CSEF
Centre for Studies in Economics and Finance

WORKING PAPER NO. 345

Systemic Risk, Sovereign Yields and Bank Exposures in the Euro Crisis

Niccolò Battistini, Marco Pagano and Saverio Simonelli

October 2013

University of Naples Federico II
University of Salerno
Bocconi University, Milan

CSEF - Centre for Studies in Economics and Finance
DEPARTMENT OF ECONOMICS – UNIVERSITY OF NAPLES
80126 NAPLES - ITALY
Tel. and fax +39 081 675372 – e-mail: csef@unisa.it

WORKING PAPER NO. 345

Systemic Risk, Sovereign Yields and Bank Exposures in the Euro Crisis

Niccolò Battistini[*], Marco Pagano[**] and Saverio Simonelli[***]

Abstract
Since 2008, euro-area sovereign yields have diverged sharply, and so have the corresponding CDS premia. At the same time, banks' sovereign debt portfolios featured an increasing home bias. We investigate the relationship between these two facts, and its rationale. First, we inquire to what extent the dynamics of sovereign yield differentials relative to the swap rate and CDS premia reflect changes in perceived sovereign solvency risk or rather different responses to systemic risk due to the possible collapse of the euro. We do so by decomposing yield differentials and CDS spreads in a country-specific and a common risk component via a dynamic factor model. We then investigate how the home bias of banks' sovereign portfolios responds to yield differentials and to their two components, by estimating a vector error-correction model on 2008-12 monthly data. We find that in most countries of the euro area, and especially in its periphery, banks' sovereign exposures respond positively to increases in yields. When bank exposures are related to the country-risk and common-risk components of yields, it turns out that (i) in the periphery, banks increase their domestic exposure in response to increases in country risk, while in core countries they do not; (ii) in most euro area banks respond to an increase in the common risk factor by raising their domestic exposures. Finding (i) hints at distorted incentives in periphery banks' response to changes in their own sovereign's risk. Finding (ii) indicates that, when systemic risk increases, all banks tend to increase the home bias of their portfolios, making the euro-area sovereign market more segmented.

Keywords: sovereign yield differentials, dynamic latent factor model, home bias, vector error-correction model.

JEL Classification: C32, C51, C58, G11, G15

Acknowledgements: We are grateful to Ignazio Angeloni, Andreas Baumann, Stefano Borgioli, Noella Delvaux, Stefano Grande, Peter Hoffmann, Julien Idier and Flemming Wurtz for helpful discussions, and particularly to Plamen Nikolov, Andrea Nobili and Michael Thiel for comments and suggestions on earlier versions of this paper. We also thank participants to the 2012 Annual Research Conference on "Economic growth perspectives and the future of the Economic and Monetary Union", to the Infiniti 2013 Conference, to the Conference on "The Sovereign Debt Crisis and the Euro Area" at the Bank of Italy and to a seminar at the Center for Studies in Economics and Finance. Henning Ahnert and Antonio Colangelo (ECB) kindly provided data about euro-area sovereign exposures, and Alessio Piccolo constructed the indicator based on Google searches. Financial support from the Research Fellowship Programme "Future of the EMU" is gratefully acknowledged. A previous version of this paper was circulated under the title "Systemic Risk and Home Bias in the Euro Area".

* Rutgers University
** Università di Napoli Federico II, CSEF, EIEF and CEPR.
*** Università di Napoli Federico II and CSEF. Corresponding author: e-mail: tullio.jappelli@unina.it

Table of contents

1. Introduction

Starting from late 2008, the euro area has experienced turmoil in financial markets: interbank markets have virtually frozen, and were replaced by the European Central Bank (ECB) as the main source of liquidity for banks; sovereign debt yields of peripheral euro-area countries have repeatedly spiked above those of core countries; bank interest rates also started to differ systematically across countries; portfolios of financial intermediaries and households have become increasingly biased towards domestic securities. Hence, most of the indicators traditionally considered as gauges of financial integration have started to point towards a reversal in the process of integration that initiated before the inception of the European Monetary Union (EMU), and proceeded in the first seven years of its life.

This paper analyses both the dynamics of sovereign yields and the concomitant changes in banks' sovereign portfolios, and explores how the two are related. Our starting point is that euro-area sovereign yield differentials may reflect both differences in sovereign default risk and in countries' exposures to common (or systemic) risk, arising from the danger of euro-area breakup and the implied currency redenomination. Especially since 2010, the budgetary crisis of Greece and its eventual default have obviously refocused investors' minds on the solvency risks of euro-area countries, especially periphery ones. But at the same time media, companies, investors and academics repeatedly voiced concerns about the possible breakup of the euro area. Between late 2010 and 2011 four issues of *The Economist* featured cover illustrations referring to the breakup of the euro.[1] In November 2011 the managers of several multinational companies disclosed to have euro-breakup contingency plans.[2] In January 2012, global institutional investor PIMCO considered in its newsletter several breakup scenarios, the mildest one being the exit by Greece, possibly followed by Portugal and Ireland, intermediate ones being the exit of all periphery or all core countries, and the extreme scenario being the abandonment of the euro by all 17 member countries.[3] Economists were no less explicit. Between April 2010 and July 2012, Paul Krugman regularly prognosticated the collapse of the euro from his columns in *The New York Times*. At the 2012 World Economic Forum meeting in Davos, Nouriel Roubini predicted that Greece would leave the euro-area in the subsequent 12 months, followed by Portugal, and assessed at 50% the chance that the euro area would break up in the subsequent three to five years.[4] Even ECB President Mario Draghi pointed to the effect of redenomination risk on sovereign yield differentials when he stated in a speech at the Global Investment Conference in London on 26 July 2012 that "the premia that are being charged on sovereign states borrowings … have to do more and more with convertibility, with the risk of convertibility".[5]

---

[1] The issues are those of 20 November and 4 December 2010, and of 16 July and 17 September 2011.

[2] "Businesses plan for possible end of euro," *Financial Times*, 29 November 2011.

[3] "Thinking about the Implications of Rising Euro-exit Risks", *European Perspectives*, Pimco, January 2012.

[4] "Eurozone will collapse this year, says Nouriel Roubini", *The Daily Telegraph*, 28 January 2012.

[5] Kenneth Rogoff sums it all up very effectively: "From early 2010 until quite recently, there was every reason to worry about a disorderly exit from the Eurozone potentially blowing up the whole thing. This was the big call – the one that everyone was focusing on." ("Britain should not take its credit status for granted", *Financial Times*, 3 October 2013, p. 9).

Hence, in this paper we proceed in two steps. The first is to decompose sovereign yield differentials relative to the euro-area swap rate in a country-specific component due to sovereign default risk and a common component arising from redenomination risk. To this purpose, we estimate a dynamic two-factor model for euro-area sovereign debt. We validate the interpretation of the common factor as arising from the risk of euro collapse by correlating it with indicators of investors' expectations of the euro breakup based on Google searches and on prediction markets.

Our second step is to explore how these two estimated components of yield differentials contribute to explain changes in the sovereign debt portfolios of euro-area banks. This allows us to discriminate to some extent between three different reasons why banks may change their domestic sovereign exposures in response to a widening differential between the domestic yield and the euro-area swap rate:

(i) High-risk sovereign issuers may exert "moral suasion" on the banks in their jurisdiction to increase their domestic sovereign holdings, in order to support demand for sovereign debt when demand is low, and therefore yields are comparatively high.

(ii) Undercapitalized banks may bet for resurrection by engaging in "carry trades" by going long on high-risk, high-yield sovereign debt, funding such exposures either by going short on low-yield debt or by borrowing from the ECB, as suggested by the bank-level evidence in Acharya and Steffen (2012): insofar as most undercapitalized banks are in periphery countries, this may result in a home bias in the sovereign portfolios of periphery-country banks.

(iii) In the event of a collapse of the euro, the liabilities of banks in each country (e.g., their deposits) would be redenominated into new national currencies, at the same time as their holdings of domestic sovereign debt. Hence, domestic banks are better hedged than foreign ones against the redenomination risk of domestic sovereign debt: they have a "comparative advantage" in bearing the systemic component of its risk.[6] Thus banks' home bias should be correlated with the systemic component of sovereign risk, but not with its purely country-specific component, which instead should equally affect domestic and foreign investors.

All three stories – the "moral suasion", the "carry-trade" and the "comparative advantage" hypothesis – share a common prediction: the home bias in banks' sovereign portfolios should be positively correlated with sovereign yield differentials. However, the first two hypotheses predict that this correlation should arise irrespective of whether changes in yields are generated by country-level or common risk; in contrast, the third predicts that this correlation should arise *only* from changes in common risk, e.g. the risk of collapse of the euro. Moreover, since in our sample period sovereign risk and yields increased appreciably only in the euro-area periphery, the first two hypotheses can only apply to periphery-country banks, while the third may also apply to core countries.

We explore the response of euro-area domestic sovereign exposures to their respective yields and their components, obtained from our dynamic factor model, by estimating a vector error-correction

[6] In the case of core-country banks, this response may have been amplified by national prudential regulators' recommendations to domestic banks to reduce the risk of their sovereign portfolios.

model (VECM) on 2008-12 monthly data for ten euro-area countries.[7] When the model is estimated using actual yields, the sovereign exposures of euro-area banks are seen to respond positively to increases in yields in most countries, except Belgium, France and the Netherlands. But this pattern stems from a very different response of sovereign exposures to the country risk factor in the core and in the periphery: (i) in most periphery countries banks respond to increases in the country risk factor by *raising* their domestic exposure, while in core countries they do not; (ii) in contrast, in almost all countries banks increase their domestic exposures in response to an increase in the common risk factor.

Finding (i) suggests that, for periphery-country banks, and only for those, there is evidence in support of the "moral suasion" and/or the "carry-trade" hypothesis, since these banks increase their exposures in response to increases in country-level sovereign risk, not just in response to systemic euro-area risk. It is worth noting that in equilibrium an increase in country-specific sovereign risk does not need to result either in an increase or a decrease of domestic banks' exposures, unless these banks are either less or more risk averse than the others. In our data, periphery banks appear to behave as if they were less risk averse than other investors, reflecting either government-dictated or opportunistic risk-taking incentives. The resulting increase in the home bias of their portfolios can be attributed to such distorted incentives, rather than to the increase in country-specific risk *per se*.

Finding (ii) indicates that, when systemic risk increases, most banks – both in core and in periphery countries – "turn back home", by increasing their domestic sovereign holdings. This suggests that increased risk of euro collapse and currency redenomination has led to greater home bias of banks' portfolios, especially in core countries. It is worth noticing that these results can be detected only as a result of the decomposition between the country and the common risk factors: they cannot be deduced only from the regressions based on the actual sovereign yields.

Even though our evidence is compatible with the "carry trade" hypothesis only for periphery banks, we cannot rule out that this hypothesis also holds for core-country banks, but testing it would require data on core-country banks' holdings of periphery debt: under this hypothesis, these banks should respond to an increased yield of periphery debt by increasing their exposure to periphery sovereigns. Unfortunately we cannot perform this test, since a two-entry matrix of euro-area banks' sovereign portfolios by holding and issuing countries is currently unavailable.

The results of our analysis have several implications for policy. First, decomposing sovereign risk into a country-specific and a systemic component allows a better understanding of the motives behind changes in the home bias in the sovereign debt market. As explained above, the increase of banks' sovereign holdings in the periphery cannot be explained entirely as a response to greater systemic euro-area risk, since this increase was associated mostly with increases in country-specific sovereign risk. In other words, it cannot be attributed only to periphery banks' comparative advantage in hedging systemic risk: it must have been also induced to some extent by national regulators' moral suasion or by banks' opportunistic carry trades. We cannot distinguish between these two motives, but in either case the behaviour of periphery banks should be regarded as problematic from the standpoint of a

[7] The countries in our sample are Austria, Belgium, Germany, France, the Netherlands (henceforth, the euro-area core countries), and Spain, Greece, Ireland, Italy and Portugal (henceforth, the euro-area periphery countries).

policy-maker. If due to moral suasion by national regulators, it indicates that these regulators tended to induce risk-taking by banks in a context where government solvency was at danger, thus enhancing the "diabolic loop" between fiscal solvency and bank solvency deterioration. If due to opportunistic carry trades by banks, it raises concerns about the appropriateness of banks' prudential regulation.

The paper is structured as follows. Section 2 illustrates the recent dynamics of yield differentials, CDS premia and bank sovereign exposures in the euro area. Section 3 uses dynamic factor analysis to decompose euro-area sovereign yield differentials in their country and common components. Section 4 investigates how the home bias of banks' sovereign portfolios is related to the components of yield differentials, by estimating a vector error-correction model. Section 5 concludes by drawing policy implications from our empirical results.

2. Euro-area sovereign yields, CDS premia and bank exposures: data description

Euro-area sovereign yields, which had converged dramatically right before the inception of the euro, have diverged equally dramatically starting from late 2008: as illustrated by Figure 1, the cross-country dispersion of interest rates on 10-year benchmark bonds increased steadily, especially in 2010-11, and peaked in late 2011, before abating somewhat in 2012. The figure shows that the increase in dispersion in 2010 arose mainly from the pattern of sovereign yields in Ireland and Portugal, while in 2011 also the sovereign yields of Spain and Italy rose well above those of the core countries (Greece is omitted to reduce the scale of the vertical axis).

The increase in the dispersion of sovereign yields in 2010 and 2011 is paralleled by that of CDS premia on sovereign debt, as shown by Figure 2: the increases in Irish, Portuguese, Italian and Spanish CDS premia in 2011 and 2012 largely coincided with the respective yield increases. But it is worth noticing that CDS premia already diverged to some extent in late 2008 and early 2009, that is, during the subprime financial crisis, even though at that time yields did not appear to react to them almost at all, except for Ireland. Hence, for the more stressed countries the CDS market appears to have been a more sensitive gauge of sovereign risk than the underlying bond market, in line with Fontana and Scheicher (2010), who find that since 2008 price discovery takes place in the CDS markets for Italy, Ireland, Spain, Greece and Portugal, and in the bond market for the core countries. Even though in principle a CDS can be replicated by a short position in the underlying risky bond and a long position in a safe bond of the same maturity, its arbitrage relationship with the underlying bond may break down due to short-sales constraints in the cash market, especially at times of great market stress. In these situations, the CDS become the cheapest way to trade credit risk, because of their synthetic nature, and therefore they also become more sensitive to changes in such risk.

Figure 3 allows to compare the time series behaviour of monthly sovereign yields and CDS premia on a country-by-country basis, from September 2008 to October 2012: for each country, it plots the difference between the 5-year sovereign yield and the swap rate for the 5-year maturity and the CDS premia for the same maturity. The two series grow over time and are very closely correlated for periphery euro-area countries and Belgium, for which it is close to 1. The correlation between them is still positive but weaker for Austria and France, is close to zero for the Netherlands, and is negative and significantly different from zero for Germany (-0.72). This striking difference can be interpreted as follows: when the risk of sovereign debt increases throughout the euro area, it triggers a "flight to safety" from periphery issuers towards core ones, and especially towards Germany, and therefore it increases the yields of periphery countries while compresses the Bund yield, even though credit risk increases in Germany too. Hence, while the yield differentials of all other euro-area issuers are positively correlated with their respective CDS premia, the German yield end up being negatively correlated with the German CDS premium, whose increase signals greater credit risk for the euro area as a whole – including Germany. Of course, the premise of this argument is that to some extent changes in euro-area sovereign risk have a common component, captured by correlated movements in CDS premia across the euro area. As we shall see in the econometric analysis of Section 3, this is indeed consistent with the data.

