European Stress Tests and Banks' Risk-taking

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Abstract

I investigate how the 2011 and 2014 EU stress tests affect the risk-taking of European banks. I document a non-monotonic relationship between banks' risk-shifting resulting from regulatory arbitrage and the tightness of their capital constraint (i.e., the distance between their ex-ante capital ratio and the regulatory level): banks with capital ratios marginally above the regulatory level do more regulatory arbitrage than banks with a level of capital ratio significantly below or above the regulatory level. I also study the indirect effect of the tests on the financing costs of banks which are excluded from the tests: their financing costs on the corporate bond market increase with the level of negative information released in the country in which they are located.

JEL-Codes: G21, G18, E58

Keywords: Bank, stress test, risk-shifting, regulatory arbitrage, sovereign bonds, corporate bonds

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1 Introduction

In this paper, I conduct an empirical analysis of the changes in banks' risk-taking due to stress tests which act as tighter regulatory constraints. After the financial crisis in 2008, both US and European authorities conducted a series of stress tests to limit the risk-taking of banks and to strengthen their capital structures. However, the regulator's objective of limiting risk-taking may not be aligned with the bank's private interests, which may then lead to regulatory arbitrage: if banks face tighter constraints on their investments, they may wish to strategically take more risks which deviates from the regulator's aim. Therefore, understanding the impact of potential new constraints on banks' risk-taking is critical for both regulators and policymakers.

The European market suffered a sovereign debt crisis during 2010-2011, resulting in sustained negative effects on the real economy. In 2013, the GDP of all 17 Eurozone countries fell by 0.5% and the Eurozone was mired in recession.[1] The Eurozone sovereign debt crisis[2] highlighted the nexus between governments and banks with potential adverse consequences in the supply of credit to the real economy. Therefore, the European Banking Authority (EBA[3]) was mandated to conduct EU-wide stress tests in a bottom-up fashion, using consistent methodologies, scenarios and key assumptions developed in cooperation with the European Systemic Risk Board (ESRB), the European Central Bank (ECB) and the European Commission (EC).

In the 2011 stress test, regulators start to incorporate EU sovereign risk into the banks' risk measures, using two test scenarios: a baseline scenario and an adverse scenario. In the adverse scenario,[4] most of the sovereign bonds are downgraded below their current credit rating levels as *hypothetical shocks* in order to increase banks' risk exposure: AAA sovereigns (no downgrade), AA and A (two notch downgrades), BBB or below (four notch

[1]See Acharya and Steffen (2014).

[2]See Altavilla, Pagano, and Simonelli (2017).

[3]In this paper, I use EBA to represent the banking union (EBA, ESRB, EC, and ECB).

[4]See the Methodological Note - Additional guidance of 2011 stress test (Page 5-6) and more in Appendix 3 C.1.

downgrades). In the 2014 test,[5] the measure[6] of sovereign risk is also linked to their credit ratings.

Since the EBA includes the EU sovereign risk in the measure of banks' risk exposure and requests banks to recapitalize, the stress tests act as tighter regulations imposed on banks' investments. In this paper, I develop a model along the lines of Glasserman and Kang (2014) to understand the potential effect of the stress tests on banks' risk-taking. The model predicts that banks which are marginally regulatory constrained (i.e., closer to the binding regulatory constraint) do more regulatory arbitrage than unconstrained banks (safe banks, i.e., far above the binding constraint) and fragile banks (i.e., below the binding constraint) after the tests.

Using the EBA database, I test the model's predictions with a difference-in-difference approach. After the announcement of the test, if banks are able to raise capital before submitting their test reports to the central banks, then this recapitalization is included into the final CET 1 (Common Equity Tier 1) ratio, which is called the adjusted CET 1 ratio. In the 2011 test,[7] banks fail the test if their adjusted CET 1 ratio under adverse scenario is lower than 5%; banks are said by the EBA to "marginally pass the test" if they have an adjusted CET 1 ratio of 5%-6%; and banks successfully pass the test if their adjusted CET 1 ratios are larger than 6%.

In the literature, Boyson, Fahlenbrach, and Stulz (2016), Efing (2016), Becker and Ivashina (2015), and Ellul et al. (2011) use the capital ratios to define two groups: regulatory constrained firms and unconstrained firms. Instead, I divide tested banks into three groups according to their CET 1 ratios without including the recapitalization conducted after the announcement of the tests. An additional group of "marginal banks" (i.e., banks

[5]See the Methodological Note EU-wide stress test 2014, page 15 and more in Appendix 3 C.2.

[6]The sovereign risk is incorporated into the Risk Weighted Assets directly through the parameter of the model. Probability of Default (PD) and Loss Given Default (LGD) were calculated for five portfolios (financial institutions, sovereign, corporate, consumer credit retail, and retail real estate) by using regression model elasticities linked to the macro variables, national supervisory inputs, the ECB Monetary and Financial Institutions database, and the LGD database at Moody's.

[7]The criteria of the 2014 test can be found in Section 3. In the 2014 test, the criteria to pass the test is based on the unadjusted CET 1 ratios

that are marginally regulatory constrained according to the EBA) is very important in order to test for a non-monotonic relationship between banks' regulatory arbitrage and the tightness of their capital constraint. Banks are supervised differently by local central banks after the release of test results based on whether banks successfully pass the test, marginally pass the test or fail the test.

Banks do regulatory arbitrage on the investment of sovereign bonds by shifting their holdings of sovereign bonds with the same credit rating from low-yield (lower than the median) to high-yield. This is because, on a given credit rating, banks can choose assets with higher yields without increasing the level of risk measured by the regulations. For instance, consider two sovereign bonds with an AA credit rating in the market: French and Belgian sovereign bonds. Belgian sovereign bond yields are higher than those of the French. Suppose that prior to the test, a marginal bank M holds 70% French and 30% Belgian sovereign bonds and a safe bank S holds 60% French and 40% Belgian sovereign bonds. Assume that after the test, bank M shifts to hold 30% French and 70% Belgian sovereign bonds, while bank S continues to hold 60% French and 40% Belgian sovereign bonds in its basket. Then, bank M does regulatory arbitrage on the AA credit sovereign bonds while bank S does not, and this shifting is not incorporated into the risk exposure and CET 1 ratios.

The contribution of this paper can be summarized as follows. First, I find that marginal banks do risk-shifting more aggressively on sovereigns with the same credit rating than safe banks and fragile banks: on average, they hold 146.9 and 172.4[8] more basis points of riskier sovereign bonds over total sovereigns than the other two groups respectively. Given that the average percentage of EU sovereigns over total assets in the sample is 12.68%, such risk-shifting can be executed on this important proportion of banks' assets.

Secondly, this paper also provides evidence that the home bias in EU sovereigns is driven not only by pressure from local governments but also by the banks' appetite for

[8]Both of these two estimates are statistically significant at the 5% significance level.

risk; as evidenced by the fact that banks gamble for the resurrection to earn extra returns, as in Acharya and Steffen (2015), Crosignani (2015) and Altavilla, Pagano, and Simonelli (2017). For instance, in the same country with a poor economy, the marginal banks are holding more risky home sovereigns than the safe banks.

Thirdly, I find that crowding out between sovereigns and corporate lending exists among the tested banks. Fragile banks cut their lending to corporates 6.27%* more than safe banks after the 2014 test. Banks increase the investment proportion of sovereigns (with very low risk-weights) while they decrease the proportion of loans (with very high risk-weights).

Finally, this paper also detects an indirect effect of stress tests in the corporate bond market on banks which are not tested. I find that if an untested bank is located in a country with negative information shocks from the stress test, then its financing cost on the corporate bond market will be higher than a bank which is located in a country with positive information shocks.

The findings in this paper have implications for policymakers. In particular, my findings show the potentially perverse effect of rating-based risk measures. Under the extended Basel III to be executed in 2018, the leverage ratio which is not a rating-based measure, becomes a mandatory part. This will prevent banks doing regulatory arbitrage within the risk-weighting categories. The existence of banks' regulatory arbitrage identified in this paper favors the implementation of this regulation.

The remainder of the paper is organized as follows. Section 2 presents a literature review, and Section 3 describes the stress test. In Section 4, I discuss the data, while in Section 5, I develop the theoretical predictions and summarize the testable hypothesis. The econometric strategies and main results on banks' risk-taking are shown in Section 6. The analysis of corporate bond market and stock market reactions are discussed in Section 7 with robustness tests in Section 8. Section 9 concludes.

2 Literature Review

2.1 Risk Shifting and Regulatory Arbitrage

Since Jensen and Meckling (1976) highlighted the shareholder's incentive to engage in risk-shifting behavior to transfer wealth from bondholders, many studies have attempted to identify the ways to mitigate this agency problem. These include debt covenants (Smith and Warner (1979)), debt maturity (Barnea et al. (1980)), convertible debt (Green (1984)), and managerial compensation (Brander and Poitevin (1992); John and John (1993)). Landier, Sraer, and Thesmar (2015) provide the empirical evidence on risk-shifting in the lending behavior of a large subprime mortgage originator. The implication of my paper that marginal banks under the stress test engage in risk-shifting to the depositors on the sovereign bonds is consistent with their paper. Landier, Sraer, and Thesmar (2015) also show that firms would like to choose the assets whose returns are more correlated with their probability of default. New Century originated more loans in regions where real estate prices are correlated with the return of its "legacy" assets. In my paper, the fact that banks will shift the risk into the assets (e.g., home sovereign bonds) that are related to their survival is consistent with the results of Landier, Sraer, and Thesmar (2015).

Banks are able to do risk-shifting without violating the regulations by increasing the level of risk, which is called *regulatory arbitrage*. The evidence that certain financial firms use regulatory arbitrage to increase risk can be found in different types of investments. Efing (2016) provides evidence for regulatory arbitrage within the class of asset-backed securities based on the individual asset holding data of German banks. Conditional on ratings, insurance companies choose insurance portfolios which are systematically biased toward higher yield and higher CDS bonds (Becker and Ivashina (2015)). Banks can also take more risks by putting assets off-balance sheet (Acharya, Schnabl, and Suarez (2013)). Boyson, Fahlenbrach, and Stulz (2016) predict that banks wanting to take more risks than permitted by capital regulations (constrained banks) use regulatory arbitrage. Besides,

Houston, Lin, and Ma (2011) find strong evidence that banks have transferred funds to markets with fewer regulations. This paper studies banks' risk-shifting on sovereign bond investments.

It is evident that banks may do regulatory arbitrage. However, there is no single driving force behind regulatory arbitrage that is widely accepted. On the one hand, Spamann (2010) argues that regulatory arbitrage is driven by misaligned managerial incentives that lead banks to take on excessive risk. Other researchers argue that exploiting too-big-to-fail subsidies is a major determinant of regulatory arbitrage by large banks (Acharya and Richardson (2009), Carbo-Valverde, Kane, and Rodriguez-Fernandez (2013)). On the contrary, Boyson, Fahlenbrach, and Stulz (2016) find strong evidence that the too-big-to-fail status is not the main driver of regulatory arbitrage. I find no evidence to support the concept that larger banks would do more regulatory arbitrage, which supports the findings of Boyson, Fahlenbrach, and Stulz (2016).

2.2 Holding of EU Sovereigns and Home Bias in EU

The significant increase in the holdings of home sovereigns from 2010 to 2015 in EU banks is noticeable and well documented. There are two main branches of explanations for this trend. Uhlig (2014) proposes the "moral suasion" hypothesis whereby the banks' rapidly increasing balance sheet exposures to the domestic sovereign debt during the Eurozone sovereign debt crisis led both academics and policymakers to speculate that this development was partly the result of domestic sovereigns putting pressure on some banks to extend material support to the government. The estimates of Ongena, Popov, and Van Horen (2016) consistently suggest that collusion between banks and sovereigns (or "moral suasion") took place during the sovereign debt crisis. De Marco and Macchiavelli (2016) and Becker and Ivashina (2014) also support the "moral suasion" theory.

Other researchers suggest that banks follow a "carry trade" strategy to gamble for the resurrection to earn extra returns, as suggested by Acharya and Steffen (2015) and

Crosignani (2015). Altavilla, Pagano, and Simonelli (2017) show the evidence that in GIIPS[9] countries, the banks with low regulatory capital increase their holdings of distressed public debt more than the others. In my paper, I show that not only would the banks in the GIIPS countries with low regulatory capital increase their holdings of distressed public debt more than the others, but also the banks with low regulatory capital outside the GIIPS countries.

2.3 Stress Testing and Information Disclosure

There are two distinct channels documented by the literature through which financial shocks propagate across institutions. The first channel is the *direct linkage* between banks: when two parties write a financial contract such as a swap agreement, a negative shock to one party can be transmitted to the other as soon as one is unable to honor the contract Giglio et al. (2011). Direct linkages of this type can propagate distress, because, once defaulted upon, the creditor bank may lack the funds required to deliver on its obligations to third parties (Duffie (2013), Kallestrup, Lando, and Murgoci (2016), Diebold and Yılmaz (2014)).

The second channel is the *indirect linkage* between banks through the common assets held across banks. Tressel (2010) claims that cascade effects can be triggered by bank losses or contractions of interbank lending activities. After the shocks on assets or on the liabilities of banks, global de-leveraging of international banking activities can occur. Also, Greenwood, Landier, and Thesmar (2015) show that fire sales propagate shocks across bank balance sheets.

The information released by EBA on the stress tests is vast, and how it is transmitted and affects the market is highly relevant. Camara, Pessarossi, and Philippon (2016) show that the stress tests are informative. Petrella and Resti (2013) focus on the 2011 EU-wide stress test by using the event study method, and they find that stress tests

[9] Portugal, Italy, Ireland, Greece and Spain

produce valuable information for market participants and can play a role in mitigating bank opaqueness. Goldstein and Sapra (2012) emphasize that the disclosure of stress test results can achieve the macro-prudential role of helping to stabilize the financial system as a whole, but may not necessarily achieve the micro-prudential role of providing market discipline for specific individual banks.

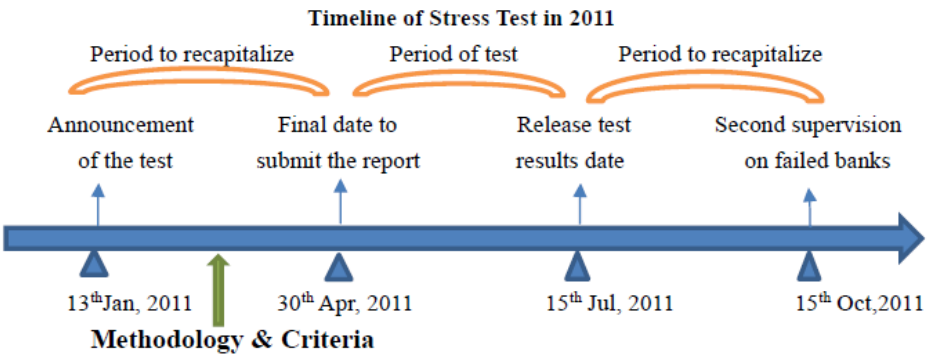
Cardinali and Nordmark (2011) study the stock market reaction to the 2010 and 2011 EU stress tests. They find that the test results in 2010 are relatively uninformative for investors and that the announcement of the methodology to be used in 2011 triggers negative CARs (cumulative abnormal returns) for tested banks, while non-tested institutions are roughly unaffected. Also, Petrella and Resti (2013) show that the abnormal returns of tested banks are strongly related to some stress test outputs and that stress tests have provided investors with relevant information. On the contrary, Candelon and Sy (2015) show that the 2011 EU exercise is the only EU-wide stress test that results in a significantly negative market reaction. The comparison with past exercises suggests that the qualitative aspects of the governance of stress tests may matter for stock market participants more than the technical elements, such as the level of the minimum capital adequacy threshold or the extent of data disclosure. In this paper, I also assess the direct effect and indirect effect of the information disclosure from the stress test on the corporate bond market.

3 EU-wide Stress Tests

The stress tests are run under general macro-economic scenarios across all countries in the EU. The results shed light on the sensitivities of the European banking sector to a general economic downturn and movements in external variables, such as interest rates, economic growth and the unemployment rate.

There are two types of scenarios in the tests: (1) *a baseline scenario*, which is primarily based on the European Commission forecast, and (2) *an adverse scenario*, which assumes

the existence of a series of external economic shocks, such as a set of EU shocks tied to the persistence of the ongoing sovereign debt crisis, a global negative demand shock originating in the US, and a USD depreciation to all currencies. Based on these two types of scenarios, EBA calculates the exposure levels of banks to different types of risk in future years, including credit risk, market risk, sovereign risk, and securitization risk. [10]



After the announcement of the test in Jan 2011, banks have three months to raise new capital (recapitalization) before submitting their reports to the local central banks. The EBA then releases the test results on 15th July 2011 and re-supervises banks who have not successfully passed the test. A similar time line for the 2014 EU stress test can be found in Appendix II B.

Criteria to pass the test. The criteria to pass the test is based on the Common Equity Tier 1 (CET 1) ratio, which is defined as:

$$CET1 \quad ratio = \frac{CET1}{RWA},$$

where Common Equity Tier 1 (CET 1) is assessed according to the Basel III,[11] and RWA, referring to risk weighted asset,[12] consists of exposure to the debtors, probability of default and loss given default.

[10] Based on the static balance sheet in 2010, the 2011 EU-wide test provided exposures to different risks in 2011 and 2012. The 2014 EU-wide stress test, based on the 2013 balance sheet data, provided the exposure values in the years 2014, 2015 and 2016.

[11] Basel III: A global regulatory framework for more resilient banks and banking systems (December 2010), page 13.

[12] See definition of RWA of 2011 test and 2014 in CRR/CRD 3 and CRR/CRD 4 respectively.

Criteria to pass the tests

CET 1	Successfully passed	Marginally passed	Failed
2011 test	$> 6\%$	$5\% \sim 6\%$	$\leqq 5\%$
2014 test	$> 6.5\%$	$5.5\% \sim 6.5\%$	$\leqq 5.5\%$

For a bank to pass the 2011 stress test, the adjusted CET 1 ratio under the adverse scenario for the bank has to be greater than 5%. If the CET 1 ratio is between 5% and 6%, the bank is said to marginally pass the test. If the CET 1 ratio is greater than 6%, the bank is defined by the EBA to pass the test successfully. Meanwhile, a bank passes the 2014 stress test if its CET 1[13] ratios under adverse scenarios and baseline scenarios are greater than 5.5% and 8% respectively. A bank marginally passes the 2014 test if its CET 1 ratio under the adverse scenario is between 5.5% and 6.5%, and successfully passes the 2014 test if the ratio is higher than 6.5%.

After the 2011 test, the EBA recommends that marginally passed banks whose CET 1 ratios under the adverse scenario are above but close to 5%, and which have sizable exposure to EU sovereigns under stress, take specific steps[14] to strengthen their capital positions. These banks are expected to plan remedial actions within three months. The plans need to be fully implemented within nine months (by April 2012).

In contrast, failed banks whose final CET 1 ratios are below the 5% threshold, must first promptly remedy the capital shortfall. Then national supervisors should ensure that these banks are requested to present a plan to restore the capital position to their competent authorities within three months. The remedial measures that should be agreed with the competent authority have to be fully implemented by end of 2011. Similar actions are taken after the 2014 stress test.

[13] Unlike the 2011 test, in the 2014 test the criteria of passing the test is based on the CET 1 ratio before the recapitalization.

[14] Including necessary restrictions on dividends, de-leveraging, issuance of fresh capital or conversion of lower quality instruments into CET1 capital.

