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Systemic Risk and Home Bias in the Euro Area*

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Abstract
According to conventional indicators, the euro-area financial integration has receded since 2007, mainly in the money market, sovereign debt market and uncollateralized credit markets. But price-based measures of debt market segmentation are inappropriate when solvency risk differs across countries: only the component of yield differentials that is not a reward for the issuer's credit risk may reflect segmentation. We apply this idea to the euro sovereign debt market, using a dynamic factor model to decompose yield differentials in a country-specific and a common (or systemic) risk component. As the country-specific component dominates, purging yields from it produces much smaller measures of bond market segmentation than conventional ones for the crisis period. We also investigate how the home bias of banks' sovereign portfolios – a quantity-based measure of segmentation – is related to yield differentials, by estimating a vector error-correction model on 2008-12 monthly data. We find that the sovereign exposures of banks in most euro-area countries respond positively to increases in yields, especially in periphery countries. When yield differentials are decomposed in their country-risk and common-risk components, we find that: (i) in the periphery, banks respond to increases in country risk by increasing their domestic exposure, while in core countries they do not; (ii) in contrast, in most euro-area countries banks respond to an increase in the common risk factor by raising their domestic exposures. Finding (i) hints at distorted incentives in periphery banks' response to changes in their own sovereign's risk. Finding (ii) indicates that, when systemic risk increases, all banks tend to increase the home bias of their portfolios, making the euro-area sovereign market more segmented.

Keywords: euro-area financial integration, sovereign debt yield differentials, dynamic latent factor model, sovereign portfolio home bias, vector error-correction model
JEL Classification: C32, C51, C58, G11, G15

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1. Introduction

Starting from late 2009, the euro area has experienced increasing turmoil in financial markets: interbank markets have virtually frozen, and were replaced by the European Central Bank (ECB) as the main source of liquidity for banks; sovereign debt yields of peripheral euro-area countries have repeatedly spiked above those of core countries; bank interest rates also started to differ systematically across countries; portfolios of financial intermediaries and households have become increasingly biased towards domestic securities. Hence, most of the indicators traditionally considered as gauges of financial integration have started to point towards a reversal in the process of integration that initiated before the inception of the European Monetary Union (EMU), and proceeded in the first seven years of its life. Indeed, based on the behaviour of these indicators, it has become almost commonplace to talk of increasing "fragmentation" or "segmentation" of euro-area financial markets: for instance, on 4 September 2012 the *Financial Times* titled its main front-page article "Loan rates highlight cracks in eurozone" and another article "Convergence in reverse" (p. 8).

This paper takes a fresh look at this phenomenon, with three purposes. First, we wish to verify whether, according to conventional indicators, financial integration is receding across the board in the euro area, or is doing so only in some markets. As we shall see, according to conventional indicators the degree of integration is indeed decreasing but only in debt markets, and within these especially in (i) the money market, (ii) sovereign markets, and (iii) uncollateralized credit markets. There is less evidence of segmentation in collateralized credit markets and in equity markets.

Our second contribution is to question the appropriateness of price-based measures of financial integration, and put forward a more suitable measure of segmentation for debt issuers: starting from the definition of segmentation as a situation in which an issuer is required to pay a premium only because it belongs to a specific jurisdiction, irrespective of the issuer's own risk profile, we argue that only the component of yield differentials that is not a compensation for the issuer's own risk can be related to segmentation. For instance, the yield differential between Italian BTPs and the euro-area swap rate of the same maturity contains (i) a component that reflects the default risk of Italy, and (ii) another component that reflects Italy's exposure to common (or systemic) risk. During the euro debt crisis period that we analyse, such risk was dominated by the danger of collapse of the euro system, and the implied currency redenomination of sovereign debts.

We implement such decomposition by estimating a dynamic factor model for euro-area sovereign debt, and show that most of the dispersion among euro-area yield differentials arises from differences in country-specific risk. Hence, once yields are purged from the portion that compensates investors for different country-specific risks, their dispersion becomes considerably smaller than the unconditional one, which is typically used as a measure of euro-area bond market segmentation. The dispersion of these "purged yields" changes over time: compared to the actual dispersion, it is large in 2008-09 and in late 2012, that is, respectively in the middle of the subprime crisis and in the recent period of relative calm in the euro area.

Thirdly, we explore whether the increasing home bias of the sovereign debt portfolios of euro-area banks (a quantity-based measure of segmentation) is correlated with sovereign yield differentials, and more specifically with their country-related and systemic components. There are at least three concomitant reasons why this form of home bias may be expected to increase in response to widening differentials between sovereign debt yields and the euro-area swap rate:

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

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

(iii) In the event of a collapse of the euro, the liabilities of banks in each country (e.g., their deposits) would be redenominated into new national currencies, and so would presumably be the domestic sovereign debt that they hold. Hence, domestic banks are better hedged against the redenomination risk of domestic sovereign debt than foreign banks: they have a "comparative advantage" in bearing the systemic component of its risk.[1] Hence, home bias should be correlated with the systemic component of sovereign risk, but not with its purely country-specific component, which instead should equally affect domestic and foreign investors.

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

We explore the response of euro-area domestic sovereign exposures to their respective yields and their components, obtained from our dynamic factor model, by estimating a vector error-correction model (VECM) on 2008-12 monthly data for ten euro-area countries.[2] When the model is estimated using actual yields, the sovereign exposures of euro-area banks are seen to respond positively to increases in yields in most countries, except Belgium, France and the Netherlands. However, this pattern stems from a very different response of sovereign exposures to the country risk factor in the

[1] 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.

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

core and in the periphery: (i) in most periphery countries banks respond to increases in the country risk factor by *raising* their domestic exposure, while in core countries they do not; (ii) in contrast, in almost all countries banks increase their domestic exposures in response to an increase in the common risk factor.

Finding (i) suggests that, for periphery-country banks, and only for those, there is evidence in support of the "moral suasion" and/or the "carry-trade" hypothesis, since these banks increase their exposures in response to increases in country-level sovereign risk, not just in response to systemic euro-area risk. Finding (ii) indicates that, when systemic risk increases, most banks – both in core and in periphery countries – "turn back home", by increasing their domestic sovereign holdings. This suggests that increased risk of euro collapse and currency redenomination has led to greater home bias of banks' portfolios, especially in core countries. It is worth noticing that these results can be detected only as a result of the decomposition between the country and the common risk factors: they cannot be deduced only from the regressions based on the actual sovereign yields.

Notice that, 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, since to test it we would need data on core-country banks' holdings of periphery debt: if this hypothesis were true, these banks should respond to an increased yield of periphery debt by increasing their exposure to periphery sovereigns. Unfortunately we cannot perform this test, since a two-entry matrix of euro-area banks' sovereign portfolios by holding and issuing countries is currently unavailable.

The results of our analysis have several implications for policy. First, in a context where solvency risk can differ markedly between issuers, price-based measures of segmentation must be "purged" from issuer-specific solvency risks. Operationally, this opens the door to the estimation of more reliable price-based indicators of segmentation than those currently used by the ECB and the European Commission.

Second, 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. This is exemplified by our findings for the euro area in the 2008-12 period: as explained above, the increase of banks' sovereign holdings in the periphery cannot be explained entirely as a response to greater systemic euro-area risk, since this increase was associated mostly with increases in country-specific sovereign risk. In other words, it cannot be justified only as a response due 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 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 policy-maker. If due to moral suasion by national regulators, it indicates that these regulators tended to induce risk-taking by banks in a context where government solvency was at danger, thus enhancing the "diabolic loop" between fiscal solvency and bank solvency deterioration. If due to opportunistic carry trades by banks, it raises concerns about the appropriateness of banks' prudential regulation.

Finally, it is worth clarifying what might be seen as a contradiction between the two main conclusions of this paper. In the first part, we argue that proper price-based measures of sovereign debt market segmentation should be purged from differences in yields that reflect country-specific risk. In the second part, we find that, in the case of euro-area periphery banks, also country-specific risk has contributed to increase the home bias of these banks' portfolios. But it is important to recognize that *in equilibrium* an increase in the country-specific component of sovereign risk does not need to result either in an increase or in 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*. In the presence of such distorted incentives, quantity-based indicators of financial segmentation, such as the home bias of banks' sovereign portfolios, can diverge from appropriately computed yield-based measures.

The paper is structured as follows. Section 2 illustrates the recent dynamics of conventional indicators of euro-area financial segmentation. Section 3 uses dynamic factor analysis to decompose euro-area sovereign yield differentials in their country and common components, and presents new measures of financial segmentation that do not include the country-risk component. Section 4 investigates how the home bias of banks' sovereign portfolios is related to yield differentials, by estimating a vector error-correction model. Section 5 concludes.

2. Conventional indicators of euro-area financial segmentation

Conventional indicators of financial market segmentation belong to two broad classes: *price-based indicators*, which measure the extent to which the return required on debt or equity finance varies according to the geographic origin of the issuer; and *quantity-based indicators*, which generally measure the degree of home bias in portfolio choices of households, banks and institutional investors, or the degree of cross-border issuance of debt or equity. In this section, we ask for which euro-area financial markets these indicators point to increasing segmentation, while pointing out the limitations of some of these indicators in the current situation.

2.1. Debt markets: price-based measures of segmentation

In this section we consider measures of cross-country dispersion in interest rates for various euro-area debt markets: the money market, the sovereign debt market and the credit market, leaving quantity-based measures for these markets to the next subsection.

Figure 1 shows that the dispersion of interbank overnight rates has surged since 2007, and spiked at three dates: the collapse of Lehman Brothers in 2008, the pressures in euro-area sovereign markets

in 2010, and a further deterioration in those markets in the second half of 2011. A similar, though less extreme, pattern is visible for unsecured lending rates at 1-month and 1-year maturities, and to still lower extent in the repo market. Hence, these indicators of segmentation in the money market are particularly strong at short maturities and for unsecured lending, which is highly sensitive to market stress.

Figure 2 shows the same type of statistic for the euro-area sovereign market: the cross-country dispersion of interest rates on 10-year benchmark bonds increased steadily throughout 2010 and 2011, and peaked in late 2011, before abating somewhat in 2012. Figures 3 and 4 show that the increase in dispersion in 2010 arose mainly from the pattern of sovereign yields in Greece, Ireland and Portugal, while in 2011 also the sovereign yields of Spain and Italy rose well above those of the core countries (the latter being more clearly visible in Figure 4, where 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. Figure 5 shows that the CDS on Greek sovereign debt spikes first in 2011 and then again in the Spring of 2012, in coincidence with the two corresponding spikes in the Greek yield shown in Figure 3. Figure 6 allows to see that also the increases in Irish, Portuguese, Italian and Spanish CDS premia in 2011 and 2012 largely coincided with the respective yield increases.

It is interesting to see however 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 yield differentials did not appear to react to them almost at all, except for Ireland. Hence, for the more stressed countries the CDS market appears to have been a more sensitive gauge of sovereign risk than the underlying bond market, in line with Fontana and Scheicher (2010), who find that since 2008 price discovery takes place in the CDS markets for Italy, Ireland, Spain, Greece and Portugal, and in the bond market for the core countries. Even though in principle a CDS can be replicated by a short position in the underlying risky bond and a long position in a safe bond of the same maturity, its arbitrage relationship with the underlying bond may break down due to short-sales constraints in the cash market, especially at times of great market stress. In these situations, the CDS become the cheapest way to trade credit risk, because of their synthetic nature, and therefore they also become more sensitive to changes in such risk.

As shown in Figure 7, CDS premia have a strikingly different relationship with the *differentials* of sovereign yields vis-à-vis the German Bund and with the *levels* of these yields. The left panel of Figure 7 shows that the correlation between yield *differentials* and the respective sovereign CDS premia is close to 1 in almost all euro-area countries except Finland and the Netherlands. In contrast, the correlation between the *level* of the sovereign yield and the respective CDS premium is negative in all the core countries, and close to –1 for Germany; instead, it is positive in all periphery countries, and close to 1 in Greece, Ireland and Portugal. This striking difference can be interpreted as follows: when the risk of sovereign debt increases throughout the euro area, it triggers a "flight to safety" from periphery issuers towards core ones, and especially towards Germany, and therefore it compresses their yields while it increases those of periphery countries. Since the German yield drops the most (in spite of increased risk of German bonds), the yield differentials of all other euro-area issuers relative to the Bund increase together with their respective CDS premia. This also

generates a negative correlation between the German yield and the German CDS premium, since the latter also increases signalling a greater credit risk also for the euro area as a whole – including Germany. Of course, the premise of this argument is that to some extent changes in euro-area sovereign risk have a common component, captured by correlated movements in CDS premia across the euro area. As we shall see in the econometric analysis of Section 3, this is indeed consistent with the data.

Further, CDS premia on sovereign debt are correlated with the CDS premia on corporate debt issued by banks and telecom companies: Figure 8 shows that the cross-country dispersion of the CDS premia increases steeply especially for sovereigns and banks starting from 2010, and for telecom companies since late 2011. This underscores the feedback loop between sovereign risk and bank risk which is the very root and the overarching feature of the euro debt crisis: the solvency problems of banks threaten the fiscal stability of sovereigns, as they raise the likelihood of bank bailouts by the respective governments; by the same token, concerns about sovereign solvency threaten the perceived solvency of banks, both by reducing the value of their sovereign debt holding and by sapping the credibility of the respective governments as backstops in case of distress.

To what extent do the increasing differentials between money market rates and government bond yields extend to the respective credit markets? Figure 9 shows that the differentials between the loan rates that banks charge to firms differ across countries much less than the sovereign bond yields but more than the money market rates, especially towards the end of the sample and for floating rate loans on small loans (below 1 million euro). The dispersion between interest rates is not as strong for large loans (above 1 million): this may reflect the fact that in the periphery countries banks perceive a greater increase in the credit risk of their clientele of small and medium enterprises compared to that of large firms. Another fact that emerges from the figure is that the dispersion of fixed-rate long-term loans over 1 million euro parallels closely that of the money market rates in Figure 1: it increases first during the subprime crisis of 2009 and then again in the second wave of the sovereign debt crisis in 2011. This suggests that the interest rates on these long-term, large loans are more responsive to the conditions that the banks of the respective countries meet on the money market.

The situation appears to be quite different in the household credit market: as illustrated by Figure 10, the cross-country dispersion of mortgage interest rates is quite low and has increased only slightly since 2009, probably because of the secured nature of these loans. In contrast, the dispersion of (unsecured) consumer credit rates appears to have been much higher throughout the 2003-11 interval, and to have increased already as early as 2006, well before the euro debt crisis.

On the whole, it appears that the dispersion of bank interest rates, especially in the housing mortgage market, is considerably smaller than that in sovereign yields. This probably reflects the fact that the main source of risk during the crisis originated from concerns about government solvency, more than about the solvency of the typical household or firm. Of course, the rationing of riskier debtors by banks may also account for this phenomenon, if in periphery countries rationing has been more severe than in core ones, in the sense of cutting off a larger fraction of the lower-tail risks. Such rationing is consistent with the evidence by Albertazzi et al. (2012) that the increase in

the Italian sovereign spread has had a direct negative effect on lending growth, beyond that implied by the rise in lending rates.

