Systemic risk

SUMMARY

Since 2008, eurozone sovereign yields have diverged sharply, and so have the corresponding credit default swap (CDS) premia. At the same time, banks' sovereign debt portfolios have featured an increasing home bias. In this paper, 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 2007–13 monthly data. We find that in most countries of the eurozone, and especially in its periphery, banks' sovereign exposures respond positively to increases in yields. When bank exposures are related to the country and common risk components of yields, it turns out that (1) in the periphery, banks increase their domestic exposure in response to increases in country risk, while in core countries they do not; (2) in most eurozone countries banks respond to an increase in the common risk factor by raising their domestic exposures. Finding (1) suggests distorted incentives in periphery banks' response to changes in their own sovereign's risk. Finding (2) indicates that, when systemic risk increases, all banks tend to increase the home bias of their portfolios, making the eurozone sovereign market more segmented.

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Systemic risk, sovereign yields and bank exposures in the euro crisis

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1. INTRODUCTION

Starting from late 2008, the eurozone has experienced turmoil in financial markets: interbank markets have virtually frozen, and have been replaced by the European Central Bank (ECB) as the main source of liquidity for banks; sovereign debt yields of peripheral eurozone countries have repeatedly spiked above those of core countries; bank interest rates have also started to differ systematically across countries; portfolios

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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 eurozone 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 eurozone break-up 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 eurozone countries, especially periphery ones. But at the same time media, companies, investors and academics repeatedly have voiced concerns about the possible break-up of the eurozone. Between late 2010 and 2011 four issues of *The Economist* featured cover illustrations referring to the break-up of the euro.[1] In November 2011 the managers of several multinational companies disclosed euro break-up contingency plans.[2] In January 2012, the newsletter of global institutional investor PIMCO contemplated several break-up 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 eurozone in the subsequent 12 months, followed by Portugal, and assessed at 50% the chance that the eurozone 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]

Hence, in this paper we proceed in two steps. The first is to decompose sovereign yield differentials relative to the eurozone swap rate in a country-specific component due to sovereign default risk and a common component arising from redenomination

[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.)

risk. To this purpose, we estimate a dynamic two-factor model for eurozone 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 break-up 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 eurozone 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 eurozone swap rate:

1. 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.
2. Undercapitalized banks may bet for resurrection by engaging in 'carry trades' whereby they go 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 (2013) and Drechsler et al. (2013): insofar as most undercapitalized banks are in periphery countries, this may result in a home bias in the sovereign portfolios of periphery-country banks.
3. 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, for example the risk of collapse of the euro. Moreover, since in our sample period sovereign risk and yields increased appreciably only in the eurozone 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 eurozone domestic sovereign exposures to their respective yields and their components, obtained from our dynamic factor model, by estimating a vector error-correction model (VECM) on 2007–13 monthly data for ten

[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.

eurozone countries.[7] When the model is estimated using actual yields, the sovereign exposures of eurozone 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: (1) 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; (2) in contrast, in almost all countries banks increase their domestic exposures in response to an increase in the common risk factor.

Finding (1) 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 eurozone risk. It is worth noting that in equilibrium an increase in country-specific sovereign risk need not 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*.

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. Testing it would require data on core-country banks' holdings of periphery debt: if they engage in carry trades, these banks should respond to higher yields on periphery debt by increasing their exposure to periphery sovereigns. Unfortunately our data do not allow us to perform this test, since a two-entry matrix of eurozone banks' aggregate sovereign portfolios by holding and issuing countries is currently unavailable. However, using bank-level data on bank borrowing from the ECB, Drechsler *et al.* (2013) find that, during the euro crisis, banks from both core and periphery countries engaged in risk shifting (akin to our 'carry trade' hypothesis): in both groups of countries, weakly capitalized banks borrowed more and pledged riskier collateral to the ECB over time. Actually, according to their estimates in core countries risk-shifting can explain the entire variation in banks' collateral risk, while in periphery countries this variation is partly to be attributed also to other factors, including political economy motives (similar to our 'moral suasion' hypothesis).

Finding (2) 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

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

between the country and the common risk factors: they cannot be deduced only from the regressions based on the actual sovereign yields.

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 eurozone risk, since this increase was associated mostly with greater 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 policymaker. 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, credit default swap (CDS) premia and bank sovereign exposures in the eurozone. Section 3 uses dynamic factor analysis to decompose eurozone 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 explores the policy implications of our results.

2. EUROZONE SOVEREIGN YIELDS, CDS PREMIA AND BANK EXPOSURES: DATA DESCRIPTION

Eurozone 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 5-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

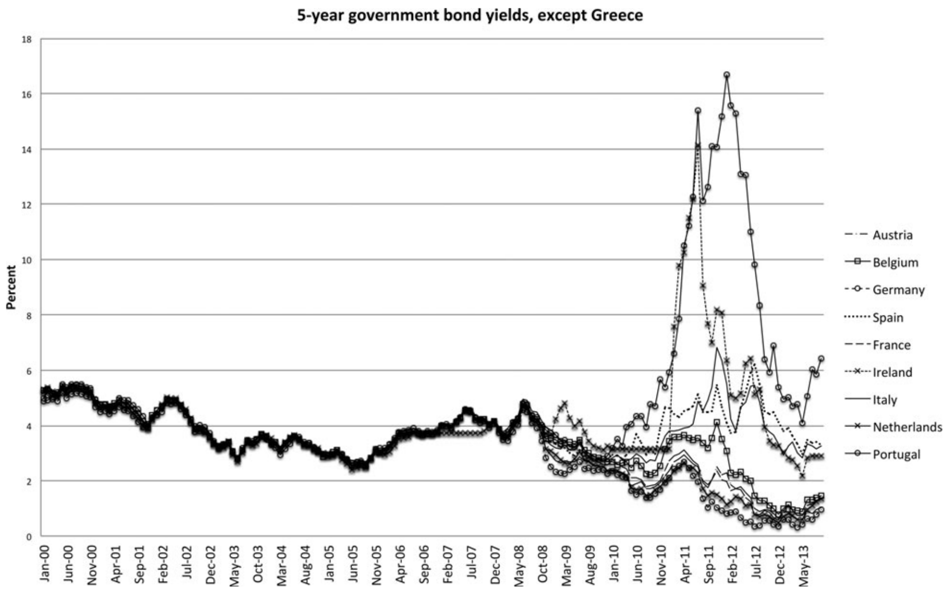

Figure 1. Eurozone 5-year benchmark government bond yields (monthly, percent)
Source: Bloomberg.

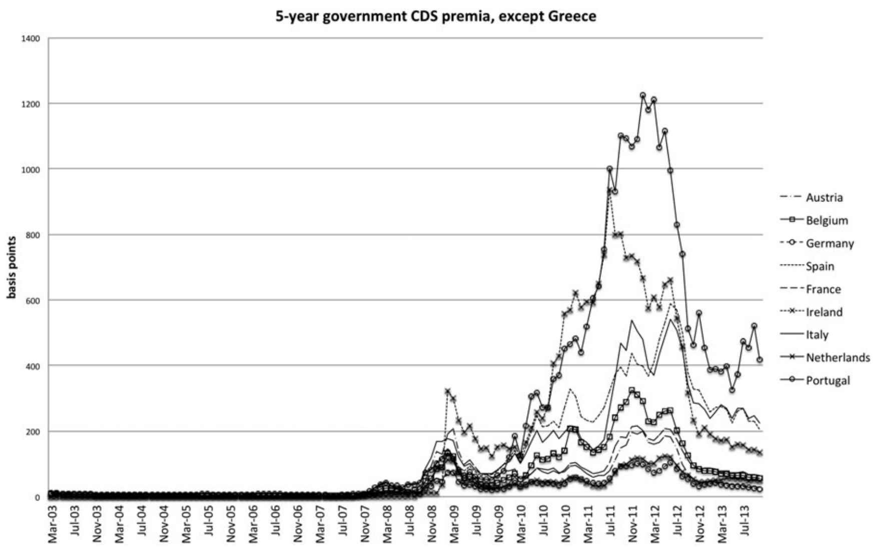

Figure 2. Eurozone 5-year government CDS premia (monthly, basis points)
Source: Bloomberg.

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 us to compare the time series behaviour of monthly sovereign yields and CDS premia on a country-by-country basis, from March 2007 to October 2013: for each country, it plots the difference between the 5-year sovereign yield and the swap rate for the 5-year maturity, together with the CDS premia for the same maturity. The two series grow over time and are very closely correlated for periphery eurozone 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 (–0.68). This striking difference can be interpreted as follows: when the risk of sovereign debt increases throughout the eurozone, it triggers a 'flight to safety' from periphery issuers towards core ones, and especially towards Germany, and therefore it increases the

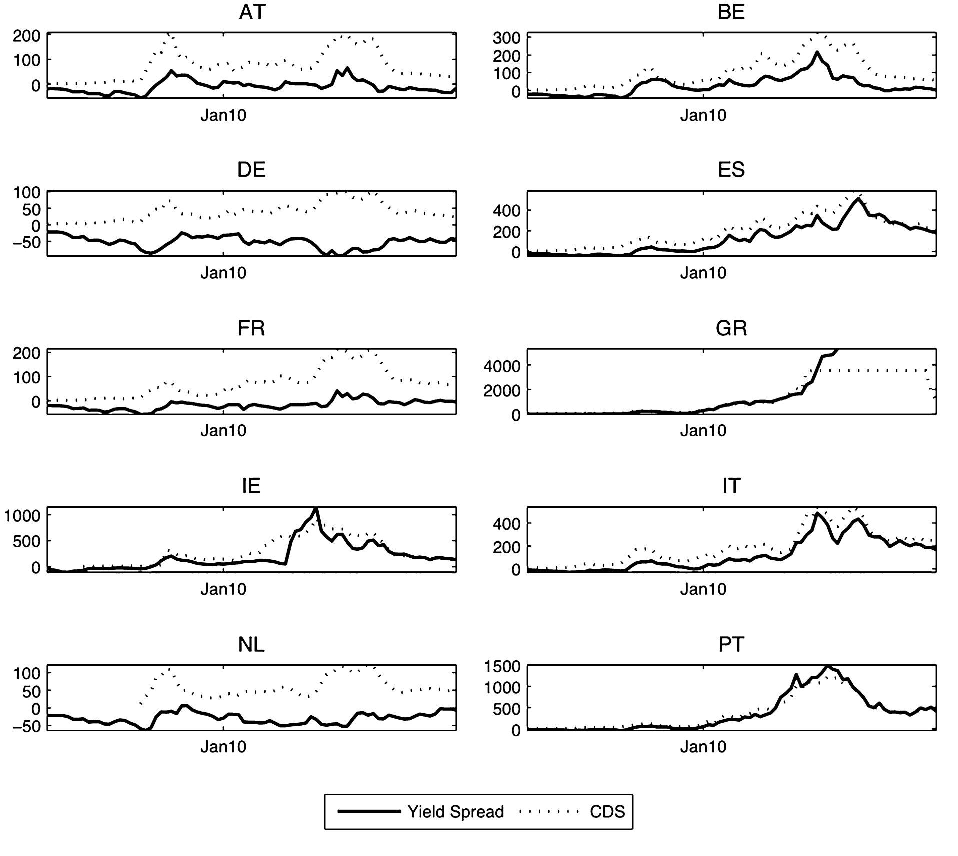

Figure 3. Sovereign yield differentials and CDS premia, by country

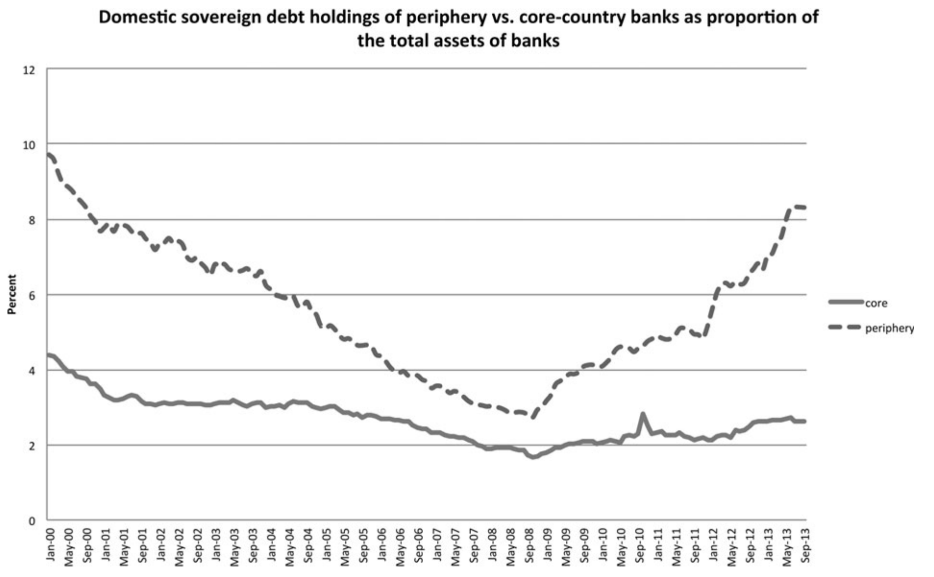

Figure 4. Domestic sovereign debt holdings of periphery versus core-country banks as proportion of the total assets of banks
Sources: ECB and authors' calculations.

yields of periphery countries while compressing the Bund yield, even though credit risk increases in Germany too. Hence, while the yield differentials of all other eurozone 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 eurozone as a whole – including Germany. Of course, the premise of this argument is that to some extent changes in eurozone sovereign risk have a common component, captured by correlated movements in CDS premia across the eurozone. 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 eurozone banks have featured an increasing degree of home bias. Figure 4 shows the time series of the domestic eurozone sovereign exposure of banks in eurozone core and periphery countries. Specifically, it plots the sum of the monthly values of the eurozone sovereign debt holdings of the banks from each of these two groups (drawn from the Statistical Data Warehouse (SDW) database) scaled by the total assets of those banks.[8]

[8] For the purpose of Figures 4, 5 and 6 we define Austria, Belgium, Finland, France, Germany and the Netherlands as 'core countries', and Greece, Ireland, Portugal, Spain and Italy as 'periphery countries' of the eurozone. In the econometric analysis of the subsequent sections, however, Finland is not included owing to data availability problems, and the set of 'core countries' is redefined accordingly. Our monthly data for banks' sovereign debt holdings 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 eurozone countries. These data contain the holdings by the banks in each eurozone country of (1) debt issued by all eurozone governments and (2) domestic government debt, from September 1997 onwards.

