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"Zero Risk Contagion - Banks' Sovereign Exposure and Sovereign Risk Spillovers"

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Zero Risk Contagion -
Banks' Sovereign Exposure and Sovereign Risk Spillovers

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We investigate whether the application of risk weights impairs financial stability. Zero risk weight regulation associated with euro-denominated sovereign debt creates a "sovereign subsidy" for European banks, which amplifies the co-movement between sovereign credit default swap (CDS) spreads and a European sovereign CDS index. We do not find a similar co-movement with sovereign CDS spread changes of non-euro area sovereigns. More capital as well as less aggressive risk weighting mitigates this effect. Our results are robust to alternative hypotheses, and controlling for common shocks due to financial linkages among European countries, and the exposure of European banks to non-sovereign sectors.

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

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

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1. Introduction

Does the application of risk weights impair financial stability? 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. Banks are holding large amounts of sovereign debt on their balance sheets for liquidity purposes (Holmström and Tirole, 1993), for example, as collateral for private market repo transactions or to obtain funding from the European Central Bank (ECB).

Importantly and central to our paper is that European banks are not required to hold a capital buffer against the sovereign debt holdings of *any* European Union (EU) member state, regardless of the sovereign risk. According to EU legislation, namely the Capital Requirements Directive (CRD), European banks are allowed to employ a "zero risk weight" for EU sovereign debt. Moreover, financial regulators in the EU removed the concentration limits for sovereign debt exposures.[1] EU banks could therefore accumulate excessive leverage by investing in risky sovereign debt (such as from the European periphery), thereby taking advantage of zero risk weights.[2]

If sovereign risk becomes a concern (as occurred during the ongoing European sovereign debt crisis), banks find themselves severely under-capitalized because they have not accumulated a capital buffer for their sovereign debt exposure. Domestic sovereigns are responsible for providing capital backstops for their financial sector if necessary and in compliance with EU state-aid regulation. 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

[1] 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.

[2] Acharya and Steffen (2014) 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.

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,[3] the sovereign CDS spread of Cyprus, and the risk-weighted Greek sovereign debt exposure of Cypriot banks. These exposures reflect the risk-weighted assets against which the Cypriot banks had to hold capital 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.

Recent theoretical contributions support our empirical analysis. Bolton and Jeanne (2011), for example, argue that financial integration allows banks to diversify by holding sovereign debt from different countries, which might cause ex post contagion and too much supply of "risky" relative to "safe" sovereign debt. Countries that are financially stable eventually either provide support for their financial systems or they bailout the riskier sovereign. Acharya et al. (2014) develop a model in which banks are overleveraged because they invest too much in low risk-weighted assets[4] instead of adequately diversifying and balancing risk. Sovereign CDS spreads should therefore reflect its domestic bank sector's exposure to risky sovereign debt. More precisely, we hypothesize that sovereign CDS spreads exhibit a larger co-movement with other European sovereign CDS spreads if domestic banks have large exposures for which they do not hold capital.

To investigate this hypothesis, we construct a new measure that quantifies banks' risk-adjusted exposure to European sovereign debt. We assign risk weights to each sovereign debt holding based on the credit ratings (or, alternatively, CDS spreads) of the respective sovereign and

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

4 In empirical contributions, Kacperczyk and Schnabl (2013) and Becker and Ivashina (2014) provide further evidence for yield causing the investment behavior of financial institutions. Acharya et al. (2011) and Boyson et al. (2014) provide evidence for bank behavior due to capital arbitrage incentives.

compute the corresponding risk-weighted assets for each bank's sovereign portfolio. Given that banks are not required to hold capital against these assets, we call this measure a "sovereign subsidy." Constructing 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, we document that the total sovereign subsidy amounts to more than €500 billion at each of the stress test dates, or, on average, to more than 50% of Tier 1 capital.[5]

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 spread have a stronger co-movement with the European sovereign CDS index if the domestic banks of the former hold a larger non-domestic sovereign subsidy. This is consistent with the interpretation that sovereign risk increases with an increase in the expected bailout costs of its financial sector due to a non-domestic sovereign default.[6]

A possible concern with our results might be that a bank's choice to hold foreign sovereign bonds is endogenous and jointly determined with the choice of holding riskier bonds (Fahri and Tirole, 2012). Riskier banks could shift from safer into riskier government bonds by placing a bet on their own survival (risk shifting). This action would likely shift risk into the states of the world (government defaults) where they are likely to experience bank runs, as argued by Diamond and Rajan (2011). We split our sample and investigate exposures of non-GIIPS (Greece, Italy, Ireland, Portugal and Spain) banks to GIIPS countries and the exposures of GIIPS banks to non-GIIPS countries individually. We find that sovereign subsidies associated with exposures of arguably less

[5] The EBA has published detailed sovereign bond holdings of European banks together with stress test results since March 2010.

[6] We perform a variety of robustness tests. First, we add changes in a broad CDS market index (iTraxx Europe index), changes in an equity market index (Datastream total return index), changes in market volatility (VSTOXX), changes in the term spread, changes in the EUR effective exchange rate, and bank sector control variables; we also add time and/or country-quarter fixed effects. In other tests, we use non-domestic sovereign exposure data from the EBA stress tests instead of the BIS. Moreover, we employ changes in bond yields instead of CDS spreads to measure sovereign default risk and we construct the sovereign subsidy using CDS implied risk weights instead of ratings implied risk weights.

risky non-GIIPS banks to GIIPS countries significantly increase the co-movement of sovereign CDS spreads with the European CDS index.[7] In other words, elevated default risk of peripheral European countries impairs the financial stability of core European countries.[8]

To further strengthen our identification, we include country-quarter fixed effect that control for time-invariant variation across countries within a quarter. Financial stability consequences of zero risk-weights also apply to holdings of domestic sovereign debt, particularly for bonds of those countries in which the subsidy is at its highest. The fixed effects control for the levels of *domestic* sovereign bond exposures within each quarter. Importantly, even within countries in which banks chose to hold larger domestic versus foreign sovereign bond holdings, we find a significant effect of non-domestic sovereign subsidies on the co-movement of domestic and sovereign CDS spreads.

Another concern might be that holdings of foreign bonds are 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 would have a larger weight in the overall CDS index than smaller countries as they also issue more debt themselves. There also might be strong co-movement of GIIPS CDS spreads that is not explained by fundamentals and that increases the co-movement of sovereign CDS spreads with the European CDS index. To address these concerns, we re-estimate our tests and replace the CDS index with individual GIIPS sovereign CDS spreads and interaction terms with sovereign subsidies with respect to these countries. We also exclude GIIPS countries from our analysis, i.e. we investigate

[7] More general, banks might choose to hold larger positions of sovereign bonds to maximize the risk-adjusted-return on capital (RAROC). An interesting identification strategy would involve observing countries entering the EU or mergers among our sample banks that exogenously shift banks' sovereign holdings. Unfortunately, the relative short observation period does not provide us sufficient observations to conduct such tests. Splitting our sample into GIIPS and non-GIIPS countries helps us to address concerns that this choice is driven by unobservable bank risk characteristics.

[8] An implicit assumption of our analysis is that sovereigns provide an implicit guarantee for their domestic banks to cover their shortfalls. Given, for example, highly elevated GIIPS sovereign bond CDS spreads there is a difference across countries as to whether sovereigns are able to bail out their banks. We show that co-movement of CDS spreads increase for stronger non-GIIPS countries if sovereign risk rises.

spillovers from GIIPS to non-GIIPS countries. We also 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 also run a similar analysis using the exposures of our sample banks to Japanese, Norwegian, Swiss, and U.S. sovereign debt for which European banks are required to hold capital and do not find similar effects. Overall, these results are consistent with the interpretation that the application of zero risk weights for banks' exposure to sovereign debt impairs financial stability.

We investigate several other alternative explanations that are consistent with our findings. For example, trade and other economic linkages could explain the co-movement of sovereign CDS spreads. Moreover, banks typically hold a large amount of domestic sovereign debt to use as collateral. An increase in sovereign risk though a common economic shock affects a country's financial system because government bonds decline in value and are less valuable as collateral; government guarantees also decline in value (Acharya, Drechsler, and Schnabl, 2014). We use the Pesaran (2006) common correlated effects estimator, which accounts for unobserved common factors with heterogeneous effects on the different countries, and rerun our tests. Our results remain unchanged.

As Bolton and Jeanne (2011) suggest sovereigns have the choice to support their own financial system or directly bailout risky governments [e.g., through the ESM]. We measure the (implicit) bailout responsibility of a country toward other EU countries as its capital share in the ECB (ECB, 2011). Moreover, we measure the ability to bail out other sovereigns using the debt-to-GDP ratio of each sovereign. A country with less debt relative to its GDP, ceteris paribus, is likely to have a larger commitment in a bailout. Although we find that a larger ECB share significantly increases sovereign CDS spreads, our results regarding the effect of the sovereign subsidy remain

unchanged.

Finally, it could also be that the co-movement of sovereign CDS spreads might be explained by banks' non-sovereign exposures. Using information on bank level exposure to various assets classes across the Eurozone, we examine the impact of cross-sectional variation of bank exposure to retail, corporate, real estate, and financial sectors in other countries on sovereign CDS spreads. We still find that sovereign CDS spreads exhibit a larger co-movement with European CDS spreads if domestic banks have large sovereign bond exposures for which they do not hold capital.

Although some European banks take advantage of the zero risk weight regulation, others are less aggressive in setting risk weights and voluntarily hold capital against these exposures. 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 zero the 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. We then examine whether risk spillovers between sovereigns are lower if banks report non-zero risk-weighted exposures (and thus hold capital against sovereign bonds) and, more broadly, if banks have lower leverage. We find that the co-movement of sovereign CDS spreads is significantly reduced if banks apply higher risk weights. Moreover, we find that this channel is mitigated if banks have larger equity-to-asset ratios (i.e., lower leverage).

