The Zero Risk Fallacy
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Banks' Sovereign Exposure and Sovereign Risk Spillovers

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Abstract

European banks are exposed to a substantial amount of risky sovereign debt. The "missing bank capital" resulting from the zero risk weight exemption for European banks for European sovereign debt amplifies the co-movement between sovereign CDS spreads and facilitates cross-border financial-crisis spillovers. Risks spill over from risky periphery sovereigns to safer core countries, but not in the opposite direction nor for exposures to countries not exempted from risk-weighting. More bank capital as well as positive risk-weighting for sovereign exposures mitigates spillovers. Our results are robust to alternative hypotheses such as common shocks due to financial linkages among European countries, direct sovereign-sovereign spillovers, and the exposure of European banks to non-sovereign sectors.

JEL classification: G01, G21, G28, G14, G15, F3

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1. Introduction

The European financial system is highly integrated because banks are the largest holders of sovereign debt; on average, 70% of the government debt of each country was held by foreign investors at the beginning of the sovereign debt crisis at the end of 2009. While financial integration has benefits such as access to liquidity or diversification of bank portfolios (Holmström and Tirole, 1997, Gennaioli et al., 2014), it might give rise to contagion as risks can spill over more easily from riskier to safer countries that could even outweigh the ex-ante benefits (Bolton and Jeanne, 2011). In this paper, we focus on potential costs of financial integration and investigate channels how financial crises can spill over between countries.[1]

Importantly and central to our paper is that European banks are not required to fund even risky sovereign debt holdings of *any* European Union (EU) member state with equity. According to EU legislation, namely the Capital Requirements Directive (CRD), European banks are allowed to use a "zero risk weight" for EU sovereign debt. Moreover, financial regulators in the EU removed the concentration limits for sovereign debt exposures.[2] EU banks could thus accumulate excessive leverage by investing in risky sovereign debt (such as from Greece, Ireland, Italy, Portugal or Spain (henceforth, GIIPS)).[3]

[1] We discuss possible benefits and costs of financial integration in detail in the last section of this paper.
[2] For comparison, European banks are only allowed to have exposure to single name corporate debt if that exposure does not exceed 25% of Tier 1 capital.
[3] Our data set does not allow us to investigate the reasons as to why banks already had invested in sovereign debt before the crisis started or why they increased their exposures during the crisis because data on banks' different foreign exposure classes start only in Q4 2010. Several recent papers have done that for banks' domestic sovereign exposures and highlighted different motives. Acharya and Steffen (2015) show that banks even increased holdings of riskier sovereign debt when yield spreads widened in a search for yield as a response to arbitrage and risk-shifting incentives. Crosignani (2015) finds that under-capitalized banks act as buyer of last resort for domestic sovereign debt as they gamble for resurrection. De Marco and Macchiavelli (2016) and Ongena et al. (2016) focus on moral suasion as channel that leads to home bias during the sovereign debt crisis. Gennaioli et al. (2016) is the first comprehensive study investigating banks' sovereign bond exposures in developed and less-developed countries highlighting important differences. While large

If sovereign risk increases (as we have observed during the European sovereign debt crisis since 2010), banks find themselves severely under-capitalized because they have not accumulated a capital buffer for their sovereign debt exposure. Sovereigns arguably extend an (implicit) guarantee to provide capital backstops for their domestic banking sector. Sovereign risk, as measured, for example, using credit default swap (CDS) spreads, should therefore reflect a country's expected bailout costs for its financial sector when Eurozone sovereign risk increases. Zero risk weights thus provide a channel through which sovereign risk can spread among EU member states.

Cyprus is a recent example of sovereign risk spillovers in Europe. Figure 1 shows the development of the Greek sovereign debt rating by Moody's, the sovereign CDS spread of Cyprus, and the risk-weighted Greek sovereign debt exposure of Cypriot banks. These exposures reflect the risk-weighted assets Cypriot banks needed to fund with equity if zero risk weight regulation did not apply. The figure strikingly shows how Cyprus' CDS spread increased as Cypriot banks' risk-weighted exposure increased from 36% to 73% of the country's GDP between January 2011 and January 2012. We show these spillovers are pervasive across the Eurozone.[4]

We take banks' choice to hold a diversified portfolio of sovereign bonds as given and show that sovereign CDS spreads exhibit a larger co-movement with other European sovereign CDS spreads if domestic banks have large foreign sovereign bond exposures that they do not fund with capital because of zero risk weights. While the two important papers by Acharya et al. (2014a) and Gennaioli et al. (2014) analyze sovereign-bank

European banks increased their exposures during the crisis, banks in less-developed countries already have large exposures in normal times.

[4] Another quintessential example includes Dexia. Dexia required (a second) government support due to its sovereign exposures in 2011, not because the exposures were so big but because it had very little equity due to the zero weight exemption (Admati and Hellwig, 2013).

feedback loops and linkages in crisis countries such as Ireland and Greece, we show that a sovereign-bank loop might develop even in the banking sectors of *safer* countries because of exposure to non-domestic sovereign debt and increase the risk and funding costs of sovereigns because of implicit bailout assumptions. This is the central result of our paper.

Our empirical analysis is motivated by a recent theoretical model in Bolton and Jeanne (2011) who analyze international spillovers between financially integrated economies. They show that financial integration allows banks to diversify their portfolios by holding sovereign debt from different countries. However, this might cause contagion of sovereign debt crises ex-post. In fact, safe countries issue too few (safe) and riskier countries too many (risky) government bonds, the latter because they do not internalize the costs of other member countries associated with higher financial fragility. Riskier countries can thus eventually extract fiscal concessions either in the form of transfers (i.e. bailouts) or when safer governments choose to recapitalize their domestic banking sectors.[5]

We operationalize this idea in the following way. Sovereign CDS spreads should reflect their domestic bank sectors' exposure to risky non-domestic sovereign debt resulting in a co-movement of sovereign CDS spreads in the monetary union. We hypothesize that the co-movement is even more pronounced if domestic banks have large non-domestic sovereign bond exposures that are not funded with capital reflecting the implicit expectation that governments bail out their domestic banks.

To investigate this hypothesis, we construct a new measure of "missing capital" in the banking sector stemming from the fact that banks hold sovereign debt with high credit

[5] Note that the authors cannot distinguish between fiscal transfers and recapitalization of domestic banks in their model. Philippon (2009) has a model about bank recapitalization in an open economy.

risk in their portfolios combined with the fact that sovereign risk weights are set to zero. We assign risk weights to each sovereign bond based on the sovereign's credit rating (or, alternatively, CDS spread) and compute the corresponding risk-weighted assets for each bank's sovereign bond portfolio. Given that banks are not required to fund these exposures with equity, which represents a wealth transfer from taxpayers to banks' shareholders due to implicit bailout assumptions, we call this measure a "sovereign subsidy."[6]

We construct a sovereign CDS market index that is representative of the CDS spreads of all European countries using the outstanding government debt of these countries as weights. We find that sovereign CDS spreads have a stronger co-movement with the European sovereign CDS index if the domestic banks of the former obtain 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 financial sector due to a non-domestic sovereign default.

The model in Bolton and Jeanne (2011) suggests that a sovereign-bank loop can develop in safer countries because of financial crisis spillovers. We thus split our sample in riskier GIIPS countries and safer non-GIIPS countries and find that non-GIIPS sovereigns exhibit a larger co-movement with the sovereign CDS index if banks have large foreign sovereign bond exposures not backed by own funds. We find no evidence, however, for spillovers to riskier GIIPS countries from their foreign sovereign exposures.

We also re-estimate our tests for the non-GIIPS countries and replace the CDS index with individual GIIPS sovereign CDS spreads and interaction terms with sovereign

[6] We construct this measure for all banks that participated in the stress tests conducted by the European Banking Authority (EBA) during the period from March 2010 to June 2012 and document that the total sovereign subsidy accumulates to more than €500 billion at each of the stress test dates, or, on average, to more than 50% of Tier 1 capital.

subsidies with respect to these countries. Again, we find a larger co-movement of sovereign CDS spreads with other sovereign CDS spreads if the banking sector has more exposure to sovereign bonds of the respective country that is not supported with capital.

We then investigate the effect of European sovereign risk on bank sector credit risk using bank level exposure data. Sovereign risk differentially affects the risk of GIIPS and non-GIIPS banks. Importantly, our results support the view that domestic sovereign-to-bank linkages are particularly important for GIIPS banks as in Acharya et al. (2014a). However, non-domestic sovereign risk spills over to safer countries and increases bank risk particularly of those banks which have non-domestic sovereign bond exposures not funded with capital.

Next, we investigate several other alternative explanations that are consistent with our findings such as cross-sectional dependence between countries caused by unobserved common factors (e.g. the global financial crisis or spillovers between countries due to, for example, trade and other economic linkages) that could explain the co-movement of sovereign CDS spreads. Moreover, sovereigns might choose to provide fiscal transfers and directly bail out risky governments [e.g., through the European Stability Mechanism, or ESM]. Finally, it could also be that the co-movement of sovereign CDS spreads might be explained by banks' non-sovereign exposures. Accounting for these alternatives, we still find results consistent with the zero risk weight channel.

In a last step, we investigate the role of bank capital in mitigating sovereign risk spillovers. Banks have to use own funds when they invest in sovereign debt that is not exempted from regular risk-weighting. We thus run a similar analysis using the exposures of our sample banks to Japanese, Norwegian, Swiss, and U.S. sovereign debt and do not

find evidence of elevated co-movement if banks have larger risk-weighted exposures.

Further, the EBA conducted a "capitalization exercise" in September 2011 requiring banks to hold a (temporary) capital buffer to account for the risks associated with their sovereign bond portfolios as of June 2012, effectively removing the zero-risk weight exemption. We find that the effect of sovereign subsidies on sovereign risk spillovers becomes insignificant after the capital requirement comes into effect, again suggesting that under-capitalization of the financial sector due to the zero risk weights amplifies sovereign risk spillovers in Europe.

Finally, not all banks use the exemption provided in the CRR. The EBA has provided information on banks' risk-weighted exposures relative to their nominal exposures in different asset classes for the first time in June 2012. If banks apply the zero risk weight regulation, we expect the risk-weighted exposures to European sovereign bonds to be zero. We document substantial cross-sectional variation in risk-weighted exposures to European sovereign bonds across banks and find that the co-movement of sovereign CDS spreads is significantly reduced if banks apply higher risk weights and if banks have larger equity-to-asset ratios.

Our paper connects with different strands of literature. First, it is related to the growing literature studying sovereign-bank linkages. The two important papers by Acharya et al. (2014a) and Gennaioli et al. (2014) mentioned above are closest to this study. Acharya et al. (2014a) study how sovereign-bank feedback loops develop.[7] The

[7] Other papers modeling the sovereign-bank feedback loop include Cooper and Nikolov (2013), Bocola (2014) and Farhi and Tirole (2016). In contrast to the two aforementioned papers, Farhi and Tirole (2016) study the feedback loop in an open economy and can thus explain also the re-nationalization of sovereign debt when a crisis deepens. An emerging empirical literature studies determinants and consequences of re-nationalization of sovereign debt during the sovereign debt crisis such as Acharya and Steffen (2015) or Gennaioli et al. (2016). As explained above, our data set does not allow us to make clear predictions as to

authors argue that the loop originates in the banking sector and spills over to the domestic sovereign due to the bailouts of its domestic banks which then feeds back into the banking sector ("Irish-style" crisis). Gennaioli et al. (2014), on the other hand, do not model a feedback loop but show that an increase in sovereign risk affects the domestic banking sector due to its holdings of domestic sovereign bonds ("Greek-style" crisis). Both papers describe the importance of sovereign-bank linkages in crisis countries because of banks' holdings of *domestic* sovereign bonds.

Our paper investigates how crises can spill over from crisis to safe countries in financially integrated economies. This effect stems from banks' holdings of *non-domestic* sovereign debt combined with the fact that they do not fund their exposures with capital because of zero risk weights. A sovereign-bank loop can thus develop in the banking sectors of safe countries because of exposure to non-domestic sovereign debt that increases the risk and funding costs of sovereigns because of implicit bailout assumptions.

This distinction is important as it relates to two different types of financial sector problems from sovereign exposures that we observed during the financial and sovereign debt crisis. Acharya et al. (2014a) and Gennaioli et al. (2014) discuss problems related to "home bias", i.e. chunky sovereign exposures that created the well-known problems in risky countries in the periphery. Our paper exposes problems associated with small non-domestic sovereign bond positions that cause problems because banks had very little equity – examples include Cypriot banks or Dexia – and their (previously healthy) sovereigns.

Second, our paper contributes to the literature on international spillovers. Ang and

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why banks hold sovereign bonds and we thus take banks' sovereign bond exposures as given in our empirical analysis.

Longstaff (2013) and Chen (2013), for example, evaluate the co-movement of sovereign default risk and find that financial linkages are likely to provide a channel for sovereign risk spillovers. We provide evidence that banks in safer countries hold sovereign debt with high credit risk in their portfolios that, combined with the fact that sovereign risk weights are set to zero, is a first order channel for financial crisis spillovers. Other literature in this area argues that bank health in safer countries can be affected through cross-border exposures (Kallestrup et al., 2016; Beltratti and Stulz, 2015) and safer countries might themselves be affected due to a decline in bank health in riskier countries (Breckenfelder and Schwaab, 2016). We further show that spillovers can be mitigated if banks fund these exposures with capital.

Third, our paper is related to a literature that studies the implications of risk weights in internal bank risk models such as Behn et al. (2015) and Acharya et al. (2014b). Behn at al. (2015) analyze German banks around the introduction of Basel III and find that banks that use internal risk models calculate lower risk-weights compared to banks using the standardized approach for the same exposures and even increase the risk in their loan portfolio. Acharya et al. (2014b) argue that banks become overleveraged as risk weights (e.g. on mortgage loans) are too low. We find that the application of zero risk weights due to exemptions in the regulatory framework creates a lack of capital in the banking system that facilitates the spillover of financial crises among financially integrated countries such as in the European Monetary Union.

The paper proceeds as follows. In section 2, we explain the regulatory treatment of sovereign debt. In section 3, we describe the data and derive the measure of "missing capital" in the banking sector. Section 4 presents our main results, section 5 investigates

alternative channels. In section 6, we discuss the role of bank capital and in section 7, we conclude with a discussion on costs and benefits of financial integration.

