Bank and sovereign credit risk: Spillover effects from the ECB's Comprehensive Assessment*

H.-Johannes Breckenfelder,(†) Bernd Schwaab(†)

(†) European Central Bank, Financial Research

Abstract

We study spillovers from bank risk to sovereign risk in the euro area. Using difference specifications around the European Central Bank's release of the results of its stress test of 130 significant banks on 26 October 2014, we show that this information shock led to a decline in bank equity prices in stressed countries. Surprisingly, CDS spreads of banks in stressed countries were not significantly affected, and non-stressed sovereigns' CDS spread increased. In addition, the co-movement between non-stressed sovereigns and banks in stressed countries strengthened. This suggests that market participants understand that euro area countries share the burden of rescuing foreign banks in distress.

Keywords: bank-sovereign nexus, risk transmission, stress test, European Central Bank, Comprehensive Assessment.

JEL classification: C68, F34.

*Johannes Breckenfelder, European Central Bank, Sonnemannstraße 22, 60314 Frankfurt, Germany, email: johannes.breckenfelder@ecb.europa.eu. Bernd Schwaab, European Central Bank, Sonnemannstraße 22, 60314 Frankfurt, Germany, email: bernd.schwaab@ecb.int. We thank seminar participants at the BIS in Basel, the European Central Bank, the Frankfurt School of Finance and Management, the London School of Economics, the SYRTO conference on systemic risk analytics, and the VU University Amsterdam. We further thank three anonymous referees, Thorsten Beck, Geert Bekaert, Vítor Constâncio, Jon Frost, Philipp Hartmann, Marie Hoerova, Luc Laeven, André Lucas, Simone Manganelli, Albert Menkveld, and Sascha Steffen for valuable comments. Francesca Barbiero provided excellent research assistance. The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank or the Eurosystem.

1 Introduction

The sovereign debt crisis that erupted in the euro area in 2010 highlighted that sovereign and bank credit risk are strongly interconnected. As a result of the crisis, the sharing of banking sector risks across sovereigns in a monetary union became a first-order policy concern; see Draghi (2014). A growing strand of literature points towards a close connection between individual sovereigns and their domestic banks; see, for example, Cooper and Nikolov (2014), Acharya et al. (2014), and Farhi and Tirole (2014). This bank-sovereign nexus may cause a 'deadly embrace,' or 'doom loop,' resulting in both banks and sovereign simultaneously ending up in a crisis. In addition, different types of cross-border links may matter. First, there are cross-border links between banks, for example, owing to counterparty credit risk and information contagion; see e.g. Jorion and Zhang (2009) and Helwege and Zhang (2016). Second, risk dependence may occur across sovereigns; see e.g. Benzoni et al. (2016). Finally, adverse sovereign news can impact banks' health elsewhere; see e.g. Beltratti and Stulz (2015), Kirschenmann et al. (2016), and Kallestrup et al. (2016).

In this paper, we focus on an additional channel. There is a cross-sector cross-border link through which *bank risk* surprises in *stressed* countries can affect the credit risk of *non-stressed sovereigns* in the euro area.[1] While the bank-sovereign nexus is discussed predominantly for single countries, recent work also studies risk spillovers across borders; see e.g. Fratzscher and Rieth (2015), Kirschenmann et al. (2016), and Kallestrup et al. (2016). This cross-border strand of literature tends to focus on risk transmission through counterparty credit risk, or information contagion. In addition, the origin of the shock is often sovereign stress.[2] We complement this literature by pointing to risk transmission

[1]Throughout the paper, we refer to Greece, Ireland, Italy, Portugal, and Spain (GIIPS) as stressed countries, and to Austria, Belgium, France, Germany, and the Netherlands as non-stressed countries. Non-stressed countries were less affected by the earlier sovereign debt crisis between 2010–2012. Cyprus and Slovenia could be considered stressed countries, but do not exhibit banks that are referenced by a liquid CDS contract and are therefore not part of our sample. For an identical grouping of countries see, for example, Acharya and Steffen (2014), Fratzscher and Rieth (2015), and Eser and Schwaab (2016), among others.

[2]For example, Kirschenmann et al. (2016) demonstrate that an increase in sovereign risk in stressed countries can affect sovereign risk in other, non-stressed countries when banks do not hold equity against sovereign risk exposure.

through other cross-country mechanisms, such as the European Stability Mechanism (ESM), or unconventional monetary policies adopted by the European Central Bank (ECB) that involve risk sharing across sovereigns.[3] Risk transmission through counterparty credit risk or information contagion alone does not appear to rationalize our data.

Our study exploits variation from the information shock associated with the publication of the European Central Bank's (ECB) Comprehensive Assessment (CA) results on 26 October 2014. The release of new information led to a substantial reassessment of banking sector risks within a subset of euro area countries. This variation allows us to estimate the effect of bank credit risk on sovereign risk both *within* and *across* countries. Bank equity prices declined sharply after the arrival of adverse news of bank risk in stressed euro area countries. In particular, equity prices dropped by approximately 12 percent on average for banks located in stressed countries from before to after the announcement of the CA results. Simultaneously, banks' equity prices remained approximately flat on average in non-stressed euro area countries. This suggests that the net effect of the information shock on bank risk was approximately zero on average for these non-stressed countries, balancing good news from the CA with the bad news through exposure to troubled entities.

The CA consisted of a year-long examination of the resilience of the 130 largest banks in the euro area, and consisted of a backward-looking Asset Quality Review (AQR) and a forward-looking supervisory stress test (ST) of the examined banks. The CA covered bank assets of €22 trillion, which represented more than 80% of total banking assets in the euro area. The ECB carried out the CA together with 26 national supervisors from November 2013 to October 2014, involving a total of approximately 6000 people. The completion of the CA on 26 October 2014 was a major milestone in the ECB's preparation for the Single

[3]The ESM is a support facility established in September 2012 and is backed by euro area sovereigns according to their share in the ECB's equity capital. Since the ownership structure of ESM and ECB is identical, it is hard to disentangle the two channels. In addition, some ECB non-standard policies, such as its Outright Monetary Transactions (OMT) program, are backed financially by the ESM and are conditional on a country's participation in an ESM program. In late 2014, the ESM had approximately €80 bn in equity, allowing it to raise debt to achieve a total size of approximately €700 bn. Germany (27.0%) and France (20.2%) together contributed approximately half of the ESM's equity.

Supervisory Mechanism (SSM), the newly created cross-border banking supervisor within the euro area. The SSM became operational on 4 November 2014, two weeks after the release of the CA results. In turn, the SSM is a key pillar of the European 'Banking Union.' The Banking Union is a set of legislation that was ratified by the European Council and the European Parliament in successive steps between 2012 and 2014, with the main objective of breaking, or at least minimizing, the bank-sovereign nexus within European Union (E.U.) countries; see, for instance, EC (2012) and Constâncio (2014). Regulation intended to mitigate bank-sovereign dependence *within* countries, however, may inadvertently have increased bank-sovereign dependence *across* countries.

The notion of risk (implicitly, wealth) transfers across countries is hyper-sensitive from a public policy perspective. In addition, such transfers may be just borderline legal. For example, the 'no-bail-out' clause in Article 125 of the Lisbon treaty makes it illegal for one member to assume the debts of another. During the crisis, this clause led to fears that Germany's constitutional court could strike down E.U. bail-outs. Despite its prominence in media and policy discussions, research on the changes in cross-border sovereign-bank risk dependence is limited.

Quantifying the transmission from bank risk to sovereign risk usually suffers from the strong two-way dependence between these two sectors. On the one hand, banks depend on their own sovereigns because they hold large amounts of sovereign debt for investment and liquidity purposes. On the other hand, sovereigns provide a fiscal backstop to their banking sectors, in particular in times of financial crisis; see, for instance, Farhi and Tirole (2014). Other channels may also matter; see Fratzscher and Rieth (2015). Fortunately, the variation in bank risk after the announcement of the CA results can serve as a promising setup that allows us to study the risk transmission from banks to sovereigns. Changes in sovereign CDS spreads after the announcement of the CA results appear to be plausibly triggered by the arrival of adverse news about the health of the banking sector, rather than new information about sovereign risk. As a result, we rely on difference estimates to test for changes in risk

dependence between banks and sovereigns.

We focus on four findings. First, we demonstrate that the announcement of the CA results on 26 October 2014 revealed significant new information to market participants beyond what was anticipated.[4] This is not (entirely) obvious for two reasons. First, banks had had ample time to respond to the likely result by raising enough equity capital between 31 December 2013 and October 2014 to avoid a shortfall; indeed, the participating banks raised a total of €57.1 bn in bank capital during that time; see ECB (2014a). Second, two confidential documents were leaked in the two weeks preceding the announcement of the CA results on 26 October, revealing, for example, that 25 banks will 'fail' the CA. In fact, we find no evidence that suggests that the market was surprised about the *aggregate*, euro area-wide, headline results of the AQR, or the aggregate capital shortfalls implied by the stress test. The pronounced country- and bank-level dispersion of AQR losses and capital shortfalls, however, was much harder to predict. In other words, market participants were less surprised that 25 banks eventually failed the CA, but were taken by surprise by the fact that 20 of these banks were concentrated in stressed countries. Changes in bank-level equity prices ranged from -38.6% in the case of Banca Monte dei Paschi di Sienna (Italy), to +10.1% for Erste Bank (Austria) around the announcement of the CA results. Changes in bank equity prices, both at the bank and country-group level (approximately zero for non-stressed countries, and -12% for stressed countries) corroborate that the adverse news about banking sector health was concentrated in stressed countries.

Second, we show that sovereign CDS spreads increased in all euro area countries on average from before to after the announcement of the CA results. This increase is striking, because non-stressed countries' banks received no bad news on average. Sovereign CDS spreads in non-stressed countries increased by approximately 5 basis points (bps), from approximately 31 to 36 bps, even though their corresponding banks' CDS spreads were approximately flat, and, again, respective bank equity prices did not move significantly. As

[4]Recent literature investigates whether stress tests provides information that is new to investors; see e.g. Petrella and Resti (2013), Sahin and de Haan (2016), and Goldstein and Leitner (2016).

a result, the increase in sovereign CDS spreads for non-stressed countries appears to be a direct consequence of the CA results for banks in stressed countries. Indeed, the highest AQR asset value adjustments were imposed on banks located in Cyprus, Greece, Italy, Portugal, and Slovenia; see ECB (2014, p. 5).

