially by 3 basis-points, increasing to 4 basis-points by the third quarter. GDP growth in other EMU countries increases by up to 4 basis-points in the first 3 quarters, indicating that a rise in Greek debt stimulates aggregate demand in the rest of the eurozone. The effect is however short-lived, as economic growth slows down (-4 basis points) between the 5th and 7th quarters.
When the debt-to-GDP ratio of a larger periphery country such as Spain increases by one standard deviation (620 basis-points), other countries’ debt-to-GDP ratios are also not affected. However, the risk premia in other countries decreases almost 4 basis-points by the second quarter. The decreasing borrowing costs indicate that other countries benefit from flight-to-quality. The slight increase in GDP growth rate after the sixth quarter indicates that the rise in Spanish debt helps stimulate aggregate demand in other EMU countries.

When Italian debt-to-GDP ratio is shocked—another large EMU economy, but plagued with high debt-to-GDP (see Figure 1)—the risk-premia in other countries fall by 4 basis-points. This response is likely triggered by capital-flight from Italy and a decline in global risk aversion. Despite the declining risk premia, remaining EMU countries do not experience a fall in their debt-to-GDP ratios. Unlike Spain, an increase in Italian debt does not help stimulate economic growth in other countries.

A worsening of the German debt-to-GDP ratio (increase by 350 basis-points) does not significantly affect other countries’ debt ratios, however their risk premia fall during the first year following the shock. This is consistent with a “liquidity effect” (also found in Caporale and Girardi (2011)) in which the overall level of risk falls when a country, viewed as less risky by investors, issues more debt causing a fall in the other countries’ risk premia. This liquidity effect could also explain the initial fall in the GRA index. Finally, given the size of the Germany economy in the eurozone, an increase in German debt-to-GDP ratio has a stronger positive effect on economic growth (+ 4 basis-points at the end of the first year) in other countries.
b. Crisis period (2008-2011)

A noticeable difference in this set of simulations is that shocks to one country’s debt-to-GDP ratio causes changes in other countries’ debt-to-GDP ratios.

A 1550-basis-point increase in the Greek debt-to-GDP ratio triggers very few changes in other countries (Figure 16). Initially, countries see their risk premia fall slightly, as a consequence of capital flight from Greece (and the rest of the world since the GRA index increases slightly in the second quarter). By the sixth quarter, economic growth increases and subsequently the debt-to-GDP ratio in other countries falls while global risk aversion falls.

When the debt-to-GDP ratio of a larger periphery country such as Spain increases by one standard deviation (1080 basis-points), remaining countries in the EMU see their debt-to-GDP ratios decrease by 200 basis-points at the end of the simulation horizon, probably due to a rise in economic growth and a decline in risk premia following the 5th quarter. The risk premia fall initially by 20 basis-points and then by 60 basis-points ten quarters later. We observe the same capital flight from Spain, as in the pre-crisis period, however the responses are stronger (even accounting for the larger standard deviation here). This latter effect might be due to the negative response of economic growth in the first year.

A shock to the debt ratio of highly-indebted Italy triggers no statistically significant response from the other EMU economies during the crisis period possibly because Italy is considered “too
big to fail” and the ECB will intervene. The ECB announced on August 7th, 2011 that it would buy Spanish and Italian debt to stem contagion.

Figure 18 here –

A shock to Germany’s debt-to-GDP ratio (+ 610 basis-points) triggers a set of responses similar to those obtained for Spain. After an initial limited response, a worsening of the German debt-to-GDP ratio leads to a decline in other EMU countries’ debt-to-GDP ratios by 100 basis-points the 6th quarter. Sovereign spreads also decrease slightly in the first year and continue to decline around the 6th quarter (approximately 20 basis-points). We therefore observe the same liquidity effect as in the pre-crisis period, but with a larger magnitude. Countries might also benefit from a drop in the GRA index. Finally, a larger German debt level seems to stimulate aggregate demand in neighboring countries, as economic growth accelerates during the first three quarters following the shock.