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 exposures until 2008, with periphery banks reducing their domestic 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 behaviour 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 eurozone debt holdings of banks in periphery and core countries (in billions of 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 €781 billion between October 2008 and September 2013, while those of core-country banks rose from €352 to €548 billion, a 131% increase in the former versus a 56% increase in the latter.

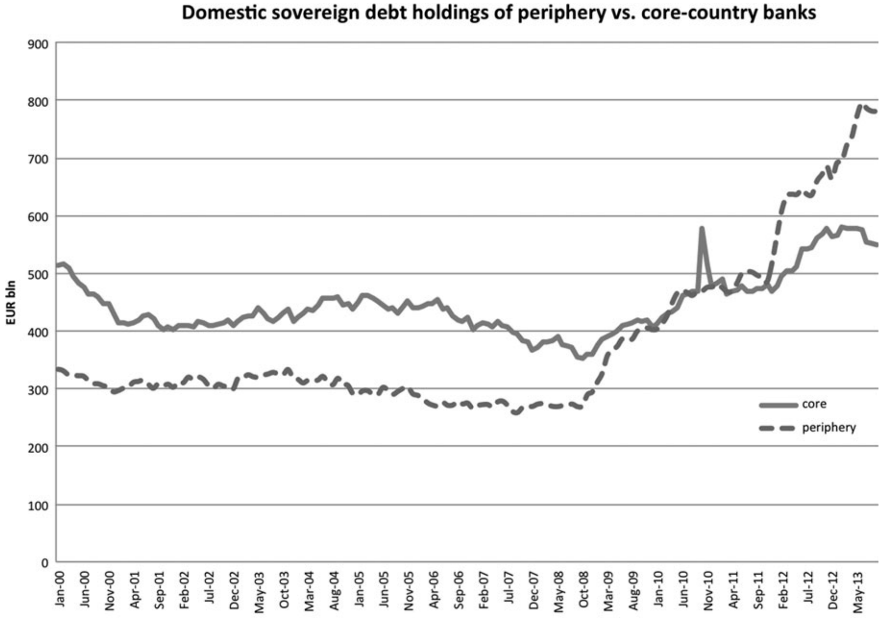

Figure 5. Domestic sovereign debt holdings of periphery versus core-country banks

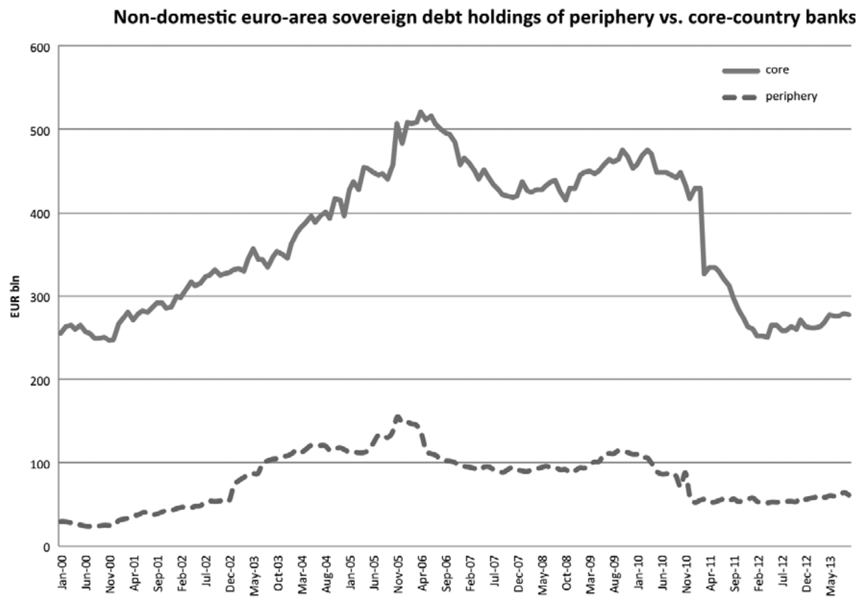

Figure 6. Non-domestic eurozone sovereign debt holdings of periphery versus core-country banks
Sources: ECB and authors' calculations.

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 foreign eurozone sovereigns: starting from 2006, banks in each group of countries have reduced their holdings of debt issued by the non-domestic sovereigns, 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 non-domestic sovereign debt from €430 billion in February 2011 to €277 billion in September 2013. Hence the overall picture is that of core-country banks reallocating their portfolios away from non-domestic sovereign debt and towards the debt issued by their domestic governments. Indeed, their shift away from non-domestic sovereign debt has been so large as to exceed their investment in domestic public debt, so that their eurozone sovereign holdings have decreased since late 2010. This has not been the case for banks in periphery countries, whose total holdings of eurozone sovereign debt have sharply increased.

Incidentally, this reshuffling of banks' sovereign portfolios towards domestic public debt is part of an increase in the home bias of their overall portfolios: during the eurozone crisis banks have also raised the fraction of domestic loans in their total lending, a 'flight-home' phenomenon that appears regularly in financial crises. Giannetti and Laeven (2012) document that the collapse of the global market for syndicated loans during the financial crises that occurred from 1997 to 2009 is partly owing to lenders rebalancing their loan portfolios in favour of domestic borrowers. Similarly, De Haas and van Horen (2012) show that after the collapse of Lehman Brothers large international banks reduced their cross-border lending, especially to clients located far away.

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 eurozone 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 the 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 eurozone issuer in three components: (1) a common factor, capturing world and eurozone shocks; (2) a country factor, reflecting shocks to that country's credit risk; (3) an unexplained idiosyncratic shock.[9] Of these three components, the country factor captures the shocks 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 eurozone as a whole: for instance, a statement by the Prime Minister of a major eurozone country that raises the likelihood of sovereign default by that country might lead investors to reassess the likelihood of collapse of the monetary union, and thereby 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.

[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 *et al.*, 2004, and Watson, 2004).

Our study is related to Ang and Longstaff (2013), who use CDS spreads to study the nature of sovereign credit risk for the US Treasury, individual US states, and major European countries. They use a multifactor affine framework that allows for both systemic and sovereign-specific credit shocks, and find that the sensitivity to systemic risk differs considerably across US and European issuers, which parallels our findings for eurozone countries. Interestingly, Ang and Longstaff document that the highly integrated US 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 eurozone, a danger clearly absent in the United States.

Many other studies have analysed 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-to-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 break-up 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 eurozone. 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

Monthly sovereign yield differentials and CDS premia are the main inputs of our dynamic factor model. Data for both are drawn from the Bloomberg database. For each country, we compute the difference between the 5-year sovereign yield and the 5-year euro swap rate (referring to a swap between a 5-year bond and 12-month Euribor). CDS premia also refer to the 5-year maturity. The dynamic factor model includes 15 countries, 10 of which belong to the eurozone (Austria, Belgium, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) and 5 do not (Denmark, Japan, Sweden, United Kingdom, and United States).

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: (1) measures of the 'appetite for risk' at the global and European level, namely the percentage change of the VIX and VSTOXX indices; (2) 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 swap rate, Δp_c the percentage change in its sovereign CDS premium, and z_c its stock market return. Moreover, let $(x_1, \ldots, x_n)'$ 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:

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

[10] Stock market price indices, the VIX index, and the VSTOXX index are drawn from Bloomberg. The euro-dollar exchange rate and the effective exchange rate are drawn from the ECB database.

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

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

where $A(L)$ is diagonal with two lags, so that the factors are orthogonal, and the errors 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).[11]

3.3. Results

We now present the results of the estimation of the dynamic factor model just described over the interval from March 2007 to October 2013. 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 September 2013.

One way to gauge the concern of investors about the risk of euro break-up is to look at the intensity with which such concern translated in their Google clicks, as captured by a Google Trends index that measures how often search-terms related to the

[11] This maximum likelihood approach differs from the principal component (PC) analysis for three reasons. First, it allows imposing over-identifying restrictions on the factor model to capture the presence of common and country-specific factors. Second, it may lead to efficiency improvements over the principal component method. Finally, once we have a parametric model estimated by likelihood methods, it is possible to handle missing data. The latter feature is important in our case, because we have an unbalanced panel due to the missing observations for CDS premia and sovereign yield spreads, both at the beginning and at the end of the sample. Hence, compared with PC analysis, our maximum likelihood approach allows us to estimate factors over a longer time interval, which also includes the sub-periods from March 2007 to September 2008 and from February 2012 to October 2013.

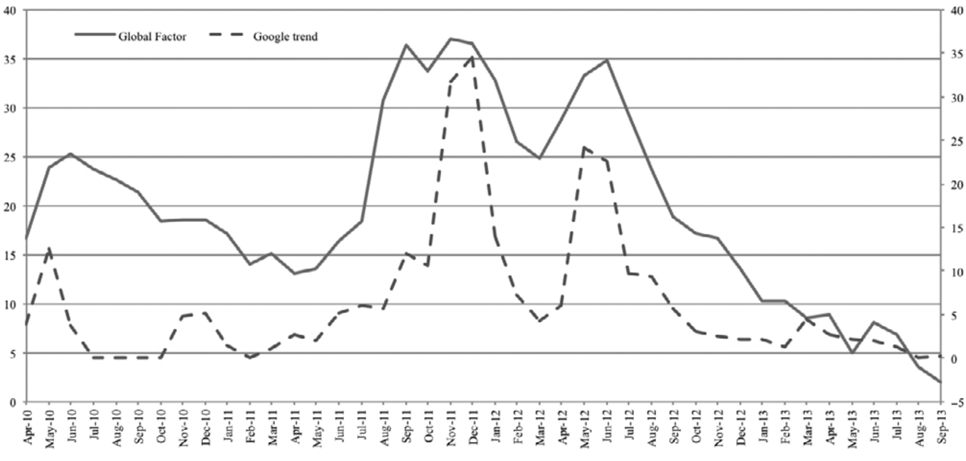

Figure 7. Common factor of yield differentials and CDS premia (left axis) and Google trend indicator of eurozone break-up risk (right axis)
Sources: Authors' calculations and Google website.