Over the same period, the sovereign debt portfolios of euro-area banks have featured an increasing degree of home bias. Figure 4 shows the time series of the domestic euro-area sovereign exposure of banks in two groups of euro-area countries: those of the "core" (Belgium, Finland, France, Germany, Netherlands) and those of the "periphery" (Greece, Ireland, Portugal, Spain and Italy). Specifically, it plots the sum of the monthly values of the euro-area sovereign debt holdings of the banks from each of these two groups (drawn from the SDW database) scaled by the total assets of those banks.[8] The figure shows that, in both groups of countries, banks' sovereign exposures were considerably larger at the inception of the European Monetary Union than they are now. However, while in both groups of countries banks reduced their domestic sovereign debt exposure until 2008, with periphery banks actually reducing their domestic sovereign exposures proportionately more, they both started increasing it again after 2008, with periphery banks increasing it by more than core-country banks.

One may suspect that the behavior of the time series for the domestic sovereign exposures in periphery and core-country banks illustrated in Figure 4 is driven more by the denominator than by the numerator, namely, is dominated by the time pattern in banks' total assets, rather than by that of their sovereign holdings. To investigate this point, Figures 5 and 6 plot the time series of the *level* of the domestic and non-domestic euro-area debt holdings of banks in periphery and core countries (in billion euro). The two figures show that also the *levels* of banks' sovereign debt holdings – not just their *ratio* to total assets – have a turning point in 2008, and that they behaved quite differently in the two groups of countries starting in the last part of that year.

Specifically, Figure 5 shows that, while after 2008 banks have increased their domestic sovereign debt holdings in both groups of countries, they have done so to a much greater extent in periphery than in core countries: the domestic sovereign debt holdings of periphery banks rose from €270 to €625

[8] These monthly data are drawn from the ECB Statistical Data Warehouse (SDW), where they appear under the name of "Balance sheet item: Securities other than shares of MFIs (excluding ESCB)", for securities issued by the General Government of all euro-area countries. These data contain the holdings by the banks in each euro-area country of (i) debt issued by all euro-area governments and (ii) domestic government debt, from September 1997 onwards.

billion between October 2008 and March 2012, while those of core-country banks rose from €352 to €505 billion: a 131% increase in the former versus a 43% increase in the latter!

Taken together, Figures 5 and 6 indicate that, at least partly, the recent increase in banks' holdings of domestic sovereign debt has resulted from a substitution away from the debt issued by the other group of euro-area sovereigns: starting from 2006, banks in each group of countries have reduced their holdings of sovereign debt issued by the sovereigns of the other group, and therefore have increased the home bias of their sovereign debt portfolios. This reallocation has been relatively modest for banks in the periphery, but very sharp in core-country banks, which have reduced their holdings of periphery-country sovereign debt from €430 to €248 billion since February 2011. Hence the overall picture is that of core-country banks reallocating their portfolios away from periphery sovereign debt and towards the debt issued by their domestic governments. Indeed, their shift away from periphery sovereign debt has been so large as to exceed their investment in domestic public debt, so that their euro-area sovereign holdings have decreased since late 2010. This has not been the case for banks in periphery countries, whose total holdings of euro-area sovereign debt have sharply increased.

3. Sovereign yields, country-specific risk and systemic risk

The dynamics of sovereign yield differentials illustrated in Section 2 suggest that since 2008 investors have dramatically reassessed the risk of euro-area sovereign issuers, especially those of periphery countries. However, in principle, this reassessment may have concerned either one or both of two different risks: the default risk of individual sovereign issuers or the currency redenomination risk stemming from the collapse of the euro. While sovereign default risk should reflect mainly country-specific factors, redenomination risk should stem from common threats to the survival of the monetary union, even though exposure to this common risk may differ across countries depending on their different expected exchange rate adjustment in a post-euro regime (as argued by Di Cesare et al., 2013). As highlighted in the introduction, this source of common risk loomed large on investors' horizon between 2010 and 2012.

We propose to identify these two components of sovereign risk – a country-specific and a common or systemic one – by estimating a dynamic latent factor model, which partitions the shocks driving the sovereign yields of each euro-area issuer in three components: (i) a common factor, capturing world and euro-area shocks; (ii) a country factor, reflecting shocks to that country's credit risk; (iii) an unexplained idiosyncratic shock.[9] Of these three components, the country factor captures the shocks

[9] Dynamic factor models were originally proposed as a time-series extension of factor models previously developed for cross-sectional data. They have the ability to model simultaneously and consistently data in which the number of series exceeds the number of time-series observations. The assumption of a dynamic factor model is that a few latent dynamic factors drive the comovements of a high-dimensional vector of time-series variables, which is also affected by a vector of mean-zero idiosyncratic disturbances. These idiosyncratic disturbances arise from measurement error or from the intrinsic characteristics of an individual series. The empirical evidence shows that these assumptions are appropriate for many macroeconomic series (see for instance Giannone, Reichlin, and Sala, 2004, and Watson, 2004).

that affect only the yield, CDS premium and financial variables of a specific country, and therefore can be interpreted as the credit risk that concerns only the country itself, without spreading to other countries. The common factor is instead supposed to capture common shocks as well as country-level shocks whose effects spread beyond a specific country, such as those capable of destabilizing the euro area as a whole: for instance, a statement by the Prime Minister of a major euro-area country that raise the likelihood of sovereign default by that country might lead investors to increase the likelihood of collapse of the monetary union, and therefore contribute to the common factor. Importantly, the model allows the same common shock to elicit responses in yields and CDS premia that are completely different in sign and magnitude across countries: hence, the same perceived risk of collapse of the euro may have widely different impacts on different countries.

Our study is related to Ang and Longstaff (2011), who use CDS spreads to study the nature of systemic sovereign credit risk for the U.S. Treasury, individual U.S. states, and major European countries. They use a multifactor affine framework that allows for both systemic and sovereign-specific credit shocks, and find the sensitivity to systemic risk differs considerably across U.S. and European issuers, which parallels our findings for euro-area countries. Interestingly, Ang and Longstaff document that the highly integrated U.S. sovereign debt market features far less systemic risk than its European counterpart. This is in line with the view that the systemic component reflects mainly the danger of collapse of the common currency in the euro area, a danger clearly absent in the U.S.

Many other studies have analyzed the determinants of sovereign yield spreads and CDS premia. A first strand of the literature has explored the role of country-level variables such as the debt-GDP ratio, the projected fiscal balance and other macro fundamentals, attributing the unexplained component of yield spreads or/and CDS premia to the mispricing of risk due to panic or contagion effects or, in the context of the euro crisis, to the perceived risk of breakup of the common currency (Aizenman et al., 2011; Di Cesare et al., 2013). Another strand of the literature allows for both country-specific and common factors in the determination of sovereign yield spreads, by regressing spreads on a vector of country-specific variables (especially fiscal and macroeconomic variables) and one that is common across countries, aimed at capturing time-varying global risk aversion or contagion effects. Attinasi et al. (2009) and De Santis (2012) proxy risk aversion by the spread between the US AAA corporate bonds and the US 10-year sovereign bonds, Caceres et al. (2010) estimate it as the market price of risk of a stress event, and Sgherri and Zoli (2009) measure it as a latent common factor in spreads by estimating a first-stage regression. Giordano et al. (2012) not only include country-level and common risk variables, but also attempt to capture contagion by interacting these variables with a post-Greek-crisis dummy variable, and find evidence that country-level fundamentals have a greater impact after the Greek crisis ("wake-up call" contagion), while common factors do not (no "pure contagion").

A possible pitfall of these studies is that they ignore that in some circumstances, country-specific shocks can have effects on several countries, and therefore turn into common shocks: for instance, a fiscal imbalance in a distressed country such as Italy can be perceived as a possible threat to the survival of the euro, and therefore affect yield spreads not only in Italy but also in other periphery countries of the euro area. Our methodology avoids this pitfall by decomposing yield spreads via a latent factor approach that identifies a country-specific and a common component. This allows to quantify the role played by each of these two components without relying on an assumed relation between them and a set of observables, as in the studies discussed above.

3.1. Data

Sovereign yields differentials and CDS premia are the main inputs of our dynamic factor model. For each country, we compute the difference between the 5-year sovereign yield and the swap rate for the corresponding maturity. CDS premia also refer to the 5-year maturity. The dynamic factor model includes 15 countries, 10 of which belong to the euro area (Austria, Belgium, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) and 5 do not (Denmark, Japan, Sweden, United Kingdom. and United States). The data are at monthly frequency and span the time period from September 2008 to October 2012, except for Greece (where we drop the period after April 2012, where the sovereign debt prices becomes purely notional) and the United States (where the CDS premium is unavailable before September 2009).

The yield and CDS series are non- stationary, and therefore they are all differenced in the estimation of the dynamic factor model. However, the correlation pattern just described for their levels is similar when computed on the first differences of both variables.

To proxy for the conditions of the financial system in each country, we use the percentage change in the national stock market indices of all the 15 countries present in our sample. We also include variables intended to capture global risk: (i) measures of the "appetite for risk" at the global and European level, namely the percentage change of the VIX and VSTOXX indices; (ii) measures of the possible concerns for the stability of the euro, namely the percentage change of the euro-dollar exchange rate and of the effective exchange rate of the euro.[10]

3.2. Methodology

To identify the different factors, we impose appropriate zero restrictions in the factor loading matrix. Formally, let Δy_c denote the first difference of the government bond yield of country c relative to the relevant swap rate, Δp_c the percentage change in its sovereign CDS premium, and z_c its stock market return. Moreover, let $(x_1,...,x_n)$ be a vector of the variables capturing world risk, namely the percentage change in the VIX index, the VSTOXX index, the euro-dollar exchange rate, and the effective euro exchange rate.

To give an idea of the restrictions imposed in the estimation, consider (for simplicity) the case of two countries ($c = \{1, 2\}$). Then, the dynamic factor model would be as follows:

[10] Stock market price indices are drawn from Datastream. The VIX and VSTOXX indices are obtained from Yahoo! Finance and stoxx.com, respectively. The euro-dollar exchange rate and the effective exchange rate are drawn from the ECB database.

$$
\begin{bmatrix} \Delta y_1 \\ \Delta p_1 \\ z_1 \\ \Delta y_2 \\ \Delta p_2 \\ z_2 \\ x_1 \\ \dots \\ x_n \end{bmatrix} = \begin{bmatrix} \alpha_{1G} & \alpha_{1C} & 0 \\ \alpha_{2G} & \alpha_{2C} & 0 \\ \alpha_{3G} & \alpha_{3C} & 0 \\ \alpha_{4G} & 0 & \alpha_{4C} \\ \alpha_{5G} & 0 & \alpha_{5C} \\ \alpha_{6G} & 0 & \alpha_{6C} \\ \alpha_1 & 0 & 0 \\ \dots & \dots & \dots \\ \alpha_n & 0 & 0 \end{bmatrix} \begin{bmatrix} f_G \\ f_1 \\ f_2 \end{bmatrix} + \boldsymbol{\xi} = \boldsymbol{\Lambda}\mathbf{f} + \boldsymbol{\xi}, \qquad (1)
$$

where f_G is a global common factor, f_1 and f_2 are the country-specific factors, $\boldsymbol{\Lambda}$ is the matrix of factor loadings, and $\boldsymbol{\xi}$ is the vector of idiosyncratic errors. The latent factors – whether common or country-specific – are assumed to have an autoregressive structure:

$$
\begin{bmatrix} f_G \\ f_1 \\ f_2 \end{bmatrix} \equiv \mathbf{f}_t = \mathbf{A}(L)\mathbf{f}_{t-1} + \mathbf{u}_t, \qquad (2)
$$

where $\mathbf{A}(L)$ is diagonal with two lags, so that the factors are orthogonal, and the errors $\mathbf{u}_t$ are modelled as AR(1) . The factors are estimated via a two-step procedure: in the first step, they are estimated by principal components and, in the second, by the Kalman filter. The asymptotic justification for this procedure is given in Doz et al. (2011).

3.3. Results

We now present the results of the estimation of the dynamic factor model described above. First, we show that the common latent factor arising from our estimates can be interpreted as the time-varying redenomination risk arising from the potential collapse of the euro. Second, we assess the relative importance of the common and country factors in explaining the dynamics of yield differentials and CDS premia in different countries, by looking at their variance decomposition and by illustrating how the dynamics of the two components differ across countries.

3.3.1. Interpreting the common factor as Euro collapse risk

Figures 7 and 8 shows that the time series of the common factor estimated by our model correlates closely with two estimates of the risk of euro collapse between April 2010 and August 2012.

One way to measure the concern of investors about the risk of euro breakup is to look at the intensity with which such concern translated in their Google clicks, as measured by a Google Trends index that shows how often search-terms related to the collapse of the euro were entered in the Google search engine, relative to the total worldwide search-volume.[11] In Figure 7, we plot this search volume index together with the estimated common factor: the correlation between the two series is 0.60, and their turning points coincide.

The perceived risk of exit of member countries from the euro can also be gauged from prediction markets. We look at data drawn from the Intrade online exchange, where individuals can take positions (trade "contracts") on whether (non-sports-related) future events will or will not occur. The exit of member countries from the euro area is one such event, and the price of the corresponding contract (relative to its payoff if the event occurs) is an estimate of its probability. Figure 8 plots our common factor together with the probability that any country that used the Euro as of March 12th, 2008 would announce its intention to drop the Euro as its national currency or would be expelled from the Euro-area before the end of 2013, based on Intrade data.[12] This series is even more closely correlated with our common factor than the Google search volume index: the correlation coefficient is 0.74, and again the two series' turning points are synchronized.

Interestingly, our common factor peaks at times when the media expressed particular concern about the sustainability of the euro: in November 2011 the *Financial Times* reported of multinational companies' preparations for the possible euro breakup, and in May 2012 the *Sunday Telegraph* published an interview with Lloyds' CEO Richard Ward describing his company's preparations for euro collapse. Conversely, our common factor declined after ECB President Draghi delivered his famous "whatever-it-takes" speech on 26 July 2012.[13]

3.3.2. The relative importance of the common and country risk factors

Identifying the common and country specific factors allows to estimate the fraction of the variance in the yield differentials relative to the swap rate that can be attributed to each of them: the resulting variance decomposition is shown in Table 1. Three main results emerge from it.

First, country risk plays a dominant role in explaining yield differentials relative to the swap rate, especially for periphery countries and Belgium (not Greece, whose yield is mainly idiosyncratic). In

[11] The search-terms are: "end of euro", "end of the euro", "euro break-up", "euro break up", "euro breakup", "euro exit", "euro collapse", "collapse of the euro". We specifically exclude all searches containing the words "euro20" and "euro cup" to avoid contaminating the data with searches related to the UEFA Championships from 2000 onwards.

[12] The market is settled when an announcement is made: the Euro does not actually have to be dropped as a national currency by the date specified in the contract. For example, if there is an announcement on December 1st 2013 that the Euro will be dropped in June 2014 the market will be settled at $10.00 (the contact's notional settlement value) on the date of the announcement (December 1st 2013) and not the date the Euro will no longer be used (June 2014).

[13] On that date, Mario Draghi stated in a speech at the Global Investment Conference in London: "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough."

contrast, the common factor affects mainly the German yield, which can be interpreted as reflecting investors' "flight to quality" as they become more concerned about the survival of the euro.

Second, the variance decomposition for CDS premia indicates that common risk is important for all euro-area countries, but that its role differs greatly across countries, in line with what is found by Ang and Longstaff (2011) with a different methodology. In particular, common risk plays a minor role in countries that have been involved in a sovereign bailout programme from EFSF/ESM (Greece, Ireland and Portugal). But for most of the euro-area periphery, country-specific risk is also important: this is the case for Ireland, Portugal and Spain, and to a more limited extent for Italy.

Third, common risk appears to explain the bulk of the variability in financial variables: the stock returns in the third block and the volatility and exchange rate measures in the fourth block of Table 1. In particular, it accounts for over 60% of the variability in the stock returns of almost all euro-area countries, and for over one fifth of the variation in the VIX index.

