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WORKING PAPER

BANK/SOVEREIGN RISK SPILLOVERS IN THE EUROPEAN DEBT CRISIS

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Bank/sovereign risk spillovers in the European debt crisis

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Abstract

This paper investigates contagion between bank risk and sovereign risk in Europe over the period 2006-2011. We define contagion as excess correlation, i.e. correlation between banks and sovereigns over and above what is explained by common factors, using CDS spreads at the bank and at the sovereign level. Moreover, we investigate the determinants of contagion by analyzing bank-specific as well as country-specific variables and their interaction. We provide empirical evidence that various contagion channels are at work, including a strong home bias in bank bond portfolios, using the EBA's disclosure of sovereign exposures of banks. We find that banks with a weak capital and/or funding position are particularly vulnerable to risk spillovers. At the country level, the debt ratio is the most important driver of contagion.

Keywords: Contagion, bank risk, sovereign risk, bank business models, bank regulation, sovereign debt crisis

JEL Classifications: G01, G21, G28,H6

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"The most serious threat to financial stability in the European Union stems from the interplay between the vulnerabilities of public finances in certain EU member states and the banking system, with potential contagion effects across the Union and beyond".

Jean-Claude Trichet, 22th of June 2011, ESRB[1]

1. Introduction

Due to the absence of a common European policy framework for handling the banking crisis as well as missing bank resolution mechanisms, several European governments were forced to respond at the national level by rescuing troubled banks headquartered in their countries during the financial crisis. Various measures have been taken, ranging from equity injections in troubled banks to the setting-up of bad banks (Petrovic and Tutsch (2009)). Invariably, these rescue operations have increased national debt burdens and caused a deterioration of public finances. One consequence of the risk transfer from the private sector to sovereign treasuries has been an increased interdependence of banks and states, causing negative feedback loops between their financial conditions. With the rise of the sovereign debt crisis in Europe, the link between bank- and country risk has intensified further, especially for the countries that were quickly identified as vulnerable, namely Greece, Ireland, Italy, Portugal and Spain (the GIIPS countries). This increased interdependence is illustrated in the figures in appendix. The figures depict the country CDS spread and the average bank CDS spread for the countries in our sample. They illustrate that there is a lot of heterogeneity in both the level of the sovereign and bank CDS spreads and in the comovement between the sovereign and bank spreads. The link between the risk profile of banks and countries in which they are headquartered varies over time and is partly influenced by shocks in the economy or the banking system. A major shock stemming from the banking system was the demise of Lehman Brothers in September 2008, which provoked a substantial increase of CDS spreads for banks and also for certain countries, typically smaller countries with large banks or countries where banks had to be rescued. The sovereign debt crisis further intensified the link between bank- and country risk. The sovereign debt crisis is usually considered to have started at the end of 2009, when the newly elected Greek government announced that the country's budget deficit was much larger than previously reported. In the case of Greece, two bailout packages were put together under the surveillance of the "troika" (IMF, ECB, European Commission), one of them including a substantial write-off of Greek

[1] http://www.esrb.europa.eu/news/pr/2011/html/is110622.en.html

debt in the books of private investors. Later, further rescue packages were implemented for Portugal and Ireland, all under the supervision of the troika. A series of credit rating downgrades of the affected countries followed, causing bond and CDS spreads to widen considerably, as shown, e.g., in the Global Financial Stability Reports of the IMF.[2]

During the sovereign debt crisis, banks in Europe were and remain confronted with stress in their capital and liquidity positions. A substantial number of banks had to rebuild their capital buffers after the losses they innitially incurred in their securities (mainly asset-backed) and lending portfolios, especially those with real estate exposures. A general lack of trust hampered the access of banks to money market funding, which was eventually alleviated, at least temporarily, by non-conventional longer-term refinancing operations set up by the ECB. Further, the European Banking Authority (EBA) decided to conduct a sovereign stress testing exercise and required that banks execute detailed capital rebuilding plans before mid-2012. The disclosure of detailed information on banks' exposures to sovereign risk in the EBA (and former CEBS) stress testing exercises provided valuable information to market participants to gauge the risk profile of European banks. Overall, the consequence of the continued stress in the banking system and the vulnerability of certain European sovereigns is that the financial conditions of banks and sovereigns became increasingly intertwined.

Considering this increased interaction between sovereign and bank credit risk, the objective of this paper is twofold. First, we analyze whether we find empirical evidence of contagion. We investigate the time-varying intensity of the risk spillovers using excess correlations as our preferred contagion metric. Second, we attempt to explain the contagion effect by investigating the relationship between excess bank/sovereign correlations and both bank and country characteristics. While there have been several papers investigating the determinants of either bank risk or sovereign risk in isolation, there is less evidence on the potential mutual contagion effects. By analyzing a number of relevant variables and the interplay between bank and country characteristics, we are able to identify critical interactions that are related to bank/country contagion. This allows us to tackle a series of relevant policy questions concerning the banking system as well as the financial condition of sovereigns.

The main findings of this paper can be summarized as follows. We document significant empirical evidence of contagion between bank and sovereign credit risk during the European sovereign debt crisis. In 2009, when the sovereign debt crisis emerged, we find significant spillovers for 86% of the banks in our sample. Second, given the home bias in banks' government exposures, i.e. their typically larger expo-

[2] Throughout the paper we use the terms contagion and risk spillover interchangeably.

sure towards the home sovereign, we provide empirical evidence confirming the expectation that contagion between banks and their home country is stronger. Third, we find that the degree of contagion is significantly linked to bank capital adequacy, and this effect is economically very significant. Furthermore, the higher a bank's reliance on short-term funding sources, the higher the intensity of spillovers between banks and sovereigns. Making use of the EBA stress test disclosures, which include bank-specific information on banks' sovereign debt holdings, we confirm that higher sovereign debt holdings are associated with a stronger bank-sovereign contagion. This suggests that the disclosures made in the context of the EBA stress tests have increased the degree of transparency of bank risk exposures and that market participants use this information to assess the creditworthiness of banks.

The remainder of this paper is structured as follows. Section 2 reviews the literature on contagion and more specifically the European sovereign debt crisis. In Section 3 we describe the data and the methodology. Section 4 reports our empirical findings**,** including robustness checks. Section 5 summarizes the conclusions and policy implications.

2. Bank/Sovereign Contagion: Literature Overview

This paper is closely related to three strands of the existing literature. First, our paper is linked to work on the emergence of the European sovereign debt crisis and the transmission channels through which it propagates. Second, our empirical analysis is closely related to work on financial contagion. The third strand of relevant literature investigates the risk profile of bank business models.

Regarding the risk transmission channels, BIS (2011b) identifies four main channels through which sovereign risk can have an impact on financial institutions. First, there is an *asset holdings channel*, since the asset side of banks' balance sheets may directly be weakened through losses on holdings of sovereign debt. This channel is investigated by Angeloni and Wolff (2012), who study whether banks' sovereign exposure to GIIPS countries had an effect on their stock market values. They find that banks' market performance in the period July to October 2011 was impacted by Greek debt holdings, and in October to December 2011 by Italian and Irish sovereign exposures. Spanish exposure did not appear to have an impact on banks' stock market values. On the relationship between sovereign risk and bank risk, Kyle and Wirick (1990) test whether the August 1982 advent of the Latin American debt crisis affected the implicit value of commercial bank equities. They find indeed that the market value of banks with major Latin American

loan exposure was significantly reduced.The second transmission channel is a *collateral channel.* Sovereign risk can potentially spread to banks when the value of collateral that banks hold in the form of sovereign debt is reduced. This relates to studies such as Kiyotaki and Moore (2005) and Kaminsky et al. (2003), who describe how negative shocks in one market can directly affect collateral values or cash flows associated with securities in other markets. Related to this, a *rating channel* may impact banks' funding conditions, since downgrades of sovereigns may influence the rating of domestic banks negatively. This may in turn affect banks' funding costs and possibly worsen their access to money market and deposit markets. Arezki et al. (2011), for example, focus on European sovereigns between 2007 and 2010 and show that sovereign rating downgrades cause a significant spillover, both across markets and countries. Finally, the *guarantee channel* is related to the too-big-to-fail status of some large banks. When the fiscal position of sovereigns is weakened, implicit and explicit government guarantees might lose value, making it harder for the financial sector to derive benefits from such guarantees.

In line with the guarantee channel, Brown and Dinc (2011) provide evidence that a country's ability to support its financial sector, as reflected in its public deficit, affects its treatment of distressed banks. Demirguc-Kunt and Huizinga (2011) find that in 2008 systemically large banks saw a reduction in their market valuation in countries running large fiscal deficits, as these banks became too big to save. When governments bail out banks, Ejsing and Lemke (2011) show that there can be a 'credit risk transfer'. Exploring the developments of CDS spreads for Euro area countries and banks from January 2008 to June 2009, they show that the bailouts during that period caused a credit risk shift from the banking to the sovereign sector, with banks' CDS spreads decreasing at the expense of increasing sovereign risk spreads. Alter and Schuler (2012) also focus on bank bailouts during the recent financial crisis in Europe. They use a vector error correction framework to analyze price discovery mechanism of CDS spreads prior to and after government rescue packages. Their main results state that before bank bailouts, increased bank default risk was transmitted to sovereign CDS, yet the impact the other way around was weak. They further find that after bank rescues, increased sovereign default risk does have an impact on banks' CDS spreads.

We contribute to the literature on risk transmission channels by analyzing different credit risk transmission channels. First, we use detailed sovereign bond holdings data - collected from the EBA stress test reports - to better identify the asset holdings channel. Further, we focus on the collateral channel by investigating the impact of bank funding structures. The guarantee channel is addressed by including data on bank size relative to the GDP of the country where it is headquartered.

Second, this study is closely related to existing work on financial contagion. The literature on contagion is very broad; excellent overviews can be found in Pericoli and Sbracia (2003), Dungey et al. (2005) and Pesaran and Pick (2007). We are particularly interested in default risk contagion at the bank and the sovereign level. As mentioned by Caporin et al. (2012), recent research on sovereign credit contagion especially focused on the relationship between sovereign risk and common global and financial factors (see, e.g., Kamin and von Kleist (1999), Eichengreen and Mody (2000), Mauro et al. (2002), Pan and Singleton (2008), Longstaff et al. (2011) and Ang and Longstaff (2011)). At the bank level, there exists a vast literature on systemic risk, which is closely related to contagion, since systemic risk usually refers to situations where multiple financial institutions fail as a result of a common shock or a contagion process (Allen et al. (2010)). For an excellent overview on this topic, we refer to Allen et al. (2009). Papers looking at contagion between the sovereign and the banking level, however, are rather scarce as this topic only recently gained importance during the European debt crisis (see Angeloni and Wolff (2012), Ejsing and Lemke (2011), Demirguc-Kunt and Huizinga (2011), Alter and Schuler (2012), Acharya et al. (2012), Alter and Beyer (2012), Gross and Kok (2012) and Bosma and Wedow (2012)). Acharya et al. (2012), for example, provide empirical evidence of a two-way feedback between financial and sovereign credit risk during the recent crisis. They find evidence for widening sovereign spreads and narrowing bank spreads shortly after a bailout, but significantly higher comovement in the long term. Finally, sovereign credit risk is found to be related to the crash risk of the euro. Hui and Chung (2011) investigate the relationship and find that the impact of sovereign credit risk on crash risk is mainly driven by individual euro-area countries with weaker fiscal positions.

We add to this part of the literature by documenting the evolution of risk spillovers between the sovereign and the banking sector during the recent financial crisis and by explaining differences in spillovers based on observable characteristics of banks and sovereigns.