Third, we study changes in the magnitude of sovereign-bank risk dependence *within countries* based on difference and difference-in-differences regression specifications. These specifications allows us to investigate which group of countries experienced a change in sovereign-bank risk dependence from before to after the announcement of the CA results. We find no significant increase in the dependence between sovereign and bank risk for stressed countries. Risk dependence remains insignificant after the CA announcement. This is in line with a second fiscal backstop that provides equity insurance to banks in stressed countries, for example through cross-border risk sharing facilities, including the ESM. ESM recapitalizations are subject to strict conditionality, available only in the very last instance, and are capped in terms of magnitude at €60 bn per bank. Such insurance nevertheless reduces the credit risk borne by bank debt holders, independent from the financial health of its sovereign; see Geeroms and Karbownik (2014) and Farhi and Tirole (2014, Section 5).[5]

Sovereign-bank correlations within non-stressed countries become significantly positive after the announcement of the CA results. This is in line with the notion that the completion of the CA and a progressing Banking Union transferred risk across borders to non-stressed sovereigns and, as a result, increased their dependence on domestic banks. This notion is consistent with theoretical work by Acharya et al. (2014) and Leonello (2015), who argue that an adverse shock to either banks or sovereign increases the risk of a 'deadly embrace'.

Finally, we relate changes in the CDS spread of non-stressed sovereigns to changes in the

[5]To our knowledge, the theoretical literature on the sharing of banking sector risks across sovereigns in the context of a monetary union is fairly sparse. The most related economic modeling framework is Farhi and Tirole (2014) who comment on, but do not explicitly model, cross-country sovereign-bank risk dependence subject to international risk sharing facilities. Theoretical asset pricing frameworks that allow for shocks to investors' information sets are more abundant, and include King and Wadhwani (1990), Veldkamp (2006), and Pavlova and Rigobon (2007).

equity market capitalization of banks located in stressed countries, controlling for changes in domestic banks' CDS spreads, common factors, as well as other effects.[6] We find that changes in the health of foreign banks affect non-stressed sovereigns' CDS spreads significantly *more* after the announcement of the CA results. Before the announcement of the CA results, the loading on foreign banks' equity returns is approximately zero and statistically insignificant. Following the announcement, the cross-country elasticity decreases by -0.74 and becomes strongly statistically and economically significant. These findings are robust to plausible variations in the econometric approach, data frequency, as well as to variations in the length of the data sample.

Section 2 discusses the main aims, results, and communication timeline of the CA. Section 3 studies the impact of the announcement of the CA results on banks' equity valuations and sovereign CDS spreads. Section 4 investigates changes in sovereign-bank risk dependence, both within and across euro area countries. Section 5 presents evidence from a time-varying parameter model. Section 6 concludes. A supplementary Web Appendix contains additional data statistics and empirical results.

2 The ECB's Comprehensive Assessment

First, this section discusses the main goals, results, and communication features of the ECB's CA. Then, we argue that the announcement of the CA results is a significant event, which allows us to study the impact of an increase in bank risk on sovereign risk.

2.1 Aims and results of the CA

The CA started in November 2013 and was conducted to ensure that, when the ECB became the euro area's single supervisor (SSM) in late 2014, banks' assets and risks would be eval-

[6]The quantification of spillovers from one bank to another are outside of the scope of this paper. We refer to e.g. Fratzscher and Rieth (2015), Helwege and Zhang (2016), and Kallestrup et al. (2016) for a quantification of such effects. We control for bank-to-bank spillovers in our econometric specifications.

uated according to the same rules across all countries. It consisted of a backward-looking AQR and a forward-looking supervisory stress test of the euro area's most significant banks. The CA covered bank assets of €22 trillion, representing 82 percent of the respective total banking assets. This test was carried out by the ECB together with 26 national supervisors during the 12 months between November 2013 and October 2014, involving approximately 6000 people.

The objectives of the CA were threefold. First, to strengthen banks' balance sheets by repairing any problems uncovered; second, to enhance transparency by improving the quality of information available on the health of the individual banks; and third, to build confidence by assuring that, on completion of the required remedial actions, all banks would be soundly capitalized; see ECB (2014a). The CA concluded with the release of the overall results and recommendations for subsequent supervisory measures, on 26 October 2014. In addition to the CA's headline results, the ECB also disclosed detailed bank-level balance sheet information on a dedicated website. These bank-level templates were only partially available on Sunday 26 October 2014, and became fully available during the first week after the announcement of the CA results. Arguably, these bank-level supervisory data were of the most immediate interest to market participants and bank analysts.

As the CA's headline result, a total capital shortfall of €25 billion was identified, at 25 banks. Of these 25 banks, 20 were located in stressed countries, nine of which were located in Italy, and four in Greece. Twelve out of these 25 banks had already covered their capital shortfall by increasing their capital during 2014 (near-pass), leaving 13 banks that fell short (near-fails or fails). The 13 failing banks were required to prepare capital plans within two weeks of the announcement of the CA results, and were given up to nine months to cover their capital shortfall. If the required new equity could not be raised in private markets, the respective sovereign was called upon to provide a fiscal backstop by purchasing the remaining number of shares. This procedure was known ex-ante, and connected the health of the banks to that of their respective sovereign. In case the respective sovereign were unable to provide

a sufficient public sector backstop, the ESM was made available as a second backstop for both sovereigns and banks.[7]

The AQR was a point-in-time assessment of the accuracy of the carrying value of banks assets as of 31 December 2013 and provided a starting point for the stress test. The AQR audits revealed that banks' non-performing exposures needed to be adjusted upwards by €136 billion (to a total of €879 billion). This value adjustment is economically significant, as it corresponds to approximately 1.3% of 2014 euro area GDP of €10.1 trn.[8] In addition, the end-of-2013 book values of banks' assets needed to be adjusted downwards by a total of €48 billion.

The stress test provided a forward-looking examination of the resilience of banks solvency to a baseline and a severe stress scenario, also reflecting the new information arising from the AQR. Based on the AQR results, the stress test found that the severe macro-financial stress scenario would deplete banks' loss-absorbing CET1 capital by about €263 billion. This would decrease the median CET1 ratio by approximately 4 percentage points from 12.4% to 8.3%. This reduction was substantially higher than those found in earlier exercises, such as the stress tests previously undertaken by the European Banking Authority between 2010–2013. The relative harshness of the test likely contributed to a perception that, this time, the results were more credible.

[7]The direct recap option of the ESM was introduced by euro area head of states on 29 June 2012. The respective announcement clarified that the ESM can be used to *i*) support countries who get into economic difficulties, for example following adverse banking sector outcomes, and *ii*) to directly recapitalize banks, provided Banking Union (single supervision) is in place by then. The experience during the peak of the euro area sovereign debt between 2010–2012, however, may also have taught market participants that such rules can change over the course of a weekend if deemed necessary. We do not consider an event study around the 29 June 2012 announcement because it is unclear to what extent the statement was unexpected, and how it would have generated country-specific banking sector risk.

[8]Source: `http://ec.europa.eu/eurostat/.`

Figure 1: Communication timeline

A timeline of official communication and news reports. We distinguish a Pre-CA (29 September – 10 October), Soft-Info (13 – 24 October), and Post-CA (27 October – 04 November) period. During the Soft-Info period, official ECB communication is printed above the timeline, and news reports based on leaked documents are printed below.

2.2 The ECB's CA as a significant event

The announcement of the CA results permits an interesting event study, allowing us to study the impact of an increase in banking sector risk on the priced default risk of multiple sovereigns. This is the case because, first, the CA involved a genuine and significant shock to investors' information sets, leading to a substantial reassessment of banks' risk, and, second, because banks subject to negative surprises were located in a certain subset of euro area countries.

This section clarifies the CA's communication timeline. Figure 1 plots the chronology of the ECB communication up to the announcement of the CA results. The ECB announced on 10 October 2014 that the final CA results would be published in about two weeks' time, on 26 October 2014. Following that initial announcement, media attention turned to the CA.

News coverage of the upcoming CA was particularly intense during the two weeks leading up to the CA announcement. Indeed, news reports and rumors were so frequent, and the resulting market movements so volatile, that the ECB offered a press release on 22 October stating that "any media reports on the outcome of the tests are ... highly speculative." Arguably, two news reports stand out. Both reports appear to have had a significant impact on financial markets. First, a Bloomberg News report on Tuesday 14 October quoted from a leaked confidential ECB document, dated 6 October, that some banks "need to fail" to prove the exam's credibility; see Bloomberg (2014). A pressing worry was that the exam would not "reveal big enough capital shortfalls to prove its rigor," according to the leaked document. Second, a Bloomberg News report on Friday 24 October, again based on a leaked ECB document, stating that exactly 25 banks had failed the ST, the correct number. No report contained bank-level information, such as bank identities, or accounting data. As a result, the news was perceived as euro area-wide news.

To ensure a reliable quantification of the different effects over time, we distinguish three periods for our empirical study of risk dependence within and across borders: (*i*) a baseline pre-announcement period (Pre-CA, 29 September – 10 October), (*ii*) a soft information period in which some information was involuntarily released to financial markets through leaked confidential documents (Soft Info, 13 – 24 October), and (*iii*) a post-announcement period during which all hard information about the CA results became available to all market participants (Post-CA, 27 October – 04 November).[9] Our two-week post-CA period also accounts for the fact that the bank-level data templates were only partially available on the ECB's website on Sunday 26 October 2014. The templates became fully available only during the first week after the announcement of the CA results.

To be clear, two events happened around 26 October 2014. First, the announcement released information about each bank: Some passed the bar, others did not and needed

[9]Sahin and de Haan (2016) study announcement effects of the ECB's CA based on a narrow window around the 26 October and find little variation in market prices around the event. More variation is found based on wider windows. The gradual leakage of confidential information during our Soft Info period explains this outcome.

recapitalization. This explains differential stock prices; see Section 3. Simultaneously, the willingness to share risks across borders in a Banking Union did not extend to so-called "legacy assets" from the crisis. After the 26 October 2014 AQR, however, this issue was out of the way for banks that passed, or received recapitalization. This feature, most likely, explains changes in correlations between sovereign and bank CDS spreads before and after the CA. The impact of the CA announcement on risk levels and risk correlations is best conceptualized as the joint impact of both events.

3 The impact of the CA on bank and sovereign risk

This section studies the impact of the CA results on banks' equity valuations at the bank and aggregate (country-group) level. We then investigate the impact of the announcement of the CA results on sovereign and bank risk as measured by CDS spreads. Finally, an approximate back-of-the envelope calculation puts the increase in sovereign CDS spreads into perspective.

3.1 Data

We consider standard equity and CDS data for our study. Bank equity data are taken from Bloomberg for all listed CA banks. Stock returns are based on daily closing prices, and are available at a daily frequency.

CDS spreads are obtained from the Credit Market Analysis (CMA) database via Thomson/Reuters Datastream. All CDS refer to a 5-year maturity, and are subject to a full-restructuring credit event clause. Bank and sovereign CDS are subject to pre-determined and comparable contractual (ISDA) agreements. This comparability permits a consistent measurement of point-in-time credit risk perceptions for both banks and sovereigns. The Web Appendix A reports descriptive statistics, distinguishing the Pre-CA, Soft Info, and

Post-CA event windows. The CA results are publicly available from the ECB's website[10]; see also ECB (2014a).

