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## Monetary policy, bank bailouts and the sovereign-bank risk nexus in the euro area

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# **Monetary policy, bank bailouts and the sovereign-bank risk nexus in the euro area**

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**Preliminary**

## **Abstract**

The paper analyses the empirical relationship between bank risk and sovereign credit risk in the euro area. Using structural VAR with daily financial markets data for 2003-13, the analysis confirms two-way causality between shocks to sovereign risk and bank risk, with the former being overall more important in explaining bank risk, than vice versa. The paper focuses specifically on the impact of non-standard monetary policy measures by the European Central Bank and on the effects of bank bailout policies by national governments. Testing specific hypotheses formulated in the literature, we find that bank bailout policies have reduced solvency risk in the banking sector mostly at the expense of raising the credit risk of sovereigns. By contrast, monetary policy was in most, but not all cases effective in lowering credit risk among both sovereigns and banks. Finally, we find spillover effects in particular from sovereigns in the euro area periphery to the core countries.

**Keywords:** Credit risk, banks, sovereigns, monetary policy, bank bailout, heteroscedasticity, spillovers.

**JEL No.:** G10, E52.

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# 1 Introduction

A key feature of the European crisis has been the ever closer link between sovereign risk and bank risk in the euro area. A major concern of policymakers has been the negative feedback loop, in which adverse shocks to banks lead to an increase in sovereign risk, and a deterioration in sovereign risk, in turn, raises the solvency risk for banks. In fact, the correlation between credit default swap (CDS) spreads of banks and of sovereigns in the euro area rose from 0.1 to 0.8 between 2007 and 2013 (see Figure 1). This negative feedback loop has also been blamed for deepening the recession, thereby making an escape from the European crisis ever more difficult.

Policymakers have adopted two principle approaches of dealing with sovereign risk and bank risk during the 2008-09 global financial crisis and the subsequent European crisis. On the one hand, national governments have implemented bank bailout and rescue policies, in particular by providing capital injections into ailing banks, by offering debt guarantees or by issuing deposit guarantees. On the other hand, monetary policy has played a central role, by providing liquidity to banks on a massive scale and by intervening in sovereign debt markets through outright purchases or by giving an implicit guarantee against a speculative run on sovereign debt of specific countries.

Have these policies been effective in reducing sovereign risk and bank risk and in breaking the negative feedback loop? The academic literature has analysed different channels through which these two policy approaches function. Concerning government policies for banks, there are two competing hypotheses about how such policies affect bank risk and sovereign risk (see Allen, Carletti, Goldstein, and Leonello, 2013, Leonello, 2013). Guarantees and capital injections essentially imply a transfer of risk from banks to governments. If such policies are effective not only in preventing bank runs and ensuring the viability of the banks, reducing uncertainty and overall improving the outlook to the economy and the financial system, then these policies are expected to both lower the risk to the banking sector and to improve sovereign risk. However, if the bank bailout policies are large in magnitude and imply a major challenge to the sustainability of public debt, then such a transfer of risk may actually worsen sovereign risk, while improving the risk to banks. In an extreme case, a large deterioration in sovereign risk could become so dominant, that in fact it worsens both sovereign risk and bank risk together.

There is also an extensive literature focusing on the impact of non-standard monetary policies on financial markets during the global and European crises. In particular, there is a growing literature on the effect of the Federal Reserve's quantitative easing (QE) policies (see, for example, Gagnon, Raskin, Remache, and Sack, 2011, Fratzscher, Lo Duca, and Straub, 2012) and the effectiveness of the European Central Bank's (ECB)

policies (see, for example, Manganelli, 2012, Eser and Schwaab, 2013). The controversy in this literature is about the question to what extent these non-standard policies have been successful in reducing risk to banks and to sovereigns, but these risks have mostly been analysed in isolation, without studying the mutual feedback effects.

The paper provides an empirical test of the effect of various bank rescue policies implemented by different euro area countries, and the various non-standard policies of the ECB since 2007 on the nexus between sovereign risk and bank risk. The primary interest lies in the question whether such policies have helped to break the nexus, or whether they have intensified it. The analysis starts with a more general analysis of the causality between bank risk shocks and sovereign risk shocks. The paper then goes into detail of this link, by investigating whether these two types of policies have functioned differently for healthy euro area countries versus crisis countries, and whether the impact has changed over time. Importantly, we also analyse whether there is evidence for cross-country spillovers, that is, whether shocks to bank risk or sovereign risk in one country affect those in others.

We employ a set of structural vector auto regression (VAR) models, which exploit the heteroscedasticity of financial market variables to identify shocks to bank risk, sovereign risk and the other variables of the system. The baseline specification includes five endogenous variables: credit risk of the sovereign, banking, and non-financial sector, respectively, the term spread, and an equity market return index. We take as exogenous variables the non-standard monetary policy measures of the ECB as well as the announcement of major bank guarantees and of capital injections. In addition, the empirical model also includes implied volatility, a risk premium in the money market, and 12 macroeconomic news shocks as controls.

In a multi-equation model with daily financial market data, it is hard to defend identification schemes based on exclusion, sign, or long-run restrictions. Instead, we identify contemporaneous causal effects through heteroscedasticity, following Sentana and Fiorentini (2001) and Rigobon (2003). The methodology exploits that periods of higher volatility contain additional information on the covariance between the credit risk of the sovereign and the banking sector. We thus exploit the heteroscedasticity to extract additional moment conditions, which allow us to recover structural parameters from the reduced form estimates.

The advantage of this methodology is that identification is agnostic in that it does not impose structural relationships on the variables of the system. However, the analysis of bank bailout policies and monetary policies does not depend on this identification approach. Moreover, we deal with potential endogeneity of the policy interventions through different alternative specifications.

The empirical analysis of the paper starts by analysing the general link between sovereign risk and bank risk in the euro area since 2007. It investigates this nexus using daily financial market data for euro area countries for the period 2003-13. The correlation between both has increased dramatically over the years, from around 0.1 in 2007 to 0.8 in mid-2010, and staying at these elevated levels since. As to the causality, the analysis finds evidence for a two-way causality between these two types of risk. On average across euro area countries and over time, the benchmark specification suggests that an increase in bank risk by 100 basis points raises sovereign risk by 28 basis points. Equally, a deterioration in sovereign risk by 100 basis points worsens bank risk by 38 basis points.

Our methodology allows distinguishing between the direct and indirect effects, via third variables, between these two types of risk. While the direct causality between bank risk and sovereign risk dominates, we also find evidence that the transmission channels function via risk to non-financial institutions, the term spread and equity markets. A decline in equity markets and a worsening in the solvency of non-financial firms both significantly raise the solvency risk of banks and sovereigns. Moreover, an exogenous increase in sovereign and bank risk both also leads to a deterioration in equity markets and the solvency of non-financial institutions.

If one interprets the solvency of non-financial firms and the equity markets as reflecting the prospects of the real economy, then the implication of these findings is that the negative feedback loop between banks and sovereigns also extends to the real economy. In terms of economic significance, the forecast error variance decomposition suggests that indeed shocks to bank risk and to sovereign risk explain a sizable magnitude of the variance of each other and the real economy variables. Generally, shocks to sovereign risk appear to be more important in driving bank risk, then vice versa.

The empirical analysis also reveals a high degree of heterogeneity across countries in the euro area as well as over time. Before and during the global financial crisis, the impact of sovereign risk shocks on bank risk was generally insignificant or small in magnitude. The striking finding is that during the height of the global financial crisis in late 2008 and early 2009, a reduction of bank solvency risk was associated with higher sovereign risk. One possible interpretation of this finding is that expectations of bailouts and guarantees for banks may actually have raised the sovereign risk of vulnerable countries.

Since the start of the European crisis in early 2010, we find an increase in the impact of sovereign risk on bank risk. Moreover, a shock that raises the solvency risk of banks during this period also increased sovereign risk. This finding confirms that the sovereign-bank feedback loop indeed intensified during the European crisis. As to the heterogeneity across countries, such a feedback loop hardly existed for core euro area countries, such as Austria, Germany and the Netherlands. By contrast, the feedback loop intensified and reached high magnitudes for most of the crisis countries in the euro area periphery.

The empirical findings also suggest that there are strong cross-country spillovers of sovereign and bank risk. The largest spillovers stem from shocks to sovereign risk in the euro area periphery to sovereigns in the core, as well as from shocks to banks in the periphery to banks in the core. A positive shock to sovereign risk or bank risk by 100 basis points in the periphery raises solvency risk in the corresponding market of core euro area countries by 14 and 27 basis points, respectively. What is striking is that the impact of sovereign risk in the periphery on the core euro area countries has been larger than the causality running in the opposite direction. This is important as the core countries constitute the much larger share of the euro area, and its underlying sovereign debt market, than the periphery countries.

Finally, concerning the main hypotheses formulated above, the empirical analysis tends to question whether government policies on banks and ECB non-standard monetary policy measures were effective in reducing the feedback loop between banks and sovereigns. For bank bailout policies, the estimates indicate that debt and deposit guarantees and capital injections into banks were moderately effective in reducing bank solvency risk. The important announcement by individual euro area countries to provide debt or deposit guarantees, or to recapitalize certain banks, lowered bank CDS spreads by 65 basis points on average.

By contrast, these policies had a much smaller impact on sovereign risk, and generally induce an increase in the solvency risk of national governments. This confirms the hypothesis, as formulated by (Allen, Carletti, Goldstein, and Leonello, 2013) and others in the literature that the second channel dominates. In other words, bank bailout policies indeed lowered risk to the domestic banking sector somewhat, but this impact came at the expense of a lower solvency of its sovereign.

As to monetary policy, ECB policies generally exerted a large and significant impact on sovereign risk and bank risk, but also on the real economy, as measured by stock market returns and the risk to non-financial firms. The empirical analysis reveals an interesting yet intuitive difference in the effects of monetary policy announcements as compared to their actual implementation. For instance, announcements about the SMP program to buy government securities of crisis countries, which was first announced in May 2010, was initially quite effective in lowering both sovereign and bank CDS spreads. However, the actual implementation, that is, the purchases over the different weeks, tended to rather increase sovereign risk or be ineffective. While it is hard to deal with the underlying endogeneity, the empirical estimates seem fairly robust to different specifications.

Also the effects of the other non-standard ECB policies show an intriguing picture. While the initial announcement of the three-year LTROs in early December 2011 was taken as a disappointment by financial markets, with sovereign and bank risk actually increasing, the implementation at the end of December 2011 and at the end of February 2012 was

actually effective in reducing bank risk. The OMT announcements of late July 2012 and early September 2012 also exerted a significant impact on financial markets, lowering sovereign CDS spreads on average by 55 basis points among euro area countries.

Overall, these findings suggest that both rescue policies of the banking system and monetary policy exerted a significant impact on sovereign and bank risk as well as on risks and prospects of the real economy. The empirical estimates also indicate that neither of the two policies was unanimously effective. Thus, this entails a note of caution to policymakers that policies that are intended to reduce risk can in fact lead to an intensification of the negative feedback loop between sovereigns and banks.

The intended contribution of the present paper is to analyse the sovereign-bank nexus, that is, the two-way causality between sovereign credit risk and banking sector risk during the global financial crisis and the subsequent European crisis. In particular, we analyse and compare how the two key policy instruments of monetary policy and bank bailout policies have affected this link.

Our paper is related to the literature on the interdependence of sovereign and bank credit risk. One strand of research uses vector error correction (VECM) or (global) VAR models. Authors address the endogeneity of credit risks through several approaches. Stanga (2011) applies sign restrictions for identification of a structural VAR. Nucera (2012) uses exclusion restrictions in a VECM. Alter and Schöler (2012) obtain generalised impulse response functions (GIRF), following Pesaran and Shin (1998). The authors estimate both VECM and VAR specifications. In the same vein, Lahmann (2012) and Alter and Beyer (2013) derive GIRFs. Finally, Gross and Kok (2013) and Bicu and Candelon (2013) apply GIRFs in global VARs. Overall, the literature finds a significant relationship between the credit risk of the sovereign and banking sector of the euro area and that the relationship has changed since the outset of the global financial crisis.

Another strand applies panel data analysis. Most studies use specific models for each direction to explore the effects between sovereign and bank credit risk in isolation. Acharya, Drechsler, and Schnabl (2011) provide a theoretical model for credit risk linkages between both sectors and test its implications empirically. They find no relation prior to bailout periods, a negative during, and a positive afterwards. A similar result is obtained by Mody and Sandri (2012), Merler and Pisani-Ferry (2012) and by Ejsing and Lemke (2011). Finally, Kallestrup, Lando, and Murgoci (2013) focus on financial sector linkages, while De Bruyckere, Gerhardt, Schepens, and Vennet (2012) analyse determinants of contagion between both sectors.

The paper is also related to a literature on unconventional monetary policy. The IMF (2009), Kozicki, Santor, and Suchanek (2011), or Stone, Fujita, and Ishi (2011) provide a review of the evidence for the US and UK. Regarding non-standard measures of the ECB,

most studies focus on the effects on key monetary policy variables such as interest rates, credit supply, inflation, or output (see, for example, Peersman, 2011, Giannone, Lenza, Pill, and Reichlin, 2011, De Pooter, Martin, and Pruitt, 2012, Eser and Schwaab, 2013). Only few studies assess the effects on credit risks. Lucas, Schwaab, and Xin (2013) apply a multivariate framework to assess conditional probabilities of credit events in the euro area. Focusing exclusively on Italy, Falagiarda and Reitz (2013) use event-study and GARCH models and Pelizzon, Subrahmanyam, Tomio, and Uno (2013) apply regression analysis. The authors mostly find a decline of sovereign risk around the announcements of non-standard policy measures.

The paper is organised as follows. Section 2 provides a conceptual discussion of the feedback loop between sovereign risk and bank risk, and outlines different channels that link these two types of credit risk. The subsequent section then discusses the empirical methodology and the data that is being used in the analysis. Section 4 presents the empirical estimates for the overall, unconditional transmission of bank shocks and sovereign risk shocks both domestically and internationally. The section offers a number of extensions and robustness tests. Section 5 then focuses on the specific effects of bank bailout policies and of the ECB non-standard monetary policy instruments on the various types of credit risk. The final section concludes and draws out policy implications.

## 2 Conceptual framework

In this section, we derive priors for our empirical analysis. We first discuss the endogeneity of asset prices, the effects of bailouts on bank and sovereign credit risk, and transmission channels of structural asset price shocks. Then, we outline potential effects of non-standard monetary policy measures on asset prices.

### *2.1 Endogeneity of credit risks, term spread, and equity market returns*

A main hypothesis of the paper is that credit risk in the sovereign sector can affect credit risk in the banking sector and vice versa. In this subsection, we describe potential channels of shock transmission. The propagation of shocks can either be direct, through several links between both sectors, or indirect, through other financial markets. In addition, we outline how shocks to other asset prices can affect credit risks.