Finally, this paper relates to an extensive literature on the impact of bank business models on their risk profile. Previous studies primarily focused on the impact of business model characteristics on idiosyncratic or systematic bank risk. Wheelock and Wilson (2000) focus on US banks between 1984 and 1994 and find that lower capitalized banks are at greater risk of failure, as are banks with low earnings. Stiroh (2004), Stiroh (2010) and Baele et al. (2007) investigate the link between non-interest income and risk-taking. Others focus on the impact of funding structure on bank risk. Calomiris and Kahn (1991) argue that institutional investors tend to be relatively sophisticated compared to depositors and hence are expected to provide more market discipline. The recent crisis also brought out the dark side of bank wholesale funding, as described

by Huang and Ratnovski (2011). They show that in an environment with a costless but noisy public signal about bank quality, short-term wholesale financiers have lower incentives to monitor, and instead may withdraw based on negative public news, which could lead to severe funding problems for banks. Related to this, several recent studies have linked these business models to bank performance and riskiness during the recent financial crisis. Beltratti and Stulz (2011) and Demirguc-Kunt and Huizinga (2010) find that banks heavily relying on wholesale funding were perceived as being more risky by the market during the recent financial crisis. Altunbas et al. (2011) confirm these findings and also show that undercapitalization was a major driver of bank distress. Ayadi et al. (2011) screen 26 major European banks for their business models before and after the crisis and conclude that wholesale banks had the worst performance and were most likely to receive state support, whereas retail banks exhibit less risk with a more stable performance. We contribute to this part of the literature by investigating the impact of bank business models on their vulnerability to contagion risk, which became particularly important during the European sovereign debt crisis. Rather than focussing on idiosyncratic or systematic bank risk, we are interested in business models that can allow banks to minimize contagion exposure.

3. Data & Methodology

3.1. Measuring credit risk

To make inference on contagion between bank and sovereign credit risk, we make use of the spreads on credit default swaps. CDS contracts are bilateral swap agreements that represent a protection provided by the CDS seller to the buyer. The seller engages to compensate the buyer in case of the occurrence of a pre-defined credit event.[3] The buyer makes regular payments to the seller, the so-called CDS spread, and in return receives a compensation for his loss in case of a credit event. Given the setup of CDS agreements, their spreads capture the credit risk of the underlying asset. An important feature of CDS quotes is that CDS markets react instantly to changes in credit risk. Hence, the premia reflect market perceptions in real time, as opposed to rating agencies, for instance, which may take a broader view before changing ratings of entities. Alternative indicators of sovereign and bank credit risk are government and bank bond yields. As mentioned by Aizenman et al. (2011)**,** CDS spreads have three main advantages compared to sovereign

[3]CDS are typically based on the standard industry terms for credit events, as defined by the International Swaps and Derivatives Association (ISDA). For further information, see http://www.isda.org.

bond spreads. First, CDS spreads provide timelier market-based pricing. Second, using CDS spreads avoids the difficulty in dealing with time to maturity as in the case of using interest rate spreads (of which the zero coupon bonds would be preferred). Third, bond spreads include inflation expectations and demand/supply for lending conditions as well as default risk. As we explicitly want to capture default risk, we focus on CDS spreads. Similar to previous studies on CDS spreads (e.g. Aizenman et al. (2011), Alter and Schuler (2012), Anderson (2011) and Barrios et al. (2009)), we use CDS spreads on 5-year senior debt contracts, since these are known to be the most actively traded and therefore most liquid ones. All CDS quotes are obtained from Bloomberg, CMA.[4] We obtain CDS spread series for 15 countries[5] and for more than 50 banks over the years 2006-2011. The number of banks in our sample increases over time due to data availability. The CDS spread series are transformed into arithmetic returns. We impose strict liquidity criteria to ensure that the CDS spread changes reflect meaningful information on bank and sovereign credit risk. More specifically, we only retain CDS spread changes during a certain quarter if at least 70% of observations are non-zero during the quarter.

Table 1 shows the summary statistics of the CDS spread changes for both sovereigns and banks. The volatility of sovereign credit risk was highest during 2008, for the banks covered in our sample volatility was highest during 2007 and 2008.

3.2. Measuring contagion

The concept of contagion is difficult to grasp and there exist several different methodological approaches to analyze contagion. The first important question is: How to identify contagion? Constancio (2012) lists four criteria that have been used in the literature to define contagion, namely: "(i) the transmission is in excess of what can be explained by economic fundamentals; (ii) the transmission is different from regular adjustments observed in tranquil times; (iii) the events constituting contagion are negative extremes; (iv) the transmission is sequential, for example in a causal sense." There is no agreement in the literature on a single

[4]Credit Market Analysis. CMA receives quotes for credit instruments from large investors active in over-the-counter markets. Different sources are aggregated and combined by CMA to calculate one average quote. We use daily end-of-day London prices. Mayordomo, Peña and Schwartz (2010) find that the CMA quotes lead the price discovery process in comparison to quotes provided by other databases (GFI, Fenics, Reuters EOD, Market or JP Morgan). Leland (2009) mentions that CDS spreads from Bloomberg are frequently revised weeks after, and often disagree substantially with Datastream CDS spreads.

[5]The 15 countries are Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden, the UK, Norway and Switzerland.

definition, however the first criterion, which is mainly attributed to Bekaert et al. (2005), has been widely used, and this is also the one we focus on in our study.[6]

As discussed in the introduction, we are interested in potential contagion between sovereign and bank default risk. The risk transfer from the private to the public sector through bank rescue schemes during the recent financial crisis has increased bank and sovereign interdependence. Furthermore, the exposure of banks to governments through sovereign debt and the potential lower probability of future bailouts for banks due to deteriorating public finances are additional reasons to expect higher interconnectedness between banks and states. An intuitive starting point to measure this potential increase in interdependence could be looking at simple correlations between two default risk indicators. However, simple correlations during crisis periods could be misleading, as one would simply expect higher correlations during periods of higher volatility (see Boyer et al. (1999) and Forbes and Rigobon (2002)). Following Bekaert et al. (2005), we define contagion as excess correlation, which is correlation over and above what one would expect from economic fundamentals. By defining a factor model in the first stage of our analysis, we avoid problems with the bias correction for correlations that Forbes and Rigobon (2002) propose. Assuming that CDS spreads are adequate credit risk proxies and assuming that CDS spread changes follow a linear factor structure, increased correlation between bank and sovereign credit risk can be driven by three potential sources (also see Anderson (2011)): (i) an increase in exposure of CDS spread changes to common factors, (ii) increased correlation between the common factors, and (iii) an increase in the correlation between unexplained CDS spread changes, which is what we label as contagion. More specifically, the correlation between CDS spread changes of a bank b and a country c can be decomposed as follows:

$$\begin{aligned} E[\Delta CDS_{b,t}\Delta CDS_{c,t}^{'}] &= E[(\beta_b F' + \varepsilon_{b,t})(\beta_c F' + \varepsilon_{c,t})'] \\ &= \beta_b E[F'F]\beta_c' + E[\varepsilon_{b,t}\varepsilon_{c,t}'] \end{aligned}$$

The excess correlation between a bank b and a country c is then defined as

[6]The difficulty of identifying contagion is not only present in academic literature, but practitioners and bankers face the same challenge. In 2009, the Fitch Global Credit Derivatives Survey revealed that many banks were surprised by the sovereign-bank contagion that built up in the markets during the previous year. In particular, "market participants, when referring to contagion, highlight the speed at which credit spreads widened, particularly for financial institutions and sovereigns, the volatility of credit spreads, the unanticipated convergence in correlation values across asset classes and the heightened perception of counterparty risk which resulted in many institutions refusing to deal with other ones in the financial markets."

$$corr_{b,c,t} = E[\varepsilon_{b,t}, \varepsilon_{c,t}]$$

Hence, we investigate the presence of contagion between banks and countries by considering excess correlation, which is the correlation between bank and sovereign credit risk over and above what can be explained by fundamental factors. When the jump in correlation is fully driven by fundamental factors, we expect the excess correlations to be zero. However, when bank and sovereign CDS spreads are still correlated after controlling for fundamental factors, we see this as evidence of contagion between the bank and the country level.

In order to address these common risk factors, we condition CDS spreads on four state variables. To control for market-wide credit risk, we include the *iTraxx Europe* index[7], an index constructed as the equally weigthed average of the 125 most liquid CDS series in the European market. A higher iTraxx indicates a higher overall default risk in the economy, thus we expect a positive relationship between the iTraxx index and the bank and sovereign CDS spreads. To control for market-wide business climate changes in the European Union, we include Datastream's *total stock market index* for the EU[8]. A better overall business climate should reduce default probabilities and hence we expect a negative sign for the stock market index in our factor models. The third common factor is the *Vstoxx*[9] volatility index, capturing market expectations of volatility in the Eurozone (also see, e.g., Berndt et al. (2005), Tang and Yan (2010)). This index is generally perceived as a market sentiment or investor fear indicator. The higher the volatility, the higher the economic uncertainty. We thus expect a positive relation between credit spreads and market volatility. Finally, we control for market expectations about future conditions in the financial market, measured with the *Term Spread*. The term spread is calculated as the difference between the 10-year government bond yield for each country and the 1-year Euribor rate. We expect a negative relationship between the term spread and CDS spreads. All state variables are obtained from Datastream and transformed into arithmetic returns, except for the term spread, which we include in first differences.

[7]DS mnemonic "DIXE5EC". Both financial and non-financial firms are included. In order to be consistent with our bank and sovereign CDS data, we use the index that is based on 5-year maturity assets with end-of-day quotes.

[8]DS mnemonic "TOTMKEU". It mirrors all EU stock markets, not only the financial sector.

[9]DS mnemonic "VSTOXXI". The calculation of the VSTOXX is based on option prices for EURO STOXX 50, which incorporates stocks from 50 supersector leaders from 12 Eurozone countries. For more information, see: http://www.stoxx.com.

With the above selection of state variables, the regression specification of the factor model looks as follows:

$$\Delta CDS_{i,t} = c + \beta_1 \cdot Market_t + \beta_2 \cdot Itraxx_t + \beta_3 \cdot Vstoxx_t + \beta_4 \cdot Term_t + \varepsilon_{i,t} \quad (1)$$

where $\Delta CDS_{i,t}$ is the change in CDS spread for bank or country i, $Market$ is the stock market index for the EU, $Itraxx$ is the iTraxx Europe CDS index, $Vstoxx$ is the a volatility index and $Term$ is the term spread. To control for possible time variation in the exposures we run this factor model for every year in the sample separately. This way, we obtain time-varying coefficient estimates. In Section 4.3, we redo our analysis for two alternative specifications of the factor model: (i) we run the factor models including the Itraxx index as the only state variable, and (ii) we take a different choice of the regression windows, coinciding with major credit events in the CDS market. The main results remain unaltered.

The above analysis allows us to investigate whether, on a year-by-year basis, there is contagion between all bank/sovereign pairs. However, we are also interested in how this contagion evolves over time. To formally test whether changes in excess correlation are statistically significant, we make use of the Fisher transformation of (excess) correlation coefficients. We denote with $corr$ the correlation between a bank and a country (the home country or another country). The Fisher transformed correlation is then given by $corr^*$

$$corr^*_{b,c} = 0.5 \cdot \log(|\frac{(1 + corr_{b,c})}{(1 - corr_{b,c})}|)$$

The standard error or $corr^*_{b,c}$ is given by $\frac{1}{\sqrt{N-3}}$ where N is the number of observations. The test-statistic for the difference between two measures of (excess) correlation $corr^*_{b,c}$ (labeled the Z-statistic) is given by

$$Z_{t_1,t_2} = \frac{(corr^*_{t_1} - corr^*_{t_2})}{\sqrt{\frac{1}{\sqrt{N_{t_1}-3}} + \frac{1}{N_{t_2}-3}}}$$

where N_{t_1} is the number of observations during the first period, and N_{t_2} the number of observations during the second period. The Z-statistic is normally distributed, and hence significance can be assessed with the usual test statistics.