2. Regulatory treatment of sovereign exposures

The European Commission established common rules on capital requirements for credit institutions and investment firms to increase financial stability in the Eurozone. The first Europe-wide regulatory approach was the introduction of a single Banking Directive in 2000, which was amended in 2006 to reflect the Basel Capital Accord (Basel II) guidelines together with the Capital Adequacy Directive (Capital Requirement Directive (CRD) I). As a response to the financial crisis, the Commission adopted the second legislative package (CRD II) in September 2009. An additional set of rules was adopted in November 2010 (CRD III). Finally, and to further strengthen the banking system, the Commission adopted a Capital Requirement Directive (CRD IV) to address access to deposit taking activities as well as a Capital Requirement Regulation (CRR) to establish prudential requirements for banks in July 2011.

Basel II stipulates that banks back all exposures with own funds based either on a given regulatory risk weight (the so-called "standardized approach", or SA) or on an internally modeled default probability (the so-called "internal ratings-based approach", or IRB). Sovereign exposures receive a risk-weight ranging from 0% to 150% in the SA as stipulated in paragraph 53 of the Basel II accord. However, paragraph 54 states: "At national discretion, a lower risk weight may be applied to banks' exposures to their sovereign (or central bank) of incorporation denominated in domestic currency and funded in that currency." This provides national regulators an option to deviate from the original risk-weighting and might imply zero risk weights.

The Basel II IRB approach for calculating risk weights does not necessarily stipulate zero risk weights for highly rated sovereign debt, but suggests a granular approach. Paragraph 260 of the Basel II accord, however, allows banks to use the standardized approach for certain exposure, if they are "immaterial in terms of size and perceived risk profile."

The CRR - which implements the new Basel framework – also contains two approaches for calculation sovereign risk weights that are generally based on the Basel II accord. In the standardized approach, according to Article 114(4) of the CRR, "exposures to Member States' central governments and central banks denominated and funded in the domestic currency of that central government and central bank shall be assigned a risk weight of 0%." In the EMU, this exemption is thus immediately applicable to all banks and all their holdings of domestic and non-domestic sovereign debt issued by EMU countries and in euros, leading to a preferential treatment of sovereign bonds irrespective of sovereign risk. Article 150 of the CRR also permits banks using the IRB approach to apply the standardized approach only to sovereign bond exposures and irrespective of their size as long as these exposures have a zero risk weight in the standardized approach ("permanent partial use") – an exemption that IRB banks frequently employ (Hannoun 2011). The CRR is thus much more comprehensive in exempting sovereign bonds from applying risk-adjusted risk weights compared to the Basel accord. In this paper, we investigate the implications of zero risk weighting of sovereign debt for crisis spillovers in the EU.

3. Measuring sovereign risk spillovers

3.1. Data sources

To identify crisis spillovers in the EU, we construct our dataset from various sources. We measure sovereign default risk using 5-year sovereign CDS spreads and collect daily sovereign CDS spreads together with other financial market indicators (e.g., iTraxx, equity indices, VSTOXX, EONIA, Euribor, and EUR effective exchange rates) from Bloomberg, Thomson Reuters Datastream and the ECB. Data on banks' non-domestic sovereign exposures come from two sources. First, and as our primary source, we use quarterly data (from 2010-Q4 to 2012-Q4) obtained from the Bank for International Settlements' (BIS) consolidated banking statistics for all non-domestic sovereign exposures at the banking sector level for seven countries: Belgium, France, Germany, Ireland, Italy, Spain, and the United Kingdom.[8] This dataset is the most comprehensive both regarding time series and cross-sectional data availability and we use banks' exposure to all 27 EU sovereigns.

As this dataset only includes seven countries, we use data from the stress tests and capital exercises that were conducted and published by the EBA during the period from March 2010 to June 2012 as a second data source. The EBA data comprise sovereign bond holdings at the individual bank level for up to 90 major European banks from 21 countries at five points in time: December 2009, December 2010, October 2011, December 2011, and June 2012.

We complement our dataset with quarterly bank financial data from SNL Financial and quarterly country-level macroeconomic data provided by the Organization for Economic Cooperation and Development (OECD) and the ECB. Appendix 1 provides an overview of the data sources and detailed definitions of the variables used in our analysis.

[8] Note that the BIS only provides a separation into different exposure classes starting in Q4 2010.

3.2. Constructing the "sovereign subsidy" measure

To adequately reflect the risk of its assets, a bank translates its exposures into risk-weighted assets (RWA) using specific risk weights and funds a percentage of these RWA with capital against unexpected losses. As discussed above, risk weights associated with sovereign debt are set to zero. However, to estimate the extent of missing capital in the banking system due to zero risk weights, we assign appropriate risk weights to each sovereign exposure and compute the corresponding RWA that are not funded with capital.[9] We call this new measure a "sovereign subsidy". The subsidy is computed as follows:

$$Sovereign\ Subsidy_{i,t} = \sum_{j=1}^{J} RW_{j,t} * \ Sovereign\ Exposure_{i,j,t},$$

with *i* indicating the sovereign/country, *j* the exposure (i.e., the counterparty sovereign), both measured at book values, and *t* the time (i.e., a quarter).

To compute the appropriate risk weights for sovereign exposures, we follow a three-step procedure. First, we collect ratings information on all EU sovereigns from the three largest rating agencies (Standard & Poor's, Moody's, and Fitch) for each exposure date (i.e., end of quarter for the BIS dataset and stress test dates for the EBA 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 Internal IRB formula and standard assumptions of loss given default (LGD) of 45% and 2.5 years maturity to compute the risk weight for

[9] 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 as described in Appendix 2.

each sovereign exposure. Appendix 3 provides an overview of the resulting risk weights.[10]

3.3. Sovereign exposures and sovereign subsidy

Figure 2 shows the size of the sovereign subsidy and its development over time. It provides the sum of the total (domestic and non-domestic) sovereign subsidy for all banks that were part of the EBA stress tests in 2009-2012.

Banks from non-peripheral countries accumulate a sovereign subsidy of more than €300 billion and non-domestic sovereign debt accounts for more than two-thirds of it. Interestingly, the total sovereign subsidy and the fraction of non-domestic sovereign debt hardly change over time. The subsidy of banks from peripheral countries (i.e., Greece, Ireland, Italy, Portugal, and Spain), in contrast, increases from approximately €150 billion in 2009 to more than €300 billion in 2012. About 80%-90% of this subsidy is driven by domestic sovereign debt. This is consistent with an increase in home bias of peripheral banks that accelerated with the Long-Term Refinancing Operations (LTRO) of the ECB in December 2011 and February 2012.[11]

Table 1 complements the Figure 2 results and shows the total banking sectors' sovereign exposures and sovereign subsidies for each country in the BIS dataset. Panel A documents that the non-domestic EU sovereign exposures of domestic banks amount to more than €200 billion for individual countries, or about 16% of a country's national GDP. The sovereign subsidy ranges between 1% and 5.8% of national GDP. French and German banks have the largest non-domestic EU sovereign bond exposures and sovereign subsidies in absolute numbers, whereas Belgium has the largest exposures and subsidies

[10] We use CDS spread implied PDs to estimate risk weights as an alternative method. All results continue to hold. For further details on the formula and assumptions refer to Appendix 2 and Basel Committee on Banking Supervision (2005).

[11] The increase in home bias after the LTROs has been documented also in Acharya and Steffen (2015), Acharya et al. (2016b) and Farhi and Tirole (2016), among others.

relative to GDP. Although some of the core countries' banks slightly decreased their non-domestic sovereign exposure (Belgium, France, and Germany), the sovereign subsidy of French and German banks actually increased over time. A notable exception among the non-peripheral countries is the U.K. banking sector, which nearly doubled its non-domestic EU sovereign exposures to €245 billion in 2012. However, Panels B and C show that U.K. banks considerably increased their exposures to non-peripheral sovereigns and decreased their exposures to peripheral sovereigns. In peripheral countries (Ireland, Italy, and Spain), banks also increased their non-domestic sovereign bond exposures (and subsidies) between year-end 2010 and year-end 2012. Panels B and C imply that banks in peripheral countries attempt to diversify their holdings away from their (increasingly risky) domestic sovereigns as they increase their exposures to non-peripheral sovereigns. For the countries for which BIS data are available, the total exposure to non-domestic EU sovereigns amounts to more than €800 billion in 2012, an increase of about 25% since 2010.

Overall, Figure 2 and Table 1 emphasize how strongly integrated European financial markets are with respect to banks' sovereign bond holdings and that the sovereign subsidy, and thus the missing capital in banks' balance sheets, related to these sovereign bond holdings, is considerable.

3.4. The co-movement of sovereign CDS spreads in the EU

To investigate the impact of non-domestic sovereign subsidies on sovereign risk, we construct $\Delta LogCDS_{i,t}$ as our main dependent variable, which is defined as the daily change in the natural log of the CDS spread of a specific sovereign i:[12]

[12] CDS spreads have a unit root and we make them stationary using first differences.

$$\Delta LogCDS_{i,t} = \alpha + \beta_1 * \Delta LogCDS\ Index_{i,t} + \beta_2 * \frac{Sovereign\ Subsidy_{i,t}}{GDP_{i,t}} + \beta_3$$

$$* \left[\Delta LogCDS\ Index_{i,t} * \frac{Sovereign\ Subsidy_{i,t}}{GDP_{i,t}}\right] + \beta_4 X_t\ + \delta_t + \gamma_{i,t} + \varepsilon_{i,t}.$$

We estimate the model using a 60-day period (i.e., 30 days before and 30 days after the reporting date (last day of the quarter)).[13]

$\Delta LogCDS\ Index_{i,t}$ is the change in a logarithmic European sovereign CDS index that is weighted with the non-domestic (*j*) sovereign exposure of country *i*'s financial sector during time *t* (i.e., by $Sovereign\ Exposure_{i,j,t} / \sum_{j=1}^{J} Sovereign\ Exposure_{i,j,t}$). β_1 thus accounts for the relation between the exposure-weighted average change in non-domestic sovereign CDS spreads and the change in a country's CDS spread. $Sovereign\ Subsidy_{i,t}/GDP_{i,t}$ is the non-domestic sovereign subsidy (i.e., the risk-weighted exposures of country *i*'s financial sector to all non-domestic EU sovereigns in time *t* as described in detail in section 3.2.) scaled by the GDP of country *i* and β_2 captures its relation to the change in a country's CDS spread.

The coefficient of primary interest is β_3, which captures how the co-movement between a country's CDS spread with the European sovereign CDS index varies with the country's sovereign subsidy. We expect to see an amplification of risk spillovers, i.e., a stronger co-movement of the country's CDS spread with the European sovereign CDS index, through sovereign subsidies, which implies a positive and significant coefficient

[13] 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 of the sovereign debt holdings during the 30 days before and after the reporting date. Both assumptions are common in the literature (e.g., Acharya et al., 2011).

β_3.[14] In some specifications, we also add week fixed effects (δ_t) and country-quarter ($\gamma_{i,t}$) fixed effects.

Table 2 presents summary statistics of our variables. In the periods surrounding the reporting dates for financial sector sovereign bond holdings (end of quarter from 2010-Q4 to 2012-Q4), the average CDS spreads of the sovereigns in our dataset exhibit an average daily change of -0.17% (the average sovereign CDS spread around the reporting dates is 252 bps). Although the average change is rather small, the standard deviation for the daily changes is relatively high and there are periods with large changes of approximately 20% (both upward and downward). The average daily change in the exposure-weighted sovereign CDS index (*ΔLogCDS Index*) is -0.14% during our sample period, but also shows a relatively large standard deviation.[15]

Figure 3 provides preliminary evidence how CDS spreads co-move in the EU and the role of the sovereign subsidy plotting *ΔLogCDS* on *ΔLogCDS Index x Sovereign Subsidy/GDP*. The correlation is positive and significant, which is consistent with our hypothesis that the application of zero risk-weights increases the co-movement of sovereign CDS spreads in the Eurozone.

[14] In addition, we use a set of time-varying control variables at the daily level (X_t) to account for additional covariates that might affect changes in credit risk, including changes in a corporate CDS market index (*ΔiTraxx*), an equity market index (*ΔDS Equity Index*), the market volatility (*ΔVSTOXX*), the term spread (computed from EONIA and 12-month Euribor, *ΔTerm Spread*), and the EUR effective exchange rate (*ΔEUR Exchange Rate*). We also include quarterly banking sector characteristics, such as the *Capital Ratio* (the ratio of equity to total assets), the *Deposit Ratio* (the ratio of deposits to total assets), the *Funding Fragility* (the ratio of net loans to deposits), the *Income Diversity* (the ratio of net interest income to total operating income), the *Liquidity* (the ratio of cash and cash equivalents to total assets), and the financial sector *Concentration* (measured by the Herfindahl-Hirschman index). All bank characteristics are aggregated at the country level weighted by bank asset size.

[15] EU sovereign CDS spreads within the eurozone but also with non-eurozone EU countries such as the U.K. show significant 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 from 2010 to 2012.

4. Understanding sovereign risk spillovers

4.1. Benchmark specification

Table 3 Panel A reports the results of our baseline model. Column (1) shows the results of an OLS regression without control variables. As expected and reflecting the co-movement of CDS spreads across EU countries, the effect of *ΔLogCDS Index* on *ΔLogCDS* is positive and significant at the 1 percent level. If the CDS index increases by 100bps the sovereign CDS spread increases, on average, by 85bps. Importantly, the coefficient of the interaction term *ΔLogCDS Index* x *Sovereign Subsidy/GDP* is positive and highly significant, i.e. a change in the European sovereign CDS index has a larger impact on the CDS spread of an individual sovereign if its banking sector as a whole has a larger exposure to non-domestic sovereign debt not funded with capital. If the subsidy increases from the 25th to the 75th percentile, the sovereign CDS spread increases by another 9bps, on average, in addition to the effect resulting from the co-movement of the CDS spread and the CDS index. This is consistent with the interpretation that a larger sovereign subsidy increases the likelihood of a capital shortfall of the domestic financial sector in case of a sovereign default (and thus the likelihood of a government bailout), which is reflected in elevated sovereign CDS spreads.

In column (2) of Table 3 Panel A, we add variables that capture capital market fluctuations and the macroeconomic environment with daily frequency. We also control for quarterly bank fundamentals that might affect sovereign CDS spreads such as leverage, asset and funding liquidity and bank competition. As expected, changes in corporate CDS spreads (as measured through the *iTraxx* index) also increase sovereign CDS spreads. In column (3), we add week fixed effects, which control for short-term interest rates.