First, we turn to the propagation of bank risk shocks to sovereign risk. One channel is via credit supply. As the balance sheets of banks deteriorate, say, as a result of unexpected losses, they reduce the supply of credit. This reduction depresses investment, economic growth, and hence the tax base. Another channel is via bailout schemes. Before a bailout, banks often enjoy implicit state support promises. After a bailout, sovereigns explicitly guarantee for bank's liabilities or deposits. During both periods, rising bank risk increases



contingent liabilities of sovereigns. So far, both the credit supply and the bailout channel imply a positive effect from bank risk on sovereign risk.

However, during bailout periods, the sign of the effect is ambiguous. It can be nil, if the bailouts are fully effective in that they prevent bank runs beforehand such that actual resource injections into the banking sector are not needed, as in the traditional literature on banking crisis, following Diamond and Dybvig (1983). It can be positive, if favorable fundamentals of the economy, such as the levels of productivity and government expenditures, render the bailout credible and lead to a reduction in the solvency risks of the banking sector and hence of the sovereign sector, as in Leonello (2013). Finally, it can be negative, if the recourse transfer from governments to banks undermines the creditworthiness of the former, as in Acharya, Drechsler, and Schnabl (2011).

Altogether, the sign of the direct effect of bank risk shocks on sovereign risk is ambiguous. It depends on the types of shocks hitting the banking sector and their importance relative to other sector specific shocks. If bailout shocks dominate, we expect a negative effect since transmission via the bailout channel prevails. Otherwise, we look for a positive sign.

Next, we outline potential transmission channels of the reverse effect, that is, from sovereign risk shocks on bank risk. Two channels work through banks' holdings of government bonds. If a sovereign default becomes more likely, say, due to an unanticipated fall in tax revenues, the market value of bonds declines which has two implications. First, banks incur balance sheet losses on their government bond portfolios. Second, bank funding conditions deteriorate since the value of the collateral that they use for refinancing operations, namely, government bonds, falls. Refinancing conditions deteriorate as the collateral devalues. Kallestrup, Lando, and Murgoci (2013), Angeloni and Wolff (2012), and De Bruyckere, Gerhardt, Schepens, and Vennet (2012) provide evidence for these two channels in the euro area. In addition, there is a rating channel. Most rating agencies use sovereign ceilings which state that private entities cannot be rated higher than their sovereign. Then, a down rating of the sovereign triggers a down rating of this country's banks which, in turn, increases their credit risk since many investors are legally constrained in the rating structure of their portfolio. Arezki, Candelon, and Sy (2011) find evidence for this channel. All three channels imply a positive effect from sovereign on bank risk. Contrary, as outlined above, the bailout channel can entail negative spillovers.

Now, we discuss other influences on sovereign and bank risk. We start with shocks to credit risk in the non-financial corporate sector, which reflect, for example, negative surprises regarding its economic performance. They increase both bank risk and sovereign risk as the number of non-performing loans rises and the tax base declines. Ejlsing and Lemke (2011) show that a common credit risk factor accounts for large part of

the variation of sovereign and bank CDS spreads. As concerns sovereign risk, Dieckmann and Plank (2012) and Gerlach and Schulz (2010) find that its first principal component explains more than three fourths of its variance. Regarding bank risk, Acharya, Drechsler, and Schnabl (2011) identify the iTraxx Europe CDS index as one important determinant. Guided by these findings, we include credit risk of the non-financial sector into our model and expect it to be positively related to sovereign and bank credit risk.

For the term spread, it consists of two components: expectations of future real rates and inflation and sovereign credit risk. The first component reflects business cycle expectations. In recessions, government deficits widen and the number of non-performing loans of banks grows which implies a negative co-movement between the term spread and solvency risk in the sovereign-banking nexus. On the other hand, the credit component reflects sovereign risk perception in the cash bond market and hence implies a positive co-movement. Indeed, Palladini and Portes (2011) suggest that the European sovereign CDS market moves ahead of its cash market while Fontana and Scheicher (2010) find that price discovery can run in both directions. Overall, we expect the business cycle components to dominate in normal times. But in times of economic and financial stress, we look for the credit risk component to prevail.

The discussion of potential transmission channels of both term spread shocks and bank risk shocks highlights the need to let the data decide the sign and magnitude of causal effects. Theory gives no clear guidance for exclusion or sign restrictions.

For equity markets, they reflect real growth expectations and risk appetite of investors. Both higher expected earnings and profits in the corporate sector or increased willingness of investors to gain risk exposure lowers credit risk in the sovereign, banking, and non-financial sector. Regarding sovereign CDS spreads, Longstaff, Pan, Pedersen, and Singleton (2011) show that equity market returns are an important determinant. Altogether, we expect a negative relation between equity markets and credit risks.

Finally, all asset price shocks can be amplified or attenuated through other financial markets, depending on the signs of causal effects across markets. Specifically, given that the two-way effect between sovereigns and banks is hypothesized to be positive (outside bailout periods), we expect that shocks to the sovereign-bank nexus are magnified through mutual feedback loops. More technically, we look for the overall effect, which takes into account these adverse loops, to be larger than the direct effect. In addition, we expect that propagation via other financial markets also amplifies shocks to the sovereign-bank nexus since, based on the considerations above, we anticipate the signs of mutual effects between the nexus and other asset prices to be largely symmetric. Lastly, while this subsection is mainly phrased in economic terms, from a financial market perspective, our model provides a detailed description of the credit market and its relation to the two most important other asset classes, that is, bonds and equities.

## ***2.2 Transmission channels of non-standard monetary policy measures on credit risks***

In this subsection, we discuss potential transmission channels of specific non-standard monetary policy measures by the ECB on sovereign and bank credit risk. Given that our prior from the previous subsection is a positive link between sovereign and bank risk, we expect a specific measure to affect both risks in the same direction. In particular, we focus on LTROs with maturity 6-12 and 12-36 months, respectively, SMP, and OMTs. We group the measures in two.

First, both types of LTROs provide liquidity to banks. Their objective is to restore the functioning of impaired interbank markets. Lower funding risk for banks reduces the probability that liquidity turns into solvency risk. In addition, if this improvement in bank risk translates into higher credit supply to the non-financial sector, it stimulates output and increases prospective tax revenues. Hence, we expect LTROs to lower both bank and sovereign credit risk.

On the other hand, through purchases of government securities, SMP and OMTs support the depth and liquidity of secondary government bond markets. There are three main channels through which the two programs can affect sovereign and bank risk. First, through a portfolio channel, ECB purchases lower the outstanding amount of debt securities, thereby increasing their price if assets are imperfect substitutes (see Tobin, 1958, or Vayanos and Vila, 2009). Second, large potential demand for these securities by the ECB lowers liquidity premia (see De Pooter, Martin, and Pruitt, 2012). Both channels lower sovereign yields, reduce government refinancing costs, and hence sovereign risk. A third channel works in the opposite direction via bank's holdings of government bonds (see Buiter and Rahbari, 2012). They constitute claims on sovereigns but these claims are crowded out, and hence decrease in value, as the ECB denies to be treated *pari passu* with other creditors and instead postulates its senior creditor status. This effect increases bank risk and, insofar as sovereigns guarantee for bank's liabilities, sovereign risk. Overall, the effect of asset purchase programs on bank and sovereign risk is thus ambiguous.

Finally, both for LTROs and SMP, we distinguish between actual implementation and announcement effects. The latter work through market expectations of future monetary policy and economic conditions and hence affect asset prices today. Without particular reasons to anticipate announcement and implementation effects to go in opposite directions, *a priori* we expect them to be of the same sign.

### 3 Empirical methodology and data

In this section, we present our baseline econometric model and the data set. Then, we describe our identification strategy, which exploits heteroscedasticity in the data, and the estimation procedure.

#### 3.1 *Model specification and data*

Our baseline specification is a five-variable VAR which includes credit risk in the sovereign, banking, and non-financial sector, respectively, the term spread, and a stock market index. The endogenous variables depend on current and past values of themselves and of other endogenous variables, on exogenous variables, and an error term. Exogenous variables are non-standard monetary policy measures, implied stock market volatility, a risk premium in the money market, and macroeconomic news shocks.

The VAR model is given by

$$Ay_t = \tilde{c} + \tilde{A}_1 y_{t-1} + \dots + \tilde{A}_p y_{t-p} + \tilde{\Gamma}_0 x_t + \dots + \tilde{\Gamma}_q x_{t-q} + \varepsilon_t, \quad (1)$$

where  $y_t$  is the vector of endogenous variables and  $x_t$  is the vector of exogenous variables. The matrix  $A$  contains the contemporaneous impacts,  $\tilde{c}$  is a vector of constants,  $\tilde{A}_i$  with  $i=1, \dots, p$  and  $\tilde{\Gamma}_j$  with  $j=0, \dots, q$  are coefficient matrices, and  $\varepsilon_t$  a vector of structural shocks with diagonal variance matrix  $\Sigma_\varepsilon = E(\varepsilon_t \varepsilon_t')$ . The focus of the paper is on the impact matrix  $A$  and on the parameters in  $\tilde{\Gamma}_j$  capturing the effects of non-standard monetary policy. The off-diagonal elements in  $A$  contain the contemporaneous effects of shocks on the endogenous variables.

We estimate the model using either euro area averages or country specific data for the endogenous variables. For the exogenous variables, we keep the specification constant as they reflect influences common to all euro area countries and country specific data are not available for all countries. We collect daily data up to 31 July 2013 for Austria, Belgium, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain. The longest available sample starts on 20 January 2004 for Austria. The shortest period is for Ireland, starting on 24 October 2006.

To measure credit risk of each sector, we use CDS spreads on senior unsecured debt, modified-modified restructuring, mid spread, with maturity of five years. It is the most liquid maturity segment. We collect CDS spreads of all ten sovereigns and of, altogether,

41 corresponding banks and 56 non-financial corporations.<sup>2</sup> We compute unweighted CDS averages for each sector at the euro area level and at the country level. We exclude Greece from euro area averages since its sovereign spread series ends shortly after the Greek haircut in 2011. For the term spread, we use the difference between the yield on government bonds with maturity of ten years and the three month interest rate on treasury bills, if available, or in the national interbank market otherwise. For the euro area, we compute the unweighted average term spread. Concerning equity markets, we employ the Euro Stoxx 50 for the euro area level and local stock market indices, when looking at single countries.

As regards the exogenous variables, we consider the following non-standard monetary policy measures: LTROs with maturity 6-12 and 36 months, SMP, and OMTs. We distinguish between announcements by the ECB regarding the introduction of a specific program, indicated by dummy variables, and actual implementation, measured in billion euro. To capture uncertainty in euro area financial markets, we employ the VDax New, which measures option-implied volatility in the German stock market index Dax.<sup>3</sup> To measure the risk premium in the money market, we use the difference between the 3 month Euribor and the corresponding OIS spread. Finally, to account for macroeconomic news, we include the unexpected component of 12 economic indicators of the euro area. They are the differences between expectations and actual announcements. For expectations we use the mean of Bloomberg surveys among up to 50 market participants, taken a few days prior to data releases. Our choice of indicators follows construction of the Citi Economic Surprise Index which is widely observed by financial market participants. We provide a list of all variable definitions and sources in the Appendix.

To account for non-stationarity in the data, we estimate the model in first differences of variables already expressed in basis points, that is, of CDS spreads, the term spread, the VDax New and the interbank risk premium.<sup>4</sup> We use first log differences of equity market indices. We include two lags of the endogenous variables, mainly based on the Hannan and Quinn information criterion as it strikes a reasonable compromise between other selection criteria. All exogenous variables enter the model contemporaneously, except of the announcements of non-standard monetary policy measures for which we

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<sup>2</sup> We combine CDS data from two sources, Thomson Reuters and Credit Market Analysis (CMA). Since CMA data end in 2010, we use growth rates of respective Reuters series for updating. The correlation between prices from both sources is mostly higher than 0.98 for an overlapping period 2007-2010.

<sup>3</sup> We use the VDax New instead of its analogue for the Euro Stoxx 50 since the VStoxx is only available since 2009. The correlation between both indices is 0.92.

<sup>4</sup> We perform augmented Dickey-Fuller and Phillips-Perron tests on sovereign and bank CDS spreads at the euro area level. The tests do not reject the null hypothesis of a unit root, irrespective of whether we include a drift term.

incorporate ten lags to account for information processing in financial markets. All eigenvalues of the VAR companion matrices lie well within the unit circle.

### 3.2 Identification through heteroscedasticity

For estimation of the structural parameters of the VAR, we multiply equation (1) by  $A^{-1}$ :

$$y_t = A^{-1}\tilde{c} + A^{-1}\tilde{A}_1 y_{t-1} + \cdots + A^{-1}\tilde{A}_p y_{t-p} + A^{-1}\tilde{\Gamma}_0 x_t + \cdots + A^{-1}\tilde{\Gamma}_q x_{t-q} + A^{-1}\varepsilon_t. \quad (2)$$

Next, we define  $c \equiv A^{-1}\tilde{c}$ ,  $A_i \equiv A^{-1}\tilde{A}_i$ ,  $\Gamma_j \equiv A^{-1}\tilde{\Gamma}_j$ , with  $i = 1, \dots, p$  and  $j = 0, \dots, q$  and re-write (2) as

$$y_t = c + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \Gamma_0 x_t + \cdots + \Gamma_q x_{t-q} + u_t, \quad (3)$$

where  $u_t$  is a vector of reduced-form residuals. It is related to the structural shocks  $\varepsilon_t$  through the impact matrix  $A$  according to  $u_t = A^{-1}\varepsilon_t$ . The matrices  $c$ ,  $A_i$ , and  $\Gamma_j$  and the covariance matrix of reduced-form shocks  $\Sigma_u$  of model (3) can be estimated consistently by ordinary least squares.

To recover the structural parameters from these estimates, using the above definitions, we need to identify the impact matrix  $A$ . From equations (1)-(3), we know that the covariance matrix of reduced-form and structural shocks are related according to  $\Sigma_u = A^{-1}\Sigma_\varepsilon(A^{-1})'$ . However, in this system, the number of unknown parameters is larger than the number of independent equations. To see this, we consider a bivariate system without constants, lags, and exogenous variables for expositional purposes, following Rigobon (2003). The same logic applies to the general case. We have

$$\begin{pmatrix} \omega_{11} & \omega_{12} \\ \omega_{12} & \omega_{22} \end{pmatrix} = \begin{pmatrix} 1 & -a_{12} \\ -a_{21} & 1 \end{pmatrix}^{-1} \begin{pmatrix} \sigma_{11} & 0 \\ 0 & \sigma_{22} \end{pmatrix} \begin{pmatrix} 1 & -a_{12} \\ -a_{21} & 1 \end{pmatrix}^{-1},$$

where  $\omega_{kl}$ ,  $a_{kl}$ , and  $\sigma_{kl}$  denote the elements of  $\Sigma_u$ ,  $A$ , and  $\Sigma_\varepsilon$ , respectively. Since  $\Sigma_u$  is symmetric, the system contains only three independent equations but four unknowns.