In September 2011, the EBA conducted a "capitalization exercise," which required banks to hold a capital buffer to account for the risk associated with their sovereign bond portfolios as of June 2012. This can be interpreted as a de-facto introduction of risk weights for European sovereign debt. We find that the effect of sovereign subsidies on sovereign risk spillovers becomes insignificant after the capital requirement comes into effect. Consistent with our earlier results, this

indicates that under-capitalization of the financial sector due to the zero risk weights of sovereign debt amplifies sovereign risk spillovers in Europe.

Our paper is related to two streams of the literature. There is a growing body of theoretical and empirical literature on the determinants and interdependence of sovereign risk (Duffie et al. 2003; Bolton and Jeanne 2011; Barth et al. 2012; Acharya, Drechsler, and Schnabl 2014). Ang and Longstaff (2013), for example, evaluate the co-movement of sovereign default risk, while Chen (2013) finds that financial linkages are likely to provide a channel for sovereign risk spillovers. Kallestrup et al. (2013) argue that the non-sovereign exposure of banks help explain contagion in the eurozone. Our paper also relates to the literature on regulatory arbitrage. This regulatory treatment can lead to severe distortions and has consequences for bank investment behavior and risk (e.g., Barth et al. 2012; Acharya, Drechsler, and Schnabl 2014; Acharya and Steffen 2015).

Our paper incorporates and complements this literature. In particular, documenting that zero risk weight regulation impairs financial stability in the Eurozone is an important contribution to the literature.

The remainder of this paper is organized as follows. In Section 2, we describe the institutional framework of capital regulation in the EU. We also discuss the data. In Section 3, we present the methodology and provide descriptive evidence related to European banks' domestic and non-domestic sovereign exposures and to the sovereign subsidy associated with these exposures. In Section 4, we report the results from our multivariate analyses. Section 5 provides robustness tests. In Section 6, we analyze the effects of less aggressive risk weighting and more capital on co-movement of CDS spreads. We conclude in Section 7.

2. Institutional Setting and Data

In this section, we describe the institutional setting and the data used in our study.

2.1. Capital regulation in the European Union

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 response to the financial crisis, the Commission adopted the second legislative package (CRD II) in September 2009. An additional set of rules has been 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.

Prudential capital requirements stipulate that banks have to hold capital against all of their assets; the amount required to be held is based either on a given regulatory risk weight (the so-called standardized approach under the Basel Accords) or on an internally modeled default probability estimation (the so-called internal ratings-based approach, or IRB). However, this central idea of the Basel Accords has not been followed in the CRD with regard to banks' exposure to European sovereign debt. Under the standardized approach, the CRD suggests a zero risk weight for exposures to the ECB and to member states' sovereign debt in domestic currency. Although banks using the IRB approach might have a non-zero capital requirement for their sovereign

exposures,[9] they can also choose to switch to the standardized approach when assessing the capital requirements for their sovereign debt portfolio following the IRB permanent partial use — an exemption that banks operating under IRB frequently employ (Hannoun 2011). Hence, European banks might eventually employ zero risk weights for sovereign debt and, consequently, do not hold capital against any of these exposures, regardless of their actual risks. In this paper, we investigate the impact of application of zero-risk weights by banks on financial stability in the Eurozone.

2.2. Data sources

To identify the effects of zero risk-weight regulation, we construct a novel dataset from various sources. We collect daily market information on sovereign CDS spreads and other financial market indicators (e.g., iTraxx, equity indices, VSTOXX, EONIA, Euribor, and EUR effective exchange rates) from Bloomberg and the ECB. We use CDS[10] spreads as our main measure for sovereign default risk (Alter and Schüler, 2012; Black et al., 2013.[11]

Data on banks' domestic and non-domestic sovereign exposures come from two sources. We use data from the EBA stress tests and capital exercises that were conducted and published by the EBA during the period from March 2010 to June 2012. These datasets comprise sovereign bond holdings at the individual bank and exposure level for approximately 90 major European banks from 21 countries at five points in time: December 2009, December 2010, October 2011, December

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

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

[11] As robustness tests, we conduct our main analyses using sovereign bond yields as a measure of sovereign credit risk. For reasons of liquidity and comparability, we use the 10-year benchmark (i.e., maturity adjusted) bond yields.

2011, and June 2012.[12] The Online Appendix provides an overview of these stress tests and of the identities of the banks included in the stress test. Although these data provide detailed insights into bank-level exposures to domestic and non-domestic sovereigns, they do not cover the overall financial systems' exposures for the respective countries. Thus, 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.[13] Thus, our data allow us to conduct analyses at the bank and at the country level.

We complement the bank-level exposure data with quarterly bank financial data sourced from SNL Financial and the country-level data with macroeconomic variables provided by the Organization for Economic Cooperation and Development (OECD) and the ECB. The consolidated financial sector data are from SNL Financial.[14]

3. Constructing the "Sovereign Subsidy" Measure

3.1. Ratings implied sovereign subsidy (EBA risk weights)

To adequately reflect the risk of its assets, a bank translates its exposures into risk-weighted assets (RWAs) using specific risk weights for each exposure and holds a fraction of these RWAs as regulatory capital against unexpected losses. As discussed above, risk weights associated with sovereign debt are zero. However, to estimate the extent that banks are under-capitalized due to zero risk weights, we assign appropriate risk weights to each sovereign debt holding and compute

[12] Note that this is the status at the time of writing. The EBA has scheduled further data publications.
[13] Note that this dataset is the most comprehensive, both regarding time series and cross-sectional data availability. Although it is the most comprehensive dataset and we use all 27 EU sovereigns in the exposure data, the limitation of the dataset in the country dimension should be kept in mind when interpreting the external validity of our results. Nevertheless, a broader country coverage is contained in our analyses using the EBA data.
[14] Appendix 1 provides detailed definitions of the variables used in our analyses.

the corresponding RWA that is not adequately reflected in banks' capital positions.[15] We call hits new measure a "sovereign subsidy." This subsidy is computed as follows:

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

with *i* indicating the sovereign/country, *j* the exposure (i.e., the counterparty sovereign), 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., stress test dates for the EBA dataset and end of quarter for the BIS dataset).[16] 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 Ratings Based Approach (IRB) formula and standard assumptions of loss given default (LGD) of 45% and 2.5 years maturity to compute risk weights for sovereign exposures.[17] Panel A of Table 1 provides an overview of the resulting risk weights.

[Table 1]

3.2. Descriptive statistics

Table 2 presents the summary statistics. 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 were 252 bps and exhibited an average daily change of

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

-0.17%. Although the average change is rather small, we report a rather high standard deviation for the daily changes and show that there are periods with large changes of approximately 20% (both upward and downward).

[Table 2]

We compute an index of European sovereign CDS spread changes as the sum of the changes in each sovereign *j*'s CDS, which are weighted by the share of sovereign *j* in the non-domestic sovereign exposure of country *i*'s financial system during period *p* (i.e., the change in the CDS index corresponds to an exposure-weighted average change in non-domestic CDS spreads). The average daily change in the exposure-weighted sovereign CDS index was -0.14% during our sample period.[18]

On average, banks have a non-domestic sovereign exposure of about €104 billion, which corresponds to 8.6% of a country's GDP. Risk weighting this exposure translates into a sovereign subsidy in the range of €30 billion to €56 billion, depending on how we compute risk weights (EBA methodology or CDS-implied risk weights). The average equity-asset ratio of banks is 4.9%. 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%. The average country exhibits government debt that totals 102% compared with its GDP, with debt ratios ranging from 60% (Spain in 2010) to nearly 140% (Italy in 2012).

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

[18] We document that sovereign CDS spreads experience 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. This observation holds across the eurozone and also with non-eurozone EU countries such as the U.K.

of the total (domestic and non-domestic) sovereign subsidy for all banks that were part of the EBA stress tests in 2009-2012.

[Figure 2]

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 hardly changes over time. The subsidy of banks from peripheral countries (i.e., Greece, Ireland, Italy, Portugal, and Spain) 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.

Table 3 documents that the non-domestic EU sovereign exposures of domestic banks increases to several hundred billion euros for individual countries, or about to 16% of a country's national GDP. French and German banks have the largest non-domestic EU sovereign bond exposures and sovereign subsidies. Notably, although some of the core countries' banks slightly decreased their non-domestic sovereign exposure (Belgium, France, and Germany), in peripheral countries (Italy, Ireland, and Spain) they actually increased their domestic sovereign bond exposure between year-end 2010 and year-end 2012. This finding might be due to a retrenchment of banks' sovereign positions in core countries, whereas banks in peripheral countries attempt to diversify their holdings away from their (increasingly risky) domestic sovereigns. A notable exception is the U.K. banking sector, which nearly doubled its non-domestic EU sovereign exposures to €245 billion in 2012. 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. The magnitude of these exposures emphasizes how strongly European financial markets

are integrated.

[Table 3]

4. Understanding Sovereign Risk Spillovers

In this section, we describe our empirical approach and define the key variables. We then discuss our main analyses and robustness tests.

4.1. Methodology

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 change in the natural log of the CDS spread of a specific sovereign *i* from time *t*-1 to *t* (i.e., on a daily level).[19] The main explanatory variables are (1) $\Delta LogCDS\ Index_{i,t}$, 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 $Sovereign\ Exposure_{i,j,t} / \sum_{j=1}^{J} Sovereign\ Exposure_{i,j,t}$); and (2) $Sovereign\ Subsidy_{i,t}/GDP_{i,t}$, 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*), scaled by the GDP of country i. Time (i.e., week) fixed effects (δ_t) and country-quarter ($\gamma_{i,t}$) fixed effects are used to control for influences constant either across countries in a given week (e.g., financial market variables) or over a specific quarter for a given country (e.g., macroeconomic and financial sector variables). As an addition or alternative to the fixed effects, 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 (Δ*iTraxx*), an equity market index (*DS Equity Index*), the market volatility (*VSTOXX*), the *term spread* (computed from EONIA and

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

12-month Euribor), and the EUR effective exchange rate. Alternatively, we also control for country-quarter-varying bank sector covariates ($Z_{i,t}$), including the capital ratio, deposit ratio, funding fragility, income diversity, liquidity, and the financial sector concentration (Herfindahl-Hirschman index). All variables are defined in Appendix 1. The baseline model is specified as follows:

$$\Delta LogCDS_{i,t} = \alpha + \beta_1 * \Delta LogCDS\ Index_{i,t} + \beta_2 * \frac{Sovereign\ Subsidy_{i,t}}{GDP_{i,t}} + \beta_3 * \left[\Delta LogCDS\ Index_{i,t} * \frac{Sovereign\ Subsidy_{i,t}}{GDP_{i,t}}\right] + \delta_t + \gamma_{i,t} + \varepsilon_{i,t}.$$

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)].[20] We expect to see an amplification of risk spillovers through sovereign subsidies, that is, a positive and significant coefficient β_3.

