Zero Risk Contagion -

Banks' Sovereign Exposure and Sovereign Risk Spillovers*

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Abstract

This paper identifies banks' exposures to non-domestic sovereign debt as a transmission channel for sovereign risk spillovers in Europe. We construct a new measure - the 'sovereign subsidy' - that quantifies non-domestic sovereign exposures that are not adequately reflected in bank capital due to the application of zero risk weights. A larger sovereign subsidy for the banking sector amplifies the co-movement between its domestic sovereign's CDS spread and a European sovereign CDS market index. This result is robust to controlling for alternative spillover channels and a variety of other tests highlighting the importance to address sovereign risk in bank regulation.

JEL classification: G01, G21, G28

Keywords: Sovereign debt, sovereign risk, bank risk, CDS, contagion, zero risk weight, Basel III, CRD, EBA capital exercise

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1 Introduction and Related Literature

The European sovereign debt crisis has sparked an intense debate on the causes and consequences of sovereign risk among academics, policymakers, and practitioners. We argue in this paper that the treatment of sovereign debt under current capital regulation in the European Union (EU) is an important channel through which domestic banks' non-domestic sovereign exposures amplify contagion among European sovereigns.

Central to our paper is that European banks have not been required to hold a capital buffer against the sovereign debt holdings of any EU member state, regardless of its actual risk. Basel capital requirements stipulate that banks have to hold capital against any of their assets either based on a given regulatory risk weight or based on internally modeled default probabilities. However, in accordance with the European legal framework, the Capital Requirements Directive (CRD), European banks typically employ a zero risk weight for sovereign debt. Thus, they do not hold capital against their EU sovereign exposures. European governments can therefore issue excessive debt by taking advantage of a sovereign subsidy of *other* EU member states in the form of the zero risk weight for their domestic banking sector.

If sovereign risk materializes (as occurred in the European sovereign debt crisis), banks are left severely under-capitalized because they have not built a capital buffer for their sovereign exposure and require capital backstops by their domestic sovereigns. Consequently, sovereign risk, as measured, for example, using the credit default swap (CDS) spreads of each sovereign's debt, also reflects the expected bailout costs of this country for its domestic banking sector. Zero risk weights increase these expected shortfalls as sovereign exposures are not adequately reflected in the capital of the domestic banking system and, hence, create a channel through which sovereign risk can be transmitted among EU member states.

[Figure 1]

A recent example of such a channel for sovereign risk spillover is Cyprus. Figure 1 shows the development of the Greek sovereign debt rating[1] and the sovereign CDS spread of Cyprus. It also shows the risk-weighted Greek sovereign debt exposure of the two largest banks in Cyprus (i.e., Bank of Cyprus and Marfin Popular Bank) as reported as part of the stress tests conducted by the European Banking Authority (EBA). The exposures are scaled by the country's GDP and reflect the risk-weighted assets against which these two banks had to hold capital if zero risk weights did not apply. In other words, they represent the banks' expected shortfall regarding a Greek sovereign default that was, however, not reflected in their capital. The figure strikingly shows how Cyprus' CDS spread rose when

[1] Note that we only display the Moody's rating for readability of the figure. The Standard and Poor's and Fitch ratings, however, show directionally similar developments.

the expected shortfall increased from 36 percent to 73 percent of Cyprus' GDP between January 2011 and January 2012, reflecting the country's expected bailout costs for their banks and, consequently, the elevated default risk of Cyprus itself. Although we do not dispute that there are other channels facilitating the spillover of sovereign risk between Greece and Cyprus (e.g., strong linkages in the real economy), we propose that the large and not adequately covered sovereign exposure on Cypriot banks' balance sheets contributed to the deterioration of Cyprus' sovereign credit risk.

[Figure 2]

The theoretical literature also supports the existence of such a channel. Figure 2 presents a stylized overview, which has been formally modeled, for example, by Bolton and Jeanne (2011). The intuition is that banks in country B will hold sovereign debt of both sovereigns A and B for diversification purposes when financial sectors are highly integrated across countries. Although these non-domestic exposures might initially provide diversification benefits, they also generate contagion ex post by transmitting sovereign risk through bank balance sheets. Notably, the authors also emphasize that the equilibrium outcome is an inefficiently high supply of risky debt in a setting in which the sovereign debt issued by the countries differs fundamentally in its risk. In such a setting, the risky sovereign does not fully internalize the costs associated with its default. Instead, through its debt held by banks in the safe country, the risky sovereign might even trigger bailouts by the safe sovereign, which, in turn, faces the choice of either bailing out the risky sovereign or its domestic banks. Applying this theoretical argument to the European context, sovereign default risk is not only immediately linked to the risk of other European sovereigns through the CDS market and their joint responsibility for avoiding a sovereign default but also through the bailout responsibility each sovereign has toward its domestic banking sector.

At the heart of this paper is a new measure that quantifies the sovereign subsidy of a country for its domestic banking sector. To estimate a bank's capital savings resulting from zero risk weights for sovereign debt, we assign adequate risk weights to each sovereign debt holding and compute the corresponding risk-weighted assets that are not adequately reflected in banks' capital. We call the latter the 'sovereign subsidy'. We collect sovereign bond holdings from two sources, the consolidated banking statistics of the Bank for International Settlements (BIS) and the stress test disclosures by the European Banking Authority (EBA).[2] In our empirical analyses, we use rating implied risk weights for the computation of the sovereign subsidy but also perform robustness tests in which we use CDS implied risk weights. Constructing this measure for all banks that participated in the stress tests conducted by the EBA, we document that the total sovereign subsidy amounts to approximately EUR

[2]The EBA conducted five stress tests and capital exercises between March 2010 and June 2012. Detailed information on these stress tests are provided in Appendices B and C.

500 billion or more at each of the stress test dates, or, on average, to more than 50 percent of these banks' Tier 1 capital.

As the first step, we document the domestic and non-domestic sovereign exposures in addition to the associated sovereign subsidy of the banks that participated in the EBA stress tests and capital exercise. The largest sovereign subsidies for peripheral banks (i.e., banks headquartered in Greece, Ireland, Italy, Portugal, and Spain) emanate from domestic sovereign debt holdings, whereas non-domestic sovereign debt holdings account for the largest share of the total sovereign subsidies of non-peripheral banks. Driven mostly by increasing sovereign risks, the domestic sovereign subsidies of peripheral banks increased from EUR 97 billion to EUR 276 billion during the period from October 2011 to June 2012, whereas the domestic sovereign subsidy of non-peripheral banks only increased from EUR 105 billion to EUR 111 billion during this period.

The zero risk weight channel hypothesis suggests that non-domestic sovereign exposures (and particularly their regulatory treatment) amplify sovereign risk spillovers. We bring this hypothesis to the data using an econometric framework similar to that of Acharya et al. (2011; 2012). We create a sovereign credit default swap (CDS) market index that represents the CDS spreads of all European countries by using the external debt of these countries as weights. We find that an individual domestic sovereign's CDS spread co-moves stronger with the European sovereign CDS market index if domestic banks of the former hold a larger non-domestic sovereign subsidy. This is consistent with the interpretation that sovereign risk increases with an increase in the expected bailout costs of its banking sector due to a non-domestic sovereign default.

We perform a variety of robustness tests. First, we add changes in a broad CDS market index (iTraxx Europe index), changes in an equity market index (Datastream total return index), changes in market volatility (VSTOXX), and changes in the term spread; we also add date and/or country-quarter fixed effects. In other tests, we use CDS data obtained from Datastream as opposed to Bloomberg. We also perform our tests using non-domestic sovereign exposure data from the EBA stress tests instead of the BIS. Moreover, we employ changes in bond yields instead of CDS spreads to measure sovereign default risk. In addition, we construct the sovereign subsidy using CDS implied risk weights instead of ratings implied risk weights. The results remain largely unchanged.

As explained above, we argue that spillovers among European sovereigns are amplified because banks hold too little capital as the result of zero risk weights associated with holdings of EU member states' sovereign debt. Therefore, we would not expect to observe a similar effect for exposures to non-EU member states because European banks must hold capital that reflects the risk of these respective sovereigns. We collect the exposures of our sample banks to Japanese, Norwegian, Swiss and U.S. sovereign debt, run our baseline model using the resulting sovereign subsidy measures, and do not

find similar effects. These results suggest that the lack of capital relative to the risks associated with holding non-domestic sovereign debt of EU member countries indeed increases the expected bailout costs of the banking sector. Consequently, zero risk weights seem to facilitate a channel for sovereign risk spillovers.

An alternative explanation for our results might be the direct sovereign bailout risk of other member countries. We measure the (implicit) bailout responsibility of a country toward other EU countries as its capital share in the European Central Bank (ECB, 2011). Moreover, we measure the ability to bail out other sovereigns using the debt to GDP ratio of each sovereign. A country with less debt relative to its GDP, ceteris paribus, is likely to have a larger commitment in a bailout. Although we find that a larger ECB share seems to significantly increase sovereign risk spillovers, our earlier results regarding the effect of the sovereign subsidy remain unchanged.

In September 2011, the EBA conducted a so-called capital exercise (CE), which required banks to hold a capital buffer that accounts for the risky sovereign debt in their portfolios. We argue that this requirement can be interpreted as a de facto introduction of a risk weight on sovereign debt exposures for the largest banks in Europe that also hold the majority of sovereign debt. Because the additional capital requirement was introduced in late 2011 but did not become fully effective until the end of June 2012, we define all quarters up to 2011-Q3 as the period before the EBA CE and all quarters from 2012-Q2 as the period after the EBA CE. We run our baseline model with and without fixed effects separately for both periods and find that the effect of sovereign subsidies on sovereign risk spillovers becomes insignificant after the EBA capital exercise. Consistent with our falsification tests using non-EU member sovereign exposures, these results suggest that under-capitalization of the banking sector due to zero risk weights of sovereign debt amplifies risk spillovers in Europe.

Our paper is related to two streams of the literature. There is a growing body of empirical literature on both the determinants and interdependence of sovereign risk. Building on earlier studies (e.g., Bulow and Rogoff (1989); Cole and Kehoe (2000); Duffie et al. (2003); Eaton and Gersovitz (1981); Edwards (1984)), the literature on the determinants of sovereign risk has attracted particular attention with the onset of the European sovereign debt crisis (e.g., Attinasi et al. (2009); Dieckmann and Plank (2012); Gerlach et al. (2010)). Recent contributions have also evaluated the direction, timing, and dynamics of the spillovers between bank risk and sovereign risk (e.g., Acharya et al. (2011); Alter and Schüler (2012); Barth et al. (2012); DeBruyckere et al. (2012); Ejsing and Lemke (2011)) and have documented spillovers and contagion among sovereign risk (e.g., Arezki et al. (2011); Caporin et al. (2013); Kalbaska and Gatkowski (2012)). However, there is limited evidence on the determinants of these sovereign-to-sovereign risk spillovers, particularly with respect to the alternative channels through which they might work. Building on Ang and Longstaff (2013), who evaluate the co-movement of sovereign default risk,

Chen (2013) finds that financial linkages are likely to provide a channel for sovereign risk spillovers and proposes careful investigation into which and how financial linkages drive the degree of co-movement in sovereign risk. The closest papers related to these channels are Kallestrup et al. (2013), who evaluate banking sector variables such as total cross-border exposures as an important amplifier of the effect that non-domestic sovereign risk has on domestic sovereign risk, and Gorea and Radev (2012), who show that bilateral trade and reciprocal banking sector claims can partly explain sovereigns' joint probability of default.

This paper supplements these findings by exploring a specific channel, i.e., the exposures to non-domestic EU member countries' sovereign debt on the balance sheets of banks that are not sufficiently supported with capital, and explicitly testing it against possible alternative explanations.

We also relate to the literature evaluating the current regulatory treatment of sovereign debt. This regulatory treatment can lead to severe distortions and has consequences for bank risk and regulatory arbitrage behavior (see, e.g., Acharya et al. (2013); Acharya and Steffen (2013); Barth et al. (2012)). We extend these findings not only by connecting them to the literature on sovereign risk spillovers but also by evaluating de facto changes in the regulatory treatment of sovereign debt that occurred in the context of the EBA capital exercise. There is no evidence thus far on how these changes impact banks' non-domestic sovereign debt holdings and, consequently, the sovereign risk spillovers.

The remainder of this paper is organized as follows. Section 2 describes the institutional framework of capital regulation in the European Union. Section 3 presents the data and explains the methodological aspects of how the sovereign subsidy is derived. Section 4 provides descriptive evidence related to European banks' domestic and non-domestic sovereign exposures and to the sovereign subsidy associated with these exposures. Section 5 reports the results from our multivariate analyses and our robustness tests. Section 6 analyzes the effects of the EBA capital exercise. Section 7 concludes.

2 Institutional Framework: Capital Regulation in the European Union

Essentially, European banks have not been required to hold a capital buffer against the sovereign debt holdings of any European Union member state, regardless of the actual risk of such sovereign debt. Typically, banks must hold capital against all of their assets; the amount required to be held is based either on a given regulatory risk weight (the so-called standardized approach under the Basel accords) or on an internally modeled default probability estimation (the so-called internal ratings-based approach, IRB). However, this central idea of the Basel accords has not been followed in its European legal implementation equivalent, the Capital Requirements Directive (CRD). Under the standardized

approach, the CRD stipulates a zero risk weight for exposures to the European Central Bank and to member states' sovereign debt in domestic currency. Although banks using the IRB approach might have a non-zero capital requirement for their sovereign exposures in theory,[3] they can also choose to switch to the standardized approach when assessing the capital requirements for their sovereign debt portfolio following the IRB permanent partial use - an exemption that banks operating under IRB indeed frequently employ (Hannoun, 2011). Hence, the vast majority of banks eventually employ a zero risk weight for sovereign debt and, consequently, do not hold capital against any of their exposures to European Union sovereigns, regardless of the actual riskiness of these exposures as evaluated, e.g., by the capital markets.

This regulatory treatment of sovereign debt under EU legislation contradicts the spirit of the Basel accords and can also lead to severe distortions (Hannoun, 2011; Nouy, 2012). Because capital is costly and scarce, but sovereign bonds (particularly those associated with higher risk) pay a premium, European banks - particularly the weakly capitalized ones - might revert to excessive sovereign debt exposures as part of regulatory arbitrage and risk shifting incentives (Acharya and Steffen, 2013; Acharya et al., 2013). Therefore, European governments can issue excessive debt whose holding is incentivized by a sovereign subsidy in the form of the zero risk weight. However, if the zero risk exposure materializes as risky (as recently occurred in the European sovereign debt crisis), banks are left with too little capital against potential losses because they have not built a capital buffer for their sovereign exposure. If it is the weak banks, in particular, that shift to particularly risky non-domestic sovereign debt treated with a zero risk weight, the domestic sovereign might eventually face a decision about whether to bail out the domestic banks or the risky sovereign, as happened in the European sovereign debt crisis. Consequently, sovereign risk, as reflected in CDS spreads, for example, is not only immediately linked to the risk of other EU sovereigns through the CDS market and their joint responsibility for avoiding a sovereign default in the European Union but also through the bailout responsibility that a particular sovereign has with respect to its domestic banking sector. Essentially, the zero risk weight thus creates a channel - beyond the common linkages through markets and joint bailout responsibility - through which sovereign risk can transmit across EU member states.

Taken together, we hypothesize that there is a spillover of sovereign risk through bank balance sheets, i.e., the correlation between sovereign risks in the EU increases in domestic banks' exposures to non-domestic sovereigns. We apply this hypothesis to the data in the remainder of this paper.

[3] For example, Nouy (2012) shows that using the IRB approach does not necessarily produce a positive risk weight on sovereign exposures. The probability of default (PD) applied to sovereign portfolios is not subject to a floor (contrary to the PD for other exposures). Thus, the IRB approach might well result in a zero risk weight for sovereign exposures.

3 Data and Methodology

3.1 Data sources

To identify banks' exposures to non-domestic sovereign debt as a transmission channel for sovereign risk spillovers, we construct a unique dataset with three main components. First, we collect daily market information on sovereign credit default swap (CDS) spreads, sovereign bond yields and other financial market indicators (e.g., iTraxx and Datastream CDS indices, equity indices, VSTOXX, EONIA, and Euribor) from Bloomberg and Thomson Reuter's Datastream. We use CDS[4] spreads as our main measure for sovereign default risk for two reasons. First, compared with alternative proxies such as bond spreads, CDS spreads are considered an appropriate measure of credit risk (Black et al., 2013). Second, CDS spreads are a real-time reflection of the credit risk perception in the market (Aizenman et al., 2011; DeBruyckere et al., 2012), particularly compared with ratings, and they generally lead the price discovery process compared with alternative measures such as bond spreads (Blanco et al., 2005; Coudert and Gex, 2010). Consistent with prior studies, we use spreads on 5-year CDS contracts, which are widely traded and thus the most liquid (Alter and Schüler, 2012). As robustness tests, we conduct our main analyses using sovereign bond yields as a measure of sovereign credit risk. For reasons of liquidity and comparability, we use the 10-year benchmark (i.e., maturity adjusted) bond yields.