3.3. Explaining contagion

Once we have established the presence of contagion between sovereign and bank credit risk, we take the analysis a step further by investigating bank- and country-specific characteristics that could be driving this

excess correlation. For each country-bank combination in our sample, we calculate excess correlations on a quarterly basis using daily CDS data[10]. This is the dependent variable of interest in our panel analysis. Throughout the analysis, we exploit the fact that we have multiple observations (i.e. excess correlations with different countries) for each bank at each point in time. This allows us to look at the impact of country-specific characteristics while making abstraction of bank-specific factors. Similarly, since we have multiple observations for each country at each point in time, we are able to analyze the impact of bank-specific characteristics on the bank-country relationship.

We start by exploring cross-sectional differences between bank-country excess correlations by focussing on bank balance sheet characteristics. For example, we hypothesize that banks with higher capital adequacy levels are better able to withstand financial shocks, lowering the expected correlation between the bank and country level. To identify the impact of bank-specific factors we regress the excess correlations on a vector of bank-specific characteristics[11] and a home/foreign country time fixed effect. By using this three-way fixed effect, we can compare the excess correlation of bank i with country j to the excess correlation of another bank k - located in the same country z as bank i - with country j at the same point in time. This way, the variation left in the country-bank correlations can only be related to bank-specific differences. The specification thus looks as follows:

$$Corr_{i,j,t} = \alpha + \beta_1 * Z_{i,t} + \eta_{z,j,t} + \varepsilon_{i,j,t} \tag{2}$$

where $Corr_{i,j,t}$ is the excess correlation between bank i and country j at time t, $Z_{i,t}$ is a vector of bank-specific variables and $\eta_{z,j,t}$ is a three-way fixed effect, which addresses differences over time at the home and foreign country level.

In a next step we use a similar setup to analyze the potential impact of country-specific characteristics. We start by analyzing whether domestic banks have a stronger relation with the sovereign, by looking at the impact of higher sovereign CDS spreads on excess correlations, and by focusing on whether bank-specific characteristics can change the impact of higher sovereign CDS spreads. We use the following specification:

$$Corr_{i,j,t} = \alpha + \beta_1 * Home_{i,j} + \beta_2 * CDS_{j,t} + \beta_3 * CDS_{j,t} * X_{i,t} + \eta_{i,t} + \varepsilon_{i,j,t} \tag{3}$$

[10] We calculate excess correlations at quarterly frequency since this is the highest frequency for which we have bank balance sheet data available. The balance sheet data is linked to correlations in a later step.

[11] More detailed information on the bank-specific variables that we use can be found below in part 3.4 Bank- and country-specific factors

where $X_{i,t}$ is a vector of bank-specific variables , $CDS_{j,t}$ is the sovereign CDS spread of country j at time t , $Home_{i,j}$ is a dummy variable, which equals one when bank i is located in country j , $\eta_{i,t}$ is a bank-time fixed effect and $\varepsilon_{i,j,t}$ is the error term. By using bank-time fixed effects, we can compare the relationship of the same bank with different countries at the same point in time. In other words, by using bank-time fixed effects we ensure that the variation left in the excess correlations can be attributed to country-specific factors. We expect the home dummy coefficient to be positive and significant for several reasons. First, banks tend to have a strong home bias in their government bond portfolios, making them more vulnerable to home country shocks. Second, when banks get into distress, the probability of a bailout of that bank increases. As bailouts are typically financed by the home country of the bank, this can cause a contagion effect. Related to this, a government in a weak fiscal position is less likely to step in when things go wrong in the banking sector, potentially increasing the credit risk of the financial institutions in the home country. Fourth, problems at the sovereign level may lead to fiscal consolidation, which, although potentially beneficial in the long term, may lead to lower economic activity in the short term, which could increase loan losses and hence bank credit risk (Avdjiev and Caruana (2012)).We also expect that higher default risk at the country level will lead to higher excess correlations. Bank default risk is more likely to be related to sovereign default risk when sovereigns are in distress situations than when default risk at the sovereign level is low. We are also interested in whether some bank business models are better in withstanding sovereign distress than others. Therefore, we also interact the sovereign CDS spread with a set of bank business model characteristics.

In a following step, we consider the actual exposures of banks towards European countries and analyze whether these exposures have a direct impact on the contagion variable. We apply a similar setup as in equation 3. We focus on sovereign debt exposures, for which we have data available from the EBA stress test reports since mid-2010. We hypothesize that a bank's default risk is more strongly correlated with a country's default risk when the bank has a higher exposure to that country.

In a last step, we focus on country-specific factors that could be driving the relationship between sovereign CDS spreads and the excess correlations. We hypothesize that a banks' default risk is more strongly correlated with countries that have higher debt-to-GDP ratios, higher government revenues in percentage of GDP, a larger banking sector (in percentage of GDP) and a less optimistic economic sentiment indicator. We again expect this effect to be stronger towards the home country, which is why we also interact each of these variables with the home country dummy. The regression specification looks as follows:

$$Corr_{i,j,t} = \alpha + \beta_1 * Home_{i,j} + \beta_2 * X_{j,t} + \beta_3 * Home_{i,j} * X_{j,t} + \eta_{i,t} + \varepsilon_{i,j,t} \quad (4)$$

where $X_{j,t}$ is a vector of country-specific variables[12]. By using bank-time fixed effects, we can compare the relationship of the same bank with different countries at the same point in time.

3.4. Bank- and country-specific factors

An important contribution of our paper is to investigate the relationship between bank/sovereign contagion and the characteristics of the banks and countries involved. For the banks in the sample, we use a variety of measures intended to capture their business model. Consequently, we focus on indicators of their retail orientation, funding structure, diversification and, especially, the banks' capital adequacy (see Baele et al. (2012), Altunbas et al. (2011), Ayadi et al. (2011)). For countries, the selected variables focus on debt sustainability and business cycle conditions. Bank-specific data is mainly taken from Thomson Reuters Worldscope database; country-specific series are taken from a range of other sources (Eurostat, Oxford Economics, ECB statistical data warehouse). Summary statistics for these variables can be found in Table 3.

The first bank-specific variable we consider is bank size, measured as the ratio of each bank's total assets over its home country GDP. The rationale is that large banks are more likely to be systemic institutions that may need a public bailout in case of distress. The larger the bank, the more likely it is that a bank bailout will affect confidence in the financial system (BIS (2011a)). We expect that the relative size of banks is positively related to the excess bank/sovereign correlations, especially with the home sovereign.

Capital regulation is the cornerstone of the prudential regulation of banks. Since capital serves as a buffer for unexpected losses (e.g. value losses on sovereign bonds), the higher the capital buffer, the less risky a bank is and, hence, the lower we expect the excess correlations with sovereigns to be. In general, banks with adequate capital buffers are perceived by market participants to be able to withstand shocks much better than their less capitalized peers, which is reflected, e.g., in a lower market beta (Altunbas et al. (2011); Baele et al. (2007)). In our main analysis, we focus on an unweighted capital ratio that is calculated as the sum of Tier 1 and Tier 2 capital over total assets. As a robustness check, we also consider the risk weighted Tier 1 ratio.

[12] More detailed information on the country-specific variables that we use can be found below in part 3.4 Bank- and country-specific factors

The fundamental role of a bank is to transform deposits into loans to businesses and households. Therefore the loan-to-asset ratio is a typical indicator of a bank's retail orientation. Retail banks have been perceived as less risky than their non-retail peers, especially during the financial crisis. Schepens and Vander Vennet (2009) show that European retail banks, defined as banks with a high loan-to-assets ratio as well as a high deposit-to-assets ratio, have considerably lower market betas. Moreover, when a bank is characterized by a high proportion of loans in its total assets, the relative weight of securities is lower, entailing less exposure to (sovereign) bonds. Finally, when a bank operates a profitable lending portfolio, this should serve as a generator of profits and capital, which make a bank safer over time. Consequently, we expect that banks with a relatively high loan-to-asset ratio will exhibit lower excess correlations.

To assess the relevance of banks' exposures to (foreign) sovereign risk, we include information on country exposures. This data is taken from the CEBS and EBA stress tests of 2010-2011 that were carried out to assess the financial strength of European banks under different scenarios. The CEBS/EBA stress tests were the first Europe-wide exercises of that kind and the results as well as the main data inputs where made publicly available. The exercises included 90/91 of Europe's largest banks, covering over 65% of the EU banking system total assets and at least 50% of each national EU banking sector. In the context of the stress testing exercise, data was published on banks' sovereign debt exposures to the 30 European Economic Area states and was made available at two points in time: in July 2010 (data collection either in December 2009, in March or in May 2010) and in July 2011 (data collection in December 2010). Such detailed data had never been available at the bank level before; therefore, it was not possible to analyze the direct impact of sovereign debt exposure on individual bank's credit risk in the past. Our study is one of the first ones to include sovereign exposures to investigate such link, which basically captures the above described 'asset holdings channel'.

On the liability side of the balance sheet, the composition of the funding sources is an important determinant of the risk profile of a bank. Several papers have demonstrated that banks relying on wholesale funding, predominantly through the interbank market, are perceived by market participants to be more risky than banks predominantly funded with retail deposits. Especially during the financial crisis, funding through potentially volatile sources proved to be catastrophic for some banks. Altunbas et al. (2011) and Schepens and Vander Vennet (2009) report that banks with a relatively high proportion of wholesale funding exhibit significantly higher systematic risk, measured by the market beta. Hence, when the asset quality of a bank deteriorates (in this case because of the exposure to bonds of fragile sovereigns), informed market partic-

ipants (e.g., institutional depositors) will focus on the sustainability of the bank's funding structure. This may hamper access to the interbank market and increase the cost of funding in the repo or deposit markets. Such risk spillovers between sovereigns and banks are another example of transmission channels that affect the cost of funding for banks. We measure the impact of a bank's funding structure by including the ratio of short term and money market funding over total funding.

The degree of revenue diversification is captured by the proportion of non-interest income in total revenues (see Stiroh (2006b) and Baele et al. (2007)). When a bank is less reliant on interest income, it is supposed to be better diversified in the case of negative shocks to its interest income or funding cost. However, non-interest sources of income may be more volatile, especially in periods of financial market stress, and hence provide an imperfect hedge. As a result, the ultimate effect on bank/sovereign excess correlations is unclear a priori.

The country-specific variables attempt to capture the state of public finances as well as the importance of business cycle conditions in each of the countries concerned. The main variable of interest is the debt-to-GDP ratio, since it is the major determinant of the sovereign rating (see, e.g., Bernoth et al. (2004)). We also include the ratio of government revenues to GDP for each country as a proxy for the revenue-generating capacity that sovereigns have to deal with banking problems. Since taxes are needed to service additional debt, this is an indicator of the hard budget constraint countries are facing. The larger the banks in a country, the more problematic bank rescues may be for public finances. Therefore, we include the size of the bank sector in each country as a proportion of GDP. The bigger the relative size of the banking system, the higher we expect bank/sovereign risk spillovers to be. Further, to account for business cycle conditions, an indicator for economic sentiment is added to our analysis. We use the economic sentiment indicator provided by the European Commission, which is composed of five sectoral confidence indicators (industrial, services, consumer, construction and retail trade) with different weights, each confidence indicator being based on surveys. Including these variables, and some interaction terms, enables us to get insight into the determinants of bank/sovereign contagion.

