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Assessing the Impact of Country-Specific Sovereign Risk on Financial and Banking System in EMU: the Role of Italy

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Abstract
This work investigates the bank-sovereign risk transmission across EMU countries, assessing how sovereign risk in Italian government bonds can affect the sovereign and credit risk of non-stressed countries. We employ a GVAR technique and measure spatial proximity by using the cross-country "distance" in debt-to-GDP ratio. Our results confirm the hypothesis of a sovereign-bank loop: a shock in Credit Default Swaps spread of one country propagates to other CDS and bank indices. The effects are stronger in more fragile financial systems. Overall, our findings highlight the importance of spillover effects and suggest a monetary policy tailored on "back-door" propagation of shocks.

JEL classification: C31, C58, E44.

Keywords: sovereign CDS, GVAR, spillovers, euro area.

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1. Introduction

The 2008 financial crisis and the sovereign debt crisis which followed relatively soon after (2010), led many economics researchers to re-open their old files on the issue of systemic financial risk. At the same time, new investigations were undertaken on the linkages between the financial sectors of different countries (Bratis et al., 2018; Zhu, 2018; Gilchrist et al., 2019).[1] Indeed, the issue of financial contagion, so widely studied after the crisis, is still in need of analysis in greater depth: in a world of strongly intertwined financial systems, a shock in one country, or in a specific sector of activity, swiftly propagates to other financial systems, very often with disruptive effects also upon the real economy (Benoit et al., 2017; S. Avdjieva et al., 2019). The consequences of the shock, the extent of the contagion and the markets involved depend on many factors, among which the interdependence of the banking system and state of government finances are of great importance (Brunnermeier et al., 2016). The aim of this paper is to analyse the cross-border effects of sovereign risk on other countries' credit default swaps (CDS) spread and bank stock market indices, employing a measure of the spatial interdependence between eight Eurozone countries. In detail, we evaluate the effect of an increase in Italian sovereign risk on both other EU CDSs and banks indices. The 2008 financial crisis and the subsequent sovereign debt crisis in the euro area also showed that sovereign risk and bank risk often move jointly in a vicious and harmful cycle. This evidence finds support in a growing literature (e.g., Acharya et al., 2014, Farhi & Tirole, 2018; Acharya & Steffen, 2015; Beqiraj et al., 2021). The link between the treasury bonds and banks' stock market value is substantiated in what is commonly called the "doom-loop" between banks and public debt securities: a vicious circle for which, as the risk on government bonds increases, the market value of banks that hold that bonds decreases, with the final result that both banks and the sovereigns' bond can end up in a simultaneous condition of crisis (Breckenfelder and Schwaab, 2018).

[1]Companies/countries considered to be a systemic risk are called "too big to fail."

Banks usually invest large portions of their portfolio in government bonds of different countries. Following a speculative attack, or a sudden worsening of government financial conditions in one country, the banking sector may experience a weakening in asset positions and could face a liquidity crisis. In turn, the liquidity crisis may exacerbate the crisis in sovereign bonds and spreads to other markets (Merler & Pisany-Ferry, 2012). A sovereign crisis, even when it is generated by pure self-fulfilling expectations, tends to create vicious circles that not only accelerate the accumulation of debt, but also worsen the state of the economy. Hence, countries that are inherently exposed to sovereign risk are also subject to instability and to the risk of not being able to sustain their debt.

Before 2008, it was deemed unlikely that developed countries could be affected by a credit risk. Moreover, the possible feedback effect from the credit risk to sovereign bonds of peripheral countries was underestimated (Acharya et al., 2014).

As underlined by Brunnermeier et al. (2016), the sovereign-bank loop occurs through two different, but mutually reinforcing, channels: a bailout loop and a real economy loop. The former works as follows: a negative (financial or economic) shock causes a deterioration in sovereign creditworthiness and reduces the market value of banks' holdings of domestic sovereign debt. This reduces the perceived solvency of domestic banks, which in turn increases the chances that banks would have to be bailed out by their (domestic) government. Therefore, the sovereign distress increases even further, engendering a bailout loop. The real economy loop, instead, sets in following a sharp deterioration in banks' financial conditions. As distressed banks cut back on lending, they trigger a reduction in economic activity and tax revenue, which also contributes to weakening government solvency in these countries, triggering a real economy loop. Moreover, when the banking distress originates from foreign countries, the domestic government is forced to bail out the ailing (domestic) banks, further increasing the counterparty risk of sovereign debt.

Because of the close linkages between countries and the nature of monetary institutions, the risk of contagion is higher in the European Monetary Union (EMU). Following an increase in country-specific sovereign risk, the lack of a credible official lender of last resort (LOLR) in the EMU exposes all member states to financial turmoil and recession (Corsetti et al., 2018) and serves as a reminder of the critical importance of the LOLR in restoring financial stability.

Theory indicates that a high degree of capital market integration improves the allocation of resources and acts as a shock absorber in the presence of a risk-sharing mechanism (see Asdrubali et al., 1996). However, this integration might expose the interconnected economies to financial turmoil and episodes of contagion. In fact, although interbank claims enhance the stability of the economic system, in the presence of negative shocks the interconnections start to serve as a mechanism for propagation of shocks (risk-spreading) and lead to a more fragile financial system (Acemoglu et al., 2015).

In this study, we investigate the additional channel of bank-sovereign risk transmission across countries, whereby sovereign risk in stressed countries can affect the sovereign and credit risk of non-stressed countries in the euro area. Starting from a measure of "spatial linkages" between eight Eurozone countries, our aim is to analyse the cross-border effects of sovereign risk on other countries' credit default swaps (CDS) spread and bank stock market indices. More specifically, we measure the impact (direct and indirect) of a possible increase in Italian sovereign risk on both other EU CDSs and bank valuation. We believe that Italy is an interesting case to analyse contagious effects in financial markets and the government bond market since it has a high level of public debt which is held in large quantities by foreigners.

Several studies have progressively documented that, besides own-country fundamentals, cross-country linkages of a different nature may explain CDS differentials in European countries (Favero, 2013; Milcheva & Zhu, 2016). In this paper, we try to build on the literature by providing further empirical evidence on the role that spillovers from shocks to government bonds play in shaping the dynamics of international financial markets. Specifically, we attempt to achieve this objective by exploiting the ability that spatial econometric analysis has to highlight linkages that other methodologies cannot fully detect. The existing literature mainly explains CDS spreads by analysing the interactions between macroeconomic variables. Moreover, in most instances, these studies cannot provide information on the feedback effects of shocks. To identify the nature and interrelationship between government bond risks in different countries and, in turn, the effect of such risks on banks' perceived valuation, we employ an econometric model belonging to the multi-country category: the global VAR model (GVAR - Pesaran et al., 2004). The latter encompasses spatial dependence between different financial systems and consists of two blocks: i) a system of domestic VAR models with cross-country interactions; ii) a VAR model for exogenous factors which affect all domestic economic systems. To the best of our knowledge, this is the first study that has focused on the spatial interactions of Italian sovereign CDS with CDSs and bank indices of other European countries by using GVAR techniques.