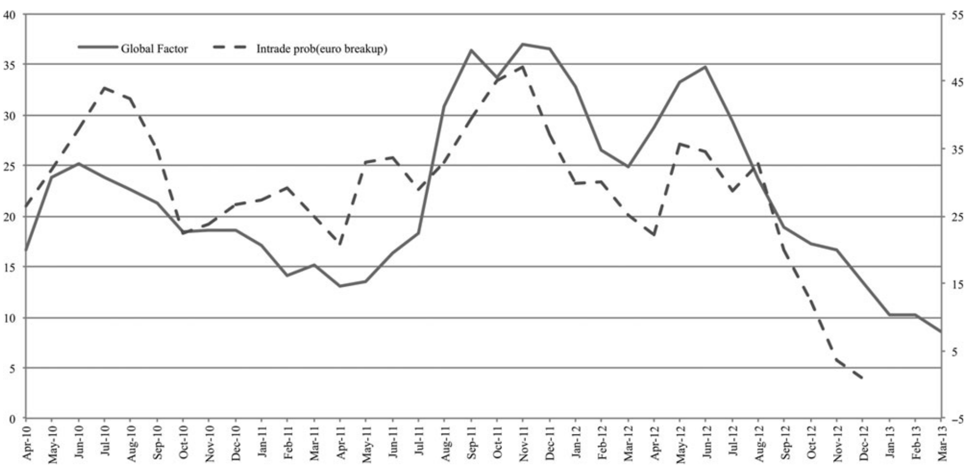

Figure 8. Common factor of yield differentials and CDS premia (left axis) and Intrade-based probability of euro break-up (right axis)

collapse of the euro were entered in the Google search engine, relative to the total worldwide search-volume.[12] In Figure 7, we plot this search frequency index together with the estimated common factor: the correlation between the two series is 0.73, and their turning points coincide.

12 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.

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 eurozone is one such event, and the price of the corresponding contract (relative to its pay-off 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 12 March 2008 would announce its intention to drop the euro as its national currency or would be expelled from the eurozone before the end of 2012, based on Intrade data.[13] The correlation coefficient with our common factor is 0.60 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 particular, it peaks in October and November 2011, when the Greek prime minister proposed a referendum for the euro, and then resigned to be replaced by Papademos. In that period, German officials approached Greek ones with proposals about a Greek orderly exit from the euro.[14] Indeed in November 2011 the *Financial Times* reported of multinational companies' preparations for the possible euro break-up. The common factor peaks again in May and June 2012, a time of considerable political uncertainty in Greece, which led to two successive general political elections in essentially a month's time. Coincidentally, 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, which laid out the basis for the ECB's Outright Monetary Transaction (OMT) policy.[15]

3.3.2. The relative importance of the common and country risk factors. Identifying the common and country-specific factors allows us to estimate the fraction of the variance in the yield differentials relative to the swap rate that can be

[13] 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 1 December 2012 that the euro will be dropped in June 2013 the market will be settled at $10.00 (the contract's notional settlement value) on the date of the announcement (1 December 2012) and not the date the euro will no longer be used (June 2013).

[14] See the statements by former ECB Board member Lorenzo Bini-Smaghi reported in www.cnbc.com/id/101031815.

[15] 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.' The OMT policy is a program under which the ECB makes secondary market purchases ('outright transactions') of eurozone sovereign bonds, once a eurozone government asks for financial assistance.

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, with the exception of Greece and Ireland, whose yields are mainly idiosyncratic, and of Germany, whose yield is equally explained by the common factor.[16] Indeed, the common factor affects mainly the German yield, which can be interpreted as reflecting investors' 'flight to quality' when 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 eurozone countries, but that its role differs greatly across countries, in line with what is found by Ang and Longstaff (2013) with a different methodology. In particular, common risk plays a minor role in countries that have been involved in a sovereign bailout programme by the EFSF/ESM (Greece, Ireland and Portugal). But for most of the eurozone periphery, country-specific risk is also important: this is the case for Italy, Portugal and Spain, and to a more limited extent for Ireland.

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 eurozone countries, and for over one-fourth 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

[16] For Greece, the idiosyncratic component is particularly large, while the country component is modest. This is explained by the fact that in October 2011 investors agreed a 'haircut' of 50% in converting their existing bonds into new loans, leading to a freeze of the Greek CDS market: in our data, the Greek sovereign CDS price becomes constant from October 2011 onwards. Since in our dynamic factor model the country component is driven by the country-level correlation between CDS and yield spreads, the constancy of the CDS premium in 1/4 of the sample considerably reduces the variance explained by the country risk component, and raises that explained by the idiosyncratic component.

Table 1. Dynamic factor model estimation: variance decomposition

Country	Variable	Common	Country	Idiosyncratic
Austria	Δ Sovereign yield	0.05	0.86	0.09
Belgium	Δ Sovereign yield	0.17	0.45	0.38
Germany	Δ Sovereign yield	0.36	0.32	0.32
Spain	Δ Sovereign yield	0.21	0.72	0.07
France	Δ Sovereign yield	0.01	0.95	0.04
Greece	Δ Sovereign yield	0.03	0.27	0.69
Ireland	Δ Sovereign yield	0.00	0.34	0.66
Italy	Δ Sovereign yield	0.29	0.74	−0.02
Netherlands	Δ Sovereign yield	0.04	0.92	0.04
Portugal	Δ Sovereign yield	0.01	0.83	0.16
Denmark	Δ Sovereign yield	0.02	0.97	0.01
U.K.	Δ Sovereign yield	0.11	0.81	0.08
Sweden	Δ Sovereign yield	0.10	0.89	0.01
U.S.	Δ Sovereign yield	0.14	0.62	0.24
Japan	Δ Sovereign yield	0.01	0.89	0.10
Austria	Δ CDS premium	0.67	0.15	0.19
Belgium	Δ CDS premium	0.56	0.17	0.27
Germany	Δ CDS premium	0.60	0.07	0.33
Spain	Δ CDS premium	0.43	0.47	0.10
France	Δ CDS premium	0.65	0.04	0.31
Greece	Δ CDS premium	0.05	0.61	0.34
Ireland	Δ CDS premium	0.13	0.21	0.66
Italy	Δ CDS premium	0.59	0.35	0.06
Netherlands	Δ CDS premium	0.49	0.06	0.45
Portugal	Δ CDS premium	0.11	0.73	0.16
Denmark	Δ CDS premium	0.56	0.01	0.43
U.K.	Δ CDS premium	0.41	0.01	0.58
Sweden	Δ CDS premium	0.58	0.03	0.39
U.S.	Δ CDS premium	0.24	0.09	0.67
Japan	Δ CDS premium	0.43	0.07	0.50
Austria	Stock market return (%)	0.79	0.02	0.19
Belgium	Stock market return (%)	0.80	0.02	0.18
Germany	Stock market return (%)	0.75	0.00	0.25
Spain	Stock market return (%)	0.69	0.03	0.28
France	Stock market return (%)	0.81	0.02	0.18
Greece	Stock market return (%)	0.72	0.02	0.26
Ireland	Stock market return (%)	0.60	0.01	0.39
Italy	Stock market return (%)	0.83	0.00	0.17
Netherlands	Stock market return (%)	0.71	0.00	0.29
Portugal	Stock market return (%)	0.68	0.00	0.32
Denmark	Stock market return (%)	0.62	0.00	0.38
U.K.	Stock market return (%)	0.67	0.08	0.25
Sweden	Stock market return (%)	0.62	0.00	0.38
U.S.	Stock market return (%)	0.71	0.00	0.29
Japan	Stock market return (%)	0.53	0.00	0.47
	Δ VIX (%)	0.26		0.74
	Δ VSTOXX (%)	0.31		0.69
	Δ effective exchange rate (%)	0.26		0.74
	Δ euro-dollar exchange rate (%)	0.08		0.92

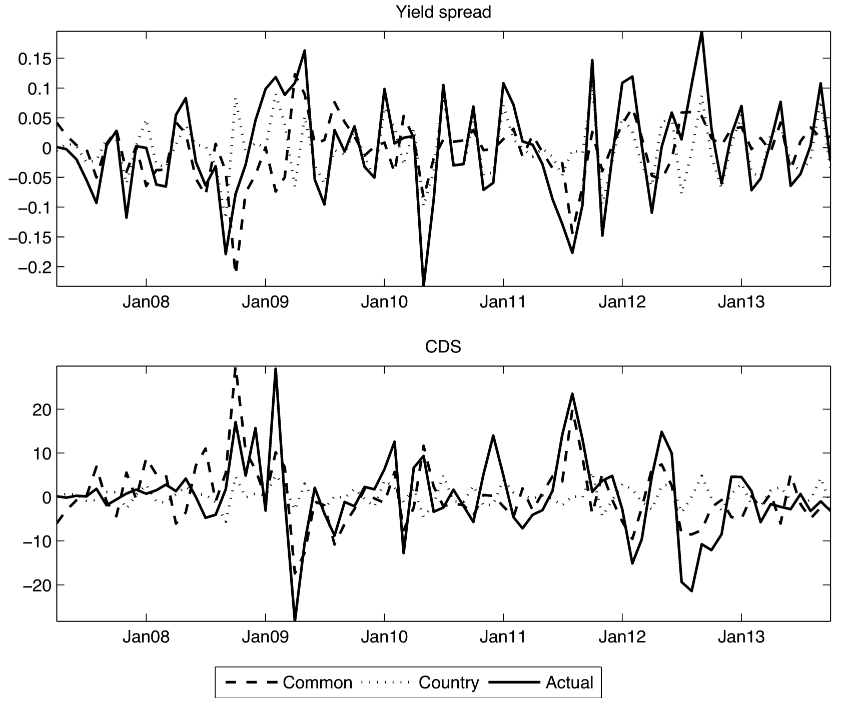

Figure 9. Common and country components of the German yield differential and CDS premium (first differences)

German one drops sharply.[17] The opposite happens towards the 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 induce generalized changes in CDS premia, including those of core countries (though more so in the periphery), while they push bond yields in opposite directions, with investors flying away from periphery bond markets towards the core of the eurozone, or vice versa.

4. HOME BIAS IN BANKS' SOVEREIGN EXPOSURES, YIELD DIFFERENTIALS AND SYSTEMIC RISK

Section 2 documents two aggregate patterns in the eurozone market for sovereign debt: (1) the home bias of banks' sovereign debt portfolios decreased until 2008, and then started increasing; (2) sovereign yield differentials were close to zero until the same date, and then started widening. In this section, we investigate whether these

[17] Interestingly, in Figure 10 the estimated country-specific component of the yield spread for Italy falls sharply at the end of December 2011 and beginning of January 2012, exactly at the time when the newly appointed Monti government announced and started implementing its new agenda and passed emergency economic legislation, thus calming the Italian public debt market.

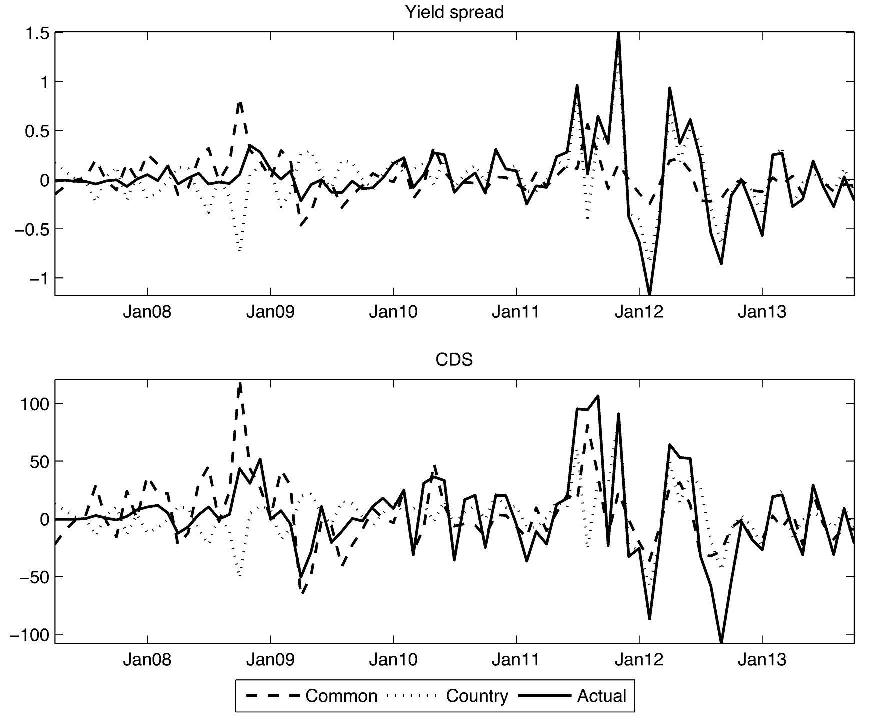

Figure 10. Common and country components of the Italian yield differential and CDS premium (first differences)

two facts are related, namely, whether banks' home bias (a quantity-based measure of segmentation) is related to domestic 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:

1. 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.
2. The tendency by undercapitalized banks, which are mostly located in the eurozone 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.
3. The 'comparative advantage' of each country's banks in bearing the currency redenomination risk of their country's sovereign debt, arising from the potential break-up of the eurozone.

