Zeppelin University

Department of Corporate Management & Economics

Chair of Empirical Finance & Econometrics

Bachelor Thesis

Capital Buffers and the lack thereof: Did they influence Bank-Sovereign risk Spillovers?

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Degree:	Sociology Politics and Economics
Semester:	Fall 2017
Deadline:	November 29th, 2017

Abstract

We investigate risk spillovers between 29 European banks and 15 sovereigns in the European debt crisis, to see if banks with more capital relative to sovereign debt had higher spillovers, and if overall spillovers decreased in the time of the sovereign buffer by the European Banking Authority. Spillovers are measured by regressing bank CDS on indexes of sovereign CDS, which are weighted by a banks' risk-weighted sovereign holdings, using the foundational internal ratings based approach. We find a strong effect of sovereign indexes on the CDS of banks from core countries, which declined when the sovereign buffer was introduced. We find no strong indication of discrimination based on the ratio of sovereign risk to capital. Our results suggest that spillovers did not reappear when the sovereign buffer was abandoned.

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1 Introduction

On the 25th of June 2012, the Cypriot President Demetris Christofias became the fifth head of state to ask for financial support during the European debt crisis. He declared that, *"*[the] *purpose of the required assistance is to contain the risks to the Cypriot economy, notably those arising from the negative spillover effects through its financial sector, due to its large exposure in the Greek economy."*(Wilson 2012) In the run up to this event, it had become clear that the partial Greek default of 2011 had caught Cypriot banks off guard, who saw their capital cushions eradicated as they had to write off approximately 21 percent of the net present value of their Greek bonds. The resulting funding gap was sizable, with PIMCO, the company asked to investigate the losses, estimating that Cypriot banks would need approximately €5.8 billion to rebuild their capital cushions, €4.5 billion of which resulted from the partial default of the Greek government, commonly referred to as the Greek Private Sector Initiative (PSI). In the end, the consortium of European Central Bank, European Commission and the International Monetary Fund provided financial aid in roughly the size of the Cypriot GDP, about 40 percent of which went to the recapitalization of its largest banks. This was still not enough to ensure the safety of deposits, which also lost a share of their face value. (Michaelides 2014)

The incident was the manifestation of a common fear throughout the European debt crisis: the inability of a government to service its debt and the spillover effects this could have on European banks holding the affected bonds, whose own governments in turn might not have the fiscal capacities to finance bail-outs.[1] It is also the intellectual place of departure of our paper, in which we study spillover effects between European banks and sovereigns. Building on the methodology of Kirschenmann, Korte & Steffen (2016), who studied the same issue with a shorter time horizon and slightly different variables, we investigate if risk spread from governments to banks in other European countries and to what extent two variables influenced this relationship. Specifically, we study the extent to which banks who held more risky debt in comparison to capital experienced stronger spillovers, and how the recommendation by the European Banking Authority (EBA) urging banks to build up capital cushions against sovereign risk, decreased the level of spillovers.

To understand the precise meaning of these questions and the way we study them, it is important to get a glance of the multiple ways through which governments and banks share a risk relation. In this respect the Committee on the Global Financial System (2011) points out that if a bank holds sovereign debt which loses in value and is marked to market, the balance sheet of the bank automatically shrinks. If it is used in repurchasing transactions, the debt

[1] See for example Treanor (2011).

will also require higher margins to account for its riskiness, increasing a bank's refinancing costs. Fundamentally, this is why we argue that the risk of sovereign bonds which banks hold should correlate with the risk of banks. On the other hand, the committee also highlights the existence of a reverse channel, which we try to exclude from our analysis. Since governments are expected to bail out its major banks, a bank that defaults automatically leads to higher debt of its domestic sovereign. In our Cyprus example, this made Cypriot sovereign debt even more risky.

We focus on spillovers between banks in one country and their foreign sovereign borrowers, since this alleviates concerns of reverse causality because no bank can be bailed out by a foreign government. For example, we measure the risk spillovers between a bank in Italy and all of the other 14 European states in our sample. We study the effect in ten time periods between December 2010 and January 2016, for which the European Banking Authority has published the sovereign holdings and capital measures of large European banks, so that we can also see whether banks with more capital relative to the risks in their bond holdings are experiencing weaker spillovers. We assess the risk in banks' bond portfolios by applying two risk-weighting mechanisms, one as calculated by Kirschenmann et al. (2016) based on Basel II standards, and one according to current European capital regulations. With this data we specify a model in which we explain the CDS of 29 EU banks with bank-specific CDS indexes of foreign EU states within each bank's sovereign bond portfolio at the time, and let the ratio of risk-weighted sovereign exposure to capital interact with the index. Using this interaction, we asses whether there is a moderating relationship between the variables in our interaction term, which would suggest an amplifying effect of the sovereign ratio. Secondly, we split our sample in the time horizon before, during, and after the sovereign buffer was introduced by the EBA. By including dummies for the first and the last period, and by interacting them with our primary variables, we can see whether the effects of the variables have changed. We divide our sample into banks from core countries which are usually argued to be less affected by the European debt crisis, and banks from periphery countries who suffered more from the crisis (Baldwin & Giavazzi 2014), to see whether these mechanisms acted differently with respect to this distinction.

Interestingly, while our results strongly suggest the presence of spillovers from sovereigns to banks, especially for banks from core countries, we do not see that banks are discriminated based on their amount of risk weighted sovereign holdings relative to their regulatory capital. Additionally, although we find a significant weakening of the relationship between bank CDS and their sovereign indexes while the sovereign buffer was in place, we do not see that it reappeared afterwards. Of these findings, the second one is especially interesting as it suggests that regulatory measurements might not be perceived as relevant by markets.

The paper is structured as follows: In section two we build the conceptual foundation by reviewing the relevant theoretical and empirical literature, and briefly summarize the regulatory treatment of sovereign debt in the capital requirements in the EU. In section three we describe our data and specify the econometric model. Fourth, we present the results of our analysis, including two robustness tests. Before we conclude our paper, we discuss our findings in section five.

2 Conceptual Foundation and Related Literature

Risk spillovers and "doom-loops" The idea that banks could be dependent on the financial health of foreign states was specifically modeled in Bolton & Jeanne (2011), who show how sovereign bond holdings can be the transmitter of sovereign stress between financially integrated economies. Here, financial integration between two countries is defined as an environment in which debt of the foreign state is commonly accepted as collateral in the domestic state. Collateral is used by banks to borrow from other banks or the central banks for sparking economic activity. On the downside if they lose the trust in the possibility of a country to repay its debt, haircuts on the collateral will rise, making it less useful for borrowing against it. If each sovereign has the same default risk, prices of the two will be the same. However, if one country is considered as the "safe haven", while the other is considered as risky, the safe country is the monopolist on safe bonds, giving it the possibility to extract a "safe haven rent" in the shape of low yields. Since banks in both countries are endowed with the same money to buy bonds, diversification means that both will hold an equal amount of both the safe and the risky debt. This creates the risk of contagion. If risky countries threaten to default, diversified safe country banks can become *hostages* to their risky borrower, enabling risky countries to extract financial assistance so that they do not internalize the entire costs of risky fiscal policies. Two other models also show the risk relationship which banks and governments share. Brunnermeier et al. (2016) show that if a bank is heavily invested into the bonds of its government and either the government or the bank threaten to default, the expectation that the government will bail out the bank can result in a so called "doom-loop". The loop describes the feedback mechanism that occurs when the government is expected but does not have the financial means to bail out its bank, meaning the state itself loses its creditworthiness, which has a negative impact on the bank. This way the crisis reinforces itself. On that basis, Farhi & Tirole (2017) also notice that in a two-country case the defaulting government may expect that if its own default questions the financial stability of foreign banks, the government has a reduced incentive to monitor its own banks. This is because the risk of international spillovers due to the doom-loop can extract financial concessions from foreign states who see their banking system at risk.

Incentives for Excessive Sovereign Holdings within the EU As became evident in the Cyprus example, banks in the EU are at the risk of holding insufficient capital to cover their losses in the case of a European sovereign default. Regulators and economists alike have pointed out that this is due to the Credit Requirements Regulation No. 575/2013 which gives banks the possibility to treat European sovereign debt as risk free, meaning they do not have to hold capital to safeguard themselves against defaults.[2] However, this was not the only mechanism driving banks into excessive bond holdings.

According to Acharya & Steffen (2015) the regulation allows the possibility for "the greatest carry trade ever", which refers to the profit possibilities of banks, arising from using short term funding to invest into bonds from periphery countries to earn the yield difference. During the European debt crisis, banks would lose on both legs of the trade, as bond prices in the periphery declined while core states saw their bond values increase. The authors find evidence that this had significant negative effects on banks share prices, which suggests that the carry trade was indeed common within European banks. Moreover, their results suggest that weakly capitalized banks "gambled for resurrection" similar to the argument by Diamond & Rajan (2011). This suggests that weakly financed banks are incentivized to load up on illiquid risky assets if there is the possibility of a government default, which would decrease its chances of survival even if they tried to safeguard themselves against it. Put more simply, a weakly capitalized bank has a high upside if it gambles on the ability of its governments to survive the crisis and this upside potential is higher if it enters the danger zone in full tilt. On the other hand, if it is only weakly financed, increasing its chance of survival might not be worth the costs. This, of course, is a form of regulatory arbitrage since banks relied on the zero risk weights to load up on EU debt. The investigation report into the crisis of the Bank of Cyprus, which was one of the core importers of Greek stress in our introductory example illustrates this point. Alvarez & Marsal, the firm investigating the issue, explain that a main reason for their high investment into Greek bonds was the "BOC managements desire to deliver net interest income and profit growth". (Alvarez & Marsal 2013)[3] It is also noteworthy, but only

[2]See for example: Andritzky et al. (2016) Lautenschläger (2013), Nouy (2012), and European Systemic Risk Board (2015).

[3]Similarly, Marcello Minenna from the Italian securities regulator, recently argued that peripheral banks would refrain from investing into a safe low yielding asset if it existed, because "peripheral banks have asset

weakly related, that banks tend to hold more sovereign debt from their home state, which Ongena et al. (2016) and De Marco & Macchiavelli (2016) find could be related to pressure on the banks to lend to their sovereigns.