2.2. Debt markets: quantity-based measures of segmentation

In this section we investigate whether, since the inception of the debt crisis, the sovereign debt portfolios of euro-area banks and investment funds feature increasing home bias, and whether cross-border lending of euro-area banks has decreased.

Figure 11 shows the time series of the domestic euro-area sovereign exposure of banks in two groups of euro-area countries: the core countries (Belgium, Finland, France, Germany, Netherlands) and the periphery countries (Greece, Ireland, Portugal, Spain and Italy). Specifically, it plots the sum of the monthly values of the euro-area sovereign debt holdings of the banks from each of these two groups (drawn from the SDW database) scaled by the total assets of those banks.[3] 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 reduce their domestic sovereign debt exposure until 2008, with periphery banks actually reducing their domestic sovereign exposures proportionately more, they both start increasing it again after 2008, with periphery banks increasing it by more than core-country banks.

One may suspect that the behavior of the time series for the domestic sovereign exposures in periphery and core-country banks illustrated in Figure 11 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 12 and 13 plot the time series of the *level* of the domestic and non-domestic euro-area debt holdings of banks in periphery and core countries (in billion euro). The two figures show that also the *levels* of banks' sovereign debt holdings – not just their *ratio* to total assets – have a turning point in 2008, and that they behaved quite differently in the two groups of countries starting in the last part of that year.

Specifically, Figure 13 shows that, while after 2008 banks have increased their domestic sovereign debt holdings in both groups of countries, they have done so to a much greater extent in periphery than in core countries: the domestic sovereign debt holdings of periphery banks rose from €270 to €625 billion between October 2008 and March 2012, while those of core-country banks rose from €352 to €505 billion: a 131% increase in the former versus a 43% increase in the latter!

Taken together, Figures 13 and 14 indicate that, at least partly, the recent increase in banks' holdings of domestic sovereign debt has resulted from a substitution away from the debt issued by the other group of euro-area sovereigns: starting from 2006, banks in each group of countries have reduced their holdings of sovereign debt issued by the sovereigns of the other group, and therefore

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

have increased the home bias of their sovereign debt portfolios. However, this reallocation has been relatively modest for banks in the periphery, where it has been very sharp in core-country banks: dating from February 2011 these banks have reduced their holdings of periphery-country sovereign debt from €430 to €248 billion. Hence the overall picture is that of core-country banks reallocating their portfolios away from periphery sovereign debt and towards the debt issued by their domestic governments. Indeed, their shift away from periphery sovereign debt has been so large as to exceed their investment in domestic public debt, so that their euro-area sovereign holdings have decreased since late 2010. This has not been the case for banks in periphery countries, whose total holdings of euro-area sovereign debt have sharply increased.

A similar pattern emerges when one looks at investment funds' holdings of debt securities issued in other euro-area countries in Figure 14: as of late 2008, also investment funds have reduced the share of their debt portfolio invested in securities issued by other euro-area residents, after increasing this share in the previous years. However, their debt portfolio has not become more biased towards domestic debt securities, because they have rebalanced it towards debt issued by non-euro residents. Indeed, the rise in the share of non-euro debt securities appears to be the mirror image of the decline in that of securities issued in other euro area countries. Rather than an increased home bias, investment funds appear to have reduced their "euro bias", most likely seeking to diversify away from an increased common "euro-area risk".

As for the credit market, Figure 15 indicates that cross-border lending to non-bank counterparts – though still quite modest – has not declined since 2008, while cross-border lending to banks in other euro area countries has significantly decreased since that date. This is one more indication that credit market segmentation in the euro area has to do chiefly with the willingness of banks to lend to other banks located in other jurisdictions, as witnessed by the virtual freeze of the interbank market.

2.3. Equity markets: price-based and quantity-based measures of segmentation

Figure 16 shows that, while from the 1973 to the late 1990s euro area stock returns was driven more by country-level than by sector-level shocks, starting from the inception of the single currency the cross-country dispersion of stock returns has effectively coincided with their dispersion across sectors. However, starting from 2007 it can be noticed that the cross-country dispersion rises again above the cross-sector dispersion, which can be interpreted as resurgence in the dominance of country-level shock to equity prices.

However, for the equity market quantity-based indicators do not unambiguously point to increased segmentation. Quite to the contrary, the share of equity issued in euro-area residents held by residents in other euro-area countries has kept increasing since 2007, although at a lower rate compared to the previous years, while the share held by residents in the rest of the world is virtually unchanged, as shown by Figure 17. Euro-area investment funds have reduced somewhat the share of equities issued in other euro-area countries in their equity portfolio since 2008, while increasing more than proportionately that invested in equities issued in the rest of the world, as can be seen in

Figure 18. This parallels the investment policy followed by investment funds in their debt portfolio: they are divesting from euro-area debt securities to diversify into extra euro-area securities.

3. Price-based measures of bond market integration in the presence of default risk

The upshot from the previous section is that, according to conventional measures of financial integration, there is an increasing segmentation in the euro area starting from 2008 and even more markedly since 2010, in all debt markets, with the partial exception of the housing mortgage market. However, the euro debt crisis has highlighted a major conceptual weakness of conventional price-based measures of debt market segmentation: as highlighted in the previous section, the key novelty of the recent crisis is that the sovereign debt of most euro-area countries is no longer perceived as perfectly safe, its perceived riskiness varying greatly both across issuers and over time.

In this situation, rising interest rate differentials and increasing dispersion of interest rates across countries can no longer be read necessarily as symptoms of increasing segmentation – or disintegration – of euro-area debt markets. The markets could still be perfectly integrated, and be simply pricing different risks for sovereign bonds issued by different governments. One would not say that, for instance, the U.S. market for municipal bonds is segmented if the bonds issued by different states, counties or cities of the U.S. were to carry different yields: one would simply suppose that they reflect differences in default risk across issuers. Segmentation occurs only when there are deviations from the law of one price, i.e. instances of the <u>same</u> risk being valued differently <u>only</u> depending on the issuer's jurisdiction. The problem is that since 2008 sovereign risk appears to differ so much between euro-area issuers that assessing whether the same risk is being priced differently depending on the issuer's nationality is extremely difficult.

Does this imply that to measure the degree of segmentation of euro-area debt markets we should abandon price-based indicators? This is not necessarily the case: bond yields and interest rates may still provide useful information on financial segmentation if one can purge them from their issuer-specific default risk. In the case of sovereign bonds, we propose a methodology to identify two components of sovereign risk: a country-specific one and a systemic one, which captures factors affecting the default probability of all countries (possibly to a different extent). Once purged from the compensation for country-specific risk, a country's sovereign yield will reflect its exposure to systemic risk. In the context of the euro-area debt crisis, such systemic risk may have arisen from the fear of collapse of the euro, and of the subsequent exchange rate changes (as argued by Di Cesare et al., 2013). This exposure may of course differ across countries: for instance, Italy is likely to have a greater exposure to this risk than Austria, because the costs that a collapse of the euro would inflict on the holders of Italian sovereign debt would be presumably larger, due to a greater devaluation of the Italian currency.

In this section, we effect this decomposition for sovereign yields by estimating a dynamic latent factor model, which partitions the shocks driving the sovereign yields of each euro-area issuer in

three components: (i) a common factor, capturing world and euro-area shocks; (ii) a country factor, reflecting shocks to that country's credit risk; (iii) an unexplained idiosyncratic shock.[4] 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 instead captures both common shocks and country-level shocks whose effects spread beyond a specific country, such as those capable of destabilizing the euro area as a whole: for instance, a statement by the Prime Minister of a major euro-area country that raise the likelihood of sovereign default by that country might lead investors to increase the likelihood of collapse of the monetary union, and therefore contribute to the euro-area common factor. Importantly, the model allows the same common shock to elicit responses in yields and CDS premia that are completely different in sign and magnitude across countries: hence, the same perceived risk of collapse of the euro may have widely different impacts on different countries.

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

Many other studies have analyzed the determinants of sovereign yield spreads and CDS premia. A first strand of the literature has explored the role of country-level variables such as the debt-GDP ratio, the projected fiscal balance and other macro fundamentals, attributing the unexplained component of yield spreads or/and CDS premia to the mispricing of risk due to panic or contagion effects or, in the context of the euro crisis, to the perceived risk of breakup of the common currency (Aizenman et al., 2011; Di Cesare et al., 2013). Another strand of the literature allows for both country-specific and common factors in the determination of sovereign yield spreads, by regressing spreads on a vector of country-specific variables (especially fiscal and macroeconomic variables) and one that is common across countries, aimed at capturing time-varying global risk aversion or contagion effects. Attinasi et al. (2009) and De Santis (2012) proxy risk aversion by the spread between the US AAA corporate bonds and the US 10-year sovereign bonds, Caceres et al. (2010) estimate it as the market price of risk of a stress event, and Sgherri and Zoli (2009) measure it as a latent common factor in spreads by estimating a first-stage regression. Giordano et al. (2012) not only include country-level and common risk variables, but also attempt to capture contagion by

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

interacting these variables with a post-Greek-crisis dummy variable, and find evidence that country-level fundamentals have a greater impact after the Greek crisis ("wake-up call" contagion), while common factors do not (no "pure contagion").

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

3.1. Data

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

Figure 19 shows sovereign yields differentials and CDS premia over the sample period. These series grow over time and are very closely correlated for periphery euro-area countries and Belgium (where 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 strongly negative for Germany (-0.72). The latter result can be explained as a result of "flight to quality" in the sovereign debt market: in the presence of a generalized increase in euro-area credit risk, investors reallocate their sovereign portfolio away from other euro-area countries towards the Bund, and therefore compress the German yield even though credit risk increases in Germany too.

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

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

the possible concerns for the stability of the euro, namely the percentage change of the euro-dollar exchange rate and of the effective exchange rate of the euro.[5]

3.2. Methodology

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

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

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

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

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

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

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

3.3. Results

Identifying the common and country specific factors allows to estimate the fraction of the variance in the yield differentials that can be attributed to each of them: the larger the fraction traceable to country-specific risk, the more inappropriate is the yield differential as a measure of segmentation, since a large portion of the differential is just a compensation for the country's default risk. This allows us to compute a measure of segmentation that purges sovereign yield differentials from the reward for country-specific risk. 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, especially for periphery countries and Belgium (except Greece, whose yield differential is mainly idiosyncratic). In contrast, the common factor affects mainly the German yield: a possible interpretation is that changes in the global appetite for risk induce investors to reshuffle their sovereign portfolios towards the Bund ("flight to quality").

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

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

To interpret these results, it is worth looking at Figures 20, 21 and 22, 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 black line shows the actual series (yield differential or CDS premium), the blue line plots the common component of the series, and the red one the country component. Figure 20 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 21 and 22 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 blue lines): CDS premia rise in all three countries, but while both the Italian and Spanish yield differentials increase, the German one drops sharply. The opposite happens towards the end of the sample (second half of 2012), when both common and country risks recede in Italy and Spain: all CDS premia decline, and the Italian and Spanish yields also drop, while the German one rises.

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

The result that the country component explains most of the yield differentials actually generalizes to all periphery countries, and as a consequence the country component also ends up accounting for most of the dispersion in yield differentials, as shown by Figure 23. The solid line plots the cross-country standard deviation of actual yield differentials in our sample, which is comparable to Figure 2, except for the different start date (2009 instead of 2006) and maturity (5-year instead of 10-year). The dotted and dashed lines show instead the cross-sectional standard deviations of the country and common components of the yields, respectively. While the dispersion of both of these components is trending upwards in our sample period, the common-factor dispersion appears to play a greater role in the early part of the sample period (2009-10), while the country-factor dispersion does so starting from the outbreak of the euro debt crisis (2011-12). Since most of the dispersion in yield differentials is concentrated in this second portion of the sample, on the whole the country factor appears to play a more important role in the data. Insofar as price-based measures of segmentation should not include the portion of yields that is a mere reward for differential country credit risk, Figure 23 suggests that reliance on conventional measures of yield dispersion greatly overstates the degree of segmentation in the euro-area sovereign market. For instance, between mid-2011 and early 2012, the conventional measures of yield dispersion were about twice as large as the common-factor dispersion, which is purged from the difference in yields arising from country risk.

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

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

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

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

(iii) the "comparative advantage" of each country's banks in bearing the currency redenomination risk of their country's sovereign debt, arising from the threat of a collapse of the euro system.

The first two motivations are compatible with banks increasing their domestic exposures not only in response to greater systemic euro-area risk but also in response to increased country-specific risk; in contrast, the third motivation implies that banks should increase their domestic exposures only in response to greater systemic euro-area risk, since they have no comparative advantage in hedging against country-specific risk. Hence, in this Section we also investigate how domestic sovereign exposures respond to the common and country risk factors that drive yield differentials, so as to shed some light on the mechanisms that have driven the response of banks' domestic exposures during the euro crisis. This is also relevant for the analysis of segmentation of the sovereign debt market in the euro area: as argued in the introduction, in principle country risk should not be a source of segmentation, since it does not necessarily lead domestic banks to increase their exposures relative to foreign ones; however, to the extent that domestic banks' portfolio choices may have been driven by the "non-standard motives" under (i) or (ii), also increases in country risk may have contributed to home bias, and therefore to segmentation.

4.1. Data and methodology

Our analysis proceeds in two steps. First, we estimate a *baseline model*, where we investigate the dynamic relationships between banks' domestic sovereign exposures and yield differentials between the domestic 5-year government bond yield and the euro 5-year swap rate. Second, we estimate a *factor-based model*, where the yield differential is replaced by the country and common risk components estimated in Section 3. Beside the 5-year yield differentials relative to the euro swap rate used in Section 3, the data used in the estimation include monthly values of aggregate euro-area banks' exposures to domestic sovereign debt, drawn from the ECB SDW.[6] The sample period ranges from October 2008 to August 2012 for all countries except Greece (whose end date is April 2010), Ireland (December 2010) and Portugal (April 2011), since we exclude observations after the inception of the IMF/ECB bailout programs implemented in those countries.

To select the econometric model most suitable for the analysis of the dynamic relationships between banks' sovereign exposures and yield differentials (and their components), we consider several features of the relevant time series. First, although we are particularly interested in the response of sovereign exposures to the sovereign yield differentials, feedback effects from banks' sovereign exposures to interest rate spreads cannot be ruled out. Second, the model should be dynamic, so as to allow for the possibility of gradual short-run adjustment of banks' sovereign portfolios towards their long-run desired composition, due to adjustment costs deriving from illiquidity, uncertainty about the persistence of yield differentials, etc. Finally, in order to have a correctly specified model, we must account for the non-stationarity of all the series in our data sample.