The first two motivations are compatible with banks increasing their domestic exposures not only in response to greater systemic eurozone risk but also in response to increased country-specific risk; in contrast, the third motivation implies that banks

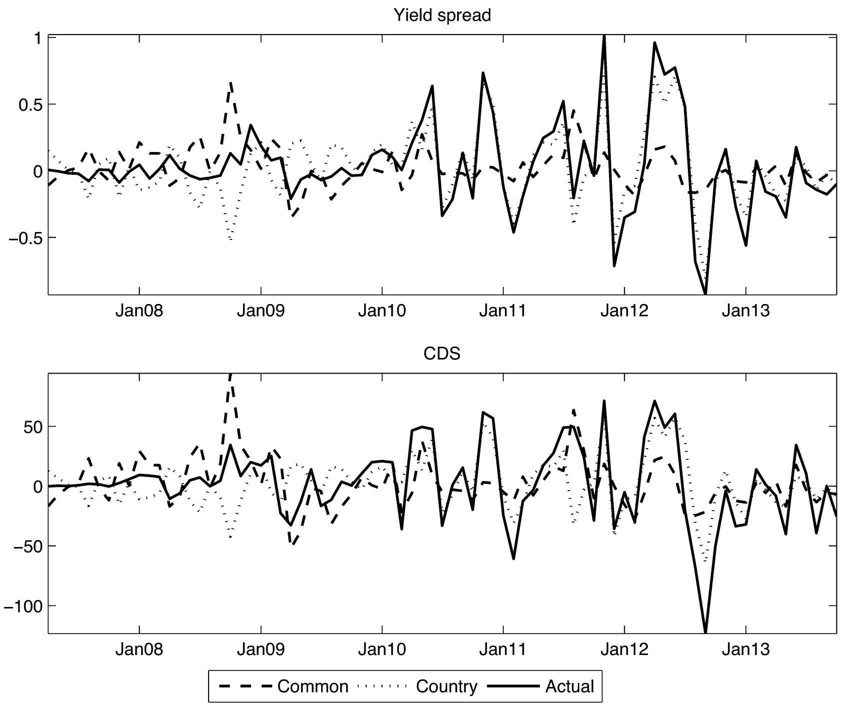

Figure 11. Common and country components of the Spanish yield differential and CDS premium (first differences)

should increase their domestic exposures only in response to greater systemic eurozone risk, as they have no comparative advantage in hedging against country-specific risk.[18] 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 5-year annual euro swap rate. Second, we estimate a *factor-based model*, where the yield

[18] Incidentally, these three reasons may also contribute to explain the increased home bias of banks' loan portfolios: banks may redirect their lending towards domestic companies because (1) this increases the probability of a bailout by domestic authorities ('moral suasion'), (2) they wish to earn the differential between the interest charged to domestic companies and their funding rate ('carry trade'), or (3) they are better hedged against redenomination of their loans than foreign banks ('comparative advantage'). An additional reason for the increased home bias of bank loans in a crisis is that in turbulent times asymmetric information problems become more acute, so that banks prefer to revert to more familiar borrowers, who typically are domestic ones.

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 eurozone banks' exposures to domestic sovereign debt, drawn from the ECB SDW.[19] The sample period ranges from April 2007 to September 2013 for all countries except Greece, Ireland and Portugal for which the sample ends in April 2011, December 2010 and April 2011 respectively, since we exclude observations after the inception of the IMF/ECB bailout programmes implemented in those countries.[20]

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 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 in order to analyse the joint determination of its banks' domestic sovereign exposure and yield differential, since this model (1) allows for all possible patterns of time-precedence among variables, (2) can capture the gradual adjustment of sovereign exposures to long-run equilibrium levels determined by movements in yield differentials, and (3) can deal with non-stationarity in the data generating process. The preliminary analysis of the data and the specification search (see the Appendix) lead us to the following VECM(p), where p denotes the number of lags, in reduced-form representation:

$$\Delta y_t = \alpha[\beta' y_{t-1} + \gamma d_{t-1}] + \Theta_1 \Delta y_{t-1} + \ldots + \Theta_p \Delta y_{t-p} + \Gamma D_t + u_t. \tag{3}$$

In this expression, y_t is a $n \times 1$ vector, n being the number of endogenous variables, defined as the 2-element vector $y_t = [spread_t \; sovexp_t]'$ in the baseline model and the 3-element vector $y_t = [common_t \; country_t \; sovexp_t]'$ in the factor-based model, where $spread_t$ is

[19] For further details about our data on sovereign exposures, see footnote 8 above. These data are also used in Figures 12, 13 and 14 to illustrate the time behaviour of domestic exposures for the core and periphery countries as a whole.

[20] The choice of the sample period is mainly driven by the fact that the dynamics of the domestic sovereign exposures and of the sovereign yields spreads during the euro debt crisis are considerably different from the previous years, showing a shift to a 'new regime' after 2007. Moreover, we do not have data for CDS premia before 2007. In order to avoid small sample bias, we estimate the VECM adopting the two-step procedure described by Lütkepohl and Krätzig (2004). Stock (1987) presents Monte Carlo examples where the OLS estimates are biased, while these biases disappear adopting the two-step procedure that we use. This is also highlighted by Engle and Granger (1987).

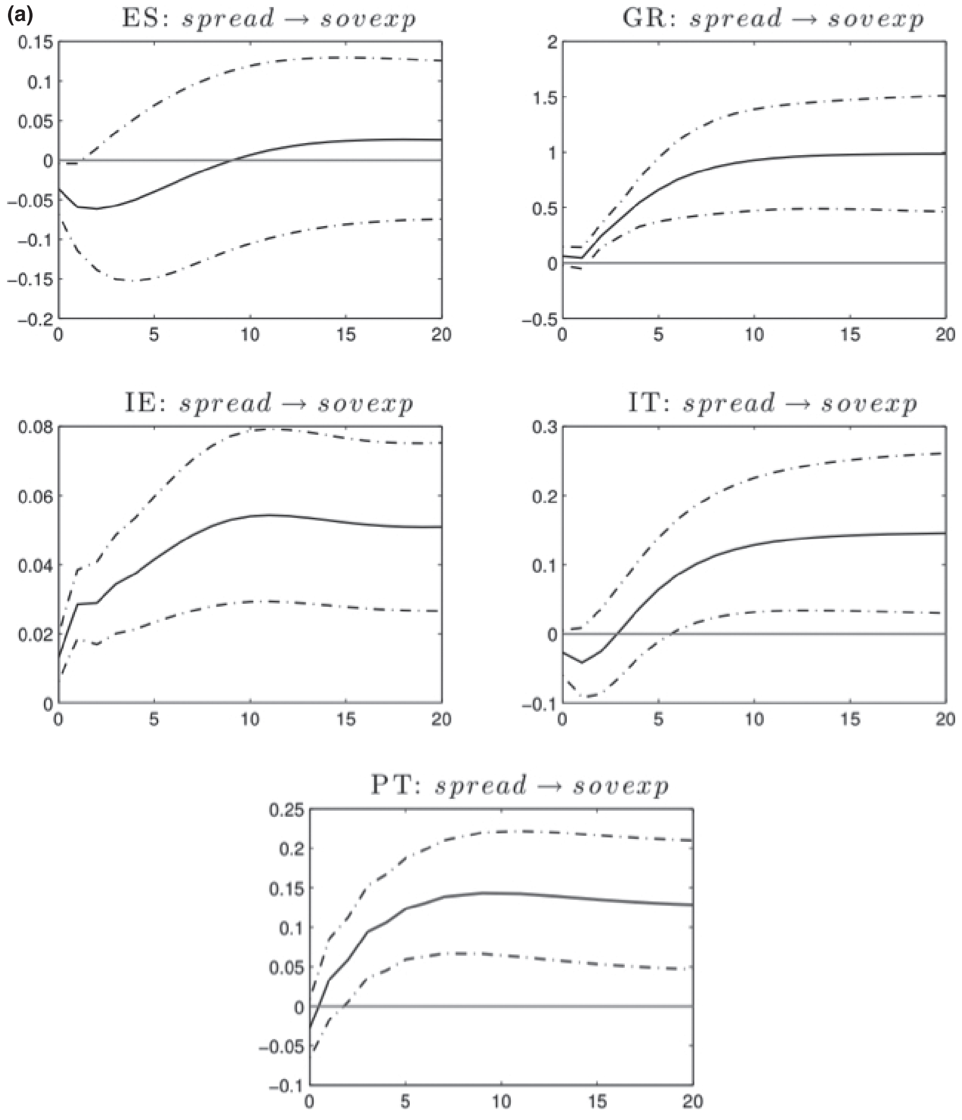

Figure 12. **Continued on next page**

the domestic sovereign debt yield differential (with respect to the euro swap rate), $sovexp_t$ denotes the domestic sovereign exposures of banks as a fraction of their total assets, 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 $m \times 1$ and $M \times 1$ vectors, referring to the restricted and unrestricted deterministic terms (or dummy variables) included in each country's specification, respectively; the $n \times 1$ vector u_t denotes the reduced form residuals. Finally, α is the $n \times r$ matrix of adjustment parameters, β is the $n \times r$ matrix of cointegrating parameters, Θ_j is the $n \times n$ matrix of short-run parameters referring to lag j, and γ and Γ are the $r \times m$ and $n \times M$ matrices of coefficients

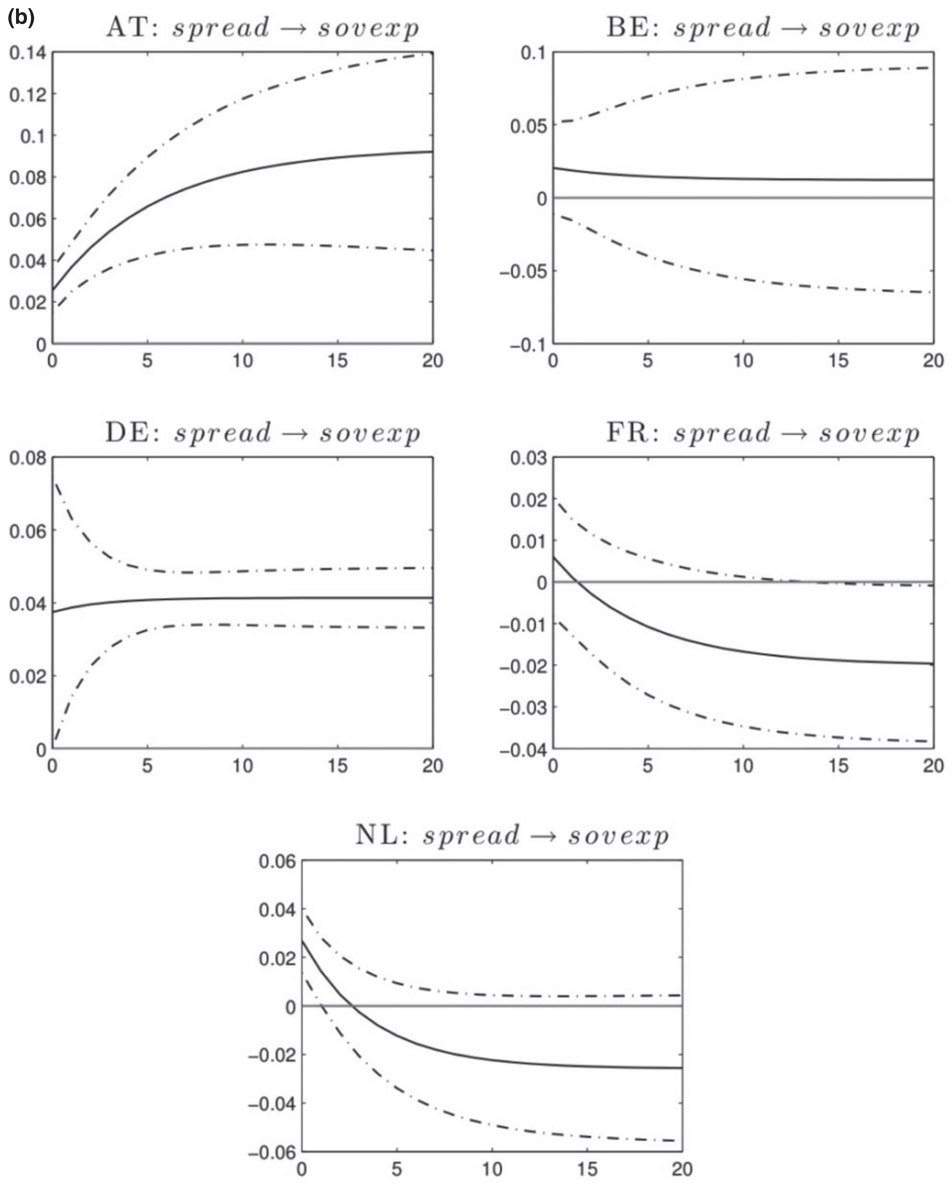

Figure 12b. IRFs of sovereign exposures to shocks in yield differentials: (a) periphery countries; (b) core countries
Notes: Each chart reports point estimates (solid line) and 90% studentized bootstrap confidence intervals (dashed lines) of the respective IRFs.

associated with the restricted and unrestricted deterministic terms, respectively; finally, r is the cointegrating rank (i.e. the number of cointegration relations) of the system. As usual, our analysis focuses on 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 vice versa).