4. Results

4.1. Excess correlations

We investigate the presence of contagion between banks and countries by examining the excess correlation, which is the correlation between bank and sovereign credit risk over and above what can be explained by fundamental factors. We start by giving an overview of the factor models used to calculate the excess correlations (see eq. 1). Table 2 reports the summary statistics of the state variables in our analysis, whereas Table 4 shows the average coefficient estimates and their significance in the bank factor models.[13] Running these models on a yearly basis allows us to analyze the evolution over time of the impact of the state variables and they eventually yield the excess correlations. We notice a sharp increase in exposure to economy-wide credit risk (measured by the iTraxx factor) during 2007 and 2008 and this exposure remains elevated until the end of the sample period. Table 4 shows that the vast majority of banks loads significantly on the iTraxx factor (up to 97% of the banks in the sample in 2007). The significance of the other coefficient estimates is much lower (below 10% for both the market factor and Vstoxx implied volatility). These results are in line with Ejsing and Lemke (2011), who use the iTraxx index of non-financial CDS premia as single common risk factor, arguing that it explains most of the variability in corporate and sovereign CDS spreads. However, including more state variables implies that we control for more possible sources of commonality, which implies that the excess country/bank correlations are estimated more conservatively[14].

In the left hand side panel of Figure 1, we investigate how the average correlation between bank and home country credit risk varies over time, whereas the right hand side panel of Figure 1 reports the corresponding correlation in residuals, i.e. excess correlation, which is our preferred contagion measure. As expected, we notice an increased correlation between sovereign and bank CDS spreads during the recent financial crisis in the left hand side panel of Figure 1. As mentioned before, an increase in correlation does not necessarily imply evidence of contagion. Instead, contagion can only be inferred from a statistically significant increase in excess correlation. The right hand side panel of Figure 1 shows the average yearly excess correlation between the sovereign CDS spread and the average CDS spread of the banks headquartered in the country. We observe that correlation in CDS spread changes are on average higher than correlation in the residuals. Table 5 indicates that the average bank/sovereign correlation in our sample is 35%, whereas

[13] For convenience, we only report the results for the banks. The results of the sovereign factor models are similar and are available upon request.

[14] In part 4.3 we discuss the robustness of our results w.r.t. an alternative specification of the factor model.

the average excess correlation is 17%. Comparing both panels in Figure 1 indicates that common factors can only partly explain the increase in correlations during the crisis; even after controlling for common factors, there is still a strong increase in correlations between sovereign and bank CDS spreads between 2006 and 2011. It are precisely these excess correlations that we try to explain using country- and bank-specific variables.

The figures show a clear increase in excess correlations over the past years. To formally test whether this increase is also statistically significant, we make use of the Fisher transformation of (excess) correlation coefficients. The left-hand side in Table 6 ('Base Year: 2007') depicts the percentage of significant bank-country excess correlations during each year compared to excess correlations in 2007; the right-hand side ('Base Year: 2008') shows the results when taking 2008 as a benchmark. Moreover, we differentiate between contagion between banks and their home country (Panel A), banks and foreign countries (Panel B) and banks and GIIPS countries (both home and foreign, in Panel C). All three panels point to significant contagion in the vast majority of our sample. For example, in 2009 and 2010 we find evidence of significant contagion for respectively 86% and 64% of the banks with their home country (base year 2007). Furthermore, we observe that, in general, evidence of contagion between banks and foreign countries is slightly lower (76% and 63% of the banks in the sample in 2009 and 2010). Finally, we also notice significant contagion between banks and the GIIPS countries, which is most pronounced in 2009. As can be seen in the table, the number of observations in 2008 is always higher than in 2007. Therefore, we verify whether the evidence of contagion is still present when taking 2008 as the base year. Our previous conclusions are confirmed, as can be seen on the right-hand side of Table 6.

To summarize, we find significant evidence of increasing contagion between banks and countries in the period covering the bank crisis as well as the sovereign debt crisis in Europe. Yet, we are particularly interested in how to explain this excess correlation. We therefore turn to the analysis of bank- and country-specific characteristics.

4.2. Explaining bank-country contagion

In this part, we study the impact of bank- and country-specific characteristics on bank-country contagion. The particular structure of our database, in which we have excess correlations for each bank in our sample with different sovereigns on a quarterly basis, allows us to disentangle the impact of bank- and country-specific characteristics. More specifically, by either comparing the relation between one bank and different

sovereigns (using bank-time fixed effects) or by comparing the relationship of different banks with one country (using country-time fixed effects), we can make a distinction between the impact of bank and country variables. Except for the home country dummy, all right hand side variables in these regressions are standardized, which means that the coefficients show the impact of a one standard deviation change of the independent variables.

In a first step, we study the impact of bank-specific characteristics on the country-bank excess correlations. We do this by comparing the excess correlations of different banks from the same country with a single country at a certain point in time. In terms of the regression setup, this implies that we introduce home country/foreign country time fixed effects. By comparing banks from the same country, we prevent that sovereign relationships that are unrelated to country-bank relationships disturb our analysis. It also allows us to control for potential differences between banks due to regulatory or institutional differences at the home country level. By comparing the different banks with a single country, we make sure that the only variation left in the excess correlations is due to bank-specific factors. The first specification of Table 7 shows the impact of a set of bank characteristics on contagion. We start by regressing the excess correlations on five bank balance sheet characteristics, i.e. bank size (total assets over GDP), asset structure (loan-to-asset ratio), funding risk (short term funding over total funding), capital adequacy (total capital ratio) and income diversification (non-interest income as a percentage of total income). In general, we find that bank size, capital adequacy levels and funding structure have a significant impact on bank-country contagion. For example, the coefficient of minus 1.76 for the total capital ratio implies that a one standard deviation increase in the total capital ratio (i.e. a rise in the total capital ratio of about 2.2 percentage points, see Table 3) leads to a decrease in country-bank excess correlations of about 1.76 percentage points. For the average bank in our sample, this means a reduction in excess correlation of almost 8 percent. Furthermore, banks with a higher proportion of short-term debt in their total funding exhibit higher bank-country excess correlations. The impact of a standard deviation change in the short-funding ratio is similar to the impact of a standard deviation increase in the capital ratio. This confirms that banks with potentially volatile funding are more exposed to shocks in the quality of their assets, confirming the presence of the collateral channel (see Section 2). This result is in line with the findings of Vuillemey and Peltonen (2012), who investigate whether sovereign CDS mitigate or amplify shocks on sovereign bonds. Their main finding is that the main risk for CDS sellers is in the sudden increases in collateral requirements.

These finding stress the importance of adequate bank capital buffers for bank stability. Whereas previous

studies showed a strong effect of bank capital on bank-specific risk indicators (see, e.g. Wheelock and Wilson (2000) and Altunbas et al. (2011)) our findings suggest that adequate capital levels are also an important buffer against contagion. Similarly, where Demirguc-Kunt and Huizinga (2010) find that banks increase most of their short-term funding at the cost of enhanced bank fragility, our findings point at the importance of stable funding as a feature in mitigating contagion.

In column 2 of Table 7 we interact each bank-specific variable with a home country dummy to analyze whether there is any asymmetry in the above results caused by a stronger relation with the home country. The results show that the impact of the bank-specific variables is equally strong towards the home country compared to other countries, as none of the interaction terms is significant. The impact of the size of a bank (in percentage of GDP) on the excess correlations, for example, is not statistically different when comparing the home country excess correlations with the foreign country excess correlations. This suggests that there is no direct evidence in favor of the guarantee channel in this setup. However, further results using a different setup (see Table 9) indicate that the guarantee channel is at work. Overall, bank size is positively related to excess correlations, irrespective of focussing on the relation with the home country or a foreign country.

In the third column, we add banks‘ sovereign debt exposure as an explanatory variable. Notice that this reduces the sample size, as we only have information on debt exposures from 2010 onwards. The results for this setup first of all confirm our previous findings; better capitalized banks and banks with a lower proportion of short-term debt in their total funding exhibit lower bank-country excess correlations, although the capital ratio becomes insignificant in this setup. Furthermore, the impact of the income diversification variable becomes significant. Thus, in this subsample, banks with a lower percentage of non-interest income have significantly lower excess correlations. The fact that this variable has a stronger impact in this subsample is due to the sample period.[15] As we only have data on sovereign debt exposures from 2010 onwards, this subsample covers the recent crisis period. Being a more retail-oriented bank, i.e. having a lower proportion of non-interest income, reduces bank risk (see, e.g. Altunbas et al. (2011), Baele et al. (2007)) and helps to survive the most stressful moments of the sovereign debt crisis. These results point to a change in risk perception during periods of increased sovereign distress of certain bank business models. The sovereign debt exposure variable itself is not significant in this setup. We would expect higher exposures to lead to

[15] We run the same regression as in column one on the sample for which we have EBA data (column 3) and reach similar conclusions. This confirms that the change in significance for the loan to asset ratio and the income diversification variable is due to a the change in sample period and is not caused by the introduction of the EBA exposure variable.

higher excess correlations. However, we control for home country/foreign country time fixed effects, which means that we compare the relationship of different banks from the same country with one and the same country at a certain point in time. Thus, the insignificant result for the sovereign exposure variable is most likely a reflection of the fact that the variation in exposures between banks in the same country is rather limited.[16] Column 4 of Table 7 shows that our results also hold when using the Tier 1 ratio as a capital ratio instead of the total capital ratio. Overall, our results lend support to the new prudential rules contained in Basel III, which focus both on the level and quality of bank capital as well as the need for stable funding sources.

Next, we focus on the impact of home country effects, sovereign CDS spreads and the actual sovereign bond exposures of the banks on excess correlations. We expect that excess correlations will be higher when a country‘s default risk is higher, when we consider the relation between a bank and its home country and/or when banks are more exposed to sovereigns through their bond portfolio (asset holdings channel). Our contagion variable measures the degree of excess correlation between a country and a bank, but in itself does not allow us to make any statements about the direction of the spillover. Using bank-time fixed effects allows us to compare the excess correlations of one bank with different sovereigns.This gives us a better view on how factors at the sovereign level can affect the excess correlations between sovereigns and banks. By interacting the sovereign CDS spread with bank-specific variable, we are also able to analyze which bank characteristics can act as a buffer againsts spillovers from the sovereign level.

In the first column of Table 8, we regress the contagion variable on a home country dummy, the sovereign CDS spread and an interaction terms between both while controlling for bank-time fixed effects and for a potential non-linear relationship between the sovereign CDS spread and excess correlations. We start by focusing on the relationship between a bank and its home country. We hypothesize that the contagion between a bank and its home country is stronger than between a bank and any other sovereign. This can be caused by several factors, be it a strong home bias in their bond holding portfolio, higher bailout risk or fiscal consolidation leading to lower economic activity in the short term (Avdjiev and Caruana (2012)). The first column of Table 8, corroborates the home country hypothesis. The excess correlation between a bank and its home country is on average 2.7 percentage points higher than with another country, after controlling for the impact of sovereign CDS spreads. Next, our results show that banks have higher excess correlations

[16]Furthermore, when using a different regression setup (bank-time fixed effects),we do find a significant impact for sovereign bond exposures, see Table 9 below.

with countries that have a higher level of credit risk. The squared term of the CDS spread is negative, indicating that the positive effect becomes negative when the spread gets higher. However, the impact only becomes negative for countries above the 96th percentile, which in practice means that we only measure a negative relationship with Greece. Hence, except for Greece, the expected positive relationship between sovereign CDS spreads and excess correlations holds. Also interesting is the positive and highly significant impact of the interaction term between the sovereign spread and the home dummy, indicating that the excess correlations of a bank with its home country is higher when the home country has a higher level of credit risk.