4 Summary Statistics

Banks' investment portfolios during 2010-2015 are available from the EBA[15] public database. European sovereign bond yields to maturity and daily stock returns can be extracted from DataStream during the same period. In addition, the European sovereign debt auctions, corporate bonds daily returns from 2007 to 2016 and sovereign bond outstanding amounts from the Eikon database are available. The Infinancial database and the Oribis bank focus provide most of the European banks balance sheet data. Finally, three daily Fama-French European factors are extracted from Kenneth French website.

4.1 Sample of Banks in the Dataset

There are two stress tests in the estimation sample, which are performed in 2011 and 2014 respectively. The EBA requires local central banks to capture at least 50% of the national banking sectors in each EU member state, as expressed in terms of total consolidated assets. In the end, the 2011 EU-wide stress test is carried out on a group of banks covering over 65% total assets of the EU banking system and the 2014 stress test covers more than 70% of total EU banking assets.

Banks have been included in the tests in descending order of their market shares based on the total assets of each Member State. As the tests are conducted at the highest level of consolidation, the tests cover all subsidiaries and branches operating in foreign countries. If the total assets of the tested banks in every Member State are more than 50% then no other bank has to be included from that Member State; unless they wish to do so on a voluntary basis.

Ninety banks[16] are tested in 2011 and 123 banks are tested in 2014; 72 banks are both included in the two tests and 51 new banks appear in the 2014 test. In other words, 18 banks are excluded from the sample in 2014, due either to bankruptcy or mergers. Using

[15] http://www.eba.europa.eu/risk-analysis-and-data/eu-wide-stress-testing

[16] The list of tested banks is in Appendix III.

the database provided by EBA, we can trace the portfolios held by 71 tested banks[17] after the test. In September 2011, December 2011, June 2012, and December 2012, the EU capital exercise provides us with further information about the banks after the 2011 stress test. Also, for the second test, the EBA releases the banks' data in the following months: June 2013, December 2013, December 2014, and June 2015.

4.2 Distribution of Banks across Regions

After the announcement of the test in 2011, tested banks can re-capitalize new funds to increase their current CET 1 ratios. Between January and April 2011, a further net amount of EUR 50 billion[18] of capital is raised. This evidence shows that banks know their CET 1 ratios before submitting reports to the national central banks, and they can raise capital before submitting their final and adjusted CET 1 ratios. In this paper, I divide the sample into three groups according to the CET 1 ratios before the recapitalization: safe banks (CET 1 ratio higher than 6%), marginal banks (CET 1 ratio between 5%-6%), and fragile banks (CET 1 ratio below 5%). This ratio does not include the re-capitalization induced by the test; in other words, the grouping CET 1 ratio does not depend on the test.

As shown in the time-line in the last section, banks may carry out recapitalization after the announcement of the test. In the released reports, the results of the test are based on the CET 1 ratios computed after the adjustment (i.e., including the re-capitalization amount before the end of April 2011). If the tested banks have not adjusted their capital after the announcement of the test, 20 banks would have failed the test and 13 banks

[17] Six Greek banks were addressed in the Greek program so the their data is not available immediately after the 2011 test (in September 2011, December 2011).

[18] EUR 46 bn net of reimbursement of capital support was received from governments, as shown in the report of the results in 2011 from http://www.eba.europa.eu/documents/10180/15935/EBA_ST_2011_Summary_Report_v6.pdf. This was achieved through: (i) the issuance by the banks of common equity in the private market; (ii) government injections of capital or the provision of other public facilities; (iii) conversion of lower-quality capital instruments (such as hybrid instruments) into CET1; and (iv) restructuring plans approved by all competent authorities and fully committed which was factored into the results.

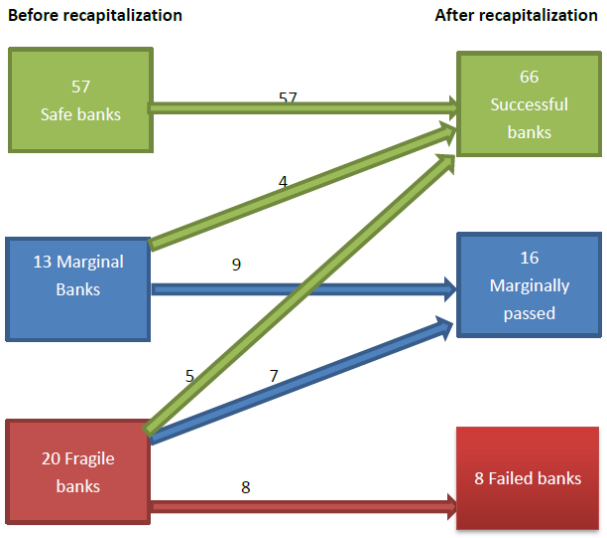


Figure 1: Test results before and after recapitalization
Note: On the left-hand side, CET 1 ratio before re-capitalization; on the right-hand side, the test results of 2011 stress test, adjusted CET 1 ratio including the recapitalization during Jan and Apr, 2011.

would have marginally passed the test. More details are shown in Figure 1. Similarly, in the 2014 stress test (see Appendix 2 B), the unadjusted CET 1 ratio is lower than the adjusted value on average. Differing from the 2011 test, the test results in the 2014 test are not based on the adjusted CET 1 ratios, but on the unadjusted values.

Taking into account these capital-raising actions implemented by the end of April 2011, eight banks fall below the capital threshold of 5% CET 1, with an overall CET 1 shortfall of EUR2.5 bn. In the 2014 test, there are 24 banks with a CET 1 below 5% before the recapitalization and only 14 banks below the threshold after the recapitalization during the period from January to September, 2014.

After the 2008 financial crisis, banks located in different countries face different challenges, especially the five Eurozone nations that are considered to have a weaker economy: Portugal, Italy, Ireland, Greece and Spain (called GIIPS in this paper). On 10th May 2010, European leaders approved a 750 billion Euro stabilization package to support these nations. Figure 2[19] shows the number of different groups of banks distributed in GIIPS

[19]The distribution of the 2014 test can also be found in Appendix 2 B.

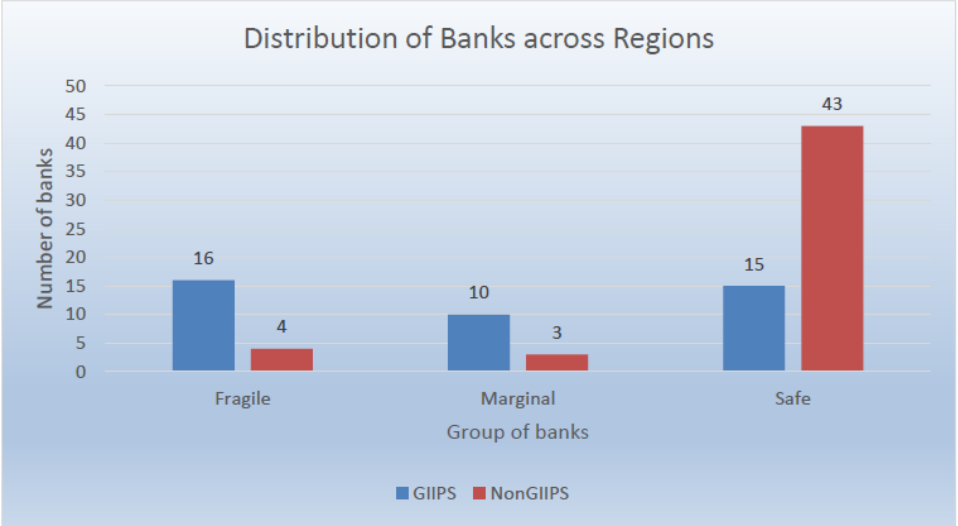


Figure 2: Distribution of banks across regions
Note: Fragile banks' CET 1 ratio (before re-capitalization) lower than 5 % under the adverse scenario in the 2011 test; marginal banks' CET 1 ratio between 5 % and 6 %; safe banks' CET 1 ratio higher than 6 %.

and non-GIIPS countries.

4.3 Annual Accounting Variables

Safe banks are on average much larger than marginal banks, which are in turn slightly larger than fragile banks. The growth of total assets is similar across groups prior to the tests (see Figure 3). Furthermore, fragile banks have much higher ratios of loans to total assets compared to the other banks (0.7, 0.6688 and 0.5734, respectively). Regulatory constrained banks lend more but have lower return rates on assets.

From the criteria to pass the stress test, we know that if a bank wants to increase its capital ratio, it has several options: first, increasing its capital ratio by generating new funds; and second, cutting RWA by either selling risky assets or shifting assets from risky ones into less risky ones. Both the generation of new funds and the re-balancing of portfolios are very costly and time-consuming, while selling risky assets is the fastest way to re-increase the capital ratio. After selling risky assets whose expected returns are

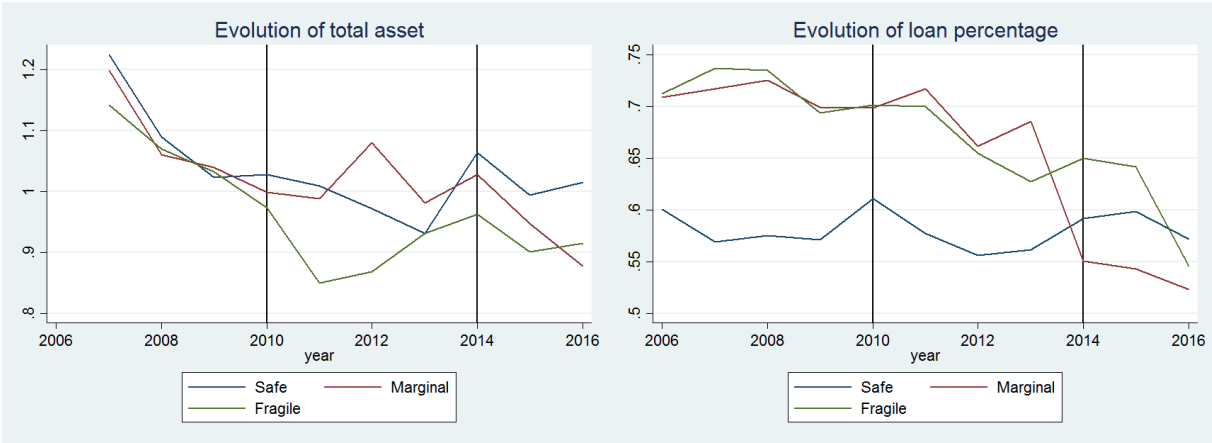


Figure 3: The evolution of some variables in tested banks
Note: The left graph shows the evolution of total asset at t scaled down by last year's total asset $\frac{TA_{i,t}}{TA_{i,t-1}}$. The right graph shows the evolution of $\frac{loan_{i,t}}{TA_{i,t}}$.

generally high, banks can pay back the debt holders and may end up with smaller sizes. There are two possible reasons to do so: either to lower the leverage ratio or to avoid the high cost when keeping low return assets. From Figure 3, we find that after two tests, the total size and the return on asset[20] of the fragile banks are smaller, and the lending rate is decreasing, which may infer that those banks sell assets with high risk-weights.

4.4 Credit Exposures

Banks are required to assess the impact of given macroeconomic scenarios (baseline and adverse) on their future credit risk losses and credit qualities. There are seven classes of credit exposure defined according to the counter-parties, shown as follows: central governments or central banks, institutions, corporates, retail, equity, securitization, and others. After the 2011 test, there is no further data disclosed on the credit exposure. Since this data is available after 2014 test, I focus more on the second test in the analysis of banks' credit exposure.

From Figure 7 in Appendix 2 , we see the decreasing trend of credit exposures to central

[20] In Figure 6

banks or government, corporates and retails. The above figure explains that fragile banks and marginal banks keep the exposure to central banks or local government around the test, while safe banks decrease this percentage after the test. Fragile banks cut their lending to financial institutions around 10% while the other two groups of banks hold it almost unchanged. All groups of banks reduce their holdings of retail loans after the test which are in general of shorter maturity compared to corporate loans. Interestingly, fragile banks reduce their exposure to corporates (from 24% to 16.5%) more than safe banks (from 19% to 17%).

4.5 Sovereign Exposures

Unlike the other types of banks' credit exposures, such as exposures to corporates, retails and institutions, the sovereign exposures of banks differ in that the counter-parties of the sovereigns are the same for every bank. Therefore, a shock to the sovereign bond i will produce the same effect for every bank.

Figure 8 of Appendix II shows the average of $(\frac{Sovereign_{i,t}}{totalasset_{i,t}})$. The average percentages of gross sovereign exposures, loans and advances, asset for sales and held for trading are constant for all banks. However, the following graphs show that banks are changing the maturity structure of the portfolios; after the stress tests, banks are increasing the percentage of longer term sovereigns and shorting more on the short-term assets. The bottom graphs in Figure 8 shows that the amount of assets for sale drives the maturity of sovereign exposures to the longer term, while those of loans and advances which represent a large percentage of sovereign exposures are much less volatile across time. As shown in Figure 9 of Appendix II, safe banks are holding their shares of long-term sovereigns constant.

In Table 1, I present the average percentages of higher yield sovereigns over total sovereigns within one credit rating[21] across groups, before and after the tests. Marginally

[21] There are six credit ratings: AAA, AA, A, BBB, B and C.

Table 1: Summary of sovereign bonds

	Before		After		Difference	
Group	Mean	S.D.	Mean	S.D.	Diff(t)	t-value
Safe banks						
RA=1	17.006	18.213	26.502	30.698	9.49**	1.944
RA=0	82.994		73.498			
Marginal banks						
RA=1	31.504	22.661	68.471	45.127	36.97***	2.351
RA=0	68.496		31.529			
Fragile banks						
RA=1	27.714	22.024	30.034	36.218	2.32	0.229
RA=0	72.286		69.966			
DID (2-1)	14.497*	8.183	41.97***	11.152	27.47**	1.99
DID (2-3)	3.789	10.355	38.44**	14.645	34.647*	1.93

The sovereign bonds defined as RA=1 are those sovereign bonds with higher yields than the median in one credit rating, while the sovereign bonds defined as RA=0 have yields lower than the median prior to the test. The first two columns are the mean and standard deviation of sovereign bond percentages $\frac{Sovereign(i,t,RA=1)}{TotalSovereign_{i,t}}$ prior to the test; the middle two columns are the percentages of sovereign bonds after the test; the last two columns present the differences between before and after the test and their t-values. DID(2-1) shows the difference-in-difference between marginal banks and safe banks. DID(2-3) includes the difference-in-difference between marginal banks and fragile banks.

constrained banks have increased much more aggressively on the holding of higher yield sovereigns on one credit rating than other groups.

In Figures 10 and 11 of Appendix II, I observe that the number of GIIPS sovereign exposures is not decreasing; while it even shows a slightly increasing trend over the period, especially for the marginal banks and failed banks. Constrained banks (fragile banks and marginal banks) tend to take more risky assets. In the right-hand graph of Figure 10 the percentages of the risky debts are at first decreasing then increasing afterwards among the constrained banks.

Meanwhile, I also document the variations of non-GIIPS sovereign bond holdings. Apparently, safe banks are holding less non-GIIPS sovereign bonds after the test, while on average the remaining marginal banks are not decreasing their shares of those sovereign bonds. The holding variations between groups again confirms the different investment strategies taken by banks when they face a poor economy or strict supervision from

regulators.

4.6 Summary of Corporate Bond Market

In Table 5, the summary statistics of banks' corporate bonds are presented. The corporate bond yields of tested banks are on average lower than those of non-tested banks; similar results are shown between non-constrained and constrained banks. Two different bid-ask spreads (in percentage) are also presented in the summary table. The first spread is computed using composite prices[22] and the second spread using evaluated prices.[23]

5 Economic Hypothesis

I develop the economic hypothesis in this section based on an extension of the model of Glasserman and Kang (2014). In contrast to their model, I introduce fragile banks and punishment from regulators into the model. Banks' risk-taking behavior can be explained by a standard version of maximizing expected payoffs given different levels of appetite for risk. There are two periods and N assets in the economy.

5.1 Banks without Regulatory Constraints

Without regulatory constraints, banks maximize their value function V by choosing an optimum portfolio x ($x \in \mathbb{R}_+^N$) at time $t = 0$ according to Glassman and Kang (2014):

$$\max_x \quad V(x) = \mu^T x - \frac{\gamma}{2} x^T \Sigma x.$$

The parameter γ reflects the unregulated bank's concern for risk, μ is the expected excess return of banks' assets and Σ represents assets' covariance matrix. Banks have the optimal portfolio x_0^* if they are unregulated:

[22] Thomson Reuters receives bond prices from multiple contributors. The bid and ask (CMPB & CMPA) composite values will be the average from all the available contributors' bid and ask quotes.

[23] Thomson Reuters Pricing Service (TRPS) evaluated prices are provided daily for a global universe of fixed income securities using evaluation models developed and maintained by the Fixed Income Pricing Service team at Thomson Reuters.

$$\Rightarrow x_0^* = \frac{\Sigma^{-1}\mu}{\gamma}$$

5.2 Regulator's Objective

The regulator's objective is to stabilize the market by minimizing the risk in the banks' portfolios. This minimization problem is equivalent[24] to the maximization function under regulation constraints at $t = 1$ (the model is shown in Appendix 3 C.3). The optimal portfolios chosen by the regulators, denoted y_1^* (see C.3.1), can be implemented by imposing a required capital ratio on banks and assigning different risk-weights (w) to banks' assets.

5.3 Banks under Regulatory Constraints

In the stress tests, banks that cannot meet the regulatory constraints will be punished by the regulators through the reconstruction of their capital under force. Under the reconstruction process, failed banks have to either generate new capital at a high cost or sell risky assets at depreciated prices. Six of the eight failed banks in the 2011 tests were eventually acquired or merged with other banks.

In this setting, banks that cannot meet the regulatory constraints may face a punishment P with probability $1 - \pi$, where $\pi \in [0, 1)$,[25] and P can be the loss from capital reconstruction. K is the required capital level and w is the risk-weights assigned to the assets in order to exercise the regulators' optimal choice.

The objective function for all types of banks at $t = 1$ becomes:

$$\max_x \quad V(x) = \pi(\mu^T x - \frac{\gamma}{2} x^T \Sigma x) + (1 - \pi)P$$
$$\begin{cases} \pi = 1 & if \quad x^T w \leq K \\ \pi \in [0, 1) & if \quad x^T w > K \end{cases}.$$

[24] Under the assumption that the return of x is normally distributed. Regulators' minimization of banks' probability of default can be transformed into the minimization problem of risk level.

[25] P and π can be a function of x. To simplify the solutions of the model, I assume that P is independent of x and π is a constant.

At $t = 1$, for banks that are able to meet the regulatory constraints, the objective function under regulation constraints is:

$$\max_x \quad \mu^T x - \frac{\gamma}{2} x^T \Sigma x$$
$$s.t. \quad x^T w \leq K$$
$$\Rightarrow x_1^* = \tfrac{1}{\gamma}\Sigma^{-1}\mu - \tfrac{(w^T\Sigma^{-1}\mu - \gamma K)^+}{w^T\Sigma^{-1}w}\tfrac{1}{\gamma}\Sigma^{-1}w.$$

If the regulatory constraints are not binding, then banks choose $x_1^* = x_0^*$. Banks are very solid from the regulators' viewpoint (holding enough adequate capital), in the sense that whether the regulations[26] arrive or not will not affect those banks' optimal portfolio choices.

However, if the regulatory constraints are binding, we have $x_1^* \neq x_0^*$. Regulators can set optimal risk-weights[27] $w^* = \alpha\mu$, which allows x_1^* to meet the following two conditions at the same time:

(1) $x_1^* = y_1^*$, banks choose the portfolios which coincide with regulators' optimal choice;

(2) $x_1^* = \frac{K\Sigma^{-1}\mu}{\alpha\mu^T\Sigma^{-1}\mu}$ is proportional to $x_0^* = \frac{\Sigma^{-1}\mu}{\gamma}$, banks' relative mix of assets unchanged.