Risk Spillovers in the European Union This leads us to the study by Acharya, Drechsler & Schnabl (2014), whose findings and methodology informed our empirical analysis. They used bank and their belonging government bond Credit default swap (CDS) data to show how risk relations, measured by the linear relation between bank CDS and government CDS, changed after the bailouts of the financial crises of 2008. For European countries, they find that in the post-bailout period between 2008 and 2011, the CDS of the domestic governments of banks explained a significant portion of bank CDS developments. This supports the existence of the sovereign loop within in a country, particularly because of bail outs. Our study also relates to the paper by Beltratti & Stulz (2015), who studied the effect of how European bank stocks reacted to sovereign CDS of peripheral countries during tail periods of the respective CDS premiums between 2010 and 2012. They too used the sovereign exposures as reported by the European Banking Authority during the stress tests and the capital exercise of 2011 to construct bank portfolios with low and high exposures relative to their assets. This way they isolated a systemic, non-exposure related, and an exposure related part of the relation, both of which significantly influenced banks' stock returns according to their findings. Altavilla et al. (2016) also investigated the bank-sovereign feedback loop with CDS data of both groups, and observed how the relation was influenced by sovereign bond holdings between 2008 and 2014. Using a proprietary data set with a monthly frequency, they interacted the ratio of sovereign debt holdings to assets of banks with the CDS of countries to explain bank risk. Their findings suggest an amplification effect in the cases in which banks were paired with their domestic sovereign. After controlling for the effect of the domestic sovereign of each bank, they did not find an amplification effect when it was paired with a foreign country. Contrary to these results are the ones by Kirschenmann et al. (2016) who studied the same relationship, but also used the EBA data. Between 2010 and 2012, they found that an interaction between a sovereign CDS index, which was weighted by the total risk-weighted sovereign exposures of EU countries to each other, could explain significant parts of European bank CDS. This effect was amplified by the non-domestic risk-weighted sovereign exposures of individual banks divided by the banks' assets. The effect was much weaker once the sovereign buffer was introduced. Interestingly, they also found that banks from stronger affected countries are less affected by their non-domestic sovereigns. These findings suggests not only that the sovereign buffer

return targets based on their funding costs." (Minenna 2017) changed something, but, more fundamentally, that markets are informed about the sovereign holdings of individual banks, which is a key assumption of our paper.

Our study is also informed by several papers studying the determinants of bank CDS. Here, multiple studies[4] find that bank CDS premiums were strongly negatively related to stock market returns and positively related to different measures of implied volatility. For us, the studies taking bank capital into account are of especially high interest. For example, Chiaramonte & Casu (2013) and Ötker-Robe & Podpiera (2010), investigate how balance sheet variables influence CDS premiums and did not find a significant influence of regulatory capital ratios. Finally, our findings point into the direction of studies such as Altunbas et al. (2018), who found that capital was not important to predict bank solvency during the financial crisis of 2008.

Sovereign Risk exemption in the European Union Before we dive into our analysis, it is necessary to briefly summarize the background of sovereign risk exemption in the EU. Specifically, the CRR builds on the intuitive idea that banks should hold capital cushions which depend on the riskiness of their investments. This is most pointedly expressed in a simple equation for capital requirements, found for example in Bonner (2014) in which different forms of liable capital in a firm are divided by the riskiness of their investments, which is the sum of capital instruments 1 to K divided by the sum of a bank's investments 1 to R multiplied by their respective riskiness represented by a risk weight:

$$CapitalRatio = \frac{\sum_{k=1}^{K} Capital\ Intstrument_k}{\sum_{r=1}^{R} risk\ weight_r * Exposure_r} \tag{1}$$

In our case, in which we use the common equity tier one ratios of banks (CET1 ratio), we divide the capital classifying as such by the risk-weighted assets. This ratio has to be above 4.5 percent according to CRR Article 92. What is important here is that during our sample period the two capital regulations Directive 2006/48/EC and the Capital Requirements Regulation (CRR) made it possible for banks to invest *any* amount into *all* risk classes of European sovereign bonds, and still assign a weight of zero to all exposures.[5] This means that they did not need to hold capital against them. For this reason, the Basel Committee for Banking Supervision found that banks were considerably understating their true capital needs. (Basel Committee on Banking Supervision 2014) The mechanism behind this is necessary to our

[4] Specifically, we refer to Samaniego-Medina et al. (2016)Annaert et al. (2010), and Drago et al. (2017).

[5] Note that scholars such as Brunnermeier et al. (2017) point out that this treatment is not only economically questionable but also legally inconsistent with the "No-Bailout Clause" in Article 125 of the Lisbon Treaty.

calculation of risk weights.[6] In general, risk weights for financial assets are either determined by a bank internally, using the "Internal Ratings-Based Approach" (IRB) or by relying on credit ratings using the "Standardized Approach" (StA). The idea of two approaches was that large banks have capable internal risk-management teams and can therefore get permission to assign risk weights based on their own calculation, while smaller banks should have a simpler way of calculating risk. In the StA the risk weights which sovereign bonds receive lie between 0 percent for highly rated and 150 percent for very risky countries. However, it also has exceptions to this rule, one of which is that European states all get a zero risk weighting under the standardized approach. Moreover, banks which use the IRB approach have the explicit possibility to also rely on the StA in the case of European states. (European Systemic Risk Board 2015) This clause was part of Basel II and was originally intended for exposures for which it would have been unnecessary to build an internal model, and is usually referred to as "permanent partial use clause", but has now become the main reason the EU is officially not compliant to Basel II. (Basel Committee on Banking Supervision 2014)

The Sovereign Buffer by the EBA As the European debt crisis became worse in 2011, the European Banking Authority decided to follow up its stress test with a recommendation to national supervisors to recapitalize banks in their custody. To protect the European banking system in light of the European debt crisis, the authority demanded that 71 banks should hold a 9 percent core tier one ratio (CT1 ratio) by June 2012, after accounting for an additional buffer against sovereign risk (European Banking Authority 2012*b*). To get an idea of what this means, one can differentiate between the CET1 ratio which we use (because it is more common) and the CT1 ratio just mentioned, by looking into which capital instruments are included in both ratios. Simply put, CET1 capital includes primarily retained earnings, provisions and paid up shareholder capital, making it the most restrictive capital measure,(Bank of England 2017) whereas CT1 capital also includes government guarantees. (European Banking Authority 2011*a*) Now, comparing the 9 percent requirement with the CRR, this seemed like a high bar for banks who would ultimately only need to hold a 4.5 percent percent CET1 ratio. On the other hand, the sovereign buffer was less specified, as the EBA only recommended for banks to apply a "conservative valuation of European sovereign bonds".(European Banking Authority 2011*c*) The recommendation was then twice renewed, once in October 2012 (European Banking Authority 2012*a*), and once in July 2013 such that banks should keep the nominal capital level they had in June 2012. Ultimately, the recommendation was withdrawn

[6] Our study relies on an intuitive understanding of risk-weights in the sense of riskiness, the mathematical idea of risk weights is explained in detail in Basel Committee On Banking Supervision (2005*a*) and Basel Committee On Banking Supervision (2005*b*).

in December 2014, concluding the time of the sovereign buffer(European Banking Authority 2014).

3 Data and Model Specification

The related studies mentioned above find that banks with more risk-weighted sovereign exposures relative to assets are more strongly affected by international spillovers, and that the sovereign buffer by the EBA reduced these spillovers. In this methodological section we build on the approaches used in the related literature, especially in Kirschenmann et al. (2016), to construct our panel data set with which we measure risk spillovers. After short summary statistics, we end with our model specification.

3.1 Calculating the Sovereign Risks of EU Banks

We start by calculating the risks that banks were exposed to due to their government bond holdings. We collect the sovereign holdings data from the EBA stress tests, transparency exercises, a capitalization exercise and the capital exercise, yielding ten cross-sections of sovereign holdings of European banks between 2010 and 2016 for which we have disaggregated holding data.[7] In total, the EBA reports holdings for 157 different banks in the whole sample period from 2010 to 2016, only 72 of which are explicitly referred to in the introduction of the sovereign buffer(European Banking Authority 2011*c*).[8] For these, we proxy the risk stemming from their sovereign bond holdings from the EU countries in our sample, by using the reported gross values of sovereign holdings and adding up all maturities.[9] Since we are mainly interested in effects of the non-domestic sovereign holdings of banks we calculate this value by multiplying each bank's sovereign exposure for all foreign EU countries in our sample all periods with the appropriate risk weights. Specifically, the risk-weighted sovereign exposure of bank i from country j at time t is the sum of the individual risk-weighted sovereign exposures

[7]Note that the EBA also released holding data in the 2016 transparency exercise for December 2015 and June 2016. This data was reported by banks based on a different methodology (European Banking Authority 2016).The outcome of this was transparency exercise was not comparable to the holdings reported in the 2016 stress test, which we show in Figure 4 in the appendix.

[8]The EBA refers to "large" banks, but to our knowledge there was no single rule in place which determined whether banks are addressed or not.

[9]Other studies, such as the one by Beltratti & Stulz (2015) did not find a significant difference between using gross and net holdings. Gross holdings are on immediate borrower basisEuropean Banking Authority 2011*b*.

of the bank stemming from country $1 = c$ to C, exempting the case in which $c = j$:

$$Risk\ weighted\ Sovereign\ Exposure_{i,t} = \sum_{c=1\ for\ c \neq j}^{C} risk\ weight_{c,t} * Sovereign\ Exposure_{i,c,j,t} \tag{2}$$

In this equation, we estimate the risk weights banks would apply if they complied to Basel II standards by using the results of calculations by Kirschenmann et al. (2016). They apply the Basel II methodology to map long-term sovereign credit ratings for debt issued in local currency to risk weights. To be specific, Kirschenmann et al. apply the Foundation Internal Ratings Based (FIRB) formula which is a "one size fits all" method for obtaining risk-weighted exposures, and is a hybrid between the standardized and the fully internal ratings based approach in the Basel II framework. The formula imposes the assumption of a 45 percent loss given default[10] for unsecured senior bonds. Whereas this assumption is a pure regulatory detail, they also assume a maturity for all bond holdings of 2.5 years, which is a methodological decision we follow. Holding these variables fixed, risk weights depended solely on the expected likelihood of default ("probability of default") of an investment. For estimates of this variable they rely on EBA calculations mapping credit ratings to default probabilities, so that they ultimately end up with a mapping between credit ratings and risk weights, which we simply apply.[11] Since our methodology only allows us to make meaningful observations about banks who have non-zero risk-weighted exposures to our sample countries, this approach also comes with the additional benefit of starting at a risk-weighting of 0.144. This allows us to include banks even if they hold only highly rated debt. For our application we obtained long term credit ratings for debt issued in local currency from Bloomberg for our EU countries at each reporting date. We divide the risk-weighted sovereign exposure of banks by their CET1 capital which we also retrieve from the EBA publications, and refer to this ratio as the "sovereign ratio".

At this point, some caveats have to be noted: *Firstly*, we rely on the above-mentioned assumptions to compute the risk-weighted sovereign exposure, meaning it can only be seen as a reasonable proxy for the "real" sovereign risks banks faced. *Secondly* the measure assumes that markets know about the sovereign bond holdings of banks at the time at which banks had to disclose their data to the EBA, even though the reports are only released later during the year.

[10] "Loss given default" strikes us as jargon, but the term is defeatingly precise: It means the loss we expect in case of default.