We need additional information to identify the unknown parameters on the RHS. For this purpose, we exploit the heteroscedasticity in the data. Suppose that there are two regimes in the variances of the structural shocks: low and high volatility, indexed by superscripts  $L$  and  $H$ , respectively. Then, the system reads

$$\begin{pmatrix} \omega_{11}^L & \omega_{12}^L \\ \omega_{12}^L & \omega_{22}^L \end{pmatrix} = \begin{pmatrix} 1 & -a_{12} \\ -a_{21} & 1 \end{pmatrix}^{-1} \begin{pmatrix} \sigma_{11}^L & 0 \\ 0 & \sigma_{22}^L \end{pmatrix} \begin{pmatrix} 1 & -a_{12} \\ -a_{21} & 1 \end{pmatrix}^{-1'} \\ \begin{pmatrix} \omega_{11}^H & \omega_{12}^H \\ \omega_{12}^H & \omega_{22}^H \end{pmatrix} = \begin{pmatrix} 1 & -a_{12} \\ -a_{21} & 1 \end{pmatrix}^{-1} \begin{pmatrix} \sigma_{11}^H & 0 \\ 0 & \sigma_{22}^H \end{pmatrix} \begin{pmatrix} 1 & -a_{12} \\ -a_{21} & 1 \end{pmatrix}^{-1'}.$$

Now, we have six independent equations and six unknowns. The problem of identification is solved.

Two assumptions are necessary for identification. They can be seen from the six-variable system. First, the structural shocks are uncorrelated, that is, the off-diagonal entries in  $\Sigma_\varepsilon$  are zero. This assumption is standard in structural VAR modelling. Second, the slope parameters  $a_{kl}$  are constant across regimes. This assumption is also common, for example, in ARCH or GARCH models. Finally, note that two regimes are enough for identification, here and in the general case. If we have more regimes, the model is overidentified.

Several alternative identification strategies exist in the literature on structural VARs. One prominent way are exclusion restrictions. They postulate zeroes for specific entries in the impact matrix  $A$ , say, as a result of delayed responses of some endogenous variables to others. However, with daily data such assumptions seem too restrictive as financial markets are likely to respond to each other at this frequency.

Another route are sign restrictions on the parameters of  $A$ . They allow for simultaneous effects among all variables. However, as we outline in Section 2.1, for several of the contemporaneous effects neither theory nor empirical evidence gives unambiguous predictions. Signs depend on which shocks and transmission channels dominate and it is precisely one of the main aims of the paper to determine the signs of contemporaneous causal effects from the data, together with their significance and magnitude.<sup>5</sup>

Our parsimony in using restrictions comes at some costs, however. First, the system of simultaneous equations is only identified up to a rotation of the  $A$  matrix. To pin down the rotation which reflects the underlying economic model, we need to impose one sign restriction on the  $A$  matrix (see also Ehrmann, Fratzscher, and Rigobon, 2011). Hence, we assume that a positive shock to the equity market lowers credit risk of the non-financial sector. We restrict the sign of the corresponding parameter in  $A$  appropriately. We choose this assumption for several reasons. First, it seems economically fairly uncontroversial as, say, higher expected revenues and profits in the overall corporate sector is likely to lower

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<sup>5</sup> Yet another identification strategy uses long run restrictions. However, it is difficult to find theoretical reasons to believe that shocks to one asset market are more persistent.

credit risk of non-financial entities. Second, the constraint does not restrict the signs of the main parameters of interest, the two-way effects between sovereign and bank risk. Third, the constraint is mainly not binding in the estimation. Finally, the second drawback of our agnostic identification approach is that the estimated structural shocks are harder to interpret. We discuss this issue in more detail below.

### ***3.3 Regime definition and estimation procedure***

Before estimation, we need to determine the volatility regimes which contain the additional information necessary for identification. We use a narrative approach, following Rigobon (2003). For application of this methodology, the global financial and the European debt crisis provide a natural framework as they are characterised by strong and persistent increases in volatility in European financial markets. Specifically, we construct a time line of major economic and political events, using media reports and previous studies (see BIS, 2009, Acharya, Drechsler, and Schnabl, 2011, Alter and Schöler, 2012, Mody and Sandri, 2012, Alter and Beyer, 2013). Based on the events, we divide the sample period 2004-2013 into seven regimes.

Figure 2 shows the time line and the regimes. Regime 1 spans until 1 July 2007 when the US subprime crisis emerges. During regime 2, these tensions are transmitted to Europe. They culminate in the bankruptcy of Lehman Brothers on 15 September 2008, with subsequent major stress in western financial and in particular interbank markets. Thereafter, in regime 3, a denotable European dimension of the banking crisis emerges with large scale state support for the European banking sector. Bailouts occur in nearly all euro area member states. They include liability guarantees, capital injections, and deposit insurance and amount to several trillion euro. These measures transfer credit risk from the banking to the sovereign sector. They relieve the former and only modestly charge the latter – according to financial market perception at that time. Regime 4 begins with the bailout of the Greek sovereign by other member states on 2 May 2011, followed by the ECB's SMP, and the bailouts of the Irish and Portuguese governments. The latter marks the start of regime 5 on 6 April 2011. Here, expectations of a restructuring of Greek sovereign debt emerge. The Greek haircut on 27 October 2011 is the beginning of regime 6 which contains the ECB's LTROs. Regime 7 starts with the announcement of OMTs by the ECB on 26 July 2012.

The choice of events (and implied regimes) is guided by several considerations. First and foremost, the events trigger major changes in European financial market volatility which are a prerequisite for identification of the structural parameters of the model. Second, they are particularly relevant for developments in the credit market. They are targeted specifically at identifying the bidirectional effect between sovereign and bank risk. Third, they affect all euro area countries. Therefore, we can keep the regime definition constant across our specifications, irrespective of whether we consider the euro area en bloc or



individual countries, which allows for a clean comparison of results. Forth, as a side product, they define sub periods of sufficient and broadly similar length that we can use to perform recursive estimations. There is no need for an additional definition of sub periods which would complicate the exposition and interpretation of results.

Regarding the first two considerations, Figure 2 shows the 200 day rolling standard deviations of the (first difference of the) average sovereign and bank CDS spread of the euro area. They increase in several steps which broadly coincide with our regimes. Starting at relatively low levels in regime 1, prior to the turmoil in the US subprime market, they peak in regime 6, after the Greek haircut. For sovereigns, the standard deviation has its minimum at 0.1 and its maximum at 16.4. For banks, it is 0.1 and 9.0, respectively. Table 1 shows the standard deviations of all five endogenous variables of the euro area by regime. For sovereigns, the standard deviation increases by a factor of 9.0 and 31.7 when moving from regime 1 to 3 to 5, respectively. For banks, the respective factors are 2.3 and 4.3. For the other asset prices, the ratios of highest to lowest volatility range from 2.6 for the term spread to 10.2 for non-financial CDS spreads.

Figure 3 presents further stylised fact in form of additional, selected 200 day rolling correlations between sovereign risk and bank risk. The upper left panel contains country-specific correlations. The upper right panel shows the average over these. The lower panels depict cross-country correlations. In particular, we divide the countries into what is usually referred to as the euro area core (CO) and periphery (PE).<sup>6</sup> For comparison, all four panels also contain the correlation between sovereign risk and bank risk at the euro area level of Figure 1 (see thick line).

There are several interesting observations. First, the correlations fluctuate significantly over the sample period. In particular, as with the rolling standard deviations in Figure 2, they increase substantially during the European crisis. This co-movement between volatility and correlations illustrates the idea underlying our identification approach. Higher volatility, say, of bank risk shocks is associated to an increase in the correlation between sovereign and bank risk. We use this additional information to estimate the reaction of sovereign risk in response to bank risk shocks. Second, for all aggregate risk measures, the increase in correlations is similar in magnitude. Specifically, we observe strong positive correlations between core and periphery countries both within sectors-across borders and across sectors-across borders. Third, while all country-specific correlations tend to increase during the European crisis, there is considerable heterogeneity regarding the magnitude and persistence of this pattern.

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<sup>6</sup> We classify as core Austria, Belgium, France, Germany, and Netherlands and as periphery Ireland, Italy, Portugal, and Spain.

An alternative to the narrative regime definition is a purely statistical approach as, for example, in Fratzscher, Schneider, and van Robays (2013). The authors use estimated reduced form residuals, compute their rolling standard deviations, and calibrate thresholds for standard deviations to classify corresponding observations into volatility regimes. While well suited for a given specification, this approach has one major drawback for our purposes. It turns out that calibrations need to be country and sample specific to yield meaningful results. However, using country- or subsample-specific calibrations would complicate the comparison of results. In addition, the exposition would be tedious as nearly 70 different calibrations needed to be detailed.

Finally, we turn to the implementation of estimation and inference. Following Ehrmann, Fratzscher, and Rigobon (2011), we estimate the parameters of  $A$  by minimizing the following matrix norm

$$\|g'g\| = \sqrt{\text{tr}(g'g)} = \sqrt{\text{vec}(g)' \text{vec}(g)}, \quad \text{whith} \quad g = \sum_{i=1}^7 [A \Sigma_{u,i} A' - \Sigma_{\varepsilon,i}]$$

*s.t.  $\Sigma_{\varepsilon,i}$  is diagonal and the direct effect of an equity market shock on non-financial credit risk is negative,*

where  $\Sigma_{\varepsilon,i}$  is the variance of structural shocks and  $\Sigma_{u,i}$  is the covariance matrix of estimated reduced form shocks for regime  $i=1, \dots, 7$ . We perform 200 bootstrap replications to gauge the significance of the estimates. In each replication, we use the regime specific covariance matrices to generate new data from which we obtain estimates using the minimisation procedure. We calculate significance by computing the share of estimates beyond zero, following Ehrmann, Fratzscher, and Rigobon (2011).

#### 4 Propagation of credit risk in the euro area

In this section, we present the results on the link between sovereign and bank credit risk and their relation to other asset prices. First, we analyse the euro area en bloc before we look at single countries. Then, we split the sample into recursive sub periods. Finally, we explore the relationship between the euro area core and periphery. Throughout the section, we normalise all endogenous variables prior to estimation to facilitate a direct comparison of the magnitude of spillover effects across variables, countries, and time.<sup>7</sup>

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<sup>7</sup> In addition, the normalisation simplifies the computational implementation of the estimation procedure as estimated impact effects are of similar order of magnitude.

#### 4.1 Analysis of the euro area en bloc

In this subsection, we first analyse the contemporaneous causal relationships among the endogenous variables at the euro area level. Then, we compute historical compositions to explain the positive correlation between sovereign and bank credit risk and its strong increase over the sample period.

##### 4.1.1 Causal effects among credit risks, term spread, and stock market

Table 2 shows the estimated contemporaneous effects among the endogenous variables of the five-variable VAR for the euro area. The upper part shows the *direct* causal effect of a structural shock (in columns) of one standard deviation on the endogenous variables (in rows), keeping all other variables constant. It corresponds to the  $A$  matrix of the structural model  $Ay_t = \dots + \varepsilon_t$  of equation (1). We reverse the signs of the off-diagonal entries for ease of interpretation. The lower part of the table shows the *overall* causal effects which take into account all contemporaneous impacts of shocks to third variables, that is, shock transmission via other financial markets. It corresponds to the  $A^{-1}$  matrix of the reduced-form model  $y_t = \dots + A^{-1}\varepsilon_t$  of equation (2). We denote statistical significance at the 1%, 5%, and 10% levels by  $a$ ,  $b$ ,  $c$  below point estimates.

Regarding the relationship between credit risk of the sovereign and of the banking sector, in both directions the direct and overall effects are positive and statistically and economically significant. An unit increase in bank risk has a direct impact on sovereign risk of 0.14 in terms of standard deviations. In basis points, this corresponds to a shock of 5.2 to bank risk which increases sovereign risk by  $0.14 \times 7.3 = 1.0$ . The reverse effect is substantially stronger, having a direct impact of 0.46 standard deviations or 3.4 basis points. Moreover, mutual feedback between sovereign and bank risk (and other asset prices) amplifies the propagation of shocks. The overall effects, both of own shocks and shocks to the other sector, are considerably larger than the direct effects. At the extreme, bank shocks on sovereigns are magnified by 43%. Finally, given that all bidirectional effects are positive, we can infer that, over the full sample period, bailout shocks play a secondary role in driving bank risk. Other sector specific shocks dominate, which imply a positive co-movement between both sectors.

For shocks to other asset prices, they significantly affect solvency in the sovereign and in the banking sector. Focusing on overall effects, non-financial risk shocks increase sovereign and bank risk by 0.07 and 0.29 standard deviations, respectively. The corresponding effects of stock market shocks are of similar magnitude, albeit with

opposite sign.<sup>8</sup> Taken together, as both shock types drive sovereign and bank risk in the same direction, they contribute to the positive correlation between credit risks in the sovereign-bank nexus. In the reverse direction, shocks to sovereign and bank risk significantly increase non-financial risk and the term spread and they depress stock market returns. For both sovereign shocks and bank shocks, the effects on a given asset price are of similar magnitude. Across all endogenous variables, the strongest overall effect is from sovereign to bank risk with value of 0.54. Altogether, coefficient signs correspond with our priors and interpretation of shocks.

#### *4.1.2 Historical decomposition: drivers of the positive correlation between credit risks*

To understand what drives the positive correlation between sovereign risk and bank risk shown in Figure 1 and reflected in the positive signs of bidirectional impact effects, we calculate historical decompositions. They yield the contribution of each structural shock to the daily evolution of sovereign risk and of bank risk over the sample period. For each shock, we compute the implied correlation between sovereign risk and bank risk over rolling windows of 200 days and compare them to the actual correlation to gauge the importance of each shock for the evolution of the latter.<sup>9</sup> Figure 4 contains the results. The implied correlations can be grouped in two.

In the first group are the correlations implied by shocks to bank risk, to non-financial risk, and to the stock market (see upper panel). They capture the dynamics and overall level of the actual correlation. Specifically, bank shocks explain a large part of the higher frequency movements. On the other hand, non-financial risk shocks and stock market shocks imply a strong positive correlation throughout the entire sample period, reflecting their aligned impact effects on sovereign risk and bank risk. Altogether, however, shocks in the first group alone cannot explain the marked level shift in the actual correlation.

Shocks in the second group explain the level increase (see lower panel). The group contains the correlation implied by sovereign shocks and by own shocks, that is, sovereign risk only driven by sovereign shocks and bank risk only by bank shocks. The actual correlation increases by about 0.7 over the sample period. Own shocks drive up the implied correlation by a similar figure.

To understand the low level of the implied correlation by own shocks before, approximately, 2010, we consider three possible shock scenarios. As regards the first

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<sup>8</sup> For the term spread, the results are less conclusive. The ambiguity seems to reflect the off-setting effects of its components. While in some periods, the business cycle component dominates, in others, the credit risk part prevails.