The upper panel in Figure 3 plots the beta of a regression of *ΔLogCDS* on *ΔLogCDS index* on the financial sector's non-domestic holdings. The correlation is positive and significant. Moreover, the lower panel of Figure 3 plots *ΔLogCDS* on *ΔLogCDS Index x Sovereign Subsidy/GDP*. Again, 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.

[Figure 3]

4.2. Baseline model

[20] 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).

Table 4 reports the results of our baseline model. Column (1) shows the results of an OLS regression without control variables. As expected, the effect of *ΔLogCDS Index* on *ΔLogCDS* is positive and significant at the 1 percent level. The effect of *Sovereign Subsidy/GDP* on sovereign CDS spread changes is insignificant. Importantly, the coefficient of the interaction term *ΔLogCDS Index* x *Sovereign Subsidy/GDP* is positive and significant at the 1 percent level, 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 uncovered exposure to non-domestic sovereign debt. 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 bailout), which is reflected in elevated sovereign CDS spreads.

[Table 4]

In column (2) of Table 4, we additionally control for bank fundamentals[21] and include variables that could affect sovereign CDS spreads such as leverage, asset and funding liquidity and bank competition. Moreover, we add variables that control for capital markets and the macroeconomic environment. As expected, changes in corporate CDS spreads (as measured through the *iTraxx* index) also increase sovereign CDS spreads. In column (3), we add weekly fixed effects (Time FE), which control for short-term interest rates. In column (4) we add country-quarter FE (but no week fixed effect). Country-quarter fixed effects control for the absolute amounts of both foreign and *domestic* sovereign bond holdings of banks, which mechanically might 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). Overall and throughout all model specifications, we find a larger co-movement of sovereign CDS spreads

[21] The bank characteristics are aggregated at the country level weighted by bank asset size.

with a European sovereign CDS index when the domestic banking sector has a larger sovereign subsidy. This is consistent with the interpretation that the application of zero risk-weights impairs financial stability in the Eurozone.

4.3. Exposure to GIIPS versus non-GIIPS countries

A possible concern with our approach might be that banks' endogenously chose to hold foreign bonds, which could be correlated with the choice of holding riskier bonds. Diamond and Rajan (2011) argue that under-capitalized banks gamble and place bets on their own survival purchasing bonds issued by their domestic governments. This way, they shift risk precisely into those situations where they most likely would experience bank runs. Acharya and Steffen (2015) document that the risk-shifting motive is particularly strong for GIIPS banks during the sovereign debt crisis. We split our sample into foreign sovereign bond exposures of GIIPS versus non-GIIPS banks. For example, we analyse the co-movement of non-GIIPS sovereign CDS spreads with a sovereign CDS spread index consisting of GIIPS countries and investigate whether this co-movement is stronger if non-GIIPS banks have larger sovereign subsidies with respect to the European periphery. Non-GIIPS sovereigns should not be affected in the same way as GIIPS countries by banks shifting risk. The results are reported in Panel A Table 5. The regressions follow the sequence of models used in Table 4.

[Table 5]

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 *Sovereign Subsidy/GDP* is also positive and significant at the 1 percent level, i.e. a change in GIIPS sovereign CDS spreads has a larger impact on the CDS spread of non-GIIPS sovereigns if their banking

sectors have a larger sovereign subsidy. Panel B of Table 5 reports the results regressing GIIPS sovereign CDS spreads on a CDS index of non-GIIPS sovereigns interacted with the sovereign subsidy reflecting GIIPS banks exposure to core European countries 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, elevated default risk of peripheral European countries impairs the financial stability of core European countries. Overall, our results suggest that risk shifting does not explain a larger co-movement of sovereign spreads.

4.4 Replacing the sovereign CDS index with individual sovereign CDS spreads

Another concern might be that holdings of foreign bonds are 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 term 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 Panel C of Table 5. Consistent with our earlier results, we find a larger co-movement of sovereign CDS spreads if banks have larger sovereign subsidies.

5. Robustness Tests and Alternative Explanations

5.1. Government bond yields

In our previous tests, we use sovereign CDS spreads to measure sovereign credit risk similar to many other empirical studies of credit risk because of their standardization and liquidity. Alternatively, using government bond yields as measure of sovereign credit risk should give identical results. 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 and reestimate our remain regressions from Table 4.

[Table 6]

We report the results in columns (1) and (2) of Table 6. We use 10-year maturity-adjusted sovereign bond yields that we obtain from Datastream to construct both the dependent variable (Δ*Log bond yield*) and the sovereign risk index (Δ*Bond Index*).[22] Column (2) includes also time fixed effects to control for the risk-free rate as well as country-quarter fixed effects to control for time-invariant variation that is country-quarter specific (such as levels of sovereign bond holdings). Similar to our baseline results, we find that an increase in the sovereign bond yield index increases bond yields of individual sovereigns more if the banking sector has a larger sovereign subsidy.

5.2. CDS implied default probabilities

As an alternative to risk weights that rely on ratings, we use probabilities of default that are implied by CDS spreads. 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

[22] These bond yields have also been used in previous studies by e.g. Pagano and von Thadden (2004) and Acharya and Steffen (2015).

above.[23] Using conversion factors from Hull et al. (2005), we approximate physical PDs from the CDS implied risk-neutral PDs. Finally, we use the Basel IRB formula and standard assumptions of loss given default (LGD) of 45 percent and 2.5 years maturity to compute risk weights for sovereign exposures from these PDs.[24] Note that applying EBA risk weights yields a smaller estimate of the sovereign subsidy than the CDS implied risk weights, which result in sovereign subsidy numbers that can be nearly twice as high. Therefore, our EBA risk weight measures should be viewed as conservative and a lower bound of the sovereign subsidy.

We re-estimate our baseline model replacing the ratings based sovereign subsidy measure with a CDS rate based sovereign subsidy measure and report the results in columns (3) and (4) of Table 6.[25] The model specification presented in column (4) again includes country-quarter and time fixed effects. We find consistent results and a larger co-movement of sovereign CDS spreads if sovereign subsidies are larger.

5.3. EBA (bank level) exposure data

The BIS data include the exposure of all banks in each respective country. However, exposures are only available for 7 countries. In columns (5) and (6), we use bank-level data from the EBA stress test results, which expands the sample and includes more countries, but unfortunately relies on a smaller time series as data are available for the March 2010 to June 2012 period and for 5 disclosure dates.[26] We aggregate individual bank exposures at the country level and estimate the regression models with and without fixed effects. Again, sovereign CDS spreads co-

[23] For a more extensive discussion of the differences in CDS implied risk-neutral PDs and physical PDs, refer to Chan-Lau (2006), Duffie (1999), and Hull et al. (2004, 2005).
[24] Because the PDs and risk-weights depend on several input factors, we do not tabulate them here for brevity.
[25] Instead of relying on ratings, we use CDS-implied probabilities of default calculated according to the methodology outlined above. In our regression models, we use CDS-implied risk weights that are averaged and lagged by one quarter.
[26] The banks included in the EBA stress tests are the largest banks in each country and also hold a large proportion of the total cross-country sovereign debt.

move more strongly if banking sectors enjoy a larger sovereign subsidy.

5.4. Falsification tests using non-EU sovereign debt exposures

An interesting identification strategy involves countries that join the EU and exogenously inherit bank benefits associated with EU sovereign debt holdings. Unfortunately, we do not have sufficient observations to conduct such a test during our observation period. As an alternative, we run falsification tests using banks' exposure to non-EU member states for which zero-risk benefits do not apply. Hence, we would not expect to observe a similar effect for these exposures, as banks have to hold capital that reflects the risk associated with holding the respective sovereign bonds. The BIS also reports the exposures of our sample financial sectors to countries such as Japan, Norway, Switzerland, and the U.S. 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 hold capital against them; we repeat our tests both for each of the four countries individually and collectively using an index of non-EU sovereigns. We report the results in Panel B of Table 6.

In columns (1) and (2) of Panel B in Table 6, 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. This result indicates that risk spillovers among EU and non-EU sovereigns are not amplified by banks' non-EU sovereign bond exposures because banks are in fact holding sufficient capital against these exposures.

5.5. Cross-country linkages and common effects

A possible concern might be that we measure direct sovereign-sovereign contagion due to trade and other economic linkages rather than through banks' balance sheets. Domestic banks typically hold a large amount of sovereign debt to use as collateral. An increase in sovereign risk though a common economic shock affects a country's financial sector because government bonds decline in value and are less valuable as collateral; government guarantees also decline in value (Acharya, Drechsler, and Schnabl, 2014). 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, using bootstrapped standard errors. The results are presented in Table 7 using the same specifications as for Table 4.

[Table 7]

The results in Table 7 are robust. 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.[27] The model fit improves when common factors are included. Thus, our results are robust to underlying common shocks that create cross-sectional dependence.

5.6. Direct bailouts and non-sovereign exposures

Bolton and Jeanne (2011) suggest that sovereigns have the choice to support their own financial system or directly bailout risky governments. To control for this alternative spillover

[27] Note that the levels of the sovereign subsidy are absorbed by the CCE estimators.