[11] In the appendix we include a table of the resulting risk-weights. For a detailed explanation of the Basel II approach and the underlying Value-at-Risk model, we refer the reader to Basel Committee On Banking Supervision (2005*a*).

The first assumption is of course also assumed in Kirschenmann et al. (2016), and the second assumption is additionally postulated in Altavilla et al. (2016) and Beltratti & Stulz (2015). *Thirdly*, our sample only includes large European banks, meaning it is not representative of the whole European banking sector. Finally, since there are no sovereign holdings for bankrupt banks, our panel faces attrition in the sense that we lose those institutions which are most risky because they default.

3.2 Sovereign-Bank Risk Relations Data

To evaluate how the ratio of risk-weighted sovereign exposure to CET1 capital of banks affects risk spillovers, we obtain daily data for both our sovereign- and bank CDS as well as our market control variables. Following Kirschenmann et al. (2016) we assume the sovereign ratio of banks to be relatively stable over time, so that we can construct periods around each disclosure date for which holdings are reported. We use data referring to the month before and after the disclosure date. Hence, we refer to ten periods within our time horizon of seven years, beginning in December 2010, and ending in January 2016.[12]

Sovereign Risk Indexes Following the literature on the sovereign-bank nexus, we primarily use spreads on credit default swaps to estimate market expectations about the riskiness of banks and sovereigns. This way of measuring risk spillovers is routinely used in the related literature, since CDS represent a contract between a protection buyer and a protection seller, in which the latter promises to ensure the former against a credit event (usually the partial or complete default) of a third party on its bonds. The premium which the buyer has to pay for the contract is therefore directly related to the probability of default of the third party, making it a good proxy for financial risk (Chiaramonte & Casu 2013). Additionally, in comparison to yields, CDS have several advantages for assessing default risk. For example, Aizenman et al. (2011) amongst others point out that CDS are priced more timely, avoid difficulties in comparing bonds with different time to maturities, and most importantly are not directly influenced by inflation expectations. Like several similar studies, we use CDS spreads on 5-year senior debt contracts because these are usually referred to as most actively traded (De Bruyckere et al. 2013).

For measuring the relation between the CDS spreads of foreign states to which a bank has sovereign debt exposures and its own CDS, each bank gets assigned a unique CDS index in the style of Kirschenmann et al. (2016). The index consists of sovereign CDS, weighted by the risk-weighted assets currently held by the bank, excluding its home state, yielding the

[12]For a detailed list of the included EBA publications we use, please see Table 6 in the appendix.

following formula to construct the index.

$$SovereignIndex_{i,t,c} = \sum_{c=1 \ for \ c \neq j}^{C} CDS_{c,t} * ExposureShare_{i,c,t} \tag{3}$$

Here, the sovereign index of bank i is defined by the sum of all sovereign CDS from country 1 to C to which the bank has an exposure, weighted by the relevance of that exposure, which is the exposure share. For example, in the period around December 2012, 50 percent of the risk-weighted sovereign exposure of a fictional bank might stem from its home state, and 30 percent and 20 percent of sovereign exposure might come from two non-domestic EU countries respectively. In this case, the sovereign index consists of the CDS spreads from both foreign countries with the weighting of 2/5 and 3/5. Thus, a significant coefficient measuring the relationship between the sovereign CDS index of the bank and its own CDS spread is interpreted as a risk spillover from the countries.[13] We obtain CDS spreads from 27 EU sovereigns from Bloomberg and Thomson Reuters Datastream, representing all EU states except Malta, which was not available to us. Of the 27 sovereign CDS, twelve time series had more than five percent missing values in our sample periods between 2010 and 2016. These states are henceforth excluded from our analysis because any missing value would results in a missing value for the whole CDS index. This way, we minimize holes in our index, without relying on imputations which we find are not common in our related literature. Thus, our sample for sovereign CDS contains 15 sovereign CDS, including all states usually taken to represent core and peripheral states except Greece, which had the highest amount of missing values in our sample period.[14] For robustness tests, we also obtain yield data for states with sufficient CDS spreads from Reuters Datastream. Yields also represent an important indicator for sovereign risk, as states which are more likely to default are usually faced with a risk premium on their debt. However, since the yield a lender has to pay on its debt decreases as the debt matures, following a simple bond over time would not effectively give an indicator of sovereign risk. Therefore, we rely on iBoxx indexes for five year rates with a constant maturity from Datastream to represent the development of yields.

Bank CDS Data For the banks in our EBA dataset, we use equivalent CDS contracts from Datastream and Bloomberg. In total we find data on 77 CDS series traded for banks from the EBA publications. Similarly to our treatment of sovereign CDS, we drop banks in periods

[13] The main difference between our approach and the one by Kirschenmann et al. (2016) is that we use bank-individual exposures, not exposures aggregated at the country level. This should give a much more detailed picture of individual risk spillovers.

[14] Namely, Austria, Belgium, Denmark, France, Germany, Netherlands and the United Kingdom are defined as core states, and Bulgaria, Ireland, Italy, Portugal and Spain are defined as periphery states.

in which they were not traded on five days to avoid illiquid CDS spreads. Additionally, we exclude banks in periods in which they had two consecutive price movements of zero, also indicating illiquidity. Ultimately, 33 bank CDS fulfill our activeness requirements, 4 of which were not in the sample during the capital exercise, meaning they were not directly addressed by the EBA to improve their capital position. We remain with 29 banks, yielding 196 data points of EBA data. 10 of these banks are from our periphery countries while 19 are from core states.

3.3 Market Control Variables

Given the strong correlation between sovereign CDS spreads in Europe, it is likely that the relation between the CDS spread of a bank and its sovereign CDS index is due to the correlation of the CDS spread of its host country to the countries in its sovereign index. Thus, without controlling for the domestic CDS of each bank, the regression would risk restating the finding by for example Acharya, Drechsler & Schnabl (2014) that bank CDS strongly correlate to the CDS of their home countries, leaving our coefficients for our main variables biased. Moreover, if we did not control for the sovereign CDS, we would risk that our findings are influenced by a reverse causality issue due to the doom-loop, meaning that a bank default could trigger the CDS of its government to rise, which as we say, we expect to correlate with the CDS of other countries. Therefore, we control for the respective domestic sovereign CDS in our regression.

More generally, we control for proxies of the general market environment to alleviate concerns about endogeneity because it is likely that some a part of the between a bank and foreign sovereigns within Europe is caused by the underlying development of the economy. This concern is further supported by studies on CDS determinants of banks as cited above, who found that market variables such as volatility and general market return were significant in determining CDS spreads of European banks. For this reason, we follow studies such as, Acharya, Drechsler & Schnabl (2014) who adopted a set of daily traded control variables which we will also include in our regression. We capture economic sentiment by controlling for the movement of the Stoxx Europe 600 and the VSTOXX. The Stoxx Europe is an equity index comprising the 600 largest equities in Europe, and the VSTOXX is similar to the VIX in that it captures the implied volatility of the largest 50 equities in the Eurozone, making it the most “European” measure of implied volatility. Moreover, we control for the general state of the European financial sector by including a routinely quoted CDS index of European financials by iTraxx. This index contains Europe’s 30 most traded CDS of financial institutions(Markit

Indices Limited 2016).[15] We obtain all of the time series mentioned in this paragraph except the sovereign CDS from Thomson Reuters Datastream.

3.4 Summary Statistics

Before we begin with our econometric analysis, we examine summary statistics, which are reported in Table 1. Focusing on our EBA data, it is interesting to see that only by adding the domestic part of banks' gross sovereign exposure, average and median increase by roughly 75 percent and 116 percent respectively, pointing towards the existence of the home bias as discussed in De Marco & Macchiavelli (2016). In general, the FIRB approach applies higher risk weights than the StA approach, which becomes evident by comparing the values of the resulting exposure levels. By todays standards of the CRR, banks in our sample range between solidly under-capitalized at 0.039 percent and well capitalized at 0.161 percent, when looking at CET1 ratios.

Table 1: This table shows summary statistics for periodical variables from the EBA reports for all 29 banks in our sample and daily variables for our sample of 15 states. The total risk-exposure of a bank is measured by the bank itself applying either internal ratings based or standardized approaches to calculate their overall risk-weighted exposures. Common equity tier1 capital (CET1 Capital) is the most restrictive measure of capital including exclusively paid up capital, retained earnings and similar capital measures. Gross sovereign exposures are the sovereign exposures as they come from the EBA banking authority. IRB risk-weighted Sovereign exposures are the gross exposures risk-weighted by the FIRB approach as indicated above. StA sovereign exposures are risk-weighted by the standardized approach based on the Capital Requirements Regulation, explained in detail in our description of the second robustness test in section 4.3. CET1 Ratio represents the ratio of CET1 capital to risk-weighted assets. All sovereign ratios are the respective (risk-weighted) non-domestic exposures divided by CET1 capital. Daily CDS are retrieved from Reuters and Bloomberg and represent CDS on five year senior bonds. Sovereign yields are iBoxx 5 year constant maturity indexes for all governments on a daily basis. The CDS and yield indexes capture the sovereigns to which a bank has exposures in each period, and are weighted by share of risk-weighted exposures in our sample. Stoxx Europe 600 is an European wide equity index of 600 largest stocks. EuroSTOXX 50 Volatiltiy captures the implied volatility of the EuroSTOXX50, which represents 50 sector leaders in the Eurozone. iTraxx Financials is an index capturing CDS premiums for 30 subordinated liquid financial CDS from Europe.