To interpret these results, it is worth looking at Figures 9, 10 and 11, which show the time patterns of the common and country components of the yield differential and the CDS premium for Germany, Italy and Spain. In all three figures, the solid line shows the actual series (yield differential or CDS premium), the dashed line plots the common component of the series, and the dotted one the country component. Figure 9 shows that the common component explains most of the movement of the German CDS premium and to some extent also of the German yield. In contrast, Figures 10 and 11 show that in Italy and Spain the country component explains most of the yield pattern, while for their CDS premium both the common and the country component play a role. It is worth considering how a rise in the common risk factor affects CDS premia and yield differentials in the three countries in late 2011. Their response is captured by the respective common components (the dashed lines): CDS premia rise in all three countries, but while both the Italian and Spanish yield differentials increase, the German one drops sharply. The opposite happens towards the end of the sample (second half of 2012), when both common and country risks recede in Italy and Spain: all CDS premia decline, and the Italian and Spanish yields also drop, while the German one rises.

The interpretation of these patterns is that common shocks are captured by generalized changes in CDS premia, including those of core countries but relatively larger in the periphery, but they push bond yields in opposite directions, with investors flying away from periphery bond markets towards the core of the euro area, or vice versa.

4. Home bias in banks' sovereign exposures, yield differentials and systemic risk

Section 2 documents two aggregate patterns in the euro-area market for sovereign debt: (i) the home bias of banks' sovereign debt portfolios decreased until 2009, and then started increasing; (ii) domestic sovereign yield differentials were close to zero until the same date, and then started widening. In this section, we investigate whether these two facts are related, namely, whether banks' home bias (a quantity-based measure of segmentation) is related to yield differentials (a price-based measure of segmentation). As explained in the introduction, a positive correlation between domestic sovereign exposures and yield differentials might arise from three different (not mutually exclusive) reasons:

(i) the "moral suasion" exerted by national regulators on the banks in their jurisdiction to purchase domestic debt when the sovereign experiences difficulties in its placement, i.e. at times when its yield is relatively high;

(ii) the tendency by undercapitalized banks, which are mostly located in the euro-area periphery, to bet for resurrection by engaging in "carry trades" in high-yield sovereign debt, i.e. by buying periphery debt at times of market stress;

(iii) the "comparative advantage" of each country's banks in bearing the currency redenomination risk of their country's sovereign debt, arising from the potential breakup of the euro area.

The first two motivations are compatible with banks increasing their domestic exposures not only in response to greater systemic euro-area risk but also in response to increased country-specific risk; in contrast, the third motivation implies that banks should increase their domestic exposures only in response to greater systemic euro-area risk, as they have no comparative advantage in hedging against country-specific risk. Hence, in this Section we also investigate how domestic sovereign exposures respond to the common and country risk factors that drive yield differentials, so as to shed some light on the mechanisms that have driven the response of banks' domestic exposures during the euro crisis.

4.1. Data and methodology

Our analysis proceeds in two steps. First, we estimate a *baseline model*, where we investigate the dynamic relationships between banks' domestic sovereign exposures and yield differentials between the domestic 5-year government bond yield and the euro 5-year swap rate. Second, we estimate a *factor-based model*, where the yield differential is replaced by the country and common risk components estimated in Section 3. Beside the 5-year yield differentials relative to the euro swap rate used in Section 3, the data used in the estimation include monthly values of aggregate euro-area banks' exposures to domestic sovereign debt, drawn from the ECB SDW.[14] The sample period ranges from October 2008 to August 2012 for all countries except Greece (whose end date is April 2010), Ireland (December 2010) and Portugal (April 2011), since we exclude observations after the inception of the IMF/ECB bailout programs implemented in those countries.

To select the econometric model most suitable for the analysis of the dynamic relationships between banks' sovereign exposures and yield differentials (and their components), we consider several features of the relevant time series. First, although we are particularly interested in the response of sovereign exposures to the sovereign yield differentials, feedback effects from banks' sovereign exposures to

[14] For further details about our data on sovereign exposures, see footnote 3 above. These data are also used in Figures 12, 13 and 14 to illustrate the time behavior of domestic exposures for the core and periphery countries as a whole.

interest rate spreads cannot be ruled out. Second, the model should be dynamic, so as to allow for the possibility of gradual short-run adjustment of banks' sovereign portfolios towards their long-run desired composition, due to adjustment costs deriving from illiquidity, uncertainty about the persistence of yield differentials, etc. Finally, in order to have a correctly specified model, we must account for the non-stationarity of all the series in our data sample.

All these motivations lead us to estimate a vector error-correction model (VECM) for each country to analyze the joint determination of its banks' domestic sovereign exposure and yield differential, since this model (i) allows for all possible patterns of time-precedence among variables,[15] (ii) can capture the gradual adjustment of sovereign exposures to long-run equilibrium levels determined by movements in yield differentials, and (iii) can deal with non-stationarity in the data generating process. The preliminary analysis of the data and the specification search (see the Appendix) leads us to the following 2-lag reduced-form specification:

$$\Delta y_t = \alpha\left[\beta' y_{t-1} + \gamma d_{t-1}\right] + \Theta\,\Delta y_{t-1} + \Gamma\, D_t + u_t, \tag{3}$$

where y_t is a n×1 vector, with n the number of endogenous variables, defined as the 2-element column vector $y_t = \left[spread_t \quad sovexp_t\right]'$ in the baseline model and the 3-element column vector $y_t = \left[common_t \quad country_t \quad sovexp_t\right]'$ in the factor-based model, where $spread_t$ is the domestic sovereign debt yield differential (with respect to the euro-area swap rate) in month t, $sovexp_t$ denotes the domestic sovereign exposures of banks as a fraction of their total assets in month t, and $common_t$ and $country_t$ denote the common and the country components of the yield differential in month t, respectively. Moreover, d_t and D_t are m×1 and M×1 vectors, referring to the restricted and unrestricted deterministic terms (or dummy variables) included in each country's specification, respectively; the n×1 vector u_t denotes the reduced form residuals. Finally, α is the n×r matrix of adjustment parameters, β is the n×r matrix of cointegrating parameters, Θ is the n×n matrix of short-run parameters, and γ and Γ are the r×m and n×M matrices of coefficients associated with the restricted and unrestricted deterministic terms, respectively, where r is the cointegrating rank (i.e. the number of cointegration relations) of the system. As usual, our analysis focuses on the parameters describing the long-term relationships among the variables, namely the coefficients in α, which capture the adjustment of each variable in response to shocks (towards the long-run equilibrium if the coefficient is negative, and away from it if positive), and β, which indicate the long-run relationship between variables (positive if the coefficient is negative, and viceversa).[16]

[15] The presence of feedback effects running from *spread* (or its components) to *sovexp* is briefly discussed in the Appendix, drawing on the results of Granger causality tests among the series analyzed here.

[16] A negative adjustment parameter indicates that, whenever the error-correction term, say $z_{t-1} = \beta' y_{t-1} + \gamma d_{t-1}$, is different from zero, the dependent variable adjusts towards its equilibrium level.[16] If instead the estimated adjustment coefficient is positive, then the process for the dependent variable is explosive.

As described in the Appendix, the cointegrating rank of the model in equation (3) is identified through Johansen's trace test for cointegration. This step is crucial to impose the most suitable restrictions and identify the parameters α of the error-correction term, which captures the adjustment of the differenced dependent variables towards their long-run equilibrium levels in response to shocks in the levels of the same variables. Our preliminary analysis suggests to set $r = 1$ for all countries in the baseline model; Johansen's trace test reveals that $r = 2$ is instead more suitable to investigate the factor-based model.

The reduced-form VECM in equation (3) is estimated using Johansen's (1995) maximum likelihood method. Accordingly, restrictions on the cointegrating parameters in $\boldsymbol{\beta}$ are imposed following Johansen's strategy, whereby in the cointegrating equation the coefficient on $spread_t$ is forced to be equal to 1 and the coefficients on $sovexp_t$ is estimated. In the specification of the model for Spain and Italy, we also include a dummy variable in order to account for the long-term refinancing operations (LTROs) executed by ECB as of December 2011. The rationale for the inclusion of this dummy variable is the alteration of the conditions of euro-area financial markets and the subsequent distortion of investors' behavior: the LTROs changed the conditions at which euro-area banks could obtain liquidity from the central bank, so that they may have affected their portfolio decisions; they also affected periphery sovereign yields, by generating a remarkable reversal in their patterns. This dummy need not be included in the specification for Greece, Ireland and Portugal, because their sample excludes observations after December 2011, as explained above.

4.2. Results

The results of the estimation of the VECM's for all countries are reported in Table 2, which shows the cointegrating parameters (β) and the adjustment parameters (α) for domestic sovereign exposures, i.e. the estimated coefficients of the *sovexp* equation for each country. As regards the baseline model (whose estimates are shown in columns 1 and 2), column 1 shows the cointegrating parameter obtained by imposing a unit restriction on the spread variable. As for the factor-based model (whose estimates are shown in columns 3-6), the cointegrating parameter in column 3 refers to the cointegrating relationship between sovereign exposures and the common factor obtained by imposing a unit restriction on the *common* variable and a zero restriction on the *country* variable; the cointegrating parameter in column 5 refers to the cointegrating relationship between sovereign exposures and the country factor obtained by imposing a unit restriction on the *country* variable and a zero restriction on the *common* variable. Columns 2, 4 and 6 show the corresponding adjustment parameters. The long-run parameters can be computed as $\alpha\beta'$.

The estimated cointegrating parameters β in the baseline model (column 1 of Table 2) are negative and significant in all countries except Belgium, France and the Netherlands, indicating that for most countries in the long run a higher yield spread is associated with a greater sovereign domestic exposure of banks. It is interesting to notice that this positive long-run correlation is present for all periphery countries, but only for two out of the five core countries in our sample. The estimated adjustment parameters α in column 2 is negative and significant at the 5 percent level in all countries, except France, where it is not significantly different from zero, and the Netherlands, where it is significant at the 10 percent level.[17] Finally, the long-run effect of a shock to the yield differential on sovereign exposures is given by the product of the vectors α and β, and is positive for all countries except Belgium, France and the Netherlands: in all countries except these three, a rise in the domestic yield differential prompts an increase of the domestic sovereign exposure of local banks, and their gradual adjustment to a higher steady-state level.

These results are consistent with the impulse response functions (IRFs) of the domestic sovereign exposure to a shock in the yield differential shown in Figure 12. The IRFs are obtained from a structural VECM specification of the baseline model, in which we impose the restriction that a shock to exposures cannot determine a contemporaneous effect on the yield differential. The solid line indicates the predicted response, while the dashed lines plot the respective Hall bootstrap 95% confidence bounds.[18] In the long run, the response of domestic sovereign exposures is positive and significant for all periphery countries and, among core ones, for Austria and Germany, whereas it is negative for Belgium and insignificant for France and the Netherlands.[19] In all periphery countries (except Ireland), the response features a small initial drop in exposures, which is reversed within two months. This initial dip may reflect the mechanical impact of an increase in domestic yields, which is equivalent to a drop in the price of domestic debt: such a price drop, if not sufficiently compensated by a buildup in exposures, mechanically translated into a drop in the market value of sovereign exposures.

Further, we investigate the effect of domestic sovereign exposures on yield differentials by looking at the IRFs of the yield differential to a shock in domestic exposures. As illustrated in Figure 13, all countries (except Spain, Italy and Germany) show a negative long-run response of their domestic differentials to an increase in domestic exposures. Hence, in these countries, increases in banks' domestic exposures effectively curb investors' concerns over sovereign solvency and contribute to tightening yield differentials. However, in Spain and Italy, a shock in banks' sovereign exposures appears to trigger an increase of the domestic yield differentials. A possible interpretation is that a greater bank exposure to sovereign risk increases investors' concerns about the solvency of the banks themselves and therefore about their eventual bailout by the respective government, thus prompting them to require a higher yield on its sovereign debt.

Turning to the factor-based model (whose estimates are shown in columns 3-6 in Table 2), for the sake of brevity it is worth focusing directly on the product of the coefficient vectors α and β, which captures the dynamic response of domestic sovereign exposures to the common component (columns

[17] The estimates indicate that domestic sovereign exposures adjust faster in response to shocks in program countries: $sovexp_t$ adjusts by more than 25 percent towards its equilibrium level within a month in Greece, Portugal and Ireland. Instead, core countries (except Germany) and Spain feature a slower adjustment, whereby only 10 percent (or less) of the error is corrected within a month.

[18] Hall bootstrap 90% confidence intervals are computed with 2,000 replications. Results do not change when the number of replications is either smaller (1,000) or larger (3,000).

[19] Positive responses are generally significant after three months (at the latest) for all countries, except Ireland (6 months) and Austria (8 months).

3-4) and to the country component (columns 5-6) of the yield differential. The response to the common risk factor is positive for all countries except Italy (where it is negative and significant) and not significant for Ireland and Portugal. This indicates that for most countries when there is an increase in systemic risk, local banks increase the home bias of their sovereign debt portfolios, consistently with the "comparative advantage" hypothesis. In contrast, the response to the country risk factor differs considerably across countries: in core countries (except Austria), an increase in country risk prompts local banks to reduce significantly (Germany and France) their domestic exposures, or not to change them significantly (Netherlands and Belgium); in contrast, in periphery countries and Austria, it leads local banks to increase their domestic exposures significantly, the only exception being Spain where the response is not significant.[20]

However, the product of the coefficients α and β does not provide a full account of the dynamic response of domestic sovereign exposures to shocks in the common and country components of the yield spread. To this purpose, we identify structural IRFs by imposing the following restrictions:

(i) only the common and the country shocks have a permanent effect;

(ii) the common and the country shocks do not contemporaneously affect each other;

(iii) a shock in the domestic sovereign exposure has no contemporaneous impact on the global factor.

The resulting IRFs are shown in Figure 14, where the graphs on the left show the response to a shock in the common factor, and those on the right the response to the country factor.

The common risk factor leads to a significant increase in domestic sovereign exposures in all the core countries except Belgium. The same applies to Greece, Italy and Spain, although initially Italian and Spanish banks feature a dip in their domestic sovereign exposure (again, possibly explained by the mechanical impact of the drop in price on the value of their exposures). Instead, the response of sovereign exposure in Ireland and Portugal is not significantly different from zero. Hence the IRFs confirm that in most countries an increase in systemic risk leads to an increase in domestic exposures.

The country risk factor prompts domestic sovereign exposures to decrease significantly in the core countries (except Austria, where the effect is positive and significant), and to increase in the periphery (except for Spain, where the effect is positive but not statistically significant). Hence, for the periphery countries (except possibly Spain) the evidence cannot be explained by the "comparative advantage" hypothesis, which predicts a positive response of exposures only to the common factor. Since exposures appear to increase also in response to increases in country-specific risk, in the euro-area periphery the "moral suasion" or/and the "carry trade" hypotheses must have played a role.

[20] Furthermore, the adjustment parameters to an off-equilibrium level of the error-correction term is positive for Italy, Portugal and France, indicating an explosive response of exposures to the common component. Hence, for these countries, no long-run equilibrium relationship connects domestic sovereign exposures and the common component of differentials. The same applies to Spain, Greece and the Netherlands in the case of the country component of yield differentials.

5. Summary and policy implications

This paper analyses the dynamics of sovereign yields in the euro-area crisis that unfolded since 2008 and the concomitant reshuffling of the sovereign debt portfolios held by banks, and the relationship between these two phenomena. We proceed in two steps. First, using a dynamic factor model we decompose yield differentials in a country-specific and a common (or systemic) risk component, in order to assess to what extent the increase in euro-area yield differentials is a reward for differential default risk as opposed to a reflection of the differential exposure to common (or systemic) risk. Our estimate of the common risk factor correlates closely with two indicators of investors' concerns about the danger of breakup of the euro area, one being the frequency of relevant terms searches in Google and the other being the euro-area breakup probability drawn from a prediction market.