In general, price formation in derivative markets can potentially be disrupted during times of financial distress; see e.g. Augustin et al. (2014). In addition, the depth of corporate CDS markets could be time-varying. We account for CDS market liquidity-related concerns in three ways. First, we exclude CDS spreads from our analysis that exhibit two or more zero returns in at least one of our three 10-day periods. This removes obviously stale derivative price quotes in one case. Second, we accommodate contract-specific differences in liquidity by allowing for bank (contract)-specific fixed effects in our panel specifications. Finally, the choice of three relatively wide 10-day periods before and after the CA should robustify our study to transitory CDS mispricing.

3.2 Impact on banks' market capitalization

This section discusses the bank-level impact of the announcement of the CA results. Table 1 lists the banks for which we observe liquid CDS spread or equity data. Banks are sorted according to their change in market capitalization from the pre-CA (average) to the post-CA period (average). For banks that do not have a stock listing, we sort according to CDS spread changes, with the largest increase first.

Most of the banks that suffered stock market valuation losses around the 26 October 2014 announcement were located in countries that were most affected by the previous euro area sovereign debt crisis between 2010–2012, such as Greece, Ireland, Italy, Portugal, and Spain (stressed countries); see Table 1. Of the top 20 worst 'performers' in terms of changes in equity market valuation, 18 were located in our group of stressed countries. Conversely, banks located in non-stressed countries tended to receive a clean bill of health. Of the bottom ten entries, referring to banks with the most positive changes in equity valuation, seven are

[10] `https://www.bankingsupervision.europa.eu/banking/comprehensive/.`

Table 1: Bank-level outcomes

Banks are sorted by their respective change in equity market valuation from the Pre-CA to the Post-CA period (in ascending order). When equity prices are missing, banks are sorted by their respective change in CDS spread (in descending order). The third and fourth columns report the increments between Pre-CA and Post-CA average prices. The last column refers to the headline CA result: pass (P), near-pass (NP), near-fail (NF), and fail (F). Stressed countries are highlighted.

Bank name	Country	Equity change	CDS change	CA outcome
Banca Monte dei Paschi di Siena SpA	IT	-38.60%	3.79%	F
Banca Carige SpA	IT	-35.23%		F
Permanent TSB plc	IE	-15.30%	-1.44%	F
Alpha Bank SA	GR	-13.33%	20.98%	P
Banco Comercial Português SA	PT	-12.22%	6.89%	F
National Bank of Greece SA	GR	-12.13%	20.98%	NF
Eurobank Ergasias SA	GR	-10.90%	20.96%	NF
Piraeus Bank SA	GR	-8.59%	11.33%	NP
Deutsche Bank AG	DE	-8.21%	10.67%	P
Liberbank SA	ES	-8.18%		NP
Banca Popolare Di Milano Scarl	IT	-7.14%	-4.03%	F
Banco Santander SA	ES	-7.03%	6.85%	P
UniCredit SpA	IT	-6.77%	4.78%	P
Unione Di Banche Italiane Scpa	IT	-6.33%	2.24%	P
Banco Bilbao Vizcaya Argentaria SA	ES	-5.62%	6.78%	P
Banca Popolare di Sondrio Scpa	IT	-4.77%		NP
Société Générale	FR	-3.78%	6.20%	P
Banca Popolare Dell'Emilia Romagna SC	IT	-3.60%		NP
Banca Piccolo Credito Valtellinese SC	IT	-3.47%		NP
Banco de Sabadell SA	ES	-3.36%	-12.70%	P
Banco Popular Español SA	ES	-3.14%	-16.70%	P
BNP Paribas	FR	-2.96%	7.66%	P
Bankinter SA	ES	-2.83%	-9.85%	P
Intesa Sanpaolo SpA	IT	-1.93%	0.09%	P
KBC Group NV	BE	-1.05%	5.59%	P
Banco BPI SA	PT	-0.77%	14.78%	P
Groupe Crédit Agricole	FR	-0.19%	8.16%	P
Raiffeisen Zentralbank AG	AT	0.61%	-11.67%	P
Banco Popolare SC	IT	0.73%	-13.13%	NP
IKB Deutsche Industriebank AG	DE	0.76%	-7.28%	P
ING Bank NV	NL	0.88%	-3.58%	P
Aareal Bank AG	DE	1.62%		P
The Governor and Company of the Bank of Ireland	IE	2.09%	-4.68%	P
Mediobanca - Banca di Credito Finanziario SpA	IT	2.80%	4.50%	P
Commerzbank AG	DE	5.93%	-2.39%	P
Erste Group Bank AG	AT	10.07%	-13.95%	P
Dexia NV	BE		13.01%	NF
Caixa Geral de Depósitos SA	PT		6.79%	P
C.R.H.	FR		0.19%	NP
Allied Irish Banks plc	IE		-1.04%	P
Banque PSA Finance	FR		-1.46%	P
Landesbank Baden-Württemberg	DE		-1.94%	P
ABN AMRO Bank NV	NL		-2.07%	P
Coöperatieve Centrale Raiffeisen-Boerenleenbank B.A.	NL		-2.10%	P
Landesbank Hessen-Thüringen Girozentrale	DE		-2.14%	P
Bayerische Landesbank	DE		-2.61%	P
Norddeutsche Landesbank Girozentrale	DE		-2.83%	P
BAWAG P.S.K.	AT		-2.84%	P
RCI Banque	FR		-2.86%	P
HSH Nordbank AG	DE		-2.89%	P
SNS Bank NV	NL		-2.95%	P
AXA Bank Europe SA	BE		-3.72%	NP
The Royal Bank of Scotland NV	NL		-14.24%	P
DZ Bank AG	DE		-16.46%	P

located in non-stressed countries. Bank-level equity surprises range from -38.6% in the case of Banca Monte dei Paschi di Siena (Italy), to +10.1% for Erste Bank (Austria).

The bottom part of Table 1 sorts banks without a stock listing according their change in CDS spread. Again, banks from non-stressed countries tended to have declining CDS spreads. For example, double-digit declines in CDS spreads are visible for DZ Bank AG (Germany) and The Royal Bank of Scotland (the Netherlands). Conversely, increased CDS spreads of banks from stressed countries are among the respective 'top' entries. For example, Caisse de Refinancement de l'Habitat (CRH) from Portugal does not have a stock listing, but its CDS spread increased by approximately 6.8%.

The final column of Table 1 indicates the headline result of the CA. Four outcomes were possible. Pass (P) if the bank met the 5.5% CET1 ratio requirement under the adverse scenario and also met the 8% ratio under the baseline scenario. Near-pass (NP) if the bank did not meet both required ratios, but had already covered its capital shortfall before 26 October 2014. Near-fail (NF) if the bank did not meet both ratios and had not covered the shortfall, but its plans to raise capital were deemed adequate. Fail (F) if the capital ratio requirements were not met and no adequate repairing measures were underway.

Whether a bank (near-)passed or (near-)failed the CA was not necessarily surprising. Recall that banks were evaluated on data only up to December 2013. Consequently, banks had the chance to anticipate and correct a potentially weak capital ratio. We therefore focus on the changes in equity valuation and CDS spreads from before to after the release of the CA results.

Deutsche Bank AG (row 9) is an outlier in Table 1. It is a large bank located in a non-stressed country with a negative equity return of approximately -8% from the Pre-CA to the Post-CA period. Deutsche Bank suffered substantial litigation losses related to mortgage mis-selling and alleged Libor rigging. These litigation losses were communicated on 29 October 2014, three days after the CA announcement. We keep Deutsche Bank in the

sample to present conservative estimates.

3.3 Equity impact at the country-group level

This section studies the impact of the CA results on banks' equity valuations at the country-group level. Figure 2 plots the cumulative log-changes in equity prices on average over the period from 29 September 2014 to 7 November 2014. The solid vertical line marks the announcement of the CA headline results on 26 October 2014.

Figure 2 distinguishes between non-stressed countries (solid line), and two groups of stressed countries. Equity prices for banks located in stressed countries dropped sharply after the CA, by approximately 12 percent compared to the pre-CA period. Italian banks' equity valuations suffered the most, followed by that of banks located in Greece, Ireland, Portugal, and Spain. By contrast, bank equity prices remained approximately unchanged in non-stressed countries. If anything, bank equity prices in non-stressed countries *increased* slightly from Friday 24 October to one week later. The net effect of the information shock on bank risk was approximately zero on average for these non-stressed countries, balancing the good news from the CA with the bad news through exposure to more risky banks (and sovereigns). Finally, we note the parallel trend in equity prices before the release of the CA results. The parallel trend suggests that bank equity prices across the euro area were driven by common factors before 26 October.

The bottom panel of Figure 2 plots cumulative bank equity returns in stressed countries relative to those in non-stressed countries. Again, negative bank risk surprises were concentrated in stressed countries. These negative surprises were only revealed with the announcement of the CA results on 26 October 2014.

Figure 2: Cumulative bank equity returns in the euro area

Equity prices are from 29 September 2014 to 7 November 2014. In each panel, the dashed vertical line marks the beginning of the Soft Info period, while the solid vertical line marks the Monday close following the announcement of the CA results. The top panel plots the cumulative log-changes in equity closing prices for non-stressed countries' bank equities (solid line), the bank equities of stressed countries excluding Italy (dashed line), and Italian bank equities (dotted line). The bottom panel plots the cumulative log-changes in the equity of banks located in stressed countries, relative to the cumulative log-changes in the equity of banks located in non-stressed countries.