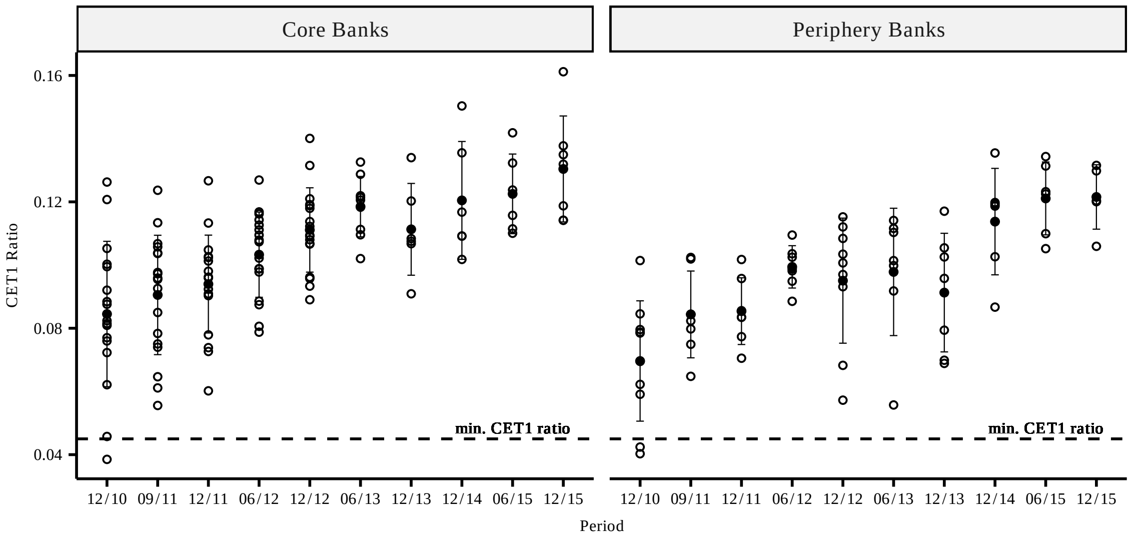
Periodical Variables	N	Mean	St. Dev.	Min	Median	Max
Total Risk-Exposure	196	288,780.900	218,846.100	42,376.110	268,644.600	1,066,401.000
Common Equity T1 Capital	196	30,490.020	24,582.260	2,717.014	28,551.750	123,406.500
Gross Sovereign Exposure	196	22,026.330	20,265.400	3.499	18,283.210	108,492.400
Gross non-domestic Sovereign Exposure	196	12,542.350	14,810.480	0.001	8,431.670	91,080.450
IRB risk-weighted Sovereign Exposure	196	15,966.850	14,832.790	1,522.208	11,947.840	74,978.120
IRB risk-weighted non-domestic Sovereign Exposure	196	6,038.162	5,314.508	0.656	4,858.337	26,394.270
StA risk-weighted Sovereign Exposure	196	2,575.140	3,079.709	0.000	1,343.950	16,768.020
StA risk-weighted non-domestic Sovereign Exposure	196	981.993	1,080.594	0.000	766.502	6,634.387
CET1 Ratio	196	0.102	0.021	0.039	0.103	0.161
Gross Sovereign Ratio	196	0.397	0.613	0.00000	0.251	3.661
IRB Sovereign Ratio	196	0.207	0.193	0.0001	0.159	1.423
StA Sovereign Ratio	196	0.038	0.053	0.000	0.023	0.534

Daily Variables	N	Mean	St. Dev.	Min	Median	Max
Bank CDS	7,433	243.881	167.559	39.119	199.186	997.012
Sovereign CDS	7,433	158.012	153.329	12.433	101.217	1,184.951
Sovereign Yields	7,433	2.000	1.803	−0.300	1.270	13.780
Bank specific Sovereign CDS Index	7,433	227.095	145.384	17.080	188.613	1,175.702
Bank specific Sovereign Yield Index	7,433	2.821	1.711	−0.242	2.600	13.661
Stoxx Europe 600	7,433	284.166	46.508	214.886	280.454	405.680
EuroSTOXX50 Volatility	7,433	49,520.870	33,606.780	9,949.960	47,057.390	126,093.000
iTraxx Financials 5 Year CDS Index (Subordinated)	7,433	324.773	140.313	122.260	285.330	580.500

[15] To us, only the index which is based on subordinated debt was available.

In Figure 1, we examine how banks' capital ratios have changed over time. Here the divide between core and periphery banks can be seen, as banks from the latter continue to be less capitalized throughout our sample period. On the other hand, the drastic increase in capital ratios can also be seen. Moreover, the meticulous reader might remember that the 9 percent CT1 ratio goal set by the EBA for June 2012 is only different from CET1 ratio displayed here in that it includes government guarantees. This shows the extent to which periphery governments had to support their banks to make the ratio.

Figure 1: Comparison of CET1 ratios of core and periphery banks over time. Bars represent standard deviations of the period, while black dots represent the mean of each period. Circles represent individual banks. The dashed line at 4.5 percent shows the current floor of CET1 ratios as stated in the Capital Requirements Regulation.



In figure 2, we compare sovereign ratios for core and periphery banks. This figure suggests that neither core nor periphery banks drastically changed their sovereign ratios once the sovereign buffer was introduced. Instead, a small decline came between September and December 2011, which coincided with the partial Greek default. For core banks the time also marked the exit of Dexia from our sample, which is the outlier in the upper left corner of the chart. On the other hand, average sovereign ratios in the periphery rose slightly but steadily once the sovereign buffer was no longer applied after December 2014.

Finally, if one includes the domestic sovereign exposure of banks into the calculation, as done in figure 3, one can see that periphery banks even increased their risk-weighted exposure relative to CET1 capital while the buffer was still applied. This casts doubts on the effectiveness of the sovereign buffer.[16]

[16]To see the exact development of sovereign exposures in absolute values we show the gross and risk-weighted non-domestic exposures in the appendix in Figures 5 and 6. Here, one can see an increase in sovereign exposure in the risk-weighted holdings, but the increase of unweighted sovereign exposure is lower. Thus, this development seems partially rating induced.

Figure 2: Comparison of sovereign ratios as derived by the FIRB approach above. Bars represent standard deviations of the period, while black dots represent the mean of each period. Circles represent individual banks.

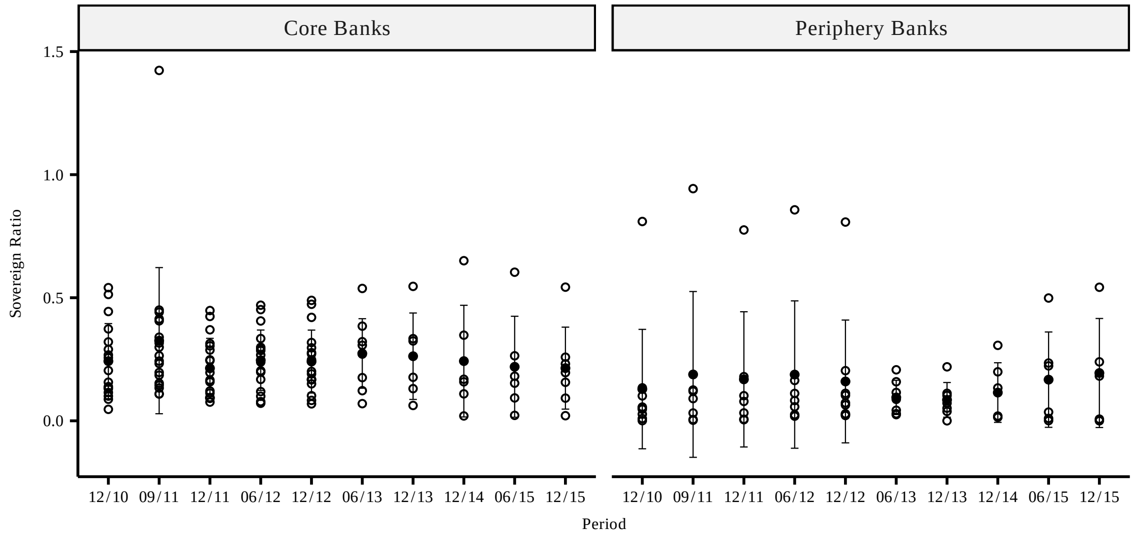
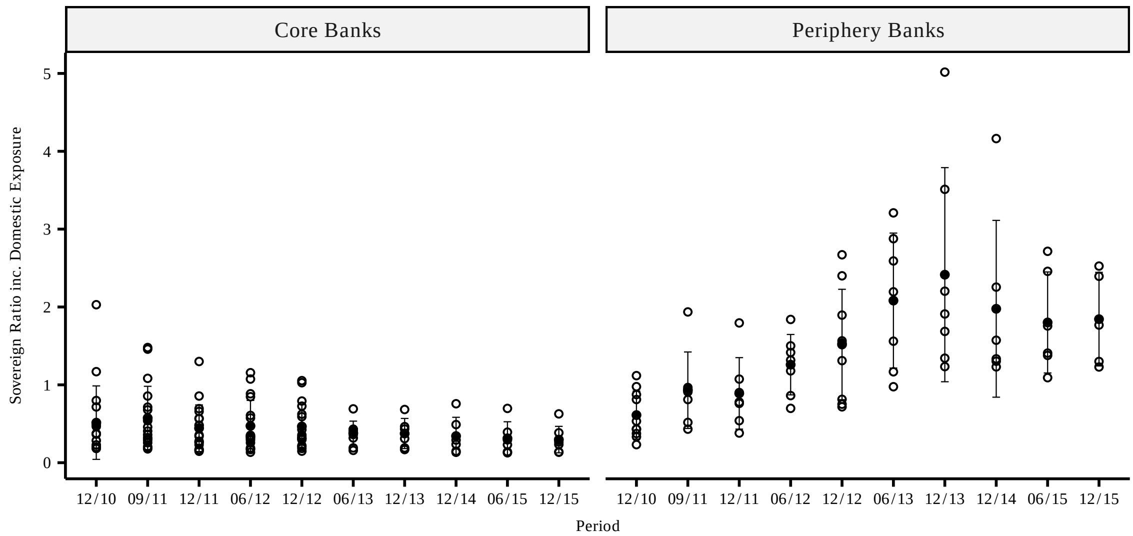


Figure 3: Comparison of sovereign ratios as derived by the FIRB approach above but including a banks home exposures. Bars represent standard deviations of the period, while black dots represent the mean of each period. Circles represent individual banks.



3.5 Model Specification

In this section, we present the model with which we analyze the non-domestic sovereign-bank feedback loop. We expect that time-independent, bank-specific variables correlate with the non-domestic sovereign ratio predictor. Most intuitively, the risk savviness of banks could lead to higher risk-weighted sovereign exposures and lower CET1 capital. Similarly, we expect that our variables could be influenced by periodical effects, an example of which can be seen in Figure 1, showing rising CET1 ratios in each period. This points us to a fixed effects (FE) model, in which we avoid concerns about non-stationarity by transforming all our daily variables into approximate growth rates using logged first differences:

$$\begin{aligned}\Delta \log CDS_{i,j,t} = \alpha_i + \delta_t + \beta_1 \Delta \log SovereignIndex_{i,t} + \beta_2 SovereignRatio_{i,t} \\ + \beta_3 \Delta \log SovereignIndex_{i,t} * SovereignRatio_{i,t} + \beta_4 CET1ratio_{i,t} + \\ \beta_5 \Delta \log DomesticCDS_{j,t} + \beta_6 \Delta \log Vola_t + \beta_7 \Delta \log EuropeStoxx600_t + \\ \beta_8 \Delta \log iTraxxFin_t\end{aligned} \tag{4}$$

In this equation, $CDS_{i,j,t}$ represents the CDS of bank i in country j at time t, which we explain by its individual non-domestic sovereign CDS index indicated by $SovereignIndex_{i,t}$, its ratio of non-domestic sovereign exposure to CET1 capital, which is scaled so that zero represents the average ($SovereignRatio_{i,t}$), and the interaction term of these variables. This term indicates how the effect of a bank's sovereign index on its own CDS is moderated by its sovereign ratio. If this coefficient is significant and positive, we interpret it as showing the amplification of spillovers due to a higher sovereign ratio. Beta four to eight relate to control variables, with $CET1ratio_{i,t}$ representing CET1 Ratios, $\Delta \log DomesticCDS_{j,t}$ indicating the domestic government CDS of banks in country j, $\Delta \log Vola_t$ referring to the VSTOXX index, and Europe Stoxx and iTraxx being represented by the last two variables respectively. Lastly, α_i are bank fixed effects and δ_t represents time fixed effects on a periodical basis. Testing this model against a random effects model indicates that the latter would be inconsistent, which is why we remain in a FE framework. However, this does not imply that coefficients are stable across banks, which is why we run a F-test, comparing the FE model against an alternative with bank specific coefficients. Here, we reject the null of equal betas, pointing to models with individual coefficients. Before we move ahead with this approach, however, we test whether we can estimate at least some parameters for all individuals, comparing our individual parameter model to a fixed effects model, in which we introduce individual betas for the market control variables. This time, the F-test fails to reject the H0 of equal betas which encourages us to remain in the fixed effects framework, and interpret our variables of interest with more ease.