Second, we collect data on banks' domestic and non-domestic sovereign exposures from two sources. We use data from the stress tests and capital exercises that were conducted and published by the European Banking Authority (EBA) during the period from March 2010 to June 2012. These datasets comprise sovereign bond holdings at the individual bank and exposure level for approximately 90 major European banks from 21 countries at five points in time: December 2009, December 2010, October 2011, December 2011, and June 2012.[5] Appendices B and C provide an overview of these stress tests and of the identities of the banks included in the stress test. Although these data provide detailed insights into bank level exposures to domestic and non-domestic sovereigns, they do not cover the overall banking systems' exposures for the respective countries. Thus, we use data obtained from the Bank for International Settlements' (BIS) consolidated banking statistics, from which we collect quarterly data (from 2010-Q4 to 2012-Q4) for all non-domestic sovereign exposures at the banking sector level for seven countries, i.e., Belgium, France, Germany, Ireland, Italy, Spain, and the United Kingdom.[6] Thus, our data allow us to conduct analyses at the bank and at the country level.

In addition, we complement the bank level exposure data with quarterly bank financial data sourced

[4]CDS are swap agreements that can be conceived of as insurance contracts in which the protection buyer pays a regular insurance premium, i.e., the CDS spread, which is typically denoted in annualized basis points of the insured notional. If a credit event occurs, i.e., a sovereign default in the context of this paper, the protection buyer is entitled to receive compensation for the incurred loss from the protection seller.

[5]Note that this is the status at the time of writing. The EBA has scheduled further data publications.

[6]Note that this dataset is the most comprehensive, both regarding time-series and cross-sectional data availability.

from SNL Financial and the country level data with (macro-)economic variables provided by the Organization for Economic Cooperation and Development (OECD) and the European Central Bank (ECB).[7]

3.2 Constructing the 'sovereign subsidy' measure

3.2.1 Ratings implied sovereign subsidy (EBA risk weights)

To adequately reflect the risk of its assets, a bank would typically translate its exposures into risk-weighted assets (RWAs) by employing a specific risk weight for each exposure and would hold a pre-specified portion of these RWAs in its regulatory capital as a buffer against potential losses. As discussed above, the risk weight applied to European sovereign portfolios in European banks is typically zero; hence, no capital has to be held against this exposure. However, to estimate the shortfall in bank capital that follows from the application of the zero risk weight, we assign appropriate risk weights to each sovereign debt holding and compute the corresponding risk-weighted assets that are not adequately reflected in banks' capital positions.[8] We call the latter the 'sovereign subsidy', which alludes to the regulatory capital savings resulting from the zero risk treatment of sovereign debt. This sovereign subsidy is computed as the following:

$$sovereign\,subsidy_{i,p} = \sum_{j=1}^{J} RW_{j,p} * sovereign\,exposure_{j,i,p} \tag{1}$$

with i indicating the sovereign/country, j the exposure (i.e., the counterparty sovereign), and p the period (e.g., quarter in our context).

To compute the appropriate risk weights for the sovereign exposures, we apply two alternative methods for robustness. The first method - which we use as the default method because it somewhat replicates the EBA stress tests - follows a three-step procedure. First, we collect ratings information on all European Union sovereigns from the three largest rating agencies (Standard & Poor's, Moody's, and Fitch) for each exposure date (i.e., stress test dates for the EBA dataset and end of quarter for the BIS dataset). In the second step, we assign a probability of default (PD) to each sovereign based on the ratings and the corresponding PD measures that were used by the EBA in its stress tests. Third, we use the Basel Committee's official IRB formula and standard assumptions of loss given default (LGD) of 45 percent and 2.5 years maturity to compute risk weights for sovereign exposures.[9] Panel

[7] Appendix A provides detailed definitions of the variables used in our analyses.

[8] Note that this approach results in an RWA measure that can be translated into a capital requirement by applying the respective capital adequacy ratio or minimum capital ratio (see Appendix E).

[9] For further details on the formula and assumptions, refer to Appendix E and Basel Committee on Banking Supervision (2005).

A of Table 1 provides an overview of the resulting risk weights.

[Table 1]

We provide an example for the computation of the sovereign subsidy using the non-domestic EU sovereign exposures of the German banking sector as of year-end 2010 in Panel B of Table 1.

3.2.2 CDS implied sovereign subsidy

As an alternative to the risk weights that rely on ratings, we use CDS implied probabilities of default. However, the CDS spread can only imply risk-neutral PDs that have to be converted into physical PDs, which incorporate the market price of risk and are thus comparable to those published by the rating agencies and assumed, e.g., by the EBA and in the calculation of risk weights discussed above.[10] Using the conversion factors published by Hull et al. (2005), we approximate physical PDs from the CDS implied risk-neutral PDs. Finally, as with the third step above, we use the Basel Committee's official IRB formula and standard assumptions of loss given default (LGD) of 45 percent and 2.5 years maturity to compute risk weights for sovereign exposures from these PDs.[11]

It should be noted that applying EBA risk weights yields a more conservative estimate of the sovereign subsidy than the CDS implied risk weights, which result in sovereign subsidy numbers that can be nearly twice as high. Therefore, our EBA risk weight measures should be regarded as a conservative and more or less lower bound estimate of the sovereign subsidy.

3.3 Descriptive statistics

Table 2 presents the summary statistics.

[Table 2]

In the periods surrounding the reporting dates for banking sector sovereign bond holdings (end of quarter from 2010-Q4 to 2012-Q4), the average CDS spreads of the sovereigns in our dataset were 252 basis points and exhibited an average daily change of -0.17 percent. Although the average change is rather small, we report a rather high standard deviation for the daily changes and show that there are periods with large changes of approximately 20 percent (both upward and downward). We compute an index of European sovereign CDS spread changes as the sum of the changes in each sovereign j's CDS, which are weighted by the share of that sovereign j in the sample's total non-domestic sovereign

[10] For a more extensive discussion of the differences in CDS implied risk-neutral PD and physical (or 'real-world') PD, refer to Chan-Lau (2006); Duffie (1999); Hull et al. (2004, 2005).

[11] Because the PDs and risk-weights depend on several input factors, we forgo a tabulation. Summary statistics are available in Table 2.

exposure during period p; i.e., the change in the CDS market index corresponds to an exposure-weighted average change in CDS spreads. This average daily change in the exposure weighted sovereign CDS market index was -0.14 percent during our period of interest.

By comparing the evolution of CDS spread changes over time, we find that sovereign risk experiences strong co-movement. Changes in CDS spreads are highly correlated across European sovereigns, with correlation coefficients between individual sovereign CDS changes ranging between 0.6 and 0.9 on average during 2010 to 2012. This observation holds across the Eurozone and also with non-Eurozone countries such as the UK.

The average exposure to non-domestic sovereign debt in each sample country is EUR 104 billion which corresponds to 8.6 percent of a country's GDP on average. Risk-weighting this exposure translates into a sovereign subsidy of between EUR 30 billion and EUR 56 billion, depending on the method of computing the risk weights (EBA methodology or CDS implied risk weights).

We use additional explanatory variables in our tests, i.e., each country's share in the capital of the European Central Bank (ECB) and data on total government debt. The average share in subscribed capital of the ECB (and likewise in the European Stability Mechanism) is 11.8 percent, with Germany holding the largest share of 27.1 percent. The average country exhibits government debt that totals 102 percent compared with its GDP, with debt ratios ranging from 60 percent (Spain in 2010) to nearly 140 percent (Italy in 2012).

4 Sovereign Exposures and Sovereign Subsidy

4.1 Bank level sovereign exposure and sovereign subsidy

Figure 4 provides a first overview of the size of the sovereign subsidy and its development over time and displays the sum of the total (domestic and non-domestic) sovereign subsidy for all banks that were part of the EBA stress tests,[12] using EBA risk weights.

[Figure 4]

According to this calculation, all stress-tested banks from non-peripheral countries accumulate an overall sovereign subsidy of more than EUR 300 billion. Non-domestic sovereign debt accounts for more than two-thirds of this subsidy. The total sovereign subsidy changes very little over time. We document that the subsidy of banks from peripheral countries (i.e., Greece, Ireland, Italy, Portugal, and Spain), increases from approximately EUR 150 billion in 2009 to more than EUR 300 billion in

[12] It is notable that the number and composition of banks change for the different stress tests. An overview of the stress tests is given in Appendix B. In addition, Appendix D contains a detailed breakdown of domestic and non-domestic exposures and sovereign subsidies at the individual bank level.

2012, even though several banks, e.g., from Greece and Spain, are removed from the stress-test sample. This increase is largely driven by the risk weight on domestic sovereign debt in these countries, which increased significantly over the given period as rating agencies downgraded these sovereigns several times. Non-domestic sovereign debt, on the other hand, accounts for only 10-20 percent of the total sovereign subsidy of stress-tested banks in peripheral countries.

A detailed overview of the sovereign subsidy related to banks' *non-domestic* sovereign exposures is reported in Tables 3 using the EBA stress test data.

[Table 3]

Panel A of Table 3 shows the total non-domestic sovereign exposures of the stress test banks at each reporting date, both in absolute terms and in relation to total assets. We also separate the banks according to their home sovereign into peripheral and non-peripheral countries. Overall, total exposures decline from EUR 923 billion in December 2009 to EUR 694 billion in June 2012, which was driven predominantly by non-peripheral banks (and some banks that dropped out of the stress tests and thus from the dataset). More importantly, we report the sovereign subsidy associated with the investments in non-domestic debt. The subsidy of all stress test banks was EUR 251 billion in December 2009, or 28.5 percent of the banks' core Tier 1 capital. The subsidy of peripheral banks is smaller both in absolute size and percentage of Tier 1 capital, which also reflects their large holdings of domestic sovereign debt. The subsidy of non-peripheral banks increases from 38.2 percent of Tier 1 capital (or EUR 220 billion) in December 2009 to 47.9 percent in December 2011 and then declines by more than 21 percentage points by June 2012. While the overall exposure of non-peripheral banks to foreign sovereign debt in fact increased during this time period, the decrease (of the sovereign subsidy relative to Tier 1 capital) is driven by a substantial increase in Tier 1 capital in the first half of 2012.

Figure 3 plots various measures of sovereign debt exposures against banks' Tier 1 ratios. Consistent with Acharya and Steffen (2013), weakly capitalized banks, in particular, hold more non-domestic sovereign debt and notably more debt issued by the peripheral sovereigns. This finding suggests that weak banks transfer risk through their non-domestic sovereign debt holdings to their sovereigns and thus exploit a regulatory arbitrage opportunity.

[Figure 3]

Panel B of Table 3 provides the non-domestic sovereign subsidy of the EBA banks at the detailed country level as of December 2010. The Cypriot and Belgian banks have the largest sovereign subsidy of all non-peripheral banks, totaling 164.3 percent of the Tier 1 capital for the Cypriot banks. Most of their sovereign investments are in Greek sovereign bonds, and Greece experienced several rating

downgrades in 2010 and 2011.[13]

[Table 4]

Panel A of Table 4 shows the total *domestic* sovereign exposures of the stress test banks at each reporting date, also in relation to total assets. The overall domestic sovereign debt exposure is remarkably stable across all five periods and increases by only a small amount from EUR 1.04 trillion to EUR 1.08 trillion. As shown above, the non-domestic exposure decreased by approximately 25 percent during this time. However, the sovereign subsidy for domestic sovereign debt nearly doubled from EUR 206 billion in December 2009 to EUR 386 billion in June 2012. This increase is driven by banks from peripheral countries, for which the sovereign subsidy almost tripled from October 2011 to June 2012. Thus, the largest sovereign subsidies for peripheral banks come from their domestic sovereign debt holdings, whereas non-domestic sovereign debt holdings account for the largest sovereign subsidies for non-peripheral banks, which also reflects the variation in risk-weights. Panel B of Table 4 provides the domestic sovereign subsidy of the EBA banks on the detailed country level as of December 2010. Notably, banks in core countries such as Germany also exhibit large domestic sovereign subsidies, even relative to their Tier 1 capital. However, in contrast to peripheral banks, this subsidy reflects the market size for German sovereign bonds and the amount of German sovereign bonds in the portfolios of domestic banks rather than a declining sovereign debt rating. In our empirical tests, we thus scale the sovereign subsidies by the GDP of the respective sovereign to account for this size effect.

Overall, these numbers not only highlight the significance of the sovereign subsidy for individual banks but also emphasize the magnitude of risk-weighted assets that are not reflected in banks' capital and the resulting contingent capital shortfall. Replacing the zero risk weight with a more risk-adequate treatment of sovereign exposures would most likely require an additional capitalization effort for banks with high sovereign subsidies relative to their Tier 1 capital.

4.2 Country level non-domestic sovereign exposure and sovereign subsidy

Although the EBA provides data on a micro (i.e., bank) level, it only reports the holdings for the largest banks in each country. Moreover, the EBA data is reported in infrequent intervals and is available for only five reporting dates (at the time of writing). To assess the role of sovereign subsidies as a catalyst of risk spillovers in Europe, we also collect data from the BIS consolidated banking statistics, which report the non-domestic[14] sovereign bond holdings of the entire banking sector, i.e., aggregated across all banks in a reporting country, on the individual counterparty sovereign level.

[13] Refer to the Cyprus case example in the introduction of this paper.
[14] Note that the BIS does not provide domestic sovereign debt data.

To start with, Figure 5 contrasts the total non-domestic sovereign debt holdings of banking sectors with their home countries' GDP by using the BIS data. On average, banks hold between 5 and 16 percent of a country's GDP in non-domestic sovereign debt, which frequently includes the relatively risky debt of peripheral European sovereigns.

[Figure 5]

We document the banking sectors' *non-domestic* sovereign exposures and the resulting sovereign subsidies in more detail in Table 5. Panel A of Table 5 shows total non-domestic sovereign exposures, Panel B presents exposures to peripheral countries and Panel C shows exposures to non-peripheral countries. We report data at the end of each year (2010, 2011 and 2012) and for all seven countries available in the BIS dataset, separated by peripheral versus non-peripheral countries. Exposures are reported both in absolute (EUR million) amounts and in relation to each country's GDP.

[Table 5]

Table 5 documents that the non-domestic EU sovereign exposures of domestic banking sectors range up to several hundred billion EUR for individual states, or up to 16 percent of their national GDP. Notably, although some of the core countries' banking sectors slightly decreased their non-domestic sovereign exposure (Belgium, France, and Germany), banking sectors in peripheral countries (Italy, Ireland, and Spain) actually increased their exposure between year end 2010 and year end 2012, i.e., over the course of the sovereign debt crisis. This finding might be due to a retrenchment of banks' sovereign positions in core countries, whereas banks in peripheral countries attempt to diversify their holdings away from their (increasingly risky) domestic sovereigns. A notable exception is the UK banking sector, which nearly doubled non-domestic EU sovereign exposures to EUR 245 billion in 2012. For the seven countries for which data are available from the BIS, the total exposure to non-domestic EU sovereigns amounts to more than EUR 800 billion in 2012, which is up from approximately EUR 650 billion in 2010. The magnitude of these exposures again emphasizes that non-domestic sovereign debt holding is a significant phenomenon in the European Union - for individual banks as well as for entire countries.

[Figure 6]

Figure 6 shows the quarterly non-domestic peripheral sovereign debt holdings (upper picture) and non-peripheral sovereign debt holdings (lower picture) by all banks included in the BIS data. Notably, the data demonstrate that banks began reducing peripheral sovereign holdings in 2011-Q2/Q3, coinciding with the EBA request for banks to hold a capital buffer reflecting the sovereign risk in their portfolios. Although European banks were already decreasing their exposures since 2011-Q2, they

reduced total exposure to peripheral sovereigns by approximately 40 percent within one year after the EBA capital exercise. At the same time, they increased their holdings of non-peripheral sovereign debt (particularly German sovereign debt), which indicates a type of 'flight to quality'.[15] Overall, this observation is consistent with the interpretation that zero risk weights gave banks incentives to load up on risky peripheral sovereign debt and that the EBA requirements effectively reduced the arbitrage opportunities created by zero risk weights.[16]

5 Modeling Sovereign Risk Spillovers

In this section, we present our baseline regression model and define the key variables. We then discuss the results of our main analyses and provide further robustness tests that help exclude alternative hypotheses.