In general, spatial econometrics appears to be well suited to analyse and study system-wide risk. This holds particularly in our case since the associated interaction matrix allows consideration of the explicit interdependence across sovereign risks. Following Favero (2013), we define spatial proximity as the cross-country distance in debt/GDP ratio weighted by the levels of Maastricht parameters. Moreover, our spatial econometric specification includes both contemporaneous and time-lagged cross-country dependences and thus allows a complete analysis of risk transmission between financial systems. We can quantify, for any horizon, how much a change in macroeconomic and financial conditions in a specific country, i.e. Italy, modifies the risk profile of other government debts (Acharya *et al.*, 2017; Adrian and Brunnermeier, 2016; Brownlees and Engle, 2017). To provide clearer policy implications, we analyse the impacts of the GVAR model, in the period 2012-2018, under two scenarios. In the first, we study a shock in the Italian CDS on the CDSs of all other countries. In the second, we analyse the impact of a shock in the Italian CDS on bank indices in all other countries. Interestingly, the results, mainly in line with expectations, also highlight what we call the "real effect" or "bad neighbours" effect. The nature of the contagion depends on the linkages of the country with all the others: the more fragile the neighbours' financial and economic fundamentals the greater the spillover effects; the stronger the linkages and market integration, the greater the direct impact. In our sample, which includes strongly integrated financial and capital markets, a positive shock in the Italian CDS spread causes a sharp increase in the sovereign risks of the other euro area countries. Our results are consistent with the theory and confirm the hypothesis of a sovereign-bank loop. We also find heterogeneity in responses of core and non-core countries.

The rest of the paper is organised as follows. We discuss the literature in section 2 and describe the interconnection of the Italian financial system with the financial systems in other countries in section 3. Section 4 presents the methodological approach and data, while section 5 discusses the empirical findings. Section 6 concludes.

2. Literature background

This paper employs a spatial econometric approach to investigate the cross-border spillovers of Italian country-specific sovereign risks to foreign financial systems. Recent years have witnessed a substantial increase in the number of studies applying spatial econometric techniques to finance and microfinance issues, and in particular to analyse problems concerning the financial contagion between contiguous countries (see Arnold et al., 2013; Milcheva & Zhu, 2016; Debarsy et al., 2018). Financial studies have also progressively employed spatial econometrics to quantify the systemic risk in financial institutions (Eder & Keiler, 2015; Tonzer, 2015) and to analyse the co-movements of international asset markets (Asgharian et al., 2013).

One of the pioneering works studying systemic risk through the lens of spatial econometric analysis is that of Dell'Erba et al. (2013) who explore spillovers in the sovereign bond market for 24 emerging economies in the time interval 1995–2010. By controlling for the influence of global factors, they find strong evidence of spillovers from both shocks in sovereign spreads and macroeconomic fundamentals in neighbouring economies. Two years later, Eder & Keiler (2015) shifted the analysis to a micro level, decomposing the credit spread into a contagion risk premium, a systematic risk premium and an idiosyncratic risk premium, and identifying considerable spillovers between economies mainly due to the linkages between financial institutions. Blasques et al. (2016) modify a generalized autoregressive score model (GAS) to develop a time-variant parameter version of the SAR model. This new model yields evidence of contagion between European countries through high spatial spillovers in perceived credit riskiness during the sovereign debt crisis. The empirical application of this model shows that spatial dependence, especially during the unconventional monetary stance, increases the probability of systemic risk.

Another strand of the literature focuses on the co-movements of financial and sovereign assets. For instance, Asgharian et al. (2013) employ spatial econometric techniques to investigate to what extent countries' economic and geographical relations influence their stock markets' co-movements. In a recent contribution, Asgharian et al. (2018) apply a spatial VAR model to analyse the importance of cross-border asset holdings for yield-curve interactions among euro area countries. The results of this study identify a systematic spatial dependence in the yield curves through cross-border long-term debt and bank lending. By contrast, Favero (2013) proposed an extension of the GVAR model to capture time-varying interdependence between government bond spreads in the euro area and to obtain a more sensitive impulse response analysis. The notion is that responses are more sensitive to shocks according to the relative position of fiscal rules between the country where the shock originates and the countries where the shock is transmitted.

Finally, the literature studies the cross-border effects of different integrated sectors and the interdependence between the default risk of sovereign, bank and corporate sectors (Acharya et al., 2014; Alter & Beyer, 2014; Billio et al., 2014; Horvàth, and Huizinga, 2015; Augustin et al., 2018).

These works mainly find that a distressed financial sector prompts government bailouts and an increase in sovereign credit risk. Increased sovereign credit risk, in turn, weakens the financial sector by eroding the value of government guarantees and bond holdings. The post-bailout changes in sovereign CDS explain changes in bank CDS and confirm the existence of interdependence between government and the banking sector.

3. Foreign bank investors in Italian government debt

Italy is an interesting case to study because of its large amount of public debt and the close links with other countries with similar fragile financial conditions. At the end of 2018 the volume of the Italian public debt was about 2,381 billion, which accounted for 134.8% of GDP. In the last thirty years the amount of debt in the hands of Italian savers has progressively decreased, both in absolute and relative terms. Correspondingly, since Italy joined the single currency, the portion of public debt held by foreign investors has grown from 4% in 1988 to 32% in 2018 and hence it has become crucial to understand the implications for the stability of the financial system generated by this change in the redistribution of Italian government bonds amongst foreigners, and especially among foreign banks. The study of the above redistribution could provide a measure of the vulnerability of the foreign securities' portfolios of Italian debt to negative shocks from the Italian economy. The distribution of Italian government bonds among EU banks, in particular, may signal the potential exposure of foreign banks to the vicious circle of sovereign-bank crises. In 2015, Eurozone investors held about 76% of Italian debt securities and this share, in 2018, remains more or less stable at 78% while the remaining 22% was held by non–euro area investors. Hence, in recent years the share of Italian government bonds held within the euro area has remained substantially high.

In particular, for our purposes it is worth pointing out that in 2018 about 15% of Italian debt securities were held by monetary financial institutions (banks). Figure 1 shows the share of sovereign Italian debt securities for the period 2013-2018 among banks in the eight EU countries which we analyse.