This is an econometric justification for a concern that Acharya, Drechsler & Schnabl (2014) explained intuitively, which is that not all banks correlate with the stock market in the same way. Some might be highly exposed to economic developments, others might not. If this is the case, a all-encompassing coefficient for all banks would dilute our controls. Thus, we follow our predecessors and interact bank dummies with all our market controls. This leads us to the following regression, which is similar to the just-mentioned studies:

$$
\begin{aligned}
\Delta \log CDS_{i,j,t} = \alpha_i + \delta_t + \beta_1 \Delta \log SovereignIndex_{i,t} + \beta_2 SovereignRatio_{i,t} \\
+ \beta_3 \Delta \log SovereignIndex_{i,t} * SovereignRatio_{i,t} \\
+ \beta_4 CET1ratio_{i,t} + \theta' * \mathbf{X}_{i,j,t} + \varepsilon_{i,j,t}
\end{aligned} \tag{5}
$$

In this equation, all our market control variables are within the $\mathbf{X}_{j,t}$ matrix, which we interact with the matrix θ', whose rows represent variables and whose columns represent banks. In order to correct for arbitrary forms of heteroskedasticity and serial correlation in the errors[17], we present our results using standard errors clustered as proposed by Arellano (1987) on bank-individual level, which alleviates concerns about both biases in fixed effect settings. However, although we do use a small sample correction, Cameron & Miller (2015) note that for small number of clusters, clustered standard errors could induce a downward bias. Rogers (1993) argued that this bias should be small, even in the case in which a cluster represents only 5 percent of the total sample, suggesting a subset of 19 core banks should not strongly bias standard errors. However, this still presents a concern, especially in the case of our periphery subsample of ten banks. For this reason we display the naive standard errors in brackets below the robust ones and only discuss coefficients if they are robust in the sense that they are solidly significant (p-value ≤ 0.05) against the respectively higher standard error. By this, we sacrifice some power of our analysis but on the other hand account for the high chance of making a type I error if we solely relied on our clustered erros for inference.

4 Exploring Risk Spillovers

Finally, this section presents our findings. As discussed above, we expect that CDS premiums of banks are positively correlated with their foreign CDS index, especially when their non-

[17]Both of which are present according to a Breusch-Godfrey test for serial correlation in the errors and a Breusch-Pagan Test for heteroskedasticity.

domestic sovereign subsidy is high. Secondly, we are interested in the sovereign buffer as explained above.

4.1 Fundamental Regression

Firstly, we estimate a rudimentary regression in which we include bank fixed effects, but only control for the CET1 ratio and domestic sovereign CDS spread of each bank. Next, we augment this regression by adding our market control variables. Lastly, we show the full model including interactions between our bank dummy and the controls as mentioned above. In table 2 we present the results. In both models with a single coefficient for the domestic sovereign CDS, our calculated sovereign index coefficient is higher. In our full model, we find that, ceteris paribus, the CDS of a bank with an average sovereign ratio is expected to rise 0.176 percent for a one percent increase of its sovereign index. Although we rely on our full model for the analysis of our questions, the basic model with market controls gives an indication of the effect of our control variables. Across banks, volatility loads slightly positive, but the STOXX Europe 600 and the iTraxx Sub-Financials Index have a stronger impact. All else equal, the average bank CDS is expected to decrease by roughly 39 basis points if the equity index increases by one percent and to increase by 32 basis points when the iTraxx increased by one percent. Interestingly, neither our interaction term, nor the CET1 ratio is significant once we control for these variables. We now slightly change the regression to focus on how the effect of our explanatory variables has changed over time and across subgroups.

Table 2: This table shows the effect of the primary explanatory variables, the CDS-Index of each bank ($\Delta \log SovereignIndex_{i,t}$), the banks risk-weighted sovereign exposure divided by its CET1 capital ($SovereignRatio_{i,t}$) and their interaction term in three different models. In the basic model, we simply control for a banks CET1 ratio ($CET1ratio_{i,t}$) and the domestic sovereign of each bank ($\Delta \log DomesticCDS_{j,t}$). In the second model we add market controls, namely the VStoxx ($\Delta \log Vola_t$) the Europe Stoxx 600 ($\Delta \log EuropeStoxx600_t$), and the iTraxx Financials index ($\Delta \log iTraxxFin_t$),to show their effect on our primary variables and on our sample banks. In our complete model, the domestic CDS of each bank and all market control variables are interacted with bank dummies, such that each bank is allowed to have individual coefficients. For daily variables, approximate growth rates were derived by taking logged first differences, the sovereign ratio was scaled so that 0 represents the average. The periodical variable CET1 ratio was not transformed. Bank fixed effects are present in all models, time fixed effects are excluded from the basic model. Standard errors in parenthesis are clustered on bank-level, the second row of standard errors in brackets are the naive standard errors.

		$\Delta\log CDS_{i,j,t}$	
	Basic Model	Basic Model with Market Controls	Complete Model
	(1)	(2)	(3)
$\Delta \log SovereignIndex_{i,t}$	0.501	0.189	0.176
	(0.054)	(0.031)	(0.027)
	[0.015]	[0.015]	[0.015]
$SovereignRatio_{i,t}$	0.005	−0.002	−0.002
	(0.006)	(0.002)	(0.002)
	[0.005]	[0.005]	[0.004]
$\Delta \log SovereignIndex_{i,t} * SovereignRatio_{i,t}$	0.163	0.009	0.121
	(0.181)	(0.164)	(0.114)
	[0.054]	[0.048]	[0.074]
$\Delta \log DomesticCDS_{j,t}$	0.189	0.086	
	(0.036)	(0.026)	
	[0.013]	[0.012]	
$CET1ratio_{i,t}$	0.063	−0.009	0.002
	(0.022)	(0.021)	(0.022)
	[0.022]	[0.031]	[0.030]
$\Delta \log Vola_t$		0.081	
		(0.021)	
		[0.015]	
$\Delta \log EuropeStoxx600_t$		−0.389	
		(0.078)	
		[0.048]	
$\Delta \log iTraxxFin_t$		0.316	
		(0.019)	
		[0.010]	
Bank&Time FE	B	Y	Y
Individual Coefficients	N	N	Y
Observations	7,237	7,237	7,237
R^2	0.330	0.477	0.531
Adjusted R^2	0.327	0.474	0.520

4.2 The Two Dimensions of Risk Spillovers

To test how spillovers have developed across time, we include two time dummies in our equation. By this, we see whether the change of the coefficients for our key explanatory variables is statistically significant between the periods in which the sovereign buffer was applied and when it was not. Specifically, we include a before-, and an after-dummy, such that the time during which the sovereign buffer was introduced represents our base period, and interact the dummies representing the different periods with the sovereign index, the sovereign ratio, and their interaction effect. The modified regression thus looks as follows:

$$\begin{aligned}\Delta \log CDS_{i,j,t} = \alpha_i + \delta_t + \beta_1 \Delta \log SovereignIndex_{i,t} + \beta_2 SovereignRatio_{i,t} + \\ \beta_3 \Delta \log SovereignIndex_{i,t} * SovereignRatio_{i,t} + \\ Before * (\beta_4 \Delta \log SovereignIndex_{i,t} + \beta_5 SovereignRatio_{i,t} + \\ \beta_6 \Delta \log SovereignIndex_{i,t} * SovereignRatio_{i,t}) + \\ After * (\beta_7 \Delta \log SovereignIndex_{i,t} + \beta_8 SovereignRatio_{i,t} + \\ \beta_9 \Delta \log SovereignIndex_{i,t} * SovereignRatio_{i,t}) + \\ \beta_{10} CET1ratio_{i,t} + \theta' * \mathbf{X}_{j,t} + \varepsilon_{i,j,t}\end{aligned} \tag{6}$$

Here, it is also interesting to see whether there is any difference in risk spillovers for core and periphery banks. Intuitively, one might imagine that peripheral banks were seen as less stable, even after controlling for CET1 ratios. On the other hand, the findings by Kirschenmann et al. (2016) indicate that peripheral banks are not strongly affected by their sovereign index, once the CDS of the domestic sovereign is controlled for. Thus, we estimate the regression separately for our full sample, periphery and core banks. Of course, if the sovereign buffer had a significant effect, the comparison should reveal that the coefficients measuring spillovers should be significantly larger in the other two periods. Table 3 shows our results of all three models.

For the full sample, the coefficient of our sovereign CDS index has slightly decreased in this specification, which can now be understood as the coefficient of the variable while the sovereign buffer was applied. Importantly, the coefficient of our before-dummy interacted with the sovereign index was also significant and positive, meaning before the sovereign buffer was introduced it was roughly 80 percent higher, which one can see by adding the coefficients of the sovereign index-before-dummy-interaction to the coefficient of the base period ($0.137+0.112 = 0.249$). The coefficient of the respective after-dummy was not significant. For periphery banks, we note that the interaction between the before-dummy and the sovereign ratio are significant with respect to the robust standard errors, but not with respect to our naive standard errors. For core banks, the pattern of our full sample is almost precisely replicated, meaning the coefficient of the sovereign index was significant both while the sovereign buffer was applied and in interaction with the before-dummy.

Table 3: This table shows the effect of the primary explanatory variables, the CDS index of each bank ($\Delta \log SovereignIndex_{i,t}$), the banks risk-weighted sovereign exposure divided by its CET1 capital ($SovereignRatio_{i,t}$) and their interaction term, interacted with two dummies representing the time phases before and after the sovereign buffer were introduced. The table shows the results for the whole sample, for banks from the periphery regions which were stronger affected by the sovereign debt crisis and core regions which were less affected. All regressions include the full set of controls interacted with bank dummies and also include fixed effects on a periodical and bank basis. For daily variables, approximate growth rates were derived by taking logged first differences, the sovereign ratio was scaled so that 0 represents the average. The periodical variable CET1 ratio was not transformed. All standard errors are clustered on bank-individual level.