5.1 Baseline model

Our baseline regression framework captures the relationship between the changes in risk of a specific sovereign's debt and the changes in overall European sovereign risk; in particular, it helps us capture how this relationship is amplified by sovereign subsidies resulting from zero risk weights. More specifically, our main dependent variable is $\Delta lnCDS_{i,t}$, the change in the natural log of the CDS spread of a specific sovereign i from time t-1 to t, i.e., on a daily level.[17] The main explanatory variables are (1) $\Delta lnCDS\,index_t$, the change in a logarithmic European sovereign CDS market index that is weighted by the importance of each sovereign j in the sample's full sovereign exposure during period p, i.e., by $sovereign\,exposure_{j,p} / \sum_{j=1}^{J} sovereign\,exposure_{j,p}$; (2) $sovereign\,subsidy_{i,p}/GDP_{i,p}$, the non-domestic sovereign subsidy, i.e., the risk-weighted exposures of country i's banking sector to all non-domestic EU sovereigns in period p, scaled by the GDP of country i; and (3) the interaction between these two variables. Day (δ_t) and country-quarter ($\gamma_{i,p}$) fixed effects are used to control for influences constant either across countries on a given day or over a specific quarter for a given country. As an alternative to the fixed effects, we use a set of time-varying control variables (X_t) to account for additional covariates that might affect changes in credit risk, including changes in a CDS market index (iTraxx Europe index), an equity market index (Datastream total return index), market volatility (VSTOXX), and the term spread (computed from EONIA and 12-months-Euribor).

In detail, the model is specified as follows:

[15] Also compare Acharya and Steffen (2013).

[16] Note that this change primarily affected the banks that were part of the EBA capital exercise. However, because these are the largest banks and the largest holders of sovereign debt, it should have considerable influence on total banking sector holdings (compare Appendix B).

[17] Because the series of CDS spreads is non-stationary - at least during market turmoil (see, e.g., Alter and Schüler, 2012; Kalbaska and Gatkowski, 2012) - using first differences also helps us make the data stationary.

$$\begin{aligned}\triangle lnCDS_{i,t} = \alpha + \beta_1 * \triangle lnCDS\,index_t + \beta_2 * sovereign\,subsidy_{i,p}/GDP_{i,p} + \\ + \beta_3 * [\triangle lnCDS\,index_t * sovereign\,subsidy_{i,p}/GDP_{i,p}] \\ + \delta_t + \gamma_{i,p} + \varepsilon_{i,t}\end{aligned} \tag{2}$$

with

$$sovereign\,subsidy_{i,p} = \sum_{j=1}^{J} RW_{j,p} * sovereign\,exposure_{j,i,p} \tag{3}$$

Following Acharya et al. (2011), we use a 60-day-period, i.e., 30 days before and 30 days after the reporting date (last day of the quarter), to estimate the model.[18]

With regard to our main hypothesis, we expect to see an amplification of risk-spillovers through sovereign subsidies, that is, a positive and significant coefficient β_3.

[Figure 7]

Some indicative evidence is provided in Figure 7. The first part of this Figure presents the relationship between the banking sector's non-domestic holdings at the beginning of a quarter and the beta of the sovereign CDS with the exposure-weighted European sovereign CDS market index, which indicates a high correlation between non-domestic sovereign debt and the beta of the banks' home sovereign CDS with a European sovereign CDS market index.

Moreover, the second part of Figure 7 demonstrates the positive relationship between changes in banks' risk-weighted non-domestic sovereign bond portfolio risk and the change in the domestic sovereign CDS. Again, this is consistent with the notion of a transmission channel through bank balance sheets. In our multivariate tests, we analyze whether this effect is purely driven by the changing CDS spreads of banks' non-domestic exposures or also moderated by the amount of their risk-weighted exposures (scaled by GDP).

5.2 Results and robustness checks

5.2.1 Baseline model estimation

Table 6 reports the results of our baseline model.

[18] Note that this practice rests on the implicit assumption that marginal CDS investors have some knowledge of these exposures and that the exposures on the reporting date are indicative for the sovereign debt holdings during the 30 days before and after the reporting date. Both assumptions are common in the literature (Acharya et al., 2011).

[Table 6]

Column (1) shows the results from estimating the baseline model without control variables. As expected, the level effect of changes in the overall sovereign CDS market index on changes in an individual sovereign's CDS spreads is positive and highly significant. The level effect of the sovereign subsidy, i.e., the domestic banks' risk-weighted non-domestic European sovereign exposure, on sovereign CDS spread changes is insignificant. More importantly, the coefficient of the interaction between the changes in the overall sovereign CDS market index and the sovereign subsidy is positive and highly significant. This is consistent with the notion that the sovereign subsidy amplifies risk spillovers, i.e., a larger sovereign subsidy increases the magnitude of a potential capital shortfall in the case of a sovereign default and thus the expected bailout costs of the domestic sovereign, and thus transmits non-domestic sovereign risk.

The coefficient on the interaction term remains highly significant and economically similar if we add a range of control variables or fixed effects. In column (2), we add changes in a CDS market index (iTraxx Europe index), changes in an equity market index (Datastream total return index), changes in market volatility (VSTOXX), and changes in the term spread. In column (3), we add date fixed effects, in column (4) we add country-quarter fixed effects and in column (5) we add both date and country-quarter fixed effects. In general, our results are consistent with larger sovereign subsidies aggravating the spillover of sovereign default risk in the European Union.

5.2.2 Robustness tests

To test the robustness of these results, we rerun our model both with and without fixed effects for alternative measures of the main dependent and explanatory variables. The results are presented in Table 7.

[Table 7]

First, we use an alternative data source for CDS spreads. While we have used Bloomberg quotes by default, we now construct our dependent variable and the CDS market index using CDS spread quotes from Thompson Reuters' Datastream. Using these alternative CDS spread quotes does not change the results, as shown in columns (1) and (2). Next, we use 10-year maturity adjusted government bond yields to construct the dependent variable and the sovereign risk index. The results are comparable to using CDS spreads: The change in the sovereign bond market index enters positively and significantly, while this effect is significantly higher the larger the sovereign subsidy is, as the positive and significant coefficients of the interaction terms in columns (3) and (4) indicate. In addition, we use an alternative methodology for computing the risk weights with which the non-domestic European sovereign exposures

of domestic banks are weighted in constructing the sovereign subsidy. Instead of relying on ratings, we use CDS implied probabilities of default calculated according to the methodology outlined above.[19] Running our baseline model with and without fixed effects on this alternative sovereign subsidy yields similar results, as shown in columns (5) and (6). Finally, we perform our tests using the non-domestic sovereign exposure data that were reported in the EBA stress test results instead of using BIS data. This approach has the advantage of broadening the sample to more countries, but the disadvantage of relying on a smaller time series dimension of just five dates on which the exposure was reported.[20] Additionally, although the banks included in the EBA stress tests hold a large proportion of the total cross-country sovereign debt,[21] the EBA data are not necessarily exhaustive on the country level. Therefore, we use these data only for a robustness test, whereas the (exhaustive) BIS data are used as our default dataset. The results of our tests on the EBA sample are displayed in columns (7) and (8) and are highly comparable in direction and significance.

Taken together, these findings support our main hypothesis and are robust to (a) alternative specifications of the model, including date and country-quarter fixed effects; (b) alternative measures of credit risk using both alternative sovereign CDS spread quotes and sovereign bond yields; (c) alternative risk-weights for computing the sovereign subsidy; and (d) alternative exposure data using the EBA stress test dataset.

5.2.3 Falsification tests using non-EU sovereign exposures

We argued above that risk spillovers among European sovereigns are amplified because banks hold too little capital as a result of the zero risk weights associated with holdings of EU member states' sovereign debt. Hence, we would not expect to observe a similar effect for exposures to non-EU member states because European banks must hold capital that reflects the risk of the respective sovereign. The BIS also reports the exposures of our sample banking sectors to countries such as Japan, Norway, Switzerland, and the U.S.. We calculate a 'quasi-sovereign subsidy' that reflects the risk-weighted assets and the resulting potential capital shortfall if banks would not have to hold capital against these exposures and repeat our baseline regressions both for each of the four countries separately and for an index of non-EU sovereigns. We report the results in Table 8.

[Table 8]

Columns (1) and (2) of Table 8 report the results focusing on European banks' exposure to U.S. sovereign debt, and columns (3) and (4) include an exposure-weighted index of non-EU sovereigns' CDS. We find that the CDS spread changes of European sovereigns are positively and significantly

[19] In our regression models, we use CDS implied risk weights that are averaged and lagged by one quarter.
[20] See table in Appendix B for an overview of countries and dates.
[21] See figure in Appendix B.

related to the CDS spread changes of non-EU member countries. However, we find that the coefficient of the interaction term of the non-EU sovereign CDS spread changes and our quasi-sovereign subsidy measure is insignificantly different from zero. This result suggests that spillovers among EU and non-EU sovereigns are not amplified by banks' non-EU sovereign exposures because banks are in fact holding sufficient capital against these exposures.

5.2.4 Alternative channels

Our results suggest that implicit bailout costs associated with non-domestic sovereign subsidies are an important determinant of sovereign CDS spreads. An alternative explanation for our results might be direct sovereign bailout risks, i.e., the responsibility but also the capacity of one sovereign to bail out others. Therefore, we augment our baseline model and include proxies for alternative risk spillover channels.

First, one possible channel for the transmission of sovereign risk in a monetary union reflects the externality that is created by market perceptions of a mutual bailout responsibility. We measure bailout responsibility using the share of the (contingent) liability sovereigns assume for one another through the stability mechanisms in the Eurozone. These are (1) each sovereign's share in the temporary assistance vehicle, the European Financial Stability Facility (EFSF), (2) each sovereign's share in the permanent support vehicle, the European Stability Mechanism (ESM), and (3) the risk that sovereigns ultimately assume through the purchase of debt instruments by the ECB. Because all of these measures are a direct function of the capital share of these sovereigns in the European Central Bank (ECB, 2011), we take this capital share as our proxy for bailout responsibility.[22]

Second, we control for a country's bailout capacity. Beyond formal responsibility, sovereigns that are in a position to contribute more toward the bailout of a failed member state might experience a relatively stronger risk spillover that is proportional to their bailout capacities. Because it proxies for fiscal capacity and the potential to raise additional debt, we use the debt ratio (expressed as government debt to GDP) as a proxy for bailout capacity.

We include these two proxies both in the levels and in an interaction with the European sovereign CDS market index, and we run all the specifications of our baseline regressions using this augmented model. Table 9 reports the results.

[Table 9]

As expected, the ECB capital share, i.e., the proxy for bailout responsibility, indeed increases the risk spillover across European sovereign CDS, as the coefficient on the interaction between the ECB

[22] Note that the share of the United Kingdom in these institutions is 0.

capital share and the sovereign CDS market index indicates, which is positive and highly significant throughout all specifications. The government debt ratio, i.e., the proxy for bailout capacity, is not significant, neither in levels nor in its interaction with the sovereign CDS market index. Importantly, the effect of the banks' non-domestic European sovereign exposures on sovereign risk spillovers remains unchanged when controlling for these alternative channels. Taken together, these findings are consistent with the presumption that domestic banking sector exposures to non-domestic European sovereigns, which are not adequately reflected in bank capital, provide an important channel for sovereign risk spillovers above and beyond direct bailout risk spillovers.

Finally, we also tested for the inclusion of other non-domestic exposures as additional control variables. We do so by including either the non-domestic, non-sovereign exposure of the domestic banking sector and its interaction with changes in the sovereign CDS market index or by including its two components, i.e., exposures to non-domestic banks and non-domestic private agents and their respective interactions with changes in the sovereign CDS market index. These tests leave our coefficient of interest unchanged in size and significance, which confirms that the sovereign subsidy has a positive and significant effect on the spillover of sovereign risk.

6 The September 2011 Capital Exercise

Although European bank capital regulation has not yet deviated from the zero risk weight for Euro denominated sovereign debt, the so-called capital exercise conducted by the EBA in September 2011 required the participating banks to build a capital buffer that accounts for the risky sovereign debt in their portfolios. We argue that this requirement can be interpreted as a de facto introduction of a risk weight on sovereign debt exposures for the participating banks, i.e., the largest banks in Europe, which also hold the majority of sovereign debt.[23] In fact, this instance represented the first time official authorities acknowledged that sovereign debt is not risk-free and should be reflected in the capital requirements for banks. Whether the capital exercise eventually reduces the de facto sovereign subsidy and, thereby, the spillover risks from non-domestic sovereign exposures is thus a testable hypothesis.

As a first indicative step, in Figure 8 we plot the quarterly estimated betas of individual sovereign CDS spreads with a sovereign CDS market index over time.[24]

[Figure 8]

[23] Refer to Appendix B.

[24] Note that we use a consistent sample of countries that are available through the entire timespan, comprising Belgium, France, Germany, Ireland, Italy, Spain, and the United Kingdom, and a consistent composition of the sovereign CDS market index over time, i.e., the Datastream series of the Markit SovX index.

We document a sharp decrease in the beta after the EBA capital exercise in September 2011. Consequently, the sovereign risk spillovers through bank balance sheets might have been mitigated in two ways: Banks were holding less non-domestic (risky) sovereign exposures, and/or banks were holding more capital for existing exposures, which decreases the likelihood of a bailout becoming necessary. Our hypothesis is that this should reduce the effect of the sovereign subsidy on the extent of the risk spillover. We test this hypothesis using our empirical model and report the results in Table 10 .

[Table 10]

Because the additional capital requirement was introduced in late 2011 but only became fully effective at the end of June 2012, we define all quarters up to 2011-Q3 as the period before the EBA CE and all quarters from 2012-Q2 as the period after the EBA CE. We then run the baseline model with and without fixed effects separately for both periods. Both specifications yield similar results: While the coefficient on the interaction term that proxies for the sovereign risk spillover through non-domestic sovereign exposures of the domestic banking sector remains positive and highly significant before the EBA capital exercise, it is insignificantly different from zero after the capital exercise.

To further test the robustness of this crucial finding, we again include proxies for the alternative channels of risk spillover and separately run the augmented model for both periods before and after the EBA capital exercise. Panel B of Table 10 shows that the coefficient on the interaction term behaves similarly to the baseline model, reconfirming our finding. Notably, however, we find that the coefficient on the interaction between the ECB capital share and the change in the sovereign CDS market index remains positive and highly significant both before and after the capital exercise, which is in contrast to our main coefficient of interest. The fact that we do not find a break in the bailout responsibility effect, while we find a break in the effect of the sovereign subsidy after the implementation of the EBA CE further supports the presumption that adequate capitalization of banks' exposures indeed matters for sovereign risk spillovers.

Overall, our findings strongly support our main hypothesis and suggest that sovereign risk spillover through banks' non-domestic sovereign exposures could indeed be mitigated if regulators introduce capital requirements for these sovereign exposures.

7 Conclusion

This paper identifies banks' exposure to non-domestic sovereign debt as a transmission channel for sovereign risk spillovers in Europe. Using bank portfolio data collected from the European Banking Authority's stress test disclosures and the consolidated banking statistics from the Bank for International Settlements we construct a new measure that quantifies each bank's 'sovereign subsidy', which is derived from its risk-weighted investment in non-domestic EU sovereign debt. This sovereign subsidy is a measure of the banks' risk-weighted assets that are not adequately reflected in their capital positions as a result of the application of the zero risk weight. In other words, the sovereign subsidy reflects a potential capital shortfall resulting from the regulation that European banks do not have to hold equity for investing in Euro denominated (risky) sovereign debt. The sovereign subsidy thus proxies for a sovereign's expected bailout costs for its domestic banking sector. The subsidy is larger when banks have larger non-domestic sovereign exposures and when sovereign credit quality deteriorates.

We document that changes in a value-weighted European sovereign CDS market index explain changes in individual sovereign CDS spreads. More importantly, this relationship is amplified by the magnitude of the sovereign subsidy of a country's domestic banking sector. This is consistent with larger expected bank bailout costs in the case of a sovereign default. These results hold when controlling for other determinants of CDS spread changes and when using alternative measures for sovereign risk and for the sovereign subsidy. The findings also hold when controlling for alternative channels of sovereign risk spillovers such as direct bailout responsibilities toward other EU member states or bailout capacity of an individual sovereign. Exploring exposures to non-EU members (i.e., Japan, Norway, Switzerland, and the U.S.), we find an insignificant effect of the sovereign subsidy on sovereign risk spillovers. Moreover, we find that the effect also becomes insignificant for non-domestic exposures to EU member states after the September 2011 capital exercise by the EBA when banks were required to hold a sovereign capital buffer.