Next, we investigate how the changes in the exposures of banks to domestic sovereign risk is related to the changes in yield differentials and in their two components, as estimated in the previous step. We perform this second step by estimating a vector error-correction model on 2008-12 monthly data. We find that the domestic sovereign exposures of banks in most euro-area countries respond positively to increases in yields, especially in periphery countries. When yield differentials are decomposed in their country-risk and common-risk components, we find that: (i) in most of the periphery countries (plus Austria), banks responded to increases in country risk by increasing their domestic exposure, while in core countries they did not; (ii) in contrast, in most euro-area countries banks reacted to an increase in the common risk factor by raising their domestic exposures.

Finding (i) indicates that in the euro-area periphery banks responded to increases in their own sovereign's risk by increasing even further their exposure to such risk, in line the "moral suasion" and the "carry trade" hypotheses. Finding (ii) indicates that most euro-area banks have responded to greater systemic risk by increasing the home bias of their portfolios, consistently with the "comparative advantage" hypothesis. Each of these findings are problematic from a policy standpoint and, also depending on their interpretation, they have different implications for policy.

5.1. Dealing with "moral suasion by regulators"

Suppose that our finding (i) – namely, that periphery banks have increased their domestic sovereign exposures in response to a rise in their relative yield – is due to moral suasion by their regulator, concerned by the distressed state of the domestic sovereign's finances. Under this interpretation, regulators themselves tended to induce risk-taking by banks in a setting where government solvency was already at danger, thus enhancing the "diabolic loop" between fiscal solvency and bank solvency deterioration. This problem, if present, should be eliminated or at least mitigated by the introduction of the planned euro-area banking union, since the prudential policy of the "single supervisor" entrusted to the ECB would inevitably be more insulated from the pressure of national governments. The rationale for this impending policy change is reinforced by the fact that it is becoming increasingly clear that, when euro-area governments are fiscally distressed, they are no longer the only ultimate backstops of their domestic banks, as illustrated by the contribution of the European Stability Mechanism (ESM) to the recapitalization of Spanish banks since late 2012: it is then consistent that, *ex ante*, a Euro-area bank supervisor should constrain the bets that euro-area banks, especially distressed ones, can take on the bonds issued by their equally distressed sovereign.

5.2. Dealing with "search for yield by banks"

Our finding (i) could equally well be interpreted as the result of periphery banks increasing their sovereign exposures to search for yield, especially considering that many of these banks were undercapitalized and could borrow cheaply from the ECB: if successful, their sovereign-debt carry trades would help them to shore up their capital ratios. Indeed, Acharya and Steffen (2012) and Buch, Koetter and Ohls (2013) provide evidence that less capitalized banks and banks that are more dependent on wholesale funding invest more in sovereign debt than others. A variant of this "carry trade" story, which is often heard when talking to euro-area bankers, is: "if my sovereign defaults, also my bank goes under, so I can ignore the default risk of my own sovereign". This argument may contribute to explain why such carry trades by banks have been far more prevalent in fiscally distressed countries than in fiscally sound countries. While such behaviour may appear rational from a bank's individual standpoint, it is no less socially inefficient than if it were motivated by moral hazard: since it leads the banks of the fiscally distressed country to overexpose themselves to sovereign risk, it also makes them more likely to require a bailout in the event of an increase in domestic yields. Insofar as this increases their demands on the public finances of their country in bad states of the world, it also exacerbates the chances that their sovereign will be distressed. In other words, however motivated, banks' carry trades strengthen the diabolic loop between financial instability and fiscal distress.

Discouraging carry trades would require revising the prudential regulation of sovereign exposures in the euro area, by scrapping the current preferential treatment of sovereign exposures in the euro area: currently, euro-area banks face no capital requirement (a "zero risk weight") for sovereign holdings of euro-area debt, irrespective of its sovereign issuer;[21] moreover, sovereign holdings are exempted from the "large exposures regime", which limits exposures to a single counterparty to a quarter of their eligible capital. Such regulation makes it particularly attractive for euro-area banks to invest in euro-denominated sovereign debt, especially high-yield debt, and especially considering that they can fund such investments by borrowing at low rates from the ECB. In principle, such carry trades can be discouraged either by imposing positive risk weights on sovereign debt in computing banks' capital or by imposing limits on banks' exposure towards each single sovereign issuer, hence requiring them to diversify their sovereign portfolios. Each of these two choices is not without problems: on one hand, the responsiveness of banks' portfolio choices to the level of risk weights on sovereign exposures is unknown, and in practice may be quite low in the presence of very profitable carry trades, so that risk weights could prove ineffective; on the other hand, setting limits to exposures vis-à-vis each single

[21] Specifically, euro-area sovereign debt carries a zero risk weight in the computation of the "risk-weighted assets" that are used to determine the capital required from a bank for prudential purposes according to the so-called "standardized approach". Alternatively, banks can opt for the "internal ratings-based approach", namely construct an internal risk model to determine the risk weight that they wish to attach to each type of sovereign debt in computing their risk-weighted assets.

sovereign issuer would require most euro-area banks to undertake very substantial portfolio adjustments, which may result in gyrations in relative yields in the euro-area sovereign debt market.

However, there are ways to guide the banks' portfolio reallocation process smoothly in the direction of greater diversification: for instance, the limit on sovereign exposures could be imposed very gradually; moreover, euro-area banks may be exempted from this limit altogether insofar as they were to invest in a well-diversified portfolio of euro-area sovereign bonds rather than in those of a specific sovereign issuer. In this respect, the portfolio reallocation process could be made smoother by the introduction of European Safe Bonds, as proposed by the Euro-nomics Group: a European Debt Agency (EDA) could buy a GDP-weighted portfolio of bonds from euro-area sovereigns, and use them as collateral to issue two securities. The first security, European Safe Bonds or ESBies, would be a senior claim on the payments from the sovereign bonds held in the portfolio. The second security, European Junior Bonds, would have a junior claim on these payments – that is, it would be first in line to absorb whatever loss is realized in the pool of sovereign bonds that serve as collateral for these issues. That is, any failure by a sovereign state to honour in full its debts would be absorbed by the holders of the junior tranche security, not by the EDA, any Euro-area entity or the European Union. Owing to the diversification of country-specific risk and to their seniority, ESBies would have virtually no exposure to sovereign risk, and therefore would be an ideal asset for euro-area banks to diversify their sovereign portfolios.[22]

5.3. Dealing with the fallout of redenomination risk

What about the policy implications of our finding (ii) – namely, that even in core countries euro-area banks have responded to greater systemic (or redenomination) risk by increasing the home bias of their sovereign portfolios? As already mentioned, this response would appear completely consistent with economic rationality and market equilibrium: in the event of euro breakup, the banks of each country would be better positioned to bear the brunt of redenomination of domestic sovereign debt in the new national currency, as their deposits would also be redenominated in the new currency. Insofar as redenomination risk gives them a "comparative advantage" in holding domestic debt relative to foreign banks, home bias in the euro-area sovereign debt market is an equilibrium phenomenon. Incidentally, such an outcome has probably been reinforced by "ring-fencing" by the regulators of core countries, who are often reported to have pressured the banks under their supervision to shed periphery-country debt in favor of core-country debt, in late 2010 and in 2011.

The only way to address this source of segmentation of euro-area sovereign bond markets – and more generally of euro-area debt markets – is to address the credibility issue, as was done by Draghi's "whatever-it-takes" July 2012 speech and subsequent inception of the Outright Monetary Transactions (OMT) program: by creating the credible threat that the ECB could buy the sovereign debt of distressed euro-area countries, the ECB reduced investors' estimate of the probability of a possible euro breakup.

[22] See http://euro-nomics.com/http:/euro-nomics.com/2011/european-safe-bonds/ for a more detailed description of this policy proposal.

Nevertheless, the degree of segmentation of euro-area debt markets remains high: in each member country, banks are still the almost exclusive source of funding for both the domestic sovereign and the local private sector, so that their private-sector lending tends to be more severely crowded-out in countries with larger stocks of public debt such as Italy and Greece. At the same time, even though cross-country differences between domestic interest rates have considerably abated, at the time of writing they are still non-negligible, and may spike again if investors' concerns about the survival of the euro were to reignite.

References

Acharya, V., I. Drechsler, and P. Schnabl (2011), "A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk," NBER Working Paper No. 17136.

Acharya, V. and S. Steffen (2012), "The Greatest Carry Trade Ever? Understanding Eurozone Bank Risks," work in progress.

Aizenman, Joshua, Michael M. Hutchison, and Yothin Jinjarak (2011), "What is the Risk of European Sovereign Debt Defaults? Fiscal Space, CDS Spreads and Market Pricing of Risk," NBER Working Paper No. 17407.

Albertazzi, U., T. Ropele, G. Sene, and F. M. Signoretti (2012), "The Impact of the Sovereign Debt Crisis on the Activity of Italian Banks," Banca d'Italia Occasional Paper No. 133.

Ang, A. and F. A. Longstaff, (2011) "Systemic Sovereign Credit Risk: Lessons from the U.S. and Europe," Columbia University and UCLA Working Paper, http://ssrn.com/abstract=1815502.

Angeloni, C. and G. B. Wolff (2012). "Are banks affected by their holdings of government debt?". Bruegel working paper 2012/07.

Attinasi, M. G., C. Checherita and C. Nickel (2009), "What explains the surge in euro area sovereign spreads during the financial crisis of 2007–09?", ECB Working Paper Series, No. 1131.

Beber, Alessandro, M. W. Brandt and K. A. Kavajecz (2009), "Flight-to-quality or flight-to-liquidity? Evidence from the euro-area bond market", *Review of Financial Studies*, 22 (3), 925–957.

Buch, Claudia, Michael Koetter, and Jana Ohls (2013), "Banks and sovereign risk: a granular view," Deutsche Bundesbank Discussion Paper No. 29/2013.

Caceres, C., Guzzo, V. and Segoviano, M. (2010), "Sovereign spreads: global risk aversion, contagion or fundamentals?," IMF Working Paper no. 120/10.

De Santis R. A. (2012), "The euro area sovereign debt crisis : safe haven, credit rating agencies and the spread of the fever", ECB Working Paper Series, No. 1419.

Di Cesare, Antonio, Giuseppe Grande, Michele Manna and Marco Taboga (2013) "Recent Estimates of Sovereign Risk Premia for Euro-Area Countries," unpublished manuscript, Banca d'Italia.

Doz, C., D. Giannone, and L. Reichlin, 2011. "A two-step estimator for large approximate dynamic factor models based on Kalman filtering," *Journal of Econometrics*, vol. 164(1), 188-205.

ECB (2012), *Financial Integration in Europe*, April.

Engle, R. F., and C. W. J. Granger (1987), "Co-Integration and Error Correction: Representation, Estimation and Testing," *Econometrica*, 55, 251-276.

Favero, C.A., Pagano, M. and von Thadden, E.L. (2010), "How does liquidity affect government bond yields?," *Journal of Financial and Quantitative Analysis*, vol. 45(1), 107-134.

Fontana, A. and M. Scheicher (2010), “An Analysis of Euro Area Sovereign CDS and their Relation with Government Bonds,” European Central Bank Working Paper No. 1271.

Giannone, D., L. Reichlin, and L. Sala (2004), “Monetary Policy in Real Time,” *NBER Macroeconomics Annual*, 2004, 161-200.

Giordano R., M. Pericoli and P. Tommasino (2012), “‘Pure’ or ‘Wake-up call’ contagion? Another look at the EMU sovereign debt crisis”, unpublished manuscript, Banca d’Italia.

Granger, C.W.J. (1981), “Some Properties of Time Series Data and Their Use in Econometric Model Specification,” *Journal of Econometrics*, 16, 121-130.

Johansen, S. (1995), *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*. Oxford University Press.

Sgherri, S. and Zoli, E. (2009), “Euro Area Sovereign Risk During the Crisis,” IMF Working Paper no. 09/222.

Watson, M. W. (2004), “Comment on Giannone, Reichlin, and Sala,” *NBER Macroeconomics Annual*, 2004, 216-221.

Table 1 – Dynamic factor model estimation: variance decomposition

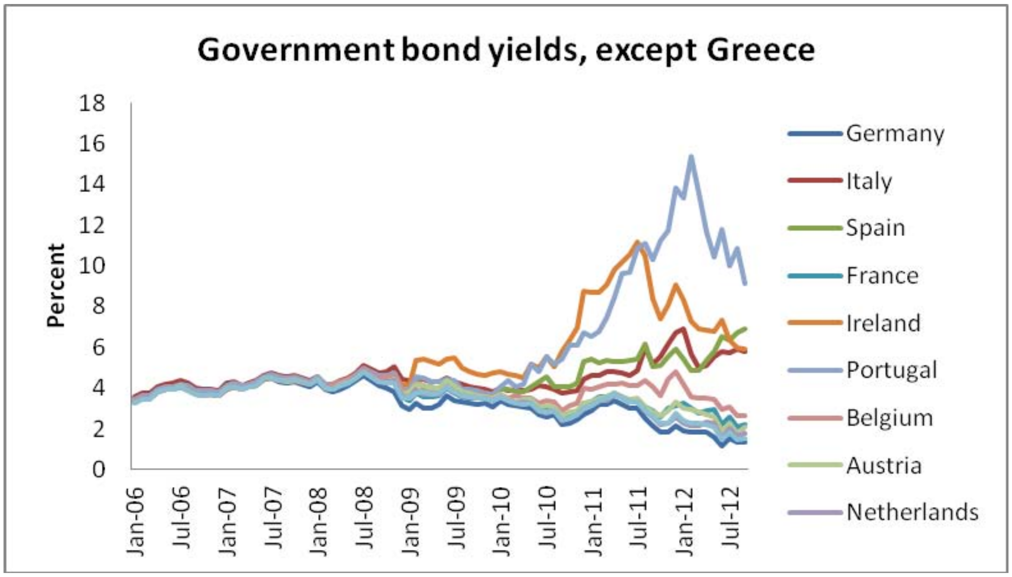
Country	Variable	Common	Country	Idiosyncratic
Austria	Δ Sovereign yield	0.09	0.18	0.73
Belgium	Δ Sovereign yield	0.24	0.55	0.21
Germany	Δ Sovereign yield	0.30	0.10	0.59
Spain	Δ Sovereign yield	0.10	0.74	0.15
France	Δ Sovereign yield	0.03	0.23	0.74
Greece	Δ Sovereign yield	0.02	0.13	0.85
Ireland	Δ Sovereign yield	0.01	0.73	0.26
Italy	Δ Sovereign yield	0.23	0.63	0.14
Netherlands	Δ Sovereign yield	0.05	0.08	0.87
Portugal	Δ Sovereign yield	0.00	0.80	0.20
Denmark	Δ Sovereign yield	0.02	0.22	0.76
U.K.	Δ Sovereign yield	0.01	0.03	0.96
Sweden	Δ Sovereign yield	0.03	0.36	0.61
U.S.	Δ Sovereign yield	0.13	1.05	
Japan	Δ Sovereign yield	0.00	0.16	0.84
Austria	Δ CDS premium	0.59	0.04	0.37
Belgium	Δ CDS premium	0.48	0.20	0.32
Germany	Δ CDS premium	0.58	0.00	0.42
Spain	Δ CDS premium	0.33	0.43	0.24
France	Δ CDS premium	0.57	0.01	0.43
Greece	Δ CDS premium	0.01	0.19	0.79
Ireland	Δ CDS premium	0.13	0.61	0.27
Italy	Δ CDS premium	0.50	0.26	0.25
Netherlands	Δ CDS premium	0.56	0.01	0.43
Portugal	Δ CDS premium	0.06	0.72	0.22
Denmark	Δ CDS premium	0.53	0.06	0.41
U.K.	Δ CDS premium	0.49	0.00	0.50
Sweden	Δ CDS premium	0.47	0.02	0.51
U.S.	Δ CDS premium	0.05	0.03	
Japan	Δ CDS premium	0.36	0.04	0.60
Austria	Stock market return (%)	0.65	0.03	0.33
Belgium	Stock market return (%)	0.62	0.02	0.35
Germany	Stock market return (%)	0.64	0.01	0.35
Spain	Stock market return (%)	0.59	0.03	0.38
France	Stock market return (%)	0.71	0.00	0.29
Greece	Stock market return (%)	0.60	0.00	0.39
Ireland	Stock market return (%)	0.57	0.00	0.43
Italy	Stock market return (%)	0.70	0.01	0.29
Netherlands	Stock market return (%)	0.64	0.01	0.35
Portugal	Stock market return (%)	0.63	0.01	0.36
Denmark	Stock market return (%)	0.56	0.08	0.36
U.K.	Stock market return (%)	0.62	0.00	0.38
Sweden	Stock market return (%)	0.58	0.01	0.41
U.S.	Stock market return (%)	0.62	0.05	0.33
Japan	Stock market return (%)	0.51	0.03	0.45
	Δ VIX (%)	0.22		0.78
	Δ VSTOXX (%)	0.06		0.94
	Δ effective exchange rate (%)	0.02		0.98
	Δ euro-dollar exchange rate (%)	0.23		0.77