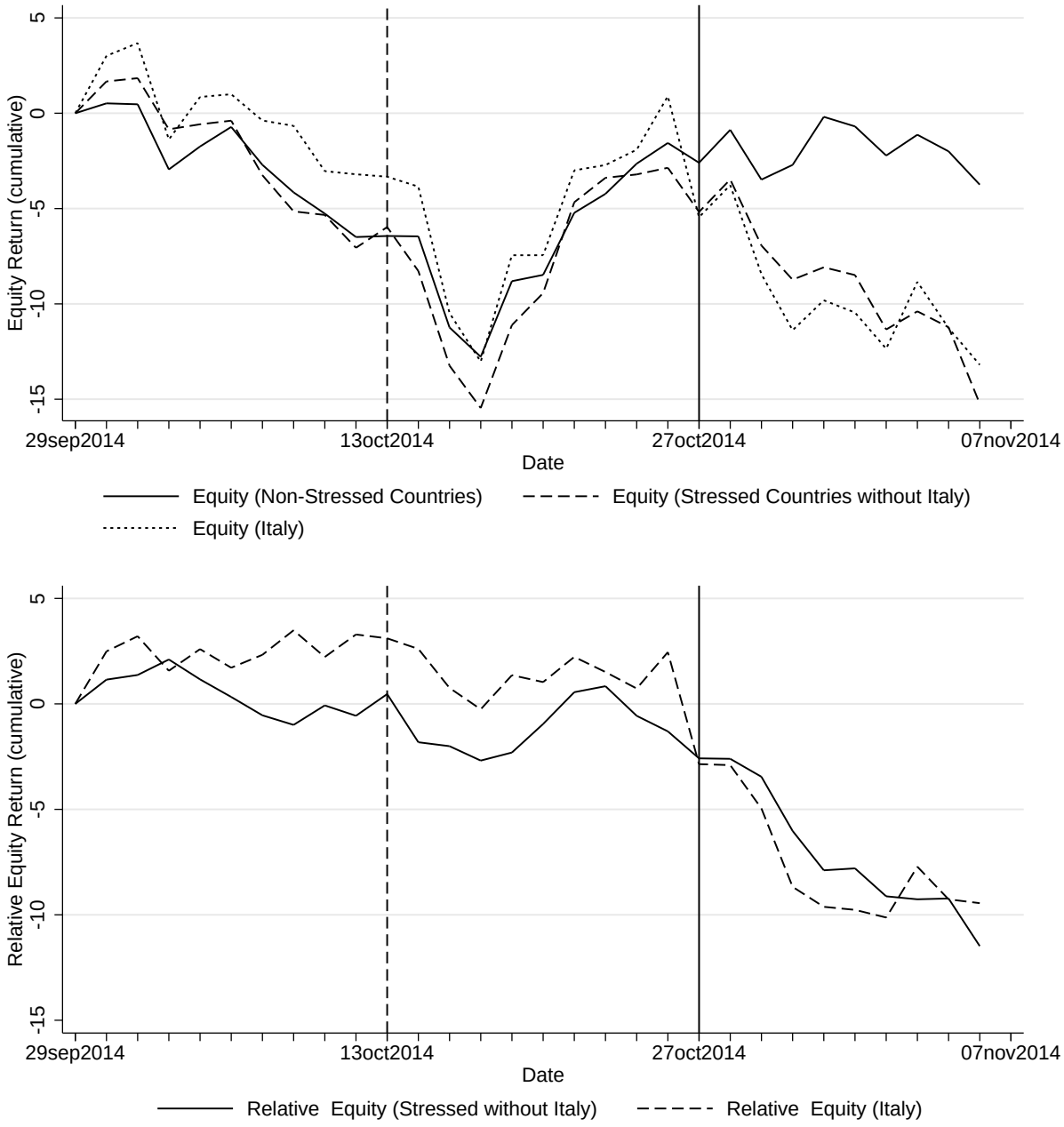
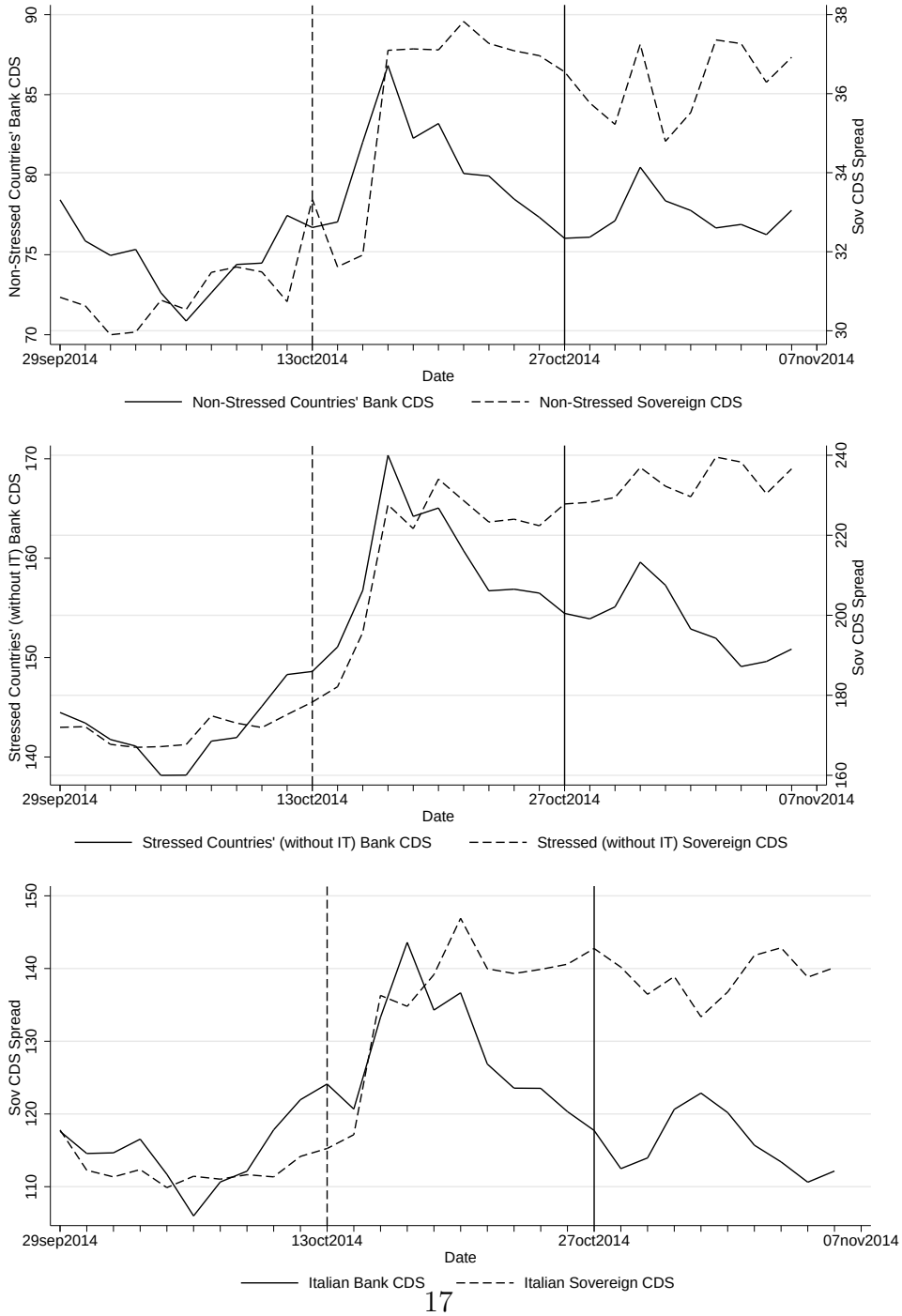


Figure 3: Weighted averages of bank CDS and sovereign CDS spreads in the euro area

Weighted averages of CDS spreads for both banks and sovereigns in the euro area from 29 September 2014 to 7 November 2014. Weights are given by the respective levels of total government debt for sovereign CDS, and bank-specific total liabilities for bank CDS, on 31 December 2013. In each panel the dashed vertical line marks the start of the Soft Info period, while the solid vertical line marks the Monday close following the Sunday announcement of the CA results. The top panel plots average CDS levels for non-stressed countries' banks' CDS (solid line) and non-stressed countries' sovereign CDS (dashed line). The middle panel plots average CDS levels for stressed countries' banks' CDS (solid line), and stressed countries (without Italy)' sovereign CDS (dashed line). The bottom panel reports Italian data.



3.4 Impact on bank and sovereign risk

This section investigates the impact of the 26 October 2014 announcement on bank and sovereign risk as measured by CDS spreads. Figure 3 reports debt-weighted averages of CDS spreads for both banks and sovereigns.[11] Each panel plots average CDS spreads for banks (solid line) and sovereigns (dashed line). The top, middle, and bottom panel refer to non-stressed countries (i.e., Austria, Belgium, France, Germany, and the Netherlands), stressed countries other than Italy (Greece, Ireland, Portugal, and Spain), and Italy. Again, we expect to see market movements in stressed countries in response to the announcement of the CA results to be particularly pronounced for Italy. Table 2 complements Figure 3 by reporting sovereign CDS spreads for selected euro area (and European Union non-euro area) countries.

We take note of the following stylized facts. First, sovereign CDS spreads increased in all euro area countries from the pre-CA to the post-CA period. In particular, debt-weighted sovereign CDS spreads in non-stressed countries increased considerably, by approximately 5 bps, from 31 bps to 36 bps (approximately +15%; see top panel of Figure 3, right scale).[12] The increase in CDS spreads around the announcement of the CA results was specific to the euro area. Non-euro area countries located within the same E.U. Single Market for Financial Services were not perceived as more risky; see Table 2. This is noteworthy, as the latter countries do not have an equity stake in the ESM, and are not directly affected by ECB unconventional monetary policies that potentially involve risk sharing.

Second, sovereign CDS spreads increase by relatively more in stressed countries than in non-stressed countries. This is in line with the allocation of banking sector losses, but

[11] The respective unweighted averages are reported in the supplementary Web Appendix B. Unweighted averages are approximately similar to Figure 3. Sovereign CDS spreads are weighted by total government debt as reported by Eurostat as of end-2013. Banks' CDS spreads are weighted by total bank liabilities in December 2013. Bank liabilities are taken from the CA templates.

[12] In principle, markets could have been surprised that no significant shortfalls were identified in non-stressed countries. Implicit or explicit guarantees for those countries would then have affected these sovereign CDS spreads positively. Figure 3 and Table 2 clarify that *all* euro area sovereign CDS spreads went up from before to after the announcement of the CA results.

also consistent with the fact that ESM support to banks could be channeled through the respective sovereign, increasing its debt-to-GDP ratio. For our group of non-stressed euro area countries, banks' CDS spreads are approximately unchanged (at approximately 76 bps), both in the pre-CA and post-CA periods; see the top panel of Figure 3, left scale. Such unchanged banking sector CDS spreads are in line with the minimal change in corresponding banks' equity prices; recall Figure 2. The approximately unchanged banking sector CDS spreads and equity prices likely reflect both the overall positive CA results for these banks, as well as the less positive results for other banks to which they are potentially connected; see Helwege and Zhang (2016).

Most sovereign CDS spreads increased following the 14 October. This is the date when Bloomberg News reported on a leaked confidential document which stated that the ECB was worried that not enough banks would fail the stress test.[13] This observation corroborates our selection of Pre-CA and Post-CA periods from Section 2.2.

Third, both bank and sovereign CDS spreads increased in stressed countries on average from the pre-CA to the post-CA period; see the middle and bottom panels of Figure 3. Sovereign CDS spreads in stressed countries (without Italy; middle panel) increased by approximately 55 bps, from 175 bps to 230 bps. The CDS spreads of stressed countries' banks increased as well, but by less, from approximately 143 bps to 153 bps.