All these motivations lead us to estimate a vector error-correction model (VECM) for each country to analyze the joint determination of its banks' domestic sovereign exposure and yield differential,

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

since this model (i) allows for all possible patterns of time-precedence among variables,[7] (ii) can capture the gradual adjustment of sovereign exposures to long-run equilibrium levels determined by movements in yield differentials, and (iii) can deal with non-stationarity in the data generating process. The preliminary analysis of the data and the specification search (see the Appendix) leads us to the following 2-lag reduced-form specification:

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

where y_t is a n×1 vector, with n the number of endogenous variables, defined as the 2-element column vector $y_t = \left[spread_t \quad sovexp_t\right]'$ in the baseline model and the 3-element column vector $y_t = \left[common_t \quad country_t \quad sovexp_t\right]'$ in the factor-based model, where $spread_t$ is the domestic sovereign debt yield differential (with respect to the euro-area swap rate) in month t, $sovexp_t$ denotes the domestic sovereign exposures of banks as a fraction of their total assets in month t, and $common_t$ and $country_t$ denote the common and the country components of the yield differential in month t, respectively. Moreover, d_t and D_t are m×1 and M×1 vectors, referring to the restricted and unrestricted deterministic terms (or dummy variables) included in each country's specification, respectively; the n×1 vector u_t denotes the reduced form residuals. Finally, α is the n×r matrix of adjustment parameters, β is the n×r matrix of cointegrating parameters, Θ is the n×n matrix of short-run parameters, and γ and Γ are the r×m and n×M matrices of coefficients associated with the restricted and unrestricted deterministic terms, respectively, where r is the cointegrating rank (i.e. the number of cointegration relations) of the system. As usual, our analysis focuses on the parameters describing the long-term relationships among the variables, namely the coefficients in α, which capture the adjustment of each variable in response to shocks (towards the long-run equilibrium if the coefficient is negative, and away from it if positive), and β, which indicate the long-run relationship between variables (positive if the coefficient is negative, and viceversa).[8]

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

The reduced-form VECM in equation (3) is estimated using Johansen's (1995) maximum likelihood method. Accordingly, restrictions on the cointegrating parameters in β are imposed following

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

[8] A negative adjustment parameter indicates that, whenever the error-correction term, say $z_{t-1} = \beta' y_{t-1} + \gamma d_{t-1}$, is different from zero, the dependent variable adjusts towards its equilibrium level.[8] If instead the estimated adjustment coefficient is positive, then the process for the dependent variable is explosive.

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

4.2. Results

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

The estimated cointegrating parameters β in the baseline model (column 1 of Table 2) are negative and significant in all countries except Belgium, France and the Netherlands, indicating that for most countries in the long run a higher yield spread is associated with a greater sovereign domestic exposure of banks. It is interesting to notice that this positive long-run correlation is present for all periphery countries, but only for two out of the five core countries in our sample. The estimated adjustment parameters α in column 2 is negative and significant at the 5 percent level in all countries, except France, where it is not significantly different from zero, and the Netherlands, where it is significant at the 10 percent level.[9] 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.

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

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 24. The IRFs are obtained from a structural VECM specification of the baseline model, in which we impose the restriction that a shock to exposures cannot determine a contemporaneous effect on the yield differential. The solid line indicates the predicted response, while the dashed lines plot the respective Hall bootstrap 95% confidence bounds.[10] In the long run, the response of domestic sovereign exposures is positive and significant for all periphery countries and, among core ones, for Austria and Germany, whereas it is negative for Belgium and insignificant for France and the Netherlands.[11] In all periphery countries (except Ireland), the response features a small initial drop in exposures, which is reversed within two months. This initial dip may reflect the mechanical impact of an increase in domestic yields, which is equivalent to a drop in the price of domestic debt: such a price drop, if not sufficiently compensated by a buildup in exposures, mechanically translated into a drop in the market value of sovereign exposures.

Further, we investigate the effect of domestic sovereign exposures on yield differentials by looking at the IRFs of the yield differential to a shock in domestic exposures. As illustrated in Figure 25, all countries (except Spain, Italy and Germany) show a negative long-run response of their domestic differentials to an increase in domestic exposures. Hence, in these countries, increases in banks' domestic exposures effectively curb investors' concerns over sovereign solvency and contribute to tightening yield differentials. However, in Spain and Italy, a shock in banks' sovereign exposures appear to trigger an increase of the domestic yield differentials. A possible interpretation is that a greater bank exposure to sovereign risk increases investors' concerns about the solvency of the banks themselves and therefore about their eventual bailout by the respective government, thus prompting them to require a higher yield on its sovereign debt.

Turning to the factor-based model (whose estimates are shown in columns 3-6 in Table 2), for the sake of brevity it is worth focusing directly on the product of the coefficient vectors α and β, which captures the dynamic response of domestic sovereign exposures to the common component (columns 3-4) and to the country component (columns 5-6) of the yield differential. The response to the common risk factor is positive for all countries except Italy (where it is negative and significant) and not significant for Ireland and Portugal. This indicates that for most countries when there is an increase in systemic risk, local banks increase the home bias of their sovereign debt portfolios, consistently with the "comparative advantage" hypothesis. In contrast, the response to the country risk factor differs considerably across countries: in core countries (except Austria), an increase in country risk prompts local banks to reduce significantly (Germany and France) their domestic exposures, or not to change them significantly (Netherlands and Belgium); in contrast, in periphery countries and Austria, it leads local banks to increase their domestic exposures significantly, the only exception being Spain where the response is not significant.[12]

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

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

[12] Furthermore, the adjustment parameters to an off-equilibrium level of the error-correction term is positive for Italy, Portugal and France, indicating an explosive response of exposures to the common component. Hence, for these

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

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

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

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

The resulting IRFs are shown in Figure 26, where the graphs on the left show the response to a shock in the common factor, and those on the right the response to the country factor.

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

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

5. Conclusions and future research

According to conventional indicators, the euro-area financial integration has receded since 2007, mainly in the money market, sovereign debt market and uncollateralized credit markets. But price-based measures of debt market segmentation are inappropriate when solvency risk differs across countries: only the component of yield differentials that is not a reward for the issuer's credit risk may reflect segmentation.

We apply this idea to the euro sovereign debt market, using a dynamic factor model to decompose yield differentials in a country-specific and a common (or systemic) risk component. As the

countries, no long-run equilibrium relationship connects domestic sovereign exposures and the common component of differentials. The same applies to Spain, Greece and the Netherlands in the case of the country component of yield differentials.

country-specific component dominates, purging yields of it produces much smaller measures of bond market segmentation than conventional ones for the crisis period. For instance, our proposed measure of bond market segmentation would have been about half as large as the conventional measure of yield dispersion between mid-2011 and early 2012.

We also investigate how the home bias of banks' sovereign portfolios – a quantity-based measure of segmentation – is related to yield differentials, by estimating a vector error-correction model on 2008-12 monthly data. We find that the domestic sovereign exposures of banks in most euro-area countries respond positively to increases in yields, especially in periphery countries. When yield differentials are decomposed in their country-risk and common-risk components, we find that: (i) in most of the periphery countries (plus Austria), banks responded to increases in country risk by increasing their domestic exposure, while in core countries they did not; (ii) in contrast, in most euro-area countries banks reacted to an increase in the common risk factor by raising their domestic exposures. Finding (i) indicates that in the euro-area periphery banks responded to increases in their own sovereign's risk by increasing even further their exposure to such risk, in line the "moral suasion" and the "carry trade" hypotheses. Finding (ii) indicates that most euro-area banks have responded to greater systemic risk by increasing the home bias of their portfolios, consistently with the "comparative advantage" hypothesis.

That periphery banks have increased their domestic sovereign exposures in response to moral suasion by their regulators or in search of high yields should be regarded as problematic from the standpoint of a policy-maker. If due to moral suasion by national regulators, it would imply that regulators themselves tended to induce risk-taking by banks in a setting where government solvency was already at danger, thus enhancing the "diabolic loop" between fiscal solvency and bank solvency deterioration. This problem, if present, should be mitigated by the introduction of the banking union in the euro area, since the prudential policy of the "Single Supervisory Mechanism" entrusted to the ECB would inevitably be more distant and insulated from the pressures of national governments. If due to search for yield, the behaviour of banks raises concerns about the appropriateness of their prudential regulation. In particular, it points to the need of changing the treatment of the sovereign debt in banks' prudential regulation, by risk-weighting sovereign debt in computing banks' capital and/or by requiring banks to diversify their sovereign portfolios.

A direction for future research is to extend to corporate yields the dynamic factor approach applied to sovereign debt in Section 3: for instance, the yield differential between the debt issued by a Spanish and a German company in the same industry should contain a component reflecting the differential company-specific default risk, another arising from the two companies being located in countries with different sovereign default risk, and a third systemic component, arising for instance from the danger of collapse of the euro. The second and the third components would respectively capture contagion from sovereigns to companies, and companies' differential exposure to euro-area systemic risk.

References

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table 1 – Dynamic factor model estimation: variance decomposition

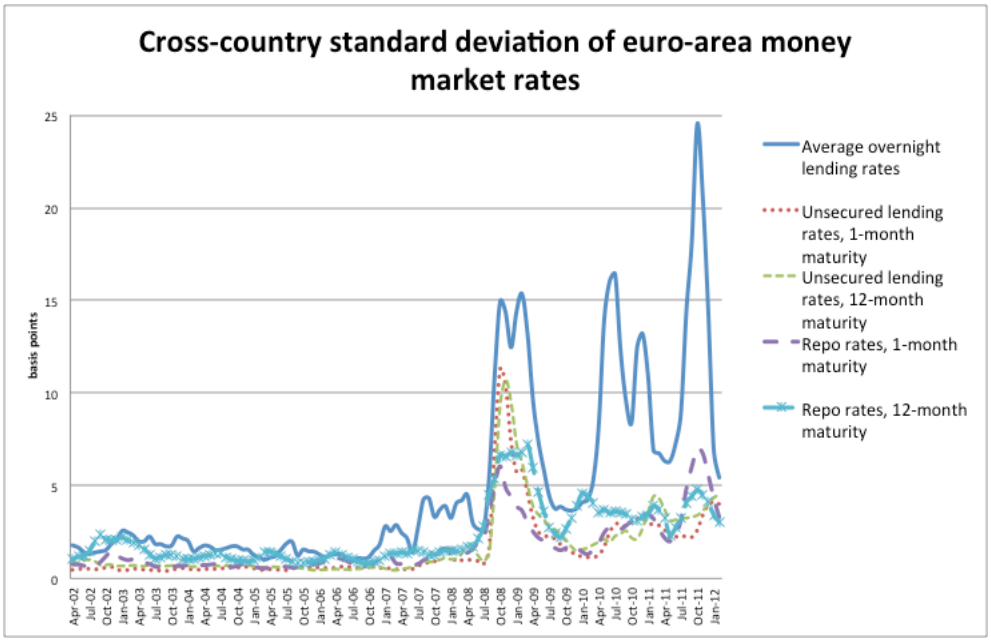
Country	Variable	Common	Country	Idiosyncratic
Austria	Δ Sovereign yield	0.09	0.18	0.73
Belgium	Δ Sovereign yield	0.24	0.55	0.21
Germany	Δ Sovereign yield	0.30	0.10	0.59
Spain	Δ Sovereign yield	0.10	0.74	0.15
France	Δ Sovereign yield	0.03	0.23	0.74
Greece	Δ Sovereign yield	0.02	0.13	0.85
Ireland	Δ Sovereign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

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

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

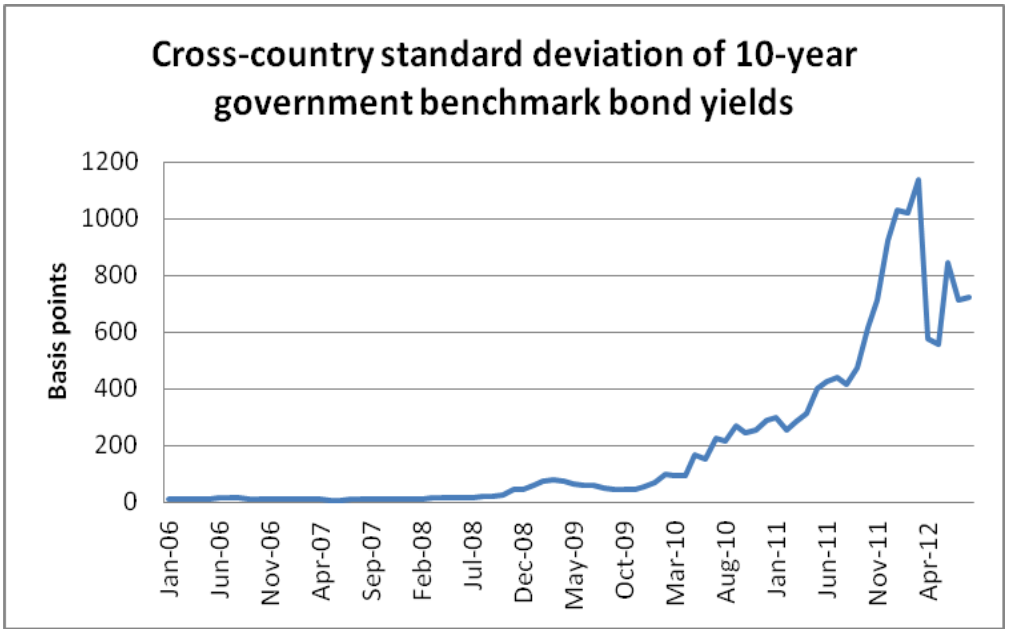
	Baseline model		*Factor-based model*			
Country	β	α	β	α	β	α
	(1)	(2)	(3)	(4)	(5)	(6)
Spain	-0.774***	-0.082**	-0.711***	-0.342***	-0.550***	0.132
	(0.003)	(0.021)	(0.000)	(0.000)	(0.000)	(0.135)
Greece	-0.586***	-0.636***	-6.134**	-0.112**	-131.752	0.011
	(0.000)	(0.000)	(0.042)	(0.017)	(0.535)	(0.227)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

Figure 1. Cross-country standard deviation of euro-area money market rates



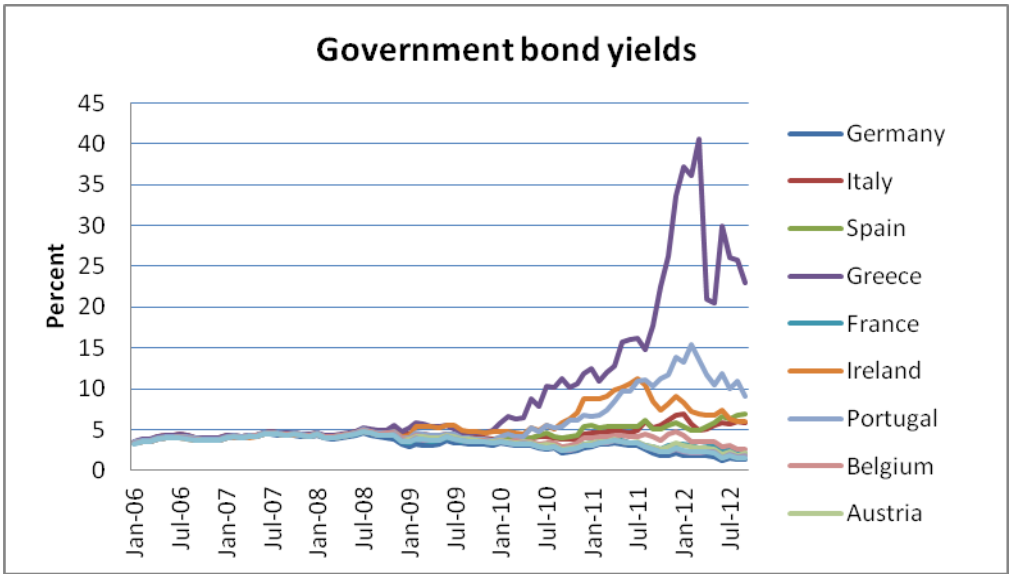
Source: ECB (2012).