In column (4), we add country-quarter fixed effects (but no week fixed effects). Country-quarter fixed effects are important for our empirical approach as they absorb all factors that might affect sovereign CDS spreads at the country level in each quarter. The missing capital concerns apply not only to foreign but also to domestic sovereign bond exposures, particularly for bonds of those countries in which the subsidy is at its highest. The country-quarter fixed effects control for the absolute amounts of both foreign and domestic sovereign bond (and other debt) holdings of banks as well as the supply of bonds within each quarter. The holdings of domestic sovereign bonds, for instance, might mechanically lead to elevated sovereign CDS spreads, particularly in riskier countries such as the European periphery. We control for time and country-quarter fixed effects collectively in column (5). Throughout all model specifications, we find a larger co-movement of sovereign CDS spreads with a European sovereign CDS index when the domestic banking sector has a larger sovereign subsidy.

4.2. Robustness tests

Panel B of Table 3 provides various robustness tests.[16]

4.2.1. Bond yields

In column (1), we use government bond yields as the measure of sovereign risk instead of sovereign CDS spreads. The latter have been used in many other empirical studies of credit risk because of their standardization and liquidity. However, CDS spreads and bond yields might diverge creating a "basis" between both measures. To address concerns that our results are driven by the use of CDS spreads rather than bond yields, we replace a country's sovereign CDS rate with its government bond yield. We use 10-year maturity-adjusted sovereign bond yields that we obtain from Datastream to construct both

[16] We only report fixed effects specifications for brevity.

the dependent variable (Δ*Log Bond Yield*) and the sovereign risk index (Δ*Bond Index*).[17] Similar to our benchmark specification, we find that an increase in the sovereign bond yield index increases bond yields of individual sovereigns more when the banking sector has a larger sovereign subsidy.

4.2.2. CDS implied risk weights

As an alternative to risk weights that rely on ratings, we use probabilities of default that are implied by CDS spreads in column (2). However, the implied risk-neutral PDs 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 in section 3.2. Using conversion factors from Hull et al. (2005), we approximate physical PDs from the CDS implied risk-neutral PDs. We then use the Basel IRB formula and standard assumptions of LGD of 45 percent and 2.5 years maturity to compute risk weights for sovereign exposures from these PDs. Applying the CDS implied risk weights results in sovereign subsidy values that are, on average, almost twice as high as those used in our main analysis. Our EBA risk weight measures should thus be viewed as conservative and a lower bound of the sovereign subsidy. Using CDS implied risk weights confirms our previous results that the co-movement of sovereign CDS spreads increase with the sovereign subsidy.

4.2.3. Financial sector health

It might be that the co-movement between a country's sovereign CDS and the European CDS index increases with the health of the country's banking sector and that the

[17] These bond yields have also been used in previous studies by e.g. Pagano and von Thadden (2004) and Acharya and Steffen (2015). As is the case with *ΔLogCDS* and *ΔLogCDS Index*, the bond yields and the bond index change relatively little from day to day on average, but show quite large standard deviations (Δ*Log Bond Yield*: mean 0.04, standard deviation 2.22, and Δ*Log Bond Index*: mean 0.04 and standard deviation 1.33).

interaction between the sovereign subsidy and the CDS index might capture this effect. For instance, well-capitalized banks might get more funding from abroad increasing the correlation between the sovereign CDS and the CDS index.[18] In column (3) we therefore interact all bank characteristics with *ΔLogCDS Index*. The results show that the co-movement between the sovereign CDS and the CDS index is larger for healthier banking systems, i.e., those with a higher *Deposit Ratio*, more *Income Diversity* and higher *Liquidity*, but also for banking systems that fund their loans to a lower extent with deposits (larger *Funding Fragility*). Most importantly, the interaction term *ΔLogCDS Index* x *Sovereign Subsidy/GDP* remains highly significant.[19]

4.2.4. EBA exposure data

The BIS data include the exposure of all banks in each respective country. However, exposures are only available for 7 countries. To test the external validity of our results, we use bank level data from the EBA stress tests, which expands the sample including more countries, but relies on a smaller time series and only includes the largest banks (that arguably also hold a large proportion of the total cross-country sovereign debt) in each country.[20] We aggregate individual bank exposures at the country level to use the same methodology as above. In column (4), we use the full EBA sample including eighteen countries for which we can obtain CDS data. The results confirm that our previous findings do not depend on the sample used for the analysis and the interaction term *ΔCDS Index* x *Sovereign Subsidy/GDP* remains positive and significant. The economic magnitude is similar compared with the benchmark specification. In the full

[18] However, as the balance sheet variables are of quarterly frequency but sovereign CDS spreads of daily frequency, they might not capture this effect.
[19] We do not report the interaction terms for reasons of space.
[20] Appendix 5 provides summary statistics of the variables using the EBA data.

EBA sample, if the CDS index increases by 100bps, the sovereign CDS spread increases an additional 8bps if the subsidy increases to the 75th percentile. In columns (5) and (6), we drop banks from Belgium and the largest three banks from Germany and France to discern that outliers might drive our results. The economic magnitude in column (5) is somewhat higher (an additional increase in the co-movement by 10bps) and somewhat lower in column (6), when we drop the largest banks in Germany and France, but the additional increase in sovereign CDS spreads is still about 5bps.

4.2.5. Exposure at default

Our earlier tests have not taken into account that the sovereign subsidy increases when either the risk weight or the actual exposure towards a foreign sovereign increases. We address this in two ways. First, we replace the sovereign subsidy with the banks' actual exposure to non-domestic sovereign debt (*EAD*) to investigate whether our results can be explained by the exposure itself and not by zero risk weights. Column (7) shows that the interaction term *ΔLogCDS Index* x *EAD/GDP* does not load significantly in our model highlighting again the importance of the riskiness of the exposure, i.e. the missing capital in the banks' balance sheets, as a first order transmission channel of sovereign risk. Second, we use banks' sovereign bond exposures at the beginning of the observation period as an instrument for exposures at later reporting dates, i.e. the sovereign subsidy only varies with changes in the risk weights.[21] The results in column (8) show that the interaction term is highly significant suggesting that our results are driven by changes in risk weights rather than by exposure changes.

[21] The intuition is that banks that have a relatively larger exposure to non-domestic sovereign debt at the beginning of the observation period also continue to have a larger exposure during the rest of our sample period. This assumption is borne out in the data. For example, the rank correlation of countries w.r.t the sovereign subsidy to its banking sector is about 0.82 from 2010 to 2011. The rank correlation is even higher in the bank level analysis ranging from 0.81 to 0.98 between different reporting periods.

4.2.6. Individual country exposures

Holdings of foreign bonds might also be more prevalent in larger countries, which could increase the connection between foreign sovereign bond holdings and the co-movement of domestic sovereign CDS and the European CDS index. Large countries have a larger weight in the overall CDS index than smaller countries as they also issue more debt themselves. Instead of using a European sovereign CDS index, we include the sovereign subsidy associated with individual GIIPS exposures (scaled with the country's GDP) both individually and as interaction terms with the change of the respective country CDS spread (e.g. *ΔLogCDS Spain* in case of exposure to Spanish sovereign debt). The results are reported in Appendix 4. Consistent with our earlier results, we find a larger co-movement of sovereign CDS spreads if banks have larger sovereign subsidies.[22]

4.3. Spillovers from peripheral to core European countries

The model in Bolton and Jeanne (2011) suggests that a sovereign-bank loop can develop in safer non-GIIPS countries because of financial crisis spillovers when markets are financially integrated, e.g. through the holdings of non-domestic sovereign debt. GIIPS banks, on the other hand, have large domestic sovereign bond exposures and are thus less affected by spillovers. We therefore split our sample in riskier GIIPS countries and safer non-GIIPS countries and investigate whether non-GIIPS sovereigns exhibit a larger co-movement with our sovereign CDS index compared with GIIPS countries. The results for the sample of non-GIIPS countries are reported in Panel A of Table 4.

Similar to above, the effect of *ΔLogCDS Index* on *ΔLogCDS* is positive and significant at the 1 percent level. The coefficient of the interaction term *ΔLogCDS Index* x

[22] The interaction term is insignificant in the subsample, in which we evaluate spillovers from exposures to Spanish sovereign debt. A possible reason is the size of the sovereign subsidy which is about one-fourth of the subsidy of banks towards Italy.

Sovereign Subsidy/GDP is also positive and significant at the 1 percent level, i.e. a change in the CDS index has a larger impact on the CDS spread of non-GIIPS sovereigns if their banking sectors have a larger sovereign subsidy. The economic magnitude, however, is about 30% larger compared with the benchmark specification, i.e. the co-movement of sovereign CDS spreads increases by 12bps if the sovereign subsidy increases from the 25th to the 75th percentile.

Panel B of Table 4 reports the results regressing GIIPS sovereign CDS spreads on the sovereign CDS index interacted with the sovereign subsidy on GIIPS banks' non-domestic sovereign exposures as well as other control variables. Interestingly and in contrast to our earlier results, the interaction term *ΔCDS Index* x *Sovereign Subsidy/GDP* does not load significantly in our model. In other words, our results are consistent with the view that financial crises can spread across financially integrated economies increasing the risk and funding cost of even safer sovereigns because of implicit guarantees for their domestic banking sectors.

4.4. Sovereign exposure and bank sector credit risk

This section analyzes the effect of European sovereign risk on bank sector credit risk. A possible concern with our country level regression is that we cannot control for common factors that increase both bank and sovereign risk or (time-invariant) bank specific risk factors that increase sovereign risk but that are unrelated to spillovers due to the sovereign subsidy. Bank level regressions can help to isolate the effect of non-domestic sovereign risk on banks due to the sovereign subsidy. If banks' sovereign exposure affects sovereign risk because banks do not fund them with capital, we expect to see an increase in banks' own CDS spreads because of elevated default risk if non-domestic sovereign risk

increases. As shown in Acharya et al. (2014a), domestic sovereign risk increases banks' CDS spread. We carefully control for domestic sovereign risk in our empirical approach because the sovereign-to-bank feedback loop should be particularly important for GIIPS banks.

4.4.1. Bank level methodology

To identify the effects of non-domestic sovereign risk exposures on bank risk, we control for heterogeneity in banks' exposure to changes in macroeconomic fundamentals using bank fixed effects and allowing for bank specific coefficients on a corporate CDS market index (iTraxx Europe index) and a volatility index (VSTOXX) which are important factors in the pricing of credit risk of banks. Moreover, we include weekly fixed effects and country-quarter fixed effects.

Specifically, we estimate the following OLS regression:

$$\Delta Log(BankCDS_{m,i,t}) = \alpha + \beta_1 \Delta Log(CDS\ Index_{i,t}) + \beta_2 \frac{Sovereign\ Subsidy_{m,t}}{Assets_{m,t}} + \beta_3 \left[\Delta Log(CDS\ Index_{i,t}) * \frac{Sovereign\ Subsidy_{m,t}}{Assets_{m,t}}\right] + \beta_4 Log(CDS_{i,t}) + \beta_5 \Delta X_{m,i,t} + \vartheta_m + \delta_t + \varepsilon_{m,i,t}.$$

where $\Delta Log(BankCDS_{m,i,t})$ is the daily change in the natural logarithm of the CDS spread of bank m headquartered in country i in the 30-day period around the exposure reporting date. $Sovereign\ Subsidy_{m,t}/Assets_{m,t}$ is a bank's non-domestic sovereign subsidy scaled by total assets using a banks' exposure at the beginning of the

sample period as an instrument. $Log(CDS_{i,t})$ is the daily change in the natural logarithm of the domestic (i) sovereign CDS spread. $\Delta X_{m,i,t}$ are daily changes in the control variables, ϑ_m are bank fixed-effects and δ_t are time fixed effects.

4.4.2. Results

Table 5 presents the results. We separately present results for the full sample, and subsamples of non-GIIPS and GIIPS banks and always show the result with and without week fixed effects. We first report the results for the full sample without the domestic sovereign CDS spread. The coefficient on the interaction term is highly significant and the results support the view that a larger sovereign subsidy (i.e., a lack of capital to support risky sovereign debt) increases bank credit risk when sovereign risk increases which is reflected in higher bank CDS spreads. An increase in the CDS index by 10% increases banks' CDS spreads, on average, by 0.1%.[23] This effect almost doubles when the sovereign subsidy increases from the 25th to the 75th percentile.

Next, we examine the sovereign-bank feedback loop and include the domestic sovereign CDS index (columns (3) and (4)). A 10% increase in the domestic CDS spread increases bank CDS spreads by 0.1% consistent with a sovereign-to-bank feedback loop. Interestingly, the coefficient on the CDS index does not load significantly anymore and an explanation might be that sovereign risk differentially affects GIIPS vs non-GIIPS bank credit risk, an issue we turn to next.

Finally, we examine the effect of an increase in non-domestic sovereign risk on bank credit risk for GIIPS versus non-GIIPS banks. Columns (5) and (6) show the results for non-GIIPS banks without and with time fixed effects and columns (7) and (8) the

[23] This effect is similar in magnitude to the one reported in Acharya et al. (2014a).

results for GIIPS banks. We find important differences in both sub-samples. The non-domestic sovereign CDS index loads significantly and positively on banks' CDS spreads in the sample of non-GIIPS banks. On average, a 10% increase in the CDS spreads increases bank CDS spreads by 1.4%. This effect is about 50% larger when the sovereign subsidy is at its 75th percentile.

We do not find similar effects in the sub-sample of GIIPS banks: a change in non-domestic sovereign risk does not increase GIIPS banks' CDS spreads. We also add the domestic sovereign CDS spread and investigate how changes in domestic sovereign risk differentially affect GIIPS and non-GIIPS banks. The effect is much smaller for non-GIIPS relative to GIIPS banks. A 10% increase of the domestic sovereign CDS spread increases non-GIIPS banks' CDS spread by about 0.46%. However, the same increase in domestic sovereign CDS spreads increases GIIPS banks' CDS spreads by about 1.6%.

These results support the view that domestic sovereign-to-bank linkages are particularly important for GIIPS banks as in Acharya et al. (2014a). In contrast, non-domestic sovereign risk spills over to safer countries and increases bank risk particularly of those banks which have non-domestic sovereign bond exposures not funded with capital.

5. Other financial crisis spillover channels

Our prior results are consistent with the interpretation that a lack of capital in the banking system due to application of zero risk weights facilitates spillovers of financial crises in the Eurozone. Using different tests, we try to further isolate the role of zero risk weights in this section. All results are presented in Table 6.