Italian banks' debt-weighted CDS premia were unchanged post-CA compared to their pre-CA values, at approximately 112 bps (bottom panel). This is despite the -13 percent drop in equity prices from pre-CA to the post-CA period, see Figure 2, and despite the observation that nine out of 25 failing or near-failing (the CA) banks were headquartered there. As a result, market participants did not perceive any additional default risk for Italian bank debt post-CA. Possibly, sufficient government and ESM funds were deemed available in case the necessary equity recapitalizations could not be accomplished with private sector

[13]The spike in sovereign CDS is visible on 15 October in Figure 3 because our CDS spread data is sampled business-daily in the early afternoon around 2pm.

Table 2: Sovereign CDS spreads

Sovereign CDS spreads in basis points for selected euro area and E.U. non-euro area countries, comparing Pre-CA and Post-CA time averages.

Country	**Level Pre-CA**	**Level Post-CA**	**Change (bps)**	**Change (%)**
Non-stressed				
AT	24.3	27.5	3.2	13.4%
BE	44.8	55.0	10.3	22.9%
DE	18.6	20.1	1.6	8.6%
FI	26.1	28.1	1.9	7.3%
FR	44.4	54.2	9.8	22.1%
NL	21.4	23.8	2.4	11.2%
Average	29.9	34.8	4.9	16.3%
Stressed				
ES	78.2	105.8	27.5	35.2%
GR	529.6	746.1	216.5	40.9%
IE	53.5	63.5	9.9	18.6%
IT	112.3	139.2	26.9	23.9%
PT	172.2	212.6	40.4	23.5%
Average	189.2	253.4	64.3	34.0%
Non-Euro area				
DK	23.2	24.4	1.2	5.1%
PL	68.0	64.9	-3.0	-4.5%
SE	13.4	15.1	1.6	12.0%
UK	19.1	19.4	0.3	1.7%
Average	30.9	31.0	0.0	0.1%

funds only. Mandatory bail-in rules in the euro area came into effect only in January 2016.

Finally, banking sector CDS spreads were occasionally below the sovereign CDS spread before and after the announcement of the CA results in stressed countries. This is curious, since banks may be considered highly unlikely to 'survive' a default of their own sovereign, given substantial holdings of domestic sovereign debt; see ECB (2014b), and given that holdings of domestic debt had increased significantly during the euro area sovereign debt crisis after the ECB's three-year LTROs in 2012; see Acharya and Steffen (2015). In any case, the observation that stressed countries banks' CDS spreads traded below the CDS spread of their respective sovereign suggests that it is not the stressed sovereign who served as the only 'guarantor-of-last-resort' in late 2012. This finding is robust to using unweighted

averages of CDS spreads; see the Web Appendix B.

3.5 Economic significance of the level effect

An approximate back-of-the envelope calculation helps to put the cross-border impact of bank risk on sovereign risk into perspective. The total size of public debt issued by our group of five non-stressed countries was approximately €5.4 trn (December 2014). Assuming an average duration of sovereign debt of about 5 years, approximately 1 trn of government debt is refinanced each year. A 5 bps change in CDS spread × €1 trn implies an increase in risk premium of €500 mn per year. As a result, the cross-border effect is economically significant, but also moderate in magnitude.

The increase in sovereign CDS spreads for non-stressed countries (from before to after the CA; +5 bps) is smaller than the increase for stressed countries (+64 bps; or +34%); see Table 2. This difference suggests that the fiscal backstop provided by the local sovereign was also priced, and by substantially more than the second, ultimate backstop that was provided across borders. Taxpayers throughout the euro area appear to have been affected by adverse news about bank health, to different extents.

4 Changes in sovereign-bank dependence within and across borders

This section discusses our conceptual framework, empirical strategy, and empirical results on changes in sovereign-bank risk dependence. The empirical approach proceeds in two steps. First, we study changes in sovereign-bank dependence, pairing countries with their domestic banks. This allows us to test whether within-country risk dependence changes from before to after the announcement of the CA results, and whether there are country-group differences in the time difference. Finally, we test for changes in cross-border dependence by relating the sovereign CDS spreads of non-stressed countries to changes in the market equity valuation for banks located in stressed countries, controlling for other effects.

4.1 Conceptual framework

Changes in reduced-form regression coefficients are difficult to interpret in the absence of a theory or conceptual framework. Following King and Wadhwani (1990), we imagine a setting in which two assets — stressed (s) and non-stressed (ns) — are traded with the following terminal payoff (i.e., fundamental, v) structure:

$$\begin{aligned} v^s &= \beta^s F + \epsilon^s \\ v^{ns} &= \beta^{ns} F + \epsilon^{ns} \end{aligned}$$

where $F \sim (0, \sigma_F^2)$ is a systematic factor, and $\epsilon^s, \epsilon^{ns}$ are idiosyncratic terms.[14]

In such a setting, most models of information transition (e.g., Kodres and Pritsker, 2002; Yuan, 2005; Veldkamp, 2006; Pasquariello, 2007; Pavlova and Rigobon, 2007) will yield the following equilibrium pricing (P) relationship between these two assets:

$$\begin{aligned} \Delta P^s &= b^s \Delta P^{ns} + g^s \Delta \epsilon^s \\ \Delta P^{ns} &= b^{ns} \Delta P^s + g^{ns} \Delta \epsilon^{ns}, \end{aligned}$$

where Δ denotes time (e.g., daily) differences, and the reduced-form equilibrium slope coefficients are given by

$$\begin{aligned} b^i &= b^i \left(\beta^s, \beta^{ns}, \sigma_F^2, \sigma_{\epsilon_s}^2, \sigma_{\epsilon^{ns}}^2, \text{frictions}\right), i = ns, s, \\ g^i &= g^i \left(\beta^s, \beta^{ns}, \sigma_F^2, \sigma_{\epsilon_s}^2, \sigma_{\epsilon^{ns}}^2, \text{frictions}\right), i = ns, s. \end{aligned}$$

In other words, the equilibrium relationship between price dynamics in stressed and non-stressed assets will depend on the structural relationship between their fundamentals ($\beta^s, \beta^{ns}, \sigma_F^2$), and on idiosyncratic shocks (with variances $\sigma_{\epsilon_s}^2, \sigma_{\epsilon^{ns}}^2$). Unobserved frictions to

[14] Our empirical analysis involves multiple stressed and non-stressed assets in a panel. The intuition developed here carries over to a more general case.

investors' trading activity ('frictions') may also be present. Such frictions could be due to, for example, time-varying risk aversion, changes in funding liquidity, noise trading, adverse selection, information asymmetries, and so on.

The variation in bank risk is most simply thought of as a negative shock to stressed banks ($\Delta\epsilon^s < 0$), while leaving non-stressed banks approximately unaffected ($\Delta\epsilon^{ns} \approx 0$). Again, sovereign CDS spreads are affected only through sovereigns' exposure to banks. In addition, parameters may break due to a structural change in the economy (the move to banking union); see Section 2.2. Sections 4.5 and 5 document a break in panel correlation (slope) parameters, controlling for other effects, from b^i before the CA announcement to, say, $b^{i\prime}$ thereafter. We take such breaks $b^i \to b^{i\prime}$ as indicative of increased cross-border risk dependence. I.e., changes in the health of foreign banks affect sovereign CDS spreads in non-stressed countries *more* after the CA announcement (or, less likely, vice versa). The question whether an increase in cross-border risk dependence constitutes 'contagion' or merely risk 'interdependence' is hard to answer in our context; see Forbes and Rigobon (2002), Corsetti et al. (2005), and Bekaert et al. (2014). For example, it is highly uncertain what the relevant systematic pricing factors F are in our setting. In addition, a relatively short sample of effectively two 10-day periods is not well-suited to control for common factors via advanced econometric techniques. We include one significant and observed (market) factor in a subset of panel specifications below; see Section 4.5.

Finally, the disclosure of the CA results may have changed the relevance of hard-to-measure financial frictions (first and foremost, informational asymmetries), and may have impacted risk dependence in this way. We conjecture that this mechanism is unlikely to account for all the documented increase in our setting. First, our panel specifications, introduced below, include time fixed effects. Such time fixed effects mitigate the impact of changes in unobserved frictions to the extent that their impact is common across assets; see Atanasov and Black (2015). Second, it is not straightforward to square an *increase* in asset price co-movement with a *decrease* in informational asymmetry, as implied by the CA

announcement; see e.g. Veldkamp (2006) and Pavlova and Rigobon (2007). Finally, we suggest that such effects could be conceptualized as knock-on, additional effects from the CA announcement.

4.2 Empirical strategy I: risk dependence within countries

To start, we consider a country-group difference panel regression

$$\begin{aligned} \Delta\texttt{cds}^{s}_{j(i),t} &= \alpha_0 + \alpha_1 \cdot \texttt{S}_j \cdot \Delta\texttt{cds}^{b}_{i,t} + \alpha_2 \cdot \Delta\texttt{cds}^{b}_{i,t} \\ &+ \alpha_3 \cdot \texttt{S}_j + \gamma_t + \delta_i + \varepsilon_{i,t}, \end{aligned} \tag{1}$$

where $\Delta\texttt{cds}^{s}_{j(i),t}$ is the daily log-change in CDS spread for sovereign $j(i)$ in which bank i is located, $\Delta\texttt{cds}^{b}_{i,t}$ is the daily log-change in CDS spread for bank i at time t, and $\texttt{S}_j$ is a dummy variable that takes the value of one for stressed countries and zero for non-stressed countries. Bank fixed effects δ_i eliminate the influence of unobserved bank- (or contract-)specific characteristics (such as differences in CDS market liquidity) on sovereign-bank risk dependence. Time fixed effects γ_t control for unobserved changes that are common to all sovereign CDS, possibly including some hard-to-measure financial frictions related to e.g. changes in CDS market liquidity; see Section 4.1. Coefficient α_1 is expected to be negative if the bank-sovereign nexus is weaker in stressed countries. Coefficient α_2 is expected to be positive if the perception of additional bank risk raises sovereign risk (or the other way around). As a first step, we estimate the parameters in Equation (1) for all three periods separately by fixed effects regression.