<sup>9</sup> We neglect the correlation implied by term spread shocks since they are insignificant in explaining sovereign and bank risk (see lower part of Table 2).

two, the implied correlation declines if only bank shocks occur or if sovereign and bank shocks go in opposite directions. Corresponding to the first scenario, as the US subprime crisis spills over the Atlantic and severe tensions in euro area interbank markets emerge, shocks mainly hit the banking sector. In contrast, the sovereign sector stands relatively sheltered at the side line. Corresponding to the second scenario, only after the collapse of Lehman Brothers, euro area member states begin providing large bailout programs to their banks. These bailouts come as negative shocks to bank risk and tend to push up sovereign risk.

On the other hand, as a third scenario, sovereign risk and bank risk are positively correlated if shocks to both variables occur and if they move in the same direction. This scenario seems particularly relevant after 2010, when the European debt crisis gathered pace. It is also mirrored in the evolution of the correlation implied by sovereign shocks. As their relative importance grows over the sample period the implied correlation increases from 0.5 to 0.9. In contrast, the importance of bank shocks remains largely at the same level over the whole sample period (see upper panel). One illustrative example for positively related own shocks is the introduction of the European Financial Stability Facility (EFSF) on 10 May 2010 which is associated to a pronounced surge in most correlations on that day. The corresponding estimated shocks to sovereign risk and bank risk are -7.0 and -10.5 standard deviations.

#### ***4.2 Overall effects between sovereign risk and bank risk in euro area member states***

As suggested by Figure 3, there is considerable heterogeneity in the relationship between sovereign risk and bank risk across member states. In this subsection, we therefore analyse the contemporaneous causal relationship among the two risks individually in each of the ten member states of our sample to detect commonalities and differences across countries and vis-à-vis the euro area en bloc. Specifically, we estimate the five-variable VAR model using country-specific measures of the endogenous variables but keeping the set of global exogenous variables constant. As before, we estimate the models in first (log) differences, include two lags, except for Greece, where we use 14 lags, and constrain the direct effect of stock market shocks on non-financial risk to be negative.

Table 3 contains the results. For brevity, we report only the bidirectional overall effects between sovereign risk and bank risk.<sup>10</sup> On average across countries, from sovereigns to

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<sup>10</sup> By and large, the signs of the other coefficients in the  $A$  and  $A^{-1}$  matrices are as expected. For example, credit risks across all three sectors tend to be positively related, while the effects between the term spread and other asset prices vary across country. In periphery countries, the credit component mostly dominates, inducing a positive relation with credit markets and a negative with the equity market, whereas in many core countries the business cycle parts prevail, implying opposite co-movements.

banks, overall effects exceed direct effects by 39%. From banks to sovereigns, overall effects are only 94% of direct effects. For comparison, the first column in the upper part of the table repeats the results for the euro area en bloc. Several facts stand out.

First, there is a group of countries with significant positive effects in both directions. It consists of Austria, Belgium, Germany, Spain, and France. For the first three countries, the bidirectional effects are smaller than for the euro area, whereas they are of similar magnitude in Spain and France. As with the euro area, the effect from sovereign risk on bank risk tends to be larger than vice versa. It ranges from 0.08 in Austria to 0.50 in Spain. From banks on sovereigns, the smallest effect is in Germany (0.05) and the strongest in France (0.36).

Second, there is another group of countries with no or only unidirectional effects between sovereign risk and bank risk. In Greece and Italy, there is an effect from sovereigns on banks of 0.12 and 0.66, respectively, while in the Netherlands only the reverse effect is significantly positive. For Ireland and Portugal we find no relation between sector risks.

Third, two underlying commonalities between countries seem relevant for understanding this grouping. First, broadly speaking, the larger is the bailout package for the banking sector, the tighter is the link between sector risks. In the first group, bank support ranges from 18% in France to 47% in Belgium in terms of GDP (see Stolz and Wedow, 2010). Italy only provides 4%. In addition, in Italy the source of credit risk is generally perceived to be the sovereign sector, similarly in Greece. An exception to the rule is Netherlands with support of 52%. Yet, for Ireland, Greece, and Portugal there seems to be a second mechanism that breaks this rule. While in Portugal and Greece state support is indeed moderate with 12% and 18%, respectively, in Ireland it amounts to 320%. However, all three sovereigns are bailed out. As a consequence, bank risk on the balance sheets of these sovereigns is, at least partly, forwarded to other sovereigns, breaking the link between domestic sectors.

Fourth and finally, except of Spain and Netherlands, the two groups broadly coincide with the widely used classification of euro area countries into core and periphery. We investigate this issue further in the following section. Overall, the findings square well with previous studies and narrative evidence on the country-specific severity of banking problems and to what extent the solvency of the sovereign played a role (see, for example, Alter and Schöler, 2012, Mody and Sandri, 2012).

### ***4.3 Overall effects between sovereign risk and bank risk in recursive sub samples***

In this subsection, we assess the relation between sovereign risk and bank risk in recursive sub samples at the euro area level and at the country level to see whether the relation changes over time, in particular, surrounding bailout periods. Specifically, we

hold the starting point fixed and let the estimation window grow in steps of our pre-defined regimes, that is, the first window consists of regimes 1-2, the second of regimes 1-3, and so on, and the last window of regimes 1-7 corresponds to the full sample.<sup>11</sup> Throughout, we leave all specifications as before and normalise variables over each window. Estimation of rolling, non-overlapping windows does not yield meaningful results. This probably reflects the importance of the marked changes in volatility when moving from regime 1 to regime 4, whereas later on volatility differences are smaller across regimes, and the need of having sufficient observations in each sub sample.

Figure 4 contains the results, presented in graphical form for ease of interpretation. Again, we report only overall effects between sovereign risk and bank risk. The upper left graph in the upper panel shows results for the euro area level. For the first window, there is no significant effect in either direction. From window 2 onwards, we observe a significant positive effect of sovereigns on banks in the range of 0.45 to 0.59 (solid line). From banks to sovereigns (dashed line), the effect is significantly negative in windows 2 and 3, and it turns positive afterwards. In line with the results above, we interpret the negative effect as mirroring actual bailouts. They come as a series of negative bank shocks which negatively affect the solvency of sovereigns. Dieckmann and Plank (2012) find a similar, sign-changing correlation pattern between CDS spreads of banks and sovereigns during and after bailout periods.

Put differently, in windows 2 and 3, actual bailout shocks dominate the risk transmission channel from banks to sovereigns. As they die out in subsequent windows, the credit supply and the *post*-bailout channel gain importance which both imply a positive effect of bank risk on sovereign risk. In contrast, for sovereigns, the relative importance of bailouts is smaller. Other channels play a more prominent role over the entire sample period, that is, the sovereign bond holdings, the collateral, and the rating channel. This seems plausible given surging government bond yields and massive sovereign down ratings in 2009-2010 during the Great Recession (see Arezki, Candelon, and Sy, 2011).

Looking at single countries, except in Austria, we find a similar sign pattern of bidirectional effects mostly in core countries. We pool them in the upper panel of Figure 5. In periphery countries, there is no clear pattern (lower panel). This grouping of countries corresponds well to that of the previous subsection and supports the interpretation that the strong links between the two sectors present in many core countries reflect bailout-induced risk transfers. The results for Greece and Ireland also strengthen the interpretations of what breaks the link. While there is a negative effect from banks on

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<sup>11</sup> For Ireland, the first window consists of regimes 2-3. For Greece, the last window contains regimes 1-6.

sovereigns in windows 2 and/ or 3, echoing bank bailouts, it turns insignificant afterwards, reflecting the transfer of bank risk to core sovereigns via sovereign bailouts.

A somewhat puzzling result is that in many cases effects from banks on sovereigns are still negative in window 3, which contains regimes 1-4, inasmuch as the introduction of bailouts was mostly confined to regime 3. We have three tentative explanations. First, as a statistical phenomenon, the estimates of window 3 contain lingering effects of window 2. Second, the bailout effects are still present in regime 4 as either new information becomes available regarding the actual implementation of the bailout packages or information processing in financial markets regarding their full consequences is still going on. Third, the sovereign bailouts of Greece, Ireland, and Portugal, which all occur during regime 4, reduce core bank risk and increase core sovereign risk as they transfer periphery sovereign risk on the balances of core banks to the balances of core sovereigns. However, all explanations should be treated with caution.

Finally, we define contagion as a significant increase of asset market interdependence after a shock or trigger event, following Forbes and Rigobon (2002) and Constâncio (2012). Specifically, and applied to the relationship between sovereign risk and bank risk, we define as contagion the emergence of a statistically and economically significant effect in either direction where no such effect existed beforehand. According to this definition, there is contagion between sovereign risk and bank risk since 2008 both at the euro area level and in nearly all countries.

#### ***4.4 Credit risk spillovers between the euro area core and periphery***

Based on the results of the previous subsections, in this subsection we group countries into core and periphery countries to investigate cross-country spillovers in the sovereign-bank nexus. In particular, we use the euro area specification and split sovereigns into core and periphery and compute the respective unweighted CDS averages. We do the same with banks. We leave the other endogenous variables unchanged such that we end up with a seven-variable VAR. In the following subsections, we first present the overall effects among all endogenous variables, then, we compute variance decompositions, before we interpret estimated structural shocks. Finally, we assess the flight-to-safety phenomenon into German Bunds.

##### ***4.4.1 Spillovers across euro area core and periphery countries and sectors***

Table 4 shows the overall effects among all endogenous variables. Concerning the relation between credit risks, the cross-effects among all five segments are highly statistically and economically significant and all have the expected positive sign. If we construct a ranking of the effects of shocks to sovereign risk and to bank risk by summing



over the top four rows of the table, the largest effects originate from periphery sovereigns (2.65), followed by core sovereigns (2.19), periphery banks (1.84), and core banks (1.56).

For the sovereign-bank relation *within each country group*, we observe significant bidirectional effects within both the core and the periphery. The magnitude of effects is similar to the euro area level specification with stronger effects from sovereigns on banks than vice versa in both the core (0.36) and periphery (0.59). The reverse effect is larger in core countries with 0.15 versus 0.11 in the periphery, where it is barely significant. These results affirm our findings above that the interdependence between sovereigns and banks is stronger in core countries and that here banking risk is relatively more important, whereas in periphery countries sovereign risk plays a larger role.

Regarding spillovers *across country groups*, we observe strong links both within and across sectors. *Within* sectors, the spillovers are larger from the periphery to the core than the other way around. For sovereign risk, the periphery has an impact of 0.54 standard deviations on the core. For bank risk, the effect is 0.52. In the reverse direction, the effects are approximately halved. *Across* sectors, the effect from sovereign on bank risk is stronger than vice versa, similar to the results within each country group. The impact from periphery sovereigns on core banks is 0.34 and it is 0.39 vice versa. From periphery banks to core sovereigns, the effect is 0.07 and it is 0.08 in the reverse direction.

Finally, for the term spread, results are less conclusive, again reflecting its off-setting components. Regarding stock market shocks, they significantly lower credit risks, with the largest effect on core sovereign risk and non-financial risk of 0.37 and 0.36 standard deviations, respectively.

#### 4.4.2 Variance decompositions

To further investigate the economic significance of particular shocks, we compute one day ahead forecast error variance decompositions. They yield the percentage that a shock type contributes to the variance of an endogenous variable. Given that shock variances are regime specific, we calculate the weighted average variance decomposition over all regimes, using the number of observations per regime as weights. Table 5 contains the results which, altogether, echo the results of the overall effects.

First, sovereign risk is more important in explaining bank risk than vice versa. Combined sovereign risks explain 24% and 11% of the variability of periphery and core bank risk, respectively. In contrast, combined bank risk shocks contribute only 3% and 4% to sovereign risk variability, respectively. Second, the dominance of the sovereign sector is particularly strong in the periphery where it contributes 16% to bank risk variance. Third, periphery shocks contribute more to the variance of core variables than vice versa which is surprising given the relative sizes of the corresponding economies and credit markets.

Fourth, partly as an implication of the first two observations, other than own shocks play an important role for bank risk variability, whereas for sovereign risk variability their contributions are smaller. In particular, for core and periphery bank risk, other than own shocks explain 39% and 44%, respectively. For core and periphery sovereigns, the fractions reduce to 28% and 14%.

Regarding non-financial risk shocks, they explain relatively large shares of bank risk but have only a limited impact on sovereign risk. Term spread shocks explain hardly any of the fluctuations in other variables. Stock market shocks contribute between 3% and 8% to the variability in credit risks.

#### *4.4.3 Interpretation of structural shocks*

Now, we return to the issue of how to interpret structural shocks. As we identify them in a rather statistical way, which does not rely on a priori assumptions, we give full voice to the data regarding the sign and magnitude of impact effects. The drawback of our agnostic approach is that the estimated shocks are harder to interpret. To address this point, we check whether the identified shocks show higher volatility in periods we would expect, given our interpretation of shocks. To this end, Figure 6 shows the daily structural shocks (grey bars) together with their 200 day rolling standard deviations (black line).

Generally, all volatilities peak around the same two points in time. Intuitively, the two maxima of the standard deviations coincide with the global financial crisis in 2008/2009 and with the European debt crisis in 2011/2012. However, there are important differences across shock series regarding which peak constitutes the global maximum that help disentangling the interpretation of shocks.

For shocks to core sovereign risk, the first peak mirrors the steep recession in these countries which impairs public finances. However, the second peak is evidently higher. This seems plausible given the severity of the European debt crisis which calls into question the sustainability of public finances even of several core countries which by now gained massive risk exposure to the European banking and sovereign sector.

In contrast, for shocks to core banks, the first volatility peak is higher. Again, this squares with our shock interpretation as during this period the global financial crisis hits the European banking sector and in addition it receives major rescue packages. In the second crisis in turn, large parts of the credit risk in the banking sector are already transferred to the sovereign sector. Comparing the two core sectors, the different timing of global maxima also supports our interpretation that bailout shocks mainly affect bank risk dynamics in these countries.

Regarding bank risk and sovereign risk in the periphery, both shock volatilities peak during the second crisis. Except Ireland, which is bailed out later on, this pattern reflects

that the main source of credit risk in the periphery is the sovereign sector, as with Italy and Portugal. In contrast, bank risks come to the forefront relatively late, as in Spain. Further, comparing the core to the periphery, the shock series affirm our reading of the stronger link between core sectors as a result of larger bank bailout packages.

Finally, concerning shocks to non-financial risk and to the stock market, volatility is higher during the first crisis. This seems reasonable given that the associated recession is deeper. For term spread shocks, both peaks are of similar height. While the first spike coincides with massive downward revisions of growth expectations and aggressive monetary easing, affecting the business cycle component of the term spread, the second hike most likely reflects elevated credit risk premia in the European government bond market. On balance, the similar importance of both shock types explains the largely insignificant effects of the term spread as the components off-set each other.