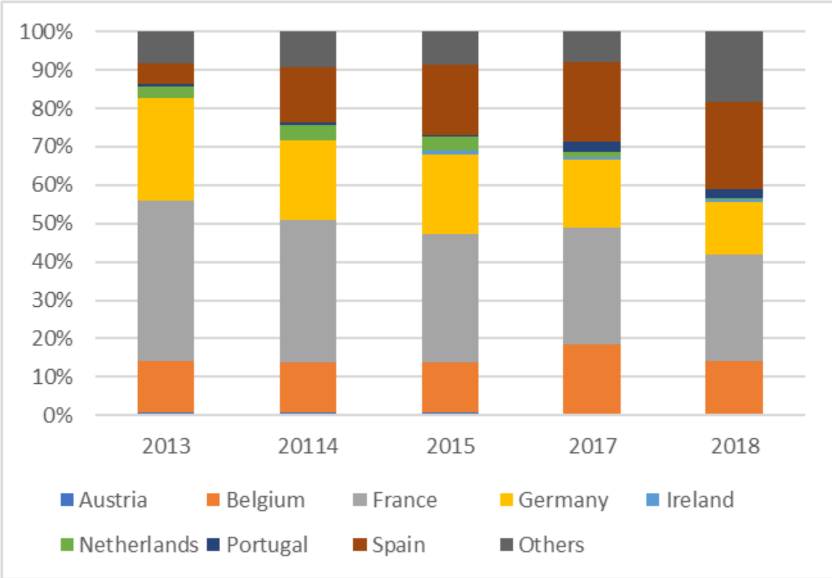

Figure 1: Percentages of sovereign debt securities issued by Italy held by EU banks, millions of euros, all maturities. Source: EBA - EU-wide transparency exercise.

In the eight countries, however, the dynamics of this distribution through time is not the same: while from 2013 to 2018 Spanish, Irish and Portuguese banks show an increasing trend in Italian government bond holdings, banks in Germany, France and the Netherlands significantly reduced their exposure. Lying between these contrasting trends, banks in Austria and Belgium did not substantially modify their position in Italian government bonds. If we look at the overall share held by EU banks in 2018, France, Spain and Germany accounted for 27%, 23% and 13% of Italian debt, respectively.

4. Methodological framework and data

4.1 Global VAR approach

We provide a description and a measure of the cross-border effects of an increase in Italian sovereign risk on eight other neighbouring Eurozone countries by applying the global VAR (GVAR) model. We follow the approach first proposed by Pesaran et al. (2004) and later modified by others (see Dees et al., 2007; Burriel & Galesi, 2018).

Each country i (i=1,2,…N) enters the model under the assumption that all the *country-specific* or *domestic variables* are related, through some form of interrelationship, to other *foreign-specific variables*, plus some deterministic and *common variables* that affect Eurozone countries in the same way (Pesaran et al., 2004). Hence, the model features a system of N domestic VAR sub-models with cross-country interactions and a model for common factors that affect our Eurozone countries in the same way.

More generally, we consider a panel of N countries over the time interval $t\in[1,T]$, where each country i is described by k_i variables which are grouped in the $k_i x$ 1 vector Y_i. The first step of the GVAR approach involves the estimate of each country-specific economy i as a VARX*(p_i; q_i) (see Burriel & Galesi, 2018):

$$Y_{it} = \delta_{it} + \sum_{j=1}^{p_i} \mathrm{H}_{ij} Y_{i,t-j} + \sum_{j=0}^{q_i} \Lambda_{ij} Y_{i,t-j}^{*} + \sum_{j=0}^{q_i} \Gamma_{ij} X_{t-j} + \nu_{it} \tag{1}$$

where δ_{it} is a vector of intercepts, H_{ij}, Λ_{ij}, and Γ_{ij} are matrices of coefficients, and ν_{it} is a vector of serially uncorrelated[2] idiosyncratic specific shocks.

The vector Y_i includes k_i different country-specific variables which represent the economic and financial conditions of national economies. The vector Y_{it}^{*} includes the foreign-specific variables which capture the presence of spatial linkages and spillovers across countries. The linkages are weighted as follows: $Y_{it}^{*} = \sum_{j\neq i} W_{ij} Y_{it}.W_{ij}$ is a row-standardized spatial weight matrix (N x N) with $\sum_{j\neq i} W_{ij} = 1$. Non-zero elements in the row and column positions of W_{ij} imply that region i is a neighbour to j (LeSage, 2014).

[2]We assume that the idiosyncratic shocks ν_{it} are serially uncorrelated with mean 0 and non-singular covariance matrix Σ_{ii} (see Ong & Sato, 2018). The idiosyncratic shocks are denoted as $\nu_{it} \approx iid(0,\Sigma_{ii})$.

The second sub-model includes the vector of common variables X_t. As in the literature, we assume that the common factors follow this autoregressive process:

$$X_t = \delta_x + \sum_{j=1}^{p_x} \mathrm{Z}_j X_{t-j} + \sum_{j=0}^{q_x} \Omega_j \tilde{Y}_{t-j} + \nu_{xt} \quad (2)$$

where δ_x is a vector of intercepts, Z_j and Ω_j are matrices of coefficients and ν_{xt} is a vector of error terms. The vector X_t is a function of the country-specific variables. $\widetilde{Y_t}$ is the vector of the endogenous variables where each variable is weighted by the national GDP shares on the euro area GDP.

Given the wide range of information that is used, the GVAR model allows us to capture the interactions across the economies through three channels: (i) cross-country relationships due to the presence of foreign-specific variables and spatial weights; (ii) dependence of domestic variables on common factors; (iii) non-zero contemporaneous dependence of shocks in a country i on the shocks in a country j ($\Sigma_{ij} \neq 0$).

To measure the long-run relationships between the region-specific and external variables, the VARX* models can be re-written in the error-correction form (VECM*). Finally, in a second step, individual VARX* models are solved simultaneously as a large VAR model.[3]

4.2 Data

To measure the transmission of a shock in Italian government bonds to the financial and economic systems of other EU countries, we build a model of eight countries, namely Austria, Belgium, France, Germany, France, the Netherlands, Ireland, Spain and Portugal. These countries represent about 80 percent of European GDP. The first five countries are the so-called Euro core countries, while Spain,

[3]For more details on the GVAR model solution, we suggest looking at Pesaran et al. (2004) and Burriel & Galesi (2018).

Portugal and Ireland are peripheral countries and are expected to be more exposed to an increase in sovereign risk. We exclude Greece from our estimates since, during the period under investigation, this country benefited from international financial assistance (the *Economic Adjustment Programmes*) and its inclusion may bias the results. We perform our analysis in the period of zero-lower bound (ZLB) and monetary easing stance since this is a period of absence of particularly harsh financial distress or interest rate volatility. Thus, for the above eight Eurozone countries, we collect weekly data from July 2012 to September 2018 also in order to avoid to the distortive effect of Covid 19 pandemic.

The vector of endogenous variables (domestic and foreign) Y_{it} provides information on the condition of the i-th country government and banking system. The first issue we face in detecting the effects of risk spillover is related to the measurement itself of sovereign risk. The measures that are commonly used in the literature are bond yield spreads (Favero, 2013; Debarsy et al., 2018) and credit default swap (CDS) spread (Blasques et al., 2016; Kışla & Önder, 2018). Both measures capture in a similar manner the level of sovereign risk for each country. In this study we employ the 5-year sovereign CDS spread, since sovereign CDS markets are more liquid than sovereign bond markets (see Longstaff et al., 2011). In addition, Augustin & Tedongap (2016) argue that CDS spreads are more comparable across countries because CDS contracts involve fewer differences in the structure and regulation across countries and markets. To account for the impact of CDS shock on banks, we employ the banking equity price indices (BANK) as a proxy of the risk that foreign banks face by holding Italian bonds in their portfolio. We collect the CDS spread series from the Bloomberg financial database and bank indices from Datastream (DS-Banks). The banking indices include all publicly traded banks in a country with the exclusion of investment banks. Evidently, we expect banks which hold a significant amount of Italian government bonds to be those that are more exposed to shocks on Italian CDS spread. Following the literature on the drivers of sovereign risk (for instance Barrios et al., 2009; Favero et al., 2010), we add to the model, as a measure of liquidity in the market, the bid-ask spread on 5-year sovereign CDS (bid-ask). This spread is the difference between the highest price that a buyer is willing to pay for an asset and the lowest price that a seller is willing to accept. A narrower value of the spread signals a more liquid market. The data source is the Bloomberg financial database.