Table 2 - VECM estimates for the response of banks' domestic sovereign exposures to yield differentials and their components

The table shows the cointegrating parameters (β) and the adjustment parameters (α) for domestic sovereign exposures, i.e. the estimated coefficients of the *sovexp* equation for each country. Column 1 shows the cointegrating parameter obtained by imposing a unit restriction on the spread variable. For the factor-based model (whose estimates are shown in columns 3-6), the cointegrating parameter in column 3 refers to the cointegrating relationship between sovereign exposures and the common factor obtained by imposing a unit restriction on the *common* variable and a zero restriction on the *country* variable; the cointegrating parameter in column 5 refers to the cointegrating relationship between sovereign exposures and the country factor obtained by imposing a unit restriction on the *country* variable and a zero restriction on the *common* variable. Columns 2, 4 and 6 show the corresponding adjustment parameters. The long-run parameters can be computed as $\alpha\beta'$. The sample ranges from October 2008 through August 2012 for all countries, except Greece, Ireland and Portugal (whose end dates are April 2010, December 2010 and April 2011, respectively). The coefficients of restricted and unrestricted deterministic terms are not reported. One, two or three asterisks denote significance at the 10%, 5% or 1% significance level, respectively. Numbers in parentheses are *p*-values.

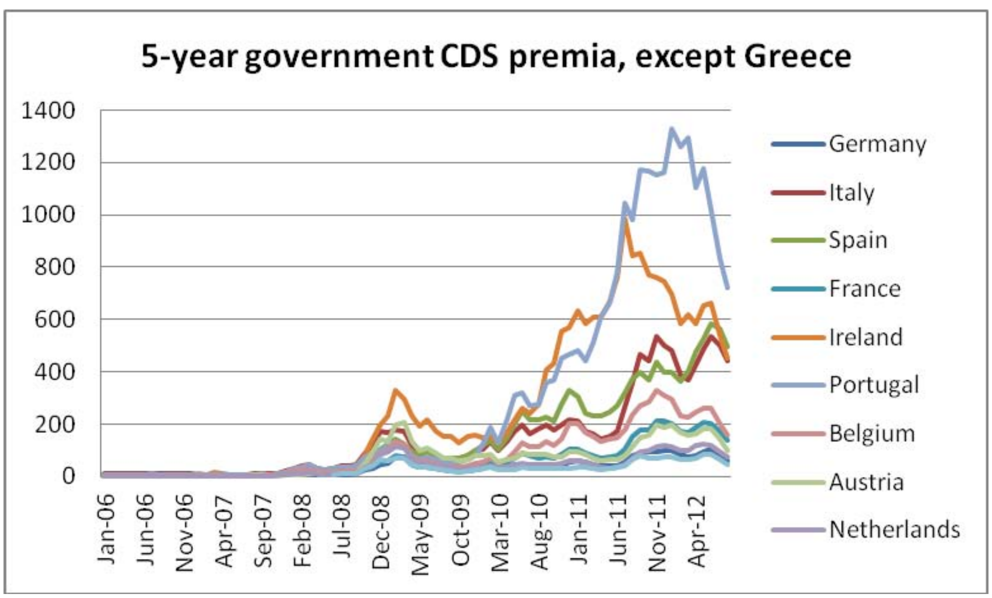
	Baseline model		*Factor-based model*			
Country	β	α	β	α	β	α
	(1)	(2)	(3)	(4)	(5)	(6)
Spain	-0.774***	-0.082**	-0.711***	-0.342***	-0.550***	0.132
	(0.003)	(0.021)	(0.000)	(0.000)	(0.000)	(0.135)
Greece	-0.586***	-0.636***	-6.134**	-0.112**	-131.752	0.011
	(0.000)	(0.000)	(0.042)	(0.017)	(0.535)	(0.227)
Ireland	-0.060***	-0.263**	1.876	-0.011	-0.090***	-0.268***
	(0.002)	(0.016)	(0.332)	(0.661)	(0.002)	(0.000)
Italy	-0.457***	-0.142***	-0.579*	0.209***	-0.293***	-0.430***
	(0.000)	(0.000)	(0.073)	(0.007)	(0.003)	(0.000)
Portugal	-0.143***	-0.486***	-0.885***	0.504	-0.070***	-1.098*
	(0.000)	(0.001)	(0.000)	(0.408)	(0.000)	(0.096)
Austria	-0.353***	-0.086***	-3.649***	-0.027	-4.016***	-0.081**
	(0.001)	(0.000)	(0.001)	(0.391)	(0.001)	(0.036)
Belgium	0.977	-0.103**	0.677**	-0.210**	3.461	-0.010
	(0.161)	(0.016)	(0.018)	(0.026)	(0.52)	(0.651)
Germany	-1.604***	-0.253**	-4.464***	-0.159*	3.731***	-0.176**
	(0.001)	(0.021)	(0.000)	(0.073)	(0.000)	(0.03)
France	0.939*	-0.034	1.243***	0.778***	0.805***	-0.965***
	(0.06)	(0.432)	(0.000)	(0.000)	(0.000)	(0.000)
Netherlands	2.347***	-0.056*	-3.906*	-0.164**	-8.403	0.036**
	(0.001)	(0.069)	(0.077)	(0.03)	(0.74)	(0.025)

Figure 1. Euro-area 10-year government benchmark bond yields (monthly, percent)



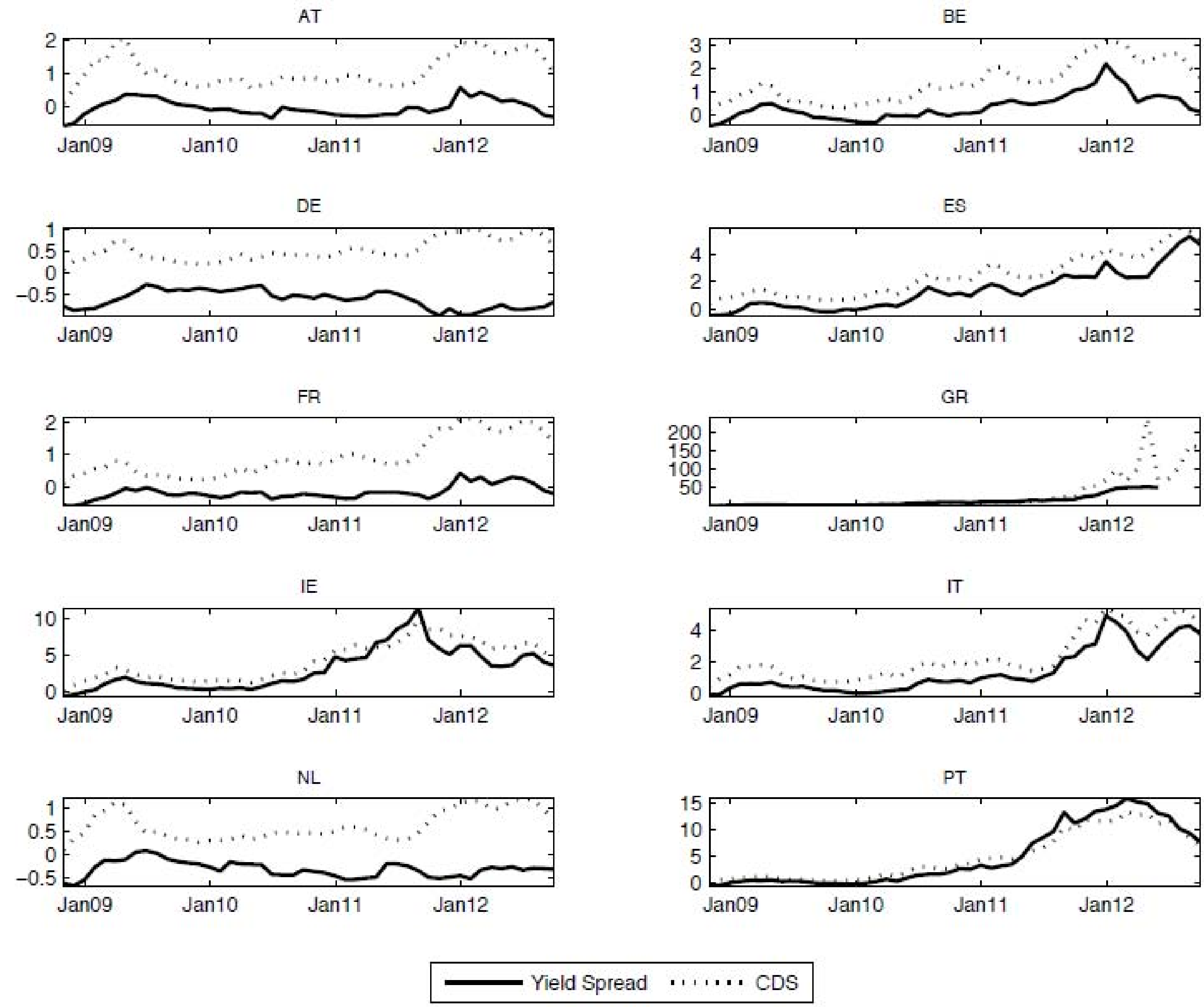
Source: Datastream.

Figure 2. Euro-area 5-year government CDS premia (monthly)



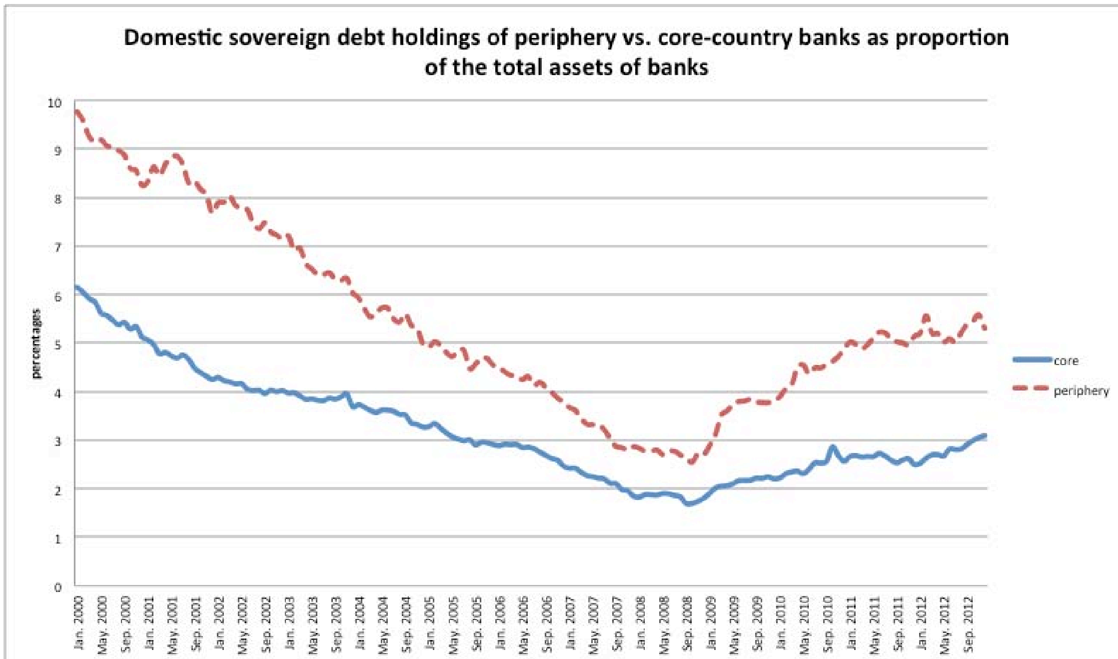
Source: Datastream.

Figure 3. Sovereign yield differentials and CDS premia, by country



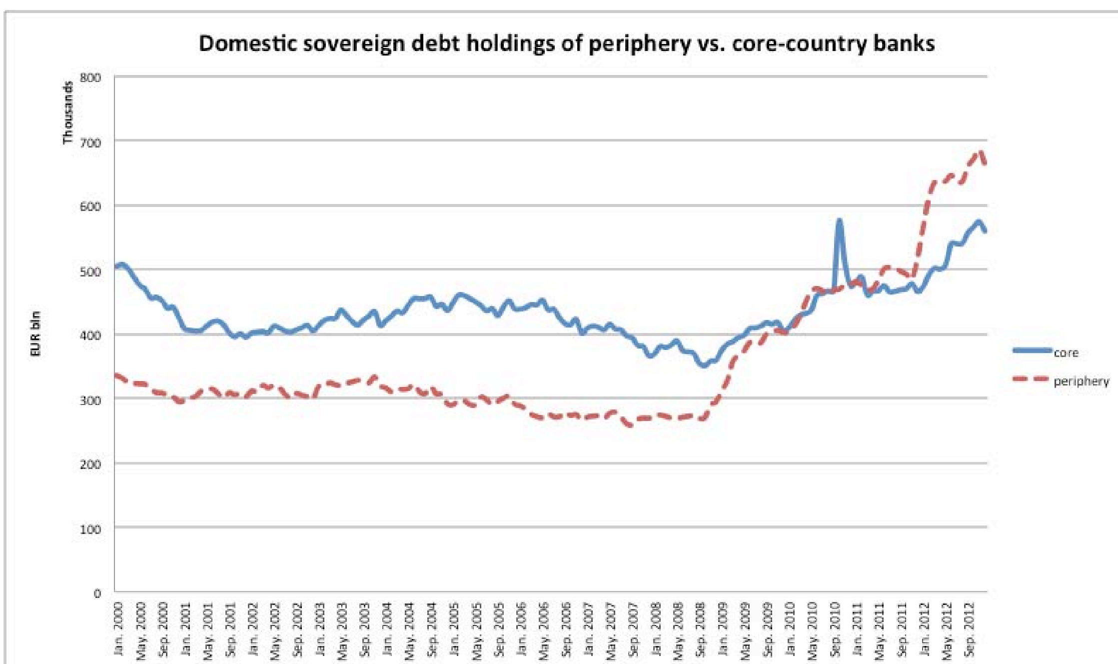
Source: Datastream.