5.4 Banks' Regulatory Arbitrage

Practical obstacles prevent the implementation of $w^* = \alpha\mu$ in the real economy. In the Basel framework, regulators design the risk-weights ($w = \alpha\delta$) linear to the standard deviation of the category of assets δ rather than their expected returns μ. Therefore, binding banks can always take extra risks by selecting the assets with higher yields within the same risk-weights without making the constraint tighter (See C.3.3). The deviation choice of the portfolio allows banks to take the extra risk without violating the regulations in the real economy; we call this *banks' regulatory arbitrage*. That is equivalent to say that banks do risk-shifting within the same risk-weights asset categories.

[26] It can also be applied to the tighter regulations case.

[27] Proposition 1 in Glasserman and Kang (2014).

Proposition 1: *(i) If banks' regulation constraints are not binding (unconstrained by regulations), then $x_1^* = x_0^*$. Banks' optimal portfolios are not changed by the regulations; (ii) If banks' constraints are binding and the optimal weights are linear to the risk, $w = \alpha\delta$, then $x_1^* \neq x_0^*$. Constrained banks can deviate from regulators' optimal choice y^* by conducting regulatory arbitrage.*

Given these results, I expect that marginally regulatory constrained banks will conduct more regulatory arbitrage than safe banks after the stress tests in the empirical studies. Safe banks in this paper have relatively higher capital ratios than regulatory constrained banks; a similar application can be found in the literature.[28] In contrast to the literature (only regulatory constrained banks and regulatory unconstrained banks are defined), I define safe banks, marginally constrained banks and fragile banks in this paper. Fragile banks have a capital ratio below the threshold required by the regulators.

If banks are fragile and have difficulty in meeting the regulatory constraints, they will maximize the piecewise utility function within the second interval at $t = 1$. Proof is shown in Appendix 3. At the optimal, there are two possible cases.

Proposition 2: *(i) If $P < \bar{P}$[29], or $\frac{\Sigma\mu^{-1}w}{K} > \gamma > \bar{\gamma}$, fragile banks shift their portfolio x (within the red line domain on the left-hand graph of Figure 4) in order to get a capital level closer to K; (ii) If $P > \bar{P}$ or $\gamma < \bar{\gamma}$, fragile banks keep their optimal $x_1^* = x_0^*$ just as under the maximization case without constraints.*

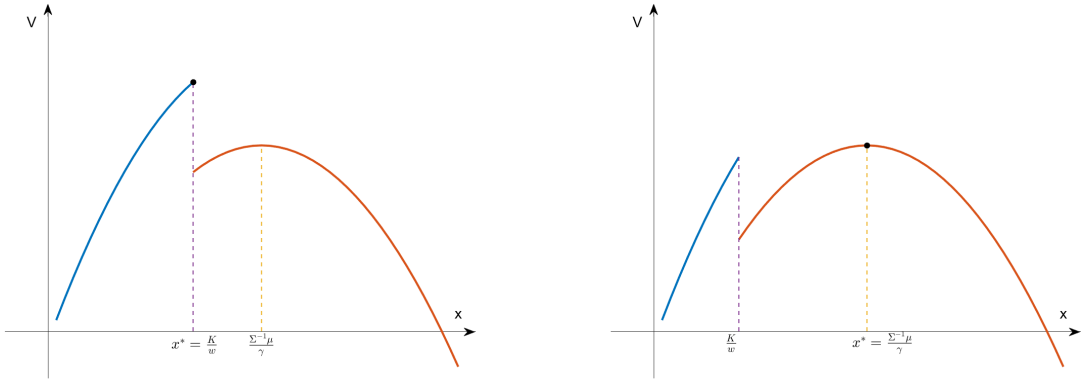
That is, fragile banks are not necessarily doing more regulatory arbitrage under the punishment framework. If both P and π depend explicitly on x, the results still hold.

Taking the special case $\pi = 0$, the payoffs are similar to the typical risk-shifting theory. Shareholders are protected by limited liability and want to take risks to maximize their option-like payoff (Jensen and Meckling (1976)). The expected payoff of banks' shareholders behaves like a call option value, with its value increasing in the standard deviation of the underlying assets x.

[28] Boyson, Fahlenbrach and Stulz (2016), Efing (2016), Becker and Ivashina (2015), Ellul et al (2011)

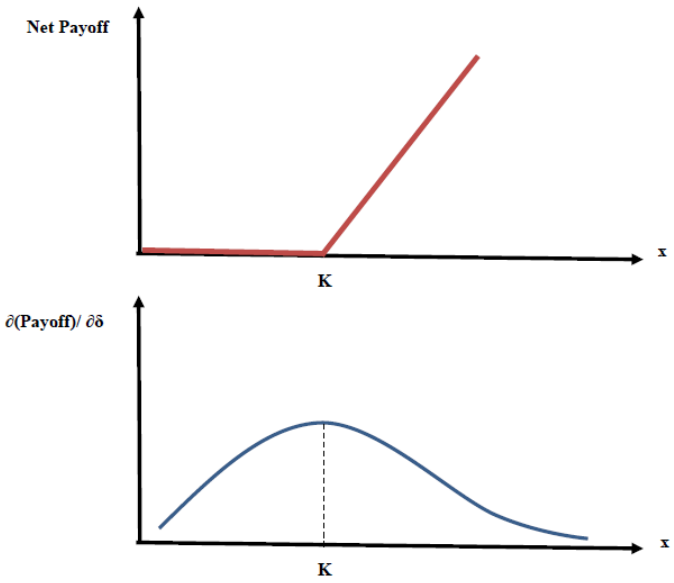
[29] $\bar{P} = \frac{V((x=\frac{K}{w}))-V(x=x_0^*))}{1-\pi}$, $\bar{\gamma} = \frac{(\frac{K}{W})^T\Sigma(\frac{K}{W})-\pi(x_0^*)^T\Sigma x_0^*}{2((1-\pi)P-\frac{K}{W}\mu)-\pi x_0^*\mu)}$

Figure 4: **Banks' V value and current asset values**



Case (i) of Proposition 2 on the left-hand graph, Case (ii) of Proposition 2 on the right-hand graph. Value function V is on the y-axis and asset portfolios x on the x-axis.

Figure 5: **Banks' expected net payoff and current bank value**



The x-axis of the graphs is the current asset portfolio x; the y-axis of the upper graph is shareholders' net expected payoff; the y-axis of the lower graph is the derivative of the shareholders' expected net payoff with respect to the standard deviation of their portfolios.

As shown in Figure 5, banks prefer to take the most risk when their bank values are closed to the strike price K[30] (the required capital level); if regulatory constraints are imposed on their investments, risk-shifting may occur. However, banks with underlying asset values much smaller than K would have a relatively lower appetite for risk than banks with relatively higher bank values. Banks[31] with a much higher franchise value, located on the right-hand side of the graph, take less risk and hold more capital, because these banks have more to lose if they fail.

In summary, marginally regulatory constrained banks will engage in more regulatory arbitrage after the stress test (acting as a tighter regulation imposed on banks) than unconstrained banks. Since doing regulatory arbitrage may not make a difference on fragile banks' expected net payoffs, they may not do so. Fragile banks may want to take less risky assets or generate more capital so as to meet the regulatory constraints. Therefore, I have the following hypotheses to test:

***Hypothesis 1*:** Due to the stress tests, safe banks will conduct more regulatory arbitrage than marginal banks which are more regulatory constrained compared to safe banks; the difference in regulatory arbitrage between marginal banks and safe banks will be greater in the 2014 test.

***Hypothesis 2*:** Fragile banks do less regulatory arbitrage than other banks after the stress test, and may take less risk than other banks.

[30] K is the outstanding debt amount under the classical option value theory. Here K is the required capital level.

[31] (Demsetz, Saidenberg, and Strahan (1996), Repullo (2004)).

6 Main Results on Banks' Risk-taking

6.1 Econometric Strategy

I test the hypotheses stated in the last section as follows. Consider the following linear fixed effect model:

$$\frac{Sovereign_{i,j,t}}{TS_{i,t}} = \beta_1 Post \times Group_i \times RA_j + \beta_2 Post \times Group_i + \beta_3 Group_i \times RA_j + \beta_4 Post \times RA_j + FE + Controls + \varepsilon_{i,j,t},$$

where $Sovereign_{i,j,t}$ is the amount of sovereign bonds of country j owned by bank i at time t, and $TS_{i,t}$ denotes the total sovereign bonds of bank i at time t. The variable $Post$ is the time dummy such that $Post = 0$ if the time t is one year before the stress test and $Post = 1$ otherwise. For each test, the time window is three years: (1) in the first test, t=2010, 2011, 2012; (2) in the second test, t=2013, 2014, 2015. The group dummy $Group_i$ indicates three groups of banks which are divided according to their core capital ratios under the adverse scenario before recapitalization: safe($>= 6\%$), marginal($5\% - 6\%$) and fragile($< 5\%$). I define $RA_j = 1$ if, the yield spread of sovereign bond j is higher than the median within the same risk-weighting category, and $RA_j = 0$ otherwise. For instance, in December 2010, the credit ratings of Spanish and Belgian sovereign bonds are AA+/Aa1 according to the Moody & Fitch reports. After computing the average spread yields of Spanish and Belgian sovereign bonds by using the last year's yields,[32] we know that the average yields of the Spanish sovereign bonds are greater than the average yields of the Belgian bonds. Then, we have $RA_j = 1$ if the sovereign bond is the Spanish bond and $RA_j = 0$ if the sovereign bond is the Belgian bond.

When estimating the parameters, I set marginal banks as the benchmark, so that β_1 measures the difference between safe banks (or fragile banks) and marginal banks in

[32] In the robustness check, the last three-month or six-month yields are used to define the variable RA.

terms of the shifting of sovereign bonds within one credit rating before or after the test. According to the hypotheses in the last section, I expect that the (2×1) column vector of β_1 should be negative. Banks' fixed effect (FE) is absorbed, and the standard errors are clustered at bank level.

6.2 Control Variables

Home bias effect. I define the dummy $local\_country = 1$ if the sovereign bond is local and $local\_country = 0$ otherwise. In the regression, I include $local\_country$ and its interaction term with time trend $local\_country \times TimeTrend$ to rule out the home bias effect.

Sovereign bond fixed effect. I use the dummy $sovereign_j$ and its interaction with time trend ($sovereign_j \times TimeTrend$) to control for the sovereign bond fixed effect. In the robustness check concerning the price shocks or supply shocks on the sovereign bonds, I also include the price evolution and issued amount of the sovereigns to verify my results.

Credit rating. I define the dummy $ratingLevel$ indicating six levels of credit ratings of the sovereign bonds: AAA, AA, A, B, BBB and C. Then I use it to interact with $Group_i \times Post$ to control for banks' appetite for each credit rating.

Bank characteristics. Previous bank size $logsize_{i,t-1}$, deposit rates $\frac{deposit_{i,t-1}}{size_{i,t-1}}$ and loan percentages $\frac{loan_{i,t-1}}{size_{i,t-1}}$ which may affect the holding of the sovereign bonds are controlled in the robustness check.

6.3 Main Results

In this subsection, I present the results of the empirical analysis of the banks' risk-shifting on sovereign bond investments. The holding of sovereign bonds captures an important proportion of around 12.68% of the total assets in a bank.

6.3.1 Risk-taking on Sovereign Bond Investments

Difference across groups after the tests. From Proposition 3, I expect that the coefficient β_1, which measures the preference of high yield sovereign bonds over low yield sovereign bonds, with the same crediting rating before and after the test across the groups, is significantly negative. Table 8 shows that, compared to fragile banks, marginal banks have on average shifted 21.4** more basis points (scaled down by total assets, 1.209 % if scaled down by total sovereigns) from less profitable sovereign bonds to more profitable sovereign bonds within the same credit rating after the 2011 test. This indicator of the effect is the same but not pronounced in the comparison between safe banks and marginal banks after the test.

Difference across groups prior to the tests. Prior to the stress test, banks can take the level of EU sovereign bonds without constraints. Banks' investment strategies are different across the groups and they choose different optimal levels of the sovereign bonds. Marginal banks may prefer Belgian government bonds to French government bonds to the extent that are not necessarily different from safe banks prior to the 2011 test. In other words, within the same credit rating of sovereigns, I expect that the banks' coefficient of the $RA \times Safe$ (or $RA \times Fragile$) is not significant prior to the 2011 test. As shown in Tables 6 and 26, the estimates are close to 0 (0.053 and 0.092) and insignificant (t-value: 0.34 and 0.55). There is no significant difference in the holding of sovereign bonds between safe banks and marginal banks (or between marginal banks and fragile banks) due to the preference of high-yield sovereign bonds or low-yield sovereign bonds in the same credit rating. These estimates coincide with the summary statistic results in Table 1.

However, after the 2011 test, banks may change the investment strategies of EU sovereign bonds for two main reasons. Firstly, due to the fact that EU sovereign bonds become riskier, banks may want to re-balance their portfolios. Therefore, they may change

their holdings across different credit-rating categories instead of within the same credit ratings. For instance, shifting from a German bond to a Netherlands bond will not change much in terms of the level of risk or future yields on their portfolios, since German bonds and Netherlands bonds are all rated as AAA by different credit agencies. However, by selling the Greek bonds (with a B rating) and buying the German bonds (AAA rating), banks shift their portfolios across different credit ratings. Secondly, the constraints of investment on these sovereign bonds becomes tighter. The EBA asks banks to provide provisions on these bonds, which affects banks' sovereign holdings and may motivate constrained banks to perform regulatory arbitrage. Therefore, in the 2014 test, the estimates of $RA \times Safe$ (or $RA \times Fragile$) may be significant. Table 8 shows that given sovereign bonds with the same credit rating, marginal banks on average have around 35.4** to 36.1** more basis points in the holding of high yield ones than safe banks and fragile banks.

Difference between first and second tests. In the 2014 stress test, the EBA values the EU sovereign bond risk to be more important: the influence of the EU sovereign risk on the risk parameters in the model directly affects every bank's RWA value and CET 1 ratio. In other words, the regulation becomes tighter on the sovereign bond risk. Therefore, I expect to have larger estimates of parameters in the 2014 test which are confirmed by the results in Table 8. After the 2014 test, marginal banks conduct more regulatory arbitrage on sovereign bonds than safe banks, by holding more than 1.729 %** in sovereign bonds with higher yields than those with lower yields. This percentage, which represents the shifting from low yield to high yield within the same credit rating, is almost doubled compared to that in the 2011 test. Similar results can be found when marginal banks and fragile banks are compared. These estimates test the hypotheses: banks that are marginally constrained can take more risk by conducting more regulatory arbitrage than unconstrained banks (safe banks), while fragile banks do not conduct more regulatory arbitrage than other banks because they are unable to make a positive net

payoff by shifting risk while leave the credit rating risk unchanged.

6.3.2 What Drives the Home Bias?

When banks' fixed effects are not included (column (1) in Table 6 and Table 7), the estimate of β_1 is significantly more negative than those discussed in the last two paragraphs. This estimate is reduced by half after the home bias effect is controlled for. One explanation is that the home bias effect is very pronounced in EU sovereign bonds, especially after the EU sovereign crisis. Becker and Ivashina (2014) state that at the end of 2013, the share of government debt held by the domestic banking sectors of Eurozone countries has more than doubled its level of 2007.

Is it the pressure from local government that leads banks to aggressively hold more local sovereign bonds than previously held, as stated in Steven, Alexander, Neeltje (2016)? Or do banks prefer to hold more sovereigns and follow a "carry trade" strategy to gamble for the resurrection to earn extra returns, as suggested by Acharya and Steffen (2015)?

In my paper, I find that the estimate coefficient of the local dummy is 6.5%*, which explains around 50% of the sovereign bond holdings.[33] If it is only the pressure from the local central banks that makes the banks hold more their home sovereign bonds, then the estimates of $local_c \times Group_j \times Post$ should be insignificant. That is to say, there is no difference between safe banks and marginal banks in the holdings of local sovereign bonds before or after the test. In Tables 10 to 13, I present the home bias preference across different groups in the two tests.

We find that marginal banks hold on average 3.869%* more home sovereign bonds in total assets than safe banks located in the same country after the 2011 test. Similar results can be found if I scale down bank i's amount of sovereigns in country j by its total sovereign bonds (presented in Table 11). However, fragile banks have a similar preference on home sovereigns after the test as marginal banks, since the percentages of

[33] On average, banks hold 12.68% sovereign bonds in total assets.

home sovereigns in total sovereigns are not significantly different (-6.04%, with t-value -0.71 in Table 11).

Up to 2013, the holding of home sovereigns is very high (around 67.34%) on average. Therefore, we expect the home bias effect will be insignificantly different across groups in the 2014 test. The results in Table 12 confirm that the difference in the percentages of local sovereigns in total assets between groups is not pronounced.

My results favor the ideas of Acharya and Steffen (2015), where banks bet on the resurrection on sovereigns from the government in order to earn extra returns. Besides the pressure from the local government, the banks' preference for risk also plays a role in the holdings of home sovereigns. Marginal banks have a greater appetite in the risk of local sovereigns than safe banks.

6.3.3 Which Credit Rating of Sovereigns is Most Preferred Among Banks?

The estimates of $Post \times Safe \times Level$ will show which credit rating the sovereigns belong to are most preferred by banks after the test. Recall that *Level* indicates the credit ratings of sovereigns. As shown in Table 8, banks have no distinct preference for the different credit ratings of sovereigns after the 2011 tests. Marginal banks most prefer the sovereigns in the BBB credit rating with the A[34] credit rating preferred second compared to safe banks after the 2014 test. In other words, they carry out more risk-shifting in these two categories of sovereigns. Compared with safe banks, marginal banks hold on average around 2.865%** and 1.185%** more in the sovereigns of credit rating BBB and A respectively after the 2014 test. Additionally, marginal banks hold sovereigns more aggressively (around 2.682%*) in the credit rating BBB than fragile banks after the test.

When the credit rating of the sovereigns is controlled, the β_1 is still significantly negative and the absolute effect in 2014 is still larger than in the previous test.

[34]The sovereigns in Czech, Malta, Poland and Slovakia have the A credit rating in both tests; those of Bulgaria, Iceland, Latvia are also in both tests.

6.3.4 Crowding out Corporate Lending?

The crowding out effect between sovereigns and lending to corporates is investigated in the literature. The more a bank holds in sovereigns, the less it can invest in industrial firms given the level of available funds. I have found that marginal banks are more active in shifting the investment of sovereigns than the other two groups. In proposition 1, I predict that safe banks are not going to decrease their optimal portfolios due to the arrival of the test. They may not cut their loans, as they are considered as risky assets and assigned higher risk-weights than sovereigns. In this regression, the benchmark is the safe bank. According to the regulations, we have six categories of credit exposure: central bank and local government,[35] institutions,[36] corporates, retail, equity and securitization. In the following, I analyze the evolution trend of the different types of credit exposure across groups.

In Table 15, the last two columns present the variations of lending to corporates across groups after the 2014 test. The $Marginal \times Post$ and $Fragile \times Post$ capture the difference in credit exposure across groups after the test.

I find that fragile banks cut their lending to corporates 6.27%* more than safe banks. The difference between marginal banks and safe banks for lending to corporates stays the same. After the test, safe banks increase their credit exposure to corporates by 2.71%*. One possible explanation is that fragile banks try to move their portfolios to safe positions (K/W stated in Section Economic Hypothesis) by cutting their risky loans; the business given up by fragile banks may be taken over by safe banks. An alternative explanation is that fragile banks may be affected by a negative demand shock to loans from their clients, so fragile banks have to involuntarily lower their lending amounts. Since the counter-parties of corporates are different across groups, it cannot be concluded that the variations on lending across groups are driven by the test. However, from Tables 15 and 16, we can see the variations of different types of credit exposures across different groups

[35] Central governments or central banks + regional governments or local authorities.