Additionally, we include in the model the outstanding amount of securities issued by the Eurozone governments (***indebtedness***).[4] This measure detects the level of national indebtedness in each country and signals a given default probability. Since data are provided by the European Central Bank Statistical Data Warehouse on a monthly basis, we transform the series through the Denton-Cholette method of interpolation to obtain higher-frequency data.

The vector of common variables includes variables capturing the state of European financial markets and affecting CDS spreads. Crucially among the common factors, we include the risk on Italian government bonds measured by the difference between the 3-month Euribor and the EONIA rate (***Eur3m-EONIA***). In addition to general risk aversion, this measure captures financial sector stress and the perceived counterparty credit risk between banks (Blasques et al., 2016). A wider spread between these two rates is linked to an increase in the level of uncertainty in the interbank and financial markets. We also include a second variable that impacts directly on the level of sovereign risk premia: the ECB monetary policy rate (***MRO***). The data are drawn from the Bloomberg financial database.

4.3 Spatial weights

Defining a weight matrix to capture cross-country spatial relationships is a very important first procedural step in spatial econometric estimation. Improper selection of the weights can, indeed, lead to distortions in the econometric estimates. The first choice is between a sparse and a dense connectivity matrix. The sparse connectivity matrix contains many zero off-diagonal elements and many elements in each row and column that converge to zero when the distance separating two units

[4] *BANK* and *indebtedness* are in logarithm, while spreads and rates are in levels.

goes to infinity. A typical example of a sparse matrix is the distance-weighted matrix. On the contrary, a dense connectivity matrix includes no, or hardly any, zero off-diagonal elements that slowly converge to zero, such as matrices constructed on trade flow. In general, the literature on spatial econometric models and the GVAR model (Dees et al., 2007; Baxter & Kouparitsas, 2005; Pesaran et al., 2004) adopts matrices constructed on bilateral trade flows, especially when the analysis entails macroeconomic models (Georgiadis, 2015; Chen et al. 2017; Burriel and Galesi, 2018; Tam, 2018; Capasso et al., 2019, among others). To define the interconnections between countries, other studies employ a measure of financial integration, such as bilateral bank claim exposures (Blasques et al., 2016; Zhu, 2018). Following Favero (2013) we use a dense matrix in which spatial proximity is measured by the "distance" between fiscal fundamentals which, in turn, control for the degree of interdependence. In detail, we use the cross-country distance in the debt-to-GDP ratio. In Favero (2013), the time-varying distance between the fiscal fundamentals is reflected in the exposure of each country's spread to other spreads in the euro area. Our analysis focuses on deeply integrated financial and capital markets, and hence the distance in fiscal fundamentals strongly reflects the impact of an increase in Italian sovereign risk on the default probability of the other euro area countries. Moreover, this distance also measures the magnitude of the impact of a positive shock to Italian CDS spread on other countries' banks that hold Italian bonds in their portfolio. As evidenced by Favero (2013), the advantage of this type of time-varying matrix is greater volatility when compared to the traditional trade matrix. A change in the weights may then explain a change in the correlation between the banking and sovereign risks of the different countries.

We model spatial proximity with the cross-country distance in the debt-to-GDP ratio (b_t^i) weighted by the relative level of the Stability and Growth Pact. Each country's deviation (*dist*) is calculated as follows:

$$dist_{jt}^{b} = E_t\left(b_t^j - b_t^i\right)/0.6 \qquad (3)$$

As the denominator immediately reveals, to ensure data comparison, we express the distances in terms of percentage deviation from the Maastricht reference values, that is 60 percent of GDP (Favero, 2013). Thus the weights are equal to:

$$w_{ji}^{*,k} = \left(dist_{ji}^{*,k}\right)^{-1} \qquad k = b \tag{4}$$

Annual data from 2012 to 2018 on GDP and debt are extracted from the Eurostat database.

5. Econometric results

5.1. GVAR estimation

To ensure stationarity in our data, we test for the presence of unit root in each series. With this aim, we apply the weighted-symmetric augmented Dickey-Fuller test (WS). Table 1A in the Appendix reports the findings of the unit root tests. The hypothesis of stationarity of the WS test is not rejected at 5 percent for all variables in level, while it is rejected in first differences. Thus, all series are stationary and integrated of order 1.

We proceed to estimate the model on a country-by-country basis and, more specifically, we estimate all country-specific models by least squares in their VARX* form as given by equation (1).

In order to identify structural shocks of the GVAR model, we follow Sims (1980) and Christiano *et al.* (1996) and order the endogenous variables by employing the Cholesky decomposition recursive method. As a result, although there is no substantial difference in the timing of responses to shock, we place the elements with a greater level of exogeneity (indebtedness) before the elements with a lower level of exogeneity (BANK, CDS, Bid-Ask). We also control whether results hold by changing the order of variables.[5]

[5]The results, which are available on request, do not change.

We determine the length of the lag structure for each country-specific model by means of the Akaike Information Criterion (AIC) and, as suggested by the AIC test, we choose for each model a relatively parsimonious lag structure and set the lag order of the endogenous variables equal to two ($p_i = 2$). The lag order of foreign-specific and common variables is also set equal to two ($q_i = 2$), except for Germany, France and the Netherlands. We estimate the vector of common factor with two lags for endogenous variables ($p_x = 2$) and opt for a lag length equal to two ($q_x = 2$) for the feedback variables in *ITA CDS spread* and *MRO* models, and just one lag for the *Eur3m-EONIA* model. Table 2A in the Appendix shows the orders of the VARX* models and the number of cointegrating relationships.

As recommended in Pesaran *et al.* (2004), overall models must be stationary and the global model must be dynamically stable. Hence, our empirical analysis starts by testing the stability of the GVAR model. Figure A1 shows that all eigenvalues are in modulus less than one, or equivalently they are inside the unit circle, which confirms the stability of the GVAR model in the case of the *DEBT* matrix. A further condition concerns the degree of dependence across the idiosyncratic shocks. To ensure the weak exogeneity in GVAR estimation, the level of cross-dependence should be quite small for the idiosyncratic shocks to be weakly correlated (Pesaran et al., 2004; Buriel & Galesi, 2018). We calculate the cumulative density function (CDF) for the correlation across residuals of the VECMX* models (Figure 2A) which confirms that there is evidence of a weak cross-sectional dependence of residuals. Figure 2A shows that more than 90 percent of residuals are concentrated below 0.25. Hence the cross-dependence of the idiosyncratic shocks is sufficiently small.