In the second column of Table 8, we test whether there is an asset holdings channel at work during the sovereign debt crisis. We do this by introducing bank-specific sovereign bond exposures, which we collect from the 2010 and 2011 EBA stress test exercises. The results in column 2 of Table 8 show that a bank with a one standard deviation higher exposure to country A than to country B has an excess correlation with country A which is about 1.5 percentage points higher. This confirms the presence of an asset holdings channel during the sovereign debt crisis. Furthermore, the positive coefficient for the interaction term between the sovereign CDS level and the exposure variable in column 3 shows that a higher sovereign CDS spread amplifies the impact of the asset holdings channel, although this interaction term is only significant at the 15% level. Overall, we find support for the asset holdings channel. Banks with a larger exposure to a country are more vulnerable to risk shocks originating from that country.

In the last three columns of Table 8, we again focus on the importance of bank-specific characteristics. More specifically, instead of looking at the direct impact of bank characteristics, which we did in Table 7, we now investigate which bank characteristics could reduce the negative impact of higher sovereign credit risk. In other words, we analyze how banks could protect themselves against increased credit risk at the sovereign level. We do this by adding interaction terms between the sovereign CDS spreads and bank-specific characteristics in our regression specification. In column 4, we focus on the sample for which we have EBA data available, in the fifth column we do the same analysis but for a broader sample and in the last column we replace the total capital ratio with the Tier 1capital ratio. Our results again stress the importance of solid capital ratios to withstand sovereign default risk. More specifically, the coefficient of -0.8 for the interaction term between the sovereign CDS spread and the total capital ratio in the fourth and the fifth column shows that a one standard deviation rise in the total capital ratio lowers the impact of a standard deviation change in sovereign credit risk on excess correlations from 1.83 percentage points to

1.15 percentage points, which is a decline of more than 35 percent. The last column in Table 8 confirms that this result also holds when using an alternative capital ratio (Tier 1 ratio). The interaction terms between the other bank-specific characteristics and the sovereign CDS spread are not significant. Overall, the results in these last three columns show that higher capital adequacy ratios not only have a direct impact on excess correlations, but also have a positive indirect effect by lowering the negative impact of higher sovereign credit risk, which underscores their importance for maintaining financial stability.

So far, the only country-specific variable we investigated is the sovereign CDS spread. We show that banks are more strongly correlated with countries that have a higher level of credit risk and that higher capital levels can reduce this negative effect. We now take this analysis one step further by studying country-specific characteristics that are expected to have an impact on the credit risk of a country and could thus be of importance for the contagion between banks and sovereigns. By again using bank-time fixed effects, we analyze the correlation of each bank in our sample with the different countries, which allows us to attribute differences in excess correlation to country-specific factors. We focus on the impact of government debt (debt to GDP ratio), government revenues (as percentage of GDP), the importance of the banking sector in a country (total bank sector size over GDP) and the overall economic sentiment.

The results in column one of Table 9 show that bank-country contagion is more pronounced for countries with a higher debt-to-GDP ratio. The positive and significant coefficient of 1.21 for the debt ratio shows that for every standard deviation change in the debt ratio, the excess correlation increases by 1.21 percentage points. Higher debt ratios reduce the probability of a bailout in the banking sector and also lead to higher bank-level credit risk through the bond portfolios of financial institutions, which explains this positive and significant effect. However, the standard deviation of the debt ratio in our sample is around 27 percent (see Table 3), hence the economic impact is rather limited in this setup. Other country-specific characteristics, such as the share of government revenues in GDP or the size of the banking sector in a country do not turn out to be statistically significant. Furthermore, even after controlling for these country-specific factors, the home-country relationship still remains an important driver of the excess correlations. The coefficient of 2.88 for the home dummy is positive and significant at the 1 percent level. The coefficient for the economic sentiment indicator is positive, which is somewhat unexpected. This could indicate that market participants base their risk assessment rather on the health of bank balance sheets than on the economic conditions in a country. Moreover, growth has been dismal in many of the countries during the sample period, which makes it more difficult to assess the potential impact of economic conditions. In the second column of

Table 9 we analyze whether the home-country effect and the country characteristics potentially reinforce each other. Interestingly, the positive and significant interaction term between the debt-to-GDP ratio and the home dummy confirms that government debt is an important contributor to the contagion between a bank and its home country. More specifically, the impact of the home country dummy more than doubles when we compare a bank operating in a country with an average debt-to-GDP ratio with a bank operating in a country that has a debt-to-GDP ratio in the 90th percentile of our sample.[17] This result is in line with the argument that banks exhibit a home bias in their bond portfolios and with the conjecture that governments in a weak fiscal position are less likely to step in to save financial institutions when needed, confirming the presence of both the asset holdings channel as well as the guarantee channel. Comparing column 1 with column 2 also shows that the influence of the debt-to-GDP ratio is most pronounced in explaining the excess correlation of banks with their home country. A one standard deviation change in the debt-to-GDP ratio adds 1.05% points to the excess correlation for foreign countries, whereas this augments to 3.04% points (1.05+1.99) for home countries. Column 3 shows that the significant impact of the debt-to-GDP ratio also holds when controlling for sovereign bond exposures. Furthermore, in this specification we also find a positive and significant coefficient for the government revenues variable. A high level of government revenues lowers the possibility to further increase taxes in future crisis situations, which will make it harder for governments to react to a crisis and could thus lead to increased credit risk. Overall, these results indicate that banks tend to be more strongly correlated with countries with less sustainable debt levels, and this effect is largest in magnitude for the home country. This confirms that worsening public finances are one of the main drivers for contagion effects between sovereigns and banks. The implication is that restoring stability in the financial system requires simultaneous efforts in the field of public finances.

4.3. Robustness

In this section we show that our main finding are robust to using alternative factor models for calculating the excess correlations and to different ways of clustering standard errors in the panel regressions. Furthermore, column 3 of Table 7 and column 5 of Table 8 already indicated that our results also hold when using an

[17] The coefficient for the home country banks becomes 2.57 (coefficient for home dummy) + 1.99*1.5 (coefficient for interaction term*standardized value of the debt to GDP ratio at the 90th percentile) = 5.5 for banks operating in a country in the 90th percentile in terms of debt ratio, whereas the coefficient for a bank operating in a country with the average debt-to-GDP ratio equals 2.57+ 1.99*0 = 2.57.

alternative capital ratio.

We start by evaluating the choice of the factor models used to calculate the excess correlations. In our main analysis, we calculate the excess correlations based on yearly factor models that include four common factors, i.e. an overall stock market index for the EU, the iTraxx Europe CDS index, the Vstoxx volatility index and the term spread. To make sure that our main results are not influenced by our choice of factor model, we calculate two sets of new excess correlations, one set based on a factor model only including the iTraxx CDS index and a set based on a factor model with the same factors, but with an alternative choice of the time periods. The iTraxx-only model is an interesting benchmark as it is a model that is frequently used in the existing CDS literature (see e.g., Ejsing and Lemke (2011) and Fontana and Scheicher (2010)). The model with alternative time periods addresses the critique that structural breaks within the yearly regression window could potentially bias our measure of contagion. To address this issue, we divide our sample period into different time windows, chosen at well specified events, to avoid structural breaks within the time windows. More specifically, we divide our sample period into 7 different periods being 2006, 2007, January 2008 until August 2008 (pre-Lehman), September 2008 - March 2009 (strong banking distress), April 2009-March 2010 (In April, the EU orders France, Spain, the Irish Republic and Greece to reduce their budget deficits, start of sovereign crisis), April 2010-March 2011 (no major events) and April 2011 - September 2011 (strong rise in default risk of Southern European countries). Both factor models confirm the results of our baseline factor model. For the model with the different time windows, the Itraxx is again the most important common factor. For both the Itraxx-only and the extended time windows model, we again find significant spillovers for the majority of the banks in our sample and a clear increase in excess correlations over the past years. The results for these factor models are available upon request.

After calculating the two sets of alternative excess correlations, we reinvestigate the impact of bank and country characteristics as done in Section 4.2. The results are shown in columns 2 and 3 of tables 10 to 12 in Appendix. The fourth column in these tables adds an extra robustness check by clustering the standard errors at either the bank level (Table 11 and 12) or at the country level (Table 10) instead of at the bank-time or at the country-time level. This alternative clustering setup allows that the error terms are correlated over time within the same bank/country, while they were only allowed to be correlated within the same bank/country at one point in time in our baseline setup. The results all confirm our main findings. Both higher capital ratios and lower money market funding decrease excess correlations (Table 10). Furthermore, higher capital ratios reduce the positive impact of higher sovereign CDS spreads on excess correlations (Table 11). The

robustness checks also confirm the existence of a home country effect and the positive relation between sovereign debt exposures and excess correlations. Finally, higher debt ratios are positively related to higher excess correlations, especially when focussing on the relationship between domestic banks and the home sovereign (Table 12).

5. Conclusions

This paper provides empirical evidence on risk spillovers between banks and sovereigns during the European financial and sovereign debt crisis. Whereas there is a substantial literature exploring the determinants of bank or sovereign credit risk (measured by bond yields or CDS spreads) separately, empirical evidence exploring contagion between the two is scarce. This paper attempts to fill the gap by examining the pattern of contagion in the sovereign-bank nexus in Europe and by investigating which bank-specific and country-specific determinants drive contagion.

We define contagion as "excess correlation", i.e. correlation over and above what is explained by fundamental factors. Our preferred measure of sovereign and bank credit risk is CDS spreads. After controlling for common factors (market risk, economy-wide credit risk, term spread changes and volatility), we document significant empirical evidence of bank/sovereign contagion. In the year 2009, when the sovereign debt crisis emerged, we find significant spillovers for 86% of the banks in the sample. This number increases to 94% when only considering spillovers between the banks and the GIIPS countries. Moreover, we provide empirical evidence of a substantial home bias, confirming the expectation that contagion between banks and their home country is stronger. The close link between domestic banks and their sovereigns can be attributed to several factors. We report evidence supporting the asset holdings channel caused by the large share of domestic debt in banks' sovereign portfolios and evidence in favor of the guarantee channel caused by the fact that the presence of large banks increases the bailout pressure on governments.

We exploit the cross-sectional differences between bank/sovereign excess correlations by relating them to bank- and country-specific variables. We include a broad set of measures intended to capture the strategic choices inherent in bank business models. The capital adequacy level of banks has the most economically significant effect; we find that an increase in the total capital ratio reduces the excess bank-country correlation significantly. Furthermore, the lower the banks' reliance on short-term funding sources (measured as the proportion of short-term funding in total debt), the lower the intensity of risk spillovers between banks and

sovereigns. These findings support the new regulatory Basel III framework which imposes more stringent capital adequacy ratios and new liquidity measures. At the sovereign level, we find that higher debt-to-GDP ratios significantly increase the degree of bank/sovereign contagion. The effect even becomes twice as big for countries with high debt-to-GDP ratios (in the sample, a ratio above 101%, compared to the average of 74%). This finding motivates the recommendation that public finances need to be consolidated, especially in the countries with high debt levels. A credible commitment to reduce debt levels over time will probably require efforts at the domestic level as well as enforceable coordination at the European level and, perhaps, some form of (partial) debt mutualisation.

We investigate the relationship between bank/sovereign risk spillovers and banks' holdings of sovereign debt. For that purpose, the EBA disclosures of banks' sovereign exposures prove to be particularly valuable, since they allow us to verify whether (i) banks with different holdings of sovereign debt exhibit higher excess correlations with the countries involved, and (ii) whether excess correlations are higher for the countries to which the bank is more exposed. Using different regression specifications, we confirm both hypotheses. Hence, investors differentiate rationally between countries with different levels of indebtedness and between banks with different sovereign debt exposures.

We also document that increased sovereign credit risk is in itself a driver of bank-sovereign excess correlations. We find that contagion is more pronounced when the sovereign CDS spreads are higher. Moreover, we document that the link between sovereign debt holdings and contagion is stronger when the sovereign CDS spread is higher. When we investigate country-specific determinants of excess correlations, we find that sovereign debt-to-GDP levels play a decisive role as the main determinant of bank-sovereign risk spillovers. In the period of increased stress in sovereign debt markets, we document that also the government revenue ratio reinforces the risk spillovers. These findings suggest that credible plans to put public finances on a sustainable track are a necessary ingredient of any crisis resolution attempt.