[36] Public sector entities + multilateral development banks + international organizations + institutions.

before or after the test. Safe banks engage in fewer securitization activities after the test, and expand their investments on lending to corporates, institutions and government.

7 Corporate Bond Market Reactions

The information released by the EBA on the stress tests is rich, and understanding how the information is transmitted and affects the market is critical. Camara, Pessarossi, and Philippon (2016) prove that the stress tests are informative. The reaction to stress tests on the stock has been documented by different papers: Petrella and Resti (2013), Cardinali and Nordmark (2011), and Candelon and Sy (2015). In this section, I investigate whether or not corporate bond markets react in the same way as the stock market to the information shocks from the stress tests.

7.1 Tested Banks' Reactions

In this paper, I use the daily corporate bond yields issued by banks on the OTC market to approximate banks' financing costs.[37] The higher the required return on bonds of bank i on the market, the more banks need to pay to new bondholders so as to issue new bonds. In the OTC market, Euro-denominated bonds are traded on average four times a day and Sterling bonds are traded 1.5 times a day (Biais and Declerck (2013)). They also find that it takes at least five trading days for the information content of a trade to be fully impounded in market pricing. In this event study, the time-window around the released information dates is from five days before to five days after. In the robustness check, time windows vary from five days to three months.

Tested banks are affected by the direct information shocks from the tests on the released report dates, 15th July 2011 and 26th October 2014 respectively. I define the bank level information shocks as the difference between real CET 1 ratios and the expected

[37] I also use the issuance costs of banks to conduct the robustness check.

CET 1 ratios, i.e., $Shock_{i,t} = CET1_{i,t} - E_{t-1}(CET1_{i,t})$, where $E_{t-1}(CET1_{i,t})$ is based on the passed CET 1 ratios released by EBA and all the CET 1 ratios are the forecasted capital ratios in two years under some hypothetical shocks. A positive $Shock_{i,t}$ means a good information shock for bank i, indicating that bank i has a solid capital structure from the regulators' view and has less difficulty in refinancing on the market than other banks affected by negative information shocks. Consider the following equation:

$$\begin{aligned} r(i,j,t) =& \beta_1 Shock_{i,t} \times Post + IssueSize_{i,t} + SovereignYield_{j,t} + lsize_{i,t-1} + ROA_{i,t} \\ &+ FE + Trend + i.Location \times Trend + \epsilon_{i,j,t}. \end{aligned}$$

The dependent variable $r(i,j,t)$ is the daily corporate bond yield of bank i at date t located in country j. Post is the time dummy indicating before or after the test. $IssueSize_{i,t}$ is the market size of bond i at time t; $SovereignYield_{j,t}$ is the sovereign bond yield of bank i that is located in country j at date t. $lsize$ is the log of total asset of bank i and ROA is the return on assets of bank i. $Trend$ controls for the time trend, and $location \times Trend$ captures the country level time trend effect. FE controls for the banks' fixed effect.

From Table 17, we see that $r(i,j,t)$ is negative; for a tested bank, its financing cost will decrease 90.6* basis points within five days around the released report date if its real tested CET 1 ratio is higher than the expected ratio of 1%. I also consider the following regression to investigate the different levels of sensitivities to shocks across groups:

$$\begin{aligned} r(i,j,t) =& \beta_1 Shock_{i,t} \times Safe + \beta_2 Shock_{i,t} \times Fragile + IssueSize_{i,t} \\ &+ SovereignYield_{j,t} + lsize_{i,t-1} + ROA_{i,t} + FE + Trend \\ &+ i.Location \times Trend + \epsilon_{i,j,t}. \end{aligned}$$

Marginal banks are treated as benchmarks. I expect that safe banks are less sensitive to shocks compared to other group of banks, i.e., $\beta_1 < 0$, and that the fragile banks are more sensitive to the information shocks than marginal banks i.e., $\beta_1 > 0$. Table 19 shows that

if banks have a 1% higher CET 1 ratio than expected, then marginal banks' financing costs will be around 48.6** basis points lower, while the fragile banks' financing costs on the corporate bond market will decrease only 10.1* basis points. On the contrary, if the real CET 1 is 1% lower than expected, then the marginal banks need to pay 48.6** more basis points, and fragile banks need to pay 86.7* more basis points if they want to finance on the corporate bond market.

7.2 Untested Banks

I expect that the untested banks may be affected by the information shock at country level. For instance, given other factors as constant, an untested bank located in Spain where five banks fail the test will face a higher financing cost after the 2011 test than an untested bank of similar size located in Germany where no banks fail the test.

I define different information shocks to all the banks of country j using the information of the tests:

(1) an average CET 1 shock: $Shock^{(1)} = CET1_{j,t} - E_{t-1}(CET1_{j,t})$;

(2) the number of marginally passed banks (M) and failed banks (F): $Shock^{(2)} = M + F$;

(3) the percentage of marginally passed banks and failed banks (with equal weights): $Shock^{(3)} = (M + F)/Totalbanks$;

(4) the percentage of marginally passed banks and failed banks with double weights: $Shock^{(4)} = (M + F \times 2)/Totalbanks$.

The results of the first regression in this section (see Table 19), show that for untested banks located in a country where there is an unexpected decrease in CET 1 ratio, their financing cost will be 118* higher than the untested banks located in a country without negative information shocks. Column (2) of Table 21 implies that if there is a bank which fails the test, the untested banks face an increase of 5.7** basis points on the financing cost which is not economically statistically significant. In the last column of Table 21, we learn that if 1% of tested banks fail the tests in a particular country, the untested

banks located in that country will face an increase in financing costs, of around 55.3* basis points, compared with other banks in countries with no shocks.

8 Robustness Check

In this section, I conduct a series of robustness checks to verify the consistency of the main results.

8.1 Other Dependent Variables

In the same credit rating, I define the dependent variable as the difference between the sum amounts of the sovereigns with higher yields and those with lower yields, $S_{1,i,t} - S_{0,i,t}$, scaled down by the total sovereigns or the total assets. The dependent variable is an approximation of the extent of risk-shifting in one credit rating. Consider the following equation:

$$\begin{aligned}\frac{S_{1,i,t} - S_{0,i,t}}{AT_{i,t}} =& \beta_1 Post \times Group_i + \beta_2 Post \times Level + \beta_3 Level + CountryFE_i \times Post \\ &+ FE + Controls + \varepsilon_{i,t},\end{aligned}$$

where $S_{1,i,t}$ is the sum amount of sovereigns whose yields are higher than the median in one credit rating, and $S_{0,i,t}$ is the sum amount of sovereigns whose yields are lower than the median in one credit rating. In Tables 24 and 25, the estimate of β_1 shows the same negative sign as that in the regression in Section 5 (see Table 8). Also, I scale down the dependent variable by its total assets in order to check the robustness of the main results (see Tables 26 and 27).

8.2 Restricted to Banks with Low Variation on CET 1

I only include banks without changing groups after recapitalization so as to rule out possible endogeneity problems from grouping. It may be of some concern that the results are driven by the fact that banks that are closed to fail the test need to aggressively increase their CET 1 ratios by adjusting all of their assets. Therefore, I keep only those banks that have not adjusted CET 1 ratios to switch into other groups. In Table 28If we only consider banks that have not adjusted their CET 1 ratio more than 1 %, the results still hold (see Table 28).

8.3 Combine Two Tests

I perform the estimation for each test separately in the main results due to the fact that the samples are not exactly the same in the two tests. Now, I run the regression combining the two tests. I define Post=0 if the dates are before the 2011 test, Post=1 if the dates are between the first and the second test, and Post=2 if the dates are after the 2014 test. In Tables 29 and 30, $PostTest1 \times RA \times Safe$ and $PostTest1 \times RA \times Fragile$ are the estimates of β_1 in the 2011 test. $PostTest2 \times RA \times Safe$ and $PostTest2 \times RA \times Fragile$ are the difference of estimates of β_1 in the 2014 test compared with the 2011 test. Both results are consistent with the main results.

8.4 Time-dependent Credit Rating

Do sovereigns become riskier during the test? Specifically, since the credit ratings of the sovereigns of Greece, Iceland and Ireland decrease after the 2011 test, it might therefore be inappropriate to treat them in the same credit rating levels. However, most of the sovereigns stay in the same category of credit ratings (see the summary in Table 35) throughout the tests. To eliminate the concern that a small fraction of sovereigns with time-dependent credit ratings may bias the estimates, I replace the time-independent

RA by the time-dependent RA. In Tables 31 and 32, the results confirm that β_1 is still significantly negative with the effect stronger in the 2014 test.

8.5 Time Trend Effect

I test the time trend effect on the holding of sovereigns across groups of banks. One potential problem is that the significant estimates are not driven by the test but only by the time trend of holdings on some sovereigns. Therefore, in the following regression, I investigate the evolution of different holdings of sovereigns across groups from 2010 to 2015.

$\frac{Sovereign_{i,j,t}}{AT_{i,t}} = \beta_1 TimeTrend \times Safe + \beta_2 TimeTrend \times Fragile + \beta_3 Group_i \times RA + \beta_4 TimeTrend \times RA + FE + TimeTrend + lsize_{i,j,t} + localCountry + LocalCountry * Post + i.sovereign_j * Post + i.sovereign_j + TimeTrend + \varepsilon_{i,t}$.

If β_1 and β_2 are not significant, then there is no significant difference on holding one specific sovereign across groups. In Table 33, the estimates of the coefficients on $TimeTrend \times Safe$ and $TimeTrend \times Fragile$ are insignificant. In other words, the fact that marginal banks conduct more regulatory arbitrage than safe banks is not driven by the time trend effect of some sovereigns.

9 Conclusion

In this paper, I empirically show that marginally regulatory constrained banks (whose regulatory constraint is closed to binding) shift their investment to those sovereign bonds with higher yields in the same risk-weighting credit rating more aggressively than unconstrained banks (safe banks, i.e., whose capital ratio is far above the regulatory level) after the stress test. Such divergence of holdings across bank groups confirms the classical regulatory arbitrage theory.

Interestingly, marginally constrained banks conduct more regulatory arbitrage than fragile banks (i.e., whose capital ratio is below the regulatory level), and are willing to perform risk-shifting in one credit rating. Also, compared to safe banks and marginally constrained banks, fragile banks engage in less lending to corporates, which is assigned a much higher risk weighting according to the Basel III Accord when computing the capital ratios. These noteworthy facts demonstrate that safe banks are less constrained when choosing their optimal portfolios and have no need to stop their long-term investments in order to pass the regulators' tests.

Furthermore, the home bias sovereign holdings are not entirely explained by pressure from local government. The fact that banks gamble for the resurrection in order to earn extra returns also plays a role in terms of the sovereign home bias.

Finally, besides tested banks, untested banks that are located in the country with negative information shocks from the test will bear higher financing costs than banks that are located in a country with positive information shocks; thus providing banking sectors with an indirect means to transmit the effects of the stress test.

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A Appendix 1

Table 2: Summary credit expoure 1

Variable	Mean	Std. Dev.	Min.	Max.	N
Total	88411.656	112844.99	175.214	608658.563	459
Central	28443.738	39499.842	0.043	192846.422	451
Institution	12194.521	19228.164	2.69	112147.148	446
Corporate	17554.668	30513.429	0.383	220334.609	452
Retail	14284.066	24990.431	0.496	177929.813	440
Equity	1114.658	1817.761	0.044	15336.038	380
Securitization	1288.998	2407.65	0	18246.969	237
Others	6589.929	13243.329	0	120423.648	424

This table presents different classes of credit exposure values: Central (central banks and local government), institutions (financial institutions), corporates, retail, equity(private equity), securitization.

Table 3: Summary risk expoure amount 1

Variable	Mean	Std. Dev.	Min.	Max.	N
Total	36678.898	55917.456	62.147	317099.469	459
Central	1707.37	4094.434	0	29846.299	392
Institution	2166.636	4091.896	0	32045.1	446
Corporate	15831.729	27662.784	0.383	206555.078	452
Retail	8735.306	15452.46	0.201	112248.703	440
Equity	1591.457	2913.149	0.044	22770.42	379
Securitization	940.676	1902.56	0	13042.757	237
Other	4344.977	8171.403	0	72820.070	421

This table presents the risk exposure amounts (computed by adding risk weights)of different credit exposure: Central (central banks and local government), institutions (financial institutions), corporates, retail, equity(private equity), securitization.

Table 4: Summary credit expoure in groups

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Panel A		Safe banks			
Total	98347.048	123744.88	175.214	608658.563	343
Central	31650.827	42261.407	236.972	192846.422	336
Institution	13526.181	20162.067	2.69	112147.148	334
Corporate	18922.946	33295.672	23.266	220334.609	341
Retail	16275.589	27838.373	0.575	177929.813	327
Equity	1232.384	2003.683	0.044	15336.038	283
Secutization	1506.424	2659.665	1.848	18246.969	181
Others	7614.16	15070.752	0	120423.648	312
Panel B		Marginal banks			
Total	120721.976	89694.871	1997.403	301014.156	32
Central	42262.049	43826.642	9.664	145510.297	32
Institution	14737.563	25242.799	151.021	77775	32
Corporate	27731.162	29988.821	243.977	100017.555	32
Retail	16928.12	18558.242	34.9	59769.918	32
Equity	1527.813	1586.817	20.494	4971.985	26
Securitization	1121.95	1362.821	49.39	4212.173	25
Other	5753.89	7094.668	0.095	22295.063	32
Panel C		Fragile banks			
Total	35318.974	23172.457	4326.869	88774.023	82
Central	10162.144	9251.352	0.043	38112.262	81
Institution	5702.688	8157.159	22.465	53133	78
Corporate	7077.155	5845.307	0.383	24330.85	77
Retail	5270.17	5801.456	0.496	22696.471	79
Equity	497.852	561.881	6.777	2675.38	69
Securitization	154.225	183.068	0	816.218	31
Other	2864.983	2688.696	0.012	10318.343	78

Table 5: Summary Corporate bond yields

Panel A			
Variable	**Mean**	**Std. Dev.**	**N**
ry	4.033	2.142	88357
spread1	-2.629	6.645	77355
spread2	-1.38	4.684	80977
MV	2212.806	22551.888	102698
Panel B	Untested banks		
ry	4.324	2.083	10847
spread1	-3.568	8.178	11847
spread2	-1.795	5.998	10723
MV	10018.465	63312.776	12414
Panel B	Tested banks		
ry	3.993	2.148	77510
spread1	-2.46	6.314	65508
spread2	-1.317	4.446	70254
MV	1139.532	4226.114	90284
Panel C	Safe banks		
ry	3.99	2.204	32821
spread1	-2.299	4.63	32765
spread2	-1.238	2.731	31505
MV	1817.313	6097.206	38842
Panel D	Marginal banks		
ry	5.164	2.628	4405
spread1	-4.358	12.511	4880
spread2	-3.202	12.377	4086
MV	505.359	899.739	5349
Panel E	Fragile banks		
ry	4.538	2.252	5829
spread1	-5.3	7.355	6510
spread2	-2.366	2.936	5745
MV	531.569	613.485	8388

Ry is the corporate bonds yields of banks (%). Spread1 and spread2 are the bid-ask spread percentage of the corporate bonds; computed by different measures. MV is the total market value of the corporate bonds.

Table 6: European banks Regulatory Arbitrage in 2011 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Post×Safe×RA	-2.463	-2.288	-1.172*	-1.221*
	(1.821)	(1.836)	(0.591)	(0.617)
Post×Fragile×RA	-4.048*	-4.027*	-1.719**	-1.773**
	(2.154)	(2.166)	(0.675)	(0.703)
Post×Safe	0.829	1.022	0.445*	0.465*
	(0.706)	(0.739)	(0.231)	(0.241)
Post×Fragile	1.537*	1.691*	0.604**	0.625**
	(0.861)	(0.908)	(0.273)	(0.286)
Safe×RA	-1.577*	-1.577*	-0.731*	-0.715*
	(0.841)	(0.844)	(0.418)	(0.416)
Fragile×RA	-0.530	-0.530	-0.319	-0.315
	(1.005)	(1.009)	(0.470)	(0.466)
Post×RA	3.571**	3.531*	2.937***	1.889**
	(1.770)	(1.779)	(0.528)	(.7669162)
RA	-1.191	-1.191	-2.110***	1.903**
	(0.776)	(0.779)	(0.374)	(0.942)
Post	-1.222*	-1.445**	-2.165***	1.274**
	(0.684)	(0.714)	(0.221)	(0.605)
lsize	0.0883**	0.577	0.146	0.133
	(0.0405)	(0.370)	(0.240)	(0.245)
Local_c			29.07***	29.61***
			(2.085)	(1.960)
Local_c×Post			34.28***	32.60***
			(2.610)	(2.519)
Constant	2.230***	-3.117	1.383	-3.044
	(0.494)	(4.471)	(2.914)	(3.056)
Bank FE	No	Yes	Yes	Yes
sovereign FE	No	No	Yes	Yes
sovereign FE×Post	No	No	No	Yes
Observations	7380	7380	7380	7380
R-squared	0.007	0.007	0.656	0.803

The dependent variable $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$ is the sovereign j held by bank i scaled down by its total sovereigns during 2010 and 2012; Post=1 if after the 2011 stress test,otherwise Post=0. RA=1, if the sovereign bonds's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's soveregin bond. T-values are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 7: European banks Regulatory Arbitrage in 2014 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Post×Safe×RA	-2.133***	-2.132***	-1.087*	-1.079*
	(0.594)	(0.595)	(0.563)	(0.551)
Post×Fragile×RA	-3.002***	-3.000***	-1.487**	-1.486**
	(0.732)	(0.735)	(0.643)	(0.629)
Post×Safe	0.897***	0.868***	0.162*	0.167*
	(0.267)	(0.266)	(0.0897)	(0.0902)
Post×Fragile	1.468***	1.195***	0.179	0.197
	(0.309)	(0.328)	(0.279)	(0.268)
Safe×RA	-0.112	-0.113	0.618	0.576
	(1.429)	(1.434)	(1.108)	(1.118)
Safe×RA	0.462	0.460	0.606	0.559
	(1.748)	(1.755)	(1.244)	(1.258)
RA	-0.505	-0.505	-1.229	-1.850
	(1.340)	(1.345)	(1.052)	(2.131)
Post	-1.071***	-1.068***	-0.0206	0.0389
	(0.257)	(0.255)	(0.0702)	(0.361)
lsize	0.00113	0.00127	-0.0158	-0.0158
	(0.00773)	(0.00119)	(0.0174)	(0.0174)
Post×RA	2.499***	2.499***	1.022*	1.762**
	(0.563)	(0.564)	(0.530)	(.651)
Local_c			58.66***	57.82***
			(4.420)	(4.513)
Local_c ×Post			-6.421**	-6.719**
			(2.858)	(2.834)
Constant	2.514***	2.487***	1.326***	0.536
	(0.520)	(0.165)	(0.254)	(0.747)
Observations	7308	7308	7308	7308
R-squared	0.001	0.001	0.668	0.689

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2013 and 2015; Post=1 if after the 2014 stress test,otherwise Post=0. RA=1, if the sovereign bonds's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond.T-values are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 8: European banks Regulatory Arbitrage