The panel regression (1) contains repeated CDS spread values on the left-hand side if multiple banks i are located in country $j(i)$. Repeated left-hand side values allow us to control for bank-specific fixed effects δ_i, and ensure sufficient cross-sectional variation ($N = 48$; see Table 1). Repeated left-hand-side values may, however, affect inference because of cross-sectional dependence in the error terms $\varepsilon_{i,t}$ at the country level. We take this issue into

account when constructing standard errors. In practice, different econometric approaches lead to approximately similar results.[15]

Second, we consider a difference-in-differences specification. This specification allows us to study country-group differences in sovereign-bank risk dependence before and after the ECB's announcement of the CA results. We consider

$$\begin{aligned}\Delta \mathtt{cds}^{s}_{j(i),t} &= \alpha_0 + \alpha_1 \cdot \mathtt{S}_j \cdot \mathtt{P}_t \cdot \Delta \mathtt{cds}^{b}_{i,t} + \alpha_2 \cdot \mathtt{S}_j \cdot \Delta \mathtt{cds}^{b}_{i,t} \\ &+ \alpha_3 \cdot \mathtt{P}_t \cdot \Delta \mathtt{cds}^{b}_{i,t} + \alpha_4 \cdot \mathtt{S}_j \cdot \mathtt{P}_t \\ &+ \alpha_5 \cdot \Delta \mathtt{cds}^{b}_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t}, \end{aligned} \tag{2}$$

where $\Delta \mathtt{cds}^{s}_{j(i),t}$, $\Delta \mathtt{cds}^{b}_{i,t}$, and $\mathtt{S}_j$ remain as explained below Equation (1). The additional dummy variable $\mathtt{P}_t$ distinguishes the Pre-CA, Soft Info, and Post-CA periods. As in Equation (1), daily time fixed effects γ_t absorb the influence of common macroeconomic and financial factors, and bank fixed effects δ_i eliminate the impact of unobserved bank heterogeneity. Two coefficients of interest are α_1 and α_3. If sovereign-bank risk dependence in stressed countries (the 'experimental group') changes by less than in non-stressed countries (the 'control group'), then α_1 is expected to be negative. If, in addition, the completion of the CA increases sovereign-bank dependence in non-stressed countries, α_3 is positive.

[15] We experimented with three approaches to inference in our panel data setting. Each has advantages and disadvantages. First, we clustered error terms at the country level, and bootstrapped the standard errors to mitigate the drawback from having a small number of country clusters (ten). This approach may not work well if between-cluster error terms are dependent. This is not unlikely to be the case for our sample of countries that share the same monetary policy and exchange rate. Second, we employed a non-parametric bootstrap. Here, residuals are drawn from the cross-section without country or group clusters. This approach is appropriate provided the cross-sectional dependence is approximately similar across the N different country-bank pairs. Finally, we computed Driscoll and Kraay (1998) standard errors. These standard errors are robust to arbitrary cross-sectional and time series dependence. They are valid, however, only asymptotically as both N, and T, go to infinity. In addition, Driscoll and Kraay standard errors are inconsistent when daily time fixed effects are included. In practice, these three approaches to inference yield approximately similar results. Each approach is substantially more conservative than standard OLS standard errors that assume cross-sectionally independent error terms. We report t-statistics based on non-parametrically bootstrapped standard errors (the second approach) in the remainder of the paper.

4.3 Empirical strategy II: risk dependence across countries

This section relates the sovereign risk of non-stressed countries to the equity returns of foreign banks, controlling for domestic banks' risks and other effects. We use equity returns as a measure of bank risk because any required equity recapitalization following a failed stress test will dilute the failing bank's current equity holders. We consider a time-difference panel regression

$$\begin{aligned} \Delta \mathtt{cds}^{s,ns}_{j(i),t} &= \alpha_0 + \alpha_1 \cdot \mathtt{P}_t \cdot \Delta \overline{\mathtt{eq}}^{b,st}_t + \alpha_2 \cdot \Delta \overline{\mathtt{eq}}^{b,st}_t \\ &+ \alpha_3 \cdot \Delta \mathtt{cds}^{b,ns}_{i,t} + \kappa' f_{t-1} + \delta_i + \gamma_t + \varepsilon_{i,t}, \end{aligned} \tag{3}$$

where $\Delta \mathtt{cds}^{s,ns}_{j(i),t}$ are daily log-changes in the CDS spread of a non-stressed (ns) sovereign (s) $j(i)$ at time t, $\Delta \mathtt{cds}^{b,ns}_{i,t}$ are log-changes in the CDS spread of bank i located in a non-stressed country $j(i)$, $\Delta \overline{\mathtt{eq}}^{b,st}_t$ is the log-change of a simple average of banks' (in stressed countries) equity prices, $\kappa' f_{t-1}$ allows for a common (market) factor, and γ_t are weekly time fixed effects. Changes in foreign banks' credit risk are measured by their equity returns, as bank equity holders (not debt holders) are diluted by a required equity recapitalization following the CA. We use weekly time fixed effects since daily effects would absorb $\Delta \overline{\mathtt{eq}}^{b,st}_t$ due to multicollinearity. Parameter α_1 allows us to test whether cross-border risk dependence increases following the announcement of the CA results. Parameter α_2 captures pre-CA risk dependence between sovereigns and banks across borders, controlling for domestic banks' credit risks.

As a final specification, we include both average equity and average CDS spreads of banks in stressed countries on the right-hand side. The panel data model becomes

$$\begin{aligned} \Delta \mathtt{cds}^{s,ns}_{j(i),t} &= \alpha_0 + \alpha_1 \cdot \mathtt{P}_t \cdot \Delta \overline{\mathtt{eq}}^{b,st}_t + \alpha_2 \cdot \Delta \overline{\mathtt{eq}}^{b,st}_t \\ &+ \alpha_3 \cdot \mathtt{P}_t \cdot \Delta \overline{\mathtt{cds}}^{b,st}_t + \alpha_4 \cdot \Delta \overline{\mathtt{cds}}^{b,st}_t \\ &+ \alpha_5 \cdot \Delta \mathtt{cds}^{b,ns}_{i,t} + \kappa' f_{t-1} + \delta_i + \gamma_t + \varepsilon_{i,t}, \end{aligned} \tag{4}$$

where covariates remain as defined below Equation (3), and $\overline{\texttt{cds}}_t^{b,st}$ is an unweighted average of CDS spreads for banks in stressed countries. We expect α_1 and α_2 to remain approximately unchanged, and the estimates of α_3 and α_4 to be small.

4.4 Changes in within-country risk dependence

This section discusses our difference estimates of within-country risk dependence. Table 3 reports the regression estimates for specifications (1) and (2). We first consider country-group differences within each 10-day period in isolation (Pre-CA, Soft Info, and Post-CA; columns 1–6). We then study time differences in the country-group differences (columns 7–8). The R-squared statistics increase substantially when time and bank fixed effects are included in (1) and (2). We focus on these specifications when interpreting the parameter estimates.

Table 3 suggests that there is no significant dependence between the CDS spreads of sovereigns and banks in stressed countries. The sovereign-bank risk dependence coefficient for stressed countries is given by the sum of α_1 and α_2; see Equation (1). This sum is economically small and statistically insignificant in all three periods; see columns 2, 4, and 6. For example, risk dependence in stressed countries is -0.101 + 0.168 = 0.067 and is not significant in the Pre-CA period (column 2). Risk dependence does not become significant following the announcement of the CA results, despite stressed countries' exposure to considerable AQR losses and adverse stress test results. Instead, risk correlations increased in non-stressed countries (+0.39; 3rd row in column 8). Taken together with the evidence presented in Section 3, our within-country estimates are strongly suggestive of cross-border effects; see Sections 4.5 and 5.

Table 3: Changes in within-country risk dependence

Results from cross-sectional difference regressions (1) and difference-in-differences regressions (2). Columns 1–2, 3–4, and 5–6 include only observations from the Pre-CA, Soft Info, and Post-CA periods. Columns 7 and 8 report difference-in-differences estimates. Soft Info FE and Post-CA FE are dummy variables that take the value one in the respective period, and zero in the Pre-CA period. Standard errors are bootstrapped. Each column indicates whether the regression contains time (Time FE) and firm (Firm FE) fixed effects.

Dep. Var.: $\Delta\texttt{cds}^s_{j(i),t}$	(1) Pre-CA	(2) Pre-CA	(3) Soft Info	(4) Soft Info	(5) Post-CA	(6) Post-CA	(7) Diff-Diff (4)-(2)	(8) Diff-Diff (6)-(2)
$\texttt{S}_j \cdot \texttt{P}_t \cdot \Delta\texttt{cds}^b_{i,t}$							0.129	-0.451***
							(0.148)	(0.124)
$\texttt{S}_j \cdot \Delta\texttt{cds}^b_{i,t}$	0.161**	0.168**	0.276**	0.292**	-0.298***	-0.290**	0.157**	0.163**
	(0.081)	(0.074)	(0.126)	(0.146)	(0.095)	(0.118)	(0.075)	(0.071)
$\texttt{P}_t \cdot \Delta\texttt{cds}^b_{i,t}$							-0.109	0.389***
							(0.123)	(0.125)
$\texttt{P}_t \cdot \texttt{S}_j$							0.000	-0.002
							(0.005)	(0.004)
$\Delta\texttt{cds}^b_{i,t}$	-0.093	-0.101	-0.185*	-0.211*	0.298***	0.289**	-0.088	-0.097
	(0.073)	(0.071)	(0.095)	(0.123)	(0.095)	(0.122)	(0.071)	(0.069)
$\texttt{S}_j$	0.005*		0.005		0.003			
	(0.003)		(0.005)		(0.003)			
Observations	480	480	480	480	480	480	960	960
R-squared	0.2515	0.2732	0.4253	0.4381	0.5326	0.5489	0.4095	0.4487
-	-	-	-	-	-	-	-	-
Bank FE	NO	YES	NO	YES	NO	YES	YES	YES
daily Time FE	YES	YES	YES	YES	YES	YES	YES	YES
-	-	-	-	-	-	-	-	-
Bootstrapped SE	YES	YES	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The low correlation between the CDS spreads of sovereigns and banks in stressed countries after the CA is in line with results by Fratzscher and Rieth (p. 15; 2015). Based on a different identification approach, and data between 2006 – 2013, the authors conclude that "... for Ireland, Greece, and Portugal there seems to be a second mechanism that breaks this ... [rule]. All three sovereigns were bailed out. This broke the link between domestic banks and sovereigns as bank credit risks on the balance sheets of these sovereigns was (partially) forwarded to other sovereigns."

The absence of within-country sovereign-bank risk dependence is similarly apparent for Italian sovereign-bank pairs in isolation; see the Web Appendix C. Italian banks were somewhat more affected by the release of information on 26 October 2014; see Figure 2.

4.5 Changes in cross-border risk dependence

This section discusses our difference estimates of cross-country risk dependence. Table 4 reports our regression results for panel data specifications (3) and (4). Columns 1–3 and 4–6 refer to observations from the Pre-CA and Post-CA periods, respectively. The middle period is omitted for space considerations. Columns 7 and 8 refer to time difference estimates.