Figure 4. Domestic sovereign debt holdings of periphery vs. core-country banks as proportion of the total assets of banks



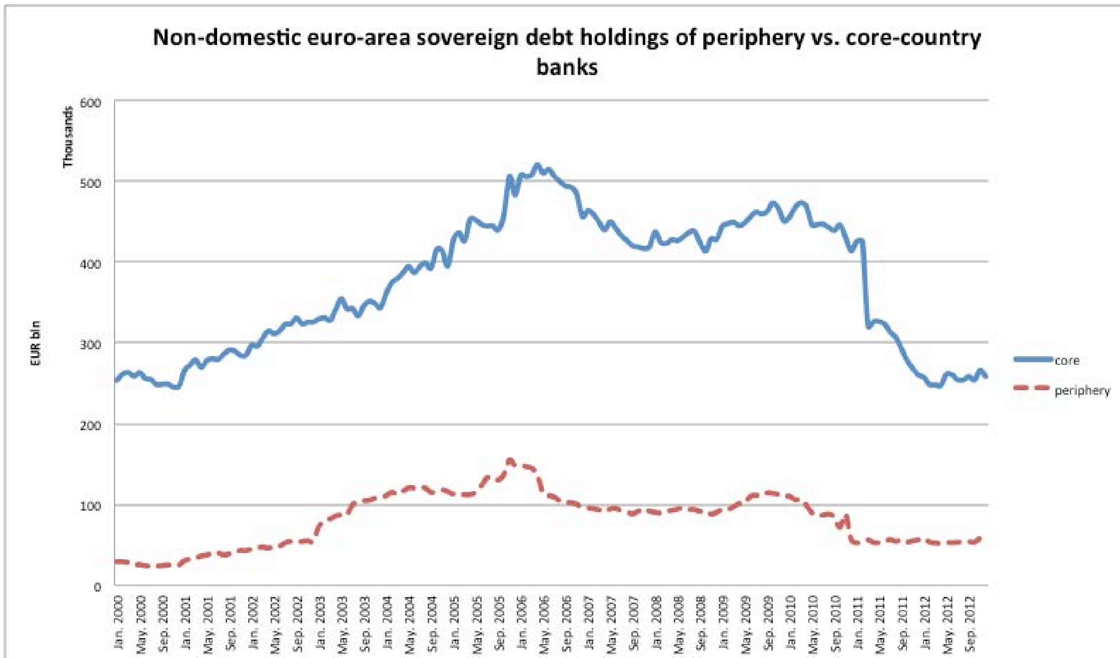
Sources: ECB and authors' calculations.

Figure 5. Domestic sovereign debt holdings of periphery vs. core-country banks



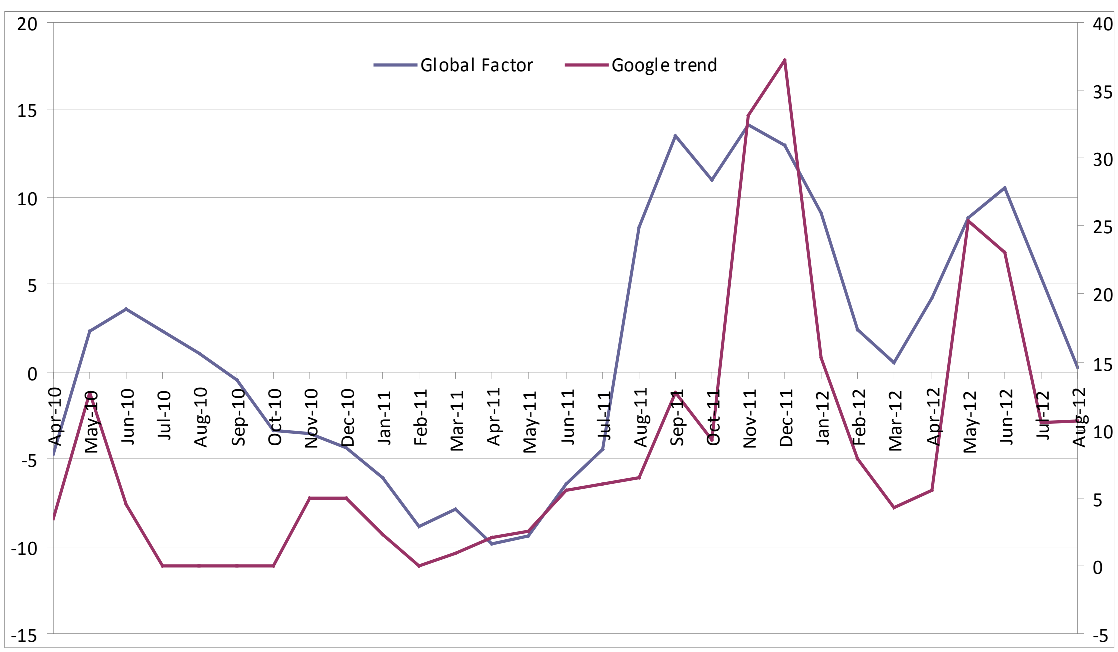
Sources: ECB and authors' calculations.

Figure 6. Non-domestic euro-area sovereign debt holdings of periphery vs. core-country banks



Sources: ECB and authors' calculations.

Figure 7. Common factor of yield differentials and CDS premia (left axis) and Google trend indicator of euro-area breakup risk (right axis)



Sources: authors' calculations and Google website.

Figure 8. Common factor of yield differentials and CDS premia (left axis) and Intrade-based probability of euro breakup (right axis)

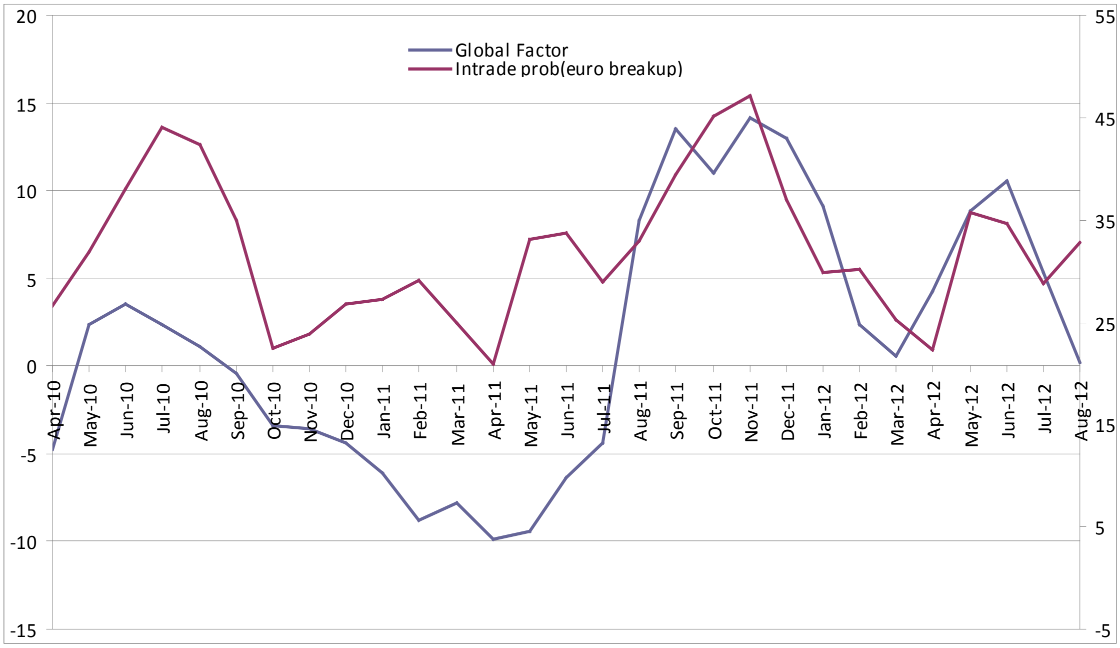


Figure 9. Common and country components of the German yield differential and CDS premium (first differences)

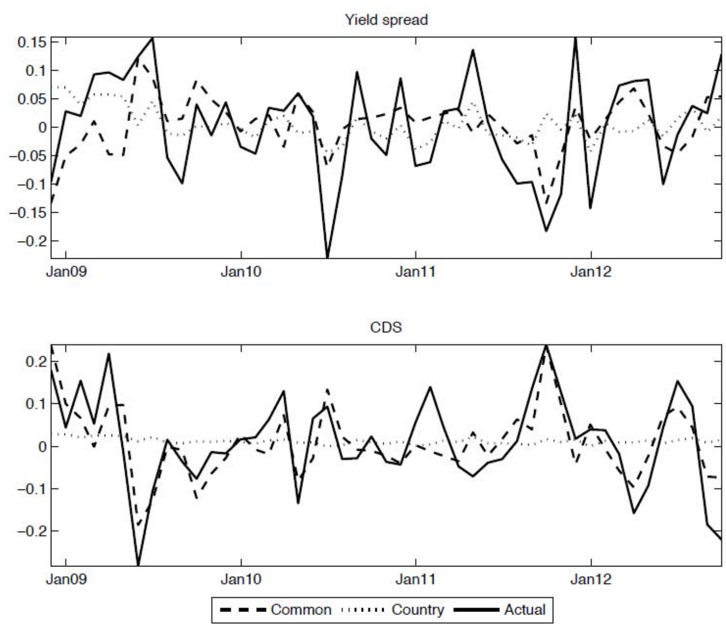


Figure 10. Common and country components of the Italian yield differential and CDS premium (first differences)

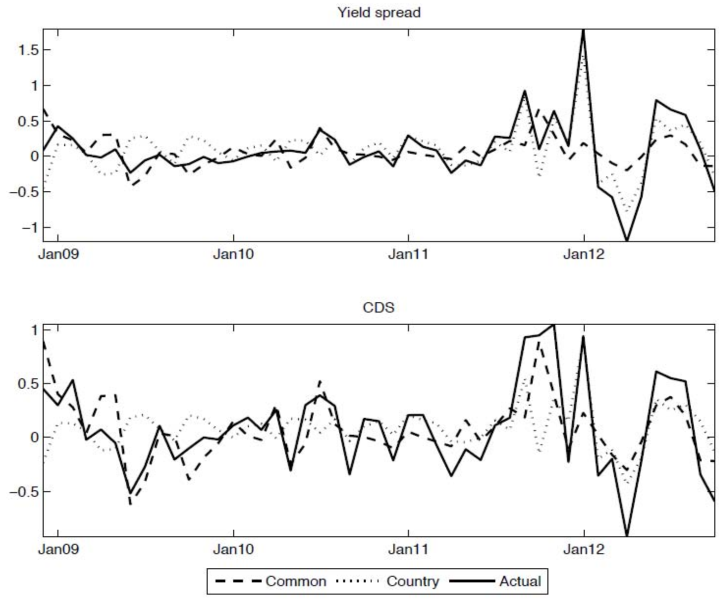


Figure 11. Common and country components of the Spanish yield differential and CDS premium (first differences)

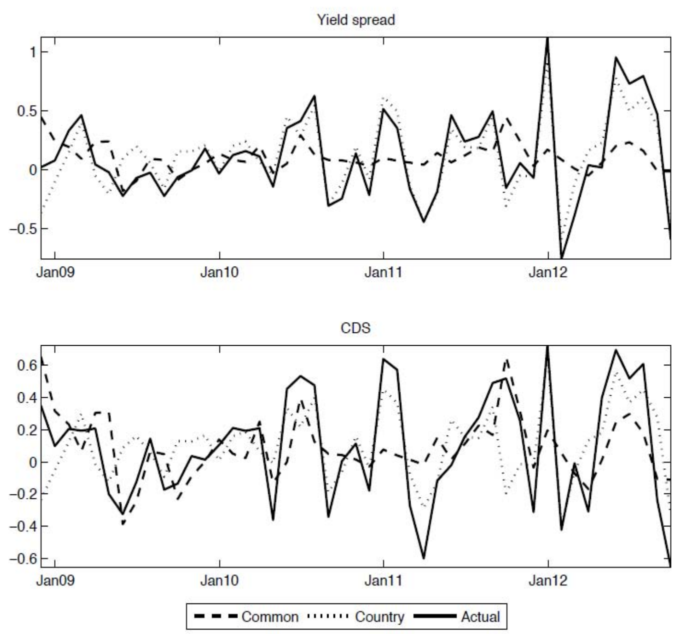
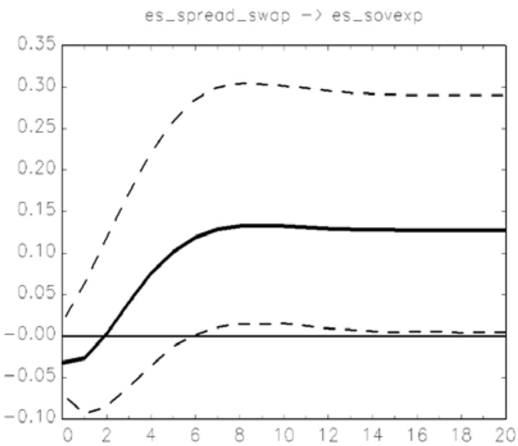


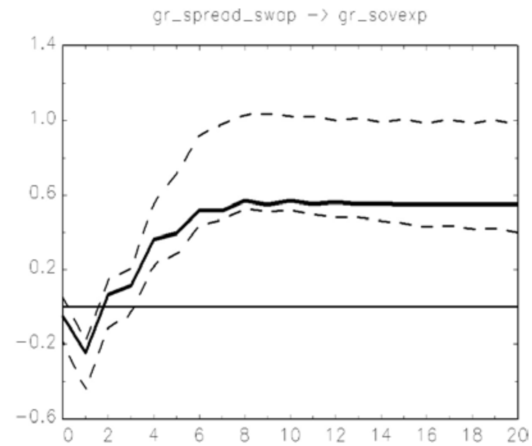
Figure 12. IRFs of domestic sovereign exposures to shocks in yield differentials

(a) Periphery countries

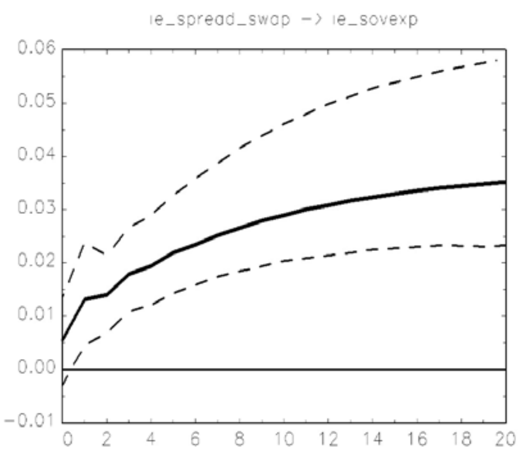
Spain



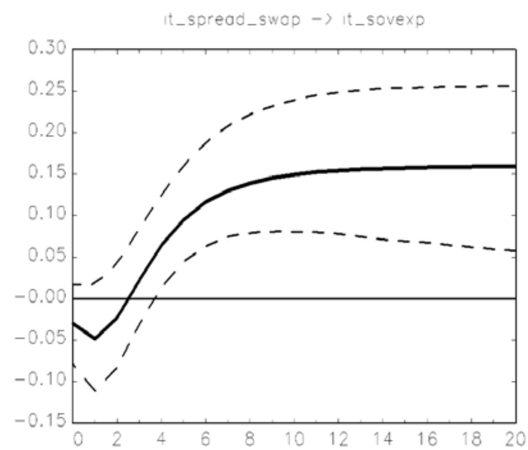
Greece



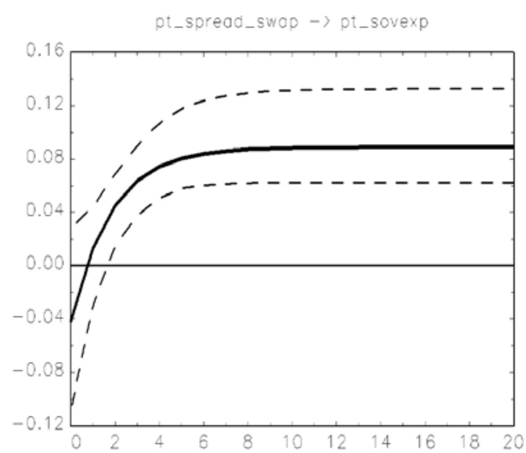
Ireland



Italy



Portugal

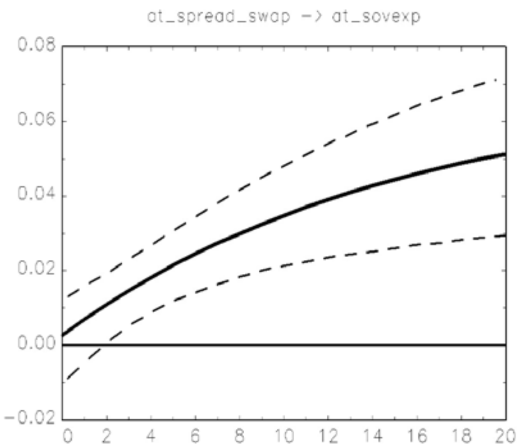


Notes: each chart reports point estimates (solid line) and 90% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