5.1. Cross-sectional dependence between countries

First, we analyze the effect of possible cross-sectional dependence between countries caused by common factors that drive both the sovereign CDS spread as well as the sovereign CDS index. These common factors can be both global shocks such as the global financial crisis or sovereign debt crisis or other factors such as spillovers between groups of countries e.g. due to trade and other economic linkages. Countries in the common currency area are interconnected and thus subject to common shocks, which, however, may impact individual countries differentially.[24]

We model economic linkages between countries using the common correlated effects (CCE) estimator of Pesaran (2006), where the unobserved common factors are proxied by the cross-sectional averages of the dependent variable and the regressors. This allows for more flexibility as the impact of the unobserved common factors can differ across countries while the evolution of these factors may be non-linear (Kapetanios et al., 2011). In the pooled sample, the average thus needs to be interacted with country dummies, so that each country can have a different parameter on the cross-section averages.[25] The results are presented in columns (1) and (2) of Table 6. As before, we find a positive and significant effect of *ΔCDS Index* on *ΔLogCDS*. More importantly, even after controlling for common effects, the coefficient of the interaction term is still comparable in size and is significant at the 1 percent level. The model fit improves when common factors are accounted for. Thus, our results are robust to underlying common shocks that create cross-sectional dependence.

[24] In our earlier fixed-effect specifications, we include time fixed effects that account for unobserved macroeconomic shocks. While these fixed effects proxy for some common factors, they do not account for heterogeneous effects among countries and, moreover, might not address the cross-sectional dependence caused by them.

[25] As the averages contain various unobserved parameters, the loadings on the interaction terms cannot be interpreted and should be seen as accounting for cross-section dependence in the data.

5.2. Direct transfers between countries

Bolton and Jeanne (2011) suggest that sovereigns have the choice to either support their domestic banking sector or to directly bail out governments in stress. To control for this alternative spillover channel, we augment our model and include proxies to measure direct bailout risk. As a first proxy, we use the share of the (contingent) liability sovereigns assume through the stability mechanisms in the Eurozone. These are (i) each sovereign's share in the temporary assistance vehicle, the European Financial Stability Facility (EFSF), (ii) each sovereign's share in the permanent support vehicle, the European Stability Mechanism (ESM), and (iii) 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 ECB (ECB, 2011), we take *ECB share* as our proxy for bailout risk. The average share in subscribed capital of the ECB (and likewise, for example, in the ESM) is 11.8%, with Germany holding the largest share at 27.1%, whereas the share of the U.K. is zero.

We also control for a country's bailout capacity. Some countries have more fiscal flexibility and might thus be less affected when sovereign risk in the Eurozone increases compared with other countries. We define a new variable *Debt Ratio* (measured as government debt over the country's GDP) as a proxy for fiscal flexibility. A higher ratio suggests less capacity for a country to bail out its banking sector or to provide direct assistance to other sovereigns. The average *Debt Ratio* is 102% ranging from 60% (Spain in 2010) to almost 140% (Italy in 2012).

In columns (3) and (4) of Table 6 we include both proxies in our regressions, as well as their interaction terms with *ΔLogCDS Index*. Consistent with a direct spillover

channel between sovereigns, a larger ECB share increases the co-movement of European sovereign CDS spreads. The coefficient of the interaction between *ΔLogCDS Index* and the *ECB Share* is positive and significant at the 1 percent level throughout all specifications. A higher *Debt Ratio*, however, does not significantly affect sovereign CDS spreads. Importantly, even when controlling for these alternative transmission channels the effect of the banks' non-domestic European sovereign exposures on sovereign risk spillovers remains largely unchanged.

5.3. Non-sovereign cross-country exposures

Finally, we investigate whether the non-sovereign cross-country exposures of banks could explain our results. We use data on banks' risk-weighted exposures to financial institutions, retail and corporate sectors as disclosed by the BIS and include them in our analysis. We also use interaction terms with *ΔLogCDS Index.* The results are reported in columns (5) and (6) without the sovereign exposures and in columns (7) and (8) with sovereign exposures as additional regressors. Overall, the coefficients on the interaction term *ΔLogCDS Index* x *Sovereign Subsidy/GDP* do not change much in economic magnitude compared to before.

Taken together, while other cross-country linkages through mutual bailout responsibilities lead to risk spillovers from stressed countries to other European sovereigns, the transmission through banks' foreign sovereign bond holdings and the corresponding sovereign subsidy (or missing capital) is an important channel that contributes to risk spillovers in addition and beyond these other channels.

6. Bank capital and sovereign risk spillovers

Our results so far indicate that sovereign risk spillovers within the EU are

amplified by banks' holdings of non-domestic sovereign bonds that are not funded with capital. If missing capital related to the zero risk weight regulation for EU sovereign bonds is a concern, then funding sovereign bonds with capital reflecting the risk of the exposure should attenuate sovereign risk spillovers.

We study the effect of funding non-domestic sovereign bonds with equity capital in three scenarios. First, we examine banks' exposures to non-EU sovereigns which they are required to fund with risk-adjusted equity levels (Section 6.1). Second, we take into account the role of banks' voluntary capital buffers for sovereign debt (Section 6.2). Third, we exploit the EBA's capital exercise in September 2011 that required banks to build up a temporary capital buffer to account for risky sovereign debt in their portfolios (Section 6.3).

6.1. Non-EU sovereign debt exposures

In a first test, we run falsification tests using banks' exposure to non-EU member states for which zero-risk regulation does not apply. Hence, we do not expect to observe a similar effect for these exposures, as banks have to deploy capital that reflects the risk associated with holding the respective sovereign bonds. The BIS also reports the exposures to countries such as Japan, Norway, Switzerland, and the U.S., for which zero risk weight regulation does not apply. We calculate a "quasi-sovereign subsidy" that reflects the risk-weighted sovereign debt exposure and the resulting potential capital shortfall if banks did not have to fund them with capital. The *Quasi-Sovereign Subsidy/GDP* for the non-EU countries is comparable in size to the sovereign subsidies towards the GIIPS countries in our sample.[26]

[26] For instance, the sum of the quasi-sovereign subsidies towards Japan, Norway, Switzerland, and the U.S. as a share of GDP is on average 0.7% which is very similar to the sovereign subsidy as a share of GDP

In columns (1) and (2) of Panel A of Table 7, we report the results focusing on European banks' exposure to U.S. sovereign debt; columns (3) and (4) include the results of an exposure-weighted index of non-EU sovereigns' CDS. We find that the CDS spread changes of European sovereigns are positively and significantly related to the CDS spread changes of non-EU member countries. However, 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.

CDS spread changes are smaller in the U.S. or Japan compared to those in stressed countries in the Eurozone. In Panel B of Table 7, we thus focus on time periods during which we observe almost a doubling of the CDS spreads in these countries.[27] The U.S. sovereign spread increased from around 40bp to 70bp between the end of 2011-Q1 and the end of 2011-Q2, whereas the Japanese sovereign spread increased from 70bp to 125bp between the end of 2011-Q1 and 2011-Q4. While there was no crisis in the U.S. and Japan comparable to the sovereign debt crisis in the GIIPS countries, an almost doubling of the CDS spread can be considered a considerable stress event. The interaction term does not load significantly in our regression models. This result indicates that risk spillovers among EU and non-EU sovereigns are not amplified by banks' non-EU sovereign bond exposures because banks have in fact sufficient equity capital funding these exposures.

6.2. Cross-sectional differences in bank capitalization

towards Italy (0.6%). The quasi-sovereign subsidy as a share of GDP on U.S. sovereign bond holdings is 0.5% and the respective quasi-subsidy on Japanese sovereign bond holdings is 0.2%. The latter is similar in size to the sovereign subsidies on Spanish, Greek or Portuguese sovereign bond holdings.

[27] In Japan, an important event that significantly increased sovereign CDS spreads was the Fukushima catastrophe. In the U.S., elevated sovereign CDS spread changes were driven by the large budget deficit and debt ceiling debate in 2011 together with the expected downgrade of U.S. government bonds.

So far we have implicitly assumed that banks take full advantage of the zero risk weight regulation, whereas some banks voluntarily fund these exposures with equity capital.[28] Banks do not usually report this information in their annual reports but the EBA published information on banks' RWA by exposures for the first time in June 2012. We aggregate the individual exposures at the country level and, given that we only have a single data point, assume that the risk weights banks applied for sovereign debt remained constant throughout our sample period. We construct a new variable *RWA Coverage* as a bank's risk weighted assets for EU sovereign exposure recorded for the banks in one country over total EU sovereign exposure. We exploit the cross-sectional variation in *RWA Coverage* to identify the effect of bank capital on sovereign risk spillovers and present the results in Table 8.

In columns (1) and (2) we augment our baseline specifications and include the triple interaction *RWA Coverage x ΔLogCDS Index x Sovereign Subsidy/GDP* (and all the respective individual interaction terms and secular effects). The triple interaction is significantly negative suggesting that a larger capital buffer related to foreign sovereign bond holdings mitigates sovereign risk spillovers. Given that the interaction term *ΔLogCDS Index x Sovereign Subsidy/GDP* is still significantly positive and larger, these voluntary capital buffers are not sufficient to eliminate sovereign risk spillovers through banks' foreign sovereign bond holdings. The economic magnitude of the coefficient of the interaction term *ΔLogCDS Index x Sovereign Subsidy/GDP* is similar as in the benchmark

[28] A common thread to different theory papers is that banks voluntary hold capital above the minimum capital requirement as it increases the survival likelihood in times of crises (e.g. Holmström and Tirole (1997), Acharya et al. (2016a), Allen et al. (2011), Mehran and Thakor (2011), and Thakor (2012)). These papers argue that capital helps banks to attract funds and provides incentives for banks to monitor their relationship borrowers more closely, to attenuate asset-substitution moral hazard, or to make innovative but risky products that elevate the probability of financial crises less attractive. Berger and Bouwman (2013) also document considerable heterogeneity in bank capital ratios in the U.S.

specification. A sovereign subsidy at the 75th percentile increases the co-movement by about 9bps relative to the 25th percentile. If the banking sector has a high exposure at the 75th percentile, an increase in the coverage ratio, say from the 25th to the 75th percentile, decreases the co-movement by about 5bps.

Instead of accounting for RWA for sovereign debt, we control for banks' equity-to-asset ratio (*Capital Ratio*) in columns (3) and (4) of Table 8. Again, a larger *Capital Ratio* (i.e., a larger capital buffer) should reduce sovereign risk spillovers. And indeed, we find a negative and significant coefficient on the triple interaction term *Capital Ratio x ΔLogCDS Index x Sovereign Subsidy/GDP*. However, even a large *Capital Ratio* is not sufficient to eliminate sovereign risk spillovers within the EU through banks' holdings of bonds of foreign EU sovereigns given that the interaction term *ΔLogCDS Index x Sovereign Subsidy/GDP* is significantly positive and larger.

6.3. The September 2011 capital exercise

While European bank regulations have not removed the advantages associated with sovereign debt in the Capital Requirements Regulation and Directive (CRR/CDR IV), the EBA conducted a capitalization exercise (CE) in September 2011. The EBA requested that participating banks accumulate a capital buffer to account for risky sovereign debt in their portfolios and temporarily increase their Core Tier 1 capital ratios to 9% by the end of June 2012.[29] This step can be interpreted as a de facto implementation of risk weights on sovereign debt exposures for the participating banks. In fact, this is the first time that bank regulators officially acknowledged that sovereign debt is not risk-free and should be

[29] Thirty-seven banks showed an initial capital shortfall of €115 billion. Ten banks, including Dexia, Volksbank AG, West LB, and Bankia, as well as the six Greek banks were already under restructuring and had separate capital plans. The remaining 27 banks had a shortfall of €76 billion; by June 2012, the 27 banks raised a total of €115.7 billion through direct capital measures (by issuing, for example, equity or convertible securities), as well as risk-weighted asset measures.

reflected in the capital requirements for banks. We examine whether the EBA CE reduces the sovereign subsidy and, thereby, the spillover risks from non-domestic sovereign exposures.

In Figure 4, we plot the quarterly estimated betas of a regression of sovereign CDS spreads on a sovereign CDS index (Datastream's Markit SovX index) over time. From 2011-Q4 onwards, the co-movement between a country's sovereign CDS spread and the CDS index is considerably lower than before 2011-Q4, which is preliminary evidence that the increased capital buffer that the CE required mitigated sovereign risk spillovers within the EU.

In the next step, we examine this more formally in our regression framework. In Table 9 we report the results from our baseline regressions with and without fixed effects for the time periods (i) before the CE, i.e. up to and including 2011-Q3, (ii) after the CE starting directly from 2011-Q4 when banks already had the information about the new requirement, (iii) after the CE starting from 2012-Q1 and (iv) after the CE starting from 2012-Q2 when the requirement had to be fulfilled to assess when the effect of the additional capital becomes observable if at all.

We find that the coefficient on the interaction term that proxies for the sovereign risk spillover through non-domestic sovereign exposures of the domestic financial sector (*ΔLogCDS Index x Sovereign Subsidy/GDP*) remains positive and highly significant before the EBA CE. In contrast, it becomes smaller over the three after-CE periods and becomes insignificant in the 2012 after-CE periods. Our results suggest that banks need some time to build up the additional capital buffer but that the additional capital eliminates sovereign risk spillovers within the EU once banks have accumulated a large enough buffer.

In December 2011, the ECB conducted the first of its 3-year Long-Term Refinancing Operations (LTROs) providing about €500 billion to the banking system. If the LTRO helps stabilizing sovereign bond yields, attenuated spillovers might be due to the ECB's program rather than an increase in equity capital to fund the exposures.

Empirical results, however, do not support this claim. Acharya et al. (2016b), for example, do not find a significant negative effect of the LTRO on sovereign yields. In contrast, sovereign yields reached new heights in mid-2012. They report that even though core country banks decreased their holdings of risky periphery sovereign bonds in early 2012, their CDS spreads increased substantially with the increased sovereign risk in Spain and Italy. Krishnamurty et al. (2014) also find only a small effect of the LTROs on sovereign yields.[30] It is thus unlikely that LTRO liquidity injections explain our results.

Overall, our findings from these three scenarios strongly support our main hypothesis that sovereign CDS spreads exhibit a larger co-movement with European CDS spreads if domestic banks have large exposures for which they do not hold (sufficient) capital. Or in other words, when banks have larger capital buffers, the sovereign risk spillovers within the EU are considerably attenuated.

7. Discussion

We take banks' choice to hold a diversified portfolio of sovereign bonds as given and show that sovereign CDS spreads exhibit a larger co-movement with other European sovereign CDS spreads if domestic banks have larger foreign sovereign bond exposures that they do not fund with capital because of zero risk weights. While prior literature

[30] Acharya et al. (2016b) emphasize the effectiveness of the OMT compared to the LTRO program that was initiated later in 2012 in reducing sovereign risk in the Eurozone. Importantly, the ECB provided liquidity to the banks in the LTRO transactions which segmented the sovereign bond market further preferentially towards GIIPS banks. This worsened the crisis when Italian and Spanish sovereign yields increased in spring 2012. In the OMT, however, the ECB provided liquidity to the market at large, reducing the risks of fire sales and stabilizing asset prices.

analyzes sovereign-bank feedback loops in crisis countries such as Ireland and Greece, we show that a sovereign-bank loop might develop even in the banking sectors of *safer* countries because of exposure to non-domestic sovereign debt and increase the risk and funding costs of sovereigns because of implicit bailout assumptions.