Most importantly, we provide an evaluation of the regulatory treatment of banks' sovereign debt exposures. Current regulatory capital requirements leave banks severely under-capitalized because of the riskiness of their sovereign bond portfolios, which amplifies risk spillovers among European sovereigns and increases the implicit bailout costs of the banking sector. The implementation of Basel III through the CRD IV does not attempt to adequately address this problem. However, the additional capital requirement for sovereign debt holdings that was introduced by the EBA's capital exercise in September 2011 is a first - albeit only temporary - step in this direction. Adequate risk weights for sovereign debt should be applied and should be part of prudential capital regulation. However, there is a potentially large contingent capital shortage due to the zero risk weight; replacing it with a more risk-adequate treatment of sovereign exposures would most likely require an additional capitalization

effort for banks with high sovereign subsidies relative to their capital position. This should be taken into account when (gradually) introducing an adequate risk weight on sovereign exposures. Overall, our results emphasize the importance of capital in the banking system to mitigate sovereign risk spillovers in Europe.

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Figure 1: **An example of spillover? The deterioration of Cyprus' sovereign credit risk and its banks' exposure to Greek sovereign debt**
This figure presents an overview of the development of the Greek sovereign debt rating and the sovereign CDS spread of Cyprus over recent years. It also displays the Greek sovereign debt exposures of the two largest banks in Cyprus, Bank of Cyprus and Marfin Popular Bank, which these banks had to report as part of the EBA stress tests. The exposures are weighted by a ratings implied risk weight suggested by the EBA and set into relation to the GDP of Cyprus.

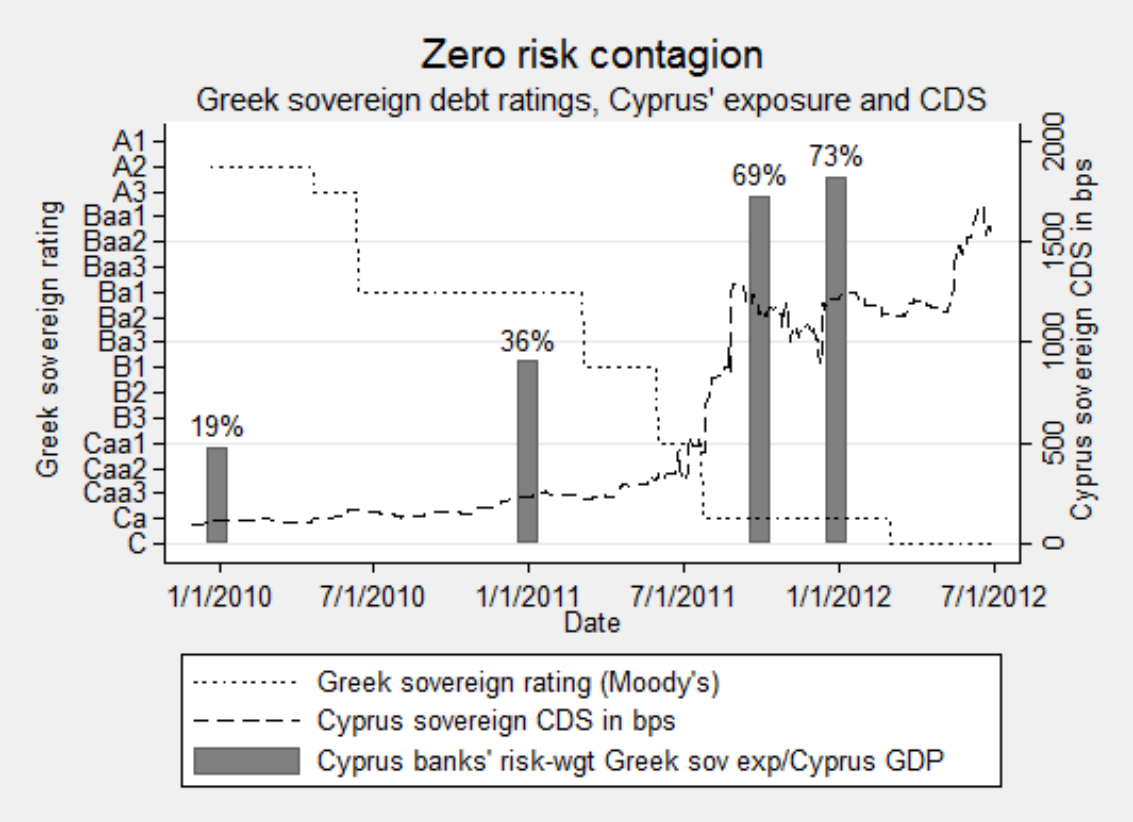


Figure 2: **Channels of risk spillovers**
This figure presents a stylized overview of sovereign contagion channels as modeled in Bolton and Jeanne (2011).

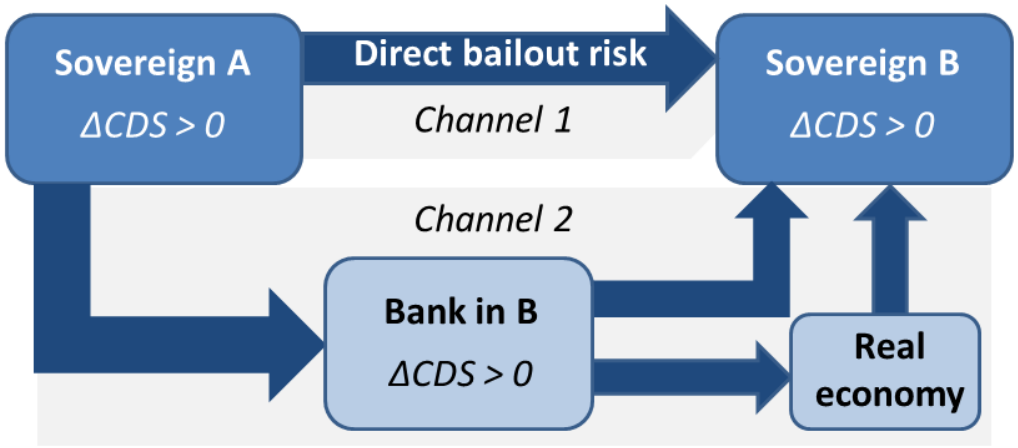


Figure 3: **Bank capitalization and non-domestic sovereign exposure (EBA, 2009-2011)** This figure plots the tier 1 ratio of banks available in the EBA stress tests and capital exercise (Dec 2009, Dec 2010, Oct 2011) against this bank's total EU sovereign exposure/assets, peripheral (GR, IE, IT, PT, ES) sovereign exposure/assets, Italian sovereign exposure/assets, and Spanish sovereign exposure/assets. The tier 1 ratio is computed as tier 1 capital to total assets. Banks from peripheral countries, Italy, and Spain are excluded in the respective figures to capture the effect of non-domestic exposure.

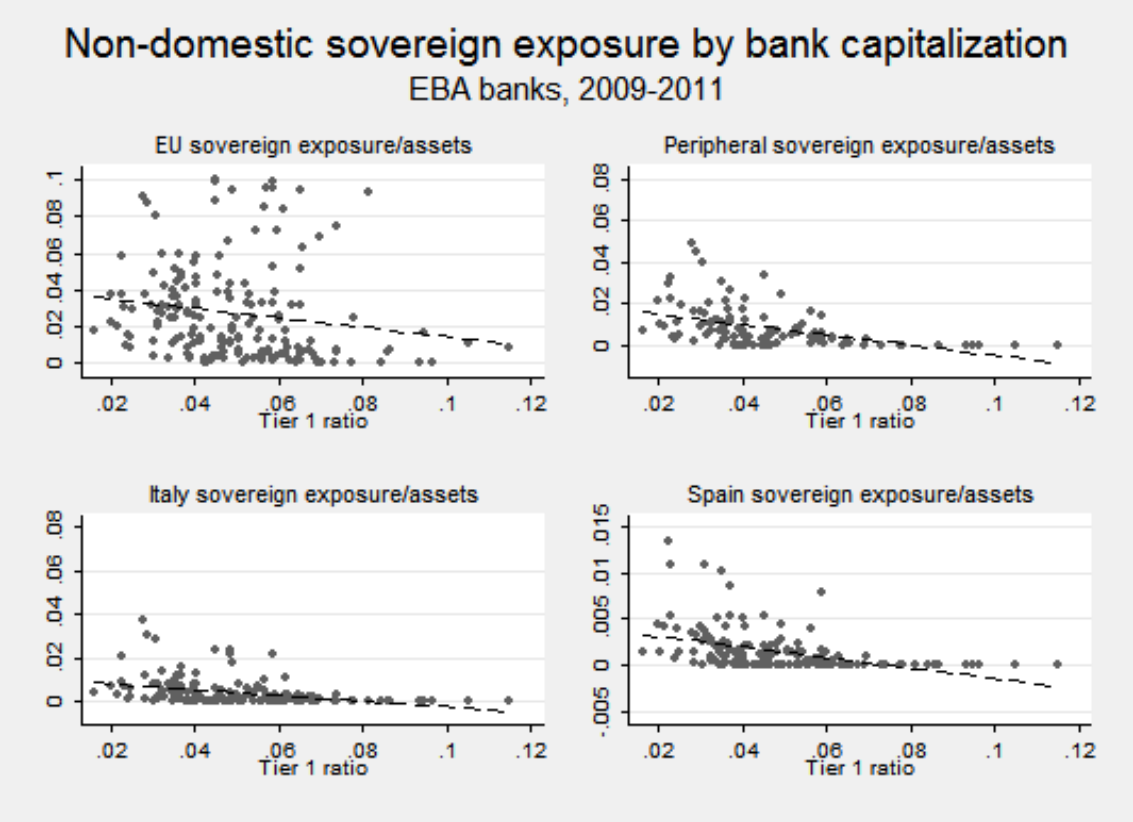


Figure 4: **Sovereign subsidy - Risk-weighted sovereign exposures of banks in peripheral and non-peripheral countries (EBA)**
These figures display the sovereign subsidy, a risk weighted asset equivalent (see main text for detailed description) of the sovereign exposures of banks in peripheral (GR, IE, IT, PT, ES) and non-peripheral countries. We display the sum of all risk-weighted domestic and non-domestic EU sovereign exposures of banks contained in the EBA stress tests.

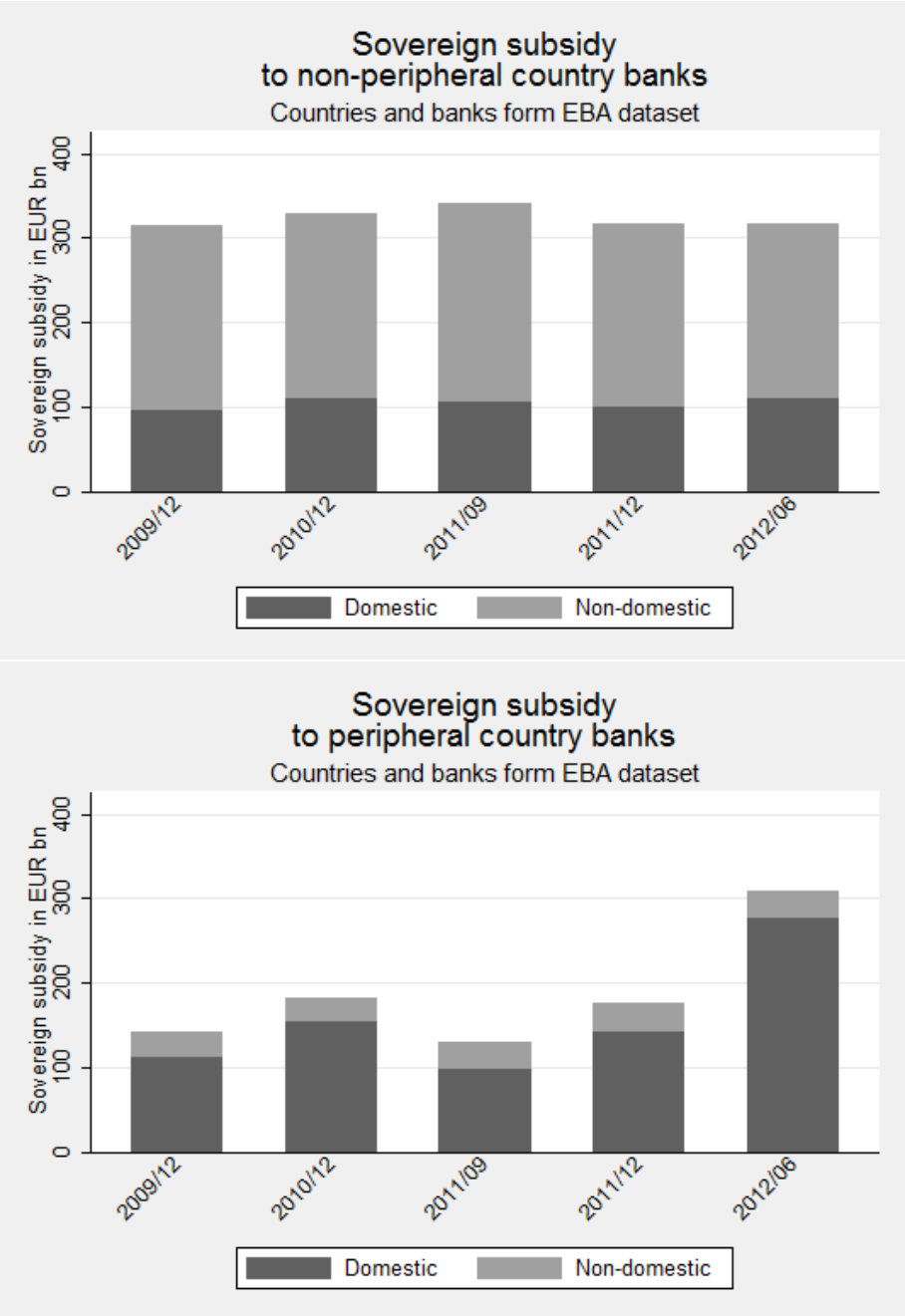


Figure 5: **Total domestic bank exposure against non-domestic EU sovereigns (BIS data, selected countries)**
This figure shows how the relation of the total domestic banking sector exposure against non-domestic EU sovereigns to the GDP of selected countries evolved over the years 2010 through 2012. All EU countries for which comprehensive data on non-domestic bank exposure is available in the consolidated banking statistics of the BIS are reported.

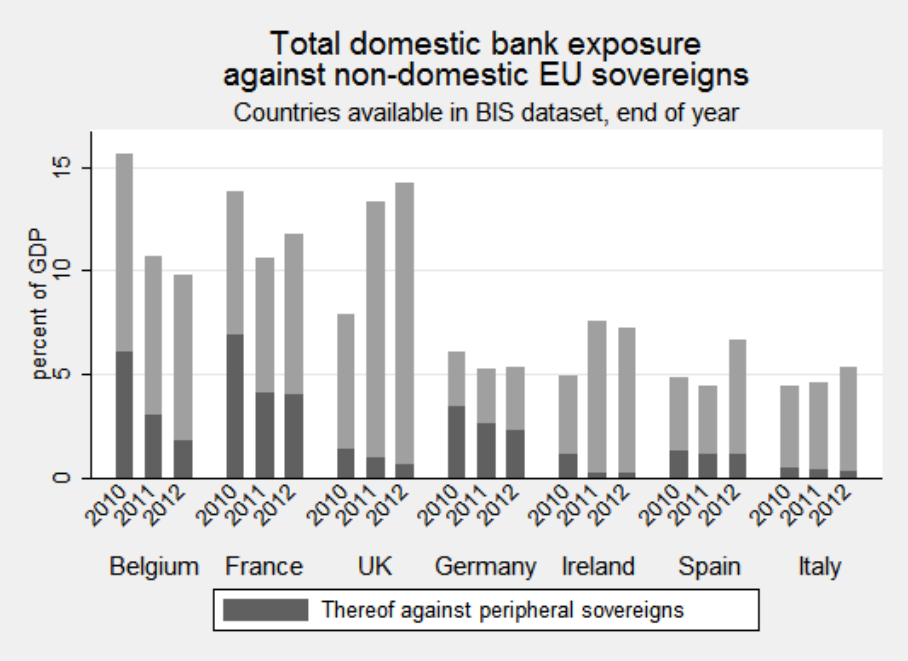


Figure 6: **Flight to quality - Total domestic bank exposure to non-domestic peripheral and non-peripheral sovereigns over time (BIS)**
These figures display the amount of total banking sector exposures to peripheral (GR, IE, IT, PT, ES) and non-peripheral European sovereigns for all EU countries available in the BIS consolidated banking statistics over time.