Figure 2. Cross-country standard deviation of euro-area 10-year government benchmark bond yields



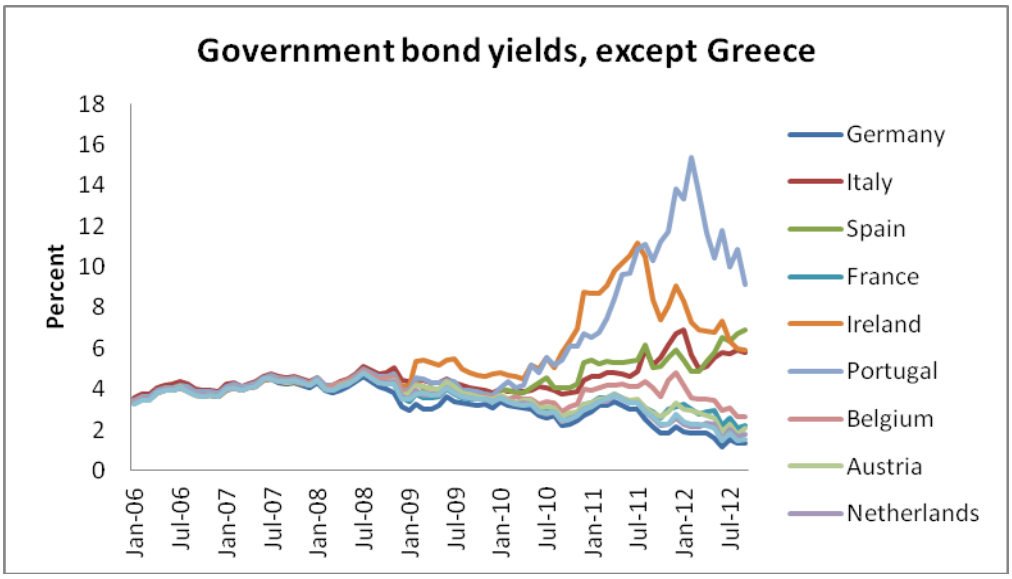
Sources: Datastream and authors' calculations.

Figure 3. Euro-area 10-year government benchmark bond yields (monthly, percent)



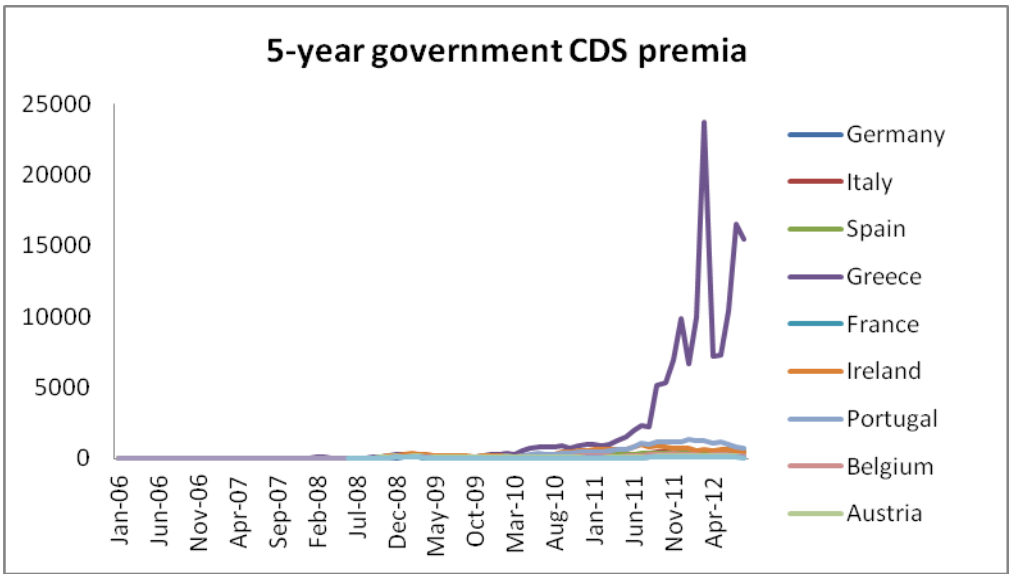
Source: Datastream.

Figure 4. Euro-area 10-year government benchmark bond yields, except Greece (monthly, percent)



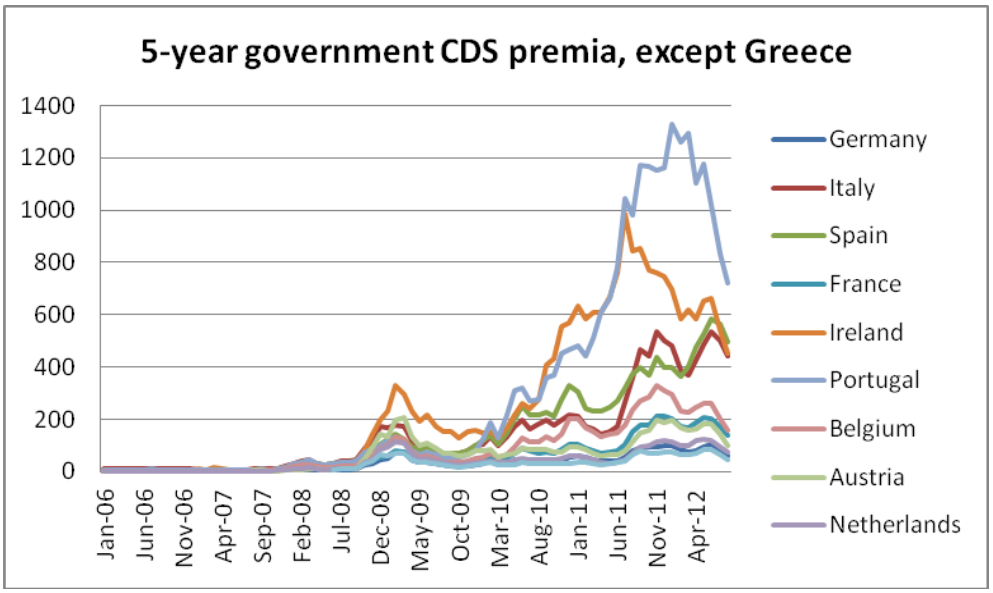
Source: Datastream.

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



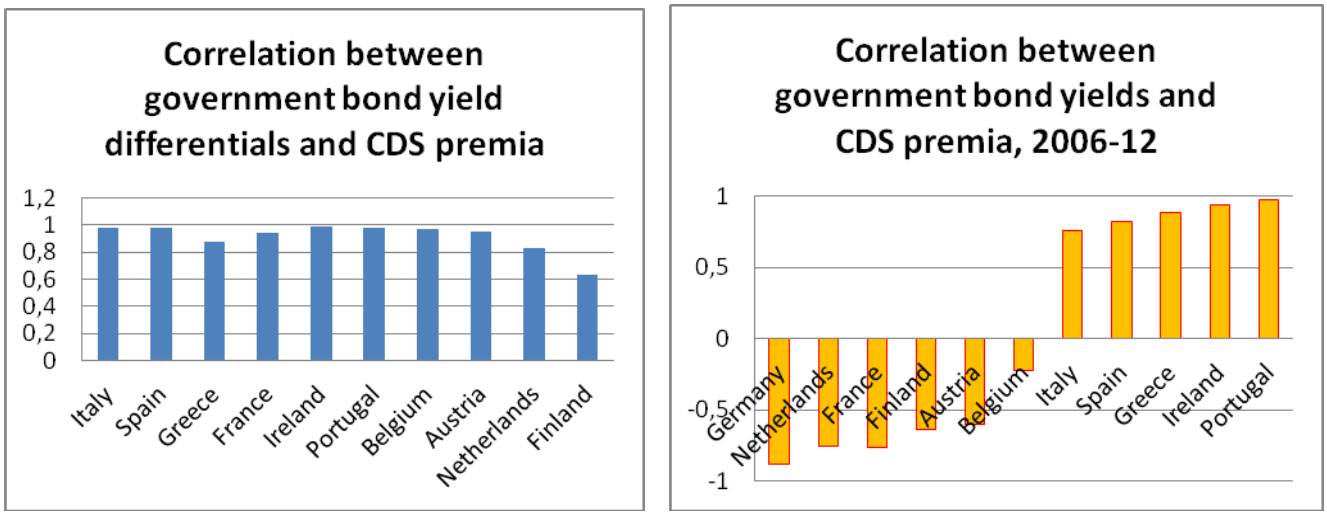
Source: Datastream.

Figure 6. Euro-area 5-year government CDS premia, except Greece (monthly)



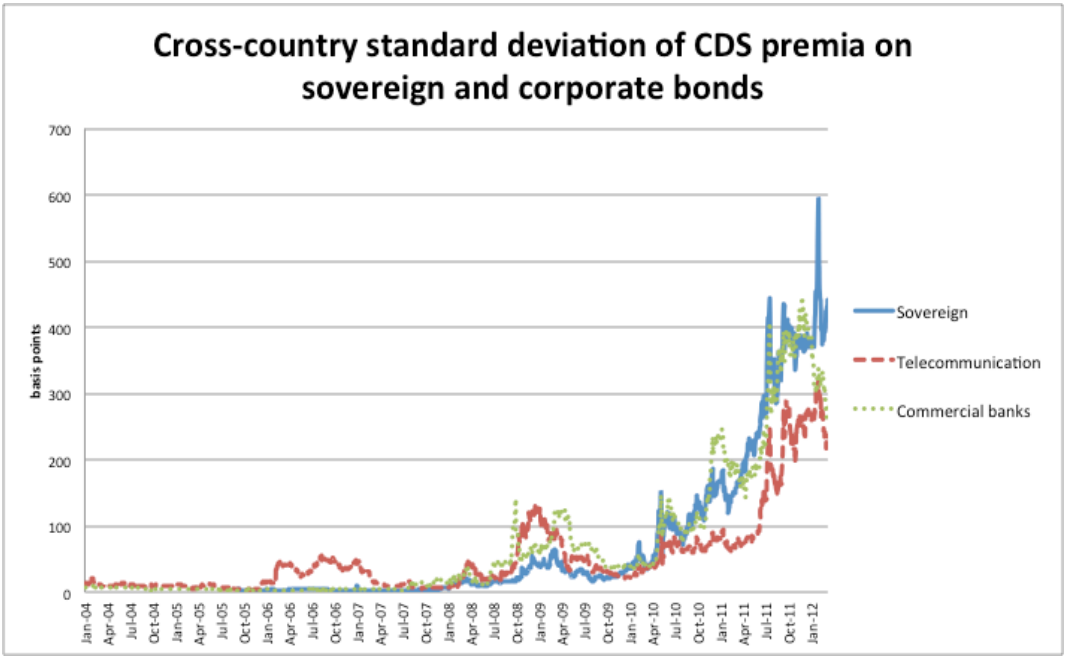
Source: Datastream.

Figure 7. Correlation of the 5-year sovereign CDS premium with the 10-year government yield differential vis-à-vis the Bund (left panel) and with the 10-year government yield (right panel) (monthly, January 2006 - August 2012)



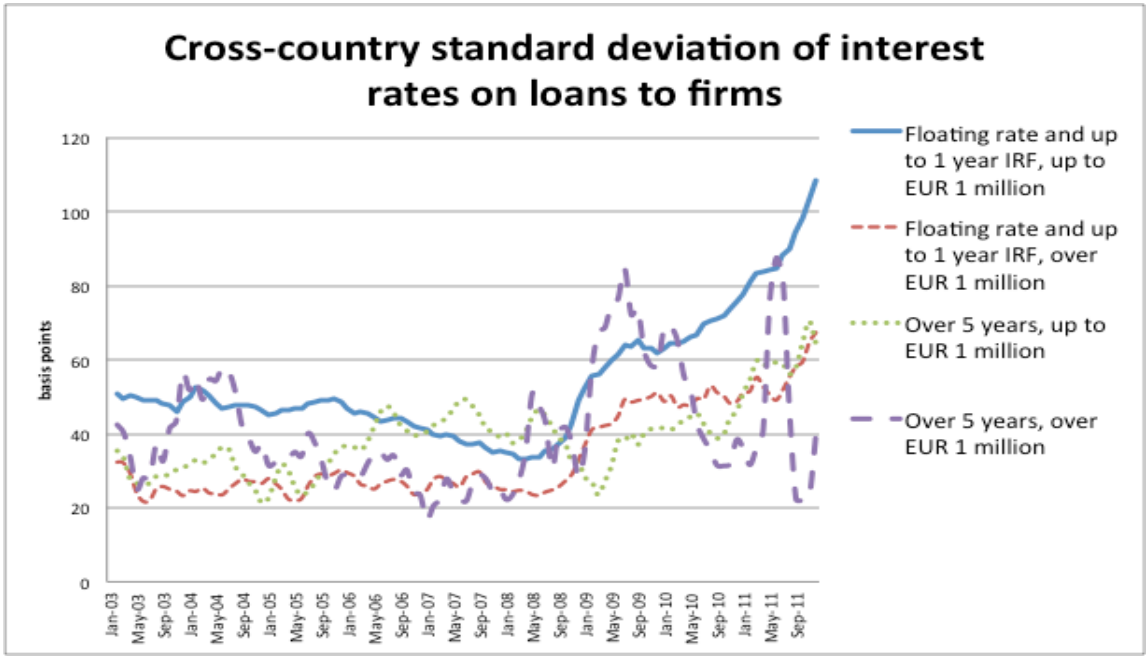
Sources: Datastream and authors' calculations.