	$\Delta\log CDS_{i,j,t}$		
	Full Sample	Periphery	Core
	(1)	(2)	(3)
$\Delta \log SovereignIndex_{i,t}$	0.137	0.031	0.192
	(0.029)	(0.056)	(0.028)
	[0.019]	[0.038]	[0.026]
$SovereignRatio_{i,t}$	−0.001	−0.004	0.001
	(0.003)	(0.016)	(0.002)
	[0.005]	[0.018]	[0.007]
$\Delta \log SovereignIndex_{i,t} * SovereignRatio_{i,t}$	0.031	−0.018	−0.197
	(0.156)	(0.288)	(0.125)
	[0.116]	[0.213]	[0.167]
$Before * \Delta \log SovereignIndex_{i,t}$	0.112	0.028	0.158
	(0.036)	(0.054)	(0.039)
	[0.023]	[0.039]	[0.031]
$After * \Delta \log SovereignIndex_{i,t}$	0.013	−0.042	0.053
	(0.027)	(0.042)	(0.040)
	[0.027]	[0.042]	[0.038]
$Before * SovereignRatio_{i,t}$	0.003	0.006	−0.004
	(0.002)	(0.003)	(0.004)
	[0.004]	[0.005]	[0.007]
$After * SovereignRatio_{i,t}$	−0.007	−0.014	0.000
	(0.005)	(0.011)	(0.003)
	[0.006]	[0.014]	[0.009]
$Before * \Delta \log SovereignIndex_{i,t} * SovereignRatio_{i,t}$	0.344	0.190	0.313
	(0.220)	(0.224)	(0.263)
	[0.133]	[0.192]	[0.202]
$After * \Delta \log SovereignIndex_{i,t} * SovereignRatio_{i,t}$	−0.088	−0.041	−0.066
	(0.127)	(0.263)	(0.135)
	[0.160]	[0.253]	[0.228]
Bank&Time FE	Y	Y	Y
Individual Coefficients	Y	Y	Y
Observations	7,237	2,541	4,696
R^2	0.533	0.596	0.511
Adjusted R^2	0.522	0.585	0.499

4.3 Robustness Tests

Before we enter the interpretation and discussion of our results, we reestimate our model changing consecutively, the measurements of our sovereign holdings and our sovereign risk indexes. We start by using government bond yields as given by Datastreams iBoxx yield indexes instead of CDS to calculate our sovereign index and control for the risk of the domestic sovereign of each bank. Through this, we see whether our results were solely due to our way of measuring sovereign risks as done in the literature (e.g. in (Acharya, Drechsler & Schnabl 2014) and (Kirschenmann et al. 2016)).

Sovereign Risks Measured by Yield Finding growth rates with logged first differences of yields takes some methodological considerations as to avoid having data points below zero, we would need to add a constant of 0.3, which would obscure our growth estimates, especially for low yielding bonds. Therefore, and for ease of comparison, we use realized growth rates to account for the developments in sovereign yields.[18] In table 4 we report our results.

In our full sample, the results remain broadly similar, except that the coefficient of the sovereign index interacted with the sovereign ratio was significant but negative, suggesting that the effect was weaker than during the time of the sovereign buffer. However, for the base period the interaction effect is only weakly significant against the less conservative clustered standard errors, meaning we have only weak evidence for the existence of the effect. The sovereign index coefficient and interaction terms behave similar to above, with the index being significantly higher before the buffer was introduced. However, here we also note that once the sovereign buffer was no longer applied, the coefficient of the sovereign index measured in yield became negative[19]. This pattern in which the sovereign index coefficient was larger when interacted with the before-dummy and smaller when interacted with the after-dummy holds across groups. Ceteris paribus, we see that banks from core countries which had an average sovereign ratio faced an increase of roughly 10 basis points for a one percent increase of the sovereign index during the base period. Once the sovereign buffer was no longer applied, the effect was practically zero ($.102 - .100$). In some cases, the two kinds of standard errors lead to different inferences. For example, in our periphery subgroup, our interaction between sovereign ratio and the before-dummy seem highly significant against our clustered errors, but only weakly significant against our naive errors, which we suspect is a sign of the downward bias induced by an insufficient number of clusters. These are cases in which we refrain from inference. Lastly, we revert back to our original measures of sovereign risks using CDS and

[18]Of course, this does not really change results, but should give a slightly more accurate picture.
[19]Since $0.082 - 0.099 < 0$

test whether our results are robust against using a different risk-weighting procedure.

Risk Weights Calculated by the Standardized Approach Now, we measure the risk weighted exposure of banks to non-domestic sovereigns using the standardized approach as set out in the Credit Requirements Regulation. Article 136 and the corresponding implementing technical standards published by all European Supervisory Authorities map our credit risk ratings into credit quality steps(Joint Committee of the European Supervisory Authorities 2015). Article 114 of the same regulation then maps these steps into actual risk weights for non-EU sovereigns. Thus, we use the procedure which banks who do not use the internal ratings based approach would revert back to when determining their risk exposure to countries outside of the EU. This comes with the peculiarity that sovereign exposures can now obtain a zero risk weight if the country at the time has a credit rating of AA or better. Thus, for example all banks from Germany have only non-domestic exposure once it is risk weighted. This also means that one bank which did not have any non-domestic exposure with a risk weight above zero drops out, since our calculation of their sovereign index would also result in an index of zeros. Table 5 reports our results.

For our full sample, the difference between the coefficients of the sovereign index in the period while the sovereign buffer was introduced and the period before it was introduced is now higher than in our main regression. We find no effects for banks from periphery countries which are significant against both standard errors. For core banks the pattern of the full sample seems to be repeated, although the interaction of our sovereign index and the after-dummy is only weakly significant against the more conservative standard error.

Table 4: This table shows the effect of the primary explanatory variables, the yield index of each bank ($Growth\ SovereignIndexYield_{i,t}$), the banks risk-weighted sovereign exposure divided by its CET1 capital ($SovereignRatio_{i,t}$) and their interaction term, interacted with two dummies representing the time phases before and after the sovereign buffer were introduced. The table shows the results for the whole sample, for banks from the periphery regions which were stronger affected by the sovereign debt crisis and core regions which were less affected. All regressions include the full set of controls interacted with bank dummies and also include fixed effects on a periodical and bank basis. For the sovereign yield index and the domestic yield, growth rates were real growth rates, but all other daily control variables were transformed into approximate growth rates by taking logged first differences. The sovereign ratio was scaled so that 0 represents the average. The periodical variable CET1 ratio was not transformed. Standard errors in parenthesis are clustered on bank-level, the second row of standard errors in brackets are the naive standard errors.

	$\Delta\log CDS_{i,j,t}$		
	Full Sample	Periphery	Core
	(1)	(2)	(3)
$Growth\ SovereignIndexYield_{i,t}$	0.082	−0.042	0.102
	(0.017)	(0.035)	(0.017)
	[0.018]	[0.038]	[0.022]
$SovereignRatio_{i,t}$	−0.003	−0.002	−0.000
	(0.003)	(0.016)	(0.002)
	[0.005]	[0.018]	[0.007]
$Growth\ SovereignIndexYield_{i,t} * SovereignRatio_{i,t}$	0.178	−0.282	0.227
	(0.097)	(0.229)	(0.120)
	[0.114]	[0.219]	[0.142]
$Before * Growth\ SovereignIndexYield_{i,t}$	0.154	0.213	0.166
	(0.034)	(0.036)	(0.046)
	[0.032]	[0.058]	[0.041]
$After * Growth\ SovereignIndexYield_{i,t}$	−0.099	−0.117	−0.100
	(0.017)	(0.050)	(0.021)
	[0.019]	[0.040]	[0.024]
$Before * SovereignRatio_{i,t}$	0.002	0.007	−0.006
	(0.002)	(0.002)	(0.004)
	[0.004]	[0.005]	[0.007]
$After * SovereignRatio_{i,t}$	−0.006	−0.016	0.001
	(0.005)	(0.010)	(0.003)
	[0.006]	[0.014]	[0.009]
$Before * Growth\ SovereignIndexYield_{i,t} * SovereignRatio_{i,t}$	0.099	0.518	−0.052
	(0.196)	(0.127)	(0.342)
	[0.186]	[0.295]	[0.271]
$After * Growth\ SovereignIndexYield_{i,t} * SovereignRatio_{i,t}$	−0.264	−0.483	−0.217
	(0.113)	(0.292)	(0.137)
	[0.121]	[0.233]	[0.155]
Bank&Time FE	Y	Y	Y
Individual Coefficients	Y	Y	Y
Observations	7,224	2,541	4,683
R^2	0.510	0.572	0.487
Adjusted R^2	0.498	0.560	0.474

Table 5: This table shows the results of our second robustness test, using risk-weighted holdings derived by the standardized approach as given by the Capital Requirements Regulation to derive the sovereign ratio. It presents the effect of the primary explanatory variables, the CDS index of each bank ($\Delta \log SovereignIndex_{i,t}$), the banks risk-weighted sovereign exposure divided by its CET1 capital ($SovereignRatioStA_{i,t}$) and their interaction term, interacted with two dummies representing the time phases before and after the sovereign buffer were introduced. The table shows the results for the whole sample, for banks from the periphery regions which were stronger affected by the sovereign debt crisis and core regions which were less affected. All regressions include the full set of controls interacted with bank dummies and also include fixed effects on a periodical and bank basis. For daily variables, approximate growth rates were derived by taking logged first differences, the sovereign ratio was scaled so that 0 represents the average. The periodical variable CET1 ratio was not transformed. Standard errors in parenthesis are clustered on bank-level, the second row of standard errors in brackets are the naive standard errors.

	$\Delta\log CDS_{i,j,t}$		
	Full Sample	Periphery	Core
	(1)	(2)	(3)
$\Delta \log SovereignIndex_{i,t}$	0.095	−0.003	0.120
	(0.021)	(0.052)	(0.017)
	[0.017]	[0.043]	[0.021]
$SovereignRatioStA_{i,t}$	−0.017	−0.087	−0.009
	(0.009)	(0.080)	(0.009)
	[0.018]	[0.071]	[0.021]
$\Delta \log SovereignIndex_{i,t} * SovereignRatioStA_{i,t}$	−0.608	−1.689	−0.790
	(0.365)	(1.077)	(0.320)
	[0.442]	[1.493]	[0.502]
$Before * \Delta \log SovereignIndex_{i,t}$	0.147	0.076	0.167
	(0.036)	(0.071)	(0.041)
	[0.024]	[0.050]	[0.030]
$After * \Delta \log SovereignIndex_{i,t}$	0.031	−0.018	0.063
	(0.023)	(0.044)	(0.027)
	[0.026]	[0.055]	[0.034]
$Before * SovereignRatioStA_{i,t}$	0.007	0.070	−0.008
	(0.010)	(0.025)	(0.009)
	[0.017]	[0.044]	[0.019]
$After * SovereignRatioStA_{i,t}$	−0.034	−0.130	0.002
	(0.027)	(0.069)	(0.012)
	[0.034]	[0.088]	[0.040]
$Before * \Delta \log SovereignIndex_{i,t} * SovereignRatioStA_{i,t}$	0.398	0.433	0.476
	(0.495)	(1.764)	(0.496)
	[0.499]	[1.598]	[0.564]
$After * \Delta \log SovereignIndex_{i,t} * SovereignRatioStA_{i,t}$	0.211	0.306	0.033
	(0.516)	(1.208)	(0.427)
	[0.761]	[2.031]	[0.874]
Bank&Time FE	Y	Y	Y
Individual Coefficients	Y	Y	Y
Observations	6,998	2,302	4,696
R^2	0.531	0.602	0.506
Adjusted R^2	0.520	0.591	0.493

5 Discussion

To discuss our findings, we will summarize and comment on our results, especially in light of the methodological limitations of this paper, talk about alternative channels, and provide some questions for further research.