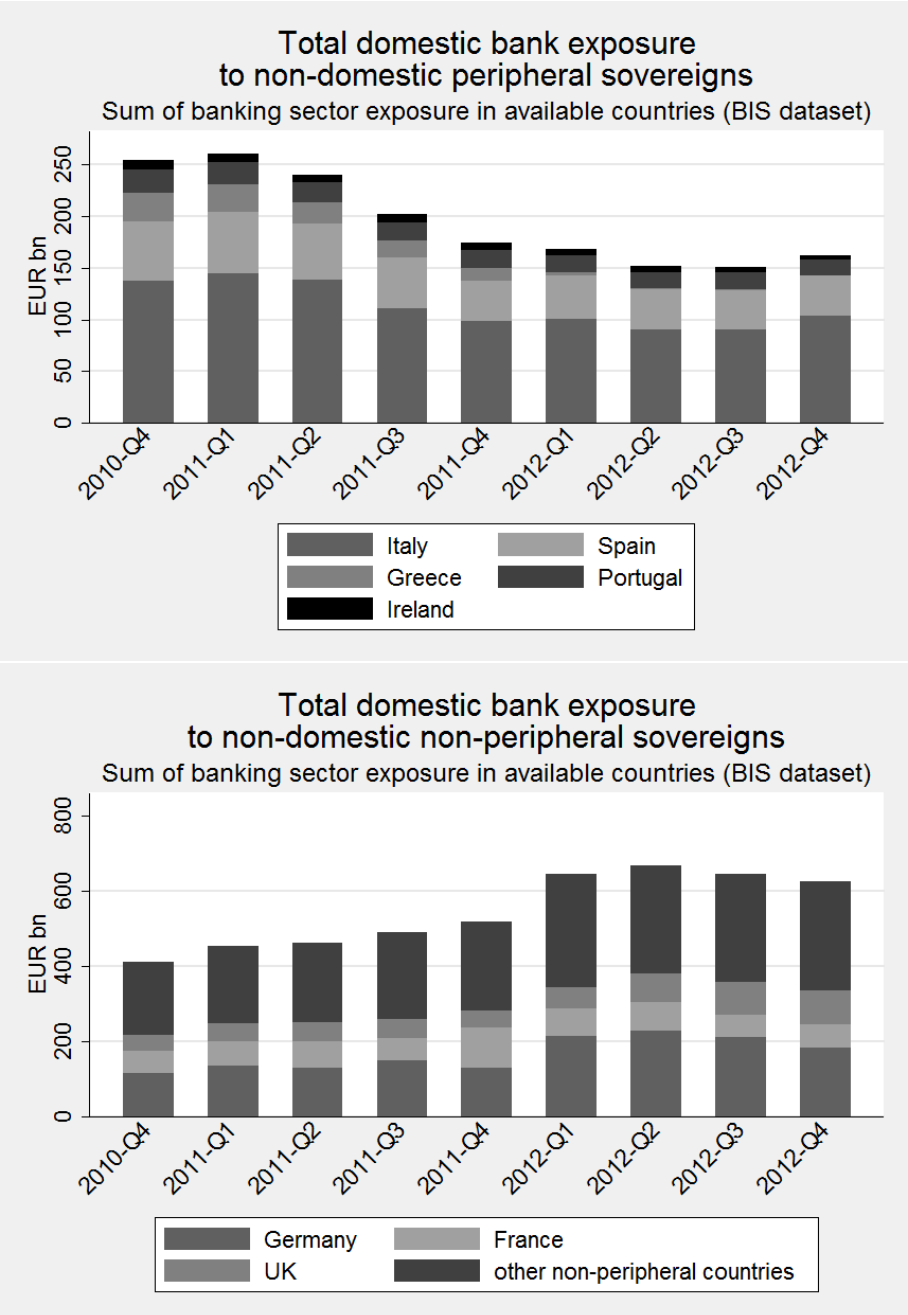
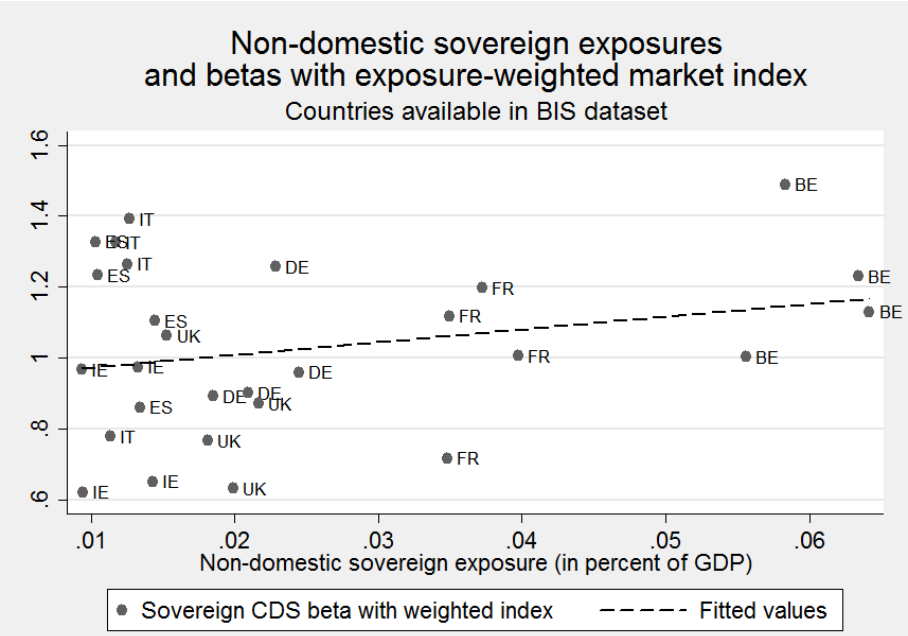


Figure 7: **Domestic banks' non-domestic sovereign exposure and domestic sovereign CDS (BIS, up to 2011-Q3)**
The first figure plots the non-domestic sovereign exposure of selected countries' banking sector in relation to the GDP of that country at the start of a quarter against the beta of this country's CDS spread changes with the changes in a sovereign CDS market index. The beta is obtained by regressing the change of a sovereign's CDS spread onto the changes of an exposure weighted sovereign CDS market index over the 30 days folowing the exposure date. The second figure plots the CDS spread changes in the risk weighted non-domestic sovereign portfolio of countries' banking sectors against the changes in sovereign CDS spreads of that country. Changes in the risk weighted non-domestic sovereign portfolio are computed as daily changes in an exposure weighted sovereign CDS market index times the total amount of the risk weighted non-domestic sovereign exposure (to GDP), on a daily basis for 10 days after the reporting days of non-domestic sovereign exposures (31.12.2010, 31.03.2011, 30.06.2011, 30.09.2011).



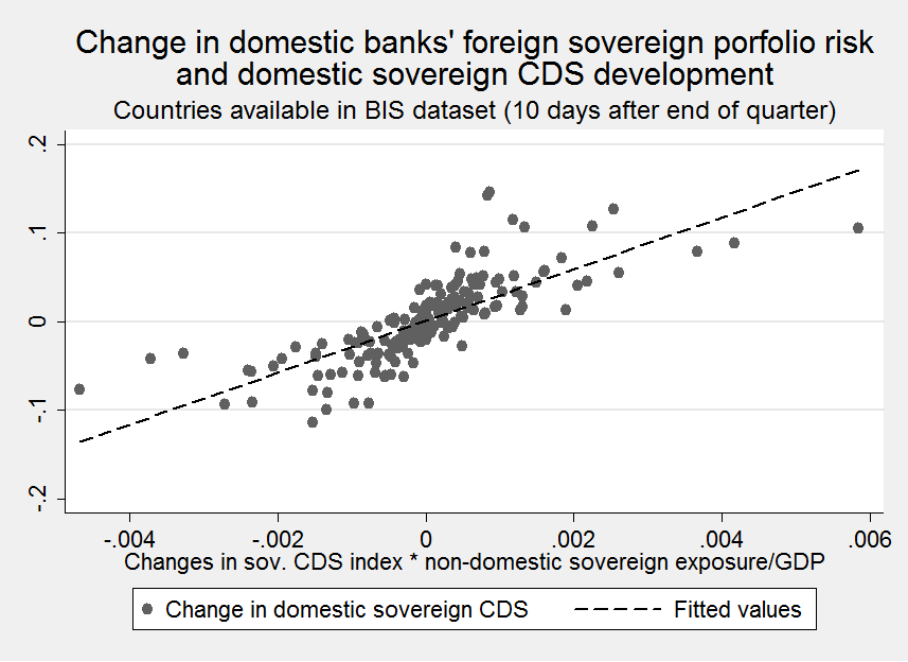


Figure 8: **Betas of individual sovereign CDS and sovereign CDS market over time**
This figure shows the development of the average beta of the available countries' CDS spread changes with the changes in a sovereign CDS market index over time. The betas are obtained by regressing the change of a sovereign's CDS spread onto the changes of a sovereign CDS market index (Datastream series of SovX index). We report averages over all EU countries for which comprehensive data is available in the consolidated banking statistics of the BIS (BE, DE, ES, FR, IE, IT, UK) and all EU countries that form part of the EBA stress test and for which CDS spread time series are available (AT, BE, CY, DE, DK, ES, FI, FR, GR, HU, IE, IT, NL, PL, PT, SI, SE, UK).

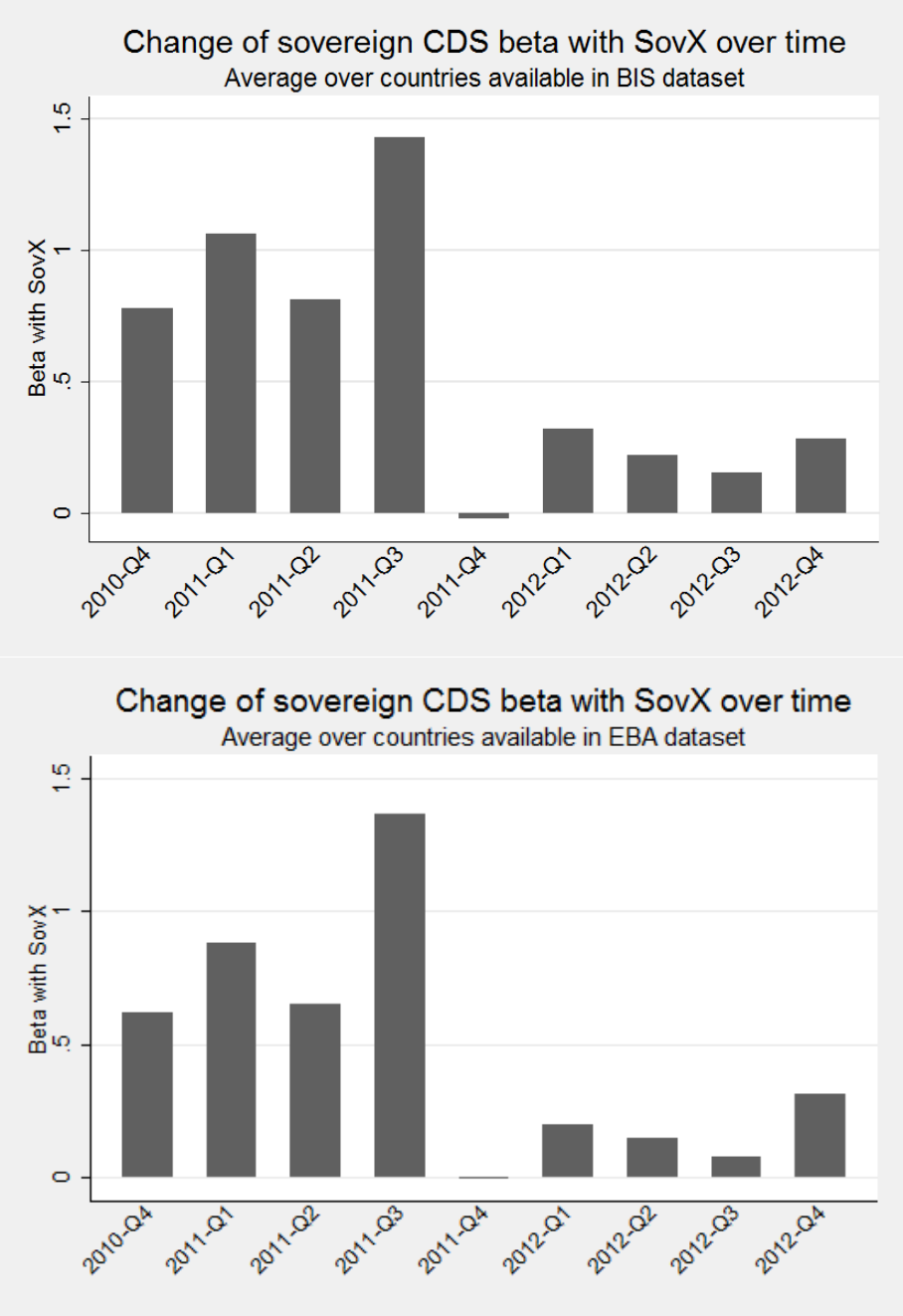


Table 1: **Ratings, risk weights, and the computation of sovereign subsidy**
Panel A of this table reports risk weights consistent with EBA stress test assumptions on PDs for rating classes and standard assumptions on LGD (45%) and maturity (2.5 years), computed according to the Basel F-IRB approach (compare Appendix E). These risk weights are used to weight non-domestic EU sovereign exposures when computing the sovereign subsidy, i.e. risk weighted assets not reflected in regulatory capital requirements. Panel B of this table exhibits an example for the computation of the sovereign subsidy for the non-domestic EU sovereign exposure of the German banking sector as of 31.12.2010. Exposure data is obtained from the Bank for International Settlements' (BIS) Consolidated Banking Statistics. The risk weights are consistent with EBA stress test assumptions on PDs for rating classes and standard assumptions on LGD (45%) and maturity (2.5 years), and computed according to the Basel F-IRB approach (compare Appendix E).

Panel A: Risk weights for computation of sovereign subsidy

S&P rating	Moody's rating	Fitch rating	EBA PD	Adequate risk weight
AAA	Aaa	AAA	0.03%	0.144
AA+	Aa1	AA+	0.03%	0.144
AA	Aa2	AA	0.03%	0.144
AA-	Aa3	AA-	0.03%	0.144
A+	A1	A+	0.26%	0.505
A	A2	A	0.26%	0.505
A-	A3	A-	0.26%	0.505
BBB+	Baa1	BBB+	0.64%	0.776
BBB	Baa2	BBB	0.64%	0.776
BBB-	Baa3	BBB-	0.64%	0.776
BB+	Ba1	BB+	2.67%	1.244
BB	Ba2	BB	2.67%	1.244
BB-	Ba3	BB-	2.67%	1.244
B+	B1	B+	9.71%	1.910
B	B2	B	9.71%	1.910
B-	B3	B-	9.71%	1.910
CCC+	Caa1	CCC+	36.15%	2.451
CCC	Caa2	CCC	36.15%	2.451
CCC-	Caa3	CCC-	36.15%	2.451
CC	Ca	CC	36.15%	2.451
C	C	C	36.15%	2.451
D	C	D	100.00%	2.451

Panel B: Example for computation of sovereign subsidy

Exposure of German banking sector against sovereign	Non-domestic exposure in EUR mn	Avg EBA risk weight	Non-domestic sovereign subsidy in EUR mn
Greece	10,817	1.088	11,766
Italy	37,562	0.265	9,940
Poland	10,783	0.505	5,446
Spain	20,978	0.144	3,030
Portugal	5,745	0.505	2,902
France	15,806	0.144	2,283
Austria	14,049	0.144	2,029
Ireland	2,292	0.685	1,571
Belgium	6,973	0.144	1,007
Netherlands	5,470	0.144	790
Others	7,038	0.213	1,499
Total	**137,515**	**0.307**	**42,263**

Table 2: **Summary statistics**
This table reports variable names, units, means, standard deviations, minimum and maximum values, and the number of observations for the main variables of the dataset. The data sources are: Bloomberg (BB), Bank for International Settlements (BIS), Thomson Reuters Datastream (DS), European Banking Authority (EBA), European Central Bank (ECB), Eurostat (EUSt) Organization for Economic Cooperation and Development Quarterly National Accounts (OECD).