We focus on three results. First, sovereign-bank risk dependence across borders is statistically and economically significant. Specifications (3) and (4) control for risk transmission to the domestic banking sector by including domestic banks' CDS spreads. As a result, it is unlikely that sovereign risks increase because of domestic banks having foreign branches which are negatively affected.[16] Lagged log-changes in the Euro Stoxx non-bank equity index are included as an additional control in a subset of specifications. The non-bank equity index is lagged one day to mitigate its correlation with $\overline{\mathtt{eq}}_t^{b,st}$ in our finite sample with $T = 10$ or 20. Cross-country effects help rationalize the finding that sovereign-bank risk dependence

[16]Conversely, sovereign risk in non-stressed countries could still be impacted by changes in the credit risk of branches of stressed countries' banks located in non-stressed countries. We expect this channel to be of second-order importance.

becomes more pronounced within a group of countries for which no additional banking sector risks were uncovered by the CA. The loading on foreign banks' equity returns is insignificant before the CA, and becomes significantly negative Post-CA (columns 4–6). Similarly, the coefficient on domestic banks' CDS spreads is insignificant before the CA and becomes positive afterwards.

Second, the difference estimates confirm a change in risk dependence across borders from before to after the announcement of the CA results. Pre-CA, the loading on foreign equity is statistically insignificant (+0.16; column 7). Post-CA, the cross-country elasticity decreases by -0.74 percentage points, to approximately -0.56 (the estimate in column 6). As a result, the respective loading on foreign banks' equity returns becomes strongly statistically significant.

Finally, the time differences in risk dependence across countries are more sensitive to banks' (in stressed countries) equity returns than to changes in their CDS spread; see column 8. This is intuitive, as a bank equity recapitalization after a stress test dilutes current equity holders. By contrast, bank creditors are less affected and may even benefit, as bank debt becomes safer owing to a larger equity cushion. The cross-country difference estimate is robust to including the CDS spreads of banks in stressed countries as an additional risk covariate. The difference estimate now takes the value of -0.66, which is approximately similar to (and not statistically different from) the estimate of -0.74 in column 7.

Table 4: Changes in cross-country risk dependence

We regress $\Delta \texttt{cds}^{s,ns}_{j(i),t}$, the log-changes in the sovereign CDS spreads for country $j(i)$ in which bank i is located, on $\Delta \overline{\texttt{eq}}^{b,st}_{t}$, the log-changes in the average bank equity price of banks in stressed countries, $\Delta \overline{\texttt{cds}}^{b,st}_{t}$, the average CDS spread of banks located in stressed countries, controlling for $\Delta \texttt{cds}^{b,ns}_{i,t}$, the log-change in bank CDS spreads of bank i located in a non-stressed country, and non-bank equity index returns $\Delta \ln(\text{Euro Stoxx non-bank})_{t-1}$. Columns 1–3 and 4–6 refer to observations from the Pre-CA and Post-CA periods. Columns 7 and 8 report difference estimates comparing the Pre-CA to the Post-CA period. Each column indicates whether the regression contains weekly time (Time FE) and bank (Bank FE) fixed effects.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.: $\Delta \texttt{cds}^{s,ns}_{j(i),t}$	Pre-CA	Pre-CA	Pre-CA	Post-CA	Post-CA	Post-CA	Diff-Diff (5)-(2)	Diff-Diff (6)-(3)
$\texttt{P}_t \cdot \Delta \overline{\texttt{eq}}^{b,st}_{t}$							-0.743***	-0.655***
							(0.229)	(0.249)
$\texttt{P}_t \cdot \Delta \overline{\texttt{cds}}^{b,st}_{t}$								0.048
								(0.225)
$\Delta \overline{\texttt{eq}}^{b,st}_{t}$	-0.027	-0.027	-0.032	-0.582***	-0.580***	-0.556***	0.161	0.148
	(0.146)	(0.149)	(0.207)	(0.142)	(0.161)	(0.196)	(0.209)	(0.178)
$\Delta \overline{\texttt{cds}}^{b,st}_{t}$			-0.098			0.068		0.195
			(0.175)			(0.226)		(0.162)
$\Delta \texttt{cds}^{b,ns}_{i,t}$	0.063	0.062	0.060	0.497***	0.508***	0.497***	0.320***	0.295***
	(0.069)	(0.083)	(0.080)	(0.139)	(0.134)	(0.182)	(0.091)	(0.077)
$\Delta \ln(\text{Euro Stoxx non-bank})_{t-1}$	-0.742***	-0.742***	-0.616*	-1.546***	-1.543***	-1.531***	-1.200***	-1.298***
	(0.211)	(0.221)	(0.326)	(0.301)	(0.299)	(0.345)	(0.198)	(0.215)
Observations	260	260	260	260	260	260	520	520
R-squared	0.1614	0.1955	0.1966	0.2198	0.2366	0.2368	0.1830	0.1878
-	-	-	-	-	-	-	-	-
Bank FE	NO	YES	YES	NO	YES	YES	YES	YES
Weekly Time FE	YES	YES	YES	YES	YES	YES	YES	YES
-	-	-	-	-	-	-	-	-
Bootstrapped SE	YES	YES	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5 Robustness: Evidence from a time-varying parameter model

This section presents a time-varying parameter model that allows us to draw inference on the time-variation in risk dependence parameters directly. We find that our cross-border findings are robust to plausible variations in the econometric approach, and to the use of weekly data outside of the 30 business-day period studied so far.

We consider the panel regression model with time-varying parameters,

$$\Delta \texttt{cds}^{s,ns}_{j(i),t} = \alpha_{1,t} \cdot \Delta \texttt{cds}^{b,ns}_{i,t} + \alpha_{2,t} \cdot \Delta \overline{\texttt{eq}}^{b,st}_{t} + \delta_i + \gamma_t + \epsilon_{i,t}, \tag{5}$$

where $\Delta \texttt{cds}^{s,ns}_{j(s),t}$ denotes the weekly difference in the log CDS spread of non-stressed (ns) sovereigns (s), $\Delta \texttt{cds}^{b,ns}_{i,t}$ is the weekly difference in the log CDS spread of bank i located in a non-stressed country $j(i)$, $\Delta \overline{\texttt{eq}}^{b,st}_{t}$ is a weekly equity return associated with banks located in stressed countries, δ_i is a bank fixed effect, $\gamma_t \sim \text{NID}(0, \sigma^2_\gamma)$ is a serially uncorrelated time effect, and $\epsilon_{i,t}$ is an idiosyncratic error term. We are most interested in estimating the time-varying cross-country effect $\alpha_{2,t}$ controlling for domestic banks' risks via $\alpha_{1,t}$.

To accommodate an extended T-dimension, we allow for time-variation in the measurement error variances in Equation (5), according to

$$\epsilon_t = (\epsilon_{j(1),t}, \ldots, \epsilon_{j(N),t}) \sim \text{NID}\left(0, H_t\right), \tag{6}$$

where the covariance matrix is specified as $H_t = \text{diag}\left(h_{j(1),t}, \ldots, h_{j(N),t}\right)$, $h_{j(i),t} = \sigma^2_\epsilon \cdot \text{CDS}^{s,ns}_{j(i),t-1} \geq 0$, σ^2_ϵ is a single parameter to be estimated, and $\text{CDS}^{s,ns}_{j(i),t-1}$ is the lagged CDS spread of the non-stressed sovereign $j(i)$ in which bank i is located. As a result, all measurement error variances are serially correlated and are higher during more stressful times; see Feldhütter and Lando (2008), Krishnamurthy et al. (2014), and Eser and Schwaab (2016) for related specifications. While somewhat restrictive, (6) is parsimonious and sufficiently flexible to allow us to test the key economic hypotheses at hand.

The time-varying parameters $\alpha_{1,t}$ and $\alpha_{2,t}$ capture the elasticities of (log-changes in) non-stressed sovereigns' CDS spreads with respect to (log-changes in) the risk of domestic and foreign banks, respectively. The parameters evolve over time as

$$\alpha_t = (\alpha_{1,t}, \alpha_{2,t})' = \alpha_{t-1} + \eta_t; \qquad \eta_t \sim \text{NID}\,(0, Q)\,, \tag{7}$$

where η_t is a two-dimensional error term, and Q a positive definite covariance matrix. Non-zero off-diagonal elements in Q allow the two time-varying parameters to be correlated. Coefficients α_t are initialized as uninformative $\alpha_1 \sim \text{N}(0, \upsilon I)$, with $\upsilon \to \infty$; see Durbin and Koopman (2012, Chapter 5).

Model (5)–(7), together with its initial condition, is a standard linear Gaussian model in state space form. The log-likelihood is easily obtained from a single run of the Kalman Filter; see Durbin and Koopman (2012). Filtered estimates of the time-varying parameters and their standard errors are also provided by the Kalman Filter.

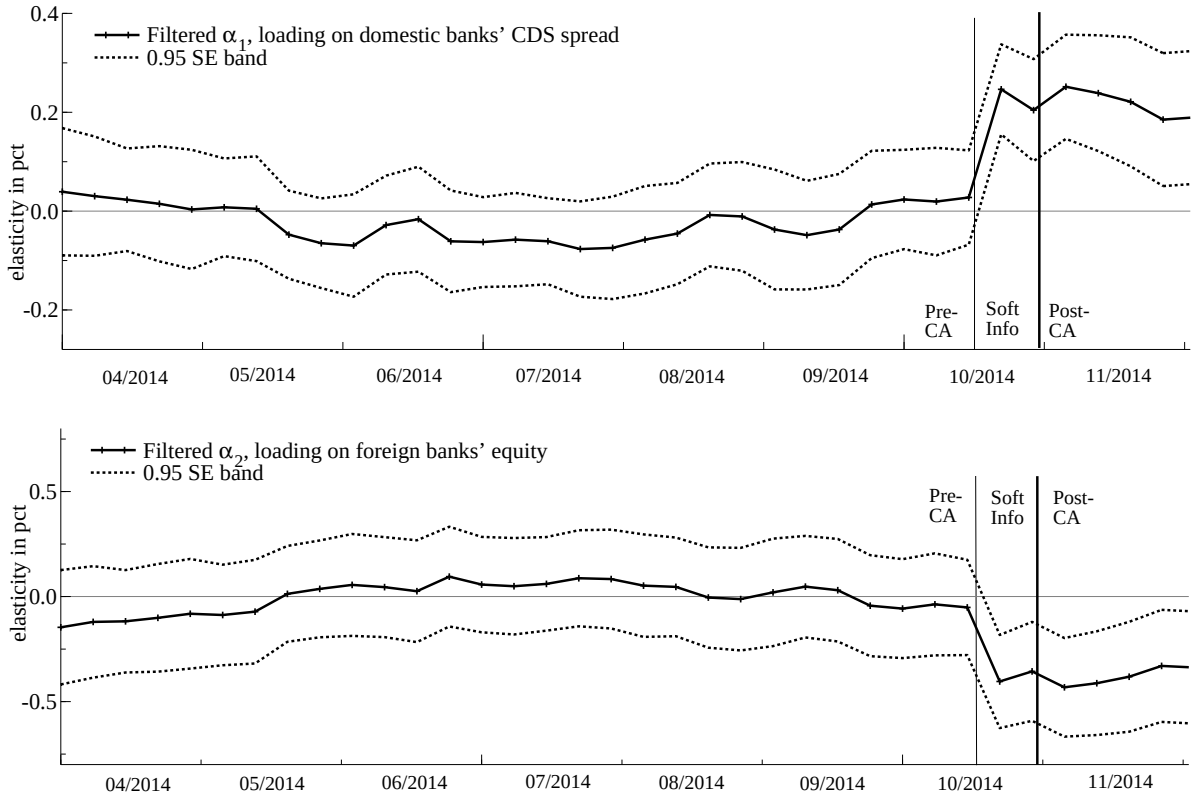
Figure 4 plots the conditional mean estimates of time-varying parameters $\alpha_{1,t}$ and $\alpha_{2,t}$ in Equation (5). Parameters are reported at a weekly frequency from 1 April to 30 November 2014.