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 (1) each sovereign's share in the temporary assistance vehicle (*ECB Share*), the European Financial Stability Facility (EFSF), (2) each sovereign's share in the permanent support vehicle, the European Stability Mechanism (ESM), and (3) the risk that sovereigns ultimately assume through the purchase of debt instruments by the ECB. Because all of these measures are a direct function of the capital share of these sovereigns in the ECB (ECB, 2011), we take this capital share as our proxy for bailout risk.[28]

Second, we control for a country's bailout capacity. Beyond formal responsibility, sovereigns that are in a position to contribute more toward the bailout of a failed member state might experience a relatively stronger risk spillover that is proportional to their bailout capacities. Because it proxies for fiscal capacity and the potential to raise additional debt, we use the debt ratio (expressed as government debt to GDP) as a proxy for bailout capacity (*Debt Ratio*). We include both proxies in our regressions, as well as their interaction terms with *ΔLogCDS Index*. Table 7 reports the results.

[Table 8]

Consistent with Bolton and Jeanne (2011) and shown in Table 8, a higher ECB share increases the risk spillover across European countries. The coefficient of the interaction between *ΔLogCDS Index and the ECB is* positive and significant at the 1 percent level throughout all specifications. That is, sovereign CDS spreads co-move more strongly if governments have a larger financial stake in case other European countries have to be bailed out. A higher *Debt Ratio* does not significantly affect sovereign CDS spreads. Importantly, the effect of the banks' non-domestic

[28] Note that the share of the U.K. in these institutions is 0.

European sovereign exposures on sovereign risk spillovers remains largely unchanged when we control for these alternative channels.

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 EBA and include them in our analysis. We also use interaction terms with *ΔLogCDS Index*. Overall, we find evidence consistent with sovereign risk spillovers due to zero risk weights. We do not report the results for brevity.

6. Bank Capital and Sovereign Risk Spillovers

Sovereign risk spillovers through non-domestic sovereign bond exposures can occur when banks do not have to hold capital for European sovereign bonds. Banks with large capital buffers or those that decide to hold capital for certain sovereign bonds should be more resilient with regard to losses related to sovereign debt. Moreover, since September 2011, the EBA has required that banks hold a sovereign capital buffer, as well as a temporary minimum Core Tier 1 capital ratio of 9%. Both, a voluntary and a mandatory buffer should eventually mitigate risk spillovers.

6.1. Cross-sectional differences in bank capitalization

So far we have implicitly assumed that banks take advantage of the zero risk weight regulation, but some banks might voluntarily hold capital against these exposures. Banks do not usually report this information in their annual reports. The EBA provided information on banks' RWAs by exposures for the first time in June 2012. We aggregate the individual exposures at thec 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.

It is a testable hypothesis that risk spillovers between sovereigns are mitigated if banks hold more capital against their exposures. The data show RWAs as reported by banks for each sovereign under both the standardized and IRB approach. We adjust the sovereign subsidy for exposure against which banks actually hold capital and exploit cross-sectional variation in RWA to identify the effect of bank capital on sovereign risk contagion. The results are presented in Table 9.

[Table 9]

In columns (1) and (2) in Table 9, we report our regressions using a sovereign subsidy measure that is adjusted by the RWAs reported by each bank aggregated at the country level (*Adj. Sovereign Subsidy*). After the adjustment, the sovereign subsidy does not include exposures that have been voluntarily included in the RWA and capital requirement calculations by the banks and for which banks hold equity. Our results are virtually unchanged in statistical and economic significance when using this adjusted sovereign subsidy.

In columns (3) and (4) in Table 9, we report the results augmented with a triple interaction of *ΔLogCDS Index*, *RWA Coverage*, and *Sovereign Subsidy/GDP*. As indicated above, these should proxy for the voluntary capital holdings for banks' European sovereign bond exposures. Additionally, and instead of accounting for RWAs for sovereign debt, we add banks' equity-to-asset ratio (*Capital Ratio*) to the model in columns (5) and (6). A larger *Capital Ratio* (i.e., a larger capital buffer) should reduce sovereign risk spillovers, and we expect a negative and significant coefficient on the triple interaction term *ΔLogCDS Index x Capital Ratio x Sovereign Subsidy/GDP*. We find evidence in all four specifications that spillovers are mitigated once we adjust for actual RWAs or banks that hold more capital. Importantly, the effect of the sovereign subsidy in interaction with the CDS index is still positive and significant.

6.2. 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. They 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 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 reflected in the capital requirements for banks. We examine whether the EBA CE reduces the de facto 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 over time.[30]

[Figure 4]

We use our baseline model to examine whether an increase in capital reduces the effect of the sovereign subsidy on the extent of the risk spillover. In Table 10, we document a sharp decline in the beta after the EBA CE in September 2011.

[Table 10]

Additional capital requirements were introduced in late 2011 but only became effective as of June 2012. Thus, we define all quarters up to 2011-Q3 as the period before the EBA CE and all quarters from 2012-Q2 as the period after the EBA CE. We then run our baseline model with and

[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.

[30] Note that we use a consistent sample of countries that are available throughout the entire sample period, comprising Belgium, France, Germany, Ireland, Italy, Spain, and the U.K., and a consistent composition of the sovereign CDS index over time (i.e., the Datastream series of the Markit SovX index).

without controls and fixed effects separately for both periods. Both specifications yield similar results: While the coefficient on the interaction term that proxies for the sovereign risk spillover through non-domestic sovereign exposures of the domestic financial sector remains positive and highly significant before the EBA CE, it is insignificantly different from zero afterwards.[31]

Overall, our findings 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 capita. Sovereign risk spillovers through banks' non-domestic sovereign exposures can be mitigated if regulators introduce capital requirements that reflect the risk of sovereign exposures.

7. Conclusion

In this paper, we investigate whether the application of risk-weights impairs financial stability in the Eurozone. Banks are the largest holders of sovereign debt and financial sectors in Eurozone countries are highly interconnected through banks' cross-border holdings of sovereign bonds. As European-wide capital regulation does not require banks to hold capital against sovereign debt issued by Eurozone countries, sovereign risk emerging in one country can impair the stability of other countries. Using bank portfolio data collected from the EBA's stress test disclosures during the March 2010 and June 2012 period and the consolidated banking statistics from the BIS, we construct a new measure that quantifies each bank's "sovereign subsidy." The sovereign subsidy is derived from the risk-weighted investment in non-domestic EU sovereign debt. This sovereign

[31] In further tests, we include proxies for alternative channels of risk spillover and separately run this augmented model for both periods before and after the EBA CE. While we do not find evidence for sovereign risk spillovers due to zero risk weights after the EBA CE, we find that the coefficient on the interaction between the ECB capital share and the change in the sovereign CDS index remains positive and highly significant both before and after the CE. We observe a co-movement of sovereign CDS spreads due to mutual bailout responsibilities within the Eurozone, which supports the interpretation that adequate capitalization of banks' exposures mitigates sovereign risk spillovers. We do not report these results for brevity.

subsidy is a measure of the banks' RWAs that is not adequately reflected in their capital positions as a result of the application of the zero risk weight.

We document that changes in a European sovereign CDS index can be used to explain the changes in individual sovereign CDS spreads. More importantly, this relationship is amplified by the magnitude of the sovereign subsidy of a country's domestic financial sector. This is consistent with larger expected bank bailout costs in the case of a sovereign default. These results hold when controlling for other determinants of CDS spread changes, for unobserved common factors, and when using alternative measures for sovereign risk and for the sovereign subsidy. The findings also hold when controlling for alternative channels of sovereign risk spillovers such as direct bailout responsibilities toward other EU member states or the bailout capacity of an individual sovereign. We find that a better capitalization of the banks reduces the risk spillover effects. Exploring exposures to non-EU members (i.e., Japan, Norway, Switzerland, and the U.S.), which are not subject to zero risk weighting, we find an insignificant effect of the sovereign subsidy on sovereign risk spillovers. We find that the co-movement of sovereign CDS spreads is significantly reduced if banks apply higher risk weights with respect to their sovereign bond exposure or have lower leverage.

Our paper has important implications regarding the regulatory treatment of sovereign debt. While advances have been made in European banking regulations, the treatment of sovereign debt was not been addressed in the CRR/CRD IV. Similarly, macroprudential regulation has not fully accounted for the effects of sovereign risk (e.g., in stress tests). Our results indicate that financial regulations have to provide banks with sufficient loss absorption capacity if sovereign risk materializes, as well as to ex ante reduce incentives for excessive investments in sovereign debt.

Possible regulatory responses could be to devise regulatory capital requirements (so-called

Pillar 1 requirements) that are stricter, remove zero risk weights on EU sovereign debt, and link risk weights to, for example, external ratings, as in the standardized approach. Concentration limits could be introduced to limit exposure to single counterparties. Moreover, Pillar 2 requirements could be increased and provide recommendations on how to include sovereign risk in macroprudential regulation. Similarly, disclosure (i.e., Pillar 3) requirements could be enhanced to require that banks provide more detailed information of their exposure to sovereigns.

Our results have implications beyond the treatment of sovereign debt and extend more broadly to the fact that risk weights are "static" and thus do not reflect that risks are changing over time. Excessive leverage of banks in asset classes where risks have increased could further impair financial stability. Other asset classes with low risk weights are mortgages or repos. Particularly large European banks use their balance sheet capacity and build substantial exposures to these securities (Acharya and Steffen, 2014).

European stress tests, most recently the comprehensive assessment of the ECB in October 2014, also relied on risk weights. The ECB calculated possible capital shortfalls using a single regulatory capital ratio and a threshold. If bank capital after accounting for losses in an adverse scenario falls below this threshold, a capital shortfall occurs. Acharya and Steffen (2014) show that results would be substantially different, if a simple debt-equity ratio (without using risk weights) had been applied: banks that showed a shortfall under one metric (debt-equity ratio) did not show a shortfall under a different metric (regulatory capital ratio using risk weights) and were eventually declared as "well-capitalized" by the ECB. The newly formed supervisory board (the Single Supervisory Mechanism (SSM)) of the ECB has recently announced that the application of risk weights is going to be reviewed. Our results have important implications for this debate.