Variable	Unit	Mean	(Std. Dev.)	Min.	Max.	N
Dependent variables						
Sovereign CDS (BB)	bps	252	(207)	25	1,233	2,646
Δ ln(CDS) (BB)	percent	-0.17	(3.82)	-21.76	18.73	2,646
Sovereign CDS (DS)	bps	200	(189)	12	1,191	2,646
Δ ln(CDS) (DS)	percent	-0.20	(4.97)	-37.14	31.87	2,646
Sovereign bond yield	bps	402	(207)	117	1,379	2,358
Δ ln(bond yield)	percent	0.04	(2.22)	-11.46	11.91	2,347
Explanatory variables						
Δ CDS index (sample weights, BB)	percent	-0.14	(3.35)	-15.42	12.96	2,646
Δ CDS index (sample weights, DS)	percent	-0.17	(4.05)	-17.01	14.48	2,646
Δ Bond index (sample weights)	percent	0.04	(1.29)	-3.65	4.69	2,646
Bank exposure to non-domestic sovereigns	mn EUR	104,284	(77,826)	6,550	309,002	2,646
Sovereign subsidy (bank exposure to non-domestic sovereigns, EBA risk weights)	mn EUR	29,791	(21,448)	1,237	72,231	2,646
Sovereign subsidy (bank exposure to non-domestic sovereigns, CDS implied risk weights)	mn EUR	56,063	(44,014)	2,043	153,253	2,646
Bank exposure to non-domestic sovereigns/GDP	percent	8.6	(3.75)	4.42	18.22	2,646
Sovereign subsidy/GDP (EBA risk weights)	percent	2.46	(1.37)	0.93	6.42	2,646
Sovereign subsidy/GDP (CDS implied risk weights)	percent	4.44	(2.34)	1.43	10.19	2,646
Controls						
iTraxx	index pts	134.23	(31.23)	94.21	207.96	2,646
DS equity index	index pts	1382.75	(137.99)	1129.06	1690.48	2,646
VSTOXX	index pts	25.8	(7.66)	14.86	53.55	2,646
EONIA	bps	52	(39)	6	172	2,646
Euribor (12 months)	bps	150	(57)	54	220	2,646
Term spread	bps	98	(32)	41	161	2,646
ECB capital share	percent	11.77	(9.69)	0	27.1	2,646
Government debt ratio	percent	102.35	(20.52)	59.42	138.34	2,646
GDP	mn EUR	1,255,582	(746,400)	132,538	2,562,339	2,646

Table 3: **Sovereign subsidy: Banks' non-domestic sovereign exposures (EBA)**
This table reports the total non-domestic EU sovereign exposures of EBA stress test banks and their relation to total assets. In addition, it shows the sovereign subsidy, a risk weighted assets equivalent of the non-domestic sovereign exposures of these banks (using EBA risk weights, see main text for detailed description) and relates this to banks' core tier 1 capital. Panel A reports the evolution of these figures for all available EBA banks over time (along the distinct stress test/capital exercise dates for which data is available from the EBA). Panel B splits these numbers up by country for the stress test in December 2010.

Panel A: EBA stress test banks, total[a] by stress test date

Stress test	Total non-domestic EU sovereign exposure in EUR mn	in % of assets[b]	Non-domestic EU sovereign subsidy (risk-weighted) in EUR mn	in % of core tier 1 capital[b]
Banks in all countries of EBA stress tests				
Dec 2009	923,387	3.3%	251,261	28.5%
Dec 2010	871,829	2.8%	248,247	29.1%
Oct 2011	828,578	3.0%	268,784	34.7%
Dec 2011	676,431	2.7%	250,160	38.1%
June 2012	693,583	2.3%	238,919	20.8%
thereof banks in peripheral countries (Greece, Ireland, Italy, Portugal, Spain)				
Dec 2009	102,245	1.3%	30,914	11.4%
Dec 2010	88,307	1.1%	28,792	12.7%
Oct 2011	92,082	1.3%	32,537	14.6%
Dec 2011	87,174	1.2%	33,985	12.5%
June 2012	86,655	1.1%	32,296	8.3%
thereof banks in other countries				
Dec 2009	821,142	4.3%	220,348	38.2%
Dec 2010	783,522	3.7%	219,455	38.7%
Oct 2011	736,496	3.5%	236,248	42.1%
Dec 2011	589,257	3.3%	216,175	47.9%
June 2012	606,928	2.7%	206,623	26.3%

Panel B: EBA stress test banks, by country in Dec 2010

Country	Total non-domestic EU sovereign exposure in EUR mn	in % of assets[b]	Non-domestic EU sovereign subsidy (risk-weighted) in EUR mn	in % of core tier 1 capital[b]
Banks in peripheral countries				
Portugal	5,264	1.8%	3,052	22.0%
Greece	3,774	0.8%	2,747	18.5%
Ireland	7,896	2.3%	1,429	14.5%
Italy	45,566	1.2%	14,431	9.7%
Spain	25,806	0.6%	7,134	4.2%
Total	**88,307**	**1.1%**	**28,792**	**12.7%**
Banks in other countries				
Cyprus	7,066	8.3%	6,875	164.3%
Belgium	75,887	8.7%	28,114	89.7%
Austria	31,717	6.7%	19,955	80.8%
Luxembourg	3,330	8.8%	960	68.8%
France	212,402	4.0%	58,041	44.0%
Germany	132,515	2.8%	40,697	42.1%
Netherlands	91,103	3.9%	19,370	26.5%
Sweden	54,108	4.2%	9,613	20.2%
Slovenia	1,315	3.8%	249	14.8%
UK	160,212	2.3%	32,418	12.8%
Denmark	26,481	2.1%	4,366	12.2%
Malta	97	1.5%	38	10.6%
Hungary	362	1.0%	270	8.2%
Finland	566	0.7%	106	2.0%
Poland	0	0.0%	0	0.0%
Total	**783,522**	**3.7%**	**219,455**	**38.7%**

[a] Excluding Norway **[b]** Averages over banks for which this data is available

Table 4: **Sovereign subsidy: Banks' domestic sovereign exposures (EBA)**
This table reports the total domestic sovereign exposures of EBA stress test banks and their relation to total assets. In addition, it shows the sovereign subsidy, a risk weighted assets equivalent of the domestic sovereign exposures of these banks (using EBA risk weights, see main text for detailed description) and relates this to banks' core tier 1 capital. Panel A reports the evolution of these figures for all available EBA banks over time (along the distinct stress test/capital exercise dates for which data is available from the EBA). Panel B splits these numbers up by country for the stress test in December 2010.

Panel A: EBA stress test banks, total[a] by stress test date

Stress test	Total domestic sovereign exposure in EUR mn	in % of assets[b]	Domestic sovereign subsidy (risk-weighted) in EUR mn	in % of core tier 1 capital[b]
Banks in all countries of EBA stress tests				
Dec 2009	1,042,408	6.9%	205,979	54.2%
Dec 2010	1,198,763	7.1%	262,524	113.3%
Oct 2011	1,050,300	5.2%	202,586	32.2%
Dec 2011	973,682	5.6%	241,541	46.1%
June 2012	1,080,462	6.3%	386,488	53.9%
thereof banks in peripheral countries (Greece, Ireland, Italy, Portugal, Spain)				
Dec 2009	423,343	8.9%	110,875	82.1%
Dec 2010	482,187	8.9%	153,660	251.8%
Oct 2011	358,822	6.5%	97,494	56.7%
Dec 2011	315,516	6.2%	141,602	71.7%
June 2012	374,611	8.0%	275,938	112.0%
thereof banks in other countries				
Dec 2009	619,066	5.4%	95,104	38.2%
Dec 2010	716,576	5.6%	108,865	32.2%
Oct 2011	691,478	4.6%	105,092	23.1%
Dec 2011	658,167	5.3%	99,939	36.2%
June 2012	705,851	5.6%	110,550	28.2%

Panel B: EBA stress test banks, by country in Dec 2010

Country	Total domestic sovereign exposure in EUR mn	in % of assets[b]	Domestic sovereign subsidy (risk-weighted) in EUR mn	in % of core tier 1 capital[b]
Banks in peripheral countries				
Greece	54,447	17.6%	58,984	865.9%
Ireland	12,466	3.1%	8,310	67.0%
Italy	164,011	8.9%	43,124	62.2%
Portugal	19,568	5.8%	9,784	60.7%
Spain	231,696	7.7%	33,457	22.8%
Total	**482,187**	**8.9%**	**153,660**	**251.8%**
Banks in other countries				
Malta	734	11.6%	367	103.7%
Hungary	4,336	12.5%	3,252	98.4%
Poland	6,562	15.4%	3,281	81.9%
Germany	315,313	10.8%	45,531	79.0%
Luxembourg	2,914	7.7%	421	30.1%
Slovenia	1,465	6.8%	212	17.7%
Netherlands	45,217	2.9%	6,529	15.2%
Belgium	29,597	4.3%	4,274	14.5%
France	118,261	2.2%	17,077	11.8%
Sweden	34,440	3.1%	4,973	11.6%
Cyprus	1,441	1.7%	379	8.8%
Austria	14,590	3.8%	2,107	8.3%
UK	120,156	1.8%	17,351	6.8%
Denmark	6,851	2.1%	989	6.0%
Finland	405	0.5%	59	1.1%
Total	**716,576**	**5.6%**	**108,865**	**32.2%**

[a] Excluding Norway **[b]** Averages over banks for which this data is available

Table 5: **Sovereign subsidy: Banking sector's non-domestic sovereign exposures (BIS)**
This table reports the total non-domestic EU sovereign exposure of selected EU countries' banking sectors over time. In addition, it shows the relation of these exposures to total GDP and computes the total amount of the sovereign subsidy, a risk weighted assets equivalent of the non-domestic sovereign exposures of the respective banking sectors (using EBA risk weights, see main text for detailed description). Panel A displays total banking sector exposures to all non-domestic EU sovereigns, while Panel B and C report banking sector exposures to non-domestic peripheral EU sovereigns (Greece, Ireland, Italy, Portugal, Spain) and other (non-peripheral) EU sovereigns respectively. These figures are reported for the year end of 2010, 2011, and 2012, for all countries for which comprehensive data on cross-border bank exposure is available in the consolidated banking statistics of the BIS.

Panel A: Total banking sector non-domestic exposure to all EU sovereigns

Country	Total non-domestic EU sovereign exposure in EUR mn			in % of GDP			Non-domestic EU sovereign subsidy (risk-weighted) in EUR mn		
	2010	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
Banks in peripheral countries									
Italy	63,307	68,103	80,122	4.5%	4.6%	5.4%	16,729	16,623	20,231
Ireland	6,550	10,778	10,890	4.9%	7.6%	7.3%	1,266	1,814	1,764
Spain	52,220	48,892	74,115	4.8%	4.4%	6.6%	11,193	16,364	21,990
Banks in other countries									
Germany	137,515	125,915	133,905	6.0%	5.2%	5.3%	42,263	54,341	59,798
Belgium	47,817	34,091	32,431	15.7%	10.7%	9.8%	17,854	14,379	11,875
France	227,701	182,334	210,061	13.8%	10.6%	11.7%	57,555	63,756	74,947
UK	130,200	221,267	245,096	7.9%	13.3%	14.2%	25,664	42,333	43,950

Panel B: Total banking sector non-domestic exposure to peripheral EU sovereigns

Country	Total non-domestic EU sovereign exposure in EUR mn			in % of GDP			Non-domestic EU sovereign subsidy (risk-weighted) in EUR mn		
	2010	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
Banks in peripheral countries									
Spain	13,619	11,899	12,140	1.3%	1.1%	1.1%	5,453	9,544	11,582
Ireland	1,528	352	277	1.1%	0.2%	0.2%	453	259	204
Italy	6,535	5,739	4,715	0.5%	0.4%	0.3%	3,004	3,269	3,914
Banks in other countries									
France	113,806	69,791	71,709	6.9%	4.1%	4.0%	39,169	44,424	51,993
Belgium	18,585	9,475	5,875	6.1%	3.0%	1.8%	6,320	6,160	4,229
Germany	77,395	61,619	56,705	3.4%	2.6%	2.3%	29,208	40,360	43,765
UK	22,890	15,145	11,076	1.4%	0.9%	0.6%	9,052	11,453	9,051

Panel C: Total banking sector non-domestic exposure to other (non-peripheral) EU sovereigns

Country	Total non-domestic EU sovereign exposure in EUR mn			in % of GDP			Non-domestic EU sovereign subsidy (risk-weighted) in EUR mn		
	2010	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
Banks in peripheral countries									
Ireland	5,022	10,426	10,613	3.8%	7.3%	7.1%	814	1,555	1,561
Spain	38,601	36,993	61,976	3.6%	3.4%	5.5%	5,741	6,820	10,408
Italy	56,772	62,364	75,407	4.0%	4.2%	5.0%	13,725	13,354	16,317
Banks in other countries									
Belgium	29,232	24,616	26,556	9.6%	7.7%	8.0%	11,534	8,220	7,646
France	113,895	112,543	138,352	6.9%	6.5%	7.7%	18,386	19,332	22,954
Germany	60,120	64,297	77,200	2.6%	2.7%	3.1%	13,054	13,981	16,034
UK	107,310	206,122	234,020	6.5%	12.4%	13.6%	16,611	30,880	34,900

Table 6: **Sovereign subsidy and sovereign risk**
This table reports the results from a regression of changes in individual sovereign CDS on changes in a European sovereign CDS market index, the sovereign subsidy (i.e., risk weighted exposures of the domestic banking sector toward non-domestic EU sovereigns), and the interaction between these two variables. The sovereign CDS index is weighted by the sum of exposures of all countries' banking systems. CDS changes are computed on a daily level, covering +/- 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). The model in column (2) controls for several market determinants of the changes in sovereign CDS spreads, namely the changes in the CDS market as indicated by the iTraxx index, in the stock market as proxied by the Datastream total return index, in overall volatility (VSTOXX), and in the term spread, computed as the yield difference between the 12 months Euribor and the EONIA. The models in columns (3) to (5) additionally control for date- or country-quarter fixed effects. Robust standard errors are reported in parentheses, significance levels are indicated by *** p<0.01, ** p<0.05, * p<0.1.

Model	(1)	(2)	(3)	(4)	(5)
Dep. variable	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)
Δ CDS index x sovereign subsidy/GDP	3.482***	3.509***	3.472***	3.532***	3.489***
	(0.998)	(0.996)	(0.951)	(1.015)	(0.962)
Δ CDS index	0.897***	0.882***		0.884***	
	(0.0333)	(0.0402)		(0.0399)	
Sovereign subsidy/GDP	-0.0268	-0.0268	-0.0265		
	(0.0261)	(0.0261)	(0.0253)		
Δ iTraxx		0.0748**		0.0726**	
		(0.0313)		(0.0312)	
Δ DS equity index		0.0979*		0.0976*	
		(0.0561)		(0.0561)	
Δ VSTOXX		-0.00324		-0.00286	
		(0.0100)		(0.0100)	
Δ Term spread		-0.00273		-0.00263	
		(0.00314)		(0.00313)	
Constant	0.000327	0.000305	-0.000908	-0.000353	-0.000512
	(0.000812)	(0.000811)	(0.000789)	(0.000376)	(0.00104)
Date FE	NO	NO	YES	NO	YES
Country-Quarter FE	NO	NO	NO	YES	YES
Observations	2,646	2,646	2,646	2,646	2,646
R-squared	0.744	0.745	0.771	0.751	0.777

Table 7: **Robustness tests**

This table reports the results of several robustness checks using alternative sources and specifications of the main dependent and explanatory variables. In all models, CDS and bond spread changes are computed on a daily level, covering +/- 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). Columns (1) and (2) report regressions of changes in individual sovereign CDS on changes in a European sovereign CDS market index, the sovereign subsidy (i.e., risk weighted exposures of the domestic banking sector toward non-domestic EU sovereigns), and the interaction between these two variables, with CDS data taken from Datastream instead of Bloomberg (standard source). The sovereign CDS index is weighted by the sum of exposures of all countries' banking systems. Columns (3) and (4) report regression of changes in individual sovereign bond yields on changes in a sovereign bond yield market index, the sovereign subsidy (i.e., risk weighted exposures of the domestic banking sector toward non-domestic EU sovereigns), and the interaction between these two variables. The sovereign bond yield index is weighted by the sum of exposures of all countries' banking systems. Columns (5) and (6) report regressions of changes in individual sovereign CDS on changes in a European sovereign CDS market index, the sovereign subsidy (i.e., exposures of the domestic banking sector toward non-domestic EU sovereigns risk-weighted by CDS implied probabilities of default), and the interaction between these two variables. Columns (7) and (8) report regressions of changes in individual sovereign CDS on changes in a European sovereign CDS market index, the sovereign subsidy (i.e., risk weighted exposures of the domestic banking sector toward non-domestic EU sovereigns using exposure data from the EBA instead of BIS), and the interaction between these two variables. The sovereign CDS index is weighted by the sum of exposures of all countries' banking systems. Robust standard errors are reported in parentheses, significance levels are indicated by *** p<0.01, ** p<0.05, * p<0.1.