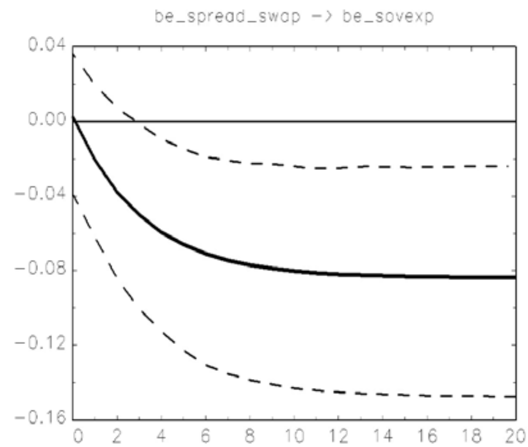
Figure 12 (continued)

(b) Core countries

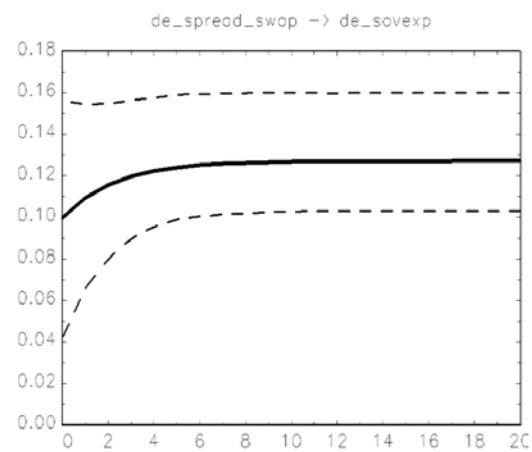
Austria



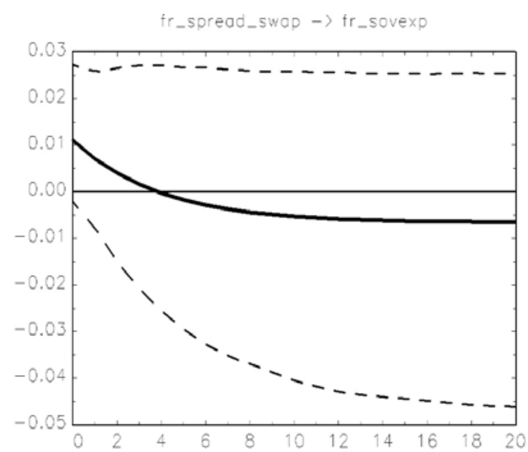
Belgium



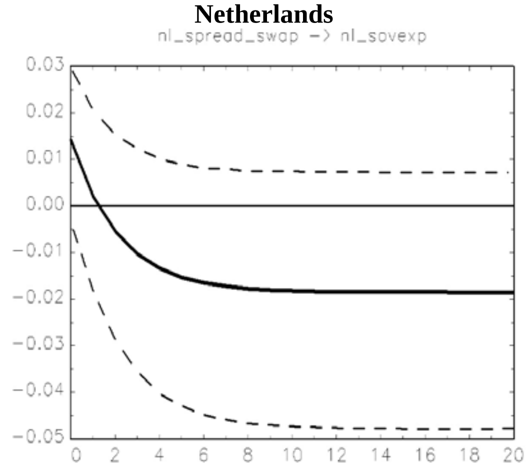
Germany



France



Netherlands

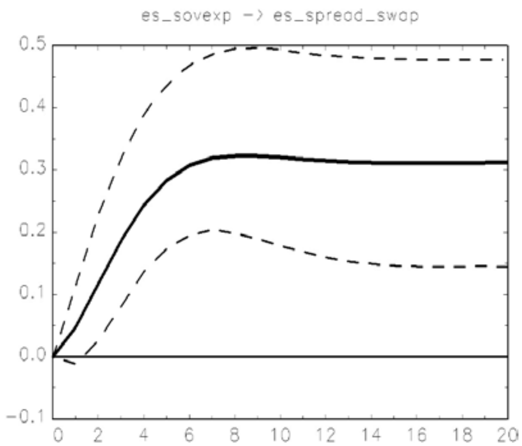


Notes: each chart reports point estimates (solid line) and 90% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

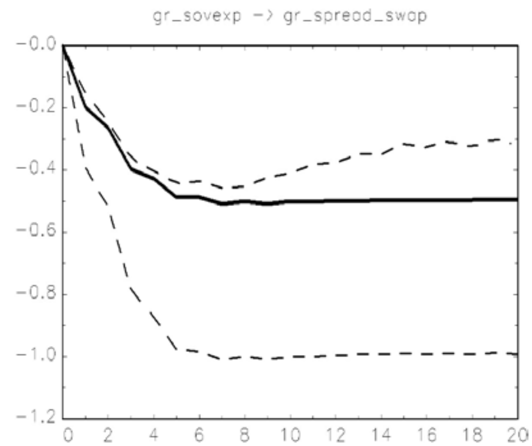
Figure 13. IRFs of yield differentials to shocks in domestic sovereign exposures

(a) Periphery countries

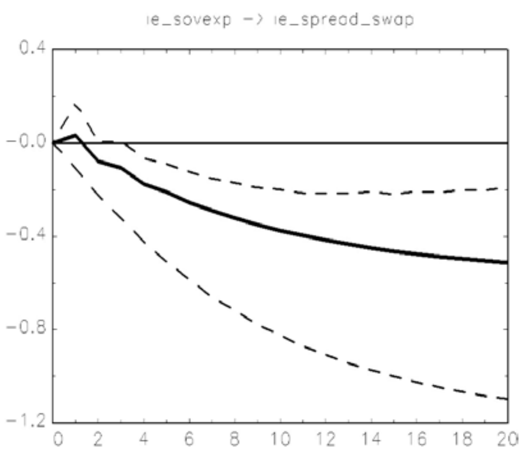
Spain



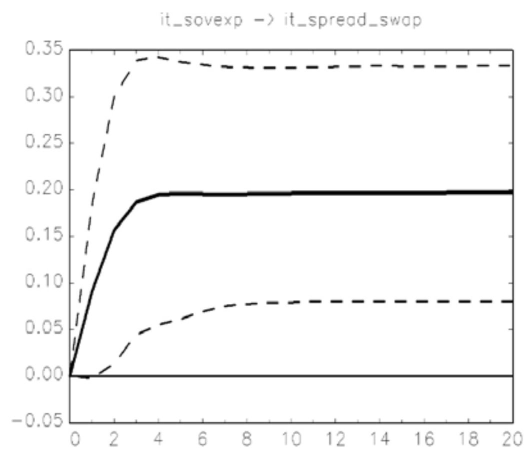
Greece



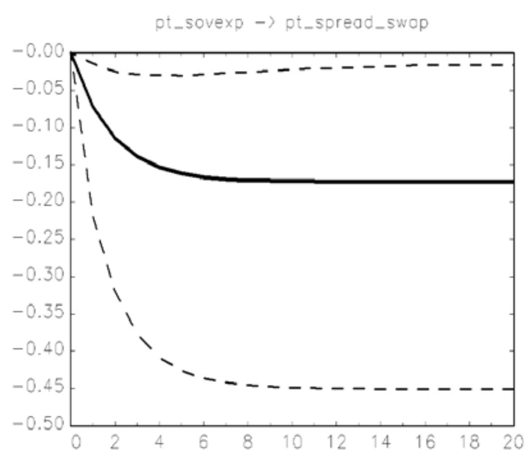
Ireland



Italy



Portugal

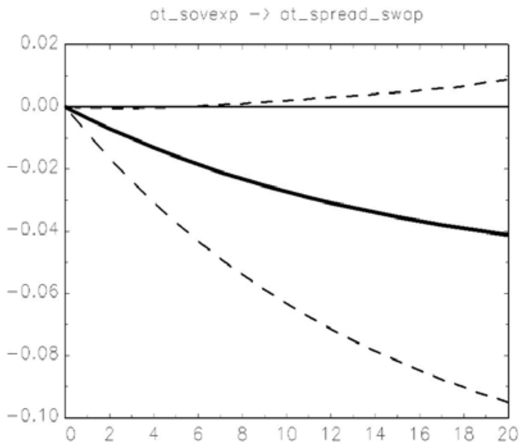


Notes: each chart reports point estimates (solid line) and 90% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

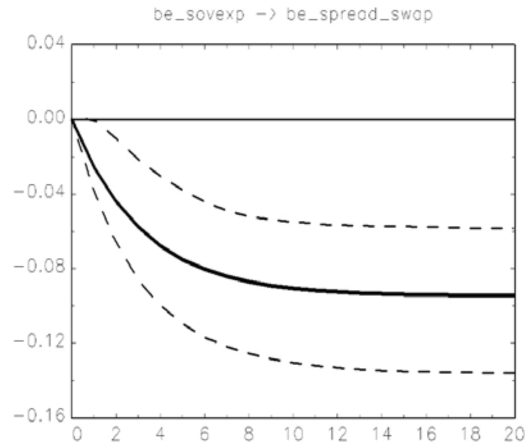
Figure 13 (continued)

(b) Core countries

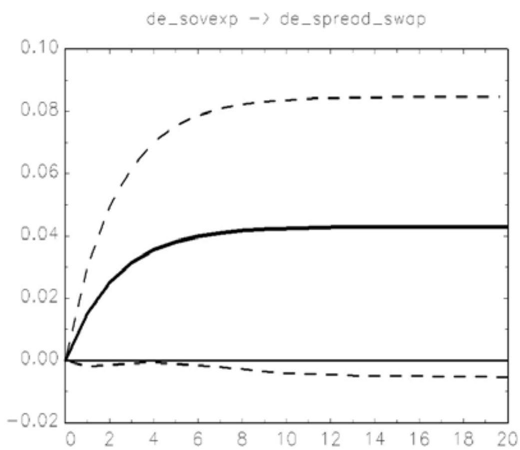
Austria



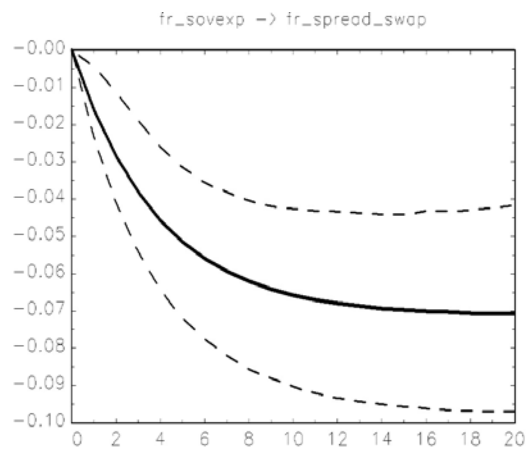
Belgium



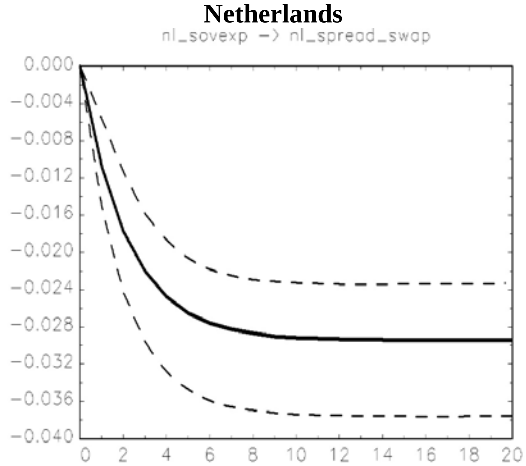
Germany



France



Netherlands

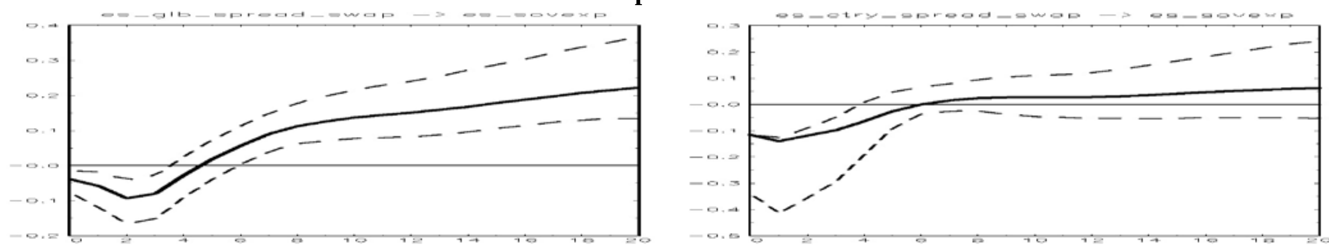


Notes: each chart reports point estimates (solid line) and 90% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

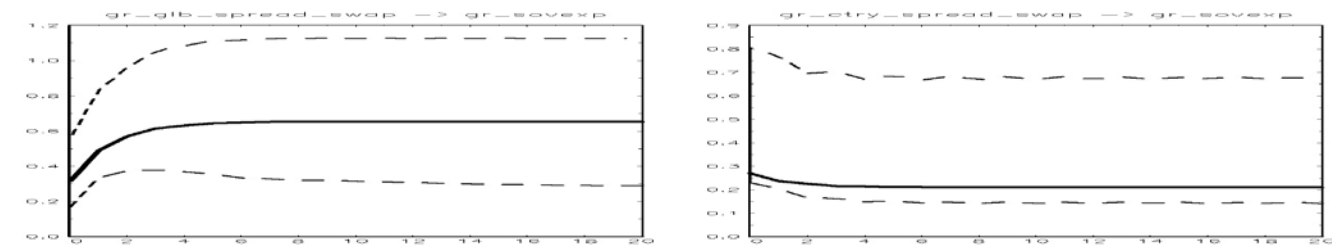
Figure 14. IRFs of sovereign exposures to the common and country components of yield differentials