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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.

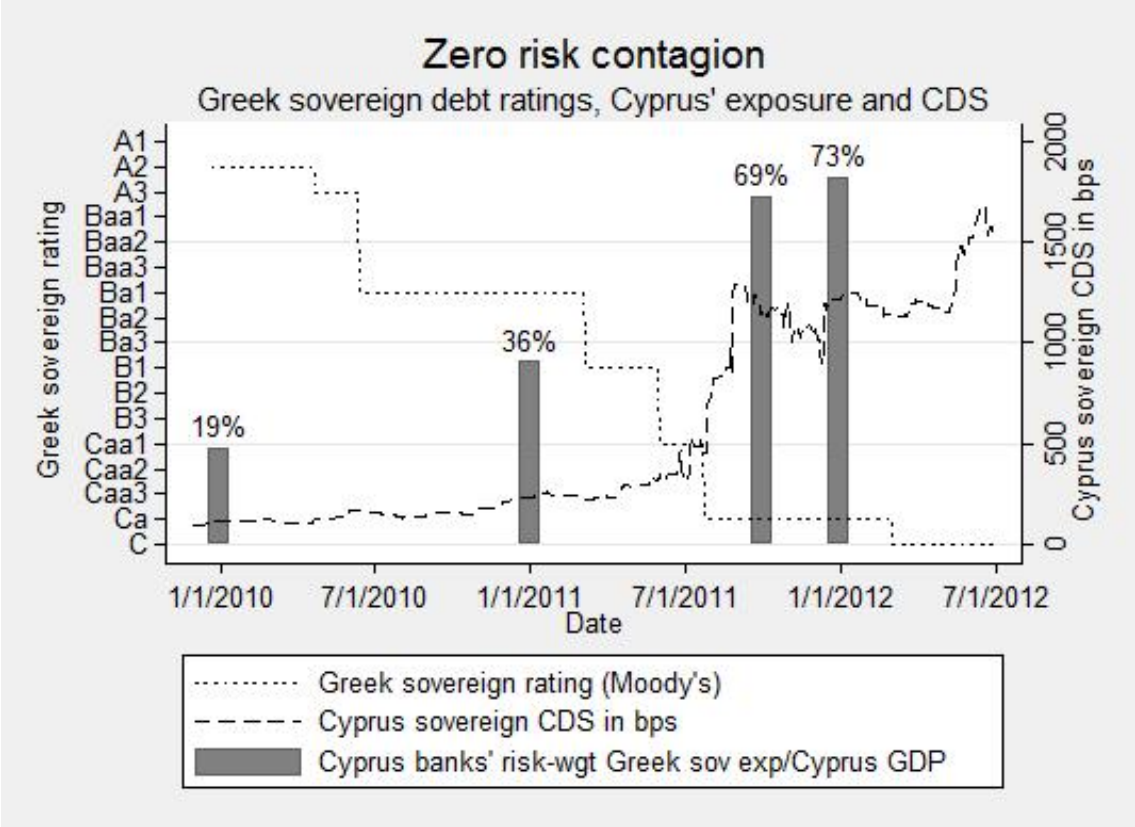


Figure 2: Sovereign subsidy: in peripheral and non-peripheral countries

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.

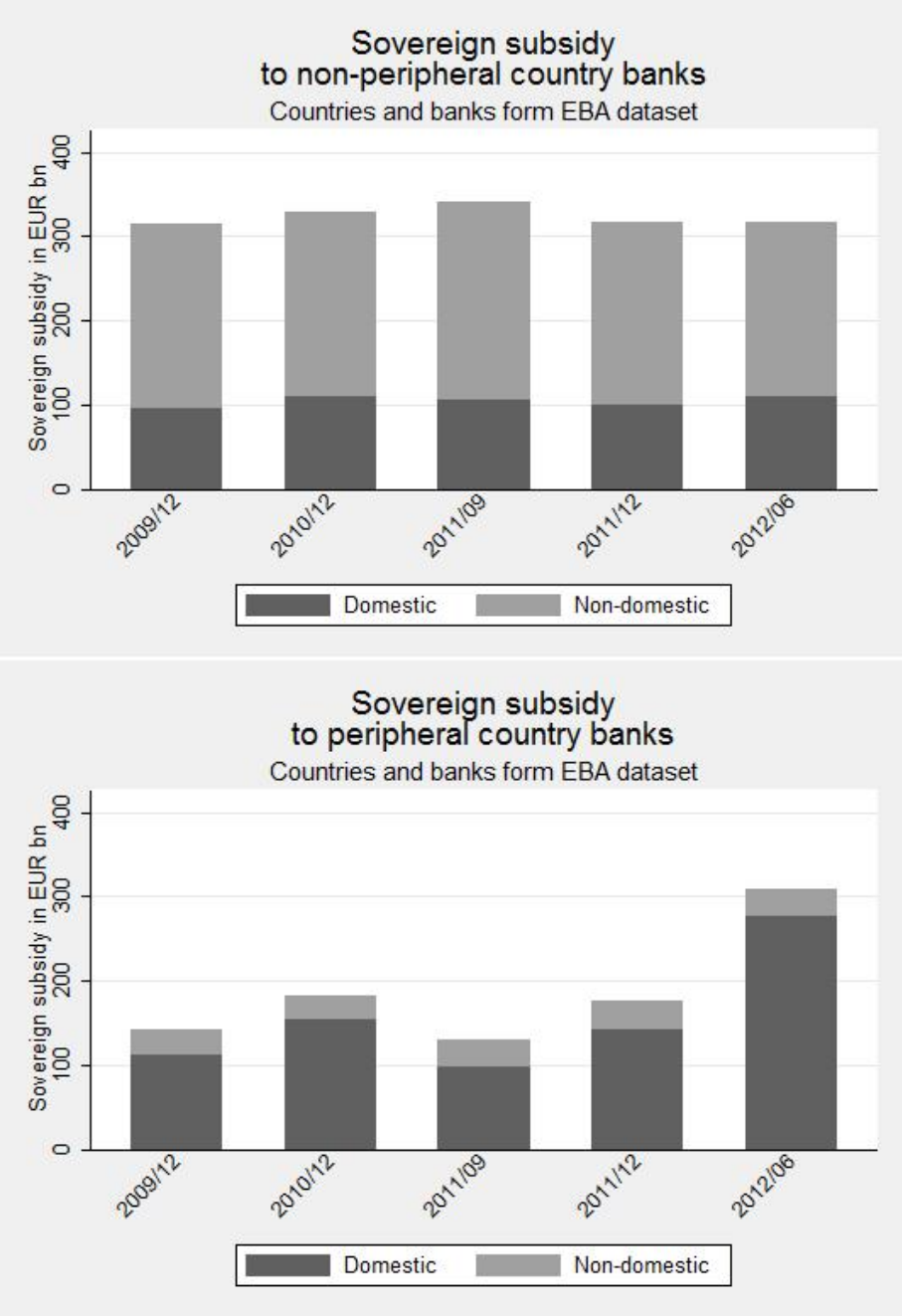
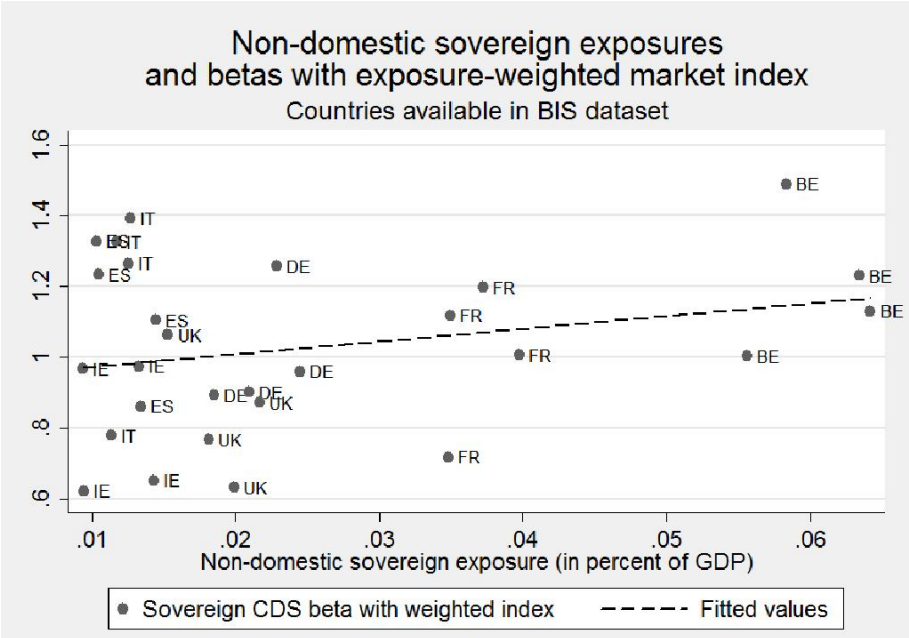


Figure 3: Domestic banks' non-domestic sovereign exposure and domestic sovereign CDS (BIS, up to 2011-Q3)

In the top panel, we plot the non-domestic sovereign exposure of selected countries' banking sector in relation to the GDP of that country at the start of a quarter against the beta of this country's CDS spread changes with the changes in a sovereign CDS index. The beta is obtained by regressing the change of a sovereign's CDS spread onto the changes of an exposure-weighted sovereign CDS index over the 30 days following the exposure date. In the bottom panel, 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).