#### *4.4.4 Flight to the safe haven of German Bunds*

Now, we investigate whether there is evidence for a flight-to-safety phenomenon in the euro area which can often be seen in times of economic or financial crisis. In particular, we explore whether adverse shocks to euro area asset markets trigger a flight of investors to the safe haven of German sovereign bonds. To this end, we use the seven-variable VAR specification of the previous subsection but we employ only German CDS spreads to measure core sovereign risk and we replace the euro area term spread by the 10 year Bund yield. Table 6 shows the overall effects among all variables. Except of the two new variables, cross-effects among the other variables are similar to Table 4.

Regarding a flight-to-safety, we indeed find evidence for this phenomenon in the euro area. Except of core banks, all credit risk shocks entail significant negative effects on Bund yields. Non-financial risk shocks have the largest negative impact. A unit shock lowers Bund yields by 0.26 standard deviations. In basis points, it corresponds to a shock of 100 that depresses yields by 29. Returning to standard deviations, shocks to periphery sovereign risk have a similar effect of -0.21, whereas shocks to periphery bank risk are less influential with -0.07. Interesting, even shocks to German sovereign risk trigger flows to the presumably safe haven of Bunds and with -0.14 this effect is even stronger than that of periphery bank shocks. In the reverse direction, Bund yield shocks significantly lower both sovereign risk and bank risk in the periphery. This result indicates that in Bund yields the business cycle component is more important than in the euro area term spread.

Compared to the impact of shocks to core sovereign risk in Table 4, for all variables the effect of shocks to German sovereign risk is smaller, and in particular on the banking sector. In addition, shocks to periphery sovereign risk do not impact on German credit risk. This stands in contrast to their effect on core sovereign risk which is highly

statistically and economically significant with value of 0.54 (see Table 4). In this regard, the credit market perception of Germany is different to that of the average core sovereign.

## 5 Effects of non-standard monetary policy and bailouts on credit risk and other asset prices

In this section, we first analyse the effects of non-standard monetary policy measures by the ECB on asset prices in the euro area, and in particular on the solvency risk of sovereigns and banks. Then, we explore the effects of announcements of specific bank bailout schemes on those risks. Throughout, all dependent variables are in basis and in percentage points, respectively, to facilitate the economic interpretation of effects.

### 5.1 *Monetary policy effects on credit risks and other asset prices*

In this subsection, we first analyse the announcement and implementation effects of non-standard monetary policy measures on all endogenous variables at the euro area level. Then, we look at individual countries, focusing on the effects on sovereign and bank risk.

#### 5.1.1 *Non-standard monetary policy effects on euro area asset prices*

In this subsection, we analyse the effects of specific non-standard monetary policy measures on sovereign risk and bank credit risk and on other asset prices in the euro area. To this end, we return to the estimated five-variable VAR for the euro area. We extract the estimated coefficients on the exogenous monetary policy variables and compute additional statistics. They are shown in Table 7. The upper part reports the point estimates and the cumulative effects of actually implemented monetary policy measures on the endogenous variables (in columns). The cumulative effects are the product of the point estimate, if significant, and the total amount allotted or purchased within the program. The lower part of the table contains the 10 day cumulative effects of ECB announcements regarding these policies, measured by the contemporaneous effect and its first 10 lags, together with the p-value of the F-test of joint significance.

Turning first to the effects of monetary policy on sovereign risk and bank risk, each measure affects both risks in the same direction. Except for 3-year LTROs allotments, this commonality holds irrespective of whether we consider implementation or announcement effects. It underscores the strong positive interdependence between credit risks of both sectors. In line with our theoretical considerations, the announcements of 6-12 month LTROs, SMP, and OMTs significantly reduce credit risks. There are, however, noteworthy differences in the magnitude of effects both across measures and sectors.

The announcements of SMP and OMTs are most effective. The former reduces sovereign and bank CDS spreads by cumulatively 51 and 40 basis points, respectively. Similarly, the latter lowers them by 55 and 34 basis points, respectively. The stronger effect on sovereign spreads is consistent with the primary announced goal of both programs which is reducing tensions in public debt markets.

Regarding the announcement effects of LTROs with maturity of 6-12 and 36 months, respectively, the results are somewhat surprising. While, as expected, the former reduces sovereign and bank CDS spreads, by 5 and 1 basis points, respectively, the latter leads to an increase of spreads by 11 and 17 basis points. There are two possible explanations for the counterintuitive positive effect. First, at the time of the announcement, market participants underestimated the final allotments within this liquidity scheme which ultimately exceeded one trillion euro. Second, they expected the announcement of a reactivation of SMP during the ECB press conference on that day and were disappointed.

Concerning announcement effects on other asset prices, they are largely in line with our theoretical priors. In particular, non-financial risk reacts mostly in the same way to a specific announcement as sovereign and bank risk, but the effects tend to be less pronounced. The effects on the stock market go in the opposite direction. For the term spread reaction, there is an interesting difference to the sovereign credit market. While the announcement of 3-year LTROs increases sovereign CDS spreads by 11 basis points, it lowers the term spread by 19 basis points. The decline seems even more pronounced in face of a 25 basis point rate reduction by the ECB on the same day. Besides different risk perception in the cash and credit market, the negative effect could mirror stepped-up bond purchases by banks in expectation of further falling yields.

For the actual implementation of the programs, we find the expected negative effect of 3-year LTROs on bank risk. The allotment of one billion euro lowers bank CDS spreads by 0.05 basis points. The cumulative implementation effect of both 3-year LTROs with a total volume of 1,020 billion euro thus amounts to -51 basis points. Taking into account both announcement and implementation effects, the overall effect of 3-year LTROs is -34 basis points on bank CDS spreads.

In contrast, purchases within SMP significantly increase CDS spreads of all three sectors. Equally, they push up sovereign and bank CDS spreads by approximately 1 basis point per billion euro. We interpret the positive effect as echoing the crowding out of private claims by the ECB's preferred creditor status. Given that the ECB bought in total 218 billion euro of government bonds within SMP, the cumulative implementation effect is +235 and +209 basis points on sovereign and bank CDS spreads, respectively. Taking into account the favourable announcement effect, the program's overall effect amounts to +184 and +169 basis points, respectively. When interpreting the implementation and announcement effect of SMP separately, one needs to keep two things in mind however.

First, the first announcement occurred on the same day as the official establishment of the EFSF. Second, both the first and the second announcement falls within the same week the ECB actually started buying sovereign bonds.

Altogether, OMTs are most successful in reducing credit risk in the sovereign-bank nexus. One of its most appealing features seems to be that it was activated or put to a test by markets. In contrast, while the announcement of SMP is equally successful, the shortcomings of the program's implementation more than offset these improvements. Finally, specifically targeted at banks, indeed the 3-year LTROs effectively reduce bank risk. On the other hand, the effect on sovereign risk is rather unrewarding.

#### *5.1.2 Monetary policy effects on sovereign risk and bank risk in single member states*

Next, we explore the effects of monetary policy on sovereign risk and bank risk of individual countries. Generally, we expect the effects to be stronger in countries of the euro area periphery. We first assess the effects on sovereign CDS spreads, before we turn to banks. Specifically, Table 8 shows the implementation and announcement effects on country-specific sovereign CDS spreads, extracted from the respective equation in the corresponding five-variable VAR. For comparison, the first column repeats the results for the euro area. Columnwise, the countries are grouped into core and periphery.

Regarding the implementation of SMP, it significantly increases sovereign CDS spreads of several core countries (Austria, Belgium, Netherlands) as well as of periphery countries (Greece, Italy, Portugal). However, in the latter group, the effect is evidently larger. On the other hand, the increases are partly offset by the negative announcement effect of SMP which is strongest in Greece (−2249 basis points), Portugal (−130), Italy (−112), and Spain (−78). Nevertheless, for all countries where both effects are significant, the implementation effect dominates such that overall SMP increases sovereign spreads.

For the announcement effects of 3-year LTROs, an interesting difference between core and periphery countries emerges. While the effects are significantly positive in all core countries, ranging from +11 basis points to +42, the effects on periphery spreads are unanimously negative, albeit relatively small (except for Ireland, where it is insignificant however). Hence, the positive announcement effect of LTROs witnessed at the euro area level seems to be driven primarily by core countries. Moreover, this divergence points to a subtle twist to our earlier interpretation of the announcement effect: at that time, market participants were not only disappointed that SMP, which in its second phase was targeted specifically at Italian and Spanish sovereign bond markets, was not reactivated. They also priced in higher core sovereign risk as, in their view, without SMP the likelihood of bailouts of these two sovereigns by their core counterparts increased. The interpretation of disappointed SMP expectations and underestimation of the final LTROs allotments is further corroborated when looking at the announcement effects on country-specific term

spreads (not reported here). Together with Belgium, only the sovereign yields of Italy and Spain increase (significantly). All other yields decline. Put differently, market participants expected the direct effect of SMP on Italian and Spanish sovereign yields to be stronger than the indirect effect of 3-year LTROs via banks. Finally, announcements regarding 6-12-month LTROs unanimously lower periphery sovereign spreads, whereas in the core the effects are smaller in absolute value and mixed in sign.

Lastly, for the effect of OMTs, it is clearly more powerful on periphery spreads. Here, the effects are all statistically significant and they range from  $-80$  basis points in Ireland to  $-121$  in Portugal. In contrast, in the core, we only find a significant negative effect on Belgian CDS spreads, which is moderate however with  $-23$  basis points.

Now, we turn to the effects on bank credit risk. Specifically, Table 9 shows the implementation and announcement effects on country-specific bank spreads, extracted from the corresponding VAR equations. Starting with 3-year LTROs, actual allotments reduce bank spreads in all countries except in Ireland and Greece. More precisely, the point estimate is significant in Belgium, Germany, and Portugal and here, as with the euro area, the cumulative implementation effect outweighs the positive announcement effect. Hence, for these countries, there is a significant negative overall effect of  $-39$ ,  $-35$ , and  $-153$  basis points, respectively. In contrast, for Greece, the overall effect is significantly positive with  $+825$  basis points.

For SMP, the results are similar to the effects on sovereign CDS spreads. While the announcement effect significantly lowers bank spreads in eight out of the ten countries, actual purchases significantly increase them in six countries. For all countries where both effects are statistically significant, the implementation effect prevails such that the overall effect of SMP is an increase of bank CDS spreads. Moreover, the overall effects tend to be larger in periphery countries with  $+1485$  basis points for Greece, about  $+280$  for Italy and Portugal, and  $+319$ ,  $+182$ , and  $+130$  for Austria, France, and Germany.

For OMTs, as with sovereign spreads, the effects are stronger on periphery than on core banks. They range from  $-71$  basis points in Italy to  $-54$  in Spain. For core banks, we only find significant negative effects in Austria ( $-40$  b.p.) and France ( $-21$  b.p.).

Altogether, the country-specific results are largely in line with our priors. The effects of OMTs and SMP are more pronounced in the periphery. The effects of 3-year LTROs are mixed. While this liquidity scheme tends to increase sovereign spreads, in particular of core countries, it mostly lowers bank spreads, irrespective of the country group.

## ***5.2 Effects of bailout announcements on euro area sovereign risk and bank risk***

In this subsection, we analyse the effects of specific bank bailout announcements on sovereign risk and bank credit risk in the euro area. Specifically, we consider three types

of announcements by national federal governments, following (CGFS & BIS, 2010): the announcement of (a) debt guarantees, (b) deposit guarantees, and (c) capital injections. The announcement dates correspond to the first official communication regarding the type and general scope of the rescue schemes. We use dummy variables at the country level to indicate these dates. Then, we average over all countries to assess the effects at the euro area level. An analysis at the member state level is prohibited by the fact that most member states announced more than one bailout type on the same day and that across countries the composition of jointly announced types differs.

We use dummy variables instead of other measures, which aim at capturing the precise magnitude of announced programs, because such measures would be difficult to compare across countries. In addition, several announcements are relatively general without specifying the overall implied amounts, for example, in euro. Further, we concentrate on the announcement and neglect the actual implementation as specifics of the latter greatly vary across countries, complicating a meaningful aggregation. Finally, note that we concentrate on the broadest and earliest announcement only and that at latter stages more information concerning the precise timing and comprised resources is released to market participants, either through communication or actual implementation.

We use the five-variable VAR specification for the euro area and include, one at a time, the bailout announcement variables as additional exogenous variable. Including all announcement types jointly does not yield meaningful results due to problems of collinearity. Therefore, to cleanly trace out the specific effects, we use 20 lags. The lag length also accounts for the fact that scale and scope of the announced measures were relatively unprecedented in the euro area at that time and information processing and learning by market participants regarding their implications probably took several weeks.

The bottom of Table 10 shows the cumulative effect of the bailout announcements. Columns (1)-(3) contain the results for the sovereign risk equation while in columns (4)-(6) the endogenous variable is bank risk. The upper part of the table shows the effects of monetary policy for comparison. They are largely unaffected.

All bailout announcements are statistically significant. While, the announcement of debt guarantees and capital injections increases sovereign CDS spreads by 3 and 7 basis points, respectively, the announcement of deposit guarantees has a negative impact of 19 basis points. This negative effect might reflect the broader nature of this measure which not only targets the banking sector but also partly shields the household sector and its savings decisions from negative spillovers.

For the effects on bank spreads, the picture is more homogenous. All bailout announcements reduce the solvency risk of the euro area banking sector. The announcement effects of deposit guarantees and capital injections are similar in



magnitude with about  $-75$  basis points. With  $-46$  basis points, the effect of debt guarantees is somewhat smaller, but still sizeable.

Overall, the results confirm the presumption that the announcement of bank bailout measures alleviated worries about the solvency of the euro area banking sector, at least for a certain period of time. However, they may contain adverse effects on sovereign risk.

## 6 Conclusions

The empirical analysis of the paper finds evidence in favour of a close bank-sovereign nexus during the European financial crisis. Using a structural VAR, that exploits the heteroscedasticity of the underlying daily series of financial market data, the analysis shows that sovereign risk shocks had an important and dominant impact on bank risk in the euro area. While also shocks to bank risk had an adverse impact on sovereign risk within the own country, sovereign risk overall appears to have been the more important driver of the bank-sovereign nexus.

This link has intensified significantly over time, with it being much weaker within Europe during the global financial crisis. We also find evidence for a negative spillover of sovereign risk and bank risk in the euro area periphery to the core euro area countries, despite the latter being much larger in magnitude. We find suggestive evidence for flight-to-safety phenomena, although overall risk stemming from the periphery generally tended to increase also bank risk in the core of the euro area.

The core analysis of the paper is the question whether and how bank bailout policies and monetary policy by the ECB have affected this bank-sovereign nexus. Bank bailout policies, such as capital injections into ailing banks and debt and deposit guarantees, exerted a significant impact on both sovereign risk and bank risk. Importantly, we find evidence that in some instances such bailout policies actually raised sovereign risk of the country. As to monetary policy, our results show that OMTs were most successful, insofar as they reduced credit risks in both sectors. In contrast, shortcomings of the actual implementation of SMP caused the program to increase solvency risk of sovereigns and banks. The 3-year LTROs effectively reduced bank risk while their effect on sovereign risk was at best ambiguous.