Figure 8. Cross-country standard deviation of CDS premia on sovereign and corporate bonds



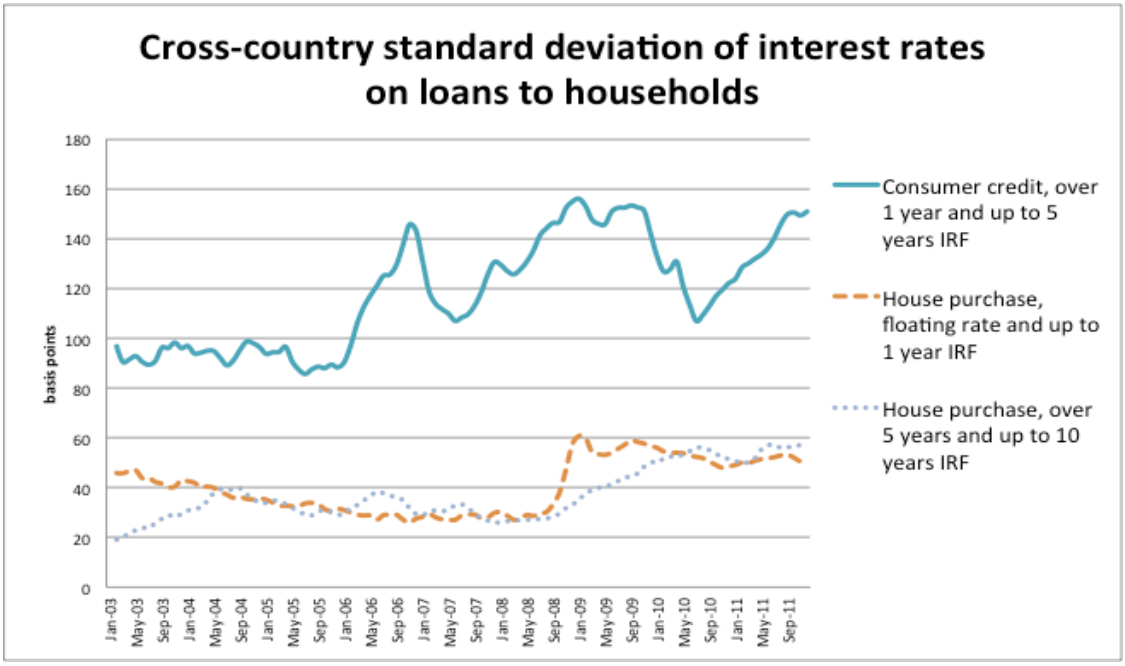
Sources: Datastream and ECB (2012).

Figure 9. Cross-country standard deviation of interest rates on loans to firms



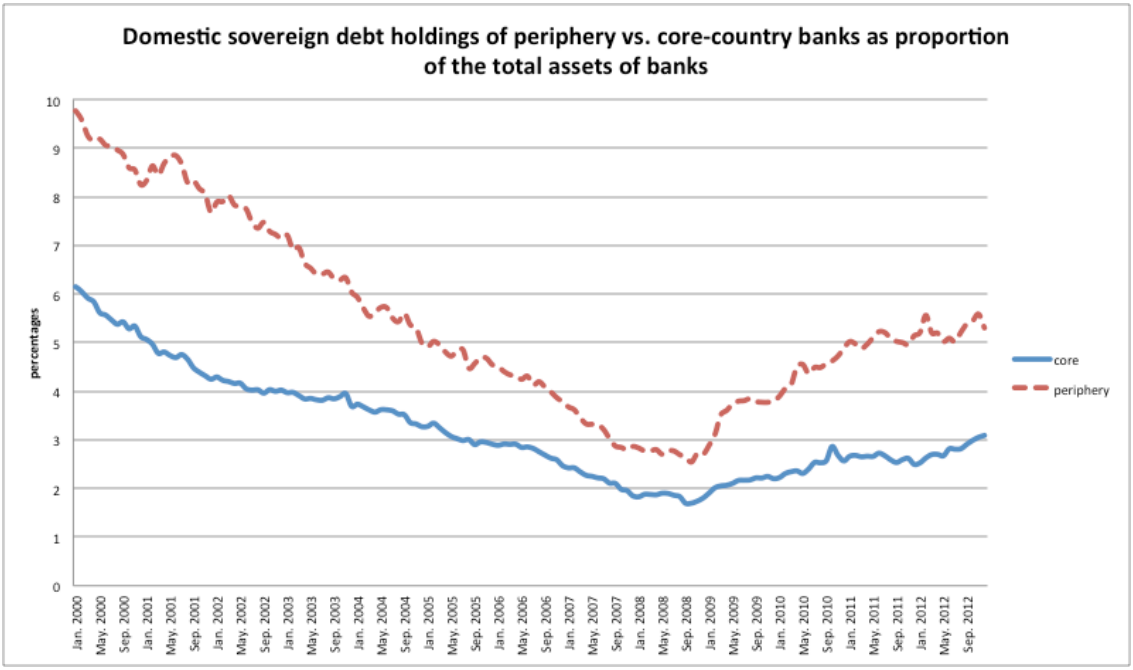
Source: ECB (2012).

Figure 10. Cross-country standard deviation of interest rates on loans to households



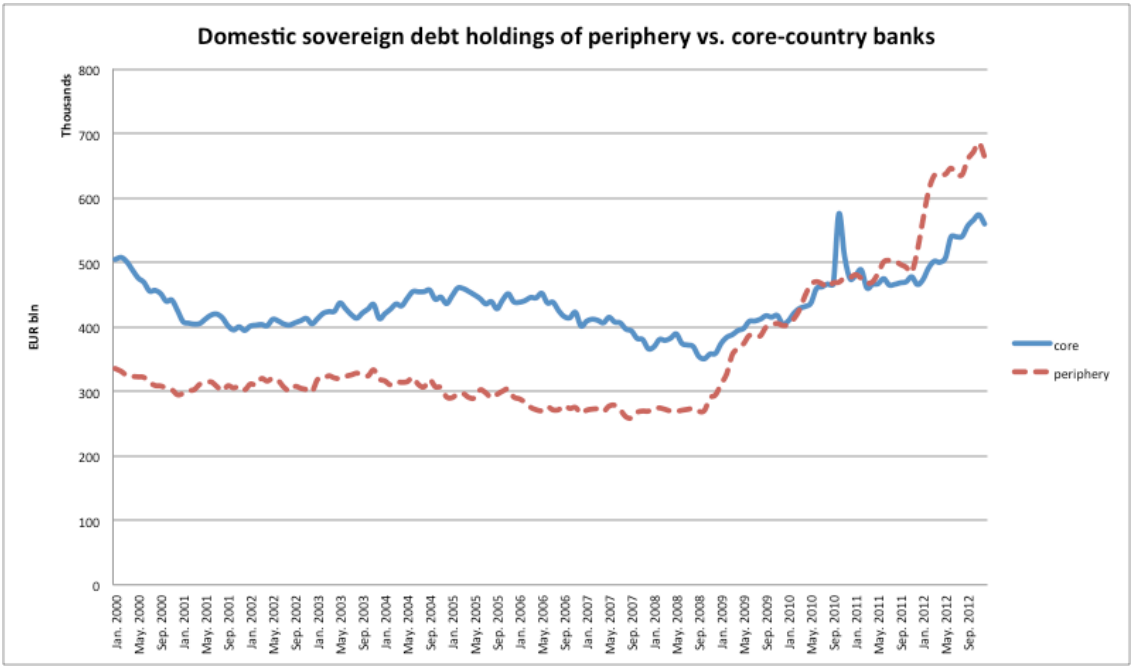
Source: ECB (2012).

Figure 11. Domestic sovereign debt holdings of periphery vs. core-country banks as proportion of the total assets of banks



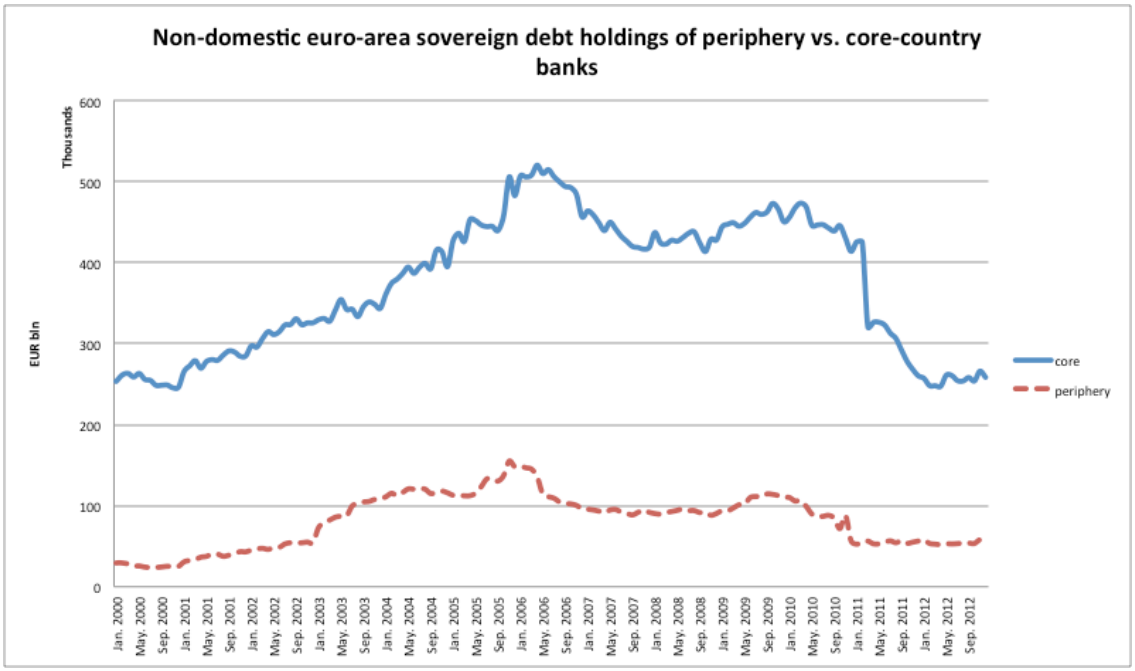
Sources: ECB and authors' calculations.

Figure 12. Domestic sovereign debt holdings of periphery vs. core-country banks



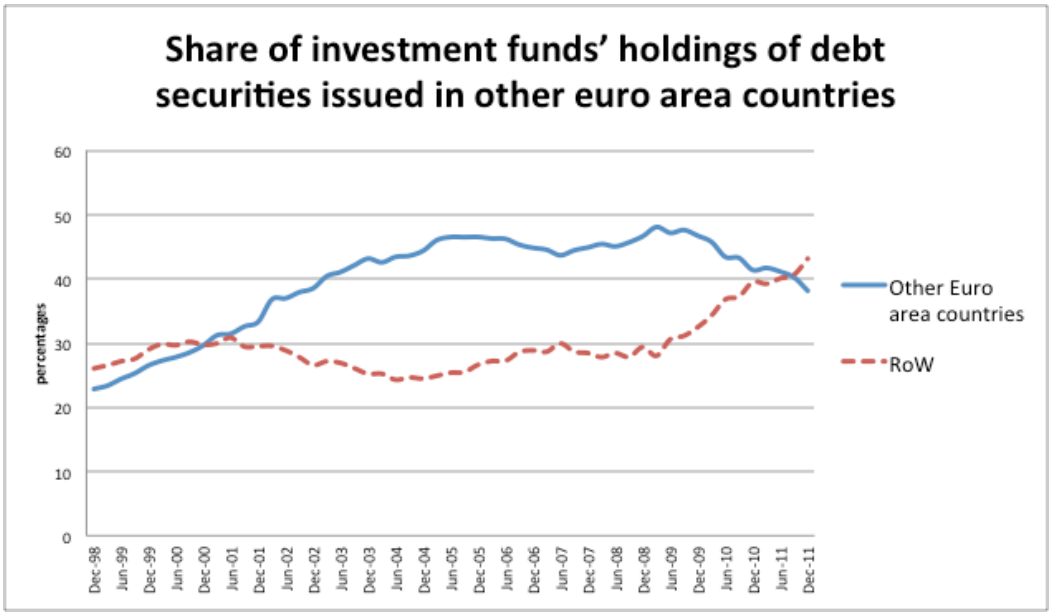
Sources: ECB and authors' calculations.

Figure 13. Non-domestic euro-area sovereign debt holdings of periphery vs. core-country banks



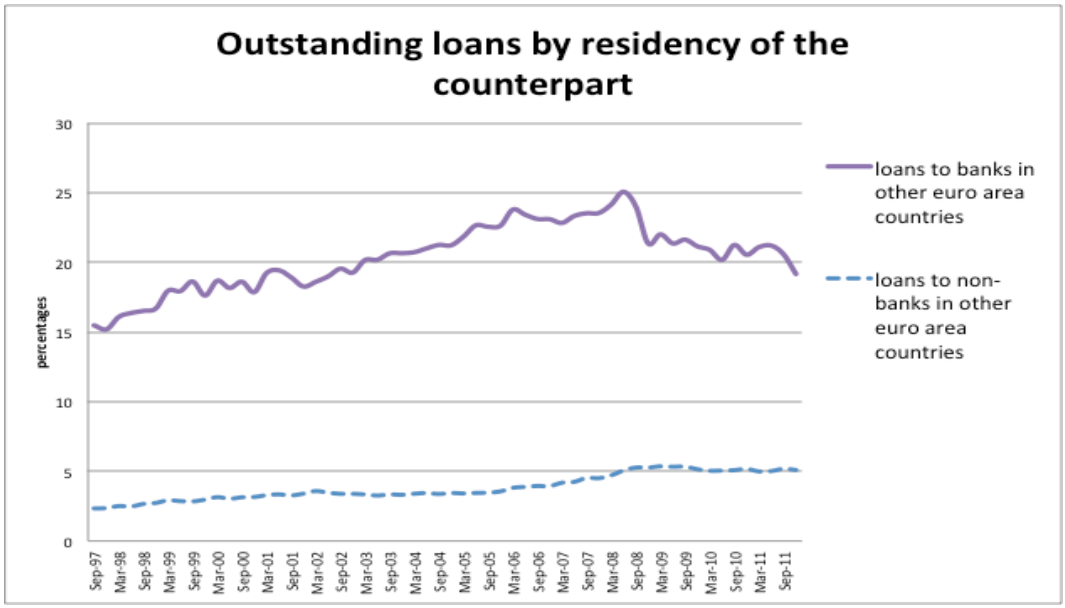
Sources: ECB and authors' calculations.