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robustness	Altern. dep var: DS CDS data		Altern. dep var: bond yields		Altern. exposure risk weight: CDS implied		Altern. exposure data: EBA	
Dep. variable	Δln(CDS)	Δln(CDS)	Δln(bond yield)	Δln(bond yield)	Δln(CDS)	Δln(CDS)	Δln(CDS)	Δln(CDS)
Δ CDS index x sovereign subsidy/GDP	4.916***	4.729***			1.682***	1.926***	2.815***	2.707***
	(1.346)	(1.164)			(0.610)	(0.585)	(0.672)	(0.693)
Δ Bond index x sovereign subsidy/GDP			15.60***	15.94***				
			(2.861)	(2.841)				
Δ CDS index	0.749***				0.903***		0.821***	
	(0.0432)				(0.037)		(0.0284)	
Δ Bond index			0.455***					
			(0.0973)					
Sovereign subsidy/GDP	-0.0283		-0.0138		-0.0149		-0.0095	
	(0.0449)		(0.0238)		(0.0161)		(0.0191)	
Constant	0.000167	-0.0023	0.000341	0.000775	0.00034	-0.003***	0.000459	-0.0014
	(0.00131)	(0.00150)	(0.000814)	(0.00112)	(0.00093)	(0.00103)	(0.000699)	(0.00136)
Date FE	NO	YES	NO	YES	NO	YES	NO	YES
Country-Quarter FE	NO	YES	NO	YES	NO	YES	NO	YES
Observations	2,646	2,646	2,347	2,347	2,352	2,352	3,592	3,592
R-squared	0.507	0.585	0.276	0.334	0.751	0.784	0.551	0.584

Table 8: **Falsification tests (non-EU sovereigns)**
This table reports the results of two falsification tests using exposures to non-EU sovereigns not falling under the zero risk weight regulation. The exposure to these non-EU sovereigns is used to compute a quasi-sovereign subsidy. In all models, CDS spread changes are computed on a daily level, covering +/- 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). Columns (1) and (2) report regressions of changes in individual sovereign CDS on changes in the US sovereign CDS, the US quasi-sovereign subsidy (i.e., risk weighted exposures of the domestic banking sector toward the US sovereign), and the interaction between these two variables. Columns (3) and (4) report regressions of changes in individual sovereign CDS on changes in a non-EU sovereign CDS index (containing Japan, Norway, Switzerland, and US), the quasi-sovereign subsidy (i.e., risk weighted exposures of the domestic banking sector toward these non-EU sovereigns), and the interaction between these two variables. The non-EU sovereign CDS index is weighted by the sum of exposures of all countries' banking systems. Robust standard errors are reported in parentheses, significance levels are indicated by *** p<0.01, ** p<0.05, * p<0.1.

Model	(1)	(2)	(3)	(4)
Falsification	US exposure		non-EU exposure (CH/JP/NO/US)	
Dep. variable	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)
Δ US CDS x US quasi-sovereign subsidy/GDP	-1.842	-1.296		
	(5.659)	(3.004)		
Δ non-EU CDS index x non-EU quasi-sovereign subsidy/GDP			-0.622	-0.425
			(4.610)	(2.428)
Δ US CDS	0.622***			
	(0.0489)			
Δ non-EU CDS index			0.796***	
			(0.0568)	
US quasi-sovereign subsidy/GDP	0.0329			
	(0.0962)			
Non-EU quasi-sovereign subsidy/GDP			0.0199	
			(0.0646)	
Constant	-0.00130	-0.00132	-0.00129	-0.00252**
	(0.000878)	(0.000999)	(0.000848)	(0.00109)
Date FE	NO	YES	NO	YES
Country-Quarter FE	NO	YES	NO	YES
Observations	2,597	2,597	2,646	2,646
R-squared	0.201	0.775	0.234	0.775

Table 9: **Explaining sovereign risk spillovers**
This table reports the results from a regression of changes in individual sovereign CDS on changes in a European sovereign CDS market index, the sovereign subsidy (i.e., risk weighted exposures of the domestic banking sector toward non-domestic EU sovereigns), and the interaction between these two variables. The sovereign CDS index is weighted by the sum of exposures of all countries' banking systems. CDS changes are computed on a daily level, covering +/- 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). In addition, the models in all columns control for alternative explanations for the impact of non-domestic sovereign CDS changes on sovereign CDS by including the ECB capital share (i.e., bailout responsibility for other Eurozone sovereigns) and the ratio of government debt to GDP (i.e., bailout capacity) as well as their interactions with the changes in the sovereign CDS index. The model in column (2) controls for several market determinants of the changes in sovereign CDS spreads, namely the changes in the CDS market as indicated by the iTraxx index, in the stock market as proxied by the Datastream total return index, in overall volatility (VSTOXX), and in the term spread, computed as the yield difference between the 12 months Euribor and the EONIA. The models in columns (3) to (5) control for date- or country-quarter invariant effects. Robust standard errors are reported in parentheses, significance levels are indicated by *** p<0.01, ** p<0.05, * p<0.1.

Model	(1)	(2)	(3)	(4)	(5)
Dep. variable	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)
Δ CDS index x sovereign subsidy/GDP	4.044***	4.068***	4.034***	4.096***	4.080***
	(1.011)	(1.009)	(0.941)	(1.038)	(0.967)
Δ CDS index x ECB share	1.314***	1.315***	1.316***	1.330***	1.331***
	(0.155)	(0.155)	(0.168)	(0.155)	(0.168)
Δ CDS index x debt ratio	0.0849	0.0870	0.0906	0.0753	0.0807
	(0.0813)	(0.0810)	(0.0739)	(0.0807)	(0.0730)
Δ CDS index	0.641***	0.624***		0.649***	
	(0.0841)	(0.0861)		(0.0841)	
Sovereign subsidy/GDP	-0.0223	-0.0224	-0.0222		
	(0.0264)	(0.0263)	(0.0254)		
ECB share	0.00766**	0.00767**	0.00773*		
	(0.00370)	(0.00371)	(0.00410)		
Debt ratio	-0.000949	-0.000925	-0.000730		
	(0.00199)	(0.00199)	(0.00190)		
Δ iTraxx		0.0755**			
		(0.0302)			
Δ DS equity index		0.0986*			
		(0.0547)			
Δ VSTOXX		-0.00337			
		(0.00973)			
Δ Term spread		-0.00273			
		(0.00313)			
Constant	0.000280	0.000234	-0.000823	-0.000335	-0.000414
	(0.00219)	(0.00218)	(0.00211)	(0.000365)	(0.00110)
Date FE	NO	NO	YES	NO	YES
Country-Quarter FE	NO	NO	NO	YES	YES
Observations	2,646	2,646	2,646	2,646	2,646
R-squared	0.757	0.758	0.784	0.762	0.789

Table 10: **The September 2011 Capital Exercise**
Panel A of this table reports the results from a regression of changes in individual sovereign CDS on changes in a European sovereign CDS market index, the sovereign subsidy (i.e., risk weighted exposures of the domestic banking sector toward non-domestic EU sovereigns), and the interaction between these two variables. The sovereign CDS index is weighted by the sum of exposures of all countries' banking systems. CDS changes are computed on a daily level, covering +/- 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). In addition, the models in Panel B control for alternative explanations for the impact of non-domestic sovereign CDS changes on sovereign CDS by including the ECB capital share (i.e., bailout responsibility for other Eurozone sovereigns) and the ratio of government debt to GDP (i.e., bailout capacity) as well as their interactions with the changes in the sovereign CDS index. Column (1) displays the reference results for the full sample, while regression results on a split sample for all quarterly data up to the EBA capital exercise in October 2011 and after the new sovereign buffer became required in June 2012 are reported in columns (2) and (3) respectively. The models in columns (4) and (5) display results from these split sample regressions controlling for date and country-quarter fixed effects. Robust standard errors are reported in parentheses, significance levels are indicated by *** p<0.01, ** p<0.05, * p<0.1.

Panel A: The September 2011 Capital Exercise (baseline)

Model	(1)	(2)	(3)	(4)	(5)
Dependent variable	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)
	Full sample (reference)	Before CE[a]	After CE[b]	Before CE[a]	After CE[b]
Δ CDS index x sovereign subsidy/GDP	3.509***	3.470***	-0.373	3.475***	-0.612
	(0.996)	(1.089)	(3.209)	(1.075)	(3.049)
Δ CDS index	0.882***	0.936***	0.925***		
	(0.0402)	(0.0447)	(0.106)		
Sovereign subsidy/GDP	-0.0268	-0.0235	-0.0493		
	(0.0261)	(0.0328)	(0.0619)		
Controls	YES	YES	YES	NO	NO
Constant	YES	YES	YES	YES	YES
Date FE	NO	NO	NO	YES	YES
Country-Quarter FE	NO	NO	NO	YES	YES
Observations	2,646	1,176	882	1,176	882
R-squared	0.745	0.785	0.695	0.805	0.737

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Table 10 – *Continued from previous page*

Panel B: The September 2011 Capital Exercise (including alternative channels)

Model	(1)	(2)	(3)	(4)	(5)
Dependent variable	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)	Δ ln(CDS)
	Full sample (reference)	Before CE[a]	After CE[b]	Before CE[a]	After CE[b]
Δ CDS index x sovereign subsidy/GDP	4.068***	3.564***	-0.844	3.558***	-0.928
	(1.009)	(1.138)	(3.105)	(1.128)	(3.019)
Δ CDS index x ECB share	1.315***	1.015***	1.326***	0.973***	1.450***
	(0.155)	(0.183)	(0.382)	(0.205)	(0.394)
Δ CDS index x debt ratio	0.0870	0.183*	-0.0483	0.187**	-0.0311
	(0.0810)	(0.0947)	(0.195)	(0.0939)	(0.168)
Δ CDS index	0.624***	0.625***	0.831***		
	(0.0861)	(0.0948)	(0.247)		
Sovereign subsidy/GDP	-0.0224	-0.0245	-0.0782		
	(0.0263)	(0.0346)	(0.0605)		
ECB share	0.00767**	0.00554	0.00913		
	(0.00371)	(0.00579)	(0.00721)		
Debt ratio	-0.000925	0.00125	-0.00488		
	(0.00199)	(0.00283)	(0.00433)		
Controls	YES	YES	YES	NO	NO
Constant	YES	YES	YES	YES	YES
Date FE	NO	NO	NO	YES	YES
Country-Quarter FE	NO	NO	NO	YES	YES
Observations	2,646	1,176	882	1,176	882
R-squared	0.758	0.794	0.707	0.813	0.750

[a] Period up to and including 2011-Q3 **[b]** Period from 2012-Q2 to 2012-Q4

Appendix A – Variable definitions

Variable sources and definitions
This table reports variable definitions and data sources. The sources are: Bloomberg (BB), Bank for International Settlements (BIS), Thomson Reuters Datastream (DS), European Banking Authority (EBA), European Central Bank (ECB), Eurostat (EUSt) Organization for Economic Cooperation and Development Quarterly National Accounts (OECD).

Variable	Source	Definition
Sovereign CDS	BB, DS	5 year credit default swap spreads of a European sovereign (in bps)
Δ ln(CDS)	BB, DS	Daily changes in 5 year credit default swap spreads of a European sovereign
Sovereign bond yield	BB	Yields of 10 year bonds issued by a European sovereign (in bps)
Δ ln(bond yield)	BB	Daily returns of 10 year bonds issued by a European sovereign
Δ CDS index	BB, BIS, DS	Daily returns of an index covering 5 year credit default swap spreads of all European sovereigns weighted by the sum of exposures of all countries' banking systems
Δ Bond index	BB, BIS	Daily returns of an index covering 10 year bond yields of all European sovereigns weighted by the sum of exposures of all countries' banking systems
Bank exposure to non-domestic sovereigns	BIS	Exposures of the domestic banking sector to non-domestic EU sovereigns
Sovereign subsidy (EBA risk weights)	BIS, EBA	Exposures of the domestic banking sector to non-domestic EU sovereigns, risk weighted by ratings-implied risk weights suggested by the European Banking Authority's stress test methodology
Sovereign subsidy (CDS implied risk weights)	BB, BIS	Exposures of the domestic banking sector to non-domestic EU sovereigns, risk weighted by weights implied by sovereign credit default swap spreads
GDP	OECD	Gross domestic product of individual European countries
ECB capital share	ECB	Share of a country's national central bank in the subscribed capital of the European Central Bank (also translates to the share in the subscribed capital and the callable capital of the European Stability Mechanism)
Government debt ratio	EUSt	General government consolidated gross debt to gross domestic product
Δ iTraxx	DS	Daily changes in the index covering credit default swap spreads of the 125 most liquid credit default swaps referencing European investment grade credits (continuous series)
Δ DS equity index	DS	Daily changes in the total return index for the European stock market
Δ VSTOXX	DS	Daily changes in the index measuring volatility in the European stock market (referencing the EURO STOXX 50)
Δ EONIA	DS	Daily changes in the effective overnight interest rate for the Euro interbank market (Euro overnight index average)
Δ Euribor (12 months)	DS	Daily changes in the effective 12 months interest rate for the Euro interbank market (Euro interbank offered rate)
Δ Term spread	DS	Daily changes in the difference between 12 months interest rate (12 months Euribor) and the overnight interest rate (EONIA)

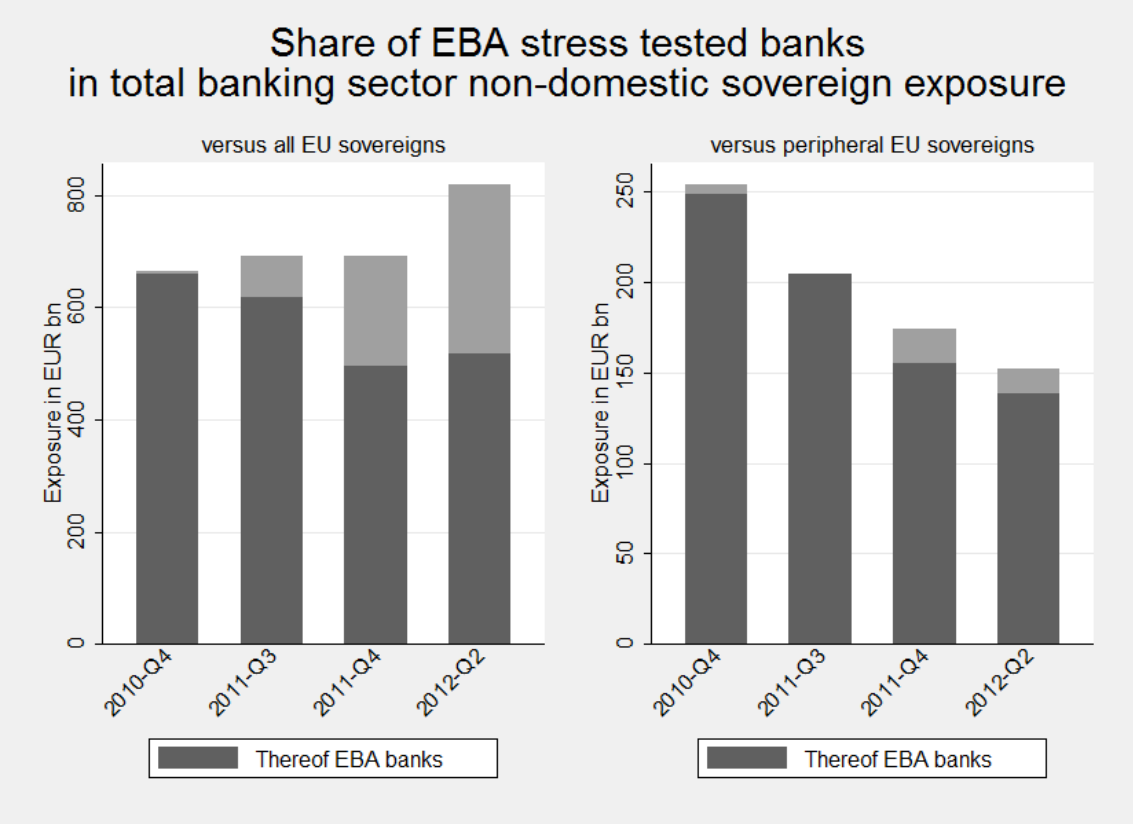
Appendix B – The EBA stress tests and capital exercises

The EBA stress tests and capital exercise
This table gives an overview of the EBA stress tests, participating banks and available data, which is used in this paper. Release date indicates the date at which the test results were published by the EBA, reporting date is the accounting date to which the published data refers.

Test	Release date and reporting date	Number of banks included	Countries included
Stress test 2010	23.07.2010, 31.12.2009	91	AT, BE, CY, DE, DK, ES, FI, FR, GR, HU, IE, IT, LU, MT, NL, PL, PT, SE, SI, UK
Stress test 2011	15.07.2011, 31.12.2010	90	AT, BE, CY, DE, DK, ES, FI, FR, GR, HU, IE, IT, LU, MT, NL, PL, PT, SE, SI, UK
Capital exercise	08.12.2011, 30.09.2011	65	AT, BE, CY, DE, DK, ES, FI, FR, HU, IE, IT, LU, MT, NL, PL, PT, SE, SI, UK
Capital exercise implementation report (1/2)	03.09.2012, 31.12.2011	62	AT, BE, CY, DE, DK, ES, FI, FR, HU, IE, IT, LU, MT, NL, PL, PT, SE, SI, UK
Capital exercise implementation report (2/2)	03.09.2012, 30.06.2012	62	AT, BE, CY, DE, DK, ES, FI, FR, HU, IE, IT, LU, MT, NL, PL, PT, SE, SI, UK

Relevance of EBA stress tested banks in total banking sectors' non-domestic sovereign exposure

This figure shows the share of non-domestic sovereign exposures held by banks that have been included in the EBA stress tests relative to the total banking sector of the respective country. All EU countries and dates for which comprehensive data on non-domestic bank exposure is available in both the consolidated banking statistics of the BIS and the EBA stress tests are included.