Overall, these findings suggest that both rescue policies of the banking system and monetary policy exerted a significant impact on sovereign and bank risk as well as on risks and prospects of the real economy. The empirical estimates also indicate that neither of the two policies was unanimously effective. Thus, this entails a note of caution to policymakers that policies that are intended to reduce risk can in fact lead to an intensification of the negative feedback loop between sovereigns and banks.

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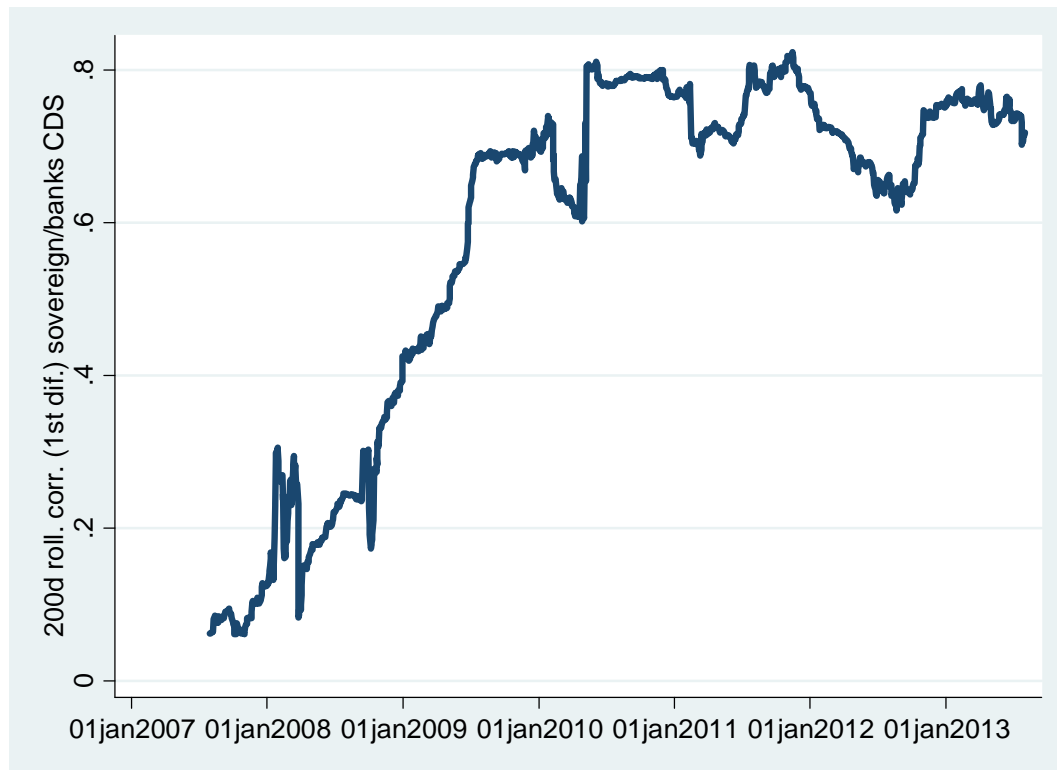
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## 8 Figures

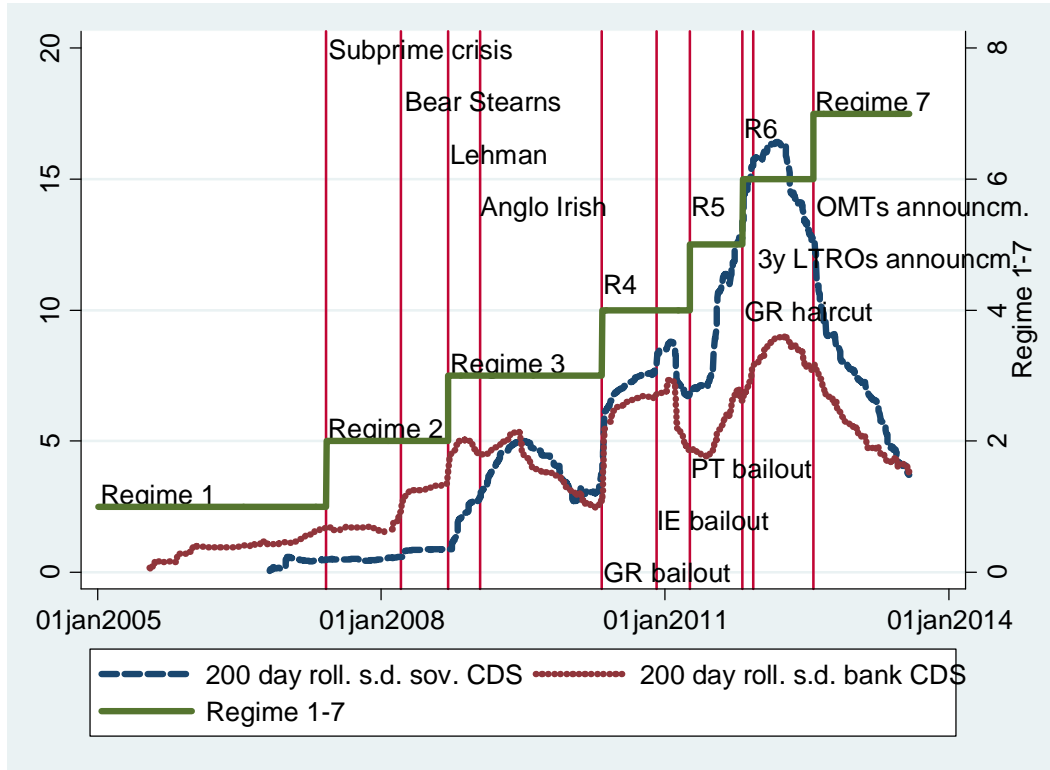
**Figure 1: Rolling correlation between sovereign and bank risk in the euro area.**

The figure shows the 200 day rolling correlation between the first difference of the average credit default swap spread (five year, senior) of the sovereign sector and of the banking sector of the euro area over the sample period.



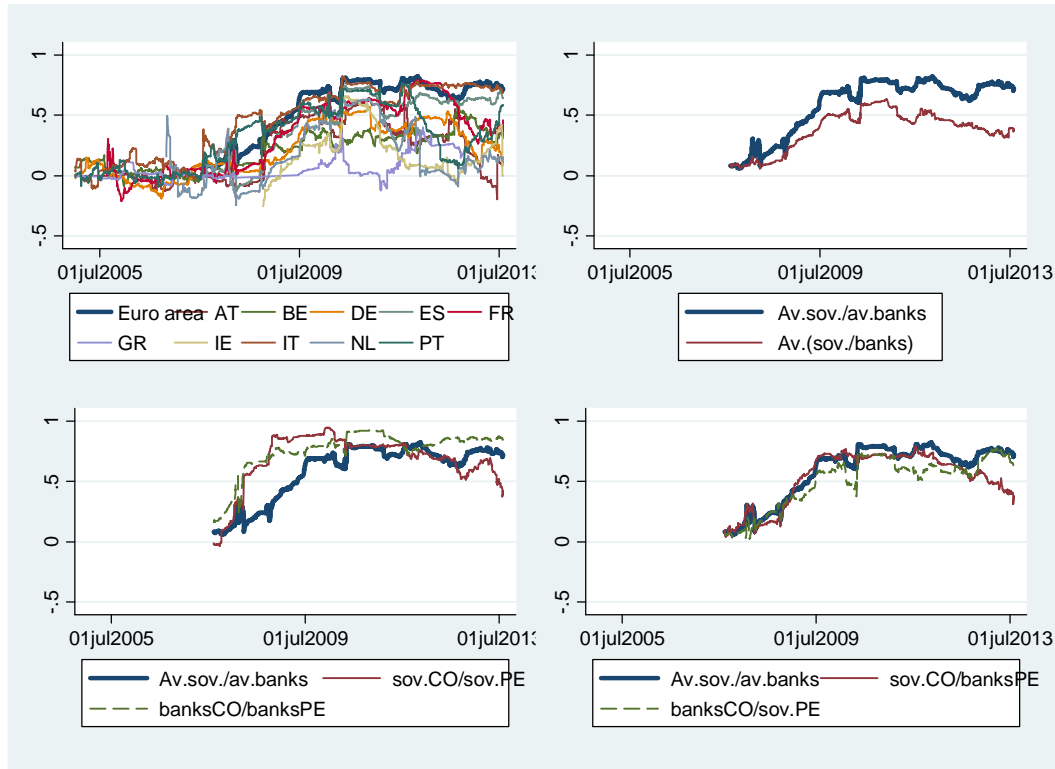
**Figure 2: Time line, regime definition, and rolling standard deviation of sovereign and bank CDS spreads of the euro area.**

This figure shows (a) a time line of the global financial and the European debt crisis, (b) the definition of volatility regimes 1-7 (green solid line, right axis), and (c) the 200 day rolling standard deviations of the first difference of the average credit default swap spread (senior, five year) of the sovereign and of the banking sector of the euro area, respectively (blue dashed and red dotted line, left axis).



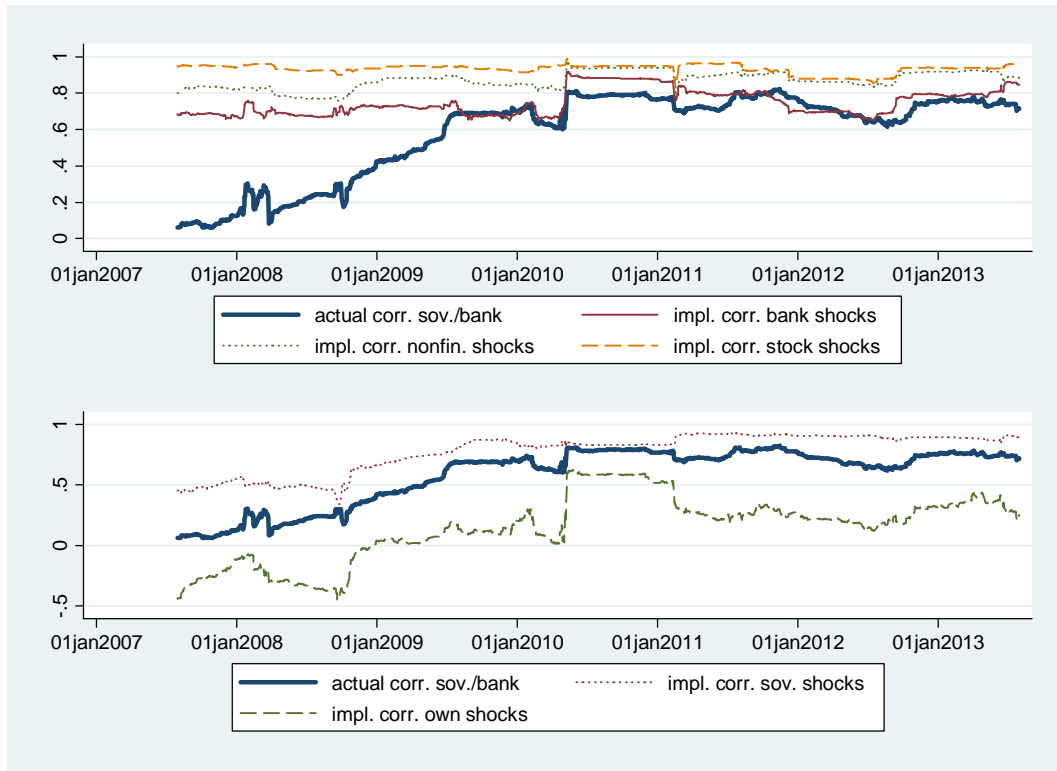
**Figure 3: Rolling correlations between sovereign and bank risk in the euro area and in individual member states and between euro area core and periphery**

The figure shows the 200 day rolling correlations between the CDS spread of the sovereign and of the banking sector in the euro area over the sample period 2004-2013. The upper left panel shows the correlation in individual member states and in the euro area en bloc (thick line). The upper right panel shows the correlation for the euro area en bloc and the average correlation across countries (thin line). The lower left panel shows the correlation between core and periphery sovereigns (thin solid line) and between core and periphery banks (dashed line). The lower right panel shows the correlation between core sovereigns and periphery banks (thin solid line) and between core banks and periphery sovereigns (dashed line).



**Figure 4: Actual and implied correlation between sovereign and bank credit risk in the euro area driven by different types of shocks**

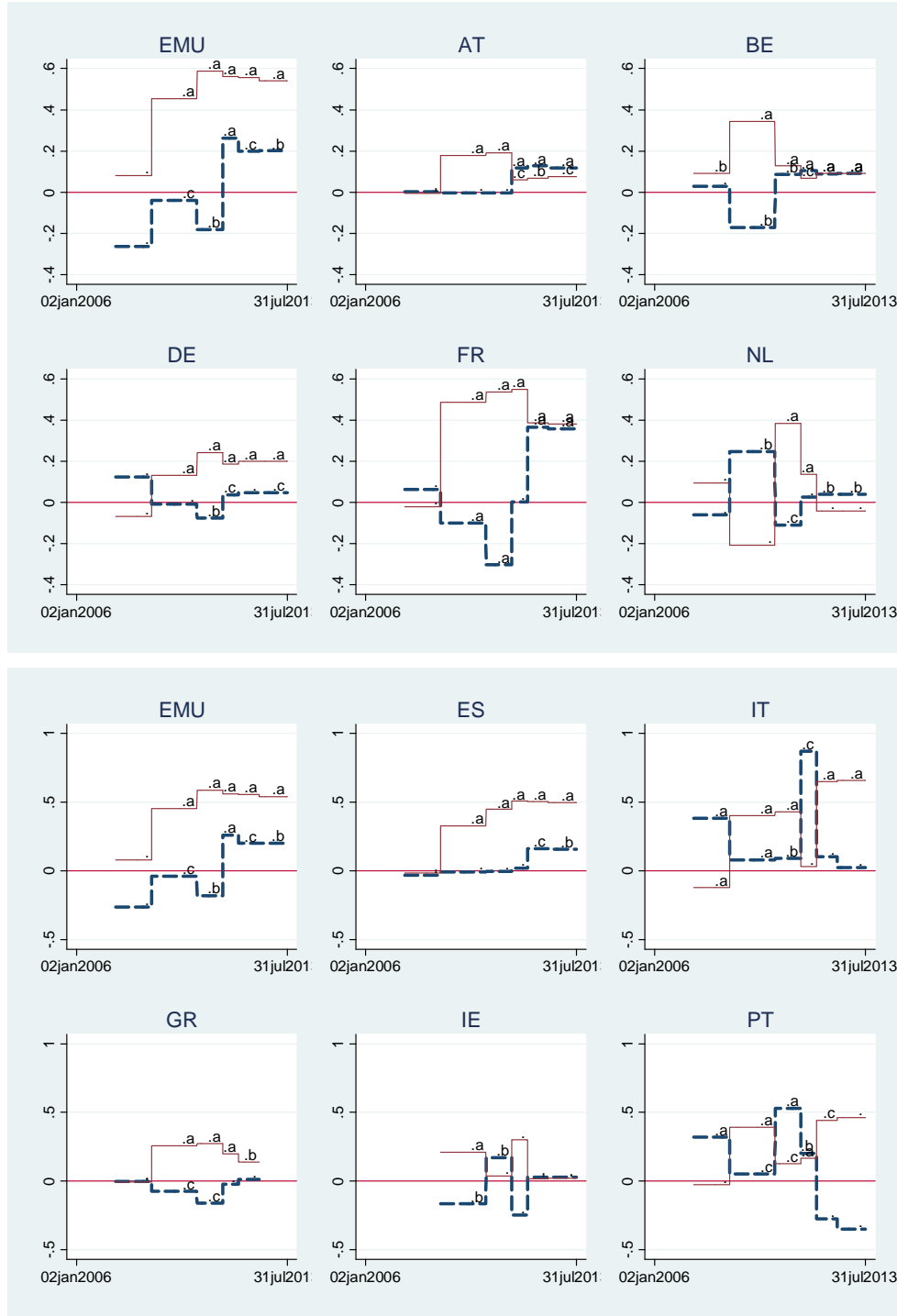
The figure shows the actual, 200 days rolling correlation between sovereign and bank credit risk in the euro area and the implied correlations which are explained by a specific shock, using the estimated historical contributions.