One key finding of our study is that even once we control for variables of general market conditions and, most importantly, the domestic sovereign CDS of each bank, the CDS of banks in our sample were still influenced by the CDS of sovereigns in their bond portfolios during the full time horizon. When dividing the sample into core and periphery banks, our results suggest that this finding was mostly due to the core banks in our sample. This is in line with the findings of Kirschenmann et al. (2016) who also found stronger spillovers for core banks. A potential reason for this could be that periphery banks were priced mostly with regard to their home country, whereas the sovereign risks from core banks came mostly from other countries. However, given our small sample of periphery banks, this result should be seen as preliminary. For core banks, our finding is in line with the predictions by the Committee on the Global Financial System (2011), the model of Bolton & Jeanne (2011) and studies investigating similar questions as mentioned above. One alternative channel of this finding could be that banks also have exposures to the rest of the economy of these states, whose developments would be a third variable influencing the credit worthiness of both sides. However, this concern is partially addressed by our market control variables, since any economic shock of this type would have to be strong enough to hit the whole economy of an European state, but at the same time local enough to not show up in our control variables. Moreover, while isolating sovereign from economic risks is statistically interesting, the case in which a government's credit worthiness declined in the absence of an economic downturn strikes us as rather unique, and we are not aware of such a case for an EU country.[20] Yet, this is an important caveat to all studies investigating this impact, and although we are not aware of bank specific datasets to control for such exposures, [21] future studies should focus on isolating the effect more clearly.

For core banks, we also see that these spillovers declined once the sovereign buffer was introduced, which fits to the findings by Kirschenmann et al. (2016). This is nonetheless interesting since our measure of sovereign risks in banks' balance sheets (the sovereign ratio) hardly points towards an improvement of capital cushions relative to sovereign risk after

[20]If anything, such an incident would look like the one of Ecuador in 2008, in which the government simply announced its default to buy its debt at a lower price later on. See for example: The Economist (2009)

[21]On an aggregated level, Kirschenmann et al. (2016) use a dataset by the Bank for International Settlements which does not change their overall findings. Altavilla et al. (2016), who use the dataset by the ECB do not account for similar concerns.

the introduction of the sovereign buffer. On the other hand, capital ratios have improved gradually during that time. We also do not find a significant increase of CDS relations after the sovereign buffer was abandoned. Moreover, when using yields the effect was the opposite, and our findings suggest a gradual decline in risk spillovers measured in this way. We argue that this is likely to be due to a divergence in interest yields and CDS movements. In 2015, while interest rates increased due to increased growth and inflation expectations, fears of sovereign defaults have decreased. On the bank side, the increase in growth will also have decreased CDS. Thus, whereas interest rates were likely to be a good predictor of risks in crisis times, it is likely that this function is inhibited when growth accelerates. [22] The effect of the last period could also be influenced by attrition, and we cannot control for general market sentiment making it difficult to separate its effects from the effect of the sovereign buffer. Indeed, the European debt crisis has become less severe across our time periods[23] which could explain why risk spillovers have not come back. What we would expect is that a ten percent CDS growth of France from 20 to 22 will not change the CDS of banks, but in times in which the CDS is at 200, it is very likely that markets will react by adjusting their positioning. Thus, another direction of research would be how the sovereign buffer changed market behavior during tail returns, along the lines of Beltratti & Stulz (2015). Therefore, our evidence for the effect of the sovereign buffer is encouraging but not conclusive.

Finally, we find close to no evidence for a discrimination between banks based on their sovereign holdings relative to their capital. In our full sample the interaction term between the sovereign index, the sovereign ratio and the after-dummy was significant once, but we have no statically significant result for the base period. This makes an interpretation difficult and drawing wide ranging conclusions from it does not seem like a fair presentation of our results. What is more interesting is why the coefficient of the interaction was not significant in the first place! This could have two possible reasons: *i*) Markets could simply be not efficient enough to precisely evaluate the sovereign risks a bank is exposed to, so that banks with especially high risks are not perceived as more risky or; *ii*) the measure could be perceived as irrelevant. Since, Altavilla et al. (2016), Kirschenmann et al. (2016), and Beltratti & Stulz (2015) find that higher sovereign holdings relative to assets tend to be more affected by CDS developments in their holdings, this leaves the denominator as the questionable candidate. Our suspicion is fueled by the findings of Chiaramonte & Casu (2013), who found that capital ratios were no relevant factor to determine bank CDS in any of their considered time periods between 2007 and 2011. The same is found by Ötker-Robe & Podpiera (2010), who do a

[22] See for example Claeys & Efstathiou (2017) for a brief discussion of this development in Europe.
[23] See for example Baldwin et al. (2015) for a more detailed narrative.

similar study between 2004 and 2008 in Europe. In this time phase it is unlikely that capital ratios would not have been relevant due to unaccounted sovereign risks, since the European debt crisis only began in 2009. Following Lautenschläger (2013), one could argue that the small explanatory power of capital ratios is due to the difficulties in comparing them, given the freedom of regulators to influence their calculation. This links our paper to critiques of capital standards, not only in the EU, but in general as laid out in the Basel proposals. Here, Altunbas et al. (2018) argue in a forthcoming paper that bank capital played only a small role in predicting bank solvency during the financial crisis. Similarly, Acharya, Engle & Pierret (2014) found that using risk-weighted assets to determine capital shortfalls leads to strongly different conclusions from approaches using more accessible data. Thus, to us, the most likely explanation of us not seeing an amplification of risk spillovers due to higher sovereign ratios is that our approach might still be too close to what Basel *defines* as risky, because we thereby are too far from what markets *perceive* as risk.

6 Conclusion

So, would more regulatory capital have prevented the Cypriot crisis? Did Cypriot consumers lose their deposits because European banks did not have a sovereign buffer? Our results do not suggest that they did. In theory, capital should be a cushion against the risks of investments, yet our findings do not point into this direction. Instead, while we do not settle for a binary answer on the impact of the sovereign buffer, we do argue that our findings point away from regulatory measures like risk-weighted assets and capital to predict the amplifying affect of risk-spillovers. If similar evidence mounts further, either regulators or markets might want to reconsider their premises.

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8 Appendix

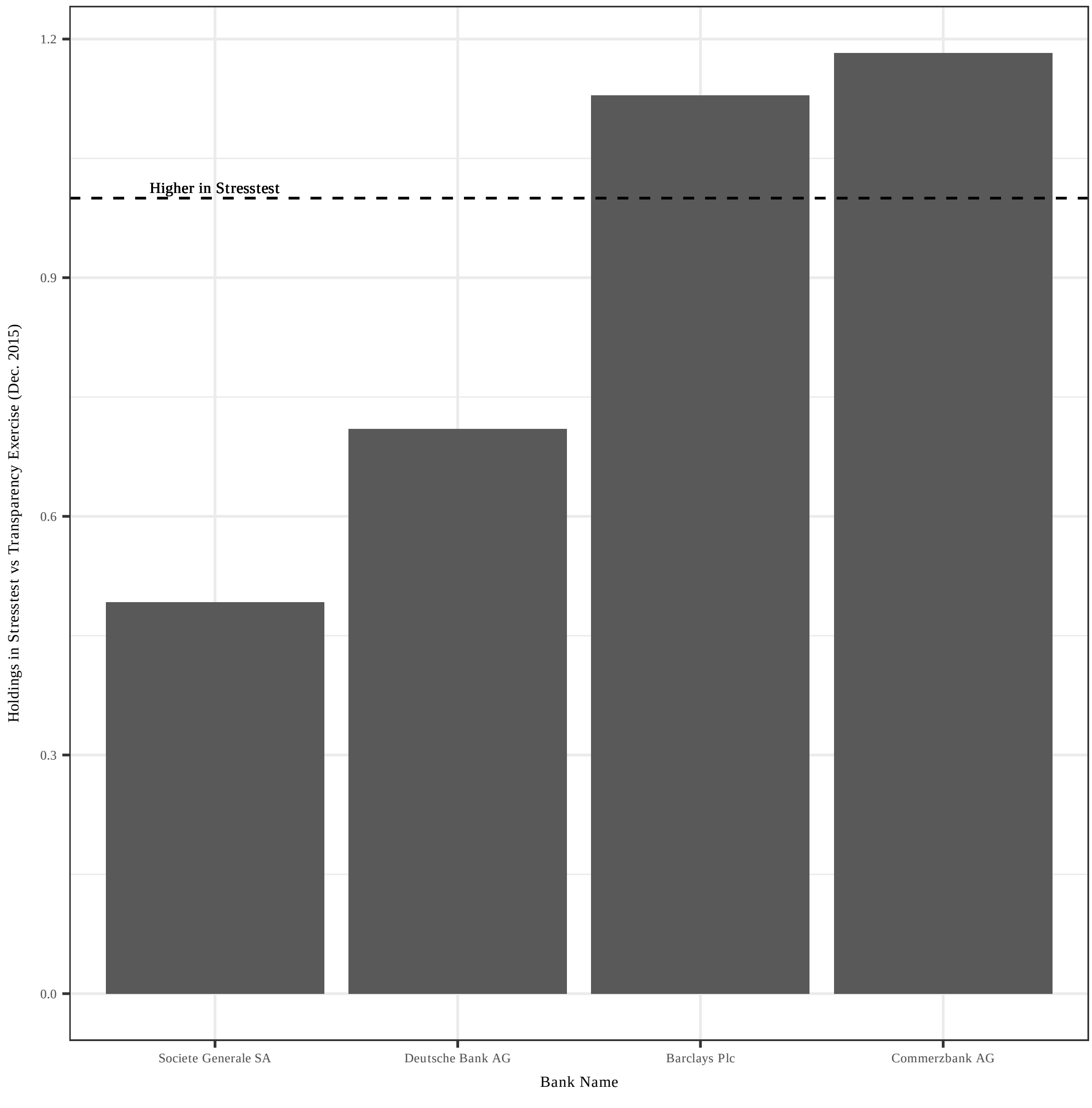
Table 6: This table shows the reporting dates of the different EBA reports from which we obtain our periodical data points. It also indicates whether the sovereign buffer was active during each specific time period.