In the last part of this paper, we discuss the implications of our findings and place them in the context of the ongoing discussion on regulating banks' sovereign exposure. Importantly, we need to discuss whether the zero risk weight exemption impairs financial stability. We cannot fully answer this question in this paper. It has facilitated cross-border holdings of sovereign debt and thus enhanced financial integration among countries in the EMU. While we discuss the ex-posts costs associated with financial integration such as financial crisis spillovers[31], we have not investigated the ex-ante benefits financial integration entails as our dataset does not allow to do so. However, the literature emphasizes benefits that need to be considered when discussing the implications of our findings for the regulatory debate.

First, as already mentioned in the introduction above, cross-border holdings of sovereign bonds allow banks to diversify their sovereign bond portfolios, e.g. because of different risk profiles or also maturity structures (Bolton and Jeanne, 2011). Second, they increase the access to liquidity as all sovereign bonds in the EMU can be used as collateral in private repo transaction or with the ECB (Holmström and Tirole, 2007). Third, increasing financial integration through sovereign bonds reduces the feedback-loop between sovereigns and domestic banks (Acharya et al., 2014a) which destabilized the

[31] The literature also emphasizes other costs associated with cross-border holdings of sovereign bonds. For example, Bulow and Rogoff (1989) argue that sovereigns are less likely to default because they cannot selectively default only on bonds held outside the domestic banking sector. Consistently, Gennaioli et al. (2016) find that even in normal times, domestic banks in less developed countries hold a substantially larger fraction of domestic sovereign bonds compared with, e.g. European banks.

GIIPS countries during the European sovereign debt crisis and even became stronger through the re-nationalization of sovereign debt when the crisis deepened in 2011 and 2012 (Farhi and Tirole, 2016). Moreover, cross-border holdings can further enhance financial stability as they reduce the risks of fire sales (Diamond and Rajan, 2011). Risky sovereign debt is held in the portfolios of safer banks that are less in need of deleveraging which stabilizes asset prices. This might even attract non-bank investors and thus increases a country's funding base.[32] In other words, there are both benefits and costs of financial integration through cross-border sovereign bond holdings and it is an important question whether the costs outweigh the benefits. More research is needed to understand this trade-off.

[32] Acharya et al. (2016b) argue that the Outright Monetary Transaction (OMT) Program of the ECB was supposed to achieve this. The credible commitment to provide liquidity to the market (instead of the banks) through asset purchases stabilized prices of particularly Italian and Spanish sovereign bonds. This attracted non-bank financial firms allowing Italian and Spanish banks to de-lever by selling some of their sovereign bonds.

References

Acharya, V. V., Drechsler, I., and Schnabl, P. (2014a). A pyrrhic victory? Bank bailouts and sovereign credit risk. Journal of Finance, 69 (5), 2689–2739.

Acharya, V. V., Engle, R., and Pierret, D. (2014b). Testing macroprudential stress tests: The risk of regulatory risk weights. Journal of Monetary Economics, 65, 36-53.

Acharya, V. V., Mehran, H., and Thakor, A. V. (2016a). Caught between Scylla and Charybdis? Regulating bank leverage when there is rent seeking and risk shifting. Review of Corporate Finance Studies, 5 (1), 36-75.

Acharya, V. V., Pierret, D, and Steffen, S. (2016b). Lender of Last Resort versus Buyer of Last Resort - Evidence from the European Sovereign Debt Crisis, Working Paper.

Acharya, V. V., and Steffen, S. (2015). The "greatest" carry trade ever? Understanding eurozone bank risks. Journal of Financial Economics, 115 (2), 215-236.

Adamti, A., and Hellwig, M. (2013). The Banker's New Clothes, Princeton University Press.

Allen, F., Carletti, E., and Marquez, R. (2011). Credit market competition and capital regulation. Review of Financial Studies 24 (4), 983-1018.

Behn, M., Haselmann, R., and Vig, V. (2015). The Limits of Model-Based Regulation, Working Paper.

Beltratti, A. and R. Stulz (2015). Bank Sovereign Bond Holdings, Sovereign Shock Spillovers, and Moral Hazard during the European Crisis, Working Paper.

Berger, A. N., and Bouwman, C. H. S. (2013). How does capital affect bank performance during financial crises? Journal of Financial Economics, 109 (1), 146-176.

Bocola, L. (2014). The Pass-Through of Sovereign Risk, Working Paper.

Bolton, P., and Jeanne, O. (2011). Sovereign default risk and bank fragility in financially integrated economies. IMF Economic Review, 59 (2), 162-194.

Breckenfelder, J., and Schwaab, B. (2015). The bank-sovereign nexus across borders, Working Paper.

Bulow, J., and Rogoff, K. (1989). Sovereign debt: Is to forgive to forget? American Economic Review, 79 (1), 43-50.

Cooper, R. and Nikolov, K. (2013). Government Debt and Banking Fragility: The Spreading of Strategic Uncertainty, Working Paper.

Crosignani, M. (2015). Why are banks not recapitalized during crises? Working Paper.

DeMarco, F. and Macchiavelli, M. (2015). The Political Origin of Home Bias: The Case of Europe, Working Paper.

Diamond D., Rajan, R. (2011). Fear of fire sales, illiquidity seeking, and credit freezes, Quarterly Journal of Economics 126(2), 557-591.

Farhi, E., and Tirole, J. (2016). Deadly Embrace: Sovereign and Financial Balance Sheets Doom Loops, Working Paper.

Gennaioli, N., Martin, A., and Rossi, S. (2014). Sovereign Default, Domestic Banks, and Financial Institutions, Journal of Finance, 69(2), 819-866.

Gennaioli, N., Martin, A., and Rossi, S. (2016). Banks, Government Bonds, and Default: What Do the Data Say? Working Paper.

Holmström, B., and Tirole, J. (1997). Financial intermediation, loanable funds, and the real sector, Quarterly Journal of Economics 112, 663-692.

Hull, J., Predescu, M., and White, A. (2005). Bond Prices, Default Probabilities and Risk Premiums, Working Paper.

Kallestrup, R., Lando, D., and Murgoci, A. (2016). Financial Sector Linkages and the Dynamics of Bank and Sovereign Credit Spreads, Journal of Empirical Finance 38(A), 374-393.

Kapetanios, G., Pesaran, M. and Yamagata, T. (2011): 'Panels with Nonstationary Multifactor Error Structures', Journal of Econometrics Vol. 160, No. 2, pp. 326-348.

Mehran, H., and Thakor, A. V. (2011). Bank capital and value in the cross-section. Review of Financial Studies, 24 (4), 1019-1067.

Ongena, S., Popov, A. and van Horen, N. (2016). The invisible hand of the government: Moral suasion during the European sovereign debt crisis, Working Paper.

Pesaran, M. H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. Econometrica, 74 (4), 967-1012.

Pagano, M. and E. v. Thadden, The European Bond Markets under EMU, Oxford Review of Economic Policy 20, 2004, 531-554. Reprinted in X. Freixas, Ph. Hartmann, C. Mayer (eds.), *Handbook of European Financial Markets and Institutions*, Oxford University Press 2008.

Philippon, T. (2010). Debt Overhang and Recapitalization in Closed and Open Economies, IMF Economic Review.

Thakor, A. V. (2012). Incentives to innovate and financial crises. Journal of Financial Economics, 103 (1), 130-148.

Figure 1: The Case of Cyprus

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.

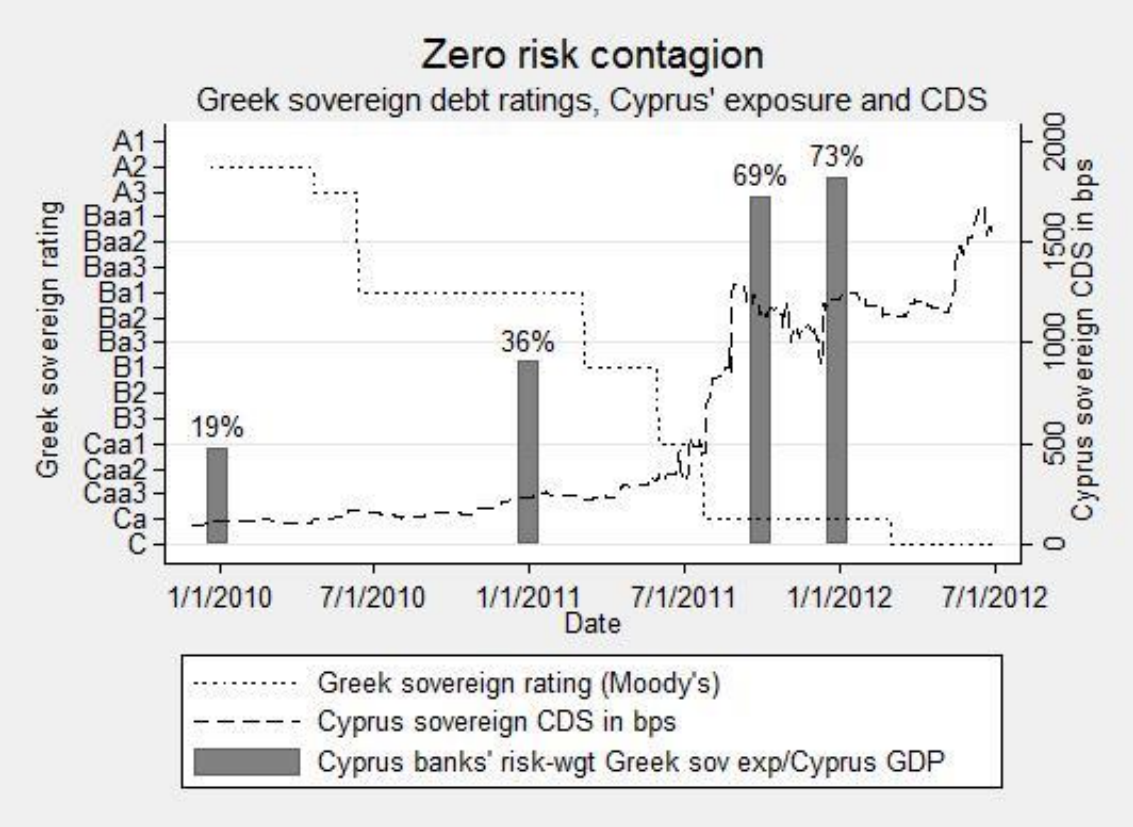


Figure 2: Sovereign subsidy: in peripheral and non-peripheral countries

These figures display the sovereign subsidy, a risk-weighted asset equivalent 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.

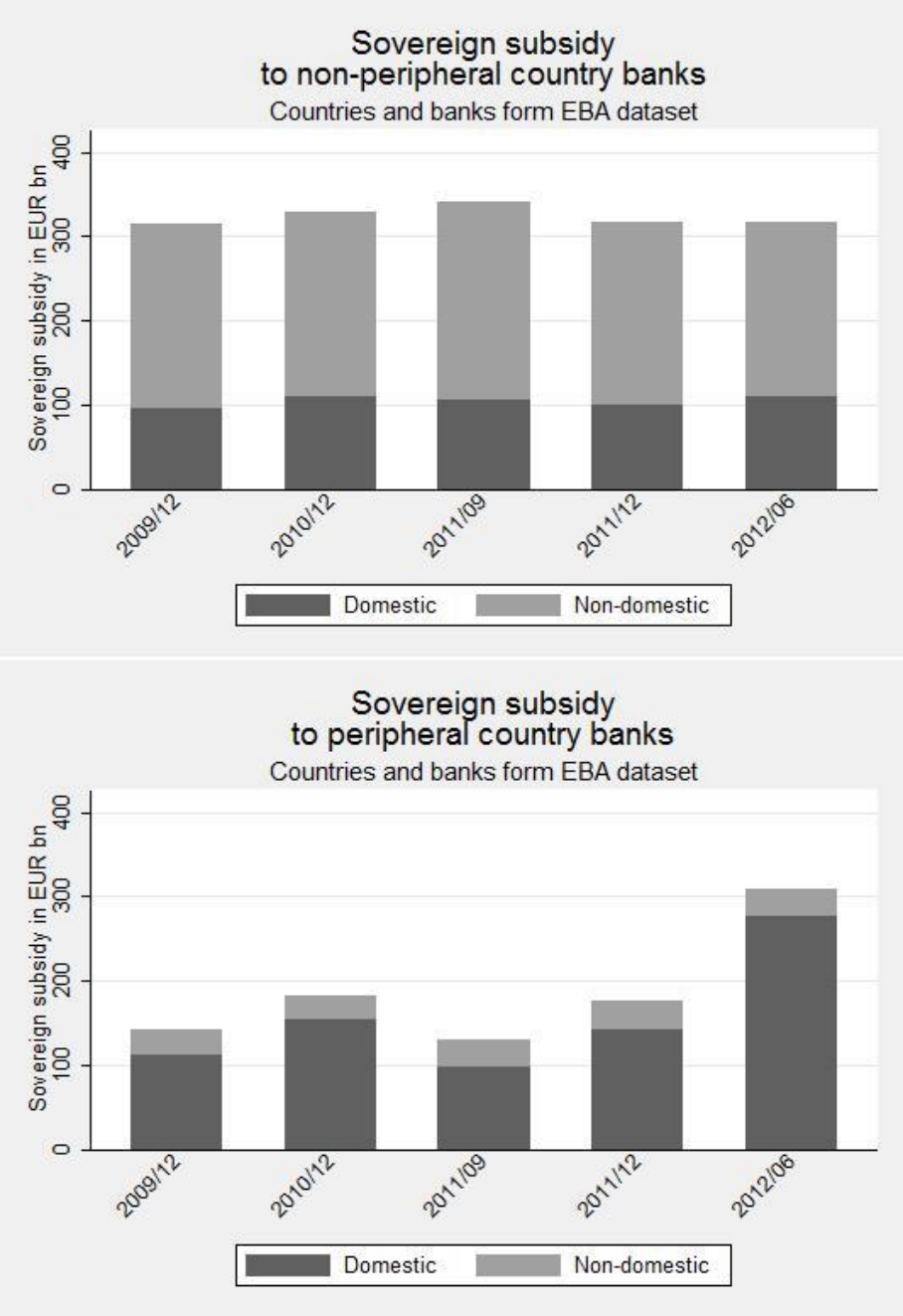


Figure 3: Domestic banks' non-domestic sovereign exposure and domestic sovereign CDS (BIS, up to 2011-Q3)

In this figure we plot 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 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).