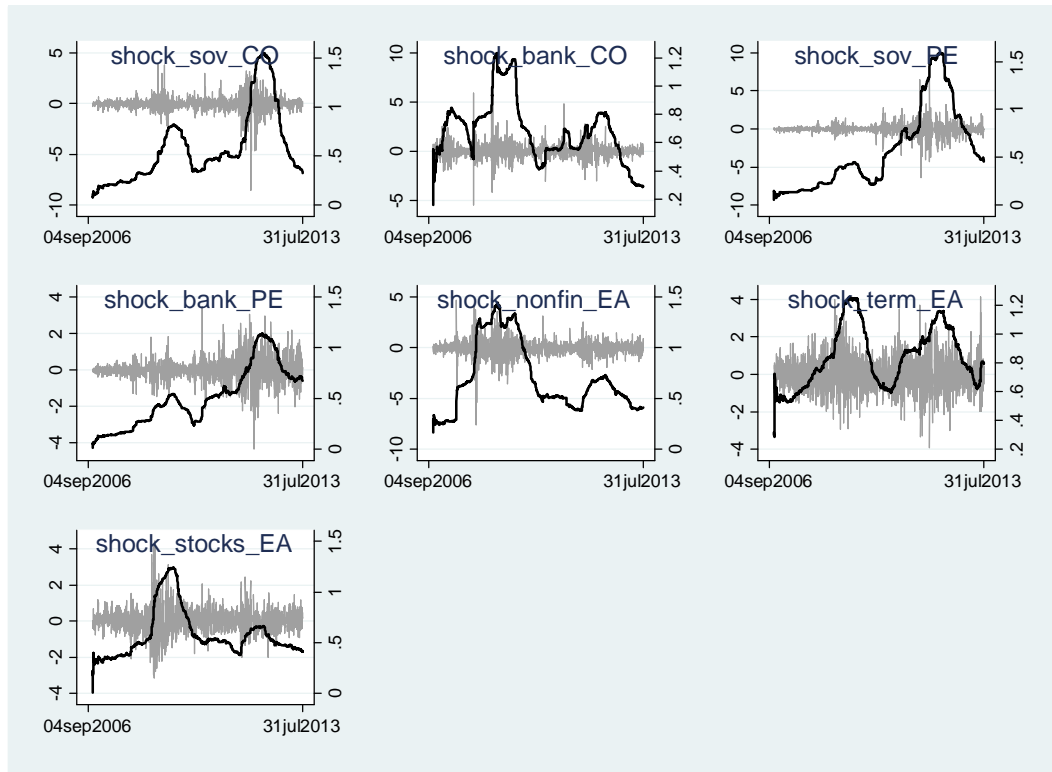
**Figure 5: Overall effects between sovereign risk and bank risk in the euro area and member states in recursive sup samples**

The figure shows the overall effect from sovereign risk on bank risk (thin solid line) and vice versa (thick dashed line), extracted from corresponding  $A^{-1}$  matrices which are estimated on recursive sup samples of the euro area en bloc and of single countries. The letters .a, .b, .c denote significance at the 1%, 5%, 10% levels.



**Figure 6: Interpretation of structural shocks for core-periphery specification**

The figure shows the daily structural shocks (grey bars) together with their 200 days rolling standard deviations. The estimated shocks are based on the seven-variable VAR for the euro area core and periphery. The sample period is 24 October 2006 until 31 July 2013.



## 9 Tables

**Table 1: Standard deviations by volatility regime**

The table shows the standard deviations of the endogenous variables of the euro area specification by regime 1-7. Specifically, it contains the standard deviations of the first (log) differences of the CDS spreads of sovereigns, banks, and non-financial corporations, of the term spread, and of the Euro Stoxx 50. The sample period is 24 October 2006 until 31 July 2013.

Regime	(1)	(2)	(3)	(4)	(5)	(6)	(7)
S.d. sovereign CDS	0.48	0.74	4.32	8.21	15.22	12.16	5.12
S.d. bank CDS	1.75	2.99	4.05	6.76	7.51	7.79	4.38
S.d. non-fin. CDS	0.49	5.08	5.08	3.82	4.27	4.10	2.87
S.d. term spread	2.29	4.11	4.68	4.55	5.63	5.92	3.59
S.d. Euro Stoxx 50	0.79	1.39	2.18	1.45	1.98	1.55	1.14
Observations	158	336	424	243	146	195	264

Source: Datastream, authors own calculations.

**Table 2: Direct and overall effects among endogenous variables at the euro area level:  $A$  and  $A^{-1}$  matrix**

The table shows the estimated direct and overall effects of structural shocks of one standard deviation on the endogenous variables, based on a five-variable structural VAR for the euro area. Impulse variables are in columns, response variables are in rows. The sample period is 24 October 2006 until 31 July 2013.

Response	Impulse				
	Sov. risk	Bank risk	Nonfin. risk	Term spread	Stock market
<u>Direct effects</u>					
Sov. risk	1.00	0.14	0.02	0.06	-0.11
<i>p</i>	.	. <i>c</i>	.	. <i>c</i>	. <i>a</i>
Bank risk	0.46	1.00	0.21	-0.09	-0.09
<i>p</i>	. <i>a</i>	.	. <i>a</i>	.	. <i>a</i>
Nonfin. risk	0.06	0.07	1.00	0.12	-0.33
<i>p</i>	. <i>a</i>	. <i>b</i>	.	. <i>a</i>	. <i>a</i>
Term spread	0.32	0.29	-0.31	1.00	0.09
<i>p</i>	. <i>a</i>	. <i>b</i>	. <i>a</i>	.	.
Stock market	-0.09	-0.12	-0.11	0.04	1.00
<i>p</i>	. <i>a</i>	. <i>a</i>	. <i>a</i>	.	.
<u>Overall effects</u>					
Sov. risk	1.13	0.20	0.07	0.05	-0.16
<i>p</i>	. <i>a</i>	. <i>b</i>	. <i>a</i>	.	. <i>a</i>
Bank risk	0.54	1.12	0.29	-0.04	-0.26
<i>p</i>	. <i>a</i>	. <i>a</i>	. <i>a</i>	.	. <i>a</i>
Nonfin. risk	0.22	0.18	1.05	0.11	-0.37
<i>p</i>	. <i>a</i>	. <i>a</i>	. <i>a</i>	. <i>a</i>	. <i>a</i>
Term spread	0.44	0.32	-0.23	0.97	0.08
<i>p</i>	. <i>a</i>	. <i>b</i>	. <i>a</i>	. <i>a</i>	.
Stock market	-0.18	-0.16	-0.17	0.02	1.09
<i>p</i>	. <i>a</i>	. <i>a</i>	. <i>a</i>	.	. <i>a</i>

Notes: .a, .b, .c denote significance at the 1%, 5%, 10% levels; number of observations 1764.

**Table 3: Overall effects between sovereign and bank risk in individual euro area member states**

The tables show the contemporaneous overall effects between sovereign and bank risk in euro area member states, extracted from corresponding  $A^{-1}$  matrices.

	Country					
	EMU	AT	BE	DE	ES	FR
Bank on sov. risk	0.20	0.12	0.09	0.05	0.16	0.36
<i>p</i>	. <i>b</i>	. <i>a</i>	. <i>a</i>	. <i>b</i>	. <i>b</i>	. <i>a</i>
Sov. on bank risk	0.54	0.08	0.09	0.20	0.50	0.38
<i>p</i>	. <i>a</i>	. <i>b</i>	. <i>a</i>	. <i>a</i>	. <i>a</i>	. <i>a</i>
# Obs	1764	2477	2142	2470	1765	2074

Notes: .a, .b, .c denote significance at the 1%, 5%, 10% levels.

	Country				
	GR	IE	IT	NL	PT
Bank on sov. risk	-0.00	0.03	0.03	0.04	-0.35
<i>p</i>	.	.	.	. <i>b</i>	.
Sov. on bank risk	0.12	0.02	0.66	-0.04	0.46
<i>p</i>	. <i>b</i>	.	. <i>a</i>	.	.
# Obs	1571	1466	2454	1765	2003

Notes: .a, .b, .c denote significance at the 1%, 5%, 10% levels.

**Table 4: Overall effects among euro area core and periphery sovereign risk and bank risk**

The table shows the estimated overall effects of structural shocks of one standard deviation on the endogenous variables for the euro area core (CO) and periphery (PE) and other asset prices, that is, the  $A^{-1}$  matrix based on a seven-variable structural VAR. Impulse variables are in columns, response variables are in rows. The sample period is 24 October 2006 until 31 July 2013.

Response	Impulse						
	Sov CO	Bank CO	Sov PE	Bank PE	Nonfin EA	Term EA	Stocks EA
Sov CO	1.15	0.15	0.54	0.07	0.09	-0.11	-0.21
<i>p</i>	.a	.a	.a	.c	.a	.c	.a
Bank CO	0.36	1.12	0.34	0.52	0.40	-0.08	-0.37
<i>p</i>	.a	.a	.a	.a	.a	.	.a
Sov PE	0.29	0.08	1.18	0.11	0.06	0.02	-0.14
<i>p</i>	.a	.a	.a	.c	.a	.	.a
Bank PE	0.39	0.21	0.59	1.14	0.21	-0.03	-0.22
<i>p</i>	.a	.a	.a	.a	.a	.	.a
Nonfin EA	0.17	0.04	0.21	0.15	1.05	0.09	-0.36
<i>p</i>	.a	.c	.a	.a	.a	.b	.a
Term EA	0.30	0.08	0.46	0.25	-0.22	0.95	0.16
<i>p</i>	.a	.c	.a	.a	.a	.a	.b
Stocks EA	-0.18	-0.04	-0.14	-0.13	-0.17	0.01	1.09
<i>p</i>	.a	.b	.a	.a	.a	.	.a

Notes: .a, .b, .c denote significance at the 1%, 5%, 10% levels. 1764 observations

**Table 5: Variance decomposition for euro area core and periphery specification**

The table shows the weighted average of one day ahead forecast error variance decomposition across regimes, based on a seven-variable VAR including the sovereign and banking sector of the euro area core and periphery. Weights are the number of observations per regime. The sample period is 24 October 2006 until 31 July 2013.

Response	Impulse						
	Sov CO	Bank CO	Sov PE	Bank PE	Nonfin EA	Term EA	Stocks EA
Sov CO	0.72	0.04	0.16	0.00	0.02	0.03	0.04
Bank CO	0.05	0.61	0.06	0.12	0.10	0.00	0.05
Sov PE	0.07	0.02	0.86	0.01	0.01	0.00	0.03
Bank PE	0.08	0.08	0.16	0.56	0.08	0.00	0.04
Nonfin EA	0.02	0.00	0.04	0.02	0.82	0.01	0.08
Term EA	0.04	0.00	0.09	0.02	0.03	0.80	0.01
Stocks EA	0.03	0.00	0.02	0.02	0.04	0.00	0.89

**Table 6: Flight-to-safety; Overall effects between Bund yields and other asset prices**

The table shows the estimated overall effects of structural shocks of one standard deviation on the endogenous variables of the core-periphery specification. It contains the  $A^{-1}$  matrix based on a seven-variable structural VAR, using only German CDS spreads to measure core sovereign risk and the 10 year yield on German sovereign bonds instead of the euro area term spread. Impulse variables are in columns, response variables are in rows. The sample period is 24 October 2006 until 31 July 2013.

Response	Impulse						
	Sov DE	Bank CO	Sov PE	Bank PE	Nonfin EA	Bund yield	Stocks EA
Sov DE	1.04	0.06	0.11	0.16	0.05	0.05	-0.17
<i>p</i>	.a	.b	.	.c	.c	.	.a
Bank CO	0.23	1.09	0.29	0.58	0.39	-0.05	-0.31
<i>p</i>	.a	.a	.a	.a	.a	.	.a
Sov PE	0.26	0.05	1.07	0.09	0.06	-0.05	-0.10
<i>p</i>	.b	.c	.a	.c	.a	.b	.a
Bank PE	0.21	0.17	0.54	1.15	0.20	-0.05	-0.19
<i>p</i>	.a	.a	.a	.a	.a	.b	.a
Nonfin EA	0.07	0.05	0.19	0.17	1.07	0.05	-0.36
<i>p</i>	.b	.c	.a	.a	.a	.	.a
Bund yield	-0.14	0.03	-0.21	-0.07	-0.26	1.00	0.43
<i>p</i>	.a	.	.a	.b	.a	.a	.a
Stocks EA	-0.09	-0.04	-0.13	-0.15	-0.17	0.03	1.09
<i>p</i>	.a	.c	.a	.a	.a	.	.a

Notes: .a, .b, .c denote significance at the 1%, 5%, 10% levels. 1764 observations.



**Table 7: Implementation and announcement effects of monetary policy on credit risk and other asset prices in the euro area**

The table shows the effects of on non-standard monetary policy measures on the endogenous variables, based on the five-variable VAR specification for the euro area level. The dependent variables are in basis points in columns (1)-(4) and in percentage in column (5). The upper part of the table shows the point estimates and the cumulative effects of implemented monetary policy measures. The lower part shows the cumulative effects of specific ECB announcements together with the p-value of the F-test of joint significance of the contemporaneous effect and its first 10 lags.