In terms of policy implications, our results suggest several actions to alleviate the contagion between bank and sovereign risk. The ambition of policymakers and supervisors should be to (1) decrease the probability of contagion and (2) when contagion occurs, decrease the intensity of the risk spillovers. In order to achieve these objectives, action in three dimensions is necessary: make banks more robust, make public finances more resilient and weaken the bank-sovereign link. On the bank side, the degree of capital adequacy turns out to be crucial. Moreover, banks should be restricted in their reliance on money market funding. Both elements are at the core of the internationally agreed Basel III rules that will be phased in gradually.

Our results lend support to these objectives and policymakers and supervisors should provide incentives to banks to adjust their business models accordingly. Since the home bias in bank bond portfolios is identified as a channel of contagion, there might be scope for concentration limits in various dimensions. On the sovereign side, making public finances more sustainable and ensuring that resolution mechanisms are in place to deal with distressed banks are important policy objectives. Finally, our results indicate that breaking the link between banks and their sovereigns should be a priority. This will require a so-called banking union at the European (or Eurozone) level, implying that not only bank supervision should be executed at the European level (e.g. by the ECB), but also that deposit insurance and bank resolution, and the associated burden sharing arrangements have to implemented on a European scale.

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6. Tables and Figures

Table 1: CDS spread changes - Summary Statistics

This table shows the summary statistics for the daily sovereign and bank CDS spread changes between the first quarter of 2006 and the third quarter of 2011 for all banks and countries in our sample. We use spreads on 5-year CDS contracts. All CDS quotes are obtained from Bloomberg, CMA. The CDS spread series are transformed into daily arithmetic returns.

Sovereign	year	MEAN	STD	MIN	MAX
	2006	-0.004	0.064	-0.250	0.344
	2007	0.012	0.123	-0.533	1.129
	2008	0.020	0.094	-0.356	1.511
	2009	-0.001	0.054	-0.382	0.989
	2010	0.004	0.046	-0.388	0.395
	2011	0.003	0.041	-0.191	0.258

Banks	year	MEAN	STD	MIN	MAX
	2006	-0.002	0.030	-0.388	0.634
	2007	0.010	0.072	-0.439	1.237
	2008	0.007	0.072	-0.560	1.109
	2009	-0.001	0.037	-0.280	0.485
	2010	0.004	0.046	-0.425	2.148
	2011	0.003	0.040	-0.361	1.229

Table 2: State variables - Summary statistics

This table shows the summary statistics for the four state variables used in our main factor model. To control for market-wide business climate changes in the European Union, we include Datastream's total stock market index for the EU. To control for market-wide credit risk, we include the iTraxx Europe index. The third common factor is the Vstoxx volatility index, capturing market expectations of volatility in the Eurozone. The fourth common factor is the term spread, which is calculated as the difference between the 10-year government bond yield for each country and the 1-year Euribor rate. All state variables are obtained from Datastream and transformed into arithmetic returns, except for the term spread, which we include in first differences.

	MARKET	**ITRAXX**	**VSTOXX**	**TERM**
MEAN	0.000	0.002	0.003	0.001
STD	0.014	0.039	0.062	0.041
MIN	-0.075	-0.278	-0.221	-0.392
MAX	0.097	0.291	0.388	0.179

Table 3: Bank and Country specific variables - Summary statistics

Statistics for the country variables are calculated at the country-time level, whereas the statistics for the bank variables are calculated at the bank-time level, which explains the differences in number of observations. The capital ratio is calculated as Tier 1 plus Tier 2 capital over total assets. Funding risk is the share of short term debt in total debt. The loan ratio is the ratio of total loans over total assets. Income diversification is calculated as the share of non-interest income over total income.

Variable	**Mean**	**Std. Dev.**	**Obs.**
Country variables			
Sovereign CDS spread	86.56	124.14	150
Debt to GDP ratio	74.37	27.44	150
Government revenues /GDP	45.30	6.44	150
Economic sentiment indicator	93.87	11.41	150
Bank variables			
Bank size / GDP	60.38	50.39	293
Capital ratio	6.35	2.46	293
Loan ratio	62.79	16.12	293
Funding risk	45.03	21.52	293
Income diversification	30.30	14.89	293

Table 4: State variables - Average coefficients and significance

This table reports the average coeffients for the four state variables used in the factor models for the banks. The state variables included are a EU stock market Index, the European iTraxx index, the Vstoxx volatility index and the term spread between the 10-year government bond yield for each country and the 1-year Euribor rate. For each of these variables, we report the average yearly coefficient for the banks in our sample and the percentage of banks for which the specific state variable is significant in the factor models. We also report the number of banks in the sample for each year and the average adjusted R-squared. Changes in the number of observations are due to data availability of bank CDS spreads.

	2006		**2007**		**2008**		**2009**		**2010**		**2011**	
	coef	**% sign**	**coef**	**% sign**	**coef**	**% sign**	**coef**	**% sign**	**coef**	**% sign**	**coef**	**% sign**
MARKET	-0.0436	0.00%	-0.2865	0.00%	0.0669	6.52%	-0.2347	0.00%	-0.1503	3.77%	-0.2918	0.00%
ITRAXX	0.0402	13.64%	0.7490	96.77%	0.6365	91.30%	0.4010	86.27%	0.4400	92.45%	0.4772	84.91%
VSTOXX	-0.0065	0.00%	-0.0784	0.00%	0.0705	8.70%	-0.0735	0.00%	-0.0022	5.66%	-0.0572	0.00%
TERM	0.0217	4.55%	0.0485	6.45%	-0.0784	0.00%	0.0080	5.88%	0.0126	18.87%	0.0232	32.08%
# banks	22		31		46		51		53		53	
adj. R^2	0%		32%		33%		18%		32%		29%	

Table 5: Correlations and Excess correlations - Summary statistics

This table shows the mean, standard deviation, minimum and maximum of the pairwise bank/sovereign correlations in our sample. The second row contains the summary statistics of the excess correlations, calculated as the pairwise correlations of the residuals from the bank and sovereign factor models.

	# OBS.	**MEAN**	**ST.DEV.**	**MIN**	**MAX**
Average correlation	3034	35.29	22.72	-36.10	87.70
Average Excess Correlation	3034	17.38	18.73	-55.94	84.27

Table 6: Contagion - statistical significance

The table presents the percentage of bank-country excess correlations that are significantly different from the excess correlation in a pre-defined base year for three different setups. We compare the excess correlations with two different base years, being 2007 (left-hand side) and 2008 (right-hand side). The table consists of panels A, B and C. In panel A, we focus on the relation between a bank and its home country. The panel shows the number of bank-home country correlations that are significantly different from the correlations in the base year. In panel B, we analyze the correlations between a bank and foreign sovereigns. We report the number of bank-country correlations that are significantly different from the correlations in the base year. In panel C, we focus on the relationship between a bank and the GIIPS countries (Greece, Ireland, Italy, Portugal and Spain). We again report the number of bank-country correlations that are significantly different from the base year.

BASE YEAR: 2007					BASE YEAR: 2008			
HOME				Panel A	HOME			
	significant	total	percentage significant			significant	total	percentage significant
2007	Base year				2007	3	14	21%
2008	3	14	21%		2008	Base year		
2009	12	14	86%		2009	24	35	69%
2010	9	14	64%		2010	26	35	74%
2011	5	14	36%		2011	19	35	54%
FOREIGN				Panel B	FOREIGN			
	significant	total	percentage significant			significant	total	percentage significant
2007	Base year				2007	45	172	26%
2008	45	172	26%		2008	Base year		
2009	130	172	76%		2009	260	467	56%
2010	108	172	63%		2010	216	467	46%
2011	67	172	39%		2011	143	456	31%
GIIPS				Panel C	GIIPS			
	significant	total	percentage significant			significant	total	percentage significant
2007	Base year				2007	4	31	13%
2008	4	31	13%		2008	Base year		
2009	29	31	94%		2009	40	46	87%
2010	23	31	74%		2010	34	46	74%
2011	16	31	52%		2011	24	45	53%

Table 7: Excess correlations and bank characteristics

This table analyzes the impact of bank characteristics on contagion. In the first column, we regress country-bank excess correlations on a set of bank-specific characteristics and a home country/foreign country - time fixed effect. By including this fixed effect, we compare the excess correlation of bank i at time t with country j to the correlation of another bank k - located in the same country as bank i - with country j at time t. Thus, the part of the variation that is left in the bank-country correlation can only be explained by differences in bank-specific characteristics. In the second column, we do a similar analysis, but we also interact each bank-specific variable with a home country dummy. This allows us to analyze whether bank-specific variables are of different importance when considering the relationship of a bank with its home country. In the third column, we control for the impact of sovereign bond exposures. In the last column we replace the total capital ratio with the Tier 1 capital ratio. All variables are standardized, such that the coefficients indicate the impact of a one standard deviation change of the variable.

	(1)	(2)	(3)	(4)
VARIABLES	Excess Correl.	Excess Correl.	Excess Correl.	Excess Correl.
Size	1.441**	1.440**	0.462	1.710***
	(0.686)	(0.711)	(0.793)	(0.641)
Size x Home		-0.0650		-0.160
		(2.773)		(2.655)
Total Capital ratio	-1.707**	-1.758**	-0.261	
	(0.789)	(0.835)	(1.075)	
Total Capital ratio x Home		0.363		
		(2.590)		
Loan to Assets ratio	0.178	0.292	-0.0642	-0.807
	(0.547)	(0.571)	(0.765)	(0.637)
Loan to Assets ratio x Home		-1.311		-1.221
		(2.021)		(2.586)
Funding risk	1.642***	1.703***	1.867***	1.855***
	(0.474)	(0.489)	(0.541)	(0.454)
Funding risk x Home		-0.769		-0.827
		(1.951)		(1.722)
Income diversification	-0.506	-0.508	1.912***	-0.573
	(0.510)	(0.528)	(0.686)	(0.530)
Income diversification x Home		0.0351		-0.0106
		(2.070)		(2.082)
EBA Country Exposures			0.618	
			(0.951)	
Tier 1 Capital ratio				-1.696***
				(0.613)
Tier 1 Capital ratio x Home				0.0476
				(2.513)
Constant	17.57***	17.57***	17.64***	17.57***
	(5.32e-08)	(0.0158)	(0.162)	(0.0228)
Observations	3,034	3,034	1,349	3,034
R-squared	0.767	0.767	0.692	0.767
Home–Foreign-Time FE	YES	YES	YES	YES
Cluster	Home–Foreign-Time	Home–Foreign-Time	Home–Foreign-Time	Home–Foreign-Time

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 8: Country-bank spillover effects

This table shows the impact of sovereign credit risk on excess correlations between banks and sovereigns. In each of the regressions, we control for bank-time fixed effects, which boils down to comparing the impact of credit risk of different sovereigns on one and the same bank. The first column presents the results when regressing the excess correlations on the sovereign CDS spread, a home dummy and the interaction between both. In the second column, we replace the home dummy with eba exposure data, which captures the sovereign bon exposure of a bank to the sovereign with which we are measuring the excess correlation. In the third column, an interaction term between the EBA exposure variable and the sovereign CDS spread is added. The fourth column shows the impact of bank-specific characteristics on the relationship between the sovereign CDS spreads and the excess correlations. The last two columns are two robustness checks. In the fifth column, we check whether the decrease in sample size due to using the EBA exposure data has an impact on the role of bank-specific variables. In the last column, we include the Tier 1 capital ratio as an alternative capital measure instead of the total capital ratio. The last two rows of the third, the fourth and the last column show the impact of the sovereign CDS spread when the foreign exposure variable is one standard deviation above its mean. The exposure is expressed as a percentage of the total sovereign exposure of the bank. All variables are standardized such that the coefficients indicate the impact of a one standard deviation change.