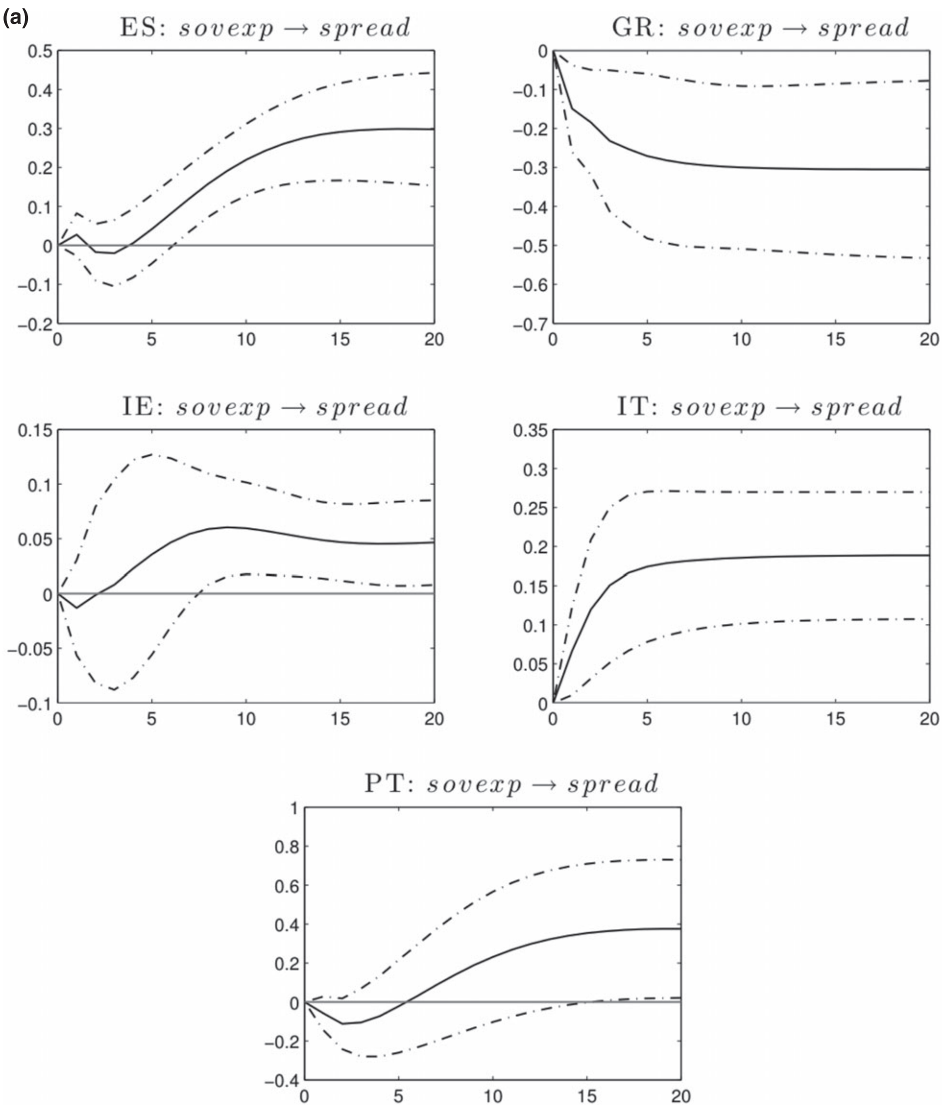

Figure 13. **Continued on next page**

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 and β of the error-correction term, which capture 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 supports setting $r = 1$ for all countries in the baseline model; Johansen's trace test reveals that $r = 2$ is 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 para-

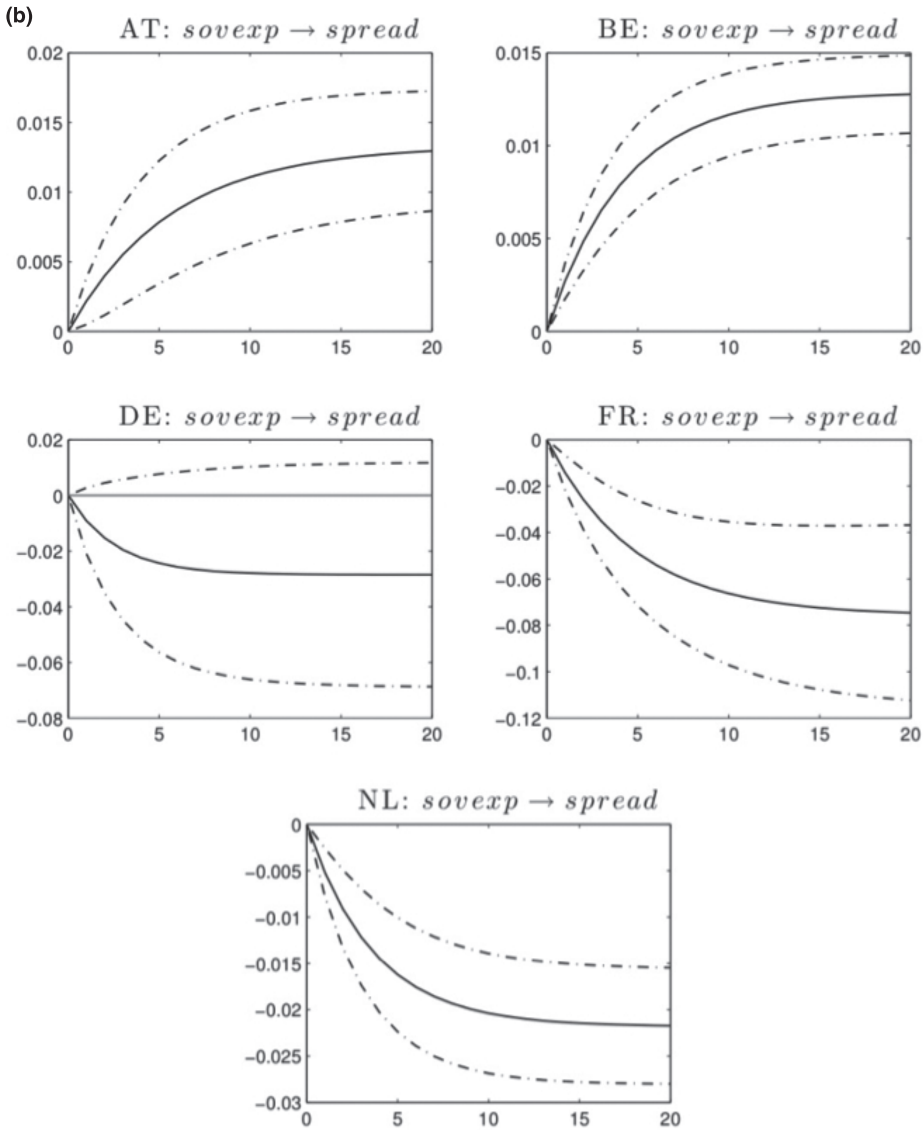

Figure 13b. IRFs of yield differentials to shocks in sovereign exposures: (a) periphery countries; (b) core countries
Notes: Each chart reports point estimates (solid line) and 90% studentized bootstrap confidence intervals (dashed lines) of the respective IRFs.

meters in β are imposed following Johansen's strategy, whereby in the cointegrating equation(s) we impose a unit restriction on the coefficient(s) on $spread_t$ ($common_t$ and $country_t$) in the baseline (factor-based) model and the coefficients on $sovexp_t$ are estimated for each cointegration relation. In the specification of the model for all countries, we also include dummy variables in order to account for two of the most important events in the recent chronicles of the euro crisis: (1) the long-term refinancing operations (LTROs) executed by the ECB since December 2011 and February 2012 (henceforth,

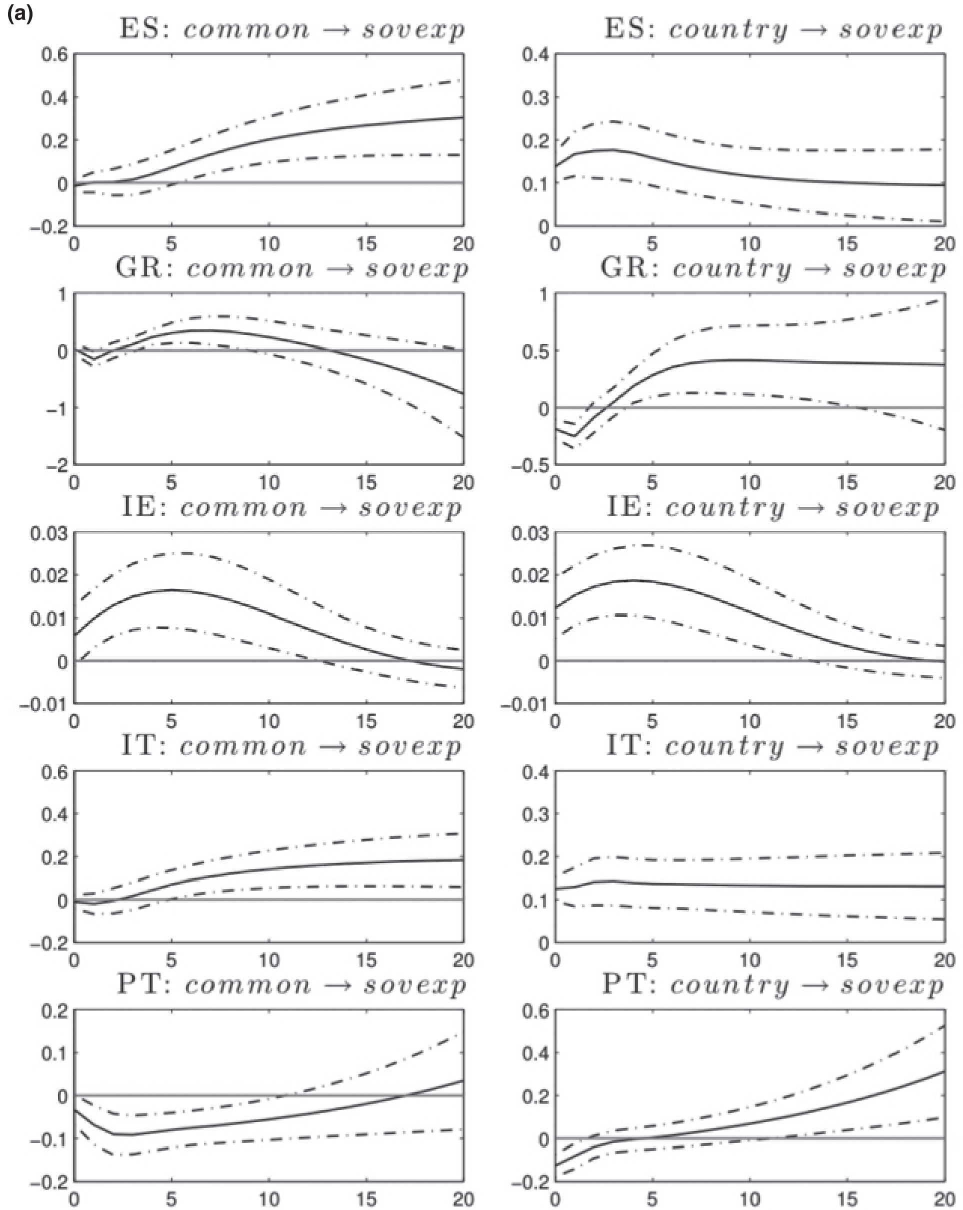

Figure 14. Continued on next page

the *ltro* dummy), and (2) the speech by ECB President Mario Draghi at the Global Investment Conference in London on 26 July 2012 where he committed to 'do whatever it takes to preserve the euro' (henceforth, the *wit* dummy – a mnemonic for whatever-it-takes).[21] The rationale for the inclusion of these dummy variables is the impact

[21] The *ltro* and *wit* dummies take a value of one after December 2011 and June 2012, respectively, and zero otherwise.