5.2 Impact of an increase of Italian risk

This section presents the main findings of the GVAR model and discusses the dynamic of the effects of changes in Italian CDS spread on the other EU countries. The section analyses the time profile of the effects of an increase in the risk associated to Italian government bond holdings by estimating the orthogonalised impulse response function (OIRF) of the endogenous variables to a shock in Italian CDS spread. We determine the error bands by means of the bootstrapping approach, resampling with 100 repetitions. Figure 2 depicts the orthogonalised impulse of an exogenous increase in Italian government bond risk as measured by an increase in the five-year Italian CDS spread.

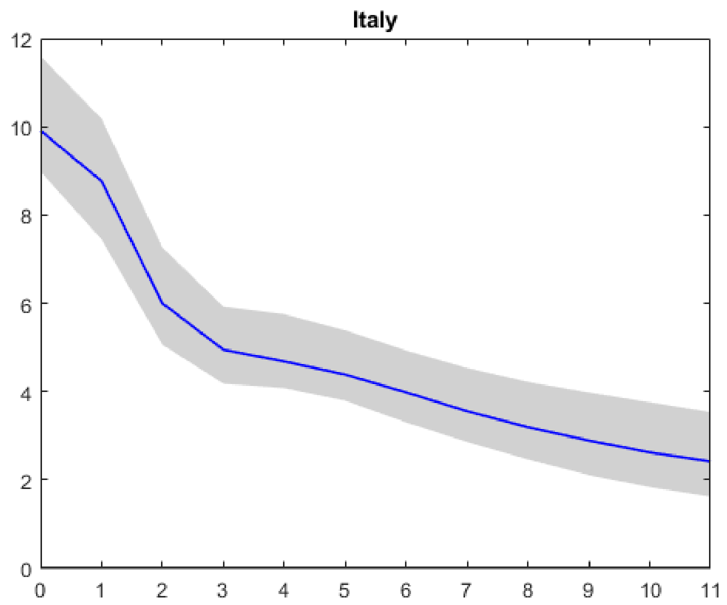

Figure 2: OIRF of IT CDS spread 5Y to an exogenous increase in Italian government bond risk. Error bands within the 10th and *90th percentiles; bootstrapped residuals (100 repetitions).*

An exogenous positive shock on the Italian government bond risk is immediately reflected in an increase in CDS spread and, interestingly, our model predicts that the shock is absorbed after approximately twelve weeks. This is in line with the behaviour of financial assets which generally adjust very rapidly after a shock. In our case, more than 50% of adjustment occurs within just three weeks.

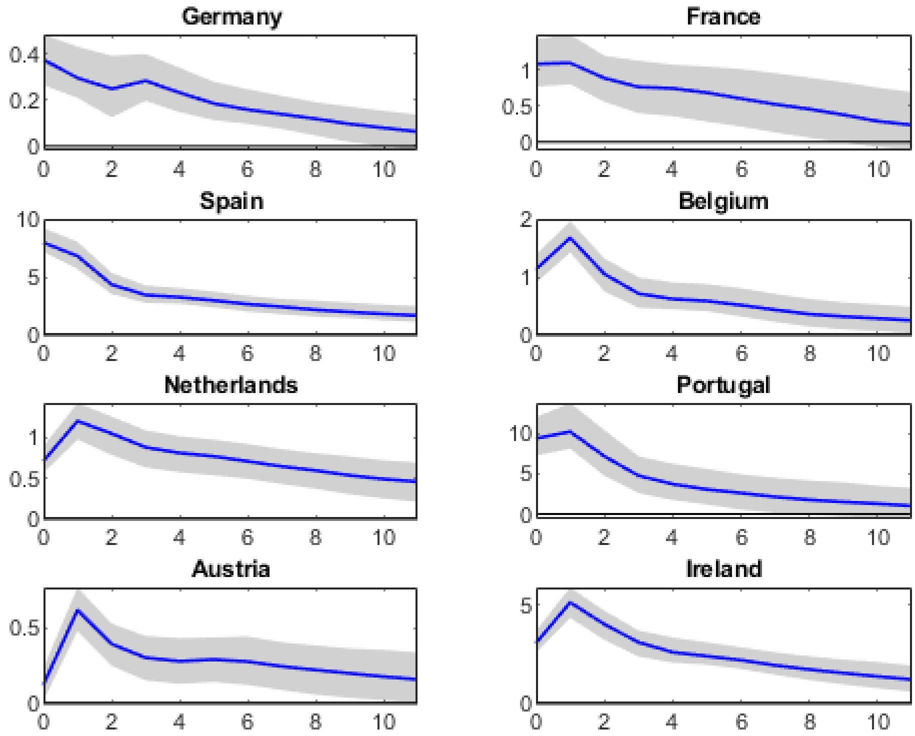

Figure 3: OIRFs of EZ CDS spreads 5Y to an exogenous increase in Italian government bond risk. Error bands within the 10th and 90th percentiles; bootstrapped residuals (100 repetitions).

Figure 3 presents the orthogonalized impulse of an exogenous increase in Italian government bond risk to other EU countries' financial market risks measured by the corresponding CDS spread. What is immediately striking is that Italian government bond risk overflows into all the other countries considered. This overall contagion effect is in line with the previous empirical results and indicates that an increase in the default risk after 2007 may generate expectations of euro exit by some countries or even an increase in the expected probability of a euro break-up (Favero, 2013). However, our estimates also signal a difference in the reaction between core and periphery countries. The initial effect is, indeed, stronger in Spain and Portugal which suffer an impact comparable to that occurring in the Italian financial market. Also Ireland faces a strong increase in its CDS spread, albeit smaller than those in Spain and Portugal. Unsurprisingly, these countries belong to non-core European countries and witnessed a substantial increase in their level of debt/GDP ratio after the financial crisis.

The time pattern of shock propagation shows a similar disparity: France, Germany and Spain begin to absorb the impact soon after the shock; Austria, Belgium, Ireland, the Netherlands and Portugal show an increasing impact in the first week followed by a smooth decrease soon after.