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Excess Correl.	Excess Correl.	Excess Correl.	Excess Correl.	Excess Correl.	Excess Correl.
Sovereign CDS spread	1.837**	1.813**	1.790**	1.776**	1.829**	1.982**
	(0.770)	(0.853)	(0.850)	(0.846)	(0.771)	(0.833)
Sovereign CDS spread _Squared	-0.723***	-0.677***	-0.648***	-0.636***	-0.710***	-0.644***
	(0.147)	(0.160)	(0.165)	(0.164)	(0.147)	(0.164)
Home dummy	2.706***				2.726***	
	(0.839)				(0.843)	
Home x	5.361***				5.408***	
Sovereign CDS	(1.453)				(1.452)	
EBA Country Exposures		1.463***	1.243***	1.237***		1.210***
		(0.328)	(0.355)	(0.360)		(0.357)
EBA Country Exposures x			0.738	0.782*		0.639
Sovereign CDS			(0.468)	(0.467)		(0.453)
Total Capital ratio x				-0.807*	-0.795*	
Sovereign CDS				(0.485)	(0.465)	
Funding risk x				-0.282	-0.144	-0.370
Sovereign CDS				(0.269)	(0.303)	(0.277)
Loan to Assets ratio x				0.363	0.405	-0.241
Sovereign CDS				(0.488)	(0.406)	(0.466)
Income Diversificationx				0.0212	0.115	-0.125
Sovereign CDS				(0.476)	(0.394)	(0.468)
Size x				-0.449	-0.443	-0.0641
Sovereign CDS				(0.368)	(0.377)	(0.356)
Tier 1 ratio x						-0.505*
Sovereign CDS						(0.297)
Constant	18.11***	18.91***	18.85***	18.83***	18.09***	18.85***
	(0.165)	(0.114)	(0.135)	(0.132)	(0.166)	(0.134)
Observations	3,034	1,349	1,349	1,349	3,034	1,349
R-squared	0.670	0.575	0.576	0.579	0.671	0.579
Bank-time FE	YES	YES	YES	YES	YES	YES
Cluster	Bank-time	Bank-time	Bank-time	Bank-time	Bank-time	Bank-time

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9: Excess correlations - Impact of country characteristics

This table shows the relationship between country characteristics and bank-country excess correlations. In the first column, we regress the excess correlations on a home dummy, a set of country-specific characteristics and bank-time fixed effects. In the second column, we also interact each country-specific variable with a home country dummy. In the last column, we replace the home country dummy with a variable that contains EBA exposure data. By using bank-time fixed effects, we ensure that the only variation left in the excess correlations can be attributed to country-specific characteristics. All variables are standardized such that the coefficients represent the impact of a one standard deviation change in the variable.

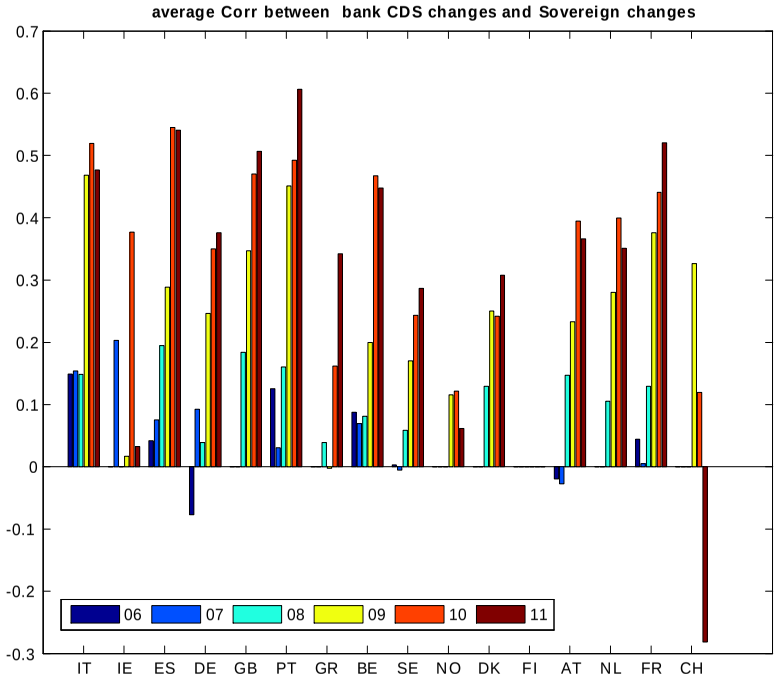
	(1)	(2)	(3)
VARIABLES	Excess Correl.	Excess Correl.	Excess Correl.
Home dummy	2.876***	2.574***	
	(0.881)	(0.925)	
Debt to GDP	1.215***	1.052***	0.919***
	(0.221)	(0.234)	(0.287)
Debt to GDP x		1.993**	
Home		(0.843)	
Government Revenues	0.0628	0.0536	1.664***
	(0.268)	(0.281)	(0.391)
Government Revenues x		-0.845	
Home		(0.861)	
Bank sector size	0.229	0.229	0.605*
	(0.229)	(0.237)	(0.322)
Bank sector size x		-0.213	
Home		(0.981)	
Economic Sentiment	1.317**	1.207**	0.489
	(0.563)	(0.563)	(0.686)
Economic Sentiment x		1.284	
Home		(1.074)	
EBA exposure			0.0954***
			(0.0182)
Constant	17.33***	17.33***	16.82***
	(0.0732)	(0.0723)	(0.353)
Observations	3,034	3,034	1,349
R-squared	0.661	0.662	0.562
Bank-Time FE	YES	YES	YES
Cluster	Bank-Time	Bank-Time	Bank-Time

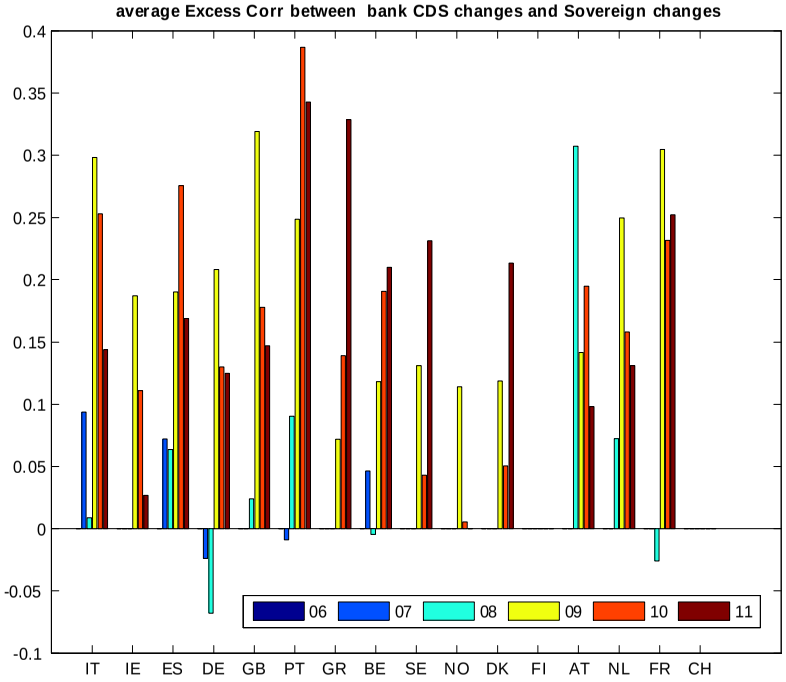
Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 1: Home country - bank CDS correlations

These figures show the correlations and excess correlations between sovereign and bank credit risk on a yearly country-by-country basis. The left hand side figure shows the average yearly correlations between the sovereign CDS spread and the banks headquartered in that country for all countries in our sample. The figure on the right hand side shows the average yearly excess correlations between the sovereign CDS spread and the banks headquartered in that country for all countries in our sample. Missing observations for some years are due to limited availabilty of either liquid sovereing CDS spread or liquid bank CDS spreads.





7. Appendix

Table 10: Robustness - impact bank characteristics

This table contains robustness checks for the impact of bank-specific characteristics on excess correlations. The first column is the benchmark regression, which corresponds to column 2 in Table 7. The second and the third column focus on the robustness of our results using different factor models to calculate the excess correlations. In column 2 we use an Itraxx only factor model, whereas we use alternative time windows to calculate the excess correlations in column 3. In the last column we use the same factor model as in our baseline setup, but we cluster standard errors at the country level instead of on the country-time level.

VARIABLES	Benchmark Excess Correl.	ITraxx only Excess Correl.	Time Windows Excess Correl.	clustering Excess Correl.
Size	1.440**	1.279*	1.279*	1.440
	(0.711)	(0.746)	(0.746)	(1.600)
Size x Home	-0.0650	1.240	2.018	-0.0650
	(2.773)	(2.864)	(2.851)	(1.560)
Total Capital ratio	-1.758**	-2.179**	-2.179**	-1.758***
	(0.835)	(0.904)	(0.904)	(0.440)
Total Capital ratio x Home	0.363	1.345	1.742	0.363
	(2.590)	(2.496)	(2.757)	(0.991)
Loan to Assets ratio	0.292	0.458	0.458	0.292
	(0.571)	(0.567)	(0.567)	(0.666)
Loan to Assets ratio x Home	-1.311	-1.258	-1.496	-1.311
	(2.021)	(2.167)	(2.005)	(0.982)
Funding risk	1.703***	1.832***	1.832***	1.703**
	(0.489)	(0.502)	(0.502)	(0.716)
Funding risk x Home	-0.769	-1.037	-1.545	-0.769
	(1.951)	(2.038)	(1.993)	(1.002)
Income diversification	-0.508	0.331	0.332	-0.508
	(0.528)	(0.556)	(0.557)	(1.778)
Income diversification x Home	0.0351	-0.701	-0.761	0.0351
	(2.070)	(2.091)	(2.033)	(1.322)
Constant	17.57***	19.28***	19.24***	17.57***
	(0.0158)	(0.0231)	(0.0245)	(0.00761)
Observations	3,034	3,060	3,060	3,034
R-squared	0.767	0.759	0.762	0.767
Home–Foreign-Time FE	YES	YES	YES	YES
Cluster	Home–Foreign-Time	Home–Foreign-Time	Home–Foreign-Time	Home Country

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 11: Robustness - impact home country and sovereign CDS

This table contains robustness checks for the impact of the home country effect, sovereign CDS spreads, and related interaction terms on excess correlations. The first column is the benchmark regression, which corresponds to column 5 in Table 8. The second and the third column focus on the robustness of our results using different factor models to calculate the excess correlations. In column 2 we use an Itraxx only factor model, whereas we use alternative time windows to calculate the excess correlations in column 3. In the last column we use the same factor model as in our baseline setup, but we cluster standard errors at the bank level instead of on the bank-time level.