Appendix C – The EBA banks

The EBA stress tests banks
This table gives an overview of the banks included in the EBA stress tests.

Country	Bank name	EBA ID	Public
Austria	Erste Group	AT001	Yes
	Raiffeisen Zentralbank	AT002a	No
	Raiffeisen Bank International	AT002b	No
	Oesterr. Volksbanken	AT003	Yes
Belgium	Dexia	BE004	Yes
	KBC Group	BE005	Yes
Cyprus	Marfin Popular	CY006	Yes
	Bank of Cyprus	CY007	Yes
Denmark	Danske Bank	DK008	Yes
	Jyske Bank	DK009	Yes
	Nykredit Bank	DK011	No
	Sydbank	DK010	Yes
Finland	OP-Pohjola	FI012	No
France	BNP Paribas	FR013	Yes
	Credit Agricole	FR014	Yes
	Societe Generale	FR016	Yes
	Groupe BPCE	FR015	No
Germany	Deutsche Bank	DE017	Yes
	Commerzbank	DE018	Yes
	LBBW	DE019	No
	DZ Bank	DE020	No
	BayernLB	DE021	No
	NordLB	DE022	No
	WestLB	DE024	No
	Deutsche Postbank	n.a.	No
	HeLaBa	DE026	No
	HSH Nordbank	DE025	No
	Landesbank Berlin	DE027	Yes
	DekaBank	DE028	No
	WGZ Bank	DE029	No
	Hypo Real Estate	DE023	Yes
Greece	National Bank of Greece	GR031	Yes
	EFG Eurobank Ergasias	GR030	Yes
	Alpha Bank	GR032	Yes
	Piraeus Bank	GR033	Yes
	ATEbank	GR034	Yes
	TT Hellenic Postbank	GR035	No
Hungary	OTP Bank Nyrt	HU036	Yes
	FHB Jelzalogbank Nyrt	n.a.	Yes
Ireland	Bank of Ireland	IE038	Yes
	Allied Irish Banks	IE037	Yes
	Irish Life and Permanent	IE039	Yes
Italy	UniCredit	IT041	Yes
	Intesa Sanpaolo	IT040	Yes
	Banca Monte dei Paschi di Siena	IT042	Yes
	Banco Popolare Societa Cooperativa	IT043	No
	Unione di Banche Italiane	IT044	Yes
Luxembourg	Banque et Caisse d'Epargne de l'Etat LUX	LU045	No
	Banque Raiffeisen	n.a.	No
Malta	Bank of Valletta	MT046	Yes
Netherlands	ING Bank	NL047	Yes
	Rabobank	NL048	No
	ABN AMRO	NL049	No
	SNS Bank	NL050	No
Norway	DnB NOR	NO051	Yes
Poland	Powszechna Kasa Bank Polski	PL052	No
Portugal	Caixa Geral de Depositos	PT053	No
	Banco Comercial Portugues	PT054	Yes
	Espirito Santo	PT055	Yes
	Banco BPI	PT056	Yes

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Country	Bank name	EBA ID	Public
Slovenia	Nova Ljubljanska Banka	SI057	No
	Nova Kreditna Banka Maribor	SI058	No
Spain	Banco Santander	ES059	Yes
	Banco Bilbao	ES060	Yes
	Banco Financiero y de Ahorros	ES061	No
	Caja de Ahorros y Pensiones	ES062	No
	Banco Popular Espanol	ES064	Yes
	Banco Sabadell	ES065	Yes
	Caixa d'Estalvis de Catalunya	ES066	No
	Caja de Ahorros del Mediterraneo	ES083	No
	Caixa de Aforros de GVOP	ES067	No
	Banca Civica	ES071	No
	Bankinter	ES069	Yes
	Caja de Ahorros y Monte de Piedad de ZAR	ES072	No
	Monte de Piedad y Caja de Ahorros de RCA-MAJ	ES073	No
	Caja Espana de Inversiones	ES070	No
	Caixa de Aforros de VOP	ES067	No
	Banco Pastor	ES074	Yes
	Bilbao Bizkaia Kutxa	ES075	No
	Caixa d'Estalvis Unio de Caixes de MST	ES076	No
	Caja de Ahorros y Monte de Piedad de GSS	ES077	No
	Banca March	ES079	No
	Banco Guipuzcoano	n.a.	No
	Banco Mare Nostrum	n.a.	No
	Caja de Ahorros y Monte De Piedad de Ontinyent	ES068	No
	Cajasol	ES081	No
	Banco Grupo Cajatres	ES080	No
	Caja de Ahorros de VA	ES063	No
	Caja de Ahorros y Monte de Piedad de Cordoba	n.a.	No
	Banco Base	ES078	No
	Colonya, Caixa d'Estalvis de Pollenca	ES082	No
Sweden	Nordea	SE084	Yes
	Skandinaviska Enskilda Banken	SE085	Yes
	Svenska Handelsbanken	SE086	Yes
	Swedbank	SE087	Yes
United Kingdom	HSBC	GB089	Yes
	Royal Bank of Scotland	GB088	Yes
	Barclays	GB090	Yes
	Lloyds	GB091	Yes

Appendix D – Sovereign exposure and sovereign subsidy of the EBA banks

Sovereign exposure and sovereign subsidy of the EBA banks
This table gives an overview of the domestic and non-domestic sovereign exposure and the sovereign subsidy of the banks included in the EBA stress tests as of December 2010. The sovereign subsidy is calculated as outlined in section 4 using EBA risk weights. All numbers are in EUR million.

	Domestic		Non-domestic	
Bank name	**Sovereign exposure**	**Sovereign subsidy**	**Sovereign exposure**	**Sovereign subsidy**
BNP Paribas	20,741	2,995	118,808	28,683
Societe Generale	19,272	2,783	55,366	18,465
Dexia	4,980	719	45,788	15,142
Commerzbank	46,930	6,777	36,546	12,993
KBC Group	24,617	3,555	30,099	12,972
Erste Group Bank	5,964	861	19,739	12,841
HSBC	56,417	8,147	60,679	12,752
ING Bank	22,210	3,207	53,995	12,597
Royal Bank of Scotland	19,575	2,827	54,149	10,768
UniCredit	49,071	12,902	36,243	10,263
Barclays	29,022	4,191	42,109	8,420
Deutsche Bank	26,861	3,879	33,862	8,323
Credit Agricole	32,176	4,646	25,054	6,331
Raiffeisen Bank International	7,165	1,035	10,248	6,035
Hypo Real Estate	15,788	2,280	21,208	5,150
SEB	6,044	873	23,890	4,627
Groupe BPCE	46,073	6,653	13,173	4,562
Rabobank	12,974	1,873	24,041	4,345
Danske Bank	4,971	718	25,783	4,145
Nordea	12,333	1,781	23,231	3,969
Marfin Popular Bank	285	75	4,003	3,928
Intesa Sanpaolo	60,152	15,816	7,326	3,641
DZ Bank	27,511	3,973	11,650	3,391
Banco Santander	46,019	6,645	10,510	3,079
Bank of Cyprus	1,156	304	3,063	2,948
Bayerische Landesbank	36,969	5,338	4,572	2,226
BBVA	55,726	8,047	8,122	2,128
WGZ Bank	21,403	3,091	5,861	1,924
NORDLB	48,000	6,931	6,930	1,860
LBBW	30,501	4,404	3,877	1,852
ABN AMRO	5,465	789	10,320	1,814
Banco Comercial Portugues	6,455	3,228	2,375	1,678
EFG Eurobank Ergasias	8,791	9,524	2,261	1,464
Landesbank Berlin	16,435	2,373	2,684	1,208
Oesterreichische Volksbanken	1,461	211	1,730	1,079
Allied Irish Banks	5,043	3,362	5,214	1,010
Banque et Caisse d'Epargne, Lux.	2,914	421	3,330	960
Svenska Handelsbanken	8,137	1,175	6,209	904
WestLB	24,593	3,551	2,712	897
Banco BPI	3,896	1,948	1,592	798
SNS Bank	4,569	660	2,748	613
Lloyds Banking Group	15,143	2,187	3,275	477
HSH Nordbank	10,091	1,457	1,594	450
Piraeus Bank	8,221	8,906	423	437
DekaBank	10,231	1,477	1,019	425
Banco Financiero y de Ahorros	25,402	3,668	2,583	424
Alpha Bank	5,475	5,932	406	399
Banco Popular Espanol	8,874	1,281	853	377
Caja de Ahorros y Pensiones de Barcelona	35,463	5,121	1,401	368
Espirito Santo	2,686	1,343	372	347
National Bank of Greece	18,796	20,362	551	334
Banca Monte dei Paschi di Siena	32,473	8,538	1,135	292

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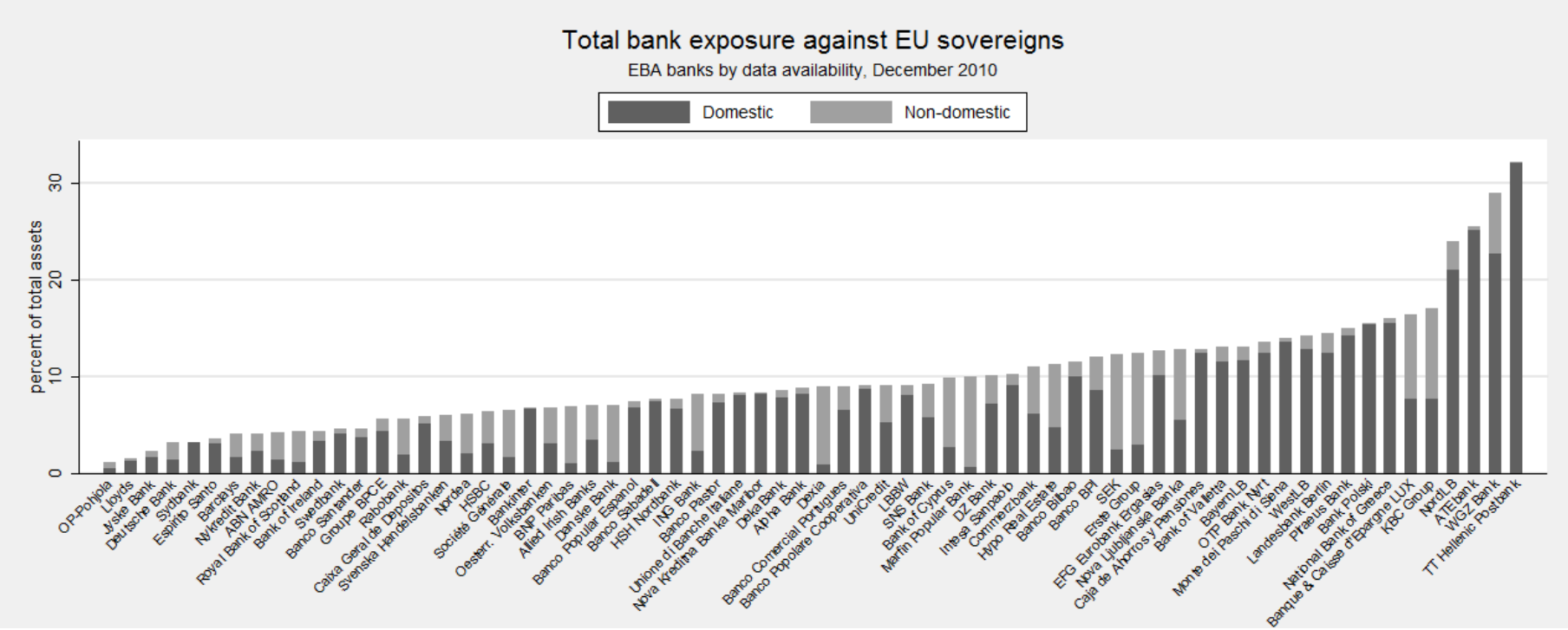
	Domestic		Non-domestic	
Bank name	**Sovereign exposure**	**Sovereign subsidy**	**Sovereign exposure**	**Sovereign subsidy**
OTP Bank	4,336	3,252	362	270
Bank of Ireland	5,570	3,714	1,713	251
Nova Ljubljanska Banka	986	142	1,301	243
Caixa Geral de Depositos	6,530	3,265	925	229
Banco Popolare	11,770	3,095	581	172
Irish Life & Permanent	1,852	1,235	969	168
Caja de Ahorros y Monte de Piedad de Zaragoza	2,909	420	593	131
Banco Pastor	2,294	331	260	129
Jyske Bank	553	80	185	116
Swedbank	7,926	1,145	778	112
Caixa de Aforros de Galicia	4,370	631	299	110
ATEbank	7,850	8,505	110	109
OP-Pohjola	405	59	566	106
Nykredit Bank	666	96	513	105
Monte de Piedad y Caja de Ahorros de Ronda	2,949	426	315	88
Caja de Ahorros del Mediterraneo	5,589	807	490	88
Banco Sabadell	7,296	1,054	130	71
Unione di Banche Italiane	10,544	2,772	281	64
Banco Base	2,941	425	53	48
Banco Mare Nostrum	3,619	523	112	47
Bank of Valletta	734	367	97	38
Caja Espana de Inversiones	7,575	1,094	27	14
Caixa d'Estalvis Unio de Caixes	2,574	372	24	12
Banca Civica	4,747	686	9	8
Banco Grupo Cajatres	1,514	219	8	6
Nova Kreditna Banka Maribor	479	69	14	6
Bilbao Bizkaia Kutxa	3,112	449	7	4
TT Hellenic Postbank	5,313	5,756	23	3
Caixa d'Estalvis de Catalunya	2,840	410	11	2
Caja de Ahorros de Vitoria y Alava	597	86	0	0
Banca March	150	22	0	0
Caja de Ahorros y Monte de Piedad de Gipuzkoa	1,512	218	0	0
Bankinter	3,594	519	1	0
Sydbank	661	95	0	0
Caja de Ahorros y Monte De Piedad de Ontinyent	6	1	0	0
Caixa d'Estalvis de Pollenca	26	4	0	0
Bank Polski	6,562	3,281	0	0
DnB NOR	14,291	2,064	0	0
Total	**1,198,763**	**262,524**	**871,829**	**248,247**

Total bank exposure against EU sovereigns (EBA)
This figure shows European sovereign debt exposures to total assets of selected European banks that were included in the EBA stress test at year end 2010.



Appendix E – Calculation of risk weights (Basel IRB approach)

As indicated above, we follow the standard formula and assumptions of the Foundation Internal Ratings Based (F-IRB) approach of the Basel Committee in computing appropriate risk weights (Basel Committee on Banking Supervision, 2005). The IRB approach calibrates the risk weights to a 99.9 percent VAR model essentially using four risk components, namely probability of default (PD), loss given default (LGD), exposure at default (EAD), and effective maturity (M), for each given exposure. Because we use the F-IRB approach, the PD is the only risk component that is estimated in a separate model, either following the EBA assumption on PDs or computing CDS implied PDs. For the remaining risk components, we follow standard assumptions setting the LGD to 45 percent (F-IRB LGD for senior unsecured exposures), the EAD to the actual exposure, and the effective maturity M to 2.5 years. The derivation of risk-weighted assets then follows from the application of the standard IRB formula using these risk components as inputs in computing the capital requirement (K) for each exposure. K is computed as

$$K = [LGD * N[(1-R)^{-0.5} * G(PD) + (R/(1-R))^{-0.5} * G(0.999)] - PD * LGD] \\ * (1 - 1.5 * b)^{-1} * [1 + (M - 2.5) * b]$$

with N and G being the standard normal distribution and its inverse, respectively, and the correlation (R) and maturity adjustment (b) being computed as

$$R = 0.12 * (1 - \exp(-50 * PD))/(1 - \exp(-50)) \\ + 0.24 * [1 - (1 - \exp(-50 * PD))/(1 - \exp(-50))]$$

and

$$b = (0.11852 - 0.05478 * \ln(PD))^2$$

The capital requirement (K) is expressed as a percentage of the exposure. To derive risk weights and risk-weighted assets, it must be multiplied by the reciprocal of the minimum capital ratio of 8 percent and, finally, by the EAD.

$$RW = 12.5 * K$$

and

$$RWA = RW * EAD$$

Table 1 provides an overview of the resulting risk weights.