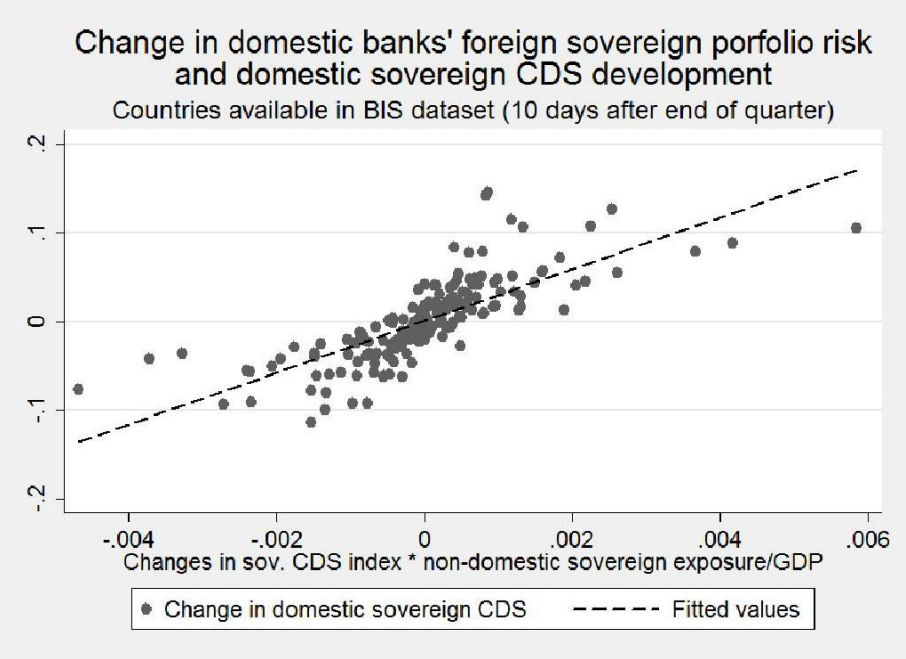
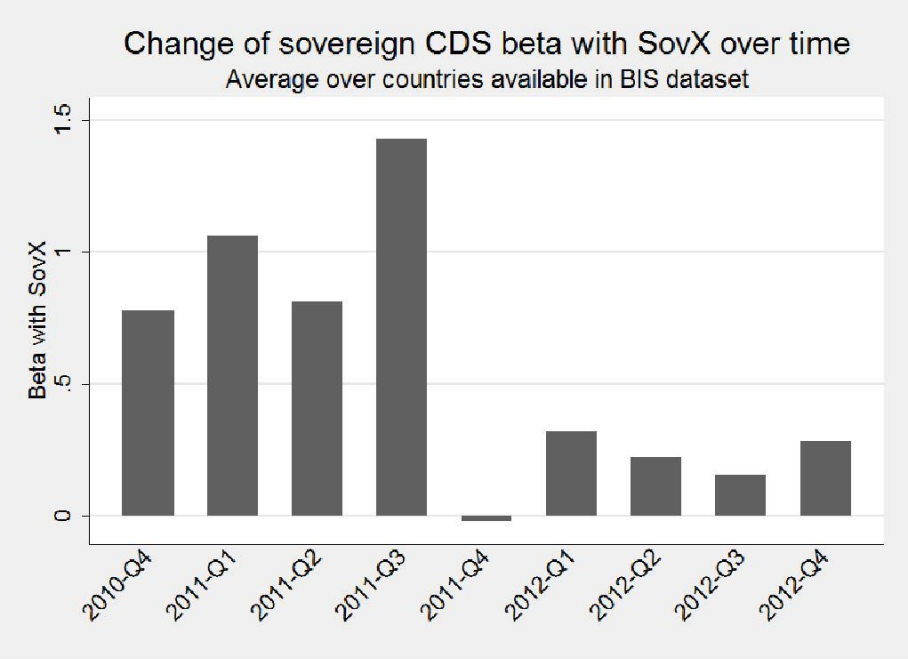


Figure 4: Betas of individual sovereign CDS and sovereign CDS market over time

This figure shows the development of the average beta of the available countries' CDS spread changes with the changes in a sovereign CDS index over time. The betas are obtained by regressing the change of a sovereign's CDS spread onto the changes of a sovereign CDS 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) in the upper panel 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) in the lower panel.



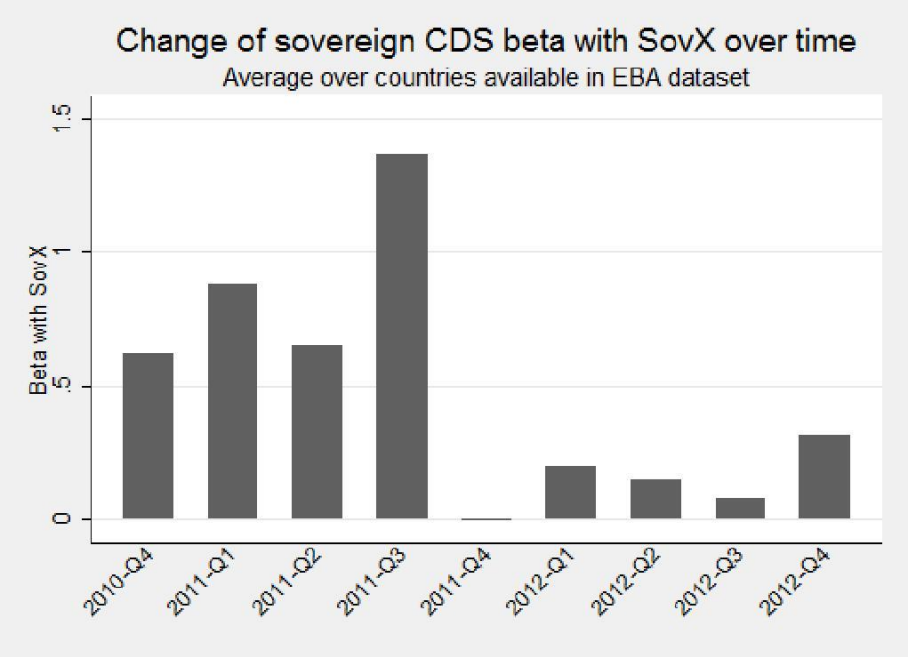


Table 1: Country-level sovereign exposure and sovereign subsidy

This table reports the total non-domestic EU sovereign exposure of those EU countries' financial sectors for which comprehensive data on cross-border bank exposure are available in the consolidated banking statistics of the BIS for the year-end of 2010, 2011, and 2012. In addition, it shows the relation of these exposures to GDP and reports the total amount of the sovereign subsidy, a risk-weighted asset equivalent of the non-domestic sovereign exposures of the respective financial sectors (using EBA risk weights) and the sovereign subsidy as a share of GDP. ***Panel A*** displays total financial sector exposures and subsidies to all non-domestic EU sovereigns, while ***Panels B and C*** report financial sector exposures and subsidies to non-domestic peripheral EU sovereigns (Greece, Ireland, Italy, Portugal, Spain) and other (non-peripheral) EU sovereigns, respectively.

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 (*in % of GDP*)		
	2010	**2011**	**2012**	**2010**	**2011**	**2012**
Banks in peripheral countries						
Ireland	6,550	10,778	10,890	1,266	1,814	1,764
	4.9%	*7.6%*	*7.3%*	*0.9%*	*1.3%*	*1.2%*
Italy	63,307	68,103	80,122	16,729	16,623	20,231
	4.5%	*4.6%*	*5.4%*	*1.2%*	*1.1%*	*1.4%*
Spain	52,220	48,892	74,115	11,193	16,364	21,990
	4.8%	*4.4%*	*6.6%*	*1.0%*	*1.5%*	*2.0%*
Banks in other countries						
Belgium	47,817	34,091	32,431	17,854	14,379	11,875
	15.7%	*10.7%*	*9.8%*	*5.8%*	*4.5%*	*3.6%*
France	227,701	182,334	210,061	57,555	63,756	74,947
	13.8%	*10.6%*	*11.7%*	*3.5%*	*3.7%*	*4.2%*
Germany	137,515	125,915	133,905	42,263	54,341	59,798
	6.0%	*5.2%*	*5.3%*	*1.9%*	*2.3%*	*2.4%*
U.K.	130,200	221,267	245,096	25,664	42,333	43,950
	7.9%	*13.3%*	*14.2%*	*1.6%*	*2.5%*	*2.5%*

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 (*in % of GDP*)		
	2010	**2011**	**2012**	**2010**	**2011**	**2012**
Banks in peripheral countries						
Ireland	1,528	352	277	453	259	204
	1.1%	*0.2%*	*0.2%*	*0.3%*	*0.2%*	*0.1%*
Italy	6,535	5,739	4,715	3,004	3,269	3,914
	0.5%	*0.4%*	*0.3%*	*0.2%*	*0.2%*	*0.3%*
Spain	13,619	11,899	12,140	5,453	9,544	11,582
	1.3%	*1.1%*	*1.1%*	*0.5%*	*0.9%*	*1.0%*
Banks in other countries						
Belgium	18,585	9,475	5,875	6,320	6,160	4,229
	6.1%	*3.0%*	*1.8%*	*2.1%*	*1.9%*	*1.3%*
France	113,806	69,791	71,709	39,169	44,424	51,993
	6.9%	*4.1%*	*4.0%*	*2.4%*	*2.6%*	*2.9%*
Germany	77,395	61,619	56,705	29,208	40,360	43,765
	3.4%	*2.6%*	*2.3%*	*1.3%*	*1.7%*	*1.7%*
U.K.	22,890	15,145	11,076	9,052	11,453	9,051
	1.4%	*0.9%*	*0.6%*	*0.6%*	*0.7%*	*0.5%*

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 (*in % of GDP*)		
	2010	**2011**	**2012**	**2010**	**2011**	**2012**
Banks in peripheral countries						
Ireland	5,022	10,426	10,613	814	1,555	1,561
	3.8%	*7.3%*	*7.1%*	*0.6%*	*1.1%*	*1.0%*
Italy	56,772	62,364	75,407	13,725	13,354	16,317
	4.0%	*4.2%*	*5.0%*	*1.0%*	*0.9%*	*1.1%*
Spain	38,601	36,993	61,976	5,741	6,820	10,408
	3.6%	*3.4%*	*5.5%*	*0.5%*	*0.6%*	*0.9%*
Banks in other countries						
Belgium	29,232	24,616	26,556	11,534	8,220	7,646
	9.6%	*7.7%*	*8.0%*	*3.8%*	*2.6%*	*2.3%*
France	113,895	112,543	138,352	18,386	19,332	22,954
	6.9%	*6.5%*	*7.7%*	*1.1%*	*1.1%*	*1.3%*
Germany	60,120	64,297	77,200	13,054	13,981	16,034
	2.6%	*2.7%*	*3.1%*	*0.6%*	*0.6%*	*0.6%*
U.K.	107,310	206,122	234,020	16,611	30,880	34,900
	6.5%	*12.4%*	*13.6%*	*1.0%*	*1.9%*	*2.0%*

Table 2: Summary statistics BIS data

This table reports the summary statistics of the main variables using the BIS dataset. Appendix 1 provides variable descriptions and information on the data sources.

Variable	Unit	Mean	Std. Dev.	Min.	Max.	N
Dependent variable						
Δ*Log CDS*	percent	-0.17	3.82	-21.76	18.73	2,646
Explanatory variables						
Δ*Log CDS index (individual weights)*	percent	-0.14	3.33	-15.94	13.32	2,646
Bank exposure to non-domestic sovereigns/GDP	percent	8.6	3.75	4.42	18.22	2,646
Sovereign subsidy/GDP	percent	2.46	1.37	0.93	6.42	2,646
RWA coverage ratio	percent	1.77	0.56	0.87	2.60	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
Controls						
iTraxx	index pts	134.23	31.23	94.2	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	52.41	39.27	6	171.5	2,646
Euribor (12 months)	bps	150.3	57.18	53.7	220.1	2,646
Term spread	bps	97.89	31.72	41.1	160.9	2,646
EUR exchange rate	ratio	100.74	2.94	94.45	106.91	2,646
GDP	mn EUR	1,255,582	746,400	132,538	2,562,339	2,646
Capital ratio	percent	4.9	1.22	3	7.77	2,646
Deposit ratio	percent	38.54	9.29	18.4	54.11	2,646
Funding fragility	percent	128.31	23.49	87.1	198.1	2,646
Income diversity	percent	62.55	10.38	49.18	83.88	2,646
Liquidity ratio	percent	11.86	2.78	6.51	18.08	2,646
Concentration	percent	10.65	4.18	6.03	19.29	2,646

Table 3: Sovereign subsidy and sovereign risk

Panel A of this table reports the results from regressions of changes in individual sovereign CDS spreads on changes in a European sovereign CDS index, the sovereign subsidy (i.e., risk-weighted exposures of the domestic financial sector toward non-domestic EU sovereigns), and the interaction between both variables. The sovereign CDS index is weighted by the non-domestic sovereign exposure of a country's financial sector. CDS changes are computed on a daily level, covering ± 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). Control variables include market determinants of the changes in sovereign CDS spreads (i.e., the changes in the iTraxx index, in the stock market total return index, in overall volatility, in the term spread, and in the EUR effective exchange rate) and bank sector controls (i.e., capital ratio, deposit ratio, funding fragility, income diversity, liquidity, and bank sector concentration). The models in columns (3) to (5) additionally control for week fixed effects and/or country-quarter fixed effects. ***Panel B*** reports the results of several robustness checks. 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) to (3), (7) and (8) use the BIS data, while columns (4) to (6) use EBA data. Column (1) reports a regression of changes in individual sovereign bond yields on changes in a sovereign bond yield index, the sovereign subsidy (i.e., risk-weighted exposures of the domestic financial sector toward non-domestic EU sovereigns), and the interaction between these two variables. The sovereign bond yield index is weighted by the non-domestic sovereign exposures of a country's financial system. Column (2) reports a regression of changes in individual sovereign CDS on changes in a European sovereign CDS 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. Column (3) adds interactions between the European sovereign CDS index and all bank characteristics to the baseline specification from Table 3A. Column (4) uses the full EBA data aggregated at the country level, while column (5) excludes Belgium from the estimation sample and column (6) excludes the three largest banks in France and Germany, respectively, to estimate the baseline specification from Table 3A. Column (7) reports results from a regression of changes in individual sovereign CDS on changes in a European sovereign CDS index, the sovereign exposure (EAD), and the interaction between these two variables. Column (8) reports results from a regression of changes in individual sovereign CDS on changes in a European sovereign CDS index, the sovereign subsidy where the sovereign exposure at the beginning of the sample period is used as an instrument, and the interaction between these two variables. Control variables include market determinants of the changes in sovereign CDS spreads (i.e., the changes in the iTraxx index, in the stock market total return index, in overall volatility, in the term spread, and in the EUR effective exchange rate). All regressions control for week and country-quarter fixed effects. Robust standard errors are reported in parentheses. Significance levels are indicated by *** p<.01, ** p<.05, * p<.1.