VARIABLES	2011 $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	2011 $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	2014 $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	2014 $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Post×Safe×RA	-0.284*	-1.209**	-0.596**	-1.729**
	(0.155)	(0.541)	(0.253)	(0.795)
Post×Fragile×RA	-0.214**	-1.752***	-0.465*	-1.706*
	(0.0990)	(0.624)	(0.253)	(0.875)
Post×Safe	0.138	0.734	0.525**	1.393***
	(0.151)	(0.477)	(0.260)	(0.514)
Post ×Fragile	0.00713	0.261	0.180	0.701
	(0.0735)	(0.562)	(0.202)	(0.483)
Safe×RA	0.106	-0.633*	-0.354**	-1.206
	(0.146)	(0.347)	(0.158)	(0.793)
Fragile×RA	0.0139	-0.505	-0.361*	-2.134**
	(0.0721)	(0.392)	(0.193)	(1.047)
RA	0.0939	0.959	0.690***	2.715*
	(0.167)	(0.714)	(0.228)	(1.556)
Post	0.291***	1.108**	0.203	0.632
	(0.109)	(0.480)	(0.146)	(0.503)
Local_c	6.055***	29.56***	6.562***	56.52***
	(1.149)	(1.955)	(0.651)	(4.248)
Local_c×Post	-0.668	33.09***	1.291	-6.242**
	(1.096)	(2.488)	(0.781)	(2.703)
lsize	-0.248***	-0.128	-1.752***	-0.00935
	(0.0775)	(0.314)	(0.193)	(0.0455)
Post×Safe×Level2	-0.841	-0.875	-0.0966	-0.262
	(0.592)	(1.179)	(0.142)	(0.636)
Post×Safe×Level3	0.163**	-0.401	-0.198	-1.185**
	(0.0757)	(0.876)	(0.262)	(0.509)
Post×Safe×Level4	0.0550	-0.0221	-0.785**	-2.865**
	(0.0508)	(0.324)	(0.352)	(1.184)
Post×Safe×Level5	0.0741	0.0485	-0.0872	-0.712
	(0.0605)	(0.437)	(0.227)	(0.569)
Post×Safe×Level6			0.191	0.513
			(0.224)	(0.481)
Post×Fragile×Level2	-0.272	-0.555	-0.0663	0.104
	(0.324)	(1.724)	(0.117)	(0.590)
Post×Fragile×Level3	0.137*	0.0950	0.00459	-0.162
	(0.0705)	(1.042)	(0.0696)	(0.442)
Post×Fragile×Level4	0.105	1.867*	-0.509	-2.682*
	(0.103)	(0.984)	(0.349)	(1.477)
Post×Fragile×Level5	0.0581	0.331	0.205	-0.0866
	(0.0576)	(0.441)	(0.425)	(1.464)
Post×Fragile×Level6			0.303*	0.635
			(0.164)	(0.501)

Continue Table 3

Table 9: Continue Table 8: European banks Regulatory Arbitrage

	(1)	(2)	(3)	(4)
Constant	2.787***	1.036	20.60***	-2.812
	(0.963)	(3.975)	(2.371)	(1.973)
Leveli	Yes	Yes	Yes	Yes
Safe×i.Level	Yes	Yes	Yes	Yes
Safe×i.Level	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes	Yes
sovereign FE×Post	Yes	Yes	Yes	Yes
Observations	7,830	7,830	7,308	7,262
R-squared	0.483	0.787	0.455	0.735

The first two columns contain the results of 2011 test and the last two columns present those of 2014. The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets and $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$ is the sovereign j held by bank i scaled down by his total sovereigns. Before the test Post is equal to 0, otherwise equal to 1. Leveli, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%.

Table 10: European banks Home Bias on sovereign in 2011 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Local_c×Safe×Post	-3.769*	-3.947*	-3.869*
	(2.011)	(2.309)	(2.155)
Local_c×Fragile×Post	-1.557	-1.472	-1.843*
	(1.128)	(1.208)	(1.007)
Post×Local_c	2.286**	2.517**	2.313**
	(0.951)	(1.125)	(0.951)
Local_c×Safe	0.968	1.320	1.164
	(2.056)	(2.298)	(2.225)
Local_c×Fragile	0.473	0.584	0.518
	(1.254)	(1.250)	(1.275)
Local_c	5.468***	5.006***	5.150***
	(0.928)	(1.049)	(1.019)
Post×Safe	0.165	0.167	0.252
	(0.116)	(0.120)	(0.201)
Post×Fragile	0.0236	0.0202	0.0691
	(0.0492)	(0.0490)	(0.0678)
Safe×RA	0.0862	0.0735	0.0826
	(0.123)	(0.116)	(0.112)
Fragile×RA	-0.00645	-0.0126	-0.00388
	(0.0653)	(0.0693)	(0.0673)
Safe×RA×Post	-0.227*	-0.218*	-0.214*
	(0.123)	(0.115)	(0.109)
Fragile×RA×Post	-0.113**	-0.112*	-0.104*
	(0.0556)	(0.0593)	(0.0539)
Post	-0.0369	0.207**	0.132**
	(0.0407)	(0.101)	(0.0606)
lsize	-0.240***	-0.240***	-0.274***
	(0.0794)	(0.0797)	(0.0916)
Constant	2.889***	2.678***	3.089***
	(0.980)	(1.004)	(1.135)
RA	Yes	Yes	Yes
RA×Post	Yes	Yes	Yes
$Group_i$×i.Level	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE×Post	No	Yes	Yes
$Group_i$×i.Level×Post	No	No	Yes
Observations	7,830	7,830	6,322
R-squared	0.475	0.491	0.463

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2010 and 2012. Post=1 if after the 2011 stress test,otherwise Post=0. RA=1, if the sovereign bonds's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's soveregin bond. Leveli, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. Clustered standard errors are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 11: European banks Home Bias on sovereign in 2011 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Local_c×Safe×Post	-11.31**	-10.69**	-12.42*
	(4.653)	(4.989)	(6.939)
Local_c×Fragile×Post	-1.098	-0.254	-6.041
	(6.147)	(6.315)	(8.458)
Post	0.231*	0.923*	0.384
	(0.120)	(0.495)	(0.480)
Post×Local_c	43.28***	42.16***	45.41***
	(3.795)	(4.311)	(6.435)
Local_c×Safe	-14.52***	-13.87***	-13.92***
	(4.169)	(4.128)	(4.217)
Local_c× Fragile	-4.190	-3.890	-4.038
	(4.926)	(4.787)	(4.891)
Post×Safe	0.900***	0.893***	1.580***
	(0.225)	(0.231)	(0.423)
Post×Marginal	0.349	0.343	0.763
	(0.272)	(0.273)	(0.481)
Local_c	40.71***	39.86***	39.97***
	(3.338)	(3.376)	(3.503)
RA	0.128	0.499	0.550
	(0.126)	(0.592)	(0.595)
Safe×RA	-0.303	-0.321	-0.367
	(0.233)	(0.238)	(0.222)
Fragile×RA	-0.236	-0.250	-0.330
	(0.212)	(0.222)	(0.210)
Safe×RA×Post	-1.249***	-1.274***	-1.309***
	(0.332)	(0.338)	(0.370)
Fragile×RA×Post	-1.229***	-1.273***	-1.382***
	(0.454)	(0.455)	(0.459)
lsize	-0.114	-0.114	0.0982
	(0.313)	(0.315)	(0.236)
Constant	1.904	1.111	-1.502
	(3.851)	(3.950)	(2.997)
RA	Yes	Yes	Yes
RA×Post	Yes	Yes	Yes
$Group_i$×i.Level	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE×Post	No	Yes	Yes
$Group_i$×i.Level×Post	No	No	Yes
Observations	7,830	7,830	6,322
R-squared	0.794	0.803	0.808

The dependent variable $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$ is the sovereign j held by bank i scaled down by his total sovereigns during 2010 and 2012. Post=1 if after the 2011 stress test,otherwise Post=0. RA=1, if the sovereign bonds's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's soveregin bond. Leveli, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. Clustered standard errors are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 12: European banks Home Bias on sovereign in 2014 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Local_c×Safe×Post	-3.441	-3.574	-3.520
	(2.488)	(2.283)	(2.363)
Local_c×Fragile×Post	-3.540	-3.578	-3.523
	(2.921)	(2.773)	(2.832)
Post×Local_c	4.336*	4.379**	4.316*
	(2.284)	(2.081)	(2.167)
Local_c×Safe	-2.518	-2.594	-2.272
	(3.793)	(3.682)	(3.699)
Local_c× Fragile	1.571	1.404	1.643
	(4.274)	(4.133)	(4.151)
Local_c	8.832**	8.775**	8.433**
	(3.720)	(3.607)	(3.624)
Post×Safe	0.372***	0.378***	0.379***
	(0.132)	(0.128)	(0.131)
Post×Fragile	0.118	0.121	0.121
	(0.126)	(0.120)	(0.123)
Safe×RA	-0.431	-0.430	-0.396
	(0.336)	(0.339)	(0.342)
Fragile×RA	-0.377	-0.377	-0.399
	(0.351)	(0.354)	(0.354)
Safe×RA×Post	-0.429**	-0.431**	-0.437**
	(0.185)	(0.188)	(0.188)
Fragile×RA×Post	-0.396***	-0.400***	-0.404***
	(0.105)	(0.107)	(0.105)
Post	-0.200*	0.184	0.189
	(0.113)	(0.152)	(0.158)
lsize	-1.833***	-1.833***	-1.833***
	(0.133)	(0.134)	(0.134)
Constant	22.31***	21.53***	21.54***
	(1.662)	(1.651)	(1.650)
RA	Yes	Yes	Yes
RA×Post	Yes	Yes	Yes
$Group_i$×i.Level	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE×Post	No	Yes	Yes
$Group_i$×i.Level×Post	No	No	Yes
Observations	5,771	5,771	5,771
R-squared	0.438	0.456	0.456

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2013 and 201. Post=1 if after the 2014 stress test,otherwise Post=0. RA=1, if the sovereign bonds's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's soveregin bond. Leveli, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. Clustered standard errors are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 13: European banks Home Bias on sovereign in 2014 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Local_c×Post×Safe	-9.017**	-8.972***	-8.597***
	(3.505)	(3.090)	(3.178)
Local_c×Post×Fragile	-13.48**	-13.04**	-12.71**
	(6.296)	(6.047)	(6.002)
Local_c ×Post	5.972**	5.597**	5.194**
	(2.788)	(2.201)	(2.306)
Local_c ×Safe	-9.581	-10.07	-10.21
	(15.80)	(15.15)	(15.41)
Local_c ×Marginal	10.73	10.06	9.577
	(17.19)	(16.45)	(16.77)
Local_c	65.99***	65.55***	65.44***
	(14.99)	(14.39)	(14.69)
Post×Safe	0.358*	0.355*	0.343
	(0.206)	(0.205)	(0.207)
Post×Fragile	0.717**	0.707**	0.697**
	(0.281)	(0.279)	(0.274)
Safe×RA	-0.724	-0.716	-0.650
	(0.803)	(0.805)	(0.787)
Fragile×RA	-0.797	-0.787	-0.782
	(0.780)	(0.793)	(0.779)
Safe×RA×Post	-0.247	-0.244	-0.246
	(0.327)	(0.334)	(0.342)
Fragile ×RA×Post	-0.805**	-0.818**	-0.820**
	(0.361)	(0.367)	(0.385)
Post	-0.301*	0.0462	0.0760
	(0.179)	(0.424)	(0.413)
lsize	0.0142*	0.0142*	0.0142*
	(0.00822)	(0.00825)	(0.00825)
Constant	1.059***	-2.989	-2.972
	(0.357)	(1.829)	(1.818)
RA	Yes	Yes	Yes
RA×Post	Yes	Yes	Yes
$Group_i$×i.Level	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE×Post	No	Yes	Yes
$Group_i$×i.Level×Post	No	No	Yes
Observations	5,742	5,742	5,742
R-squared	0.733	0.748	0.750

The dependent variable $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$ is the sovereign j held by bank i scaled down by his total sovereigns during 2013 and 2015;Post=1 if after the 2014 stress test,otherwise Post=0. RA=1, if the sovereign bonds's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's soveregin bond. Leveli, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. Clustered standard errors are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 14: Credit exposure

VARIABLES	(1) CreditEX	(2) CreditEX	(3) CreditEX	(4) CreditEX
post	0.288***	0.283***	0.246***	0.249***
	(0.0290)	(0.0650)	(0.0415)	(0.0695)
Marginal×post	-0.0587	-0.0585	-0.0701	-0.0701
	(0.0893)	(0.0840)	(0.0517)	(0.0459)
Fragile×post	0.250***	0.249***	0.515***	0.515***
	(0.0761)	(0.0860)	(0.102)	(0.124)
post×GIIPS			0.127**	0.123**
			(0.0466)	(0.0469)
Marginal×post×GIIPS			0.168	0.175
			(0.280)	(0.282)
Fragile×post×GIIPS			-0.458***	-0.454***
			(0.119)	(0.128)
lsize	0.0672	0.0542	0.128	0.123
	(0.0934)	(0.105)	(0.0885)	(0.106)
Constant	-0.611	-0.445	-1.359	-1.286
	(1.141)	(1.299)	(1.081)	(1.317)
Year Effect	No	Yes	No	Yes
Bank Effect	Yes	Yes	Yes	Yes
Observations	228	228	228	228
R-squared	0.737	0.741	0.748	0.751

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

Dependent variable is the total credit exposure value of each bank. Post=1 after the 2014 test(year 2015) and post=0 before the test(2013). lsize is the log of last year total asset. Benchmark banks are safe banks.

Table 15: Credit exposure to different types

VARIABLES	(1) Central	(2) Central	(3) Institution	(4) Institution	(5) Corporate	(6) Corporate
Marginal×Post	0.0186	0.0262	-0.00958	-0.00600	-0.0179	-0.0127
	(0.0224)	(0.0199)	(0.00767)	(0.00988)	(0.0251)	(0.0162)
Fragile× Post	0.0758**	0.0210	0.0795**	-0.0124	-0.0516***	-0.0627*
	(0.0309)	(0.0830)	(0.0375)	(0.0113)	(0.0141)	(0.0355)
Post	0.0599***	0.0533**	0.0358***	0.0334***	0.0526***	0.0271***
	(0.0177)	(0.0251)	(0.00868)	(0.00962)	(0.0160)	(0.00912)
Post×GIIPS		0.0192		0.00457		0.0429***
		(0.0221)		(0.00822)		(0.0118)
Marginal×post×GIIPS		-0.0285		-0.0208		0.00542
		(0.0810)		(0.0241)		(0.0729)
Fragile×post×GIIPS		0.0746		0.137**		-0.00146
		(0.0914)		(0.0524)		(0.0357)
lsize	0.00531	0.00670	0.0475**	0.0416*	-0.0143	-0.000304
	(0.0365)	(0.0305)	(0.0222)	(0.0226)	(0.0461)	(0.0491)
Constant	-0.00555	-0.0229	-0.556*	-0.483*	0.225	0.0650
	(0.450)	(0.377)	(0.275)	(0.280)	(0.572)	(0.595)
Date Effect	Yes	Yes	Yes	Yes	Yes	Yes
Bank Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	228	228	228	228	228	228
R-squared	0.522	0.529	0.677	0.708	0.690	0.700

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

Central is the credit exposure to Central banks and central governments scaled down by total assets; Institution is the credit risk amount exposed to institutions scaled down by total assets; Corporate is the credit exposure to corporates scaled down by total assets. GIIPS is a location dummy, GIIPS=1 if a locate locate in GIIPS country(Greece, Italy, Ireland, Portugal, Spain).

Table 16: Credit exposure to different types

VARIABLES	(1) Retail	(2) Retail	(3) Equity	(4) Equity	(5) Securi	(6) Securi
Marginal×post	-0.0315	-0.0161	-0.00257*	-0.00183***	0.00115	0.00126
	(0.0338)	(0.0112)	(0.00141)	(0.000564)	(0.00075)	(0.00096)
Fraigile ×post	-0.00369	0.00708	0.00229	0.00151*	0.000348	0.000320
	(0.0240)	(0.0591)	(0.00165)	(0.000793)	(0.00116)	(0.00146)
Post	0.0178	0.0145	0.00294***	0.00296***	-0.00048	-0.000709
	(0.0179)	(0.0143)	(0.000413)	(0.000718)	(0.00102)	(0.00132)
Post×GIIPS		-0.0257		-0.000181		0.000759
		(0.0154)		(0.00104)		(0.000989)
Marginal×Post×GIIPS		-0.102		-0.00420		1.84e-06
		(0.108)		(0.00450)		(0.00165)
Fragile ×Post×GIIPS		-0.00663		0.00120		-0.000284
		(0.0581)		(0.00247)		(0.00102)
lsize	0.0133	0.00107	0.00835**	0.00806**	0.00055	0.000803
	(0.0533)	(0.0511)	(0.00308)	(0.00297)	(0.00172)	(0.00199)
Constant	-0.112	0.0495	-0.1000**	-0.0964**	-0.00496	-0.00812
	(0.658)	(0.622)	(0.0379)	(0.0365)	(0.0203)	(0.0236)
Date Effect	Yes	Yes	Yes	Yes	Yes	Yes
Bank Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	228	228	228	228	228	228
R-squared	0.634	0.643	0.810	0.812	0.350	0.351

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

Retail is the credit exposure to rerails scaled down by total assets; Equity is the credit risk amount exposed to Equity scaled down by total assets; Securi is the credit exposure tosecuritization scaled down by total assets. GIIPS is a location dummy, GIIPS=1 if a locate locate in GIIPS country(Greece, Italy, Ireland, Portugal, Spain).