Figure 14. Investment funds' holdings of foreign debt securities as a share of total debt securities holdings



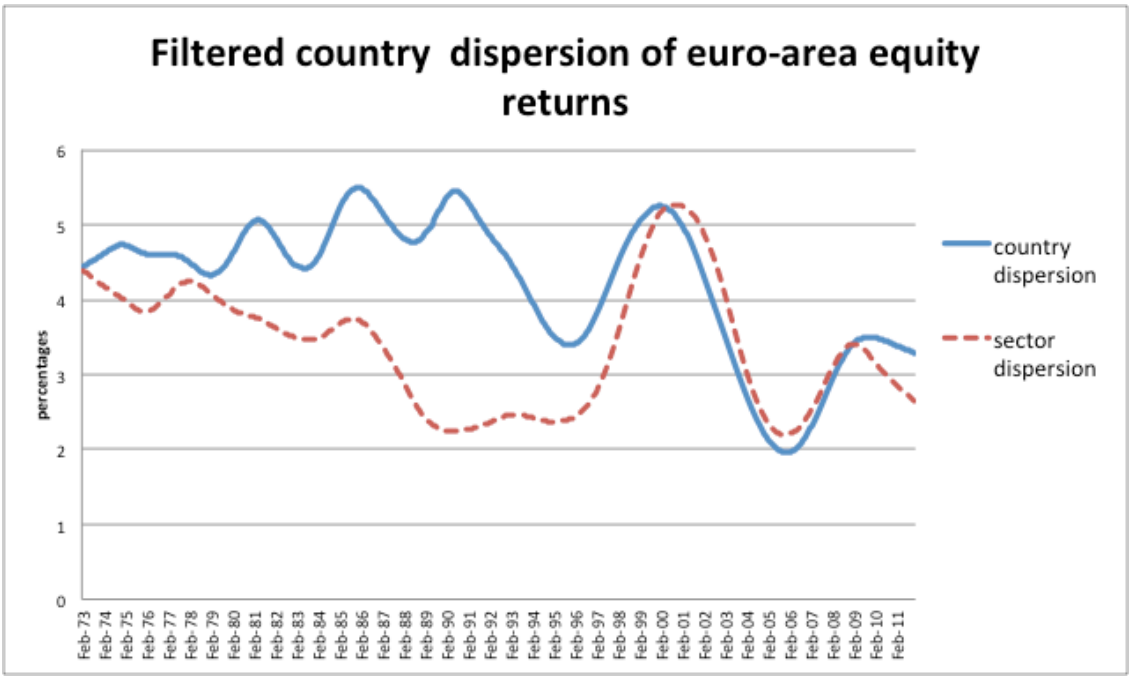
Source: ECB (2012).

Figure 15. Outstanding amount of loans to bank and non-bank counterparts in other euro-area countries, as shares of total loans to banks and non-banks respectively



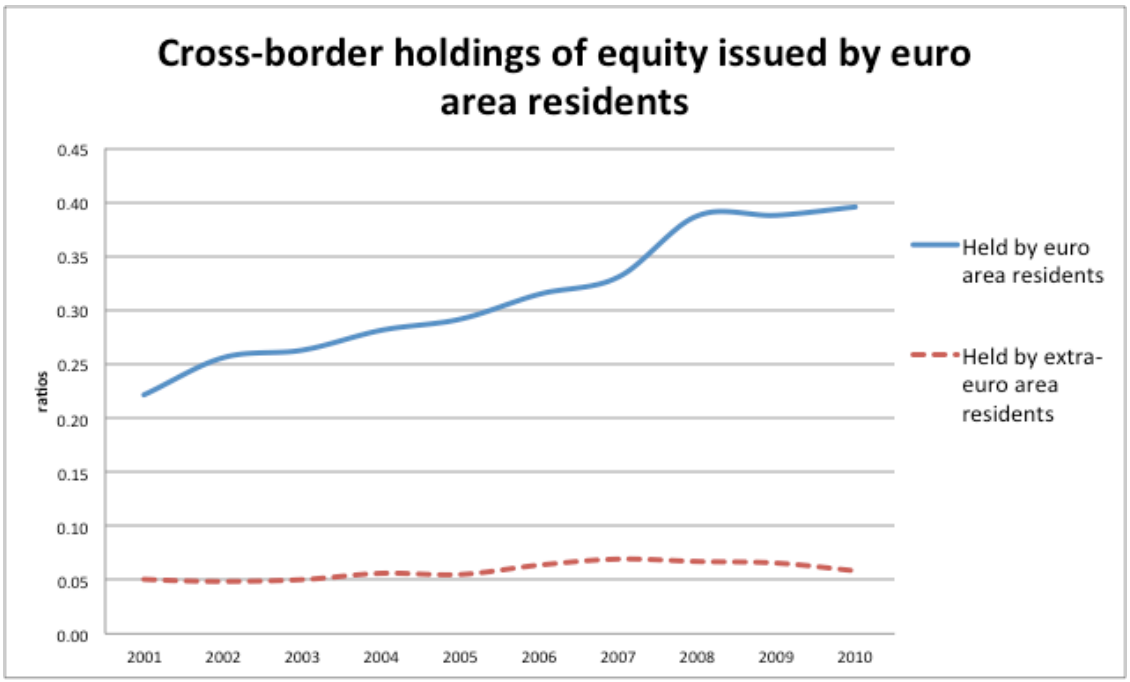
Source: ECB (2012).

Figure 16. Country and firm-level filtered dispersion of euro-area stock returns



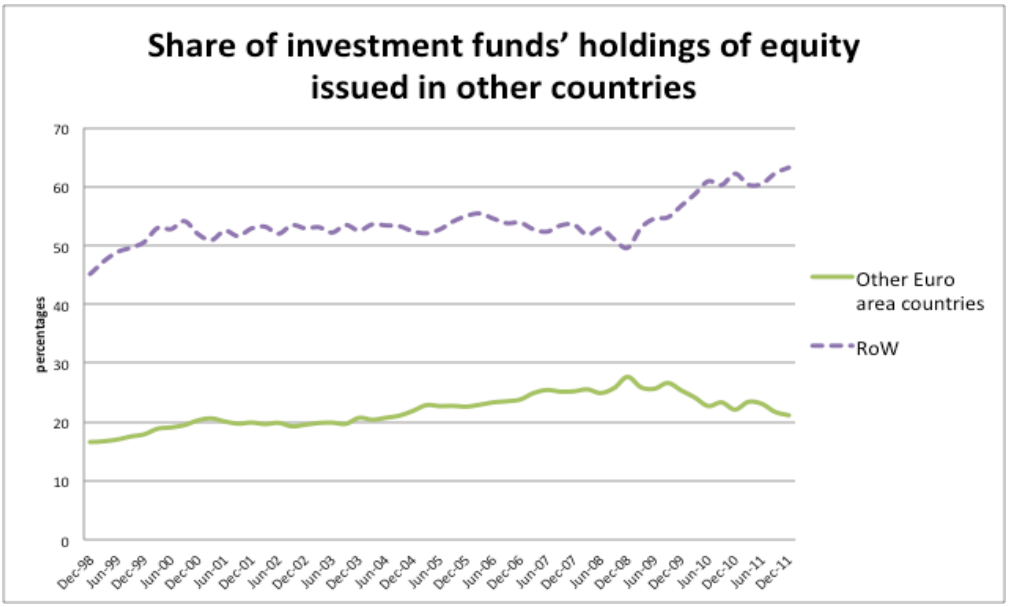
Source: ECB (2012).

Figure 17. Share of equity issued in euro area residents held by residents in other euro-area countries and by residents in the rest of the world



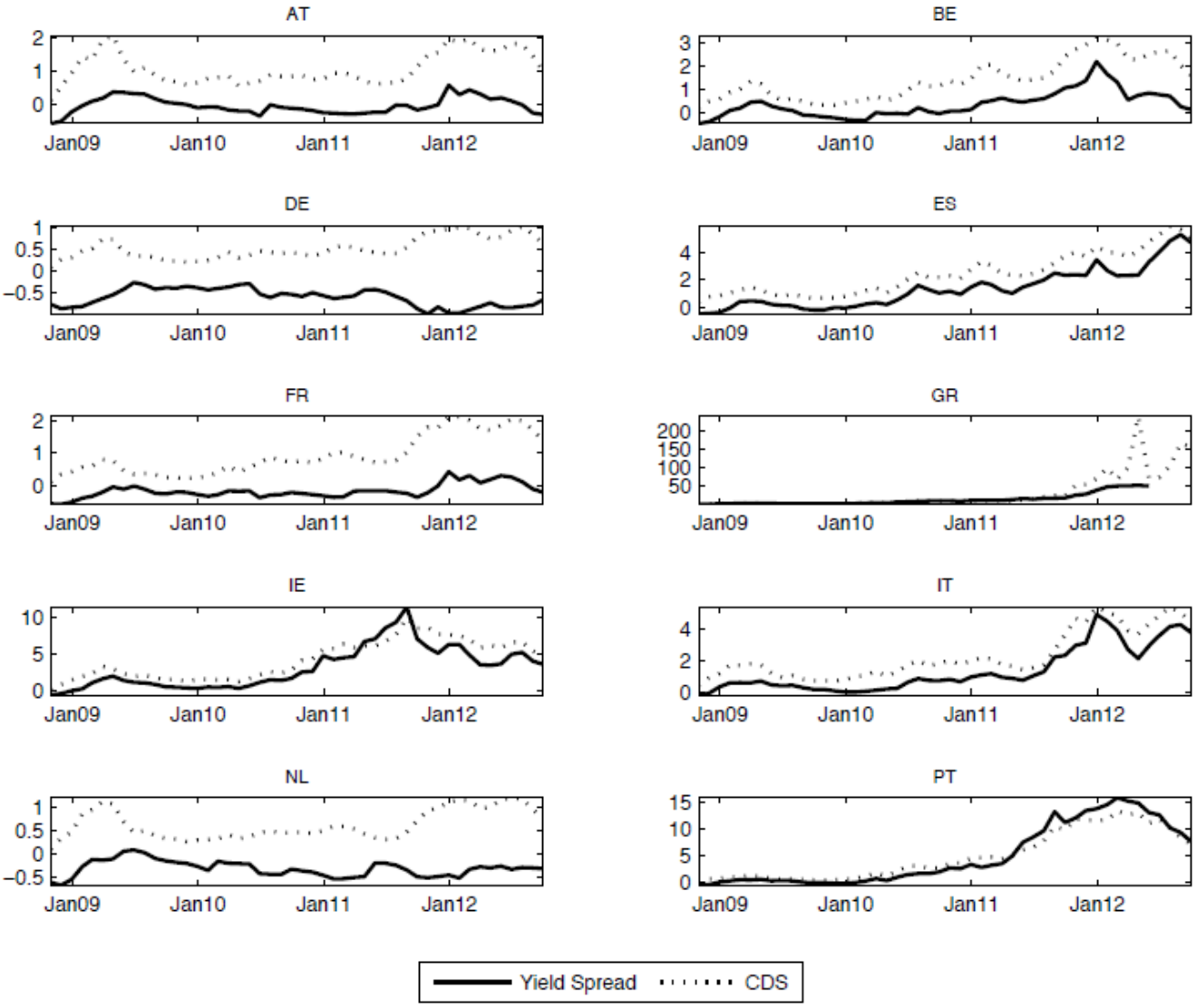
Source: ECB (2012).

Figure 18. Investment funds' holdings of equity issued in other euro-area countries and in the rest of the world, as a share of total holdings of equities



Source: ECB (2012).

Figure 19. Sovereign yield differentials and CDS premia, by country



Source: Datastream.

Figure 20. Common and country components of the German yield differential and CDS premium (first differences)

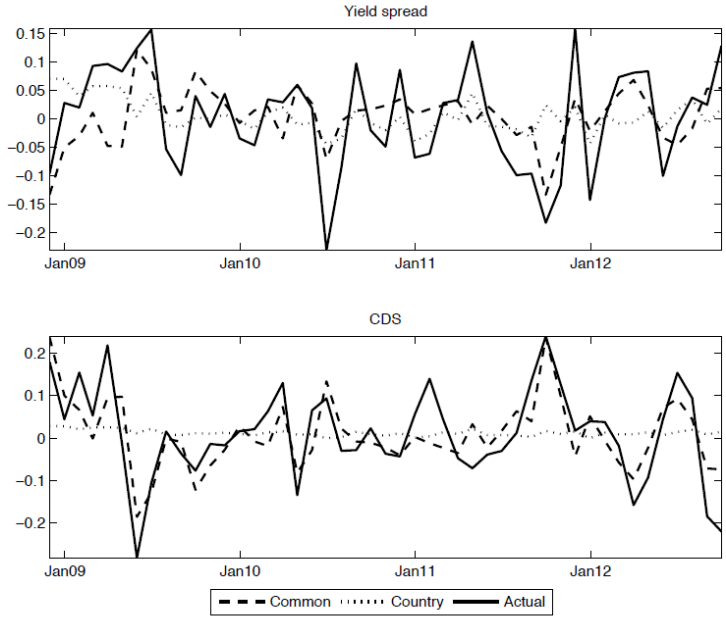


Figure 21. Common and country components of the Italian yield differential and CDS premium (first differences)

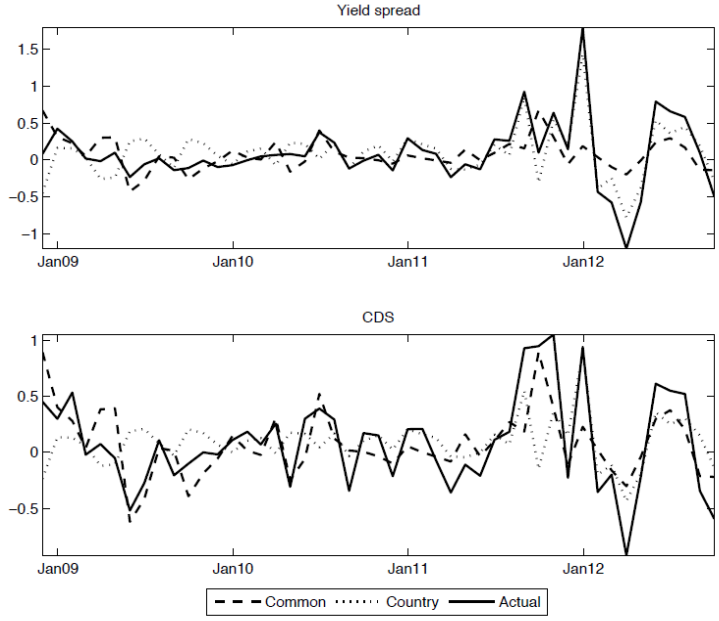


Figure 22. Common and country components of the Spanish yield differential and CDS premium (first differences)

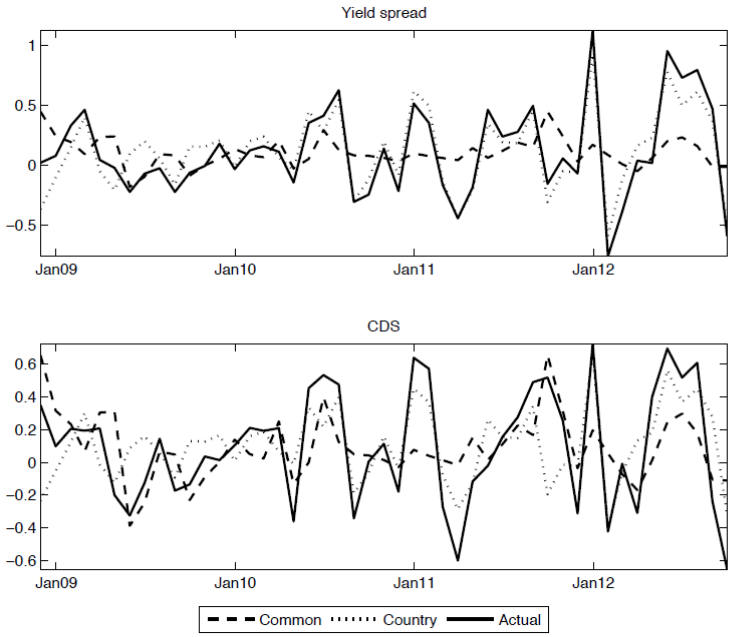


Figure 23. Cross-country standard deviation of yields differentials: actual, common and country component