(continued on next page)

Panel A: Baseline results

Model	**(1) OLS**	**(2) OLS**	**(3) FE**	**(4) FE**	**(5) FE**
Dep. variable			**Δ Log CDS**		
ΔLogCDS Index x Sovereign Subsidy/GDP	4.026***	4.058***	4.062***	4.085***	4.080***
	(1.063)	(1.058)	(1.021)	(1.090)	(1.048)
ΔLogCDS Index	0.846***	0.766***	0.705***	0.762***	0.708***
	(0.036)	(0.042)	(0.042)	(0.042)	(0.043)
Sovereign Subsidy/GDP	-0.030	0.004	0.002		
	(0.029)	(0.044)	(0.045)		
ΔiTraxx		0.151***	0.174***	0.151***	0.171***
		(0.034)	(0.036)	(0.034)	(0.036)
ΔDS Equity Index		0.069	-0.011	0.062	-0.010
		(0.065)	(0.071)	(0.064)	(0.071)
ΔVSTOXX		-0.005	-0.013	-0.005	-0.013
		(0.011)	(0.013)	(0.011)	(0.013)
ΔTerm Spread		-0.004	-0.003	-0.004	-0.003
		(0.004)	(0.004)	(0.004)	(0.004)
ΔEUR Exchange Rate		-0.182	-0.133	-0.185	-0.128
		(0.159)	(0.184)	(0.163)	(0.184)
Capital Ratio		0.026	0.021		
		(0.076)	(0.079)		
Deposit Ratio		0.005	0.006		
		(0.013)	(0.014)		
Funding Fragility		0.005	0.005		
		(0.004)	(0.004)		
Income Diversity		0.002	0.002		
		(0.008)	(0.008)		
Liquidity		0.020	0.020		
		(0.036)	(0.036)		
Concentration		-0.032	-0.031		
		(0.028)	(0.028)		
Constant	YES	YES	YES	YES	YES
Week 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^2 (adj.)	0.683	0.687	0.686	0.687	0.686

Panel B: Robustness tests

Dep. variable	**(1)** **ΔLog Bond Yield**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
					ΔLog CDS			
Robustness	**Altern. dependent variable: Bond Yields**	**Altern. exposure risk weight: CDS implied**	**All bank character-istics interacted with CDS Index**	**EBA country aggregates full sample**	**EBA country aggregates without Belgium**	**EBA country aggregates without three largest banks in France and Germany**	**Sovereign Exposure (EAD)**	**Instrumented Sovereign Exposure**
Δ*Bond Index x Sovereign Subsidy/GDP*	22.700***							
	(2.734)							
Δ*LogCDS Index x Sovereign Subsidy/GDP*		2.005***	8.886***	3.054***	3.922***	2.409***		3.179***
		(0.651)	(1.882)	(0.671)	(1.026)	(0.634)		(0.789)
Δ*LogCDS Index x EAD/GDP*							-0.598	
							(0.439)	
Δ*Bond Index*	-0.115							
	(0.090)							
Δ*LogCDS Index*		0.723***	-1.892***	0.711***	0.695***	0.730***	0.862***	0.605***
		(0.046)	(0.427)	(0.034)	(0.037)	(0.033)	(0.050)	(0.038)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES	YES	YES	YES
Week FE	YES	YES	YES	YES	YES	YES	YES	YES
Country-Quarter FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	2,347	2,352	2,646	3,592	3,383	3,592	2,646	2,646
R^2 (adj.)	0.125	0.695	0.699	0.522	0.508	0.520	0.684	0.656

Table 4: Distinguishing between exposures of non-GIIPS versus GIIPS countries

Panel A of Table 4 reports the results from a regression of changes in individual sovereign CDS on changes in a European sovereign CDS index, the sovereign subsidy (i.e., risk-weighted exposures of the domestic financial sector toward non-domestic EU sovereigns), and the interaction between both variables for a subsample of non-GIIPS banks' foreign sovereign exposures. ***Panel B*** reports the respective results for a subsample of GIIPS banks' foreign sovereign exposures. Both panels use BIS data. The sovereign CDS index is weighted by the non-domestic sovereign exposures of a country's financial sector. CDS changes are computed on a daily level, covering ± 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). Control variables include market determinants of the changes in sovereign CDS spreads (i.e., the changes in the iTraxx index, in the stock market total return index, in overall volatility, in the term spread, and in the EUR effective exchange rate) and bank sector controls (i.e., capital ratio, deposit ratio, funding fragility, income diversity, liquidity, and bank sector concentration). The FE models additionally control for week fixed effects and/or country-quarter fixed effects. Robust standard errors are reported in parentheses. Significance levels are indicated by *** p<.01, ** p<.05, * p<.1.

Panel A: Foreign sovereign exposures of non-GIIPS countries

Model	**(1) OLS**	**(2) OLS**	**(3) FE**	**(4) FE**	**(5) FE**
Dep. variable			**ΔLog CDS**		
ΔLogCDS Index x Sovereign Subsidy/GDP	7.023***	7.049***	7.119***	7.367***	7.410***
	(1.435)	(1.434)	(1.454)	(1.455)	(1.468)
ΔLogCDS Index	0.722***	0.709***	0.620***	0.691***	0.613***
	(0.056)	(0.065)	(0.066)	(0.064)	(0.066)
Sovereign Subsidy/GDP	-0.068*	-0.015	-0.010		
	(0.041)	(0.068)	(0.082)		
Controls	NO	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES
Week FE	NO	NO	YES	NO	YES
Country-Quarter FE	NO	NO	NO	YES	YES
Observations	1,512	1,512	1,512	1,512	1,512
R^2 (adj.)	0.732	0.732	0.732	0.732	0.732

Panel B: Foreign sovereign exposures of GIIPS countries

Model	**(1) OLS**	**(2) OLS**	**(3) FE**	**(4) FE**	**(5) FE**
Dep. variable			**ΔLog CDS**		
ΔLogCDS Index x Sovereign Subsidy/GDP	1.204	2.397	7.014	3.239	7.917
	(11.693)	(11.195)	(10.130)	(11.300)	(10.324)
ΔLogCDS Index	0.918***	0.731***	0.680***	0.726***	0.669***
	(0.156)	(0.156)	(0.146)	(0.157)	(0.148)
Sovereign Subsidy/GDP	0.270	0.294	0.209		
	(0.269)	(0.316)	(0.384)		
Controls	NO	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES
Week FE	NO	NO	YES	NO	YES
Country-Quarter FE	NO	NO	NO	YES	YES
Observations	1,134	1,134	1,134	1,134	1,134
R^2 (adj.)	0.625	0.642	0.670	0.642	0.669

Table 5: Bank-level data

This table reports the results from regressions of changes in individual bank CDS on changes in a European sovereign CDS index, the sovereign subsidy, and the interaction between these two variables using the EBA data at the bank level. Columns (1) to (4) show results for the full sample, columns (5) and (6) for the subsample of non-GIIPS banks and columns (7) and (8) for the subsample of GIIPS banks. All models include bank and country-quarter fixed effects and interactions of bank fixed effects with the change in the CDS market index (iTraxx) and the change in the volatility index (VSTOXX). Columns (2), (4), (6) and (8) also include week fixed effects. CDS spread changes are computed on a daily level, covering ± 30 days around the exposure reporting date (December 2009, December 2010, October 2011, December 2011, and June 2012) and the sovereign CDS index is weighted by the fixed non-domestic sovereign exposure of a country's financial system. Columns (3) to (8) additionally control for the change in the domestic sovereign CDS spread. Robust standard errors are reported in parentheses. Significance levels are indicated by *** p<.01, ** p<.05, * p<.1.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model	**FE**	**FE**	**FE**	**FE**	**FE**	**FE**	**FE**	**FE**
Sample		**Full sample**			**non-GIIPS banks**		**GIIPS banks**	
Dep. variable				**ΔLog Bank CDS**				
ΔLogCDS Index x Sovereign Subsidy/Total assets	4.984**	4.476**	4.874***	4.351**	5.464***	4.410**	-0.786	-0.790
	(2.068)	(1.998)	(1.760)	(1.693)	(1.613)	(1.617)	(1.756)	(1.868)
ΔLogCDS Index	0.091***	0.096***	0.032	0.037	0.136***	0.147***	0.001	0.003
	(0.032)	(0.034)	(0.032)	(0.032)	(0.035)	(0.035)	(0.021)	(0.018)
Sovereign Subsidy/Total assets	-0.084	-0.084	-0.086	-0.086	-0.122	-0.122	0.127	0.060
	(0.083)	(0.078)	(0.082)	(0.076)	(0.083)	(0.079)	(0.189)	(0.179)
ΔLogCDS Domestic			0.097***	0.109***	0.033*	0.046***	0.131***	0.162***
			(0.024)	(0.022)	(0.017)	(0.016)	(0.031)	(0.030)
Bank-level betas on market return and volatility	YES	YES	YES	YES	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES	YES	YES	YES
Week FE	NO	YES	NO	YES	NO	YES	NO	YES
Country-Quarter FE	YES	YES	YES	YES	YES	YES	YES	YES
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	7,673	7,673	7,673	7,673	4,926	4,926	2,747	2,747
R^2 (adj.)	0.395	0.436	0.400	0.442	0.428	0.464	0.366	0.432

Table 6: Other potential channels

This table reports results from taking other potential transmission channels into account using the BIS data. Columns (1) and (2) report results from regressions of changes in individual sovereign CDS on changes in a European sovereign CDS index, the sovereign subsidy (i.e., risk-weighted exposures of the domestic financial sector toward non-domestic EU sovereigns), and the interaction between these two variables accounting for unobserved common factors with heterogeneous factor loadings by applying the Pesaran CCE estimator. Standard errors are bootstrapped. The models in columns (3) and (4) 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. Columns (5) to (8) focus on the non-sovereign quasi-subsidy (i.e., risk-weighted exposures of the domestic financial sector toward non-domestic EU non-sovereigns such as banks, firms and households) and its interaction with changes in a European sovereign CDS index. In all models, the sovereign CDS index is weighted by the non-domestic sovereign exposure of a country's financial system. CDS changes are computed on a daily level, covering ± 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). Control variables include market determinants of the changes in sovereign CDS spreads (i.e., the changes in the iTraxx index, in the stock market total return index, in overall volatility, in the term spread, and in the EUR effective exchange rate). The FE models additionally control for week and country-quarter fixed effects. Robust standard errors are reported in parentheses. Significance levels are indicated by *** p<.01, ** p<.05, * p<.1.

Model	**(1)** **CCE**	**(2)** **CCE**	**(3)** **OLS**	**(4)** **FE**	**(5)** **OLS**	**(6)** **FE**	**(7)** **OLS**	**(8)** **FE**
Dep. variable					**ΔLog CDS**			
Channel	**Cross-country linkages**		**Mutual bailout responsibility**				**Quasi non-sovereign subsidy**	
ΔLogCDS Index x Sovereign Subsidy/GDP	3.585***	3.638***	4.441***	4.494***			6.960***	7.067***
	(1.104)	(1.226)	(1.088)	(1.079)			(1.269)	(1.236)
ΔLogCDS Index x ECB Share			1.175***	1.154***				
			(0.170)	(0.169)				
ΔLogCDS Index x Debt Ratio			0.093	0.092				
			(0.092)	(0.088)				
ΔLogCDS Index x Non-Sovereign Quasi-Subsidy/GDP					-0.393	-0.396	-1.893***	-1.935***
					(0.439)	(0.429)	(0.533)	(0.518)
ΔLogCDS Index	0.844***	0.745***	0.604***	0.474***	0.995***	0.857***	1.004***	0.869***
	(0.041)	(0.048)	(0.093)	(0.094)	(0.060)	(0.063)	(0.060)	(0.064)
Sovereign Subsidy/GDP			-0.026				-0.041	
			(0.029)				(0.032)	
ECB Share			0.008*					
			(0.004)					
Debt Ratio			-0.001					
			(0.002)					
Non-Sovereign Quasi-Subsidy/GDP					-0.001		0.004	
					(0.010)		(0.012)	
Constant	YES	YES	YES	YES	YES	YES	YES	YES
Avg. of ΔLogCDS, ΔLogCDS Index x Sovereign Subsidy/GDP, ΔLogCDS Index and Sovereign Subsidy/GDP, interactions with Country-Quarter FE	YES	YES	NO	NO	NO	NO	NO	NO
Controls, Week FE, Country-Quarter FE	NO	YES	NO	YES	NO	YES	NO	YES
Observations	2,646	2,646	2,646	2,646	2,646	2,646	2,646	2,646
R^2 (adj.)	0.718	0.716	0.692	0.696	0.680	0.684	0.685	0.689

Table 7: Falsification tests (non-EU sovereigns)

This table reports the results from 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). In ***Panel A***, 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 the 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 non-domestic sovereign exposure of a country's financial sector. ***Panel B*** focuses on times of large sovereign CDS spread increases. 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 in 2011-Q1 and 2011-Q2. Columns (3) and (4) report regressions of changes in individual sovereign CDS on changes in the Japanese sovereign CDS, the Japanese quasi-sovereign subsidy (i.e., risk weighted exposures of the domestic banking sector toward the Japanese sovereign), and the interaction between these two variables in 2011-Q2 to 2011-Q4. The FE models additionally control for week 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: Full sample period