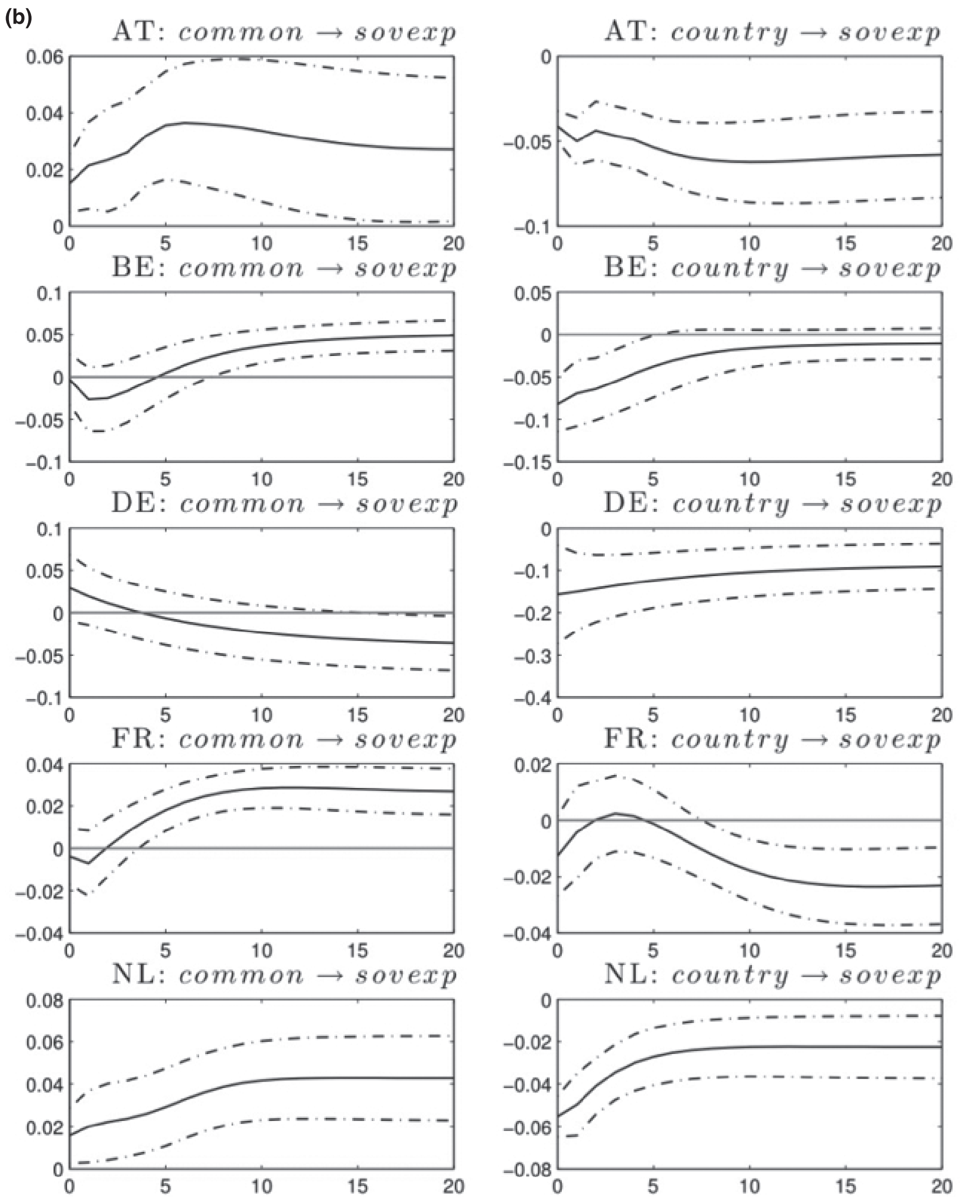

Figure 14b. IRFs of sovereign exposures to shocks in the common and country components of yield differentials: (a) periphery countries; (b) core countries
Notes: Each chart reports point estimates (solid line) and 90% studentized bootstrap confidence intervals (dashed lines) of the respective IRFs.

of both events on the conditions of eurozone financial markets and on investors' behaviour: (1) the LTROs changed the conditions at which eurozone banks could obtain liquidity from the central bank, so that they may have affected their portfolio decisions; (2) by stating the commitment of the ECB to the survival of the euro, President Draghi's speech dampened financial market volatility and eased financing conditions for governments in the eurozone periphery, and thus generated a remarkable reversal in the patterns of their sovereign bond yields.[22] These dummies are irrelevant for Greece, Ireland and Portugal, as both of these events occurred after the start of the respective bailout programmes, which mark the end of the sample for these countries.

4.2. Results

Table 2 reports the results of the estimation of the baseline (columns 1 and 2) and factor-based (columns 3–6) VECMs for all countries. First, column 1 (baseline model) and columns 3 and 5 (factor-based model) show the cointegrating parameters (β) obtained by normalizing the estimated coefficient on $sovexp_t$ to unity in each cointegration relation. More specifically, column 1 refers to the cointegrating relationship between sovereign exposures and yield differentials, and shows the normalized coefficient on $spread_t$; column 3 refers to the cointegrating relationship between sovereign exposures and the common factor, and shows the normalized coefficient of $common_t$; column 5 refers to the cointegrating relationship between sovereign exposures and the country factor, and shows the normalized coefficient of $country_t$.[23] Second, column 2 (baseline model) and columns 4 and 6 (factor-based model) report the adjustment parameters (α) for domestic sovereign exposures (i.e. the estimated coefficients of the $sovexp_t$ equation).[24] The long-run parameters can be computed as $\alpha\beta'$.

The estimated cointegrating parameter β in the baseline model (column 1 of Table 2) is negative and significant in all countries except Belgium, where it is negative but not significant, and France and the Netherlands, where it is positive and significant. This indicates 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 evidence for a positive long-run correlation is stronger for the periphery countries than for the core countries. The estimated adjustment parameter α in column 2 is negative and significant at the 5% level in all countries, except France and the Netherlands, where it is significant at the 10% level, and Belgium, where it is

[22] 'Measuring Mario Draghi's promises', *Wall Street Journal*, 26 July 2013.

[23] In order to interpret the results, let the relevant cointegration relation in normalized form (disregarding deterministic terms) be $sovexp_t = -\beta_x x_t + z_t$, where x_t denotes yield differentials, the common factor or the country factor, depending on the model and the cointegration relation of interest, and z_t represents the error-correction term. Then, if the normalized cointegrating parameter β_x is negative (positive) and significantly different from zero, we infer the existence of a positive (negative) long-run equilibrium relationship between $sovexp_t$ and x_t, i.e. sovereign exposures tend to increase (decrease) towards their equilibrium level in response to an increase in x_t.

[24] A negative and statistically significant adjustment parameter α indicates that, whenever the error-correction term, $z_t = \beta' y_t + \gamma d_t$ is different from zero, the dependent variable of the corresponding equation of the VECM adjusts towards its equilibrium level. If instead α is positive and/or statistically insignificant, then the process for the dependent variable does not converge to its equilibrium level.

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

	Baseline model		Factor-based model			
	β	α	β	α	β	α
Country	(1)	(2)	(3)	(4)	(5)	(6)
Spain	–0.906***	–0.026*	–3.001*	–0.039***	–0.693***	–0.01
	(0.000)	(0.088)	(0.072)	(0.000)	(0.000)	(0.566)
Greece	–1.299***	–0.366***	0.739***	0.465***	–0.603***	–0.653***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Ireland	–0.524*	–0.046**	0.073***	1.974***	–0.009***	–2.092***
	(0.097)	(0.03)	(0.000)	(0.001)	(0.000)	(0.001)
Italy	–0.762***	–0.077***	–8.128	–0.009***	–0.408***	–0.066*
	(0.003)	(0.000)	(0.71)	(0.003)	(0.000)	(0.054)
Portugal	–0.24***	–0.144**	1.113***	–0.195***	–0.79**	–0.095**
	(0.001)	(0.02)	(0.000)	(0.006)	(0.041)	(0.036)
Austria	–3.065***	–0.031***	5.106*	0.046***	2.023**	–0.032*
	(0.008)	(0.000)	(0.06)	(0.009)	(0.022)	(0.079)
Belgium	–12.904	0.001	–0.612***	–0.14**	1.978	–0.013
	(0.74)	(0.816)	(0.002)	(0.037)	(0.106)	(0.715)
Germany	–0.499***	–0.343***	2.374*	–0.052	7.741***	–0.097
	(0.000)	(0.000)	(0.093)	(0.228)	(0.000)	(0.129)
France	0.59***	–0.08*	–3.411***	–0.261***	1.799**	0.032
	(0.002)	(0.086)	(0.001)	(0.000)	(0.018)	(0.39)
Netherlands	2.193**	–0.064***	–3.538***	–0.082	1.214***	–0.116**
	(0.016)	(0.001)	(0.000)	(0.193)	(0.000)	(0.014)

Note: The table reports the results of the estimation of the baseline (columns 1 and 2) and factor-based (columns 3 –6) VECMs for all countries. First, column 1 (baseline model) and columns 3 and 5 (factor-based model) show the cointegrating parameters (β) obtained by normalizing the estimated coefficient on $sovexp_t$ to unity in each cointegration relation. More specifically, column 1 refers to the cointegrating relationship between sovereign exposures and yield differentials, and shows the normalized coefficient on $spread_t$; column 3 refers to the cointegrating relationship between sovereign exposures and the common factor, and shows the normalized coefficient on $common_t$; column 5 refers to the cointegrating relationship between sovereign exposures and the country factor, and shows the normalized coefficient on $country_t$. Second, column 2 (baseline model) and columns 4 and 6 (factor-based model) report the adjustment parameters (α) for domestic sovereign exposures (i.e. the estimated coefficients of the $sovexp_t$ equation). The long-run parameters can be computed as $\alpha\beta'$. The sample ranges from April 2007 through September 2013 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.

not significantly different from zero.[25] 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.

[25] The estimates indicate that domestic sovereign exposures adjust faster in response to shocks in programme countries: $sovexp_t$ adjusts by more than 37% and 14% towards its equilibrium level within a month in Greece and Portugal, respectively. Though Germany also features a high speed of adjustment, most core countries have a slower adjustment than periphery countries.

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, while the change in the domestic sovereign yields can immediately affect the corresponding domestic sovereign exposures.[26] The economic rationale of this identifying assumption is that, since domestic exposures are measured at market values, they immediately reflect changes in the yield of domestic sovereign debt, even if banks do not react to the yield change by restructuring their portfolio. Instead, changes in the amount of domestic sovereign debt owned by banks affect sovereign yields only gradually.[27]

In Figure 12, the solid line indicates the predicted response, while the dashed lines plot the respective 90% studentized bootstrap confidence bounds.[28] In the long run, in periphery countries domestic sovereign exposures respond positively to an increase in the yield differential, the response being statistically significant for all countries except Spain.[29] In core countries, the response is positive for Austria and Germany, whereas it is negative for France and insignificant for Belgium and the Netherlands. In Italy and Spain, the response features a small initial drop in exposures, which is reversed within a few 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 build-up in exposures, mechanically translates into a drop in the market value of sovereign exposures. The much smaller response for Ireland is probably explained by the fact that the Irish banking sector is dominated by the offshore activities of global banks, Ireland being a giant offshore centre whose aggregate financial sector is detached from the local economy; but unfortunately separate data for local Irish banks are not available.

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, core countries (except Austria and Belgium), together with Greece, show a negative long-run response of their domestic differentials to an increase in domestic exposures. Hence, in these countries, increases in banks'

[26] Short-run and long-run linear restrictions are imposed following the methodology described, for instance, in Vlaar (2004), based on the scoring algorithm originally proposed by Amisano and Giannini (1997).

[27] Although eurozone banks are important players in the market for domestic sovereign debt, their holdings typically do not exceed one-fourth of the total stock of debt. Between the third quarter of 2010 and 2011, banks' average holdings of domestic eurozone sovereign debt, as a percentage of the corresponding country's sovereign debt, were 13.32% for Austria, 25.73% for Belgium, 27.98% for Germany, 22.96% for France, 21.15% for Ireland, 21.15% for Italy, 10.65% for the Netherlands, and 23.02% for Portugal.

[28] Studentized bootstrap 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).

[29] However, the IRF for Spain is not only positive but also significant if the *wit* dummy is excluded from the VECM.

domestic exposures effectively curb investors' concerns over sovereign solvency and contribute to tightening yield differentials. However, in periphery countries (except Greece) as well as Austria and Belgium, 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 the market to require a higher yield on domestic 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 3–4) and to the country component (columns 5–6) of the yield differential. The response to the common risk factor is positive and significant for all countries except Italy and the Netherlands (where it is not significant but still positive) and Portugal and Germany (where it is negative but not significant). This indicates that for most countries when there is an increase in common 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 France), an increase in country risk prompts local banks to reduce their domestic exposures, while in periphery countries it leads local banks to increase their domestic exposures.