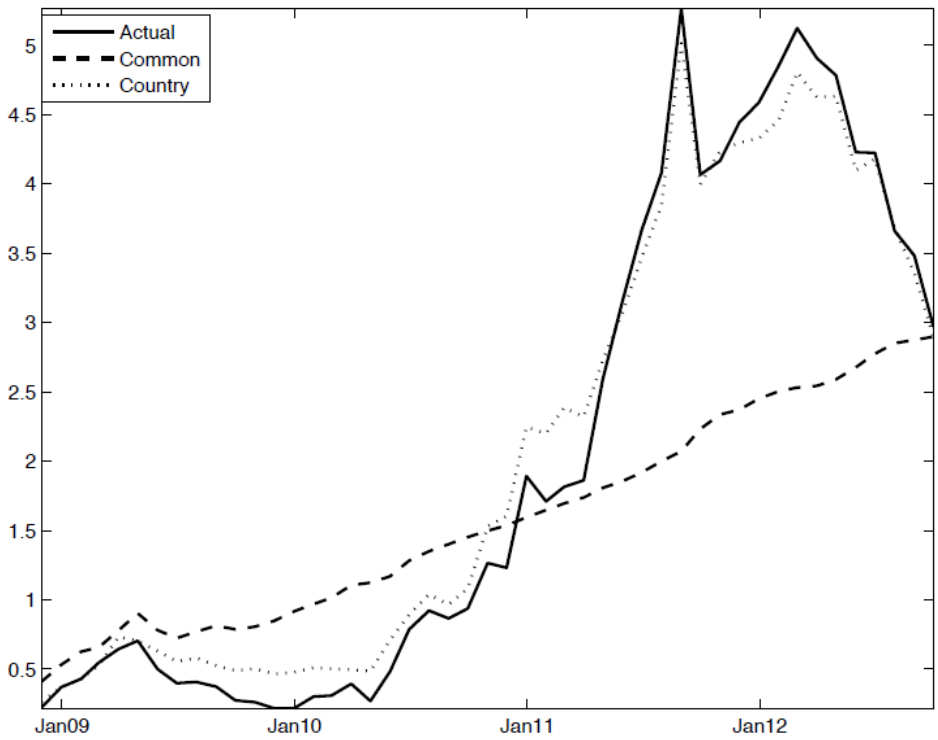
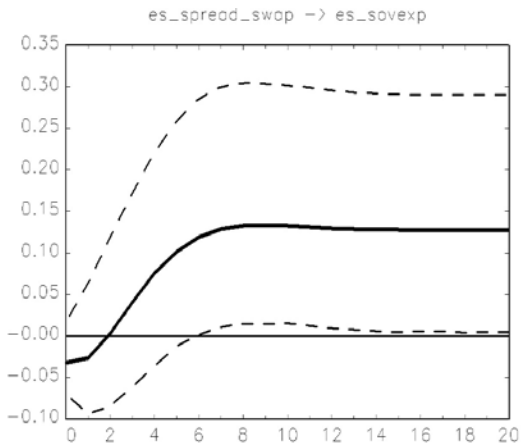


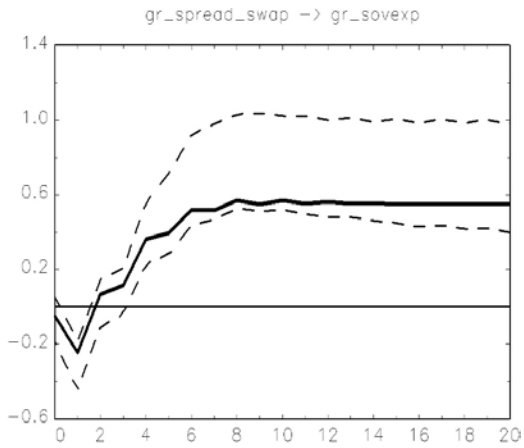
Figure 24. IRFs of domestic sovereign exposures to shocks in yield differentials

(a) Periphery countries

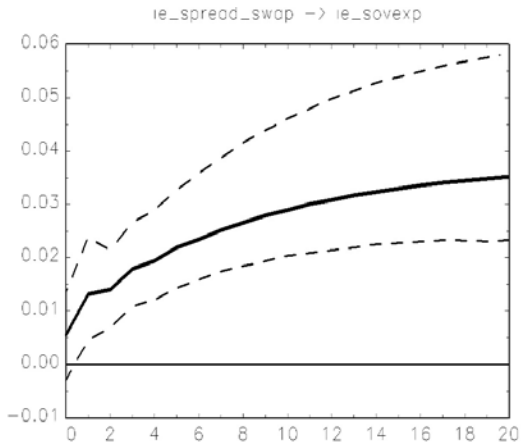
Spain



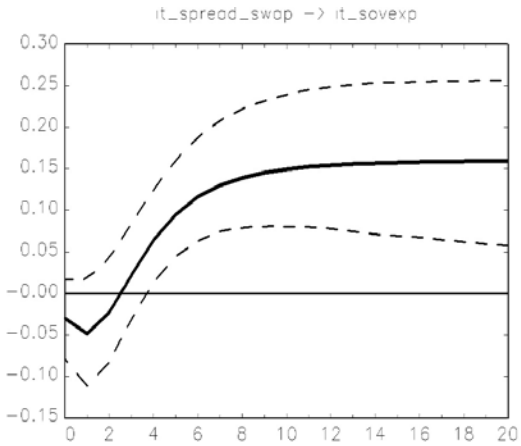
Greece



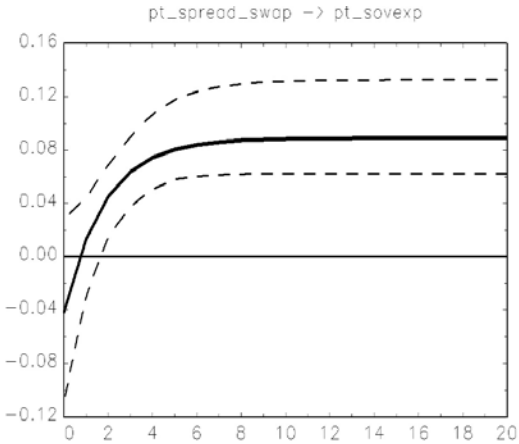
Ireland



Italy



Portugal

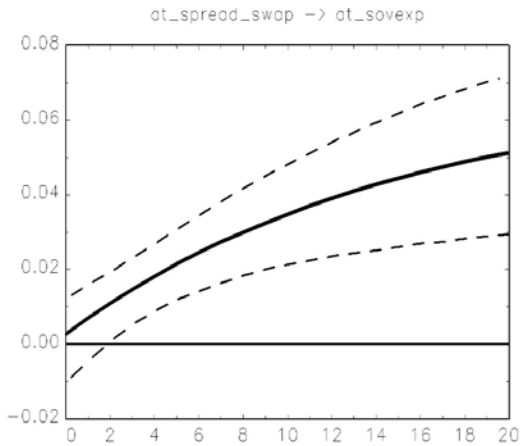


Notes: each chart reports point estimates (solid line) and 90% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

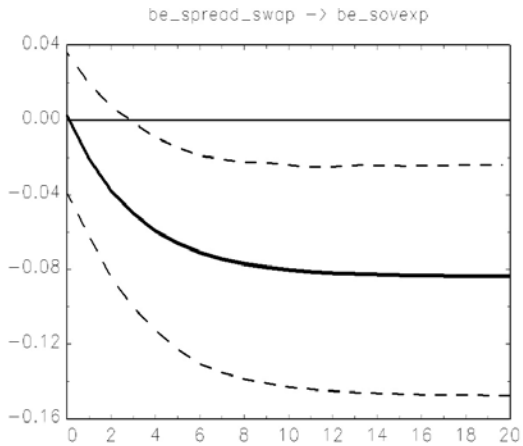
Figure 24 (continued)

(b) Core countries

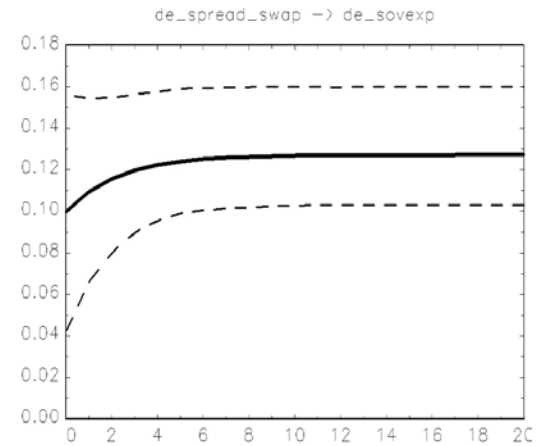
Austria



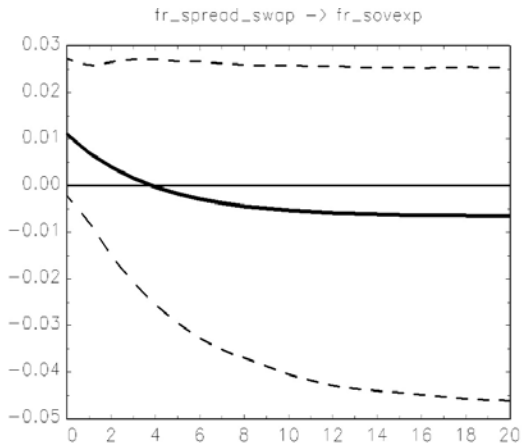
Belgium



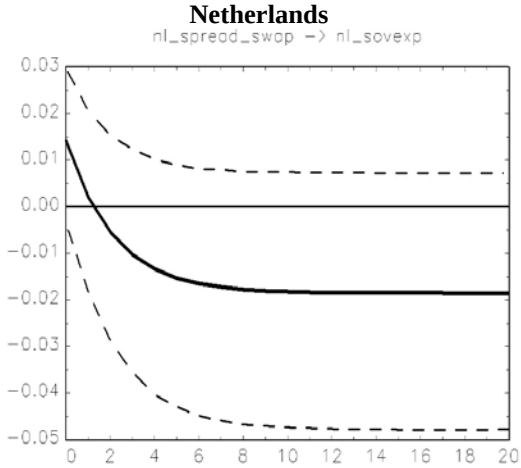
Germany



France



Netherlands

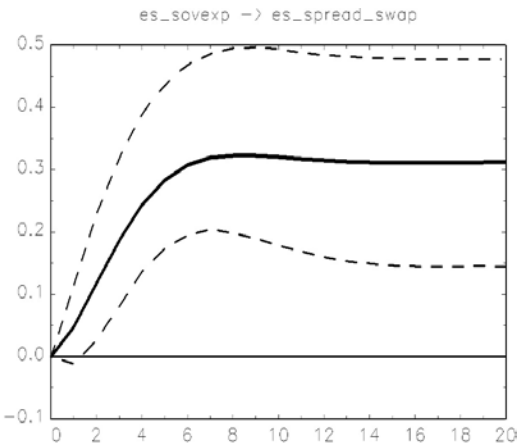


Notes: each chart reports point estimates (solid line) and 90% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

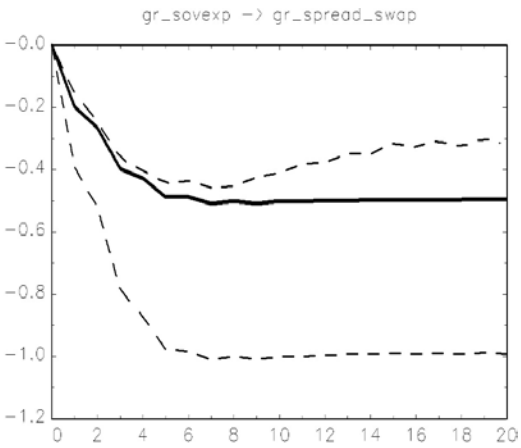
Figure 25. IRFs of yield differentials to shocks in domestic sovereign exposures

(a) Periphery countries

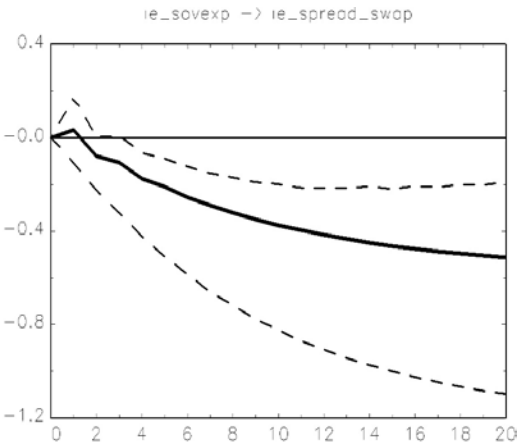
Spain



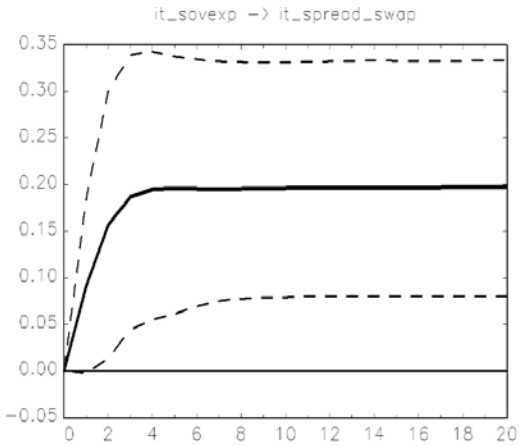
Greece



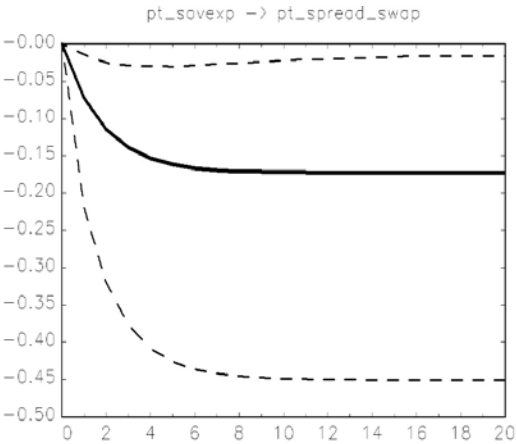
Ireland



Italy



Portugal

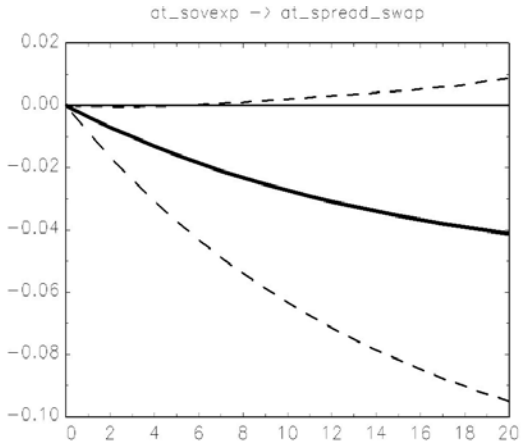


Notes: each chart reports point estimates (solid line) and 90% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