Model	**(1) OLS**	**(2) FE**	**(3) OLS**	**(4) FE**
Dep. variable	**ΔLog CDS**			
Falsification	**US exposure**		**non-EU exposure (CH/JP/NO/US)**	
ΔLogUS CDS x US Quasi-Sovereign Subsidy/GDP	-1.842	-1.618		
	(5.659)	(4.178)		
ΔLogNon-EU CDS Index x Non-EU Quasi-Sovereign Subsidy/GDP			-0.622	-0.413
			(4.610)	(3.469)
ΔLog US CDS	0.622***	0.259***		
	(0.049)	(0.040)		
ΔLog Non-EU CDS Index			0.796***	0.326***
			(0.057)	(0.047)
US Quasi-Sovereign Subsidy/GDP	0.033			
	(0.096)			
Non-EU Quasi-Sovereign Subsidy/GDP			0.020	
			(0.065)	
Controls	NO	YES	NO	YES
Constant	YES	YES	YES	YES
Week FE	NO	YES	NO	YES
Country-Quarter FE	NO	YES	NO	YES
Observations	2,597	2,597	2,646	2,646
R^2 (adj.)	0.200	0.571	0.233	0.573

Panel B: Periods of sharp CDS spread increases in the U.S. and Japan

	(1)	(2)	(3)	(4)
Model	**OLS**	**FE**	**OLS**	**FE**
Dep. variable	**ΔLog CDS**			
Falsification	**US exposure**		**Japanese exposure**	
ΔLogUS CDS x US Quasi-Sovereign Subsidy/GDP	-7.770	-6.506		
	(10.901)	(7.274)		
ΔLogJapanese CDS x Japanese Quasi-Sovereign Subsidy/GDP			12.063	12.802
			(23.160)	(16.501)
ΔLog US CDS	0.752***	0.184***		
	(0.091)	(0.063)		
ΔLog Japanese CDS			0.282***	0.016
			(0.062)	(0.047)
US Quasi-Sovereign Subsidy/GDP				
Japanese Quasi-Sovereign Subsidy/GDP	-0.110		0.041	
	(0.226)		(0.744)	
Controls	NO	YES	NO	YES
Constant	YES	YES	YES	YES
Week FE	NO	YES	NO	YES
Country-Quarter FE	NO	YES	NO	YES
Observations	581	581	826	826
R^2 (adj.)	0.272	0.675	0.045	0.616

Table 8: Sovereign risk spillovers and bank capitalization

This table reports the results of tests using the BIS data and controlling for potential risk mitigation measures by banks. All columns report regressions of changes in individual sovereign CDS on changes in a European sovereign CDS 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 non-domestic sovereign exposure of a country's financial system. 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). In addition, columns (1) and (2) contain interactions with the average risk-weighted asset coverage ratio of European sovereign bond exposures by country and columns (3) and (4) interactions with the average bank capital ratio by country and period. Control variables include market determinants of the changes in sovereign CDS spreads (i.e., the changes in the iTraxx index, in the stock market total return index, in overall volatility, in the term spread, and in the EUR effective exchange rate). The FE models additionally control for week and country-quarter fixed effects. Robust standard errors are reported in parentheses. Significance levels are indicated by *** p<.01, ** p<.05, * p<.1.

Model	**(1)** **OLS**	**(2)** **FE**	**(3)** **OLS**	**(4)** **FE**
Dep. variable			**ΔLog CDS**	
ΔLogCDS Index x Sovereign Subsidy/GDP	22.313***	22.180***	13.167***	12.756***
	(5.315)	(5.306)	(4.269)	(4.298)
ΔLogCDS Index	0.567***	0.418***	0.528***	0.400***
	(0.127)	(0.127)	(0.142)	(0.144)
Sovereign Subsidy/GDP	0.179		-0.087	
	(0.132)		(0.097)	
RWA Coverage x ΔLogCDS Index x Sovereign Subsidy/GDP	-8.837***	-8.806***		
	(2.549)	(2.551)		
RWA Coverage x ΔLogCDS Index	0.136**	0.144**		
	(0.064)	(0.063)		
RWA Coverage x Sovereign Subsidy/GDP	-0.105			
	(0.065)			
RWA Coverage	0.002			
	(0.002)			
Capital Ratio x ΔLogCDS Index x Sovereign Subsidy/GDP			-1.563**	-1.482**
			(0.748)	(0.756)
Capital Ratio x ΔCDS Index			0.053**	0.051**
			(0.023)	(0.023)
Capital Ratio x Sovereign Subsidy/GDP			0.012	
			(0.016)	
Capital Ratio			-0.000	
			(0.001)	
Controls	NO	YES	NO	YES
Constant	YES	YES	YES	YES
Week FE	NO	YES	NO	YES
Country-Quarter FE	NO	YES	NO	YES
Observations	2,646	2,646	2,646	2,646
R^2 (adj.)	0.685	0.688	0.684	0.687

Table 9: The September 2011 capital exercise

This table reports the results from a regression of changes in individual sovereign CDS on changes in a European sovereign CDS 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 using the BIS data. The sovereign CDS index is weighted by the non-domestic sovereign exposures of a country's financial system. CDS changes are computed on a daily level, covering ±30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). Column (1) displays the results for the before-CE period up to 2011-Q3. Column (2) shows results for the after-CE period starting from 2011-Q4, while column (3) focuses on the after-CE period starting from 2012-Q1 and column (4) on the after-CE period starting from 2012-Q2 (when the new sovereign buffer actually became required in June 2012). The models in columns (5) to (8) display the results from the before- and after CE regressions controlling for week and country-quarter fixed effects. Control variables include market determinants of the changes in sovereign CDS spreads (i.e., the changes in the iTraxx index, in the stock market total return index, in overall volatility, in the term spread, and in the EUR effective exchange rate). Robust standard errors are reported in parentheses. Significance levels are indicated by *** p<.01, ** p<.05, * p<.1.

Model	**(1) OLS**	**(2) OLS**	**(3) OLS**	**(4) OLS**	**(5) FE**	**(6) FE**	**(7) FE**	**(8) FE**
Dep. variable				**Δ Log CDS**				
Sample	**Before CE**	**After CE (starting 2011-Q4)**	**After CE (starting 2012-Q1)**	**After CE (starting 2012-Q2)**	**Before CE**	**After CE (starting 2011-Q4)**	**After CE (starting 2012-Q1)**	**After CE (starting 2012-Q2)**
ΔLogCDS Index x Sovereign Subsidy/GDP	3.945***	4.072*	2.154	0.711	4.040***	4.026*	1.960	0.306
	(1.165)	(2.471)	(2.987)	(3.597)	(1.164)	(2.339)	(2.753)	(3.276)
ΔLogCDS Index	0.864***	0.826***	0.871***	0.930***	0.759***	0.660***	0.669***	0.722***
	(0.041)	(0.074)	(0.090)	(0.107)	(0.054)	(0.079)	(0.092)	(0.105)
Sovereign Subsidy/GDP	-0.026	-0.038	-0.041	-0.049				
	(0.036)	(0.045)	(0.053)	(0.067)				
Controls	NO	NO	NO	NO	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES	YES	YES	YES
Time FE	NO	NO	NO	NO	YES	YES	YES	YES
Country-Quarter FE	NO	NO	NO	NO	YES	YES	YES	YES
Observations	1,176	1,470	1,176	882	1,176	1,470	1,176	882
R^2 (adj.)	0.730	0.625	0.606	0.605	0.731	0.631	0.620	0.622

Appendix 1: Variable 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), and SNL Financial (SNL).

Variable	Source	Definition
Sovereign CDS	BB	Five-year CDS spreads of a European sovereign (in bps)
ΔLog CDS	BB	Daily changes in five-year CDS spreads of a European sovereign
Sovereign bond yield	BB	Yields of 10 year bonds issued by a European sovereign (in bps)
ΔLog bond yield	BB	Daily returns of 10 year bonds issued by a European sovereign
ΔLogCDS index	BB, BIS	Daily returns of an index covering five-year CDS spreads of European sovereigns weighted by the non-domestic exposures of a country's financial system
ΔBond index	BB, BIS	Daily returns of an index covering 10 year bond yields of European sovereigns weighted by the non-domestic exposures of a country's financial system
Bank exposure to non- domestic sovereigns	BIS	Exposures of the domestic financial sector to non-domestic EU sovereigns
Sovereign subsidy (EBA risk weights)	BIS, EBA	Exposures of the domestic financial 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 financial sector to non-domestic EU sovereigns, risk weighted by weights implied by sovereign CDS spreads
GDP	OECD	Gross domestic product of individual European countries
RWA coverage	EBA	Ratio of risk weighted assets for EU sovereign exposure to total EU sovereign exposure of country level financial sector
ECB capital share	ECB	Share of a country's national central bank in the subscribed capital of the ECB (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 GDP
ΔiTraxx	DS	Daily changes in the index covering CDS spreads of the 125 most liquid CDSs referencing European investment grade credits (continuous series)
ΔDS equity index	DS	Daily changes in the total return index for the European stock market
ΔVSTOXX	DS	Daily changes in the index measuring volatility in the European stock market (referencing the EURO STOXX 50)
ΔEONIA	DS	Daily changes in the effective overnight interest rate for the euro interbank market (euro overnight index average)
ΔEuribor (12 months)	DS	Daily changes in the effective 12-month interest rate for the euro interbank market (euro interbank offered rate)
ΔTerm spread	DS	Daily changes in the difference between 12-month interest rate (12-month Euribor) and the overnight interest rate (EONIA)
ΔEUR exchange rate	ECB	Nominal effective exchange rate, Euro area-18 countries vis-à-vis the EER-20 group of trading partners (AU, CA, DK, HK, JP, NO, SG, KR, SE, CH, GB, US, BG, CZ, LT, HU, PL, RO, HR and CN) against the euro
Capital ratio	SNL	Ratio of equity to total assets of country level financial sector
Deposit ratio	SNL	Ratio of deposits to total assets of country level financial sector
Funding fragility	SNL	Ratio of net loans to deposits of country level financial sector
Income diversity	SNL	Ratio of net interest income to total operating income of country level financial sector
Liquidity	SNL	Ratio of cash and cash equivalents to total assets of country level financial sector
Concentration	SNL	Herfindahl-Hirschman index, sum of the squared market shares of all available banks, computed on the country level using total assets

Appendix 2: Calculation of risk weights

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

$$K = \left[LGD * N\left[(1-R)^{-0.5} * G(PD) + \left(\frac{R}{1-R}\right)^{-0.5} * G(0.999)\right] - PD * LGD\right] * (1 - 1.15 * b)^{-1} * [1 + (M - 2.5) * b]$$

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

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

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

$$RWA = RW * EAD$$

Appendix 3 provides an overview of the resulting risk weights.

Appendix 3: Ratings, risk weights and the computation of the sovereign subsidy

This table reports risk weights which are consistent with EBA stress test assumptions on probability of defaults (PDs) for rating classes and standard assumptions on loss given default (LGD) (45%) and maturity (2.5 years) and computed according to the Basel F-IRB approach as described in Appendix 2. 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).

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%	1.91
B	B2	B	9.71%	1.91
B-	B3	B-	9.71%	1.91
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

Appendix 4: Country-specific exposures of non-GIIPS countries

This table reports the results from regressions of changes in individual sovereign CDS spreads on specific sovereign subsidies related to exposures to single GIIPS countries interacted with changes in the respective sovereign CDS spread. The regressions use BIS data on the non-GIIPS countries. CDS changes are computed on a daily level, covering ± 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). Control variables include market determinants of the changes in sovereign CDS spreads (i.e., the changes in the iTraxx index, in the stock market total return index, in overall volatility, in the term spread, and in the EUR effective exchange rate). The FE models additionally control for week and country-quarter fixed effects. Robust standard errors are reported in parentheses. Significance levels are indicated by *** p<.01, ** p<.05, * p<.1.

Model	**(1)** **OLS**	**(2)** **FE**	**(3)** **OLS**	**(4)** **FE**	**(5)** **OLS**	**(6)** **FE**	**(7)** **OLS**	**(8)** **FE**	**(9)** **OLS**	**(10)** **FE**
Dep. variable					**ΔLog CDS**					
Country	**Spain**		**Italy**		**Ireland**		**Greece**		**Portugal**	
ΔLogCDS Country x Country Sovereign Subsidy/GDP	14.321	16.333	15.006***	15.272***	444.862***	117.439*	33.073***	9.836	69.091**	65.490***
	(16.812)	(13.169)	(3.673)	(3.044)	(93.132)	(70.102)	(10.961)	(6.590)	(30.076)	(21.477)
ΔLogCDS Country	0.530***	0.288***	0.424***	0.185***	0.057	0.070	-0.009	-0.030	0.303***	0.059
	(0.033)	(0.031)	(0.034)	(0.032)	(0.097)	(0.071)	(0.057)	(0.034)	(0.055)	(0.039)
Country Sovereign Subsidy/GDP	-0.778		-0.089		1.838		0.636		-0.275	
	(0.497)		(0.120)		(2.340)		(0.516)		(0.857)	
Controls	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Constant	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Week FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Country-Quarter FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Observations	1,512	1,512	1,512	1,512	1,512	1,512	840	840	1,512	1,512
R^2 (adj.)	0.487	0.632	0.510	0.637	0.251	0.588	0.109	0.604	0.206	0.593

Appendix 5: Summary statistics EBA data

This table reports the summary statistics for the main variables for the EBA data aggregated at the country level. Appendix 1 provides variable descriptions and information on the data sources.

Variable	Unit	Mean	Std. Dev.	Min.	Max.	N
Dependent variable						
Δ*Log CDS*	percent	-0.01	3.94	-30.85	45.39	3,592
Explanatory variables						
Δ*CDS index (ind. weights)*	percent	-0.04	3.31	-15.73	9.82	3,760
Bank exposure to non-domestic sovereigns/GDP	percent	7.77	8.71	0	39.9	3,969
Sovereign subsidy (EBA risk weights)/GDP	percent	4.1	10.71	0	69.55	3,969
Government debt ratio	percent	77.54	28.6	30.2	150.21	3,969
Controls						
iTraxx	index pts	140.58	43.55	65.3	207.96	3,969
DS equity index	index pts	1322.84	125.25	1129.06	1554.75	3,969
VSTOXX	index pts	29.2	8.16	18.36	53.55	3,969
EONIA	bps	52.84	28.9	11.1	146.3	3,969
Euribor (12 months)	bps	158.25	37.42	95.6	212.9	3,969
Term spread	bps	105.41	23.58	43.3	156.6	3,969
EUR exchange rate	ratio	102.29	4.92	94.45	113.52	3,969
GDP	mn EUR	604,845	690,916	5,651	2,630,331	3,969
Capital ratio	percent	6.48	2.65	2.55	14.29	3,845
Deposit ratio	percent	47.08	17.4	12.5	83.65	3,845
Funding fragility	percent	117.18	51.07	0	271.89	3,845
Income diversity	percent	62.73	43.14	-292.86	184.71	3,763
Liquidity ratio	percent	15.34	8.44	2.92	64.96	3,845
Concentration	percent	29.87	25.26	6.03	100.00	3,845