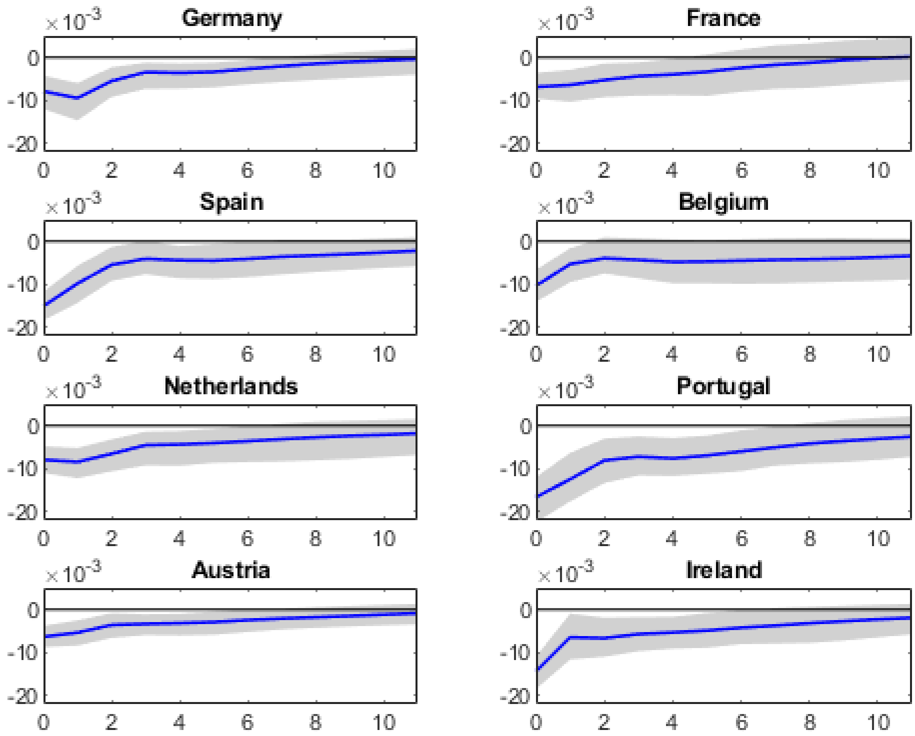

Figure 4: OIRFs of EZ BANK indices to an exogenous increase in Italian risk. Error bands within the 10th and 90th percentiles; bootstrapped residuals (100 repetitions).

Figure 4 presents the effects of an exogenous and positive shock in Italian bonds on the banking indices of the other EU countries. Similar to the contagion through the government bond markets, an increase in the perceived risk of Italian bonds is heavily and swiftly transmitted to the banking indices of other countries, albeit to different extents from country to country. Following a shock in Italian government bonds, the banking indices suffer losses in all other countries, suggesting the presence of a sovereign bank loop. Evidently, an increase in the Italian CDS spread increases the risk exposure of banks holding Italian government bonds in their portfolio which, in turn, is reflected in lower share prices. Bank indices in the stock markets of peripheral countries, i.e. Spain, Portugal and Ireland, are the most exposed. The evidence also suggests a fairly slow adjustment: the shock fades away within ten weeks in all the countries.

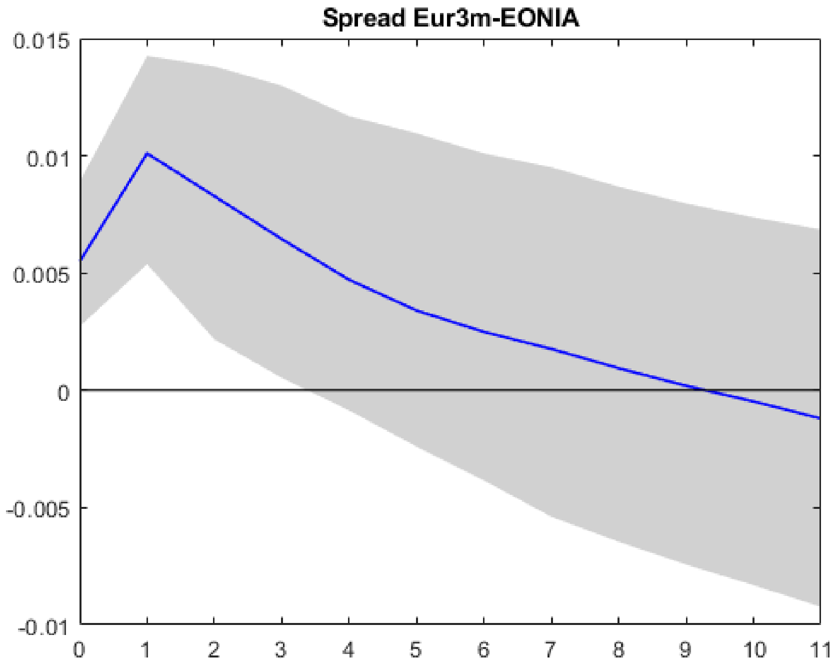

Figure 5: OIRF of Euribor 3m EONIA spread to an exogenous increase in Italian risk. Error bands within the 10th and 90th percentiles; bootstrapped residuals (100 repetitions).

Figure 5 pictures a different contagion following the sudden increase in Italian CDS spread: the response of the difference between the 3-month Euribor and the EONIA rate. A higher risk associated to holding Italian government bonds is reflected in an increase in the perceived counterparty credit risk between banks and signals a higher level of uncertainty in the interbank market. This uncertainty overflows into the *Eur3m-EONIA* spread.

Figures 6 and 7 present the mean peak responses of European countries' CDS spread and banking indices to one standard error shock in the Italian CDS spread. The average is computed on the first 10 weeks, which corresponds to the time interval in which the shock converges to zero, as evidenced by the impulse response function. We represent the direct effects (orange bars) and total effects (blue bars) of the shock. The absence of one, or both, bars denotes that the results are not statistically significant. An interesting result is that, when considering the interactions among countries (total effects), the effects of an increase in Italian risk on the other countries' CDS spread and banking indices are always statistically significant. If the cross linkages are not taken into account, the direct effects in some countries (namely, Germany, the Netherlands and Portugal for CDS, and Belgium, France, the Netherlands and Portugal for banking indices) are not statistically significant. If the cross linkages are not taken into account, when a shock to the Italian CDS spread is considered, the direct effects on some countries (namely, Germany, the Netherlands and Portugal for CDS, and Belgium, France, the Netherlands and Portugal for banking indices) are not statistically significant.

The above outcomes evidence two major aspects. The first is the importance of considering the spillover effects when studying the propagation of Italian CDS spread. The second is the need for policy makers not to ignore cross-country relationships that would otherwise entail underestimation of the effect of an increase in Italian risk.

Total effects on CDS spread are stronger in the non-core countries, namely Spain, Portugal and Ireland, as stated above. However, also the magnitude of direct effects is higher in Spain and Ireland, confirming our previous hypothesis that the greater the country's domestic debt, the higher will be the risk of exposure to spillovers. The direct effect in Portugal is not statistically significant and the total effect is the highest, underlining the importance of the spillover effect in this specific country. This result can be explained by the "bad neighbours" effect. In a deeply integrated financial and capital market, the higher the Italian sovereign risk, the higher will be the default probability of the other euro area countries whose financial fundamentals are perceived as weak. Although Portuguese banks and financial institutions do not hold much Italian debt in comparison to other EU countries (see fig. 1), the Portuguese public finances remain rather frail following the 2012 debt crisis: despite aid from the IMF and EU, Portugal's debt remains very high (121.5% of GDP). Hence an increase in the default risk of Italy (another country with high debt) may induce a fear of Portugal's potential default in the other euro countries and generate a contagion effect through the interaction matrix.