Table 17: Corporate bond yields' reaction to information shocks

VARIABLES	(1) $r_{i,t}$	(2) $r_{i,t}$	(3) $r_{i,t}$	(4) $r_{i,t}$	(5) $r_{i,t}$	(6) $r_{i,t}$	(7) $r_{i,t}$
shock1	-0.164***	-0.174***	-0.0683*	-0.130***	-0.146***	-0.0630*	-0.0906*
	(0.0541)	(0.0511)	(0.0354)	(0.0464)	(0.0434)	(0.0371)	(0.0545)
Sovereign	0.692***	0.626***	-0.0936	0.753***	0.741***	-0.0192	0.714***
	(0.141)	(0.179)	(0.137)	(0.255)	(0.255)	(0.237)	(0.228)
Bond_size		-0.290	-0.102	-0.256	-0.247	-0.0939	-0.204
		(0.294)	(0.268)	(0.302)	(0.296)	(0.267)	(0.272)
lsize		2.072*	0.701		1.851	0.634	1.481*
		(1.103)	(0.640)		(1.142)	(0.675)	(0.835)
ROA				14.55	9.625	2.056	5.645
				(12.91)	(13.09)	(8.893)	(13.20)
Post							-0.859**
							(0.360)
Trend			-0.0753***	-.0643428***	-.0631627***	-0.0726***	
			(0.00783)	(.00424)	(.00445)	(0.00921)	
GIIPS×Trend						0.00152	
						(0.0170)	
Constant	2.802***	-20.46	-1.790	4.162**	-18.25	-1.236	-13.48
	(0.185)	(13.38)	(7.941)	(1.808)	(13.80)	(8.376)	(10.17)
Bank EF	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Location×Post	No	No	No	No	No	No	Yes
Observations	3,719	3,021	3,021	2,854	2,854	2,854	2,854
R-squared	0.724	0.763	0.872	0.774	0.780	0.873	0.833

The dependent variable is the corporate bond yield of bank i at day t; $shock_{i,t} = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation;

Table 18: Corporate bond yields' reaction to information shocks(3m)

VARIABLES	(1) $r_{i,t}$	(2) $r_{i,t}$	(3) $r_{i,t}$	(4) $r_{i,t}$	(5) $r_{i,t}$	(6) $r_{i,t}$	(7) $r_{i,t}$
shock1	-0.315***	-0.328***	-0.186***	-0.164***	-0.331***	-0.176***	-0.152***
	(0.0675)	(0.0664)	(0.0533)	(0.0544)	(0.0651)	(0.0537)	(0.0455)
Sovereign	0.473***	0.387***	0.0828	0.110	0.389***	0.113*	0.0941*
	(0.123)	(0.112)	(0.0643)	(0.0692)	(0.135)	(0.0638)	(0.0505)
issue_size		-0.420	-0.208	-0.199	-0.402	-0.192	-0.207
		(0.298)	(0.264)	(0.266)	(0.297)	(0.263)	(0.262)
ROA				8.640	-2.574	5.874	-30.52*
				(6.741)	(8.665)	(8.044)	(17.91)
lsize		2.342*	1.237*		2.437*	1.064	1.089*
		(1.320)	(0.678)		(1.463)	(0.727)	(0.558)
Trend			-0.0628***	-0.0643***		-0.0633***	-0.0676***
			(0.00394)	(0.00424)		(0.00445)	(0.00894)
GIIPS×Trend						0.000287	
						(0.0127)	
Constant	3.520***	-22.34	-8.202	6.803***	-23.74	-6.245	-6.577
	(0.195)	(16.06)	(8.381)	(1.546)	(17.84)	(8.976)	(6.851)
Bank EF	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Location×Trend	No	No	No	No	No	No	Yes
Observations	31,744	24,327	24,327	22,928	22,928	22,928	22,928
R-squared	0.645	0.707	0.825	0.825	0.711	0.827	0.848

The dependent variable is the corporate bond yield of bank i at day t; $shock_{i,t} = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation;

Table 19: Untested banks' corporate bond yields' reaction to information shocks

	(1)	(2)	(3)	(4)
Shock	-0.226***	-0.193***	-0.117*	-0.118*
	(-3.81)	(-5.17)	(-2.09)	(-2.21)
own_sovereign_yield	0.293*	-0.011	-0.231***	-0.123
	(1.73)	(-0.24)	(-3.48)	(-0.83)
issue_size		-12.088***	-7.686***	-7.468***
		(-9.79)	(-4.82)	(-4.48)
lsize		-2.202	-0.700	-0.386
		(-0.88)	(-0.45)	(-0.23)
ROA				-126.567
				(-0.80)
Constant	3.576***	82.943**	48.159*	43.901
	(13.55)	(2.78)	(2.10)	(1.78)
Bank FE	Yes	Yes	Yes	Yes
Time Trend	No	No	Yes	Yes
Observation	713	345	345	345
R^2	.8076365	.9109562	.95518349	.96047013

The dependent variable is the corporate bond yield of bank i at day t; $shock_{i,t} = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation;

Table 20: Untested banks' Corporate bond yields' reaction to information shocks(3 months)

	(1)	(2)	(3)	(4)
Shock	-0.331***	-0.224***	-0.171***	-0.174***
	(-4.75)	(-5.78)	(-4.36)	(-4.35)
own_sovereign_yield	0.349**	0.013	-0.078	0.025
	(2.27)	(0.27)	(-1.46)	(0.33)
issue_size		-11.861***	-9.790***	-9.318***
		(-10.26)	(-5.06)	(-5.50)
lsize		-2.020	-1.226	-0.740
		(-0.77)	(-0.56)	(-0.36)
ROA				-200.905*
				(-2.07)
Constant	3.738***	81.182**	63.639*	56.682*
	(13.81)	(2.68)	(2.11)	(2.00)
Bank FE	Yes	Yes	Yes	Yes
Time Trend	No	No	Yes	Yes
Observation	5912	2890	2890	2890
R^2	.75155182	.88236829	.9046281	.92606128

The dependent variable is the corporate bond yield of bank i at day t; $shock_{i,t} = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation;

Table 21: Untested banks' Corporate bond yields' reaction to information shocks(different shocks)

	(1)	(2)	(3)	(4)
Shock	-0.117*			
	(-2.09)			
Shock2		0.057**		
		(2.58)		
Shock3			0.552	
			(1.80)	
Shock4				0.533*
				(2.14)
own_sovereign_yield	-0.231***	-0.275***	-0.262***	-0.260***
	(-3.48)	(-3.67)	(-3.25)	(-3.33)
issue_size	-7.686***	-6.270***	-6.780***	-6.707***
	(-4.82)	(-3.65)	(-3.95)	(-3.94)
lsize	-0.700	-0.211	-0.115	-0.136
	(-0.45)	(-0.15)	(-0.08)	(-0.09)
Constant	48.159*	36.743	37.961	37.856
	(2.10)	(1.73)	(1.69)	(1.71)
Bank FE	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes
Observation	345	345	345	345
R^2	.95518349	.95052136	.94675209	.94763693

The dependent variable is the corporate bond yield of bank i at day t; $cshock_1 = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation; $cshock_{j,t}(2)$ is the total number of marginal banks and fragile banks; $cshock_{j,t}(3)$ is the percentage of marginal banks and fragile banks over the total banks of country j; (D) $cshock_{j,t}(4)$ can be the percentage of marginal banks and fragile banks, while fragile banks is put double weights compared to marginal banks.

Table 22: Stock market reaction: GIIPS exxposure

Variable	AR(1d)	AR(3d)	AR(5d)
	(1)	(2)	(3)
Post*GIIPS	-1.206***	-2.645***	-1.351
	(-4.07)	(-4.05)	(-1.45)
Post	0.297***	0.518**	-0.682**
	(3.46)	(2.38)	(-2.16)
GIIPS	0.380	0.478	0.477
	(1.32)	(0.58)	(0.40)
Constant	-0.039	0.226	0.427
	(-0.38)	(0.78)	(1.04)
Bank FE	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes
Observation	2023	1974	1937
R^2	.02442846	.06554179	.08554726

The dependent variable is the abnormal stock return of bank i at day t; the colum(1) is the daily AR; the colum(2) is the 3 days cumulative AR; the colum(3) is the 5 days cumulative AR; GIIPS is the percentage of Greek sovereign bonds over total sovereign bonds of bank i.

Table 23: Stock market reaction: Greek sovereign bond exposure

Variable	AR(1d)	AR(3d)	AR(5d)
	(1)	(2)	(3)
Post*Greece	-1.881***	-3.431***	-1.385
	(-3.49)	(-3.68)	(-1.07)
Post	0.024	-0.085	-1.021***
	(0.31)	(-0.46)	(-3.89)
Greece	0.464	0.622	-0.832
	(0.89)	(0.37)	(-0.41)
Constant	0.070*	0.363***	0.633***
	(1.94)	(3.82)	(5.27)
Bank FE	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes
Observation	2023	1974	1937
R^2	.02180617	.05919952	.08426775

The dependent variable is the abnormal stock return of bank i at day t; the colum(1) is the daily AR; the colum(2) is the 3 days cumulative AR; the colum(3) is the 5 days cumulative AR; GIIPS is the percentage of GIIPS sovereign bonds over total sovereign bond of bank i.

Table 24: Robustness test: Dependent varaible

VARIABLES	(1) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(2) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(3) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(4) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$	(5) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$	(6) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$
Post×Safe	-6.051*	-5.238	-4.304**	-0.412	-0.441	-0.575**
	(3.411)	(3.343)	(1.828)	(0.274)	(0.278)	(0.232)
Post×Fragile	-7.259*	-8.586**	-5.430**	-0.428	-0.381	-0.624***
	(3.793)	(3.796)	(2.126)	(0.321)	(0.326)	(0.224)
Post	1.919	0.378	1.172	0.132	0.188	0.0596
	(3.284)	(3.322)	(2.685)	(0.248)	(0.254)	(0.306)
Level2	29.23***	29.18***	29.16***	3.186***	3.188***	3.191***
	(7.264)	(7.277)	(7.316)	(0.963)	(0.963)	(0.966)
Level3	19.41***	19.49***	19.72***	1.822***	1.819***	1.828***
	(6.391)	(6.376)	(6.417)	(0.629)	(0.631)	(0.635)
Level4	15.02*	15.01*	15.14*	2.533**	2.533**	2.543**
	(8.160)	(8.183)	(8.186)	(1.100)	(1.099)	(1.099)
Level5	24.86**	24.90**	25.00**	2.403**	2.402**	2.402**
	(9.880)	(9.873)	(9.884)	(1.058)	(1.060)	(1.063)
Safe×Level2	-20.20**	-20.16**	-20.15**	-2.358**	-2.359**	-2.364**
	(8.233)	(8.249)	(8.289)	(1.078)	(1.079)	(1.082)
Safe×Level3	-6.885	-6.961	-7.122	-0.888	-0.885	-0.897
	(7.278)	(7.260)	(7.298)	(0.742)	(0.744)	(0.747)
Safe×Level4	-2.997	-3.000	-3.144	-1.518	-1.518	-1.528
	(8.835)	(8.859)	(8.864)	(1.155)	(1.155)	(1.155)
Safe×Level5	-10.61	-10.64	-10.74	-1.378	-1.376	-1.376
	(10.33)	(10.32)	(10.34)	(1.107)	(1.109)	(1.113)
Fragile×Level2	-39.63***	-39.57***	-39.41***	-4.276***	-4.278***	-4.285***
	(10.73)	(10.75)	(10.81)	(1.489)	(1.490)	(1.494)
Fragile×Level3	-22.37***	-22.42***	-22.72***	-1.833**	-1.831**	-1.837**
	(8.273)	(8.255)	(8.293)	(0.776)	(0.777)	(0.776)
Fragile ×Level4	-15.96*	-15.95*	-16.08*	-2.317*	-2.317*	-2.327*
	(9.313)	(9.332)	(9.343)	(1.227)	(1.227)	(1.228)
Fragile ×Level5	-32.88***	-32.93***	-33.11***	-3.048***	-3.046***	-3.060***
	(10.77)	(10.76)	(10.80)	(1.112)	(1.114)	(1.119)
lsize	4.473	4.277	0.00532	0.865**	0.872**	0.544
	(4.437)	(4.346)	(4.760)	(0.369)	(0.370)	(0.458)
GIIPS×Post		3.401			-0.122	
		(2.222)			(0.194)	
Constant	-63.81	-61.39	-9.033	-11.36**	-11.45**	-7.463
	(53.72)	(52.53)	(57.62)	(4.500)	(4.503)	(5.581)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
CountryFE×Post	No	No	Yes	No	No	Yes
Observations	1,662	1,662	1,662	1,662	1,662	1,662
R-squared	0.173	0.174	0.179	0.158	0.158	0.159

$S_{1,i,t} - S_{0,i,t}$ is the different amount of sovereign between those of higher yields and those of lower yields at one credit rating of bank i at time t. In column (1)-(3) and (4)-(6), the difference of sovereigns is scaled down by the total sovereign amount of bank i and total asset of bank i respectively. Leveli, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. GIIPS is equal to 1 if bank i locates in one of the following countries: Greece, Ireland, Italy, Portugal, Spain. Post is the dummy variable of the 2011 test. Clustered standard errors are in the parenthesis.

Table 25: Robustness test: Dependent varaible

VARIABLES	(1) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(2) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(3) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(4) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$	(5) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$	(6) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$
Post×Safe	-4.783*	-5.240*	-5.707*	-1.862***	-1.912***	-1.781*
	(2.795)	(2.713)	(3.391)	(0.691)	(0.663)	(0.930)
Post×Fragile	-10.97***	-10.49***	-12.33***	-1.939**	-1.887**	-2.165**
	(3.228)	(3.398)	(4.157)	(0.729)	(0.767)	(1.003)
Post	6.366**	7.003**	9.083***	1.574**	1.643**	2.387**
	(2.620)	(2.677)	(3.379)	(0.663)	(0.661)	(0.928)
Level2	10.89	10.90	10.89	1.520*	1.521*	1.520*
	(7.147)	(7.150)	(7.193)	(0.883)	(0.883)	(0.887)
Level3	13.22*	13.20*	13.20*	2.191*	2.189*	2.164*
	(7.324)	(7.337)	(7.341)	(1.151)	(1.152)	(1.142)
Level4	39.24***	39.27***	39.24***	6.878***	6.881***	6.900***
	(4.652)	(4.650)	(4.693)	(1.157)	(1.155)	(1.161)
Level5	17.36**	17.36**	17.38**	2.037**	2.037**	2.050**
	(8.214)	(8.210)	(8.317)	(0.801)	(0.801)	(0.816)
Safe×Level2	-4.905	-4.896	-4.639	0.0288	0.0297	0.0558
	(8.218)	(8.226)	(8.269)	(1.216)	(1.217)	(1.225)
Safe×Level2	-2.691	-2.670	-2.610	-0.447	-0.445	-0.413
	(8.382)	(8.394)	(8.398)	(1.383)	(1.384)	(1.380)
Safe×Level3	-33.73***	-33.75***	-33.54***	-5.771***	-5.774***	-5.772***
	(6.129)	(6.139)	(6.176)	(1.366)	(1.364)	(1.372)
Safe×Level4	-7.524	-7.521	-7.397	-0.463	-0.463	-0.470
	(8.989)	(8.986)	(9.087)	(0.987)	(0.987)	(1.001)
Safe×Level5	-7.524	-7.521	-7.397	-0.463	-0.463	-0.470
	(8.989)	(8.986)	(9.087)	(0.987)	(0.987)	(1.001)
Fragile×Level2	-9.729	-9.732	-9.726	-1.352	-1.352	-1.352
	(7.331)	(7.334)	(7.379)	(0.898)	(0.898)	(0.902)
Fragile×Level3	-20.78**	-20.76**	-20.97**	-3.043**	-3.042**	-3.043**
	(9.586)	(9.597)	(9.648)	(1.369)	(1.370)	(1.366)
Fragile×Level4	-51.16***	-51.19***	-51.23***	-9.033***	-9.036***	-9.061***
	(14.78)	(14.78)	(14.91)	(2.577)	(2.577)	(2.595)
Fragile×Level5	-26.94**	-26.94**	-26.93**	-2.946***	-2.946***	-2.953***
	(10.20)	(10.20)	(10.31)	(0.921)	(0.920)	(0.936)
lsize	0.0952	0.128	0.512	6.712***	6.716***	6.881***
	(0.488)	(0.512)	(0.325)	(0.575)	(0.579)	(0.407)
GIIPS×Post		-1.115			-0.121	
		(1.499)			(0.355)	
Constant	-9.341	-9.734	-14.51***	-82.80***	-82.84***	-84.86***
	(5.882)	(6.111)	(4.138)	(7.291)	(7.336)	(5.266)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
CountryFE×Post	No	No	Yes	No	No	Yes
Observations	1,200	1,200	1,200	1,200	1,200	1,200
R-squared	0.179	0.179	0.184	0.203	0.203	0.207

$S_{1,i,t} - S_{0,i,t}$ is the different amount of sovereign between those of higher yields and those of lower yields at one credit rating of bank i at time t. In column (1)-(3) and (4)-(6), the difference of sovereigns is scaled down by the total sovereign amount of bank i and total asset of bank i respectively. Leveli, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. GIIPS is equal to 1 if bank i locates in one of the following countries: Greece, Ireland, Italy, Portugal, Spain. Post is the dummy variable of the 2014 test. Clustered standard errors are in the parenthesis.

Table 26: European banks Regulatory Arbitrage in 2011 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Post×RA×Safe	-0.514*	-0.193	-0.215	-0.223	-0.219
	(-1.89)	(-0.92)	(-1.34)	(-1.38)	(-1.36)
Post×RA×Fragile	-0.542**	-0.514**	-0.281*	-0.289*	-0.287*
	(-2.57)	(-2.19)	(-1.69)	(-1.73)	(-1.72)
Safe×RA	0.196	-0.122	0.051	0.056	0.053
	(0.90)	(-0.57)	(0.33)	(0.36)	(0.34)
Fragile×RA	0.049	0.024	0.092	0.093	0.092
	(0.43)	(0.10)	(0.55)	(0.56)	(0.55)
Post×RA	0.828***	0.617***	0.680***	0.098	0.297
	(3.78)	(3.05)	(4.49)	(0.71)	(1.58)
Post×Safe	0.161	-0.018	-0.009	-0.005	-0.007
	(1.34)	(-0.18)	(-0.11)	(-0.06)	(-0.08)
Post×Fragile	0.174	0.197*	0.092	0.097	0.096
	(1.33)	(1.82)	(1.03)	(1.07)	(1.07)
RA	-0.619***	-0.411**	-0.605***	-0.018	-0.192
	(-3.91)	(-2.06)	(-4.24)	(-0.12)	(-1.15)
Post	-0.640***	-0.480***	-0.492***	0.101	-.0126
	(-4.56)	(-5.68)	(-7.12)	(0.96)	(-0.12)
lsize	-0.039	-0.080	-0.121	-0.114	-0.116
	(-1.04)	(-0.75)	(-1.09)	(-1.03)	(-1.04)
Local_c*Post			-0.631	-0.886	-0.764
			(-0.50)	(-0.71)	(-0.68)
local_c			6.127***	6.291***	6.168***
			(4.69)	(4.87)	(5.27)
Constant	1.275**	1.747	2.094	1.330	1.457
	(2.45)	(1.35)	(1.55)	(0.98)	(1.08)
Bank FE	No	Yes	Yes	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE×Post	No	No	No	No	Yes
Observation	8049	8049	8049	8049	8049
R^2	.011	.040	.251	.490	.491

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2010 and 2012; Post=1 if after the 2011 stress test,otherwise Post=0. RA=1, if the sovereign bonds's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's soveregin bond. T-values are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 27: European banks Regulatory Arbitrage in 2014 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Post*RA*Safe	-0.717**	-0.542**	-0.393*	-0.396*	-0.398*
	(-2.61)	(-2.08)	(-1.76)	(-1.77)	(-1.77)
Post*RA*Fragile	-0.756**	-0.602**	-0.423*	-0.425*	-0.428*
	(-2.57)	(-2.21)	(-1.89)	(-1.89)	(-1.90)
Safe*RA	-0.528*	-0.703**	-0.457**	-0.461**	-0.460**
	(-1.97)	(-2.32)	(-2.44)	(-2.45)	(-2.44)
Fragile*RA	-0.634**	-0.788**	-0.436**	-0.442**	-0.441**
	(-2.35)	(-2.47)	(-2.35)	(-2.36)	(-2.35)
Post*RA	0.723**	0.571**	0.398*	0.398*	0.317
	(2.67)	(2.20)	(1.81)	(1.80)	(1.47)
Post*Safe	0.174***	0.093	0.051	0.052	0.053
	(2.89)	(1.16)	(0.79)	(0.80)	(0.81)
Post*Fragile	0.261***	0.175*	0.123	0.124	0.125
	(3.04)	(1.87)	(1.59)	(1.60)	(1.60)
RA	0.502*	0.654**	0.355*	0.315	0.353
	(1.89)	(2.21)	(1.96)	(1.56)	(1.67)
Post2014	-0.167***	-0.108	-0.065	-0.064	.0480091
	(-3.04)	(-1.37)	(-0.98)	(-0.96)	(0.75)
lsize	-0.004	-0.012	-0.013	-0.013	-0.013
	(-0.38)	(-0.25)	(-0.26)	(-0.26)	(-0.26)
Local_c*Post			0.467	0.460	0.417
			(0.91)	(0.93)	(0.87)
local_c			7.013***	6.905***	6.917***
			(8.97)	(9.43)	(9.35)
Constant	0.299**	0.410	0.276	0.210	0.198
	(2.42)	(0.69)	(0.46)	(0.35)	(0.33)
Bank FE	No	Yes	Yes	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	7732	7732	7732	7732	7732
R^2	.010	.018	.557	.586	.587

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2013 and 2015; Post=1 if after the 2014 stress test,otherwise Post=0. RA=1, if the sovereign bonds's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond.T-values are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 28: Robustness test: restricted sample to low △ on CET 1 ratio