(a) Periphery countries

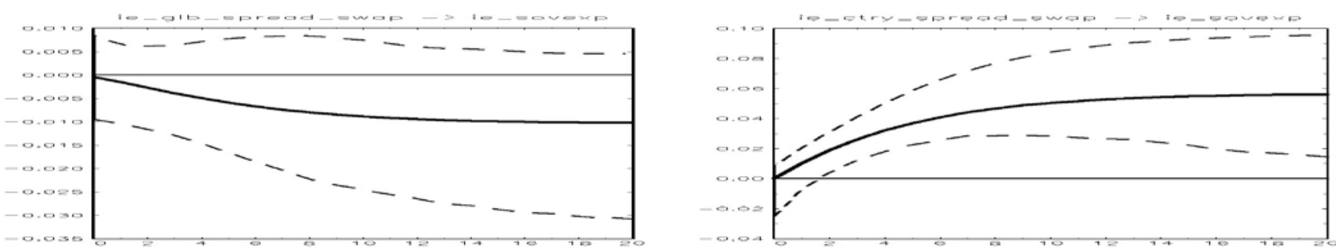
Spain



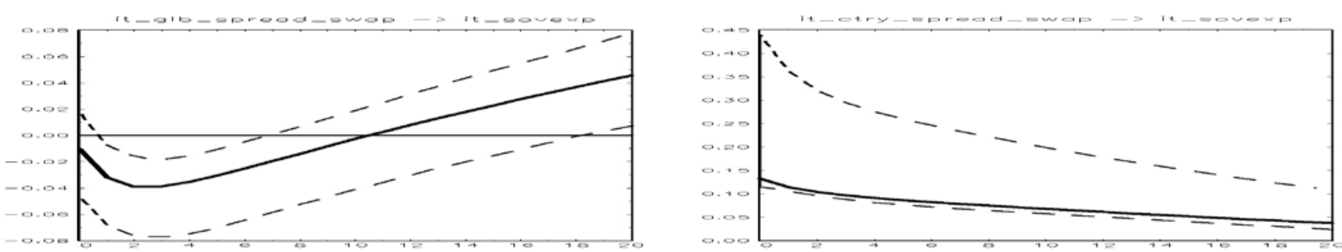
Greece



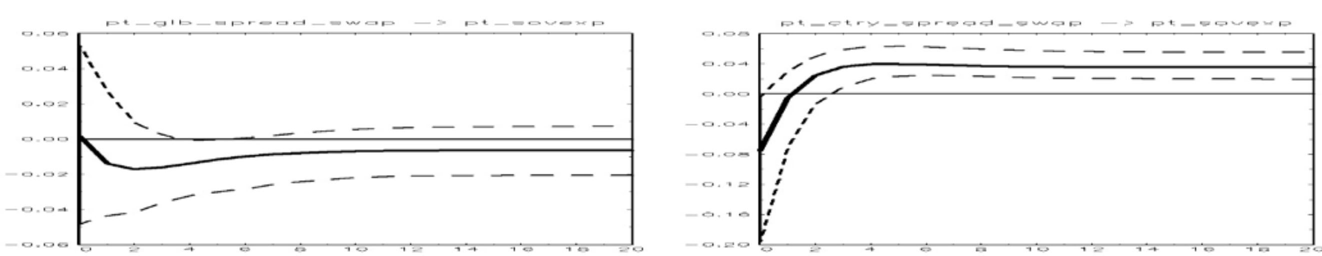
Ireland



Italy



Portugal

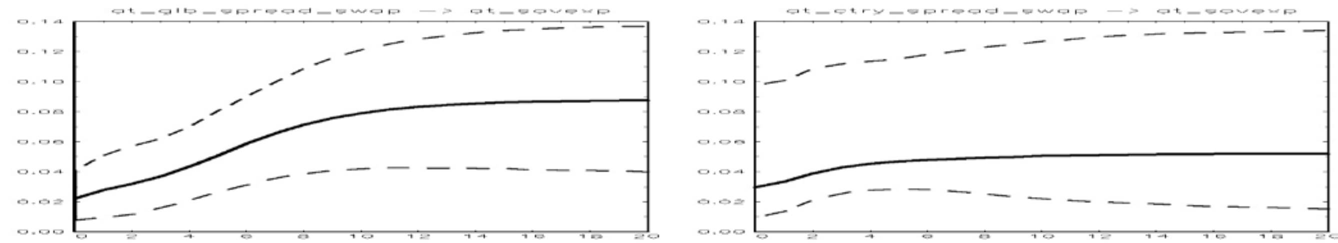


Notes: each chart reports point estimates (solid line) and 95% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

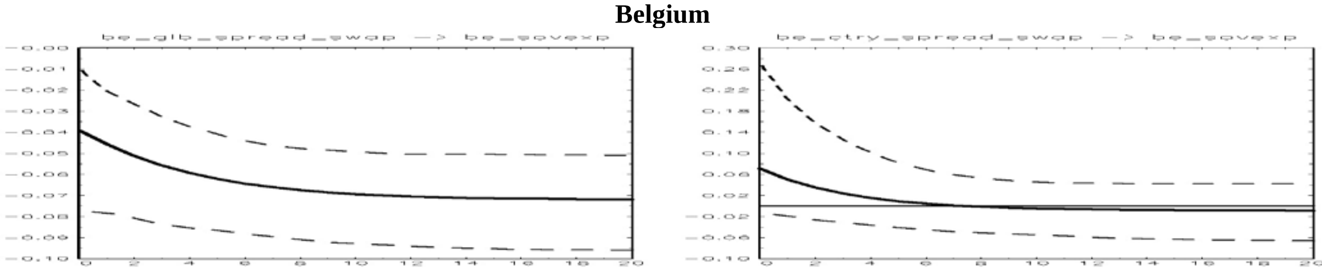
Figure 14 (continued)

(b) Core countries

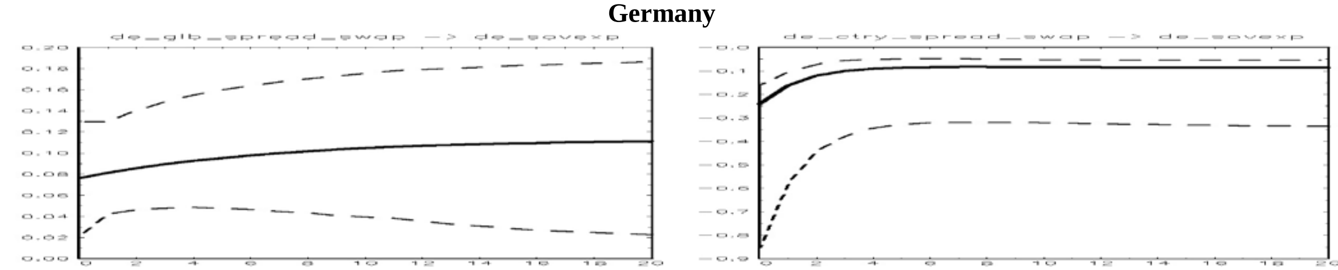
Austria



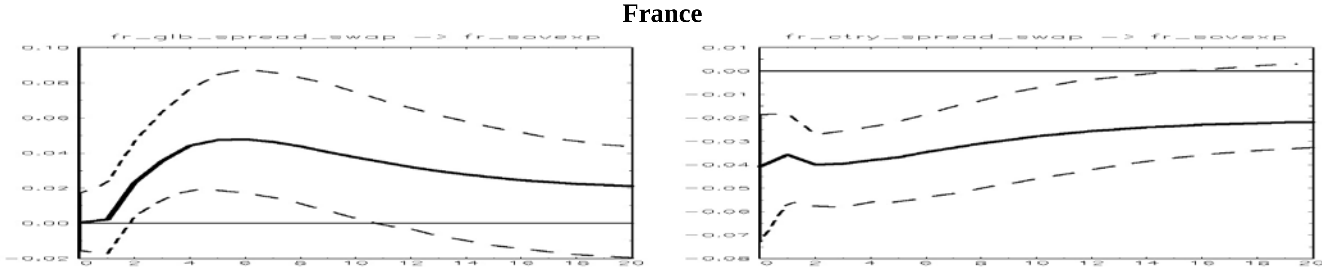
Belgium



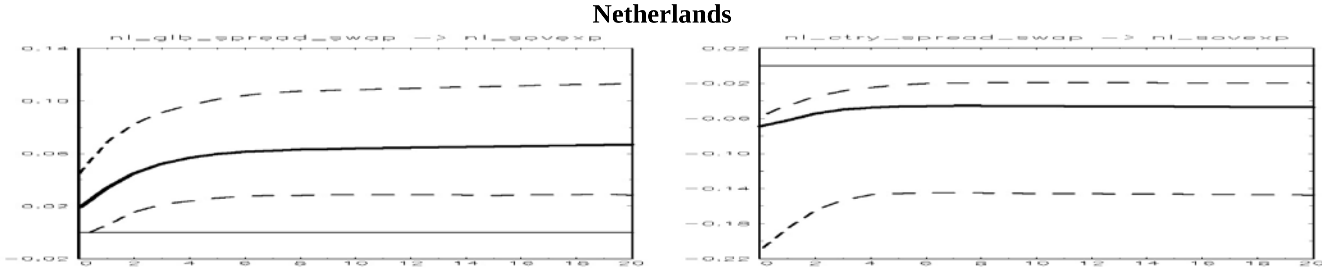
Germany



France



Netherlands



Notes: each chart reports point estimates (solid line) and 95% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

Appendix. Preliminary data analysis and specification search for the regressions of Table 2

This appendix presents the preliminary steps that lead to the specification of the VEC model whose estimates are presented in Table 2.

The first step is to control for the presence of unit roots in the data generating process (DGP). Taking a conservative approach, we carry out Augmented Dickey-Fuller (ADF) tests for all the time series and sampled countries within regressions with an optimal lag order (selected on the basis of the Schwarz-Bayes Information Criterion, SBIC, and the Hannan-Quinn Information Criterion, HQIC) and a constant drift. The results, reported in Table A1, hint at the presence of unit roots in every country's time series for the euro-area swap rate (*swap*), the domestic sovereign debt yields (*yield*) and the common component of domestic yield differentials (*common*). There is slightly weaker evidence of the presence of unit roots for the domestic sovereign exposures as a fraction of banks' total assets (*sovexp*), the domestic yield differentials (*spread*) and the country component of differentials (*country*). In particular, for Greece, Portugal and Austria, the null hypothesis of unit roots in both *sovexp* may be rejected at the 5% significance level (but not at the 1%); the Netherlands' yield differential is not significantly affected by unit roots at the 5% either (but it is at the 1%); finally, Germany, France and the Netherlands' country-level components do not display unit roots at conventional significance levels.

The second preliminary step addresses lead-lag relationships in the data. A Granger causality test is carried out on the sampled level time series. As a caveat, notice that such a test only verifies the presence of pairwise causality between two variables, hence disregarding potential effects due to other factors. As shown in Table A2, the estimates reveal that for periphery countries the variables are deeply interconnected: the null hypothesis of no Granger causality is mostly rejected (at the 10% significance level), in particular regarding the direction of causation from *spread* to *sovexp* and vice versa. On the basis of this first tests, a feedback loop does not seem to occur in core countries, where *sovexp* Granger causes *spread* but the opposite is not true (except for Austria). Notice that no signs of reverse causality between *sovexp* and *spread* emerge in Portugal at standard significance levels. As for the components of yield differentials, the strongest causation relationship runs from *common* and *country* (considered altogether) to *sovexp*: no signs of Granger causality emerge in Belgium only. Further, *sovexp*, together with *common* (*country*), apparently drives feedback effects towards *country* (*common*) at standard significance levels.

These two preliminary results indicate the presence of non-stationarity issues in the data and underscore the need to take into account the joint dynamics of domestic sovereign exposures, domestic sovereign yield differentials and their components. A vector error-correction model (VECM) has the necessary flexibility to deal with both of these issues. In searching for the specification of the VECM, we focus first on the determination of the cointegrating rank, i.e. the number of cointegration relations. Notably, we intend to verify whether long-run relationships, i.e. common stochastic trends, emerge in different dynamic systems including domestic sovereign debt exposures, domestic sovereign debt yield differentials and their components, *common* and *country*.

We carry out a Johansen's trace test in order to search for the correct specification of the VECM: the results are shown in Table A3. An analysis based on SBIC and HQIC indicates that the VECM models for different countries should include between zero- and two-lag differences of the endogenous variables. In order to achieve the best combination of simplicity and accuracy for the model, we recognize and account for the country-specificity of the considered time series. Notably, the final specification for each country's VECM is selected in light of ex-post model-checking tests (not reported), concerning (i) a stability analysis (control of eigenvalues, obtained both from the corresponding VAR companion form representation and the recursive estimation with all sampled residuals) and (ii) a residual analysis (Portmanteau and Lagrange Multiplier tests for autocorrelation in the residuals at different lag lengths and Lomnicki-Jarque-Bera test for non-normality). Hence, we opt for different specifications for the sampled countries, as shown in the table. The reported results for deterministic terms support a specification with cointegrating rank equal to 1 and 2 in the baseline model and in the factor-based model, respectively, for each country. The reported results for optimal lag orders refer to model specifications including the selected deterministic terms; where results from SBIC and HQIC differ, we carry out a recursive elimination of lag differences starting from the largest number of lags indicated by the two IC.

Table A1. ADF tests (H_0: Unit root): *p*-values

	sovexp	*yield*	*spread*	*common*	*country*	*swap*
Spain	0.236	0.132	0.272	0.493	0.074	-
Greece	0.029	0.982	0.919	0.258	0.312	-
Ireland	0.190	1.000	0.990	0.540	0.989	-
Italy	0.129	0.592	0.644	0.721	0.250	-
Portugal	0.032	1.000	1.000	0.451	0.996	-
Austria	0.022	0.836	0.576	0.721	0.155	-
Belgium	0.505	0.895	0.645	0.721	0.985	-
Germany	0.292	0.340	0.110	0.721	0.008	-
France	0.470	0.635	0.269	0.721	0.039	-
Netherlands	0.515	0.645	0.012	0.493	0.008	-
common	-	-	-	-	-	0.492

Table A2. Granger causality tests (H_0: No Granger causality): *p*-values

Dep. variable	Ind. variable	Spain	Greece	Ireland	Italy	Portugal	Austria	Belgium	Germany	France	Netherlands
sovexp	*spread*	0.035	0.000	0.003	0.001	0.346	0.039	0.596	0.975	0.491	0.104
spread	*sovexp*	0.000	0.069	0.845	0.005	0.252	0.001	0.067	0.002	0.005	0.000
sovexp	*common*	0.000	0.000	0.175	0.396	0.000	0.191	0.468	0.005	0.000	0.001
	country	0.002	0.000	0.012	0.106	0.376	0.002	0.564	0.836	0.000	0.192
	all	0.000	0.000	0.000	0.002	0.000	0.000	0.750	0.019	0.000	0.002
common	*sovexp*	0.778	0.001	0.124	0.713	0.298	0.863	0.782	0.030	0.000	0.789
	country	0.047	0.000	0.655	0.068	0.214	0.226	0.563	0.005	0.039	0.000
	all	0.140	0.000	0.252	0.069	0.115	0.389	0.655	0.003	0.000	0.000
country	*sovexp*	0.000	0.336	0.001	0.002	0.543	0.587	0.021	0.002	0.072	0.001
	common	0.077	0.437	0.017	0.045	0.099	0.000	0.874	0.004	0.115	0.019
	all	0.000	0.601	0.005	0.001	0.139	0.000	0.024	0.000	0.035	0.000

Table A3. VECM specification (based on Johansen's trace tests for cointegration and SBIC-HQIC for optimal lag order selection)

	Deterministic terms		Lag order	
	Baseline model	*Factor-based model*	*Baseline model*	*Factor-based model*
Spain	*rc, rltro*	*rc, rltro*	1	2
Greece	*uc, ut*	*uc, ut*	1	0
Ireland	*uc, ut*	*uc, ut*	1	0
Italy	*rc, rltro*	*rc, rltro*	1	0
Portugal	*uc, ut*	*uc, ut*	0	0
Austria	*rc*	*rc*	0	1
Belgium	*rc, ut, rltro*	*rc, ut, rltro*	0	0
Germany	*rc, rt, rltro*	*rc*	0	0
France	*rc, rltro*	*rc*	0	1
Netherlands	*rc*	*rc*	0	1

Notes: Reported tags for deterministic terms should be read as follows: *uc* as unrestricted constant; *rc* as restricted constant; *ut* as unrestricted trend; *rt* as restricted trend; *rltro* as restricted dummy variable (taking on value 1 from December 2011 onwards). Reported lag orders refer to the VECM representation of the corresponding model (e.g. a value of 1 indicates that the model includes one-lag differences of the endogenous variables, besides the error-correction term).