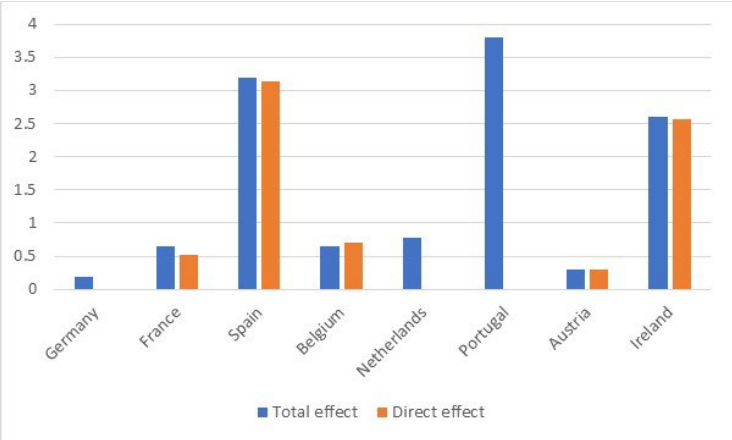

Figure 6: Average peak response of European countries' CDS spread to an increase in Italian risk. Total and direct effects.

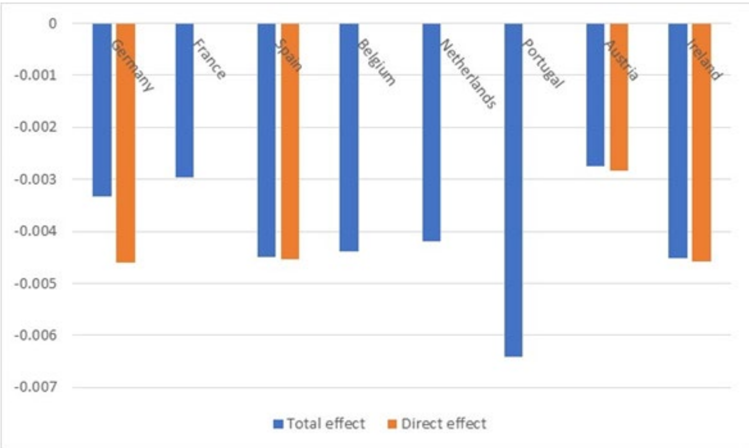

Figure 7: Average peak response of European countries' banking indices to an increase in Italian risk. Total and direct effects.

The impact of an increase in the risk of Italian government bonds on banks' stock market indices shows similar patterns. The total effect is always statistically significant and in almost all instances the spillover effect is also considerable. Core countries, such as Austria and Germany, display direct and statistically significant effects. Similar patterns are also shown by periphery countries such as Ireland and Spain.

This suggests the existence of a direct relationship between the increase in the Italian CDS spread and foreign banks. The direct link can be explained by the amount of Italian bonds held by the European banks: Germany, Ireland and Spain are among the countries holding the highest volume of Italian debt and hence the most directly exposed to an increase in Italian risk. These results, in line with the literature (Breckenfelder & Schwaab, 2018, amongst others), indicate the presence of a "doom-loop" in Europe. A case which contrasts with these results is that of France. Although French banks still hold in their portfolio a substantial share of Italian government debt, this share considerably decreased from 2013 to 2018 (-14%), which could explain the low impact on the French banks index.

6. Robustness of methodology and the weight matrix choice

As already outlined, our estimates employ a dense matrix which could cause strong cross-sectional dependence (CSD). To reduce the possibility of CSD one solution would be to employ ordinary least squares if the number/speed of convergence of zero off-diagonal elements were low/slow. As an alternative, if this is not possible, the estimates can be performed by means of Maximum Likelihood, IV or GMM. To tackle this issue and strengthen our matrix choice, we follow Bailey *et al.* (2016, a,b) and Elhorst *et al.* (2018), and use the two-step procedure by Bailey et al. (2016a) built on the CD-test proposed by Pesaran (2004, 2015) and the α-exponent estimator in Bailey *et al.* (2016b).

The CD test is the following:

$$CD = \sqrt{(2T / N(N-1))} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \tag{8}$$

where ρ_{ij} is the sample correlation between two units i and j observed over time. It is possible to show (Bailey *et al.*, 2016a) that the average correlation coefficient has the following order property:

$$\bar{\rho}N = \frac{2}{N(N-1)} \sum_{i=1}^{N} \sum_{j=i+1}^{N} \rho_{ij} = O(N^{2\alpha-2}), \tag{9}$$

where α is a parameter and $\alpha\epsilon[0,1]$. When 0<α<0.5, $\overline{\rho}_N$ quickly tends to zero, signalling weak dependence. There is, instead, moderate dependence when $0.5 \le \alpha < 0.75$, while $0.75 \le \alpha < 1$ suggests quite strong sectional dependence. Following BKP and Elhorst *et al.* (2018), α is estimated as follows:

$$\alpha = 1 + \frac{\ln \alpha_x^2}{2\ln N} - \frac{\ln \mu_\upsilon^2}{2\ln N} - \frac{c_N}{2N \ln N\sigma_x^{2'}} \tag{10}$$

where $\alpha_x^2 = \frac{1}{T}\sum_{t=1}^{T}(\bar{x}_t - \bar{x})^2$ and $\bar{x} = \frac{1}{T}\sum_{t=1}^{T}\bar{x}_t$

Parameter α can be estimated consistently only if $0.5 < \alpha \le 1$. The null hypothesis of weak cross-sectional dependence in the CD test (Pesaran, 2004) corresponds to a value 0<α<0.5 (Pesaran, 2015). If the null of the CD test cannot be rejected, the weights have to be expressed in a sparse connectivity matrix, while if the null is rejected, α may be estimated as in eq. (10). As happens in the standard spatial model, Maximum Likelihood, IV or GMM have to be employed when $0.5 \le \alpha < 0.75$ (moderate dependence). The weak exogeneity of the spatial lag WY_t is suggested by $\alpha > 0.75$. In this case, the average correlation coefficient converges slowly to 0, and each unit influences all others almost equally (dense connectivity matrix, e.g. the weighted cross-country distance in the debt-to-GDP ratio). The OLS estimator can then be used as in the standard GVAR models. A value of α which is not significantly different from 1 indicates the presence of global common factors, and this should be addressed by using a standard common factor model. Following BHP (2016), GVAR can be considered as a standard approximation of a common unobserved factor model (Dees *et al.*, 2007; Chudik *et al.*, 2011; Chudik & Pesaran, 2013). The CD test is performed at the 5% two-sided nominal significant level on the following four variables: the credit default swaps spread, CDS, the banking equity price indexes, BANK, the Bid-Ask spread on 5-year sovereign CDS, Bid-Ask, and the outstanding amount of securities issued by the Eurozone governments, *indebtedness*. The null of the test is rejected if $|CD| \geq 1.96$. The values of α and the results of the CD tests are presented in Table 1.