	(1)	(2)	(3)	(4)	(5)
	Sov. risk	Bank risk	Non-fin. risk	Term spread	Stock market
<b>6-12m LTRO allotm. (bn.)</b>					
Point estimate	-0.04	-0.01	-0.01	-0.02	-0.00
<i>p</i>	0.266	0.637	0.569	0.449	0.783
<b>3y LTRO allotments (bn.)</b>					
Point estimate	0.06	-0.05	-0.01	0.03	0.00
<i>p</i>	0.225	0.096	0.670	0.344	0.553
Cum. Effect (1,020 bn.)		-51.0			
<b>SMP purchases (bn.)</b>					
Point estimate	1.08	0.96	0.42	0.47	-0.11
<i>p</i>	0.020	0.002	0.087	0.103	0.133
Cum. Effect (218 bn.)	235.4	209.3	91.6		
<b>Cum. announ. effects (b.p.)</b>					
LTROs 6-12 months	-5.3	-1.0	3.8	9.0	-0.6
<i>p</i>	0.005	0.007	0.000	0.167	0.000
3-year LTROs	10.7	16.7	15.3	-18.9	-9.4
<i>p</i>	0.000	0.002	0.794	0.087	0.021
SMP	-51.1	-39.9	-16.3	-53.6	3.3
<i>p</i>	0.000	0.000	0.000	0.000	0.001
OMT	-55.4	-33.7	-8.1	-15.2	5.1
<i>p</i>	0.000	0.000	0.013	0.072	0.001
R squared	0.24	0.33	0.37	0.25	0.60

Note: p-values below estimates. 1764 observations.

**Table 8: Implementation and announcement effects of monetary policy on sovereign credit risk in euro area member states**

The table shows the effects of non-standard monetary policy measures by the ECB on *sovereign CDS spreads* of the euro area and of individual countries, based on the corresponding five-variable VAR specifications. The dependent variable is in basis points. The upper part of the table shows the point estimates of the implementation effects of specific monetary policy measures. The lower part shows the cumulative announcement effects of specific ECB measures together with the p-value of the F-test of joint significance of the contemporaneous effect and its first 10 lags.

	EMU	AT	BE	DE	FR	NL	ES	IE	GR	IT	PT
<b>Implementation effects</b>											
6-12m LTRO allotm. (bn.)	-0.04	-0.03	-0.04	-0.01	-0.02	-0.04	-0.06	-0.10	-0.57	-0.04	-0.09
<i>p</i>	0.266	0.237	0.228	0.344	0.439	0.159	0.334	0.216	0.602	0.364	0.446
3y LTRO allotments (bn.)	0.06	0.03	0.03	-0.01	0.02	0.03	0.08	0.06	20.84	0.03	0.30
<i>p</i>	0.225	0.390	0.485	0.336	0.498	0.452	0.292	0.583	0.000	0.677	0.055
SMP purchases (bn.)	1.08	0.57	1.19	0.11	0.33	0.79	1.11	-0.49	66.09	2.14	3.54
<i>p</i>	0.020	0.050	0.001	0.443	0.196	0.021	0.122	0.618	0.000	0.000	0.019
Cum. eff. SMP purch. (b.p.)	235.4	124.3	259.4			172.2			14,388	466.5	771.7
<b>Cum. announ. effects (b.p.)</b>											
LTROs 6-12 months	-5.3	-3.3	1.5	-1.3	3.1	-4.3	-6.7	-3.0	-131.5	-5.9	-37.2
<i>p</i>	0.005	0.000	0.008	0.000	0.067	0.012	0.075	0.014	1.000	0.004	0.001
3-year LTROs	10.7	10.8	17.4	14.6	33.5	42.3	-4.1	45.4	-2763.9	-8.4	-2.5
<i>p</i>	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.410	0.000	0.000	0.025
SMP	-51.1	-20.1	-39.8	-10.0	-11.1	-29.4	-78.3	33.0	-2249.4	-112.1	-129.8
<i>p</i>	0.000	0.000	0.000	0.006	0.034	0.723	0.000	0.000	0.177	0.000	0.000
OMT	-55.4	-10.8	-23.2	-8.3	-24.9	-21.8	-113.1	-80.1	-	-106.0	-120.8
<i>p</i>	0.000	0.875	0.055	0.304	0.174	0.811	0.000	0.037	-	0.000	0.061
Observations	1764	2477	2142	2470	2074	1765	1765	1466	1583	2454	2003
R squared	0.24	0.15	0.20	0.15	0.18	0.27	0.26	0.22	0.30	0.27	0.18

Note: p-values below estimates.

**Table 9: Implementation and announcement effects of monetary policy on *bank* credit risk in euro area member states**

The table shows the effects of non-standard monetary policy measures by the ECB on *banks CDS spreads* of the euro area and of individual countries, based on the corresponding five-variable VAR specifications. The dependent variable is in basis points. The upper part of the table shows the point estimates of the implementation effects of specific monetary policy measures. The lower part shows the cumulative announcement effects of specific ECB measures together with the p-value of the F-test of joint significance of the contemporaneous effect and its first 10 lags.

	EMU	AT	BE	DE	FR	NL	ES	IE	GR	IT	PT
<b>Implementation effects</b>											
6-12m LTRO allotm. (bn.)	-0.01	0.04	0.09	-0.00	-0.02	-0.02	-0.03	-0.04	-0.04	-0.02	-0.02
<i>p</i>	0.637	0.419	0.037	0.819	0.394	0.525	0.507	0.808	0.794	0.517	0.809
3y LTRO allotments (bn.)	-0.05	-0.05	-0.09	-0.05	-0.03	0.01	-0.05	-0.20	0.99	-0.04	-0.22
<i>p</i>	0.096	0.395	0.088	0.082	0.472	0.736	0.295	0.349	0.000	0.280	0.011
Cum. eff. 3y LTRO all. (b.p.)	-51.0		-91.8	-51.0					1,009.8		-224.4
SMP purchases (bn.)	0.96	1.67	1.51	0.75	1.02	0.34	0.62	-2.38	9.03	1.59	1.64
<i>p</i>	0.002	0.004	0.003	0.004	0.004	0.343	0.200	0.243	0.000	0.000	0.045
Cum. eff. SMP purch. (b.p.)	209.3	364.1	329.2	163.5	222.4				1,962	346.6	357.5
<b>Cum. announ. effects (b.p.)</b>											
LTROs 6-12 months	-1.0	-2.2	18.1	6.6	4.3	-5.3	21.3	37.3	6.6	-14.5	-4.9
<i>p</i>	0.007	0.000	0.000	0.000	0.007	0.273	0.000	0.473	0.719	0.209	0.073
3-year LTROs	16.7	-2.8	52.9	16.5	16.9	-5.4	20.1	-32.9	-184.6	-5.9	70.9
<i>p</i>	0.002	0.803	0.001	0.013	0.000	0.341	0.295	0.479	0.000	0.000	0.007
SMP	-39.9	-45.2	-26.4	-33.1	-39.2	-0.3	-51.3	197.9	-477.6	-62.7	-79.2
<i>p</i>	0.000	0.000	0.217	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000
OMT	-33.7	-39.6	-23.4	-5.7	-20.7	-14.0	-54.4	20.3	-	-71.1	-62.1
<i>p</i>	0.000	0.014	0.494	0.917	0.021	0.835	0.000	1.000	-	0.000	0.271
Observations	1764	2477	2142	2470	2074	1765	1765	1466	1584	2454	2003
R squared	0.33	0.18	0.19	0.16	0.26	0.11	0.28	0.11	0.27	0.29	0.20

Note: p-values below estimates.

**Table 10: Effects of bank bailout announcements on sovereign risk and credit risk in the euro area**

The lower part of the table shows the effects of announcements of specific bank bailout measures by governments on *sovereign CDS spreads* (columns 1-3) and *bank CDS spreads* (columns 4-6), based on the sovereign risk equation and bank risk equation of the five-variable VAR specification for the euro area. Specifically, it shows the 20 day cumulative announcement effects together with the p-value of the F-test of joint significance of the contemporaneous effect and its first 20 lags. The dependent variables are in basis points. The upper part of the table shows the point estimates of implementation effects of specific monetary policy measures. The lower part shows in addition the cumulative announcement effects of specific ECB measures together with the p-value of the F-test of joint significance.

	Sovereign risk			Bank risk		
	(1)	(2)	(3)	(4)	(5)	(6)
<b>Implementation effects, point estimates</b>						
6-12m LTRO allotm. (bn.)	-0.04	-0.03	-0.04	-0.01	0.00	-0.00
<i>p</i>	0.286	0.414	0.318	0.819	0.902	0.854
3y LTRO allotments (bn.)	0.06	0.06	0.06	-0.05	-0.05	-0.05
<i>p</i>	0.220	0.206	0.212	0.086	0.091	0.088
SMP purchases (bn.)	1.10	1.10	1.11	0.97	0.95	0.96
<i>p</i>	0.018	0.017	0.017	0.001	0.001	0.002
<b>Cum. announcm. effects (b.p.)</b>						
LTROs 6-12 months	-5.9	-8.6	-5.0	1.5	-0.3	2.1
<i>p</i>	0.128	0.225	0.049	0.110	0.112	0.050
3-year LTROs	11.5	11.4	11.3	17.8	17.7	17.5
<i>p</i>	0.000	0.000	0.000	0.002	0.001	0.002
SMP	-51.7	-52.9	-53.6	-41.9	-43.2	-43.1
<i>p</i>	0.000	0.000	0.000	0.000	0.000	0.000
OMT	-53.8	-53.6	-54.0	-32.2	-32.1	-32.5
<i>p</i>	0.001	0.001	0.001	0.001	0.000	0.000
Debt guarantees	2.8			-46.2		
<i>p</i>	0.033			0.000		
Deposit guarantees		-19.0			-73.1	
<i>p</i>		0.000			0.000	
Capital injections			6.6			-75.5
<i>p</i>			0.013			0.000
Observations	1764	1764	1764	1764	1764	1764
R squared	0.26	0.27	0.26	0.37	0.39	0.37

Note: p-values below estimates.

## A. Appendix: Variable definitions, sample periods, and sources

<b>Endogenous variables by country</b>					
<b>Sovereign CDS</b>	<b>Banks CDS</b>	<b>Non-financials CDS</b>	<b>Short rate*</b>	<b>Stock market index**</b>	<b>Sample start***</b>
euro area: unweighted average of all countries except Greece	Unweighted average of all bank CDS spreads (see below)	Unweighted average of all non-financial corporate CDS spreads (see below)	Term spread: unweighted average of country term spreads	Euro Stoxx 50	24.10.2006
Austria	Erste Group Bank, Raiffeisen Zentralbank, Telekom Austria	Telekom Austria	Interbank	ATX	20.01.2004
Belgium	KBC Bank	Solvay	Treasury bill	BEL 20	12.05.2005
France	BNP Paribas, Credit Agricole, Natixis, Societe Generale	Accor, Air France, Alstom, Capgemini, Carrefour, Casino, Guipchin, Electricite de France, GDF Suez, Lafarge, Legrand France, Michelin, Pernod Ricard, Renault, Sanofi- Aventis, Schneider Electrical, Technip, Vinci, Vivendi	Treasury bill	CAC 40	16.08.2005
Germany	Bayerische Landesbank, Commerzbank, Deutsche Bank, HSH Nordbank, IKB Deutsche Industriebank, LB Badenwürttemberg, LB Hessen- Thüringen, Nord-LB, Portigon	BASF, Bayer, Deutsche Post, E.ON, HeidelbergCement, Henkel, Linde, REW, Thyssen Krupp, Volkswagen	Interbank	DAX 30	09.02.2004
Greece	Alpha Bank	Hellenic Telecom	Interbank	ATHEX	09.01.2004

				COMPOSITE	
Ireland	Allied Irish BanksThe Governor and Company, Permanet SB Public	Smurfit Kappa	Interbank	IRELAND SE OVERALL (ISEQ)	24.10.2006
Italy	Banca Monte dei Paschi di Siena, Banco Popolare, Banca Popolare di Milano Soco, BNL, Mediobanca, Unicredito Italiano, Unione die Banche, Intesa Sanpaolo	Enel, Eni, Fiat, Finmeccanica, Telekom Italia	Interbank	FTSE MIB INDEX	02.03.2004
Netherlands	Cooptieve Cente Rabobank, SNS Bank, Fortis Bank, ING Bank	Aegon, Akzo Nobel, Heineken, Koninklijke Philips, Unilever, Wolters Kluwer, Eneco Holding, Essent, Koninklijke Ahold, Koninklijke DSM, Koninklijke KPN	Interbank	AEX	23.10.2006
Portugal	Banco Commercial Portugues, Banco Espirito Santo, Caixa Geral de Diposits	EDP – Energias de Portugal, Portugal Telekom, Brisa – Auto-Estradas de Portugal	Interbank	PSI-20	23.11.2005
Spain	Banco Popular Espanol, Bankinter, BBV Argentaria, Banco Santander	Endesa, Gas Natural, Iberdrola, Repsol, Telefonica	Interbank	IBEX 35	23.10.2006

Exogenous variables		All for sample period 06.01.2004-31.07.2013
Money market spread		3 Month Euribor – 3M OIS spread
ECB non-standard measures		Announcement dummies for LTROs between 6 and 12 months (28 Mar., 4 Sep., and 15 Oct. 2008; 7 May 2009; 4 Aug. and 6 Oct. 2011), Allotted amounts in LTROs (in bn. Euro, equally split over the 7 days around the auction) Announcement dummy for LTROs between 12 and 36 months (8 Dec. 2011), Allotted amounts in LTROs (in bn. Euro, equally split over the 21 days around the auction) SMP announcement dummies (10 May 2010, 8 Aug. 2011), Change in SMP holdings (Euro bn., split over the week) OMT announcement dummies (26 Jul. and 6 Sep. 2012)

Bailout announcements	CGFS, & BIS (2010, October 27). Financial sector rescue plan database, maintained by the BIS, under the auspices of the Committee on the Global Financial System
Implied volatility	Vdax New
Macroeconomic news	Ifo Pan Germany Business Climate, ECB M3 Annual Growth Rate SA, Eurostat Eurozone Core MUICP YoY NSA, European Commission Consumer Confidence, European Commission Manufacturing Confidence, Eurozone Industrial Confidence, European Commission Economic Sentiment Indicator, ZEW Germany Expectation of Economic Growth, Germany Industrial Production MoM SA, Italy Business Confidence, France Households Consumption Goods Expenditure Total MoM, Bank of France Business Sentiment Indicator, Germany Manufacturing Orders MoM SA, Germany Retail Sales Const.2005 Prices YoY NSA, Germany GDP Chain Linked Pan German QoQ, USA GDP YoY

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Notes:       \* 3 month; long rate is always yield on 10 year benchmark government bond

             \*\* total return indices

             \*\*\* sample end is always 31.07.2013, except for Greece (ends on 23.02.2012)

Source:       All financial market data are downloaded from Datastream and Bloomberg; Data on ECB measures are downloaded from the ECB's website.