VARIABLES	Safe $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	Marginal $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	All $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	All $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Post×RA	0.426***	0.872**		
	(0.0502)	(0.319)		
Post	-0.438***	-0.540***	-0.423***	0.268
	(0.0684)	(0.0519)	(0.0621)	(0.174)
RA	-0.527***	-0.871**	-0.528***	0.0532
	(0.0617)	(0.316)	(0.0634)	(0.0762)
Post×RA×Marginal			0.409*	0.412*
			(0.228)	(0.229)
Post×Group			-0.146	-0.148
			(0.122)	(0.122)
RA×Marginal			-0.322	-0.324
			(0.222)	(0.222)
Post×RA			0.432***	
			(0.0507)	
Local_c	6.321***	9.407**	7.133***	7.222***
	(1.727)	(3.350)	(1.445)	(1.349)
Local_c×Post2010	-1.262	-2.301	-2.071	-2.255*
	(1.675)	(3.466)	(1.420)	(1.317)
lsize	-0.0894	-0.471	0.0483	0.0488
	(0.108)	(0.297)	(0.182)	(0.183)
Constant	1.721	6.068	0.0106	-0.790
	(1.341)	(3.470)	(2.242)	(2.228)
Bank FE	YES	YES	YES	YES
sovereign FE*Post	YES	YES	NO	YES
Observations	7,113	1,010	7,601	7,601
R-squared	0.246	0.446	0.245	0.478

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

The dependent variable is $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$; Column (1) presents the regression on safe banks; Column (2) presents the regression on marginal banks; Column(3) and (4) present the regression of these two groups; RA=1 if the sovereign bonds's spread yield is higher than the median within the same category; Marginal banks' core capital ratio is between 5 %-6%; local_c=1 if bank i holds its own country's soveregin bond;

Table 29: Robustness test: Two tests together

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$
PostTest1*RA*Safe	-0.345*	-0.108	-0.039	-0.292*	-0.282*
	(-1.67)	(-0.60)	(-0.26)	(-1.82)	(-1.77)
PostTest1*RA*Fraigle	-0.350*	-0.442**	-0.098	-0.352**	-0.342**
	(-1.85)	(-2.13)	(-0.63)	(-2.24)	(-2.19)
PostTest2*RA*Safe	-1.518***	-1.106***	-0.943**	-0.984**	-0.984**
	(-3.41)	(-2.68)	(-2.56)	(-2.64)	(-2.63)
PostTest2*RA*Fragile	-1.479***	-1.397***	-1.015***	-1.054***	-1.054***
	(-3.24)	(-3.21)	(-2.71)	(-2.80)	(-2.79)
PostTest1*Safe	-0.042	-0.166*	-0.234**	0.059	0.047
	(-0.58)	(-1.79)	(-2.53)	(0.61)	(0.49)
PostTest1*Fragile	-0.060	0.062	-0.123	0.170*	0.159
	(-0.44)	(0.59)	(-1.29)	(1.77)	(1.66)
PostTest2*Safe	0.309**	0.115	0.087	0.084	0.085
	(2.12)	(0.69)	(0.55)	(0.65)	(0.65)
PostTest2*Fragile	0.325	0.347*	0.229	0.227	0.230
	(1.60)	(1.94)	(1.37)	(1.63)	(1.63)
Safe*RA	0.143	-0.190	-0.042	0.088	0.084
	(0.60)	(-0.84)	(-0.25)	(0.55)	(0.53)
Fragile*RA	-0.042	-0.044	-0.002	0.126	0.121
	(-0.16)	(-0.17)	(-0.01)	(0.76)	(0.73)
PostTest1*RA	0.632***	0.530***	0.506***	0.179	0.207
	(4.22)	(3.12)	(3.60)	(1.54)	(1.48)
PostTest2*RA	1.896***	1.619***	1.412***	0.876**	0.924**
	(4.47)	(3.97)	(3.88)	(2.44)	(2.54)
Local_c*PostTest1			-0.118	0.099	0.149
			(-0.09)	(0.08)	(0.13)
RA	-0.540**	-0.343	-0.511***	-0.086	-0.121
	(-2.65)	(-1.61)	(-3.36)	(-0.57)	(-0.69)
PostTest	-0.405***	-0.326***	-0.286***	0.008	0.000
	(-4.41)	(-4.10)	(-3.84)	(0.11)	(.)
lsize	-0.033	-0.099	-0.148**	-0.135*	-0.128*
	(-1.15)	(-1.51)	(-2.04)	(-1.96)	(-1.86)
local_c			6.250***	6.155***	6.145***
			(9.21)	(9.56)	(9.62)
Constant	1.084**	1.970**	2.400***	1.608*	1.545*
	(2.36)	(2.46)	(2.71)	(1.91)	(1.86)
Bank FE	No	Yes	No	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	11620	11620	11620	11620	11620
R^2	.01137219	.03551944	.30945425	.50423379	.50494939

Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$; RA=1 if the sovereign bonds's spread yield is higher than the median within the same credit rating; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's soveregin bond;

Table 30: Robustness test: Two tests together

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$
PostTest1*RA*Safe	-2.988**	-2.393*	-0.665	-1.770***	-1.791***
	(-2.11)	(-1.80)	(-1.12)	(-2.99)	(-3.05)
PostTest1*RA*Fraigle	-5.486***	-5.506***	-1.624**	-2.752***	-2.771***
	(-4.36)	(-3.90)	(-2.56)	(-4.35)	(-4.38)
PostTest2*RA*Safe	-5.215***	-4.441***	-1.955***	-2.146***	-2.154***
	(-4.26)	(-4.14)	(-3.15)	(-3.46)	(-3.47)
PostTest2*RA*Fragile	-6.365***	-6.197***	-2.083***	-2.290***	-2.296***
	(-4.39)	(-4.40)	(-2.84)	(-3.13)	(-3.13)
PostTest1*Safe	1.369***	1.001***	-0.282	0.989***	1.010***
	(3.63)	(3.67)	(-1.22)	(5.50)	(5.58)
PostTest1*Fragile	2.018***	2.180***	0.006	1.286***	1.305***
	(5.04)	(5.48)	(0.02)	(5.79)	(5.71)
PostTest2*Safe	1.730***	1.228***	0.573*	0.561***	0.563***
	(3.62)	(3.12)	(1.82)	(2.84)	(2.83)
PostTest2*Fragile	1.923***	1.873***	0.578	0.576**	0.577**
	(3.98)	(3.46)	(1.58)	(2.15)	(2.15)
Safe*RA	-0.937	-1.620	-1.130**	-0.576	-0.563
	(-1.13)	(-1.56)	(-2.56)	(-1.34)	(-1.32)
Fragile*RA	-0.639	-0.715	-0.732	-0.180	-0.170
	(-0.51)	(-0.60)	(-1.46)	(-0.37)	(-0.35)
PostTest1*RA	4.152***	3.786***	2.390***	0.932*	-0.073
	(3.44)	(3.03)	(4.83)	(1.88)	(-0.11)
PostTest2*RA	7.518***	6.993***	3.965***	1.556***	-0.454
	(6.88)	(6.94)	(7.04)	(2.74)	(-0.48)
Local_c*PostTest1			-32.039***	-30.987***	-30.794***
			(-10.93)	(-10.99)	(-10.90)
RA	-1.607*	-1.174	-1.759***	-0.030	1.353*
	(-1.79)	(-1.20)	(-4.41)	(-0.03)	(1.80)
PostTest	-1.565***	-1.480***	-1.329***	-0.008	0.000
	(-8.21)	(-7.81)	(-8.73)	(-0.07)	(.)
lsize	0.053***	0.662**	0.219	0.249	0.247
	(2.74)	(2.58)	(1.23)	(1.30)	(1.30)
local_c			61.256***	60.294***	60.266***
			(14.39)	(14.20)	(14.18)
Constant	2.900***	-4.093	0.474	-3.215	-4.098*
	(3.70)	(-1.33)	(0.22)	(-1.41)	(-1.77)
Bank FE	No	Yes	Yes	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	11620	11620	11620	11620	11620
R^2	.00780041	.00891315	.65267617	.76725228	.76791725

Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$; RA=1 if the sovereign bonds's spread yield is higher than the median within the same category; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's soveregin bond.

Table 31: Time dependent RA

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TotalAsset_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$
PostTest1*RA*Safe	-0.391*	-0.125	-0.084	-0.313*	-0.282*
	(-1.88)	(-0.70)	(-0.53)	(-1.91)	(-1.68)
PostTest1*RA*Fraigle	-0.075	-0.153	-0.115	-0.341**	-0.308*
	(-0.36)	(-0.69)	(-0.73)	(-2.15)	(-1.87)
PostTest2*RA*Safe	-1.370***	-0.904***	-0.844***	-0.873***	-0.874***
	(-3.53)	(-2.70)	(-2.89)	(-2.99)	(-2.99)
PostTest2*RA*Fragile	-1.130***	-1.014***	-0.707**	-0.736**	-0.735**
	(-2.95)	(-2.89)	(-2.38)	(-2.49)	(-2.48)
PostTest1*Safe	0.039	-0.144	-0.224**	0.034	-0.003
	(0.40)	(-1.50)	(-2.23)	(0.31)	(-0.03)
PostTest1*Fragile	-0.151	-0.121	-0.193	0.063	0.026
	(-1.00)	(-0.81)	(-1.48)	(0.45)	(0.17)
PostTest2*Safe	0.517**	0.198	0.171	0.175	0.177
	(2.07)	(1.06)	(0.96)	(1.07)	(1.08)
PostTest2*Fragile	0.369*	0.106	-0.026	-0.023	-0.020
	(1.69)	(0.47)	(-0.11)	(-0.11)	(-0.09)
Safe*RA	0.222	-0.154	-0.013	0.097	0.084
	(0.92)	(-0.67)	(-0.08)	(0.60)	(0.52)
Fragile*RA	0.041	0.015	0.025	0.133	0.117
	(0.15)	(0.06)	(0.14)	(0.80)	(0.70)
PostTest1*RA	0.612***	0.497***	0.501***	0.188	0.196
	(4.02)	(2.95)	(3.47)	(1.53)	(1.42)
PostTest2*RA	1.575***	1.253***	1.145***	0.573**	0.562**
	(4.72)	(4.06)	(4.25)	(2.10)	(2.22)
Local_c*PostTest1			-0.499	-0.266	-0.144
			(-0.41)	(-0.22)	(-0.13)
RA	-0.600***	-0.368*	-0.524***	-0.036	-0.044
	(-2.83)	(-1.69)	(-3.39)	(-0.29)	(-0.29)
PostTest	-0.415***	-0.320***	-0.281***	0.026	0.000
	(-4.21)	(-3.99)	(-3.61)	(0.33)	(.)
lsize	-0.080	-1.115***	-1.125***	-1.128***	-1.124***
	(-1.51)	(-4.40)	(-4.57)	(-4.55)	(-4.52)
local_c			6.482***	6.349***	6.330***
			(9.60)	(9.90)	(9.95)
Constant	1.657**	14.340***	14.311***	13.742***	13.682***
	(2.37)	(4.65)	(4.78)	(4.59)	(4.42)
Bank FE	No	Yes	No	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	12725	12725	12725	12725	12725
R^2	.01005513	.04638922	.27972295	.42767863	.42944719

Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TotalAsset_{i,t}}$; Post=1 if after the 2011 stress test; RA=1 if the sovereign bonds's spread yield is higher than the median within the same category; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's soveregin bond;

Table 32: Time dependent RA

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TotalAsset_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TotalAsset_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TotalAsset_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TotalAsset_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{TotalAsset_{i,t}}$
PostTest1*RA*Safe	-2.327*	-1.723	-0.362	-1.544***	-1.731***
	(-1.90)	(-1.53)	(-0.69)	(-3.14)	(-3.49)
PostTest1*RA*Fraigle	-0.721	-0.702	0.024	-1.129	-1.307*
	(-0.42)	(-0.39)	(0.04)	(-1.64)	(-1.89)
PostTest2*RA*Safe	-3.625***	-2.832***	-1.433**	-1.583**	-1.610**
	(-3.58)	(-3.06)	(-2.13)	(-2.46)	(-2.49)
PostTest2*RA*Fragile	-4.601***	-4.394***	-1.253*	-1.420**	-1.442**
	(-3.69)	(-3.61)	(-1.75)	(-2.06)	(-2.09)
PostTest1*Safe	1.404***	1.033***	-0.303	1.041***	1.250***
	(3.50)	(3.54)	(-1.21)	(5.58)	(5.46)
PostTest1*Fragile	0.247	0.355	-0.630**	0.704**	0.912***
	(0.34)	(0.49)	(-2.03)	(2.47)	(2.89)
PostTest2*Safe	1.768***	1.274***	0.659*	0.681***	0.686***
	(3.31)	(3.22)	(1.78)	(2.78)	(2.76)
PostTest2*Fragile	1.989***	1.826***	0.480	0.513*	0.519*
	(3.67)	(3.46)	(1.20)	(1.80)	(1.81)
Safe*RA	-0.840	-1.539	-1.089**	-0.527	-0.433
	(-1.02)	(-1.45)	(-2.44)	(-1.23)	(-1.03)
Fragile*RA	-0.379	-0.491	-0.677	-0.118	-0.030
	(-0.31)	(-0.41)	(-1.35)	(-0.24)	(-0.06)
PostTest1*RA	3.493***	3.116***	2.111***	0.657	0.688
	(3.44)	(3.05)	(5.03)	(1.52)	(1.40)
PostTest2*RA	5.594***	5.042***	3.112***	0.860	1.267*
	(6.25)	(6.05)	(5.42)	(1.45)	(1.77)
Local_c*PostTest1			-32.568***	-31.454***	-31.124***
			(-12.65)	(-12.65)	(-12.45)
RA	-1.688*	-1.230	-1.752***	0.865*	1.092**
	(-1.88)	(-1.22)	(-4.30)	(1.92)	(2.12)
PostTest	-1.504***	-1.407***	-1.255***	-0.009	0.000
	(-6.93)	(-7.85)	(-7.34)	(-0.07)	(.)
lsize	0.050***	0.133	0.039	0.047	0.052
	(2.71)	(1.28)	(0.94)	(1.00)	(1.04)
local_c			61.648***	60.632***	60.580***
			(16.14)	(15.80)	(15.76)
Constant	3.089***	2.319*	2.654***	-0.833	-1.469*
	(3.96)	(1.84)	(5.30)	(-0.92)	(-1.74)
Bank FE	No	Yes	No	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	12725	12725	12725	12725	12725
R^2	.00522086	.0062086	.66203939	.77382936	.77468029

Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$; Post=1 if after the 2011 stress test; RA=1 if the sovereign bonds's spread yield is higher than the median within the same category. local_c=1 if bank i holds its own country's soveregin bond.

Table 33: Robustness test: Time Trend

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$
TimeTrend*RA	0.019	-0.087
	(0.53)	(-0.29)
TimeTrend*Safe	-0.015	-0.021
	(-1.05)	(-1.64)
TimeTrend*Fragile	-0.004	0.011
	(-0.23)	(0.24)
Safe*RA	-0.109	-1.684***
	(-1.07)	(-2.68)
Fragile*RA	-0.099	-1.868***
	(-0.88)	(-3.33)
RA	-0.030	0.679
	(-0.24)	(0.93)
time_trend	0.012	-0.070
	(0.46)	(-0.97)
lsize	-0.120	0.394
	(-1.09)	(0.72)
Constant	1.516	-3.968
	(1.12)	(-0.60)
Bank FE	Yes	Yes
sovereign FE	Yes	Yes
sovereign FE*Post	Yes	Yes
Observation	8049	8049
R^2	.48981736	.76687121

Marginal banks are benchmark. The dependent variable of (1) is $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$; the one of (2) is $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$; RA=1 if the sovereign bonds's spread yield is higher than the median within the same category; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's soveregin bond;

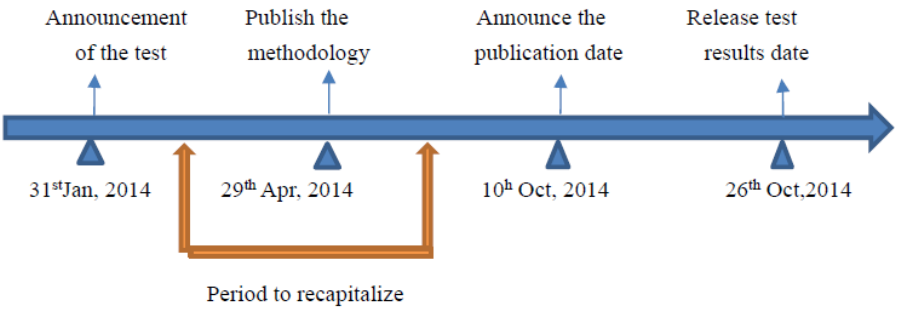
Table 34: Robustness test: Time Trend

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$
Post*RA*Safe	-3.380***	-1.035*	-1.035*
	(-3.20)	(-2.00)	(-2.00)
Post*RA*Fragile	-3.912***	-1.280**	-1.280**
	(-3.36)	(-2.10)	(-2.10)
Safe*RA	-2.668*	-2.003**	-2.003**
	(-1.84)	(-2.57)	(-2.57)
Fragile*RA	-2.988*	-1.564*	-1.564*
	(-1.87)	(-1.92)	(-1.92)
Post*RA	3.458***	0.732	0.732
	(3.36)	(1.26)	(1.26)
Post*Safe	1.739***	0.300*	0.303*
	(4.26)	(1.90)	(1.91)
Post*Fragile	2.051***	0.379**	0.381**
	(3.85)	(2.02)	(2.03)
RA	2.348	0.637	0.637
	(1.64)	(0.49)	(0.49)
lsize	0.055*	0.004***	0.003
	(1.93)	(3.21)	(1.13)
Local_c*Post		-1.844	-1.844
		(-0.98)	(-0.98)
local_c		58.939***	58.939***
		(12.36)	(12.36)
time_trend			-0.008**
			(-2.51)
Constant	1.584***	0.318**	0.379**
	(3.77)	(2.16)	(2.33)
Bank FE	No	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE*Post	No	Yes	Yes
Observation	7689	7689	7689
R^2	.00420989	.7111051	.71110523

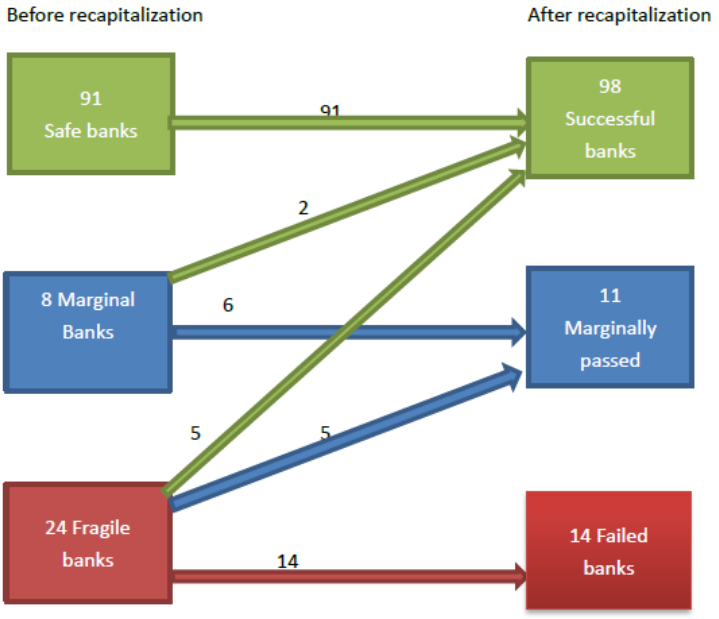
Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$; Post=1 if after the 2011 stress test; RA=1 if the sovereign bonds's spread yield is higher than the median within the same category; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's soveregin bond.