Table 1: CD test results and values of α

	CD	$\alpha_{0.05}$	$\hat{\alpha}$	$\alpha_{0.95}$
CDS	82.869	0.928	0.997	1.065
BANK	23.608	0.878	0.949	1.020
Bid-Ask	50.624	0.901	0.980	1.059
indebtedness	25.850	0.789	0.977	1.166

The null of the CD test is rejected for all variables, and α, in all four cases, is very close to 1. These results suggest the presence of a strong cross-sectional dependence. The spatially lagged term is thus weakly exogenous and the OLS estimator is consistent (Pesaran et al., 2004), reinforcing our choice of methodology. Furthermore, following Elhorst et al. (2018), the use of a dense matrix, the weighted cross-country distance in the debt-to-GDP ratio, is appropriate. We also apply the CD test to the residuals obtained by the factor model and still obtain significant results. However, as in Elhorst *et al.* (2018) and Capasso et al. (2019), it is important to stress that this could be due to a small-sample bias, since N is equal to 8.

7. Conclusions

This work investigated bank-sovereign risk transmission across countries and assessed in what way and to what extent sovereign risk in stressed countries can affect the sovereign and credit risk of non-stressed countries in the euro area. Taking into account a measure of spatial linkages, we analysed the cross-border effects of an increase in Italian sovereign risk on CDS and banking indices in eight Eurozone countries. We measured spatial proximity by using the cross-country distance in debt-to-GDP ratio and employed a GVAR technique to model spatial interactions. The notion is that in deeply integrated financial and capital markets, the distance in fiscal fundamentals, may strongly modulate the effect of an increase in Italian sovereign risk on the default probability of the other EMU countries. Moreover, this distance may determine the magnitude of the impact of an increase in Italian government bond risk on the valuation of foreign bank indices.

We also tested and controlled for the robustness of our choices of both the distance matrix and the methodology. Our results are in line with the theory and confirm the hypothesis of a sovereign-bank loop: a shock in CDS propagates to bank indices and the effects are stronger in financial systems where banks hold a larger share of Italian debt and are closer in terms of fiscal fundamentals. Our results also suggest the presence of a "bad neighbours" effect, especially for Portugal: although it does not possess a high level of Italian debt, Portugal is greatly affected by a shock in the Italian government bond risk through spillover effects. We also find, as might be expected, strong heterogeneity in the responses of core and non-core countries. Total effects on CDS spread are, indeed, stronger in Spain, Portugal and Ireland, but weaker in Austria and Germany.

Overall, our findings highlight the importance of considering spillover effects when studying the propagation of Italian risk. Policy makers would be well advised to pay particular attention to cross-country relationships in assessing the effects of an increase in Italian risk on EMU countries. As would be expected, the close linkages between EMU countries call for a monetary policy which is more functional and sensitive to the "backdoor effects" of monetary interventions. In the presence of fragile financial systems, shocks in one country swiftly propagate indirectly to other economies, even when the latter are not directly involved in the real causes of the shock. In our sample, most of the shocks to Italian government debt propagate to other distressed countries not through the direct holding of Italian government bonds but, rather, indirectly through the increase in the distress of other countries' government bonds. Close links between countries require a monetary policy which responds more rapidly to shocks and is less selective in the area of intervention. One country hit by a shock often means that a larger area is affected.

Finally, and most importantly, the paper shows that in the euro area, as generally applies in any other monetary union, the central bank should work as a lender of last resort and provide some form of buffer to the shocks prior to their occurrence. Because of spillover effects, the costs of interventions ex ante are much lower than those ex-post.

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Appendix

Table 1A. Unit root test (weighted-symmetric augmented Dickey-Fuller (WS))

Domestic variables

		ger	*fra*	*spa*	*bel*	*net*	*por*	*aus*	*ire*
indebtedness	**WS-ADF**	0.00	2.31	4.51	-0.33	-0.13	0.78	2.05	0.76
Δindebtedness	**WS-ADF**	-6.98	-8.29	-7.74	-8.21	-7.41	-6.29	-8.71	-5.27
BANK	**WS-ADF**	-1.04	0.29	-1.66	1.29	-1.90	-1.32	-1.25	-0.34
ΔBANK	**WS-ADF**	-13.55	-10.63	-14.02	-14.70	-13.16	-13.48	-13.94	-13.44
CDS	**WS-ADF**	0.60	2.03	2.61	4.87	2.45	1.35	5.22	3.84
ΔCDS	**WS-ADF**	-7.95	-7.28	-9.54	-5.11	-5.83	-8.66	-1.63	-3.47
Bid-Ask	**WS-ADF**	-1.00	-2.19	-2.32	-1.21	-1.98	-2.95	0.18	-0.67
ΔBid-Ask	**WS-ADF**	-13.28	-11.00	-13.48	-13.71	-14.48	-10.87	-14.14	-12.15

Common variables

ITA	**WS-ADF**	2.14
ΔITA	**WS-ADF**	-9.94
Eur3m-EONIA	**WS-ADF**	-0.43
ΔEur3m-EONIA	**WS-ADF**	-10.05
MRO	**WS-ADF**	0.34
ΔMRO	**WS-ADF**	-12.88

Note: The reported numbers are the t-statistics. The WS test is performed by using the Akaike Criterion (AIC) with maximum lag = 4. We calculate the unit root tests including only the intercept for all variables. The critical value at level of significance of 5% is -2.55.

Table 2A: Lag order selection and number of cointegrating relationships

EZ countries	p_i	q_i	no. of cointegrating relationships
DEBT Matrix			
ger	2	1	1
fra	2	1	3
bel	2	2	4
net	2	1	3
aus	2	2	3
spa	2	2	2
por	2	2	2
ire	2	2	3

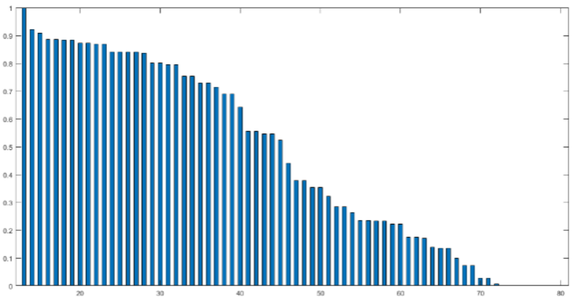

Figure 1A: Stability test of the GVAR model

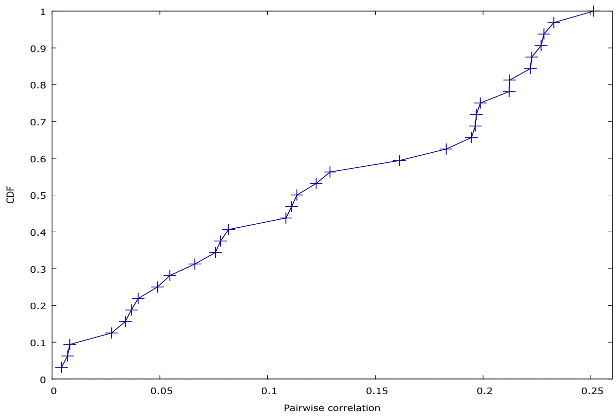

Figure 2A: Cross-sectional correlation of residuals in absolute value