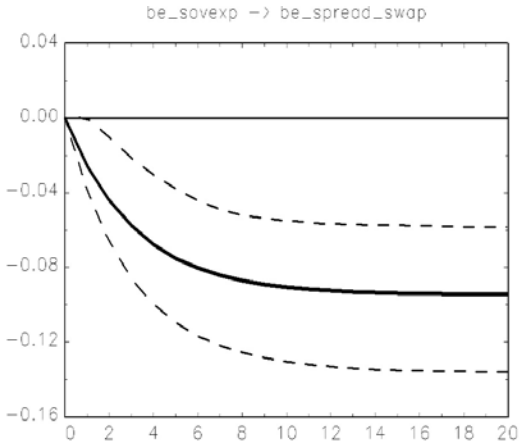
Figure 25 (continued)

(b) Core countries

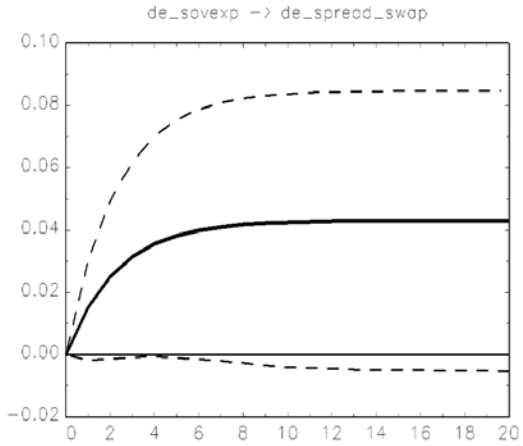
Austria



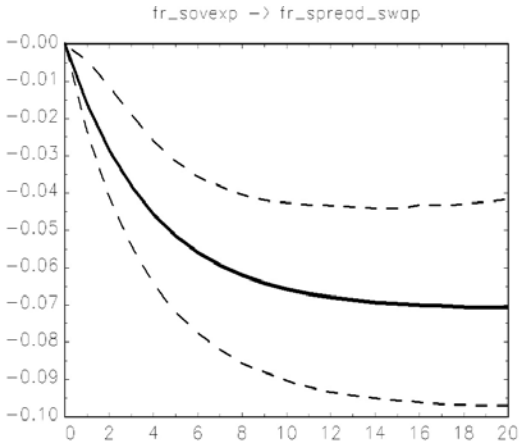
Belgium



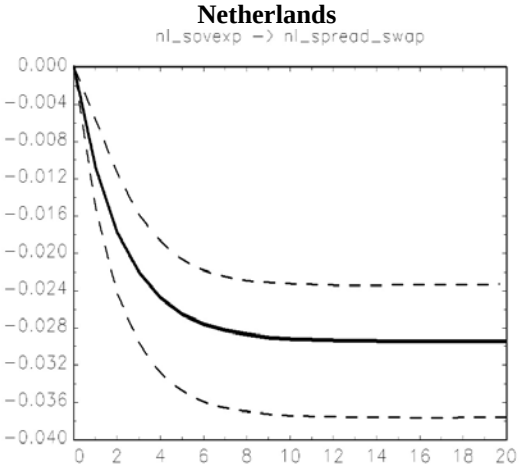
Germany



France



Netherlands

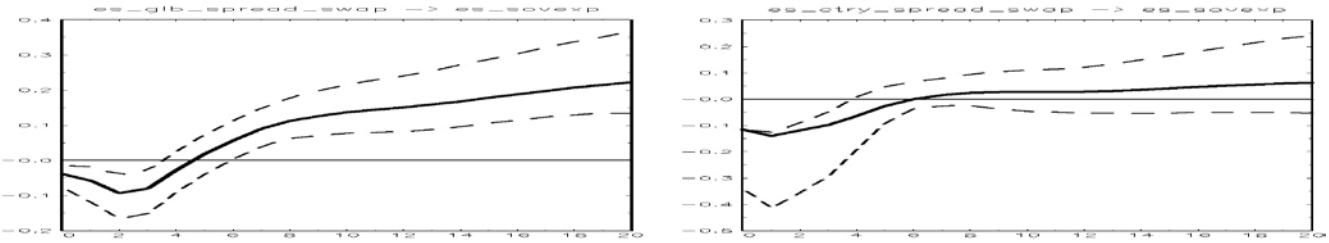


Notes: each chart reports point estimates (solid line) and 90% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

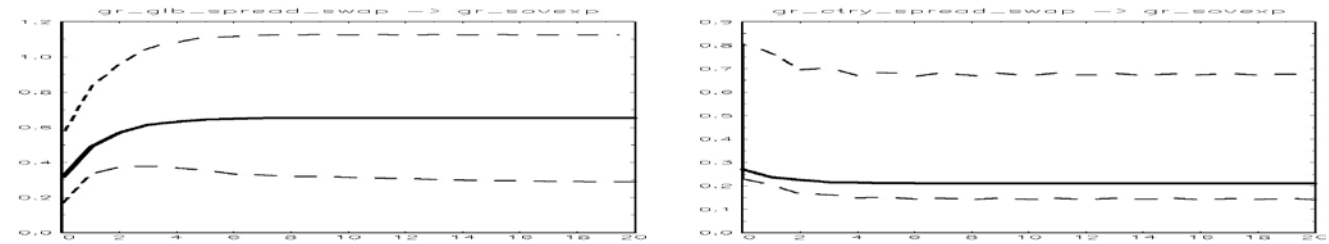
Figure 26. IRFs of sovereign exposures to the common and country components of yield differentials

(a) Periphery countries

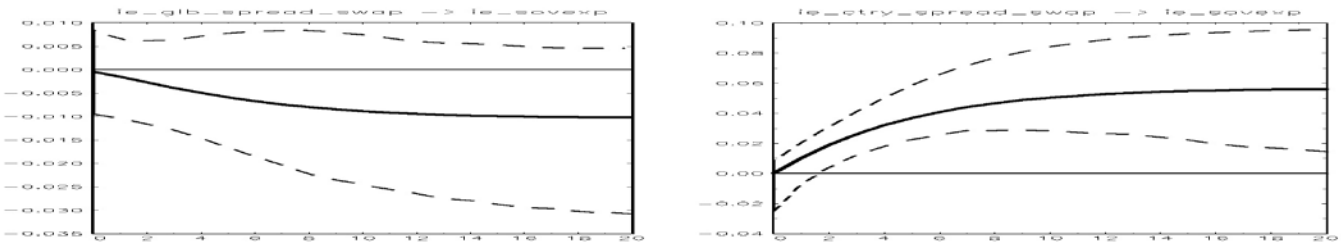
Spain



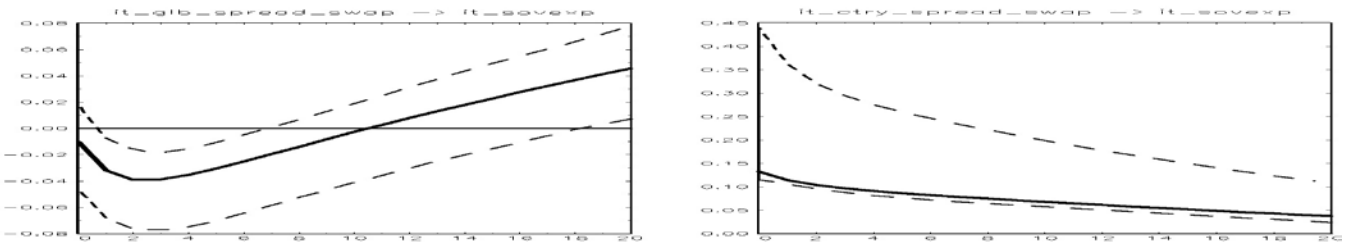
Greece



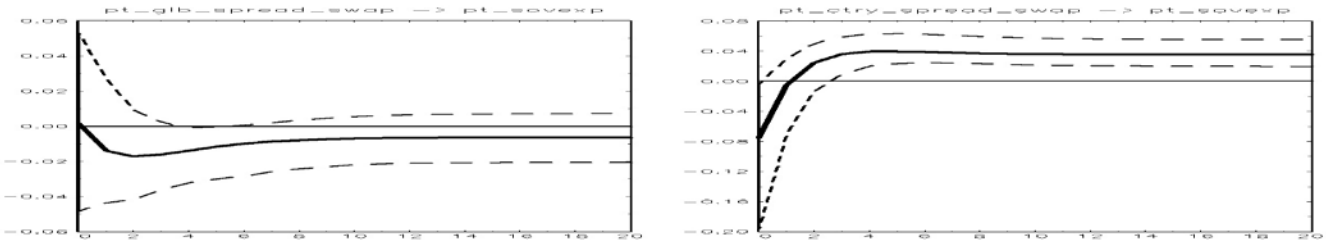
Ireland



Italy



Portugal

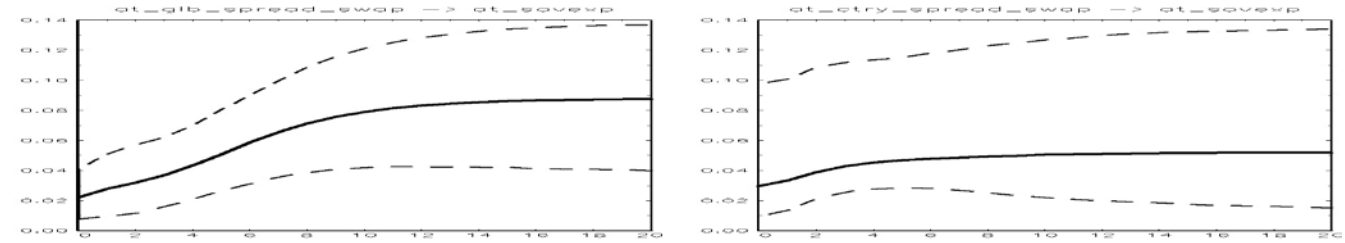


Notes: each chart reports point estimates (solid line) and 95% Hall Bootstrap confidence intervals (dashed lines) of the respective IRFs.

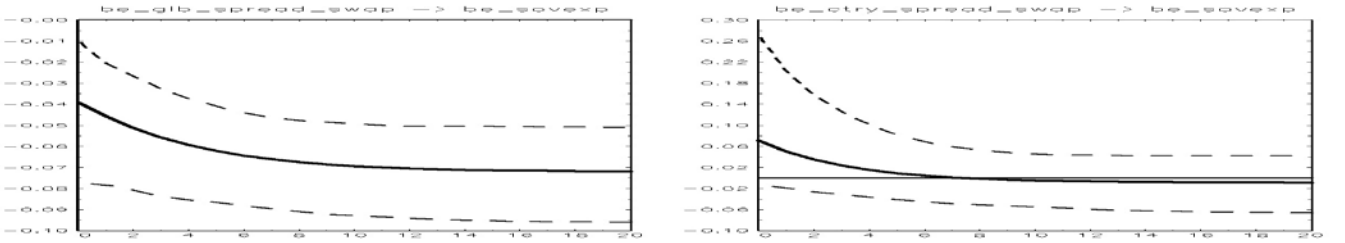
Figure 26 (continued)

(b) Core countries

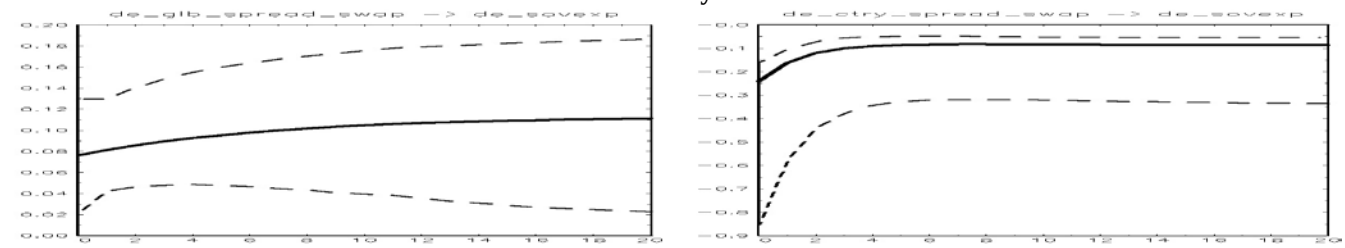
Austria



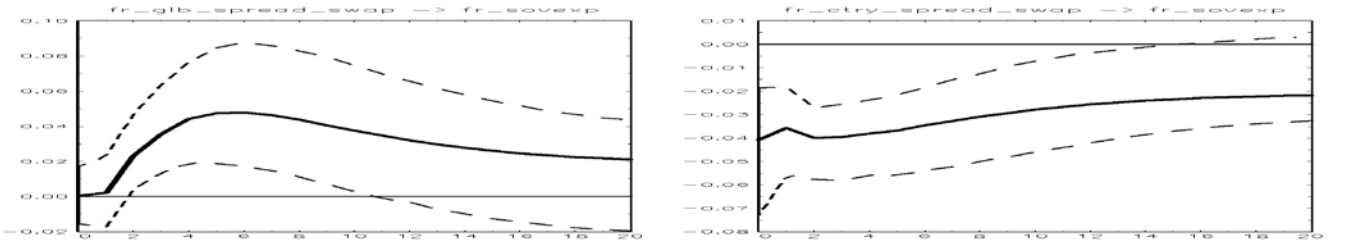
Belgium



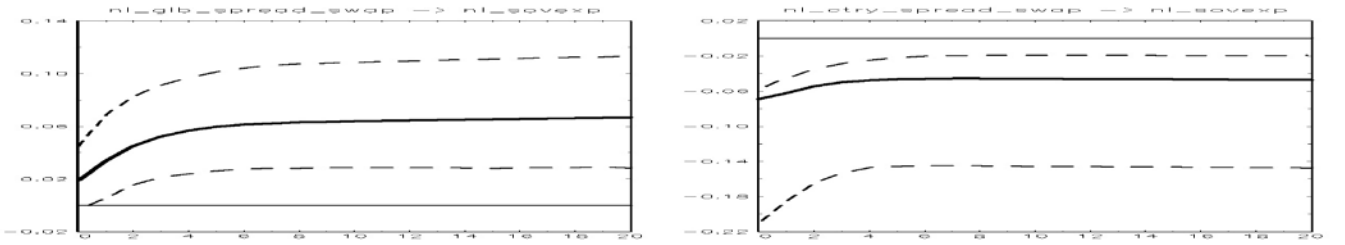
Germany



France



Netherlands



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

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

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

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

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

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

dynamic systems including domestic sovereign debt exposures, domestic sovereign debt yield differentials and their components, *common* and *country*.

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

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

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

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

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

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

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

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

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