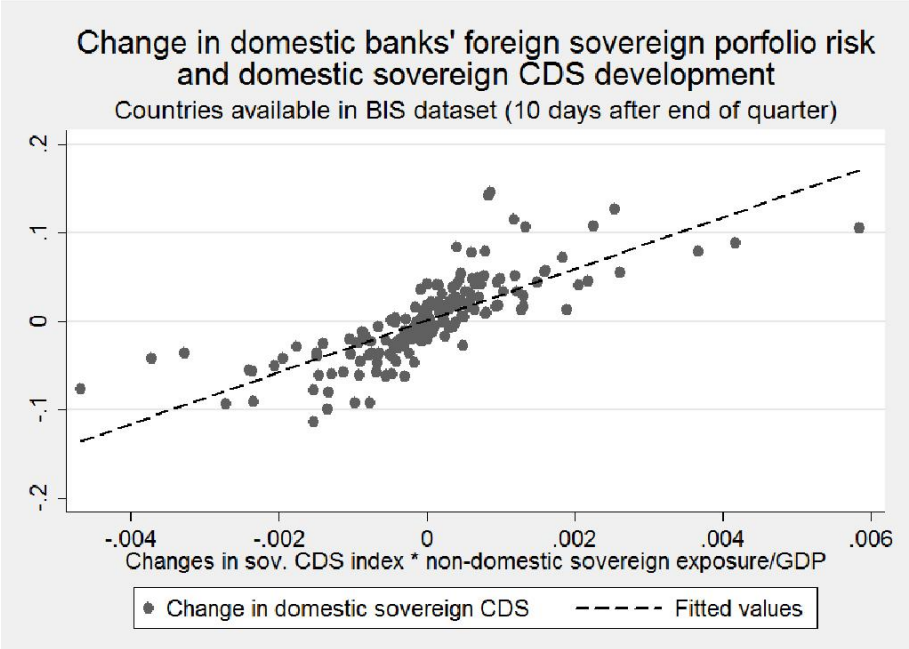
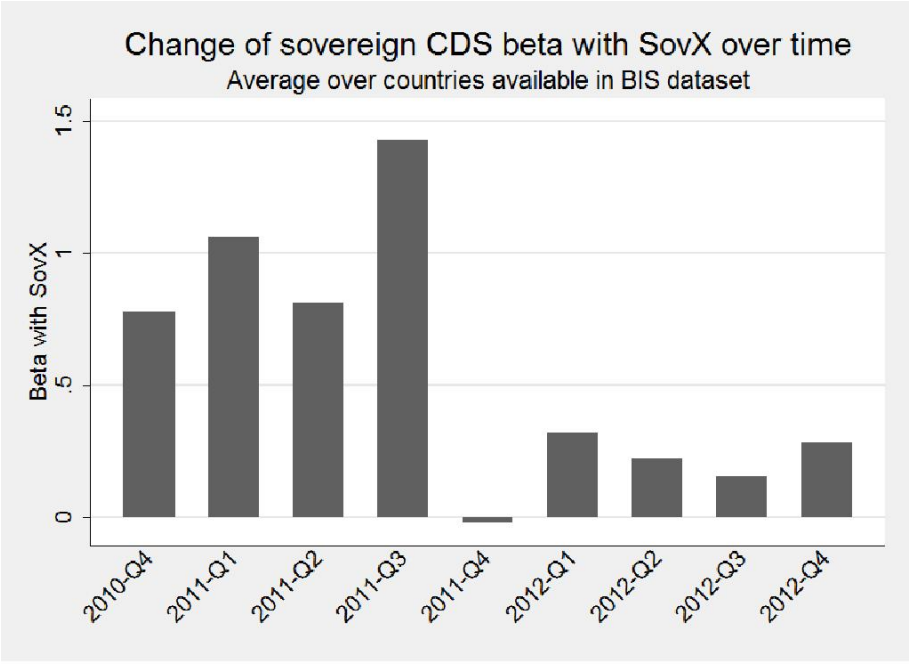


Figure 4: Betas of individual sovereign CDS and sovereign CDS market over time

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) and all EU countries that form part of the EBA stress test and for which CDS spread time series are available (AT, BE, CY, DE, DK, ES, FI, FR, GR, HU, IE, IT, NL, PL, PT, SI, SE, UK).



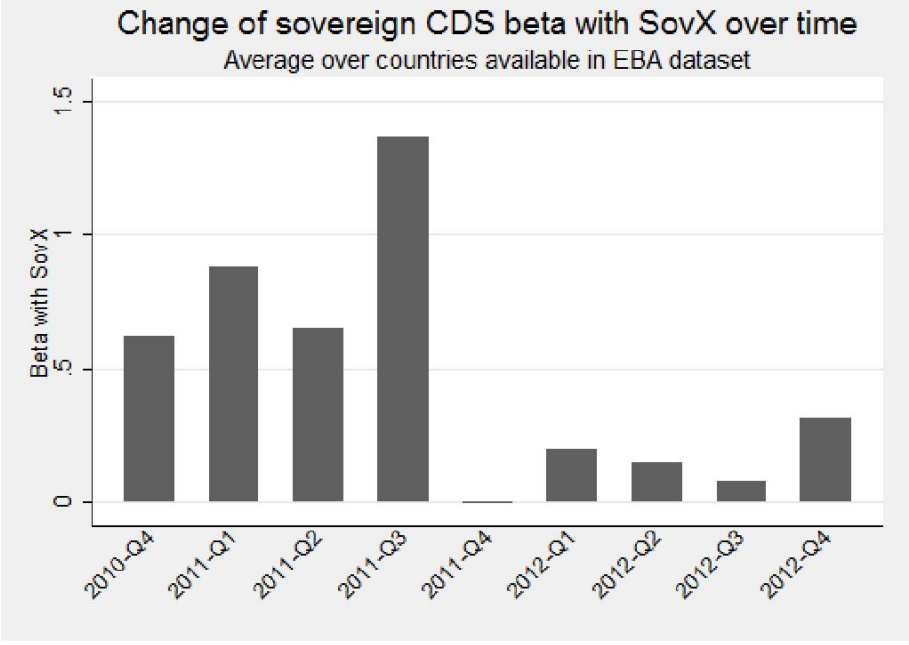


Table 1: Ratings, risk weights, and the computation of sovereign subsidy

This table reports risk weights 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), computed according to the Basel F-IRB approach as described in the 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. The risk weights are consistent with EBA stress test assumptions on PDs for rating classes and standard assumptions on LGD (45%) and maturity (2.5 years), and computed according to the Basel F-IRB approach.

Panel A: Risk weights for computation of sovereign subsidy

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

Table 2. Summary statistics

This table reports the summary statistics for the main variables. The data sources are: Bloomberg (BB), Bank for International Settlements (BIS), Thomson Reuters Datastream (DS), European Banking Authority (EBA), European Central Bank (ECB), Eurostat (EUSt) Organization for Economic Cooperation and Development Quarterly National Accounts (OECD), SNL Financial (SNL). Appendix 1 provides variable descriptions.

Variable	Unit	Mean	(Std. Dev.)	Min.	Max.	*N*
Dependent variables						
Sovereign CDS	bps	252	-207	25	1,233	2,646
Δ Log CDS	percent	-0.17	(3.82)	-21.76	18.73	2,646
Sovereign bond yield	bps	402	-207	117	1,379	2,358
Δ Log bond yield	percent	0.04	(2.22)	-11.46	11.91	2,347
Explanatory variables						
Δ CDS index (ind. weights)	percent	-0.14	(3.33)	-15.94	13.32	2,646
Bond index (ind. weights)	percent	0.04	(1.33)	-4.65	5.89	2,646
Bank exposure to non-domestic sovereigns	mn EUR	104,284	-77,826	6,55	309,002	2,646
Sovereign subsidy (EBA risk weights)	mn EUR	29,791	-21,448	1,237	72,231	2,646
Sovereign subsidy (CDS implied risk weights)	mn EUR	56,063	-44,014	2,043	153,253	2,646
RWA coverage ratio	percent	1.77	(0.56)	0.87	Feb 59	2,646
Capital ratio	percent	4.9	(1.22)	3	Jul 77	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)	94.21	207.96	2,646
DS equity index	index pts	1382.75	(137.99)	1129.06	1690.48	2,646
VSTOXX	index pts	25.8	(7.66)	14.86	53.55	2,646
EONIA	bps	52	-39	6	172	2,646
Euribor (12 months)	bps	150	-57	54	220	2,646
Term spread	bps	98	-32	41	161	2,646
EUR exchange rate	ratio	100.74	(2.94)	94.45	106.91	2,646
GDP	mn EUR	1,255,582	-746,4	132,538	2,562,339	2,646
Deposit ratio	percent	38.54	(9.29)	18.4	54.11	2,646
Funding fragility	percent	128.31	(23.49)	87.10	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	18.8	2,646
Concentration	percent	10.65	(4.18)	6.3	19.29	2,646

Table 3. Country level sovereign exposure and sovereign subsidy

This table reports the total non-domestic EU sovereign exposure of selected EU countries' financial sectors over time. In addition, it shows the relation of these exposures to total 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). Panel A displays total financial sector exposures to all non-domestic EU sovereigns, while Panels B and C report financial sector exposures to non-domestic peripheral EU sovereigns (Greece, Ireland, Italy, Portugal, Spain) and other (non-peripheral) EU sovereigns respectively. These figures are reported for the year-end of 2010, 2011, and 2012 for all countries for which comprehensive data on cross-border bank exposure are available in the consolidated banking statistics of the BIS.