B Appendix 2

Timeline of the stress-testing in 2014



Test result before and after recapitalization in 2014



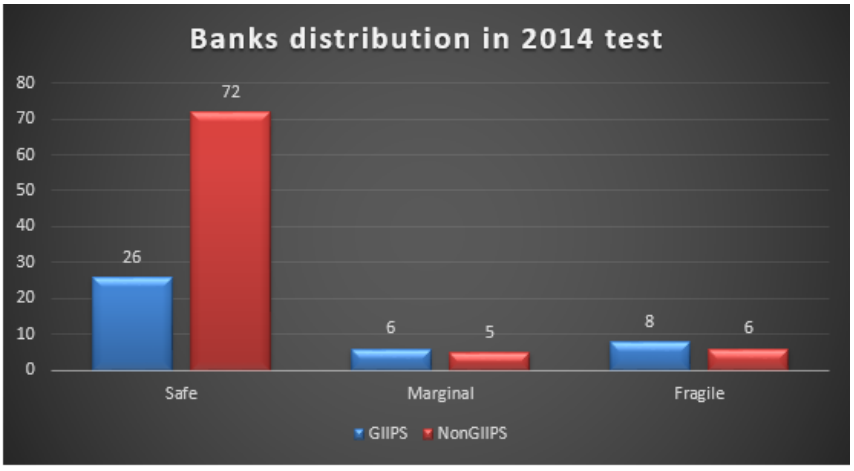


Figure 6: **The evolution net income over total assets**

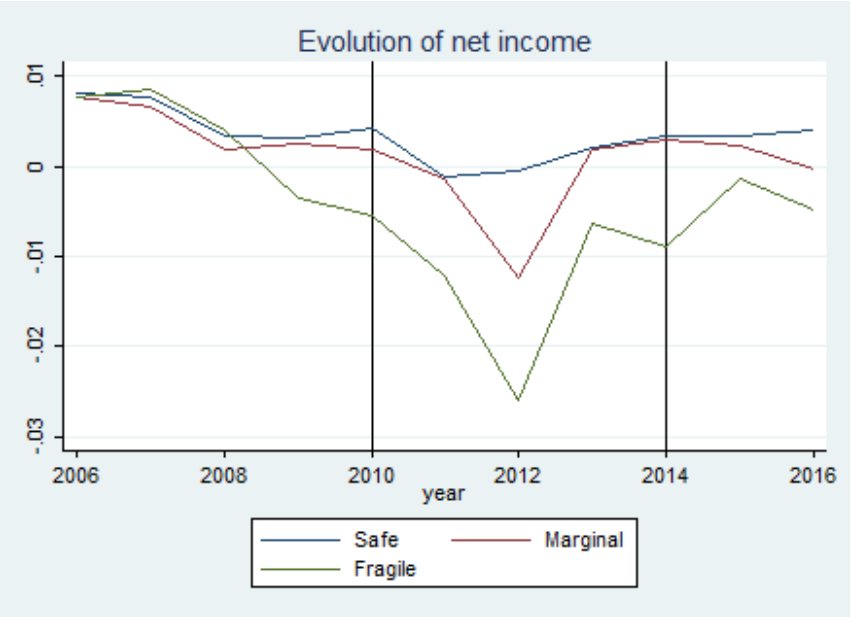


Table 35: Summary of credit ratings before or after the tests

Ratings	**Before 2011 test**	**After 2011 test**
AAA	AT, DE, DK, FI, FR LI, LU, NL, NO, SE, UK	AT, DE, DK, FI, FR LI, LU, NL, NO, SE, UK
AA	BE, ES, SI	BE, ES, SI, IT
A	CY, CZ, EE, IT, MT, PL, SK, PT	CY, CZ, EE, MT, PL, SK
BBB	BG, HU, GR, IE, IS, LT	BG, HU, LV, RO, LT
B	GR, RO	IE, IS, PT
C		GR
	Before 2014 test	**After 2014 test**
AAA	DE, DK, FI, LI, LU, NO, NL, SE	AT, DE, DK, FI, LI, LU, NO,NL, SE
AA	AT, BE, EE, FR, UK	BE, EE, FR, UK,
A	CZ, MT, PL, SK	CZ, MT, PL, SK, IE, LV,
BBB	BG, ES, IS, IT, LT, LV, SI	BG, ES, IS, IT, LT, RO
B	CY, HU, IE, PT, RO	CY, HU IE, PT
C	GR	GR

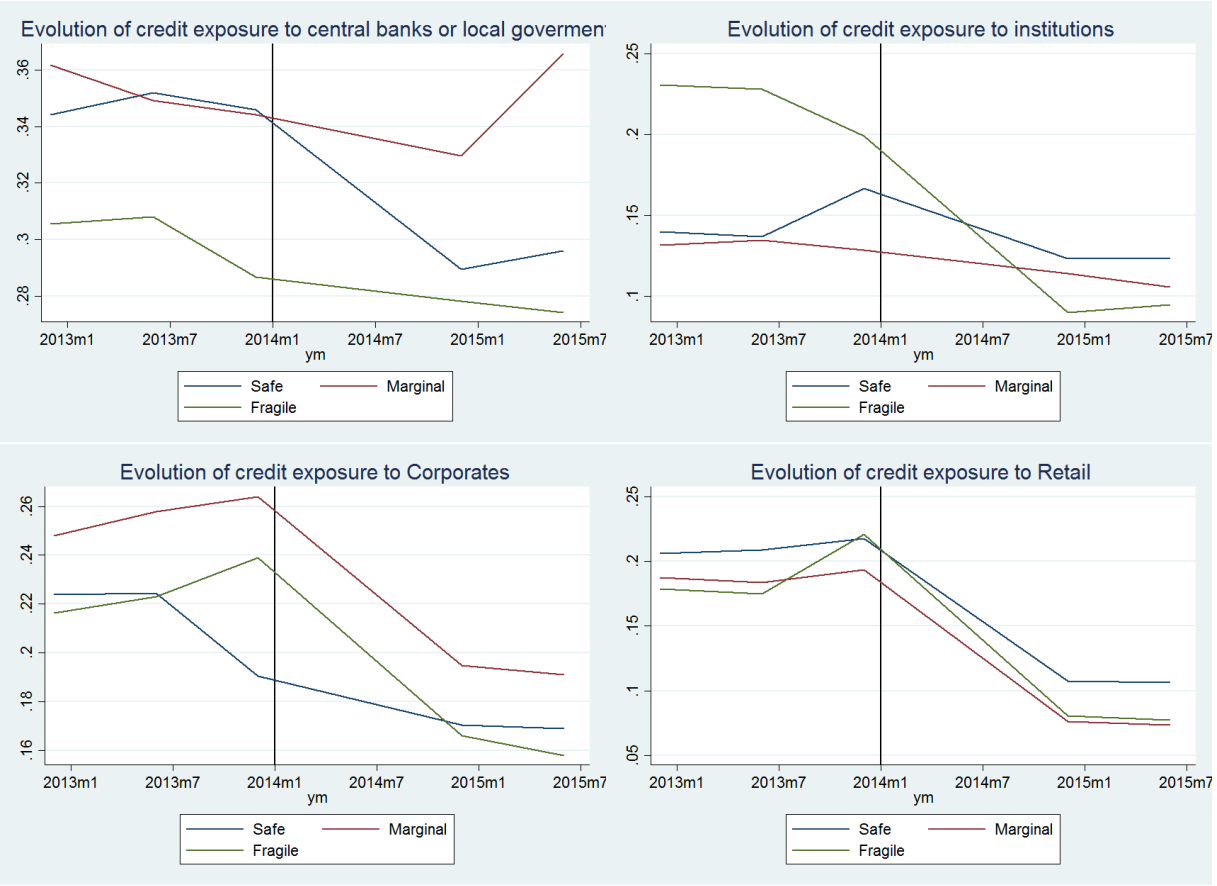


Figure 7: The evolution of different credit risk exposures

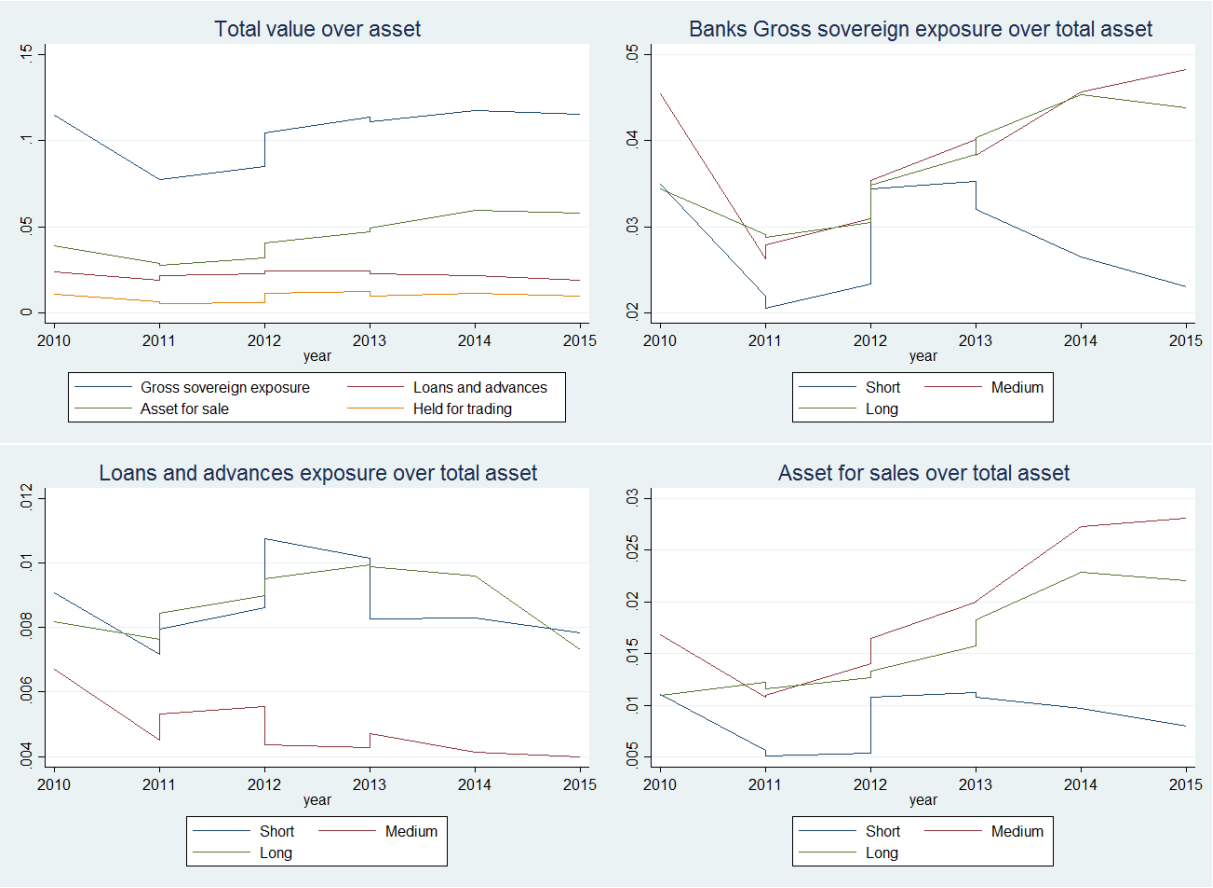


Figure 8: **Total sovereign over total assets**

Note:Sovereign debt amount is scaled down by total asset. In the graph, shows the value-weighted average across banks. Short includes the sovereign debt with a maturity less than 3 years; medium is the sovereign debt lasting less than 10 years; long represent all the sovereign amount with a maturity larger than 10 years.

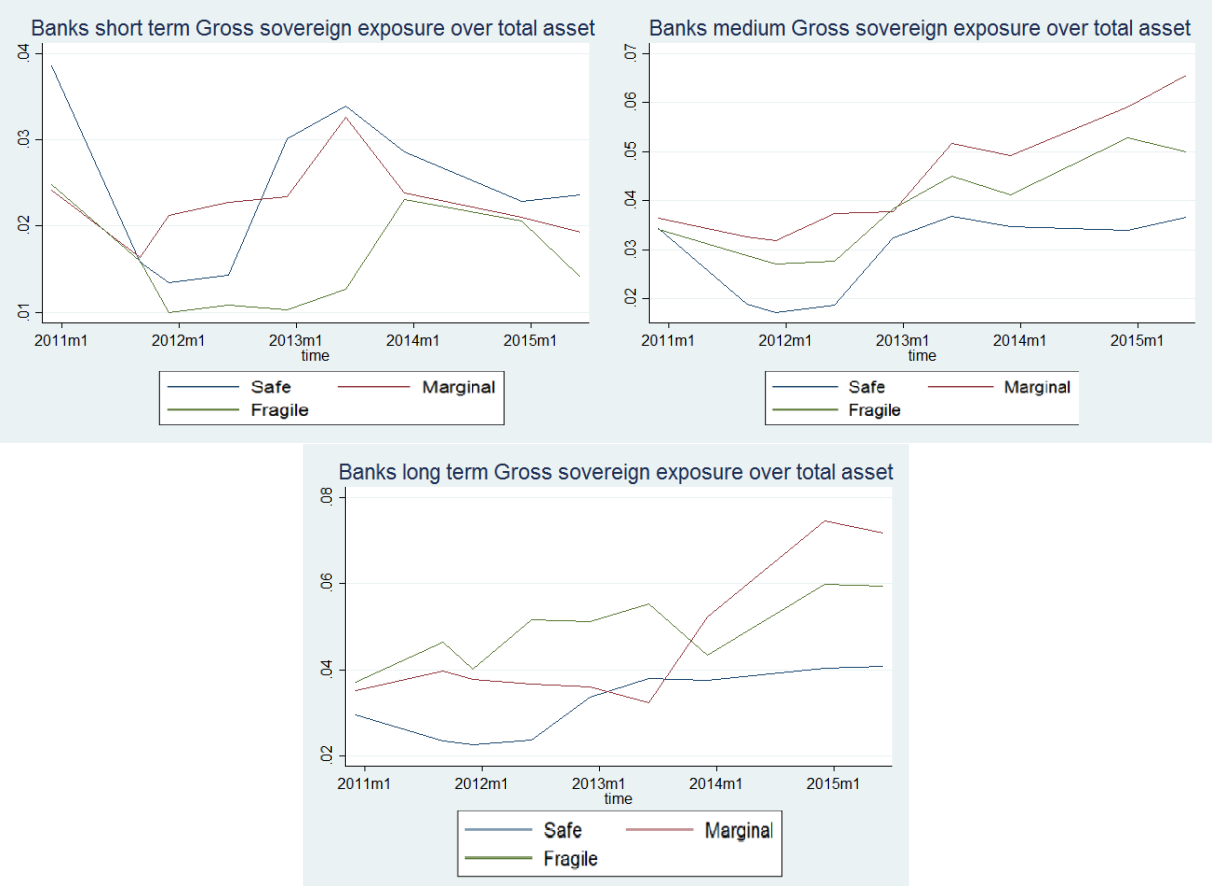


Figure 9: Different maturity of sovereign in groups
Note: Short term: maturity$\leq$ 1 Year; Medium term: maturity<10 Year; Long term: maturity $\geq$ 10 year.

GIIPS sovereign in groups

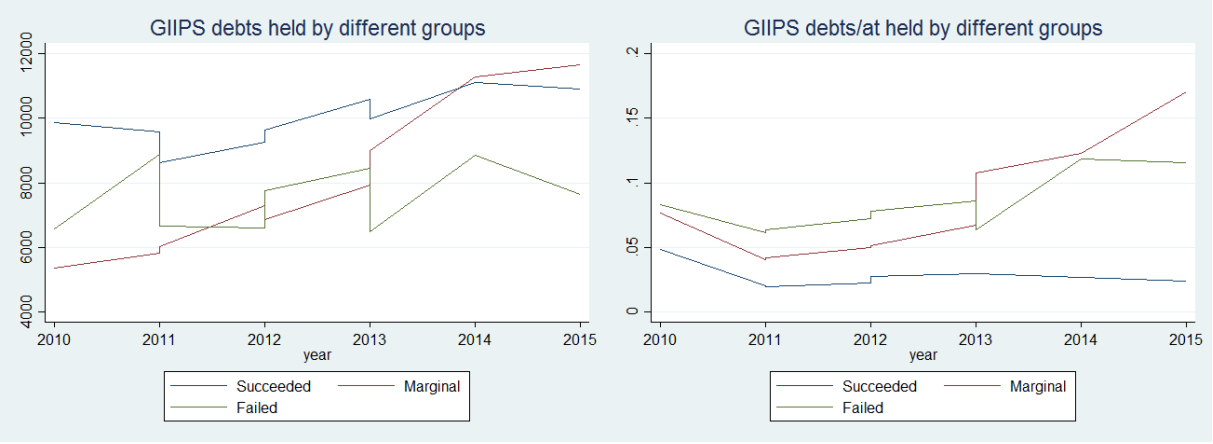


Figure 10: GIIPS sovereign in groups
Note: The left graph shows the amount of GIIPS sovereign; the right graph includes the percentage of GIIPS over total asset.

Figure 11: **Summary of GIIPS sovereigns across groups**

Before the test			**After the test**					
Dec, 2010			Sep, 2011			Deb-2011		
Safe banks			Safe banks			Safe banks		
GIIPS	9845.43	4.83%	GIIPS	9569.72	2.06%	GIIPS	8610.97	1.94%
NonGIIPS	36656.94	7.32%	NonGIIPS	24689.83	5.51%	NonGIIPS	22863	5.60%
Marginal banks			Marginal banks			Marginal banks		
GIIPS	5362.626	4.65%	GIIPS	5815.355	4.80%	GIIPS	6025.115	4.82%
NonGIIPS	3662.294	2.79%	NonGIIPS	7413.098	4.10%	NonGIIPS	7489.761	4.90%
Fragile banks			Fragile banks			Fragile Banks		
GIIPS	6581.044	5.38%	GIIPS	8873.416	7.12%	GIIPS	6663.422	7.84%
NonGIIPS	3914.486	1.05%	NonGIIPS	5693.063	0.59%	NonGIIPS	6762.248	1.23%

C Appendix3

C.1 Sovereign risk treated in the 2011 stress test

On the Methodological Note - Additional guidance of 2011 stress test (Page 5-6); EBA define a consistent approach to deal with the sovereign risk. Since simplicity is a desired element of any approach, a common PD and LGD should be identified as a starting point. They use the public credit ratings of sovereign bonds offered by Credit Agencies. Notch downgrades can then be applied in the stress taking into account the situation as of 1 June 2011. The following notch downgrades, which depend on the starting rating levels, are to be applied to the exposures vis--vis sovereign and institution exposures: (1) AAA / Aaa no downgrading; (2) AA / Aa2 to A- / A3: two notch downgrades; and

(3) BBB+ / Baa1 or below: four notch downgrades with a floor at CCC. For simplicity this approach could focus purely on determining appropriate provisions (EL) for both IRB and TSA banks. No changes would be made to RWA from the existing submission.

C.2 Different types of risk trested in the 2014 stress test

(A) Credit risk

Scope: All assets in the banking book which are exposed to credit risk excluding counterparty credit risk, on and off-balance sheet positions, IRB and STA portfolios. Methodology also applied to IRC.

Methodology: Stressed point-in-time PD and point-in-time LGD for provisioning. Potential rating migration and stressed IRB regulatory parameters for RWA.

RWA impact: Stressed RWA in IRB and STA, including RWA for defaulted assets and IRB