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:

1. Only the common and the country shocks may have a permanent effect on sovereign exposures.
2. The common and the country shocks do not contemporaneously affect each other.
3. A shock in the domestic sovereign exposure has no contemporaneous impact on the common 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 Germany, where the response is negative but not statistically significant). The same applies to periphery countries (except Portugal), although initially Greek and Italian 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). 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 Belgium, where the response is also negative but not significant), and to increase in the periphery. Hence, for the periphery countries the evidence cannot be explained only 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 eurozone periphery the 'moral suasion' or/and the 'carry trade' hypotheses must have played a role.

5. SUMMARY AND POLICY IMPLICATIONS

This paper analyses the dynamics of sovereign yields in the eurozone crisis that unfolded since 2007 and the concomitant reshuffling of banks' sovereign debt portfolios, 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 eurozone 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 break-up of the eurozone, one being the frequency of relevant terms searches in Google and the other being the eurozone break-up 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 2007–13 monthly data. The domestic sovereign exposures of banks in most eurozone countries turn out to 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: (1) in all periphery countries, banks respond to increases in country risk by increasing their domestic exposure, while in core countries they do not; (2) in contrast, in most eurozone countries banks react to an increase in the common risk factor by raising their domestic exposures.

Finding (1) indicates that in the eurozone periphery banks responded to increases in their own sovereign's risk by increasing even further their exposure to such risk, in line with the 'moral suasion' and the 'carry trade' hypotheses. Finding (2) indicates that most eurozone 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 is problematic from a policy standpoint and, also depending on its interpretation, has different implications for policy.

5.1. Dealing with 'moral suasion by regulators'

Suppose that our finding (1) – 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 – consistently with the findings by Drechsler et al. (2013) for periphery countries. Under this interpretation, regulators themselves prompted banks to increase their domestic sovereign exposures in situations 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 eurozone banking union: the ECB acting as 'single supervisor' would likely be more insulated from the pressures of governments than national banking supervisors. The rationale for this impending policy change is reinforced by the fact that it is becoming increasingly clear that, when eurozone 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 eurozone bank supervisor should constrain the bets that eurozone 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 (1) 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 (2013) and Buch *et al.* (2013) provide evidence that banks that are less capitalized and depend more on wholesale funding invest more in sovereign debt than others. A variant of this 'carry trade' story, which is popular among eurozone bankers, goes as follows: '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 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 inefficient for society than if it were motivated by plain 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. These carry trades also have severe implications for the real economy: banks with sizeable exposures to impaired sovereign debt have been forced to curtail their lending to firms and households in 2010 and 2011 (Bofondi *et al*., 2013; De Marco, 2013; Popov and van Horen, 2013), in turn leading firms to significantly reduce their investment, employment and sales growth (Acharya *et al*., 2013).

Discouraging carry trades would require revising the prudential regulation of sovereign exposures in the eurozone, by scrapping the current preferential treatment of sovereign exposures: currently, eurozone banks face no capital requirement (a 'zero risk weight') for holdings of sovereign eurozone debt, irrespective of its issuer;[30] 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 eurozone banks to invest in high-yield euro-denominated sovereign debt, especially considering that they can fund such investments by borrowing at low rates from the ECB. This problem is acutely perceived by policymakers, as witnessed by ECB President Draghi's statement on 5 December 2013: 'If we do operations similar to LTRO, we want to make sure this is being used for the economy. We want to make sure that this operation is not going to be used for subsidizing capital formation by the banking system under these carry-trade operations.'[31]

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 sovereign issuer would require most eurozone banks to undertake very substantial portfolio adjustments, which may result in gyrations in relative yields in the eurozone 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 phased in very gradually; moreover, eurozone banks may be exempted from this limit altogether insofar as they were to invest in a well-diversified portfolio of eurozone sovereign bonds rather than in those issued by a specific sovereign. In this respect, the portfolio reallocation process could be made smoother

[30] Specifically, eurozone 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.

[31] Bloomberg News, 'Draghi hints any new liquidity tools will be conditional', 5 December 2013.

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 eurozone 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 eurozone 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 eurozone banks to diversify their sovereign portfolios.[32]

5.3. Dealing with the fallout of redenomination risk

What about the policy implications of our finding (2) – namely, that even in core countries eurozone 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 break-up, 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 eurozone 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 favour of core-country debt, in late 2010 and 2011.

The only way to address this source of segmentation of eurozone sovereign bond markets – and more generally of eurozone 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) programme: by creating the credible threat that the ECB could buy the sovereign debt of distressed eurozone countries, the ECB reduced investors’ estimate of the probability of a possible euro break-up. Nevertheless, the degree of segmentation of eurozone 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

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

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.

Discussion

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The conjunction of sovereign debt crises and banking crises is well known to academics and practitioners following emerging markets. Kaminsky and Reinhart (1999) document the 'twin crisis' phenomenon of simultaneous banking crisis and balance of payments reversal. Reinhart and Rogoff (2011) further show how sovereign debt crises are often associated with banking sector collapses. This nexus has come to the forefront in discussions of the eurozone crisis. Sovereign debt yields leapt in Spain as many of the savings banks (Cajas) failed. Cypriot and Greek banks' exposure to the sovereign debt of the latter led to balance sheet problems. Further limitations on sovereign borrowing have been considered alongside transnational banking regulation as needed reforms for the eurozone.

Battistini *et al.* try to flesh out empirically the connection between sovereign yields and bank balance sheets during this interesting and recent period. The authors observe that home bias in sovereign debt holdings has increased simultaneously with the borrowing rates of eurozone sovereigns. They ask whether a direct connection can be found between the two. Dynamic factor analysis is used to decompose sovereign yields and CDS spreads into domestic and eurozone-wide factors. These factors are then used as inputs into a vector error correction model (VECM) to see how home bias in the banking sector is affected by these factors. Banks in periphery countries do appear to increase their exposure to the debt of their own sovereign in response to country-specific credit risk shocks. This is not true of banks in core eurozone countries. Banks throughout the eurozone, however, tend to increase their exposure to domestic sovereign debt in response to the eurozone-wide factor. This lends a natural interpretation to this type of shocks as an increase in eurozone break-up risk.

Rather than quibble with empirical methodology, I will take the findings of this paper at face value. Instead, I would first like to put the findings in a broader theoretical context. I will then turn to a discussion of the results of the factor analysis and VECM.

What are we to think of an increase in home bias as sovereign yields increase? The authors focus on two possible explanations. First, domestic banks may have a comparative advantage in holding the debt of their sovereign, as sovereign debt is likely to be redenominated into the new domestic currency. Second, sovereigns might impose regulatory or moral suasion on domestic banks in a form of financial repression.

There is a rich literature on home bias in equities and bonds that provides some other hints on this relationship. I follow Coeurdacier and Rey's (2013) review essay in outlining factors driving home bias in equities and bonds. These factors might also be in play alongside factors that may be specific to sovereign debt. Like the authors of this article, Coeurdacier and Rey also point to hedging motives for holding domestic-currency assets due to real exchange rate risk. This factor might be muted when a country is in a currency union. Battistini *et al.* are right to point out that home bias in sovereign debt would therefore increase as eurozone breakdown risk increases. But it is noteworthy that corporate bonds might face a similar risk. As Miles Bradshaw noted on Pimco's blog in September 2012:

'The departing state [from the eurozone] is likely to issue a new law redenominating all domestic contracts into local currency at a fixed exchange rate. Investors therefore need to be aware of their bonds' governing law. Bonds issued under domestic law would probably be redenominated into local currency and investors would now face additional currency risk.'

Using data on corporate bond yields, one could compare home bias in these instruments with home bias in sovereign debt. One could get directly at the question as to whether redenomination risk is central in affecting home bias. Such data would also potentially allow for a natural experiment to determine the importance of redenomination risk. Bonds and equities of domestic firms issued under domestic law should be affected differently by eurozone breakdown risk than those issued under a foreign jurisdiction.

Second, cross-border trading costs may be a factor in home bias. The fear of capital controls may therefore be confounded with redenomination risk as a cause for home bias in strenuous times for the Eurozone.

Third, informational asymmetries have been pointed to as an explanation for home bias. Moreover, Brennan and Cao (1997), among others, have suggested that this may lead to countercyclical home bias. The particular case of sovereign debt might be particularly subject to informational asymmetries. The same personal and professional ties that may allow sovereigns to apply moral suasion on domestic banks might also give domestic bankers better information about the likelihood of sovereign default or repayment.

Finally, there may be behavioural factors contributing to home bias. Domestic investors may be more optimistic about the risk of default and this over-optimism might be countercyclical as well.

All these factors might contribute to the relationship between sovereign spreads and home bias. Each of them might be differentially affected by eurozone-wide factors and country-specific ones. I am therefore not particularly confident about the authors' specific interpretation of their results. More than the two specific channels suggested in their analysis could explain their results. As suggested above, the study of corporate bonds alongside sovereign bonds might shed further light on the relative importance of the different channels. Moral suasion and financial repression, for example, would be less pronounced in the case of corporate bonds.

Factor analysis is conducted to determine country-specific factors versus eurozone-wide factors in affecting sovereign spreads. The authors choose to interpret the country-specific factors as related to outright default and the common factor as being related to the risk of a break-up of the eurozone. They provide some suggestive evidence in this regard. A number of variables are used in this analysis, including changes in sovereign yields, changes in credit-default-swap (CDS) spreads, and stock market returns.

A few surprising results come out of the variance decomposition of the factor model that suggests we might need to take this interpretation with a grain of salt. Close to 70% of the movement in Greece's sovereign yield is attributed to the residual, idiosyncratic, factor. This is the most credibly 'home-grown' crisis and less than 30% of spreads in this country are attributed to the country-specific factor – the lowest for any country in the study. This is perhaps less surprising when one considers that the variable used to capture country-specific factors is stock market returns. But stock markets are highly correlated and a glance at the variance decomposition of this variable shows that most of its variance is attributed to common factors.

Sovereign yields should be affected by exchange rate risk alongside the risk of outright default. One could imagine scenarios, however, where a break-up of the eurozone would not trigger a legal default event that would activate CDSs. If we accept the authors' interpretation of the two factors, we would expect CDS spreads to be no more affected by the common factor than sovereign yields are. Table 1 shows precisely the opposite result in Greece, Ireland and Italy, for example.

The focus of the VECM model is the effect of sovereign yields on home bias. It is equally interesting, in my view, to understand how shocks to home bias affect sovereign yields. To what extent do demand shocks to sovereign debt affect its price? One such demand shock is a home-bias shock. If this home bias is due to financial repression, is this strategy, often employed by financially stretched governments, effective?

It is unfortunate, in this regard, that the responses of sovereign yields to home bias are so heterogeneous. Responses differ across countries not only in magnitude, but also in sign. What are we to make of a country like Italy, where a shock that induces domestic banks to shift towards domestic sovereign debt *increases* Italy's sovereign yield? It is hard to find a common denominator between the countries whose sovereign yield responds in such a surprising way. There are crisis countries and core eurozone economies alike that show such responses.

Overall this is an interesting and competently executed paper. I look forward to future efforts by the authors of this paper and others to shed further light on the new questions that this analysis raises.

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The most overused sentence in a discussion is "I greatly enjoyed reading this paper." In fact, I rarely enjoy reading academic papers. Reading a paper is usually hard work, often disproportionate to the insight that one ultimately takes away. This paper is an exception. I *actually* enjoyed reading this paper. The reason for is not just that the paper is very clearly written, a relatively easy read, and of great policy relevance. It is also an example of a successful "didactical" paper. Most of the facts and policy prescriptions presented in the paper are familiar, but the paper takes a new approach to analysing these facts. As a result, we begin to see the wood for the trees: an evidence-based story linking these facts, both to each other and to policy.

So what are the facts? During 2010-2012, sovereign bond yields in countries such as Ireland, Greece, and Portugal and eventually Spain and Italy spiked, while bond yields at the centre of the system – particularly in Germany – declined. These movements reflected sovereign debt and banking sector problems in the peripheral countries, but also – one suspects – fears of Euro breakup that at some point threatened to become self-fulfilling. The turning point in the crisis came when the European Central Bank's OMT took away the break-up fear. By that time, however, the divergence in sovereign borrowing rates had had large knock-on effects on the private sectors of individual members of the currency union. Differences in sovereign yields were passed on through bank lending rates (and bank's willingness to lend), leading to large differences in private sector borrowing conditions across the currency union. At the same time, "home bias" in bank portfolios, particularly in periphery countries, rose sharply. Although the peak of the crisis is behind us, this fragmentation has not yet been overcome.

The paper adds to these well-known facts in two important ways. First, it quantifies – using an elegant and state-of-the-art, if somewhat black-box, technique – the extent to which sovereign yield movements were driven by domestic risk on the one hand, and common risk on the other. The authors argue convincingly that the latter can be interpreted as fear of Euro break-up. Second, it relates changes in bank asset portfolios – and in particular, their propensity to increase their holdings of domestic government bonds – to the two systematic drivers of sovereign yields.