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

Country	Total non-domestic EU sovereign exposure in EUR mn			in % of GDP			Non-domestic EU sovereign subsidy (risk-weighted) in EUR mn		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Banks in peripheral countries									
Italy	63,307	68,103	80,122	4.5%	4.6%	5.4%	16,729	16,623	20,231
Ireland	6,55	10,778	10,89	4.9%	7.6%	7.3%	1,266	1,814	1,764
Spain	52,22	48,892	74,115	4.8%	4.4%	6.6%	11,193	16,364	21,99
Banks in other countries									
Germany	137,515	125,915	133,905	6.0%	5.2%	5.3%	42,263	54,341	59,798
Belgium	47,817	34,091	32,431	15.7%	10.7%	9.8%	17,854	14,379	11,875
France	227,701	182,334	210,061	13.8%	10.6%	11.7%	57,555	63,756	74,947
U.K.	130,2	221,267	245,096	7.9%	13.3%	14.2%	25,664	42,333	43,95

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

Country	Total non-domestic EU sovereign exposure in EUR mn			in % of GDP			Non-domestic EU sovereign subsidy (risk-weighted) in EUR mn		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Banks in peripheral countries									
Spain	13,619	11,899	12,14	1.3%	1.1%	1.1%	5,453	9,544	11,582
Ireland	1,528	352	277	1.1%	0.2%	0.2%	453	259	204
Italy	6,535	5,739	4,715	0.5%	0.4%	0.3%	3,004	3,269	3,914
Banks in other countries									
France	113,806	69,791	71,709	6.9%	4.1%	4.0%	39,169	44,424	51,993
Belgium	18,585	9,475	5,875	6.1%	3.0%	1.8%	6,32	6,16	4,229
Germany	77,395	61,619	56,705	3.4%	2.6%	2.3%	29,208	40,36	43,765
U.K.	22,89	15,145	11,076	1.4%	0.9%	0.6%	9,052	11,453	9,051

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

Country	Total non-domestic EU sovereign exposure in EUR mn			in % of GDP			Non-domestic EU sovereign subsidy (risk-weighted) in EUR mn		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Banks in peripheral countries									
Ireland	5,022	10,426	10,613	3.8%	7.3%	7.1%	814	1,555	1,561
Spain	38,601	36,993	61,976	3.6%	3.4%	5.5%	5,741	6,82	10,408
Italy	56,772	62,364	75,407	4.0%	4.2%	5.0%	13,725	13,354	16,317
Banks in other countries									
Belgium	29,232	24,616	26,556	9.6%	7.7%	8.0%	11,534	8,22	7,646
France	113,895	112,543	138,352	6.9%	6.5%	7.7%	18,386	19,332	22,954
Germany	60,12	64,297	77,2	2.6%	2.7%	3.1%	13,054	13,981	16,034
U.K.	107,31	206,122	234,02	6.5%	12.4%	13.6%	16,611	30,88	34,9

Table 4: Sovereign subsidy and sovereign risk

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 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 models in columns (3) to (5) additionally control for time (week) fixed effects or 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)** **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***
	(0.0355)	(0.0422)	(0.0424)	(0.0421)	(0.0428)
Sovereign Subsidy/GDP	-0.0300	0.00356	0.00158		
	(0.0286)	(0.0442)	(0.0450)		
ΔiTraxx		0.151***	0.174***	0.151***	0.171***
		(0.0338)	(0.0361)	(0.0335)	(0.0357)
ΔDS Equity Index		0.0686	-0.0113	0.0625	-0.00975
		(0.0646)	(0.0709)	(0.0644)	(0.0708)
ΔVSTOXX		-0.00513	-0.0128	-0.00549	-0.0127
		(0.0111)	(0.0129)	(0.0112)	(0.0129)
ΔTerm Spread		-0.00363	-0.00293	-0.00369	-0.00293
		(0.00351)	(0.00378)	(0.00351)	(0.00378)
ΔEUR Exchange Rate		-0.182	-0.133	-0.185	-0.128
		(0.159)	(0.184)	(0.163)	(0.184)
Capital Ratio		0.0261	0.0214		
		(0.0758)	(0.0792)		
Deposit Ratio		0.00534	0.00614		
		(0.0125)	(0.0136)		
Funding Fragility		0.00530	0.00525		
		(0.00393)	(0.00434)		
Income Diversity		0.00246	0.00200		
		(0.00777)	(0.00807)		
Liquidity		0.0201	0.0203		
		(0.0357)	(0.0360)		
Concentration		-0.0318	-0.0307		
		(0.0278)	(0.0280)		
Constant	YES	YES	YES	YES	YES
Time 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	0.683	0.688	0.697	0.695	0.703

Table 5: Distinguishing Between Exposure to GIIPS versus non-GIIPS Countries

Panel A of Table 5 reports the results from a regression of changes in individual sovereign CDS on changes in a European sovereign CDS index, the sovereign subsidy, and the interaction between both variables for a subsample of non-GIIPS banks' exposure to GIIPS countries. Panel B reports the results for a subsample of GIIPS banks' exposure to non-GIIPS countries. The sovereign CDS index is weighted by the non-domestic exposures of a country's financial sector. Panel C reports the results from regressions of changes in individual sovereign CDS spreads on specific sovereign subsidies related to exposures GIIPS countries interacted with changes in the respective sovereign CDS spread. 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 time (week) fixed effects 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. Exposure of non-GIIPS Banks to GIIPS Countries (CDS Index)

	(1)	(2)	(3)	(4)	(5)
Model	**OLS**	**OLS**	**FE**	**FE**	**FE**
Dep. variable			**ΔLog CDS**		
ΔLogCDS Index x Sovereign Subsidy/GDP	7.023***	7.049***	7.119***	7.367***	7.410***
	(1.44)	(1.43)	(1.45)	(1.46)	(1.47)
ΔLogCDS Index	0.722***	0.709***	0.620***	0.691***	0.613***
	(.06)	(.06)	(.07)	(.06)	(.07)
Sovereign Subsidy/GDP	-0.0675*	-0.015	-0.00977		
	(.04)	(.07)	(.08)		
Controls	NO	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES
Time 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	0.733	0.735	0.749	0.74	0.753

Panel B. Exposure of GIIPS Banks to non-GIIPS Countries (CDS Index)

	(1)	(2)	(3)	(4)	(5)
Model	**OLS**	**OLS**	**FE**	**FE**	**FE**
Dep. variable			**ΔLog CDS**		
ΔLogCDS Index x Sovereign Subsidy/GDP	1.204	2.397	7.014	3.239	7.917
	(11.69)	(11.19)	(10.13)	(11.3)	(10.32)
ΔLogCDS Index	0.918***	0.731***	0.680***	0.726***	0.669***
	(.16)	(.16)	(.15)	(.16)	(.15)
Sovereign Subsidy/GDP	0.27	0.294	0.209		
	(.27)	(.32)	(.38)		
Controls	NO	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES
Time 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	0.626	0.647	0.698	0.652	0.7

Panel C. Exposures to GIIPS Countries (Country Specific Exposures)

Model	(1) OLS	(2) OLS	(3) FE	(4) FE	(5) FE
Dep. variable			**ΔLog CDS**		
ΔLogCDS Spain x Spain Sovereign Subsidy/GDP	7.204	-8.343	-1.742	-10.88	-4.249
	(50.78)	(43.88)	(42.82)	(44.25)	(43.22)
ΔLogCDS Italy x Italy Sovereign Subsidy/GDP	15.19***	19.86***	18.87***	20.22***	19.13***
	(5.87)	(5.2)	(4.94)	(5.23)	(4.94)
ΔLogCDS Ireland x Ireland Sovereign Subsidy/GDP	-14.77	-104	-109.4	-116.6	-113.6
	(127.3)	(104.2)	(107.6)	(103.8)	(107.4)
ΔLogCDS Greece x Greece Sovereign Subsidy/GDP	-4.118	-9.457	-9.907	-9.544	-9.89
	(7.97)	(6.61)	(6.58)	(6.64)	(6.59)
ΔLogCDS Portugal x Portugal Sovereign Subsidy/GDP	50.87**	41.40*	44.39**	40.34*	44.35**
	(22.05)	(21.41)	(21.89)	(21.85)	(21.95)
Controls	NO	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES
Time 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	0.683	0.688	0.697	0.695	0.703

Table 6: Robustness tests

This table reports the results of several robustness checks using alternative sources and specifications of the main dependent and explanatory variables. In all models, CDS and bond spread changes are computed on a daily level, covering ± 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). Columns (1) and (2) report regressions of changes in individual sovereign 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 exposures of a country's financial system. Columns (3) and (4) report regressions 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. Columns (5) and (6) 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 financial sector toward non-domestic EU sovereigns using exposure data from the EBA), and the interaction between these two variables. The sovereign CDS index is weighted by the non-domestic exposures of a country's financial system. Robust standard errors are reported in parentheses. Significance levels are indicated by *** $p<.01$, ** $p<.05$, * $p<.1$.

Panel A.

	(1)	(2)	(3)	(4)	(5)	(6)
Model	**OLS**	**FE**	**OLS**	**FE**	**OLS**	**FE**
Robustness	**Altern. Dependent variable: bond yields**		**Altern. exposure risk weight: CDS implied**		**Altern. Exposure data: EBA**	
Dep. variable	**ΔLog Bond Yield**		**ΔLog CDS**		**ΔLog CDS**	
ΔBond Index x Sovereign Subsidy/GDP	22.91***	22.70***				
	(2.743)	(2.734)				
ΔLogCDS Index x Sovereign Subsidy/GDP			1.972***	2.005***	1.288**	1.323**
			(0.662)	(0.651)	(0.647)	(0.624)
ΔBond Index	-0.0260	-0.115				
	(0.0881)	(0.0900)				
ΔLogCDS Index			0.855***	0.723***	0.926***	0.875***
			(0.0396)	(0.0459)	(0.0305)	(0.0436)
Sovereign Subsidy/GDP	-0.0188		-0.0185		-0.00266	
	(0.0249)		(0.0177)		(0.0243)	
Controls	NO	YES	NO	YES	NO	YES
Constant	YES	YES	YES	YES	YES	YES
Time FE	NO	YES	NO	YES	NO	YES
Country-Quarter FE	NO	YES	NO	YES	NO	YES
Observations	2,347	2,347	2,352	2,352	3,592	3,592
R^2	0.142	0.177	0.692	0.712	0.697	0.715

Panel B. Falsification tests (non-EU sovereigns)

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

Model	**(1)** **OLS**	**(2)** **FE**	**(3)** **OLS**	**(4)** **FE**
Falsification		**US exposure**		**non-EU exposure (CH/JP/NO/US)**
Dep. variable			**ΔLog CDS**	
ΔLogUS CDS x US Quasi-Sovereign Subsidy/GDP	-1.842	-1.618		
	(5.659)	(4.174)		
Δ LogNon-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***		
	(0.0489)	(0.0397)		
ΔLog Non-EU CDS Index			0.796***	0.326***
			(0.0568)	(0.0468)
US Quasi-Sovereign Subsidy/GDP	0.0329			
	(0.0962)			
Non-EU Quasi-Sovereign Subsidy/GDP			0.0199	
			(0.0646)	
Controls	NO	YES	NO	YES
Constant	YES	YES	YES	YES
Time FE	NO	YES	NO	YES
Country-Quarter FE	NO	YES	NO	YES
Observations	2,597	2,597	2,646	2,646
R^2	0.201	0.595	0.234	0.596

Table 7: Cross-country linkages within the EU

This table reports the results from a regression of changes in individual sovereign CDSs 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. All models account for unobserved common factors with heterogeneous factor loadings by applying the Pesaran CCE estimator. The sovereign CDS index is weighted by the non-domestic 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). 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 time (week) fixed effects or country-quarter fixed effects. Bootstrapped standard errors are reported in parentheses. Significance levels are indicated by *** $p<.01$, ** $p<.05$, * $p<.1$.