We focus on three findings from this medium-term study. First, the time variation in both risk elasticity parameters is initially small. Both risk parameters are not statistically different from zero for most weeks in 2014. As a result, our ten-day Pre-CA period appears to be approximately representative of the weeks and months leading up to the ECB's CA. Put differently, our Pre-CA regression estimates approximately reflect a broader baseline dependence relationship.

Second, both risk sensitivity parameters change significantly in the Soft Info period, and stay approximately unchanged in the five weeks thereafter. The cross-border elasticity α_2 decreases to approximately -0.51 during the Post-CA period. This estimate is similar to the -0.56 value reported in column 6 of Table 4. The former is based on numerically maximizing

Figure 4: Time-varying parameter estimates

Filtered estimates of time-varying parameters $\alpha_{1,t}$ and $\alpha_{2,t}$ for the panel specification given in Equation (5). Static parameters are estimated based on weekly panel data from 01 January 2009 to 30 November 2014. Standard error bands are reported at a 95% confidence level. Coefficient estimates are at a weekly (Friday-on-Friday) frequency and are reported between 1 April 2014 and 30 November 2014. Vertical lines mark the Monday boundaries of the Pre-CA, Soft Info, and Post-CA periods.



a likelihood function, while the latter is implied by moment conditions.

Finally, the loading on domestic banks' CDS spreads becomes significantly positive, and increases to approximately 0.20. Again, this is in line with the regression coefficient of approximately 0.32 in column 7 of Table 4. We conclude that the time differences reported in Section 4.5 are robust to adopting a different econometric approach (time-varying parameter model instead of moments-based estimation), data frequency (weekly instead of daily), as well as to variations in the length of the data sample.

6 Concluding discussion

We documented a transmission of credit risk from the banking sector to multiple sovereigns in the euro area. The disclosure of additional banking sector risks implied by the ECB's announcement of its CA results for 130 significant euro area banks led to increasing sovereign CDS spreads for all euro area countries. Strikingly, sovereign CDS spreads increased also for non-stressed countries, despite the fact that their domestic banks received a relatively clean bill of health, and their banks' net risks remained approximately unchanged. Cross-border risk dependence became more pronounced following the completion of the ECB's CA. Both findings point to a significant degree or risk sharing across borders.

Our findings may have policy implications. Shortly after the results of the CA were released, Mario Draghi, the ECB President, observed that "... when a [banking sector] shock hits ..., we need other ways [than exchange rate adjustments] to help spread those costs. In a monetary union like ours, there is a particular onus on private risk-sharing to play this role. Indeed, the less public-sector risk sharing we want, the more private sector risk sharing we need." (Draghi, 2014).

A publicly-funded backstop to banking sector risk across borders is problematic owing to its effects on risk-taking incentives (moral hazard), and taxpayer involvement. In this regard we recall the assessment of Geeroms and Karbownik (2014) who advised "to stop the, much

debated, direct recap [by the ESM], whereby the ESM can invest directly in problem banks ... when all other channels of support for a bank have been exhausted. This direct bank recap ... runs counter to the principle that the taxpayer should not pay for losses of banks."

Having the right kind of risk sharing mechanisms in place is an issue of crucial importance, particularly given the progressing financial integration among euro area countries in an evolving Banking Union and a forthcoming Capital Markets Union. We conjecture that endowing the relevant European authorities with a sizable bank recapitalization and resolution fund, funded by risk-sensitive contributions from banks, would support a shift in risk dependence away from the public sector to the private sector (i.e., other banks).[17] According to current plans, the common European bank resolution fund is scheduled to achieve a modest size of approximately €55 billion only in 2022, eight years after its inception in 2014. Public sector risk sharing could be further minimized if the (privately-funded) bank resolution fund could take over the conditional equity recapitalization function from the (publicly-funded) ESM. In addition, the size and leverage capabilities of the former fund could be made similar to the ESM.

References

Acharya, V. and S. Steffen (2014). Falling short of expectations? Stress-testing the European banking system. *CEPS discussion paper*, 1–25.

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

Acharya, V. V., I. Drechsler, and P. Schnabl (2014). A pyrrhic victory? Bank bailouts and sovereign credit risk. *The Journal of Finance 69*(6), 2689–2739.

Atanasov, V. and B. Black (2015). Shock-based causal inference in corporate finance and accounting research. *Critical Finance Review 5*(1), 1138.

[17] Mandatory bail-in rules came into effect for European banks in January 2016. These rules should contribute to limiting taxpayer involvement, provided they are uniformly applied.

Augustin, P., M. G. Subrahmanyam, D. Y. Tang, and S. Q. Wang (2014). Credit default swaps: A survey. *Foundations and Trends in Finance 9*(1-2), 1196.

Bekaert, G., M. Ehrmann, M. Fratzscher, and A. Mehl (2014). The global crisis and equity market contagion. *Journal of Finance 69*(6), 2597–2649.

Beltratti, A. and R. Stulz (2015). Bank sovereign bond holdings, sovereign shock spillovers, and moral hazard during the European crisis. *Unpublished working paper*.

Benzoni, L., P. Collin-Dufresne, R. S. Goldstein, and J. Helwege (2016). Modeling credit contagion via the updating of fragile beliefs: An investigation of the European sovereign crisis. *The Review of Financial Studies, forthcoming*.

Bloomberg (2014). ECBs dark room crunches bank-test data as D-Day rattles nerves. *Bloomberg News, 14 Oct 2014, by Jeff Black and Sonia Sirletti*.

Constâncio, V. (2014). The role of the Banking Union in achieving financial stability. *Keynote lecture at the FT Banking Summit "Ensuring Future Growth", London, 26 November 2014*.

Cooper, R. and K. Nikolov (2014). Government debt and banking fragility: The spreading of strategic uncertainty. *Unpublished working paper*.

Corsetti, G., M. Pericoli, and M. Sbracia (2005). Some contagion, some interdependence: More pitfalls in tests of financial contagion. *Journal of International Money and Finance 24*(8), 11771199.

Draghi, M. (2014). Stability and Prosperity in Monetary Union. *Speech at the University of Helsinki, 27 November 2014*.

Durbin, J. and S. J. Koopman (2012). *Time series analysis by state space methods, 2nd edition*. Oxford: Oxford University Press.

EC (2012). A roadmap towards a Banking Union. *Communication from the Commission to the European Parliament and the Council, Brussels, 12 September 2012.*.

ECB (2014a). Aggregate report on the Comprehensive Assessment. *available at https://www.ecb.europa.eu/pub/pdf/other/aggregatereportonthecomprehensiveassessment201410.en.pdf*.

ECB (2014b). The determinants of euro area sovereign bond yield spreads during the crisis. ECB Monthly Bulletin article, May 2014.

Eser, F. and B. Schwaab (2016). Evaluating the impact of unconventional monetary policy measures: Empirical evidence from the ECB's Securities Markets Programme. *Journal of Financial Economics 119*(1), 147167.

Farhi, E. and J. Tirole (2014). Deadly embrace: Sovereign and financial balance sheets doom loops. *Harvard University unpublished working paper*.

Feldhütter, P. and D. Lando (2008). Decomposing swap spreads. *Journal of Financial Economics 88*(2), 375–405.

Forbes, K. J. and R. Rigobon (2002). No contagion, only interdependence: Measuring stock market comovements. *Journal of Finance 57*(5), 2223–2261.

Fratzscher, M. and M. Rieth (2015). Monetary policy, bank bailouts and the sovereign-bank risk nexus in the euro area. DIW Discussion Paper 1448.

Geeroms, H. and P. Karbownik (2014). Financial firm bankruptcy and contagion. *Bruges European Economic Policy Briefings 33*, 1–30.

Goldstein, I. and Y. Leitner (2016). Stress tests and information disclosure. *FRB of Philadelphia Working Paper No. 15-10/R*.

Helwege, J. and G. Zhang (2016). Financial firm bankruptcy and contagion. *Review of Finance 20*(4), 1321–1362.

Jorion, P. and G. Zhang (2009). Credit contagion from counterparty credit risk. *Journal of Finance 64*(5), 2053–2087.

Kallestrup, R., D. Lando, and A. Murgoci (2016). Financial sector linkages and the dynamics of bank and sovereign credit spreads. *Journal of Empirical Finance, forthcoming*.

King, M. A. and S. Wadhwani (1990). Transmission of volatility between stock markets. *Review of Financial Studies 3*(1), 533.

Kirschenmann, K., J. Korte, and S. Steffen (2016). The zero risk fallacy - Banks' sovereign exposure and sovereign risk spillovers. *University of Mannheim unpublished working paper*.

Krishnamurthy, A., S. Nagel, and A. Vissing-Jorgensen (2014). ECB policies involving government bond purchases: Impact and channels. *Unpublished working paper*.

Leonello, A. (2015). Government guarantees and the two-way feedback between banking and sovereign debt crises. Unpublished working paper.

Lucas, A., B. Schwaab, and X. Zhang (2014). Conditional euro area sovereign default risk. *Journal of Business and Economics Statistics 32*(2), 271–284.

Pasquariello, P. (2007). Imperfect competition, information heterogeneity, and financial contagion. *The Review of Financial Studies 20*(2), 391424.

Pavlova, A. and R. Rigobon (2007). Asset prices and exchange rates. *Review of Financial Studies 20*(4), 1139–1181.

Petrella, G. and A. Resti (2013). Supervisors as information producers: Do stress tests reduce bank opaqueness? *Journal of Banking and Finance 37*(12), 5406 – 5420.

Pritsker, M. and L. E. Kodres (2002). A rational expectations model of financial contagion. *The Journal of Finance 57*(2), 769–799.

Sahin, C. and J. de Haan (2016). Market reactions to the ECB's Comprehensive Assessment. *Economics Letters 140*, 1 – 5.

Veldkamp, L. (2006). Information Markets and the Comovement of Asset Prices. *Review of Economic Studies 73*, 823–845.

Yuan, K. (2005). Asymmetric price movements and borrowing constraints: A rational expectations equilibrium model of crises, contagion, and confusion. *The Journal of Finance 60*(1), 379–411.