On the first point, the main result of the paper is that Eurozone breakup fears explain a good chunk (about 20-40 percent) of the variance of sovereign yields in Italy, Spain and particularly Germany, but that the role of domestic sovereign risk is much larger (above 70 per cent) in the two Mediterranean countries. On the second point, the main result is that increases in Eurozone breakup fears lead to an increase in the domestic government bond holding of banks in most Eurozone countries – as one

[33] The views expressed in this commentary are personal and not to be attributed to EBRD or any other organisation that the author is affiliated with.

would expect, if banks are trying to match their asset and liability structures in light of a possible breakup – while increases in domestic sovereign risk affect government holdings of peripheral and core country banks in opposite directions. Core country banks tended to hold less domestic sovereign assets in response to an increase in domestic risk, while peripheral country banks held more. Furthermore, in the peripheral countries, increases in sovereign exposure in turn fed back into a higher sovereign spread – consistent with worries about a potential "death loop" between sovereign and banks in these countries.

These are thought-provoking results. To be sure, the data do not always "confess". It is a bit puzzling that apart from Germany, Italy, and Spain (and to a lesser extent Belgium), Eurozone breakup fears do not seem to contribute very much to the variation of yields in Eurozone member countries (part of this may be due to the decision to exclude Greece, Ireland and Portugal from the sample after they enter Troika programmes).[34] There are also some puzzling outliers with regard to the drivers of sovereign exposures, particularly the fact that Eurozone breakup risk does not seem to prompt a flight of German banks into German government debt. Portugal is another outlier, although this may be a little less puzzling.[35] Overall, however, the messages of the paper are convincing. The differences in the reaction of peripheral and core country banks to country risk – with sovereign exposure going up in the periphery but down in the core – is a particularly stark and stunning result.

In some areas, the paper could have gone a bit further. It would be useful to know to what extent the differences in result between Greece, Ireland and Portugal on the one hand and Spain and Italy on the other reflect differences in the sample period. For Greece, Ireland and Portugal, the sample ends with their entries into Troika programmes; this happens to exclude the main period of Eurozone breakup fears, which as shown in Figure 7, started in September 2011. Did the drivers of yields change over time, with the common factor mattering much more after September 2011? In the analysis of sovereign exposures at the end of the paper, it would have been interesting to see impulse response functions from sovereign exposures back to the common and country risk factors. And it may have been worth doing a bit more to convince the reader that the impulse responses in this section of the papers are not sensitive to the particular identifying assumptions that are made.

With respect to the policy implications, it is hard to disagree with the author's main conclusions. Clearly, if perceived Eurozone breakup risk was a driver of financial

[34] It is also not obvious why one should obtain very different results, for the peripheral countries, when using CDS spreads rather than sovereign yields as the measure of sovereign risk (for Germany the difference is more intuitive; like the authors point out, sovereign yields pick up "flight to safety" flows whereas CDS spreads do not). Yet, the proportion of the variance of CDS spread movements that is explained by the country component seems to be much lower than across the board (for example, just 35 percent for Italy, versus 74 percent of the variance of sovereign yields).

[35] While German banks should have had a clear motive to flee into German assets if they were worried about Euro area breakup, this is less obvious for peripheral country banks, who may have expected a depreciation of their reborn currencies relative to Germany in the event of breakup.

fragmentation, as shown in the paper, this argues for mechanisms, such as the ECB's Outright Monetary Transactions programme, that reduce perceived breakup risks. Without such mechanisms, monetary union cannot function properly, at least not in times of stress. Similarly, the link from higher domestic risk to higher sovereign exposure in periphery country banks is deeply troubling. The remedies suggested by the authors – moving from national supervision to a single European supervisor who would be less likely to apply "moral suasion" (i.e. transmit national fiscal pressures to banks), and limiting bank exposure to domestic sovereigns through EU-wide regulatory roles – both make sense. They are also not mutually exclusive.

Are there any interpretations of the main results that the authors have missed? There may be one: suppose domestic banks are more likely be recapitalised (by the sovereign) after a sovereign default than foreign banks. This is, indeed, in line with the experience after the Greek default, and several other defaults in emerging markets (see Zettelmeyer et al, 2013; Sturzenegger and Zettelmeyer, 2007). In the presence of functioning secondary debt markets, one would then expect a concentration of sovereign debt on the books of domestic banks as domestic sovereign risk rises (see Broner et al., 2010; Brutti and Sauré, 2013). This story would be observationally impossible to distinguish – at least in this dataset – from the authors' moral suasion story. However, it has very different policy implications, as it cannot be addressed by centralising bank supervision. This said, EU-wide regulation that limits bank exposures to any sovereign, including one's own, would go some way towards addressing this problem, particularly when combined with some central Euro area control over the management and terms of debt restructurings.

Panel discussion

Lutz Kilian began the panel discussion by expressing doubts over the identification of the dynamic factor model. Specifically, he argued that the relative contributions of the country-specific and common risk components will be arbitrary if variation in both is not observed. Reinforcing his point, he alluded to Germany as an example of a country with very little country-level risk variation. Moreover, regarding the impulse responses in the VECM, he noted that a causal interpretation without the identification of structural shocks is inappropriate. He suggested the use of sign restrictions in overcoming this issue.

Ester Faia was not convinced about the argument of moral suasion in the case of Italy. She contended that Italian banks invested in the high-yield domestic government bonds primarily for profitability reasons. Andrew Ellul claimed that the heightened exposure of core and peripheral banks to peripheral bonds ('reaching for yield') is the perverse outcome of the risk-weighted capital regulatory framework. Hans-Werner Sinn first pointed out that foreign government bonds may not be useful as collateral for domestic refinancing policies in the presence of exchange rate risk, thus resulting in redenomination risk leading to home bias. Second, Sinn did not deem redenomination risk to be a systemic risk that is independent of country-specific risk. Further elaborating, he stated that though an increase in the difference between the interest spreads and CDS premia may be the result of Greek redenomination risk, it still does not constitute systemic risk as it reflects the country-specific probability of a devaluation after exit.

Replying to Jeromin Zettelmeyer and Ethan Ilzetski first, Saverio Simonelli informed the panel that the authors also consider other assets in a separate paper. On the alternative explanations of home bias, he noted that behavioural stories have already been provided by empirical research using micro data. He stressed that such studies can control for the specificity of the banks or companies. The nature of their own study on the other hand does not allow (or at least makes it very difficult) for a distinction between their proposed explanation and such alternative accounts. Regarding the 'secondary market' theory, Simonelli noted that one could attempt to investigate how a country-specific shock in one country may affect another country. Nevertheless, orthogonality problems with respect to home bias would arise. More importantly, data availability issues prevent examination of further theories. Concerning Greece, Simonelli said that after the program commenced the CDS data were no longer reflective of what was going on in the country. Referring to Kilian's remarks, Simonelli added that a short-run identification strategy is employed, as opposed to implementing sign restrictions. The authors assume that banks require at least one period (month) in order to adjust to a shock in yields. Finally, on Faia's point, Simonelli reiterated that it is difficult to draw a distinction between the carry trade and moral suasion stories in the case of Italy. However, he did accept that the result for Italy is more likely to be due to the former rather than the latter.

APPENDIX

PRELIMINARY DATA ANALYSIS AND SPECIFICATION SEARCH FOR THE REGRESSIONS OF TABLE 2

This appendix presents the preliminary steps leading 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: we perform Augmented Dickey–Fuller (ADF) tests for all the time series and sampled countries in regressions with a constant drift and four lags (assuming that a quarterly information set contains the relevant information on the considered time series). This is a conservative choice aimed at reducing the autocorrelation in the residuals: for some series, optimal lag order selection criteria (such as the Schwarz–Bayes Information Criterion, SBIC, or the Hannan-Quinn Information Criterion, HQIC) would suggest even smaller lag orders, which would, however, increase the autocorrelation of residuals. The results, reported in Table A1, indicate the presence of unit roots at the 5% significance level in all countries' time series for domestic sovereign exposures (except for France), in domestic yield differentials (except for Austria, Germany and the Netherlands), in the common component of domestic yield differentials (except for Austria, Belgium and Germany), and in the country component of domestic yield differentials (except for Austria and the Netherlands). This indicates the presence of non-stationarity in the data.

The second preliminary step focuses on the determination of the cointegrating rank, that is, the number of cointegration relations: we wish to verify whether the time series are tied by long-run relationships. Hence, we carry out a trace test (see Johansen, 1995) to verify the cointegrating rank of the time series included in our analysis. The trace test verifies the null hypothesis of the cointegrating rank being $r^* \leqslant r$, for $r = 0, 1, \ldots, n - 1$, where n denotes the number of time series, against the alternative of $r^* = n$ (which would entail that a VAR model in levels could be used to capture the dynamic interactions between time series). Table A2 reports p-values for trace tests considering the time series included in the baseline model and the factor-based model for every country in our sample. Taking a conservative approach, in order to limit the number of parameters to be estimated and to preserve comparability between countries, we include only a constant term in the cointegration relations and zero lagged differences. As regards the baseline model, our results support the presence of (at most) one cointegration relation, that is, $r^* = 1$, in every country and rule out the possibility that $r^* = 0$ in most countries (the exceptions are Belgium, Germany, France and the Netherlands) at the 10% significance level. Evidence in favour of the presence of cointegration is even stronger when the trace test is applied to the time series considered in the factor-based model. In this case, the trace test rejects the null hypothesis of no cointegration at the 10% significance level for every country, except Belgium and the Netherlands. Furthermore, in several countries, notably Austria, Greece, Ireland and Portugal (as well as France, to a lesser extent), we find evidence in favour of $r^* = 2$, whereas $r^* = 1$ is rejected at the 10% significance level. Also, for every country in the sample, the trace test reveals that a VECM with two cointegration relations is to be preferred to a VAR model in levels.

Based on these results, we choose a VECM specification with one and two cointegration relations in both the baseline and the factor-based model: this choice is consistent with the presence of cointegration among the time series, and enables us to identify long-run interactions of sovereign exposures with domestic yield differentials (in the baseline model) and with the two components of these differentials (in the factor-based model).

Finally, in order to determine the lag structure of the VECM, we perform both a pre-estimation and a post-estimation analysis: in particular, we consider (1) SBIC and HQIC, (2) a stability analysis (control of eigenvalues, obtained from the estimation with all sampled residuals) and (3) 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). Our results (not reported) indicate that the VECMs for different countries should include up to two lagged differences of the endogenous variables, and lead us to opt for different lag structures across countries, as shown in Table A3.

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

	Sovexp	Spread	Common	Country
Austria	0.972	0.002	0.012	0.001
Belgium	0.766	0.330	0.026	0.584
Germany	0.792	0.009	0.041	0.549
Spain	0.995	0.763	0.323	0.812
France	0.001	0.342	0.415	0.395
Greece	0.505	0.976	0.909	0.991
Ireland	0.955	0.291	0.773	0.987
Italy	0.998	0.661	0.144	0.853
Netherlands	0.954	0.022	0.154	0.024
Portugal	0.991	0.999	0.770	0.999

Table A2. Johansen's trace test (H_0: $r^* \leq r$; H_1:$r^* = n$): p-values

	Baseline model		Factor-based model		
	$r = 0$	$r = 1$	$r = 0$	$r = 1$	$r = 2$
Austria	0.006	0.724	0.001	0.004	0.442
Belgium	0.983	0.936	0.629	0.700	0.642
Germany	0.730	0.579	0.001	0.708	0.577
Spain	0.013	0.753	0.004	0.580	0.755
France	0.308	0.165	0.005	0.120	0.185
Greece	0.004	0.745	0.001	0.020	0.131
Ireland	0.004	0.486	0.001	0.068	0.557
Italy	0.085	0.806	0.041	0.642	0.564
Netherlands	0.867	0.718	0.567	0.757	0.710
Portugal	0.001	0.893	0.001	0.042	0.301

Table A3. VECM specification: deterministic terms and lag order

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

Notes: The acronyms in the table should be interpreted as follows. A specification with restricted constant (*rc*), trend (*rt*) and/or dummies (*rltro* and *rwit*) excludes the constant, linear trends and/or dummies from the term ΓD_t in model (3), by an appropriate choice of the matrix Γ: intuitively, such deterministic terms have an effect on the long-term relation among the variables but not on their adjustment dynamics. Conversely, a model with unrestricted constant (*uc*), trend (*ut*) and/or dummies (*uwit*) includes the constant, linear trends and/or dummies in the term ΓD_t in model (3), so that such deterministic terms have an effect on the adjustment dynamics of the variables but not on their long-term relation. The lag orders (p) reported in the table refer to the VECM(p) = VAR(p + 1) representation of the corresponding model.

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