Report	Date	Sovereign Buffer
Stress Test	31.12.2010	No
Capital Exercise	30.09.2011	No
Recapitalization Exercise	31.12.2011	No
Recapitalization Exercise	30.06.2012	Yes
Transparency Exercise	31.12.2012	Yes
Transparency Exercise	30.06.2013	Yes
Stress Test	31.12.2013	Yes
Transparency Exercise	31.12.2014	Yes
Transparency Exercise	30.06.2015	No
Stress Test	31.12.2015	No

Table 7: This table shows the variables that were used in our analysis, their source and a description including the third party provider for the indexes we obtained from Thomson Reuters DataStream.

Variable	Source	Description
Total Risk Exposure	EBA Publications	Total risk-weighted assets of each bank calculated by the banks themselves.
Common Equity Tier One Capital	EBA Publications	Total common equity tier one capital of each bank calculated by the banks themselves.
Sovereign Holdings	EBA Publications	Gross sovereign holdings of each bank split up by maturity, and exposure towards each state on immediate borrower basis.
Sovereign Debt Rating	Bloomberg	Long-Term Creditor Rating for Debt issued in local currency rated by FitchRating Ltd.
Bank CDS	Bloomberg and Thomson Reuters Datastream	Five year CDS of senior bonds of each bank of our 29 sample banks.
Sovereign CDS	Bloomberg and Thomson Reuters Datastream	Five year CDS of senior bonds of each of our 15 sample states.
Sovereign Yields	Thomson Reuters Datastream	Iboxx yield indices for 5 year sovereign bonds in our sample, maintained by Markit Ltd..
Stoxx Europe 600	Thomson Reuters Datastream	Stock market index comprising the 600 largest stocks in Europe.
EuroSTOXX50 Volatility	Thomson Reuters Datastream	Implied volatility index of EuroSTOXX50, which is an equityindex comprising 50 stocks of sector leaders in the Eurozone.
iTraxx Financials 5 Year CDS Index	Thomson Reuters Datastream	Index comprising the 30 most liquid CDS spreads of subordinated debt from financial institutions in Europe by Markit Ltd..

Figure 4: This plot shows the strongest deviations between the 2016 transparency exercise and the 2016 stress test in our sample, by showing the ratio of risk-weighted exposures according to the stress test divided by the transparency exercise. Since the Societe Generale SA showed only roughly 50 percent during the stress test, but the Commerzbank showed almost 120 percent during the stress test, exposures derived in the new methodology were obviously not comparable to the one that was used in all other reports before. The dashed line marks the one, at which point both exposures would be equal to each other.



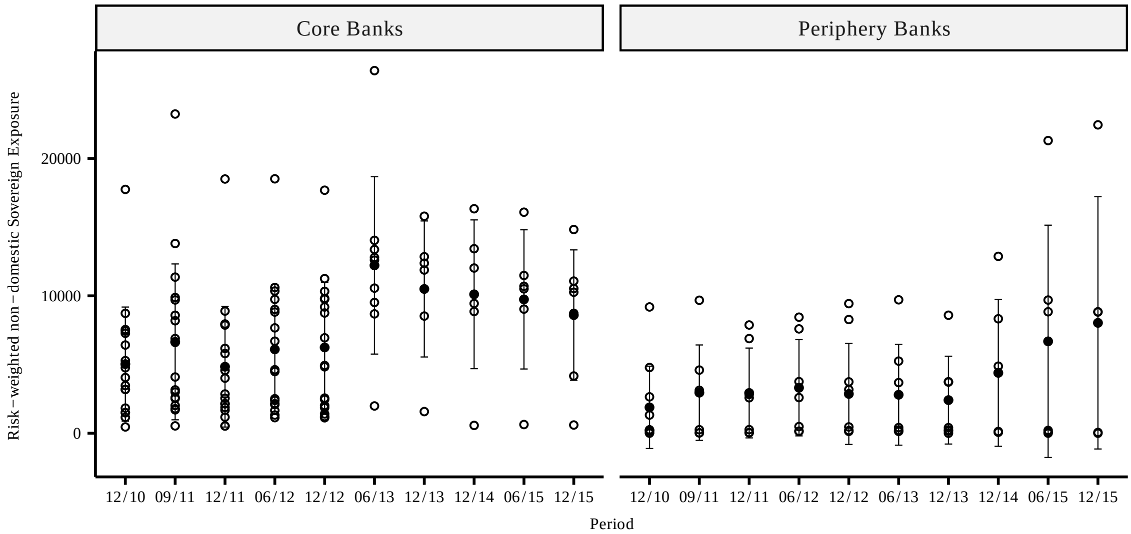


Figure 5: This plot shows the pure risk-weighted and non-domestic sovereign exposure using the IRB methodology. Bars represent standard deviations of the period, while black dots represent the mean of each period. Circles represent individual banks. It suggests a marked increase for core banks in June 2013 and a gradual increase for periphery banks starting in the last period of the sovereign buffer.

Figure 6: This plot shows the unweighted non-domestic sovereign exposure. Bars represent standard deviations of the period, while black dots represent the mean of each period. Circles represent individual banks. Both increases are less extreme in this chart, suggesting that the increase was partially due to worsening ratings of sovereigns.

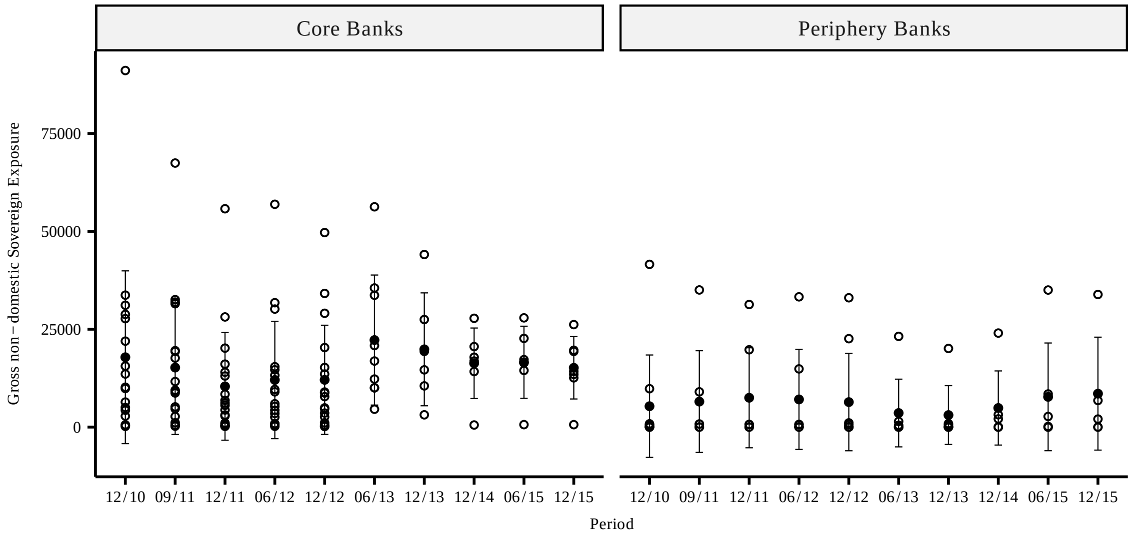


Table 8: This table shows all long-term creditor ratings for debt issued in local currency by FitchRatings Ltd. as obtained from Bloomberg for our sample countries. It also shows the distibution of our sample banks. Countries from where we did not have banks did not receive a core or periphery classification since this was only necessary for splitting our sample.

Country	Periphery or Core	Number of Banks in Sample	31.12.2010	30.09.2011	31.12.2011	30.06.2012	31.12.2012	30.06.2013	31.12.2013	31.12.2014	30.06.2015	31.12.2015
Austria	Core	1	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AA+	AA+
Belgium	Core	1	AA+	AA+	AA+	AA	AA	AA	AA	AA	AA	AA
Bulgaria	Periphery	1	BBB	BBB	BBB	BBB	BBB	BBB	BBB	BBB	BBB	BBB
Denmark	Core	1	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA
France	Core	3	AAA	AAA	AAA	AAA	AAA	AAA	AA+	AA	AA	AA
Germany	Core	7	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA
Hungary	NA	0	BBB	BBB	BBB	BBB-	BBB-	BBB-	BBB-	BBB-	BBB-	BBB-
Ireland	Periphery	1	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	BBB+	A-	A-	A-
Italy	Periphery	5	AA-	A+	A+	A-	A-	BBB+	BBB+	BBB+	BBB+	BBB+
Netherlands	Core	3	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA
Portugal	Periphery	2	A+	BB+	BB+	BB+	BB+	BB+	BB+	BB+	BB+	BB+
Slovenia	NA	0	AA	AA-	AA-	A	A-	BBB+	BBB+	BBB+	BBB+	BBB+
Slovakia	NA	0	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+
Spain	Periphery	1	AA+	AA-	AA-	A	BBB	BBB	BBB	BBB+	BBB+	BBB+
United Kingdom	Core	3	AAA	AAA	AAA	AAA	AAA	AA+	AA+	AA+	AA+	AA+

Table 9: This table shows the mapping of risk weights to the fitch ratings as obtained from Kirschenmann et al. (2016) and the StA risk weights, which are regulated in Article 114 CRR in combination with Article 136 and the corresponding ITS by the Joint Supervisory Authorities as explained in the second robustness test in section 4.3.

Fitch Rating	F-IRB Risk Weights	StA Risk Weights
AAA	0.144	0
AA+	0.144	0
AA	0.144	0
AA-	0.144	0
A+	0.505	0.2
A	0.505	0.2
A-	0.505	0.2
BBB+	0.776	0.5
BBB	0.776	0.5
BBB-	0.776	0.5
BB+	1.244	1
BB	1.244	1
BB-	1.244	1
B+	1.91	1
B	1.91	1
B-	1.91	1
CCC+	2.451	1.5
CCC	2.451	1.5
CCC-	2.451	1.5
RD	2.451	1.5
D	2.451	1.5

Ehrenwörtliche Erklärung Ich erkläre hiermit ehrenwörtlich, dass ich die vorliegende Bachelorarbeit mit dem Thema: *"Capital Buffers and the lack thereof: Did they influence bank-sovereign risk Spillovers?"* selbstständig und ohne fremde Hilfe angefertigt habe. Die Übernahme wörtlicher Zitate sowie die Verwendung der Gedanken anderer Autoren habe ich an den entsprechenden Stellen der Arbeit kenntlich gemacht. Ich bin mir bewusst, dass eine falsche Erklärung rechtliche Folgen haben wird.

Paris, January 26, 2018

Jan Felix Jörss