VARIABLES	Benchmark Excess Correl.	Itraxx only Excess Correl.	Time windows Excess Correl.	clustering Excess Correl.
Sovereign CDS spread	1.829**	3.296***	3.282***	1.829**
	(0.771)	(0.662)	(0.660)	(0.845)
Sovereign CDS spread Squared	-0.710***	-0.982***	-0.983***	-0.710***
	(0.147)	(0.131)	(0.131)	(0.157)
Sovereign CDS x	-0.795*	-0.717	-0.752*	-0.795*
Total Capital ratio	(0.465)	(0.437)	(0.439)	(0.441)
Sovereign CDS x	-0.144	-0.163	-0.181	-0.144
Funding risk	(0.303)	(0.327)	(0.330)	(0.286)
Sovereign CDS x	0.405	0.504	0.482	0.405
Loan to Assets ratio	(0.406)	(0.462)	(0.464)	(0.255)
Sovereign CDS x	0.115	0.144	0.132	0.115
Income Diversification	(0.394)	(0.365)	(0.364)	(0.274)
Sovereign CDS x	-0.443	0.136	0.112	-0.443
Size	(0.377)	(0.400)	(0.401)	(0.330)
Home dummy	2.726***	1.899**	1.287	2.726***
	(0.843)	(0.817)	(0.816)	(0.777)
Sovereign CDS x	5.408***	4.121***	2.459*	5.408***
Home	(1.452)	(1.359)	(1.364)	(1.189)
Constant	18.09***	20.12***	20.12***	18.09***
	(0.166)	(0.147)	(0.146)	(0.145)
Observations	3,034	3,060	3,060	3,034
R-squared	0.671	0.692	0.691	0.671
Bank-time FE	YES	YES	YES	YES
Cluster	Bank-time	Bank-time	Bank-time	Bank

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12: Robustness - country characteristics

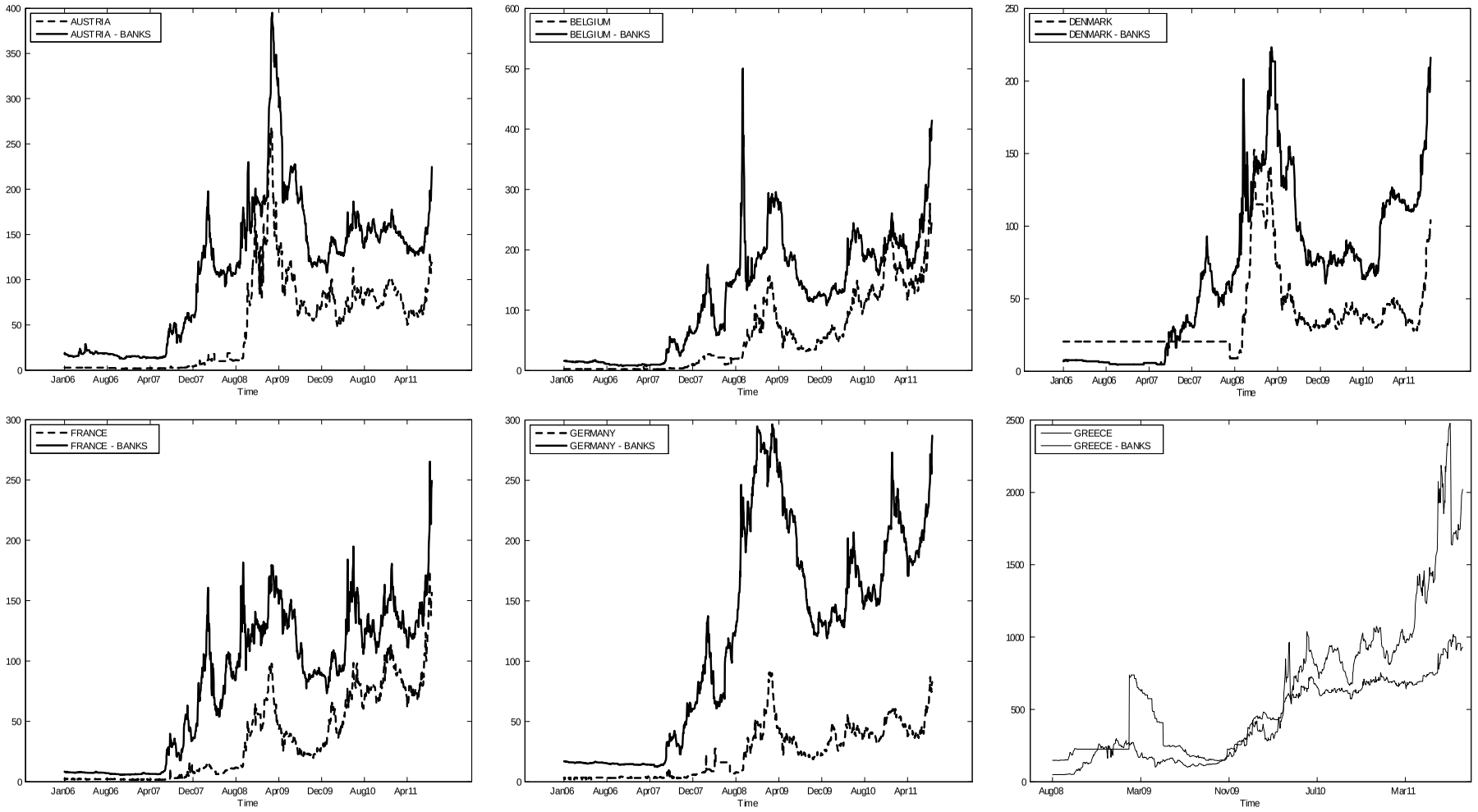
This table contains robustness checks for the impact of country-specific characteristics on excess correlations. The first column is the benchmark regression, which corresponds to column 2 in Table 9. The second and the third column focus on the robustness of our results using different factor models to calculate the excess correlations. In column 2 we use an Itraxx only factor model, whereas we use alternative time periods to calculate the excess correlations in column 3. In the last column we use the same factor model as in our baseline setup, but we cluster standard errors at the bank level instead of on the bank-time level.

VARIABLES	Benchmark Excess Correl.	Itraxx only Excess Correl.	Time Windows Excess Correl.
Home dummy	2.574***	1.756**	2.574***
	(0.925)	(0.886)	(0.878)
Debt to GDP	1.052***	0.664***	1.052***
	(0.234)	(0.242)	(0.167)
Debt to GDP x	1.993**	2.352***	1.993**
Home dummy	(0.843)	(0.823)	(0.959)
Government Revenues	0.0536	-0.496*	0.229
	(0.281)	(0.282)	(0.234)
Government Rev enues x	-0.845	-0.819	-0.213
Home dummy	(0.861)	(0.843)	(0.853)
Bank sector size	0.229	-0.126	0.0536
	(0.237)	(0.236)	(0.262)
Bank sector size x	-0.213	-0.862	-0.845
Home dummy	(0.981)	(0.962)	(0.909)
Economic Sentiment	1.207**	1.026**	1.207**
	(0.563)	(0.505)	(0.512)
Economic Sentiment x	1.284	0.357	1.284
Home dummy	(1.074)	(1.052)	(0.811)
Constant	17.33***	19.10***	17.33***
	(0.0723)	(0.0697)	(0.0750)
Observations	3,034	3,060	3,034
R-squared	0.662	0.680	0.662
Bank-Time FE	YES	YES	YES
Cluster	Bank-Time	Bank-Time	Bank

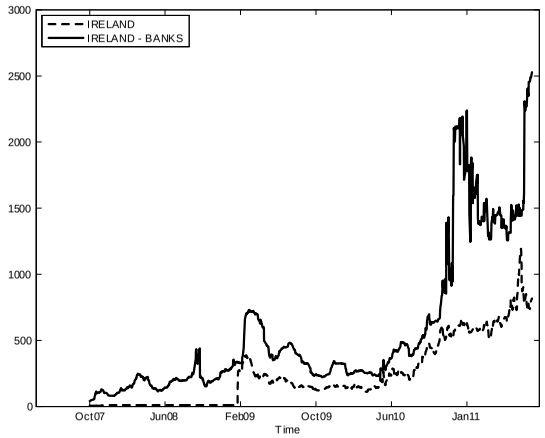
Robust standard errors in parentheses

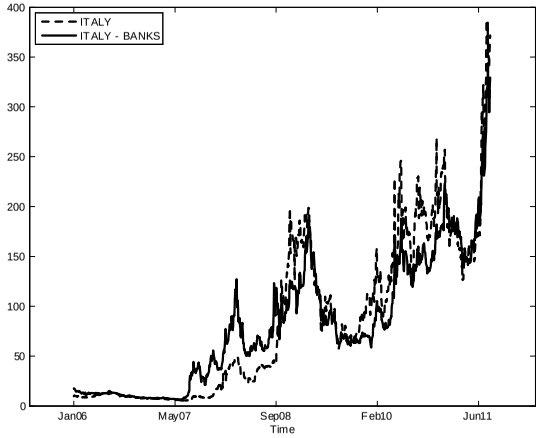
*** p<0.01, ** p<0.05, * p<0.1

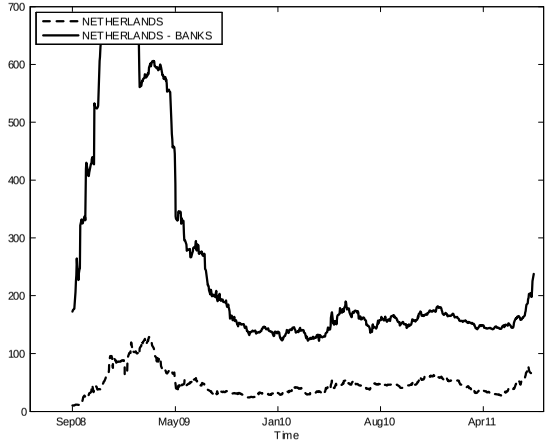
Bank and sovereign CDS spreads

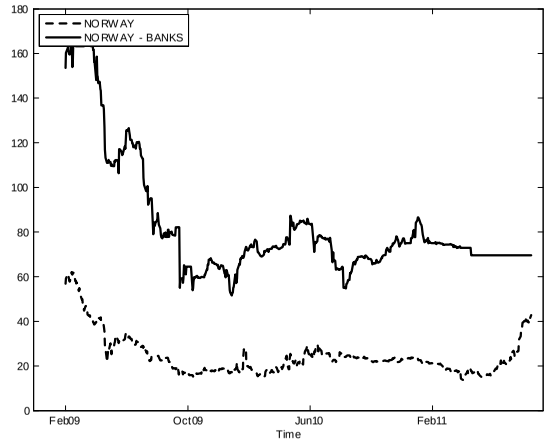


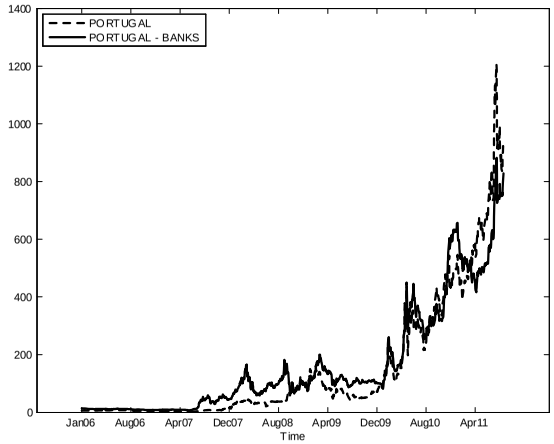
Bank and sovereign CDS spreads - continued

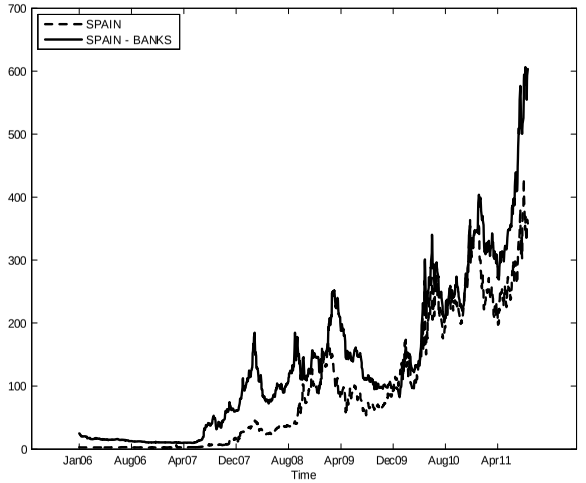












Bank and sovereign CDS spreads - continued