- Figure 19 here –

4. Conclusion

In this paper we implement a panel-VAR (PVAR) model for 11 EMU countries to examine the extent a rise in a country’s bond-yield spreads or debt-to-GDP ratio affects the other EMU countries’ fiscal and macroeconomic outcomes. Using quarterly data for the 2000-2011 period, we find some evidence of interdependence and contagion within the EMU during the 2008-2011 period. Our estimations suggest in the pre-crisis period, an increase in one country’s sovereign spread leads to an increase in the other countries’ borrowing costs and sovereign spreads, but does not affect their debt-to-GDP ratios. After 2008, the same shock to sovereign spread has a large effect on countries’ debt-to-GDP ratios, if the shock stems from Greece or Spain. This suggests the existence of contagion. In the case of a shock to Germany’s sovereign spread, however, other countries barely see their borrowing costs rise, as Germany loses some of its appeal as a safe haven for investors.
When the shocks affect debt-to-GDP ratios, we do not find evidence of contagion, but whether the shock improves or worsens the other EMU economies depends on the debt level of the country “shocked”. If Germany or Spain’s debt-to-GDP ratios increase, other countries benefit from a liquidity effect and see their sovereign spreads and borrowing costs decrease. If the shock originates from Greece or Italy, then we observe no significant response in other countries. As pointed out by Caporale and Girardi (2011), these contrasting results suggest that financial markets are able to discriminate among different debt-issuers. Moreover, we agree with these authors’ conclusion that the crowding-out effects of higher debt from Italy and Greece provides support for some fiscal discipline, but probably with a little more flexibility than what is in place in the Stability and Growth Pact.

To better distinguish between economic interdependence and contagion, further research would benefit from using a panel Vector Error Correction Model, whereby the short-term dynamics would capture the possible contagion, and the long-term coefficients would capture economic interdependence.
5. References


6. Figures and Tables

Figure 1: Debt-to-GDP ratio in EMU countries

Notes: Debt data are not available for 1999. The red line captures the Stability and Growth Pact limit on government debt set at 60% of GDP.
Figure 2: Risk Premia in EMU countries

Note: the risk premium is measured as the difference between a country’s ten-year bond rate and the rate on the ten-year U.S. Treasury note.
Figure 3: Index of Global Risk Aversion

Note: Authors’ own calculation based on Carceres et al. (2010)
Figure 4: Pre-crisis Response of EMU Countries to a shock to the Greece Risk Premium: 2001-2007

Notes: Impulse response functions estimated from six-variable VAR, controlling for country-fixed effects, and with identification achieved through Cholesky decomposition (see text for ordering). Shock defined as Cholesky one-standard deviation. Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. Sample spans the fourth quarter of 2001 through the fourth quarter of 2007. See text for additional details.

Figure 5: Pre-crisis Response of EMU Countries to a shock to Spain Risk Premium: 2001-2007

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.
Figure 6: Pre-crisis Response of EMU Countries to a shock to Italy Risk Premium: 2001-2007

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.

Figure 7: Pre-crisis Response of EMU Countries to a shock to German Risk Premium: 2001-2007

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.
Figure 8: Response of EMU Countries to a shock to Greece’s Risk Premium During the Crisis: 2008-2011

Notes: Impulse response functions estimated from six-variable VAR, controlling for country-fixed effects, and with identification achieved through Cholesky decomposition (see text for ordering). Shock defined as Cholesky one-standard deviation. Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. Sample spans the first quarter of 2008 through the second quarter of 2011. See text for additional details.

Figure 9: Response of EMU Countries to a shock to Spain’s Risk Premium During the Crisis: 2008-2011

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.
Figure 10: Response of EMU Countries to a shock to Italy’s Risk Premium During the Crisis: 2008-2011

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.

Figure 11: Response of EMU Countries to a shock to Germany’s Risk Premium During the Crisis: 2008-2011

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.
Figure 12: Pre-crisis Response of EMU Countries to a shock to Greek Debt-to-GDP ratio: 2001-2007

Notes: Impulse response functions estimated from six-variable VAR, controlling for country-fixed effects, and with identification achieved through Cholesky decomposition (see text for ordering). Shock defined as Cholesky one-standard deviation. Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. Sample spans the fourth quarter of 2001 through the fourth quarter of 2007. See text for additional details.

Figure 13: Pre-crisis Response of EMU Countries to a shock to Spanish Debt-to-GDP ratio: 2001-2007

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.
Figure 14: Pre-crisis Response of EMU Countries to a shock to Italian Debt-to-GDP ratio: 2001-2007

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.

Figure 15: Pre-crisis Response of EMU Countries to a shock to German Debt-to-GDP ratio: 2001-2007

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.
Figure 16: Response of EMU Countries to a shock to Greece’s Debt-to-GDP ratio During the Crisis: 2008-2011

Notes: Dotted lines show the plus or minus 2-standard error bands. The sample spans the first quarter of 2008 through the second quarter of 2011. Horizon measured in quarters. See notes to previous figures for additional details.

Figure 17: Response of EMU Countries to a shock to Spain’s Debt-to-GDP ratio During the Crisis: 2008-2011

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.
Figure 18: Response of EMU Countries to a shock to Italy’s Debt-to-GDP ratio During the Crisis: 2008-2011

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.

Figure 19: Response of EMU Countries to a shock to Germany’s Debt-to-GDP ratio During the Crisis: 2008-2011

Notes: Dotted lines show the plus or minus 2-standard error bands. Horizon measured in quarters. See notes to previous figures for additional details.