Model	**(1)** **CCE**	**(2)** **CCE**	**(3)** **CCE**	**(4)** **CCE**	**(5)** **CCE**
Dep. variable			**ΔLog CDS**		
ΔLogCDS Index x Sovereign Subsidy/GDP	3.585***	3.631***	3.638***	3.631***	3.638***
	(1.358)	(1.204)	(1.169)	(1.054)	(0.997)
ΔLogCDS Index	0.844***	0.760***	0.745***	0.760***	0.745***
	(0.0416)	(0.0467)	(0.0495)	(0.0443)	(0.0357)
ΔiTraxx		0.131***	0.154***	0.131***	0.154***
		(0.0355)	(0.0339)	(0.0302)	(0.0337)
ΔDS Equity Index		-0.00548	0.00172	-0.00548	0.00172
		(0.0553)	(0.0599)	(0.0585)	(0.0619)
ΔVSTOXX		-0.0110	-0.0120	-0.0110	-0.0120
		(0.0101)	(0.0137)	(0.00991)	(0.0119)
ΔTerm Spread		-0.00293	-0.00290	-0.00293	-0.00290
		(0.00350)	(0.00437)	(0.00379)	(0.00475)
ΔEUR Exchange Rate		-0.0419	-0.0884	-0.0419	-0.0884
		(0.183)	(0.169)	(0.186)	(0.153)
Constant	YES	YES	YES	YES	YES
Avg. ΔLog CDS	YES	YES	YES	YES	YES
Avg. Sovereign Subsidy/GDP	YES	YES	YES	YES	YES
Time 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	0.745	0.748	0.749	0.748	0.749

Table 8. Mutual bailout responsibility

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. The sovereign CDS index is weighted by the non-domestic 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). In addition, the models in all columns control for alternative explanations for the impact of non-domestic sovereign CDS changes on sovereign CDS by including the ECB capital share (i.e., bailout responsibility for other eurozone sovereigns) and the ratio of government debt to GDP (i.e., bailout capacity), as well as their interactions with the changes in the sovereign CDS index. Additional 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) control for date- or country-quarter invariant effects. Robust standard errors are reported in parentheses. Significance levels are indicated by *** $p<.01$, ** $p<.05$, * $p<0.1$.

	(1)	(2)	(3)	(4)	(5)
Model	**OLS**	**OLS**	**FE**	**FE**	**FE**
Dep. variable			**ΔLog CDS**		
ΔLogCDS Index x Sovereign Subsidy/GDP	4.441***	4.483***	4.446***	4.510***	4.494***
	(1.088)	(1.083)	(1.048)	(1.122)	(1.079)
ΔLogCDS Index x ECB Share	1.175***	1.168***	1.171***	1.166***	1.154***
	(0.170)	(0.170)	(0.171)	(0.169)	(0.169)
ΔLogCDS Index x Debt Ratio	0.0933	0.0872	0.0913	0.0864	0.0916
	(0.0919)	(0.0904)	(0.0886)	(0.0905)	(0.0880)
ΔLogCDS Index	0.604***	0.532***	0.583***	0.530***	0.474***
	(0.0935)	(0.0949)	(0.0915)	(0.0952)	(0.0943)
Sovereign Subsidy/GDP	-0.0256	0.0473	0.0512		
	(0.0289)	(0.0540)	(0.0572)		
ECB Share	0.00784*	-0.0106	-0.0112		
	(0.00429)	(0.00705)	(0.00776)		
Debt Ratio	-0.000778	-0.00280	-0.00311		
	(0.00226)	(0.00324)	(0.00350)		
Controls	NO	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES
Time 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	0.693	0.698	0.702	0.704	0.712

Table 9: Sovereign risk spillovers and bank capitalization

This table reports the results of tests controlling for potential risk mitigation measures by banks. In all models, CDS spread changes are computed on a daily level, covering ± 30 days around the exposure reporting date (end of quarter 2010-Q4 to 2012-Q4). Columns (1) and (2) report regressions of changes in individual sovereign CDS on changes in a European sovereign CDS index, the sovereign subsidy adjusted by average risk-weighted asset coverage ratio of European sovereign bond exposures by country (i.e., risk-weighted asset/exposure), and the interaction between these two variables. Columns (3) to (6) 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. In addition, we interact all variables with the average risk-weighted asset coverage ratio of European sovereign bond exposures by country (columns (3) and (4)) or with the average bank capital ratio by country and period (columns (5) and (6)). The sovereign CDS index for all specifications is weighted by the non-domestic exposures of a country's financial system. Robust standard errors are reported in parentheses. Significance levels are indicated by *** $p<.01$, ** $p<.05$, * $p<.1$.

	(1)	(2)	(3)	(4)	(5)	(6)
Model	**OLS**	**FE**	**OLS**	**FE**	**OLS**	**FE**
Dep. variable				**ΔLog CDS**		
ΔLogCDS Index x Adj. Sovereign Subsidy/GDP	4.143***	4.196***				
	(1.087)	(1.071)				
ΔLogCDS Index x Sovereign Subsidy/GDP			22.31***	22.18***	13.17***	12.76***
			(5.315)	(5.306)	(4.269)	(4.298)
ΔLogCDS Index	0.845***	0.707***	0.567***	0.418***	0.528***	0.400***
	(0.0356)	(0.0428)	(0.127)	(0.127)	(0.142)	(0.144)
Adj. Sovereign Subsidy/GDP	-0.0306					
	(0.0292)					
RWA Coverage x ΔLogCDS Index x Sovereign Subsidy/GDP			-8.837***	-8.806***		
			(2.549)	(2.551)		
RWA Coverage x Sovereign Subsidy/GDP			-0.105			
			(0.0652)			
RWA Coverage x ΔLogCDS Index			0.136**	0.144**		
			(0.0643)	(0.0627)		
RWA Coverage			0.00220			
			(0.00156)			
Sovereign Subsidy/GDP			0.179		-0.0874	
			(0.132)		(0.0965)	
Capital Ratio x ΔLogCDS Index x Sovereign Subsidy/GDP					-1.563**	-1.482**
					(0.748)	(0.756)
Capital Ratio x Sovereign Subsidy/GDP					0.0122	
					(0.0157)	
Capital Ratio x ΔCDS Index					0.0526**	0.0509**
					(0.0232)	(0.0232)
Capital Ratio					-0.000027	
					(0.000502)	
Controls	NO	YES	NO	YES	NO	YES
Constant	YES	YES	YES	YES	YES	YES
Time FE	NO	YES	NO	YES	NO	YES
Country-Quarter FE	NO	YES	NO	YES	NO	YES
Observations	2,646	2,646	2,646	2,646	2,646	2,646
R^2	0.683	0.703	0.686	0.705	0.685	0.704

Table 10. 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. The sovereign CDS index is weighted by the non-domestic 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 reference results for the full sample, while regression results on a split sample for all quarterly data up to the EBA capital exercise in September 2011 and after the new sovereign buffer became required in June 2012 are reported in columns (2) and (3) respectively. 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 (4) to (6) display the results from the reference and split sample regressions controlling for time (week) fixed effects and country-quarter fixed effects, respectively. 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) FE**	**(5) FE**	**(6) FE**
Dep. variable			**ΔLog CDS**			
	Full sample (reference)	**Before CE[a]**	**After CE[b]**	**Full sample (reference)**	**Before CE [a]**	**After CE[b]**
ΔLogCDS Index x Sovereign Subsidy/GDP	4.026***	3.945***	0.711	4.080***	4.040***	0.306
	(1.063)	(1.165)	(3.597)	(1.048)	(1.164)	(3.276)
ΔLogCDS Index	0.846***	0.864***	0.930***	0.708***	0.759***	0.722***
	(0.0355)	(0.0406)	(0.107)	(0.0428)	(0.0538)	(0.105)
Sovereign Subsidy/GDP	-0.0300	-0.0262	-0.0491			
	(0.0286)	(0.0363)	(0.0674)			
Controls	NO	NO	NO	YES	YES	YES
Constant	YES	YES	YES	YES	YES	YES
Time FE	NO	NO	NO	YES	YES	YES
Country-Quarter FE	NO	NO	NO	YES	YES	YES
Observations	2,646	1,176	882	2,646	1,176	882
R^2	0.683	0.730	0.607	0.703	0.746	0.644

Appendix 1

Variable Definitions

Appendix 1 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 (Basel IRB approach)

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

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

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

$$RWA = RW * EAD$$

Table 1 provides an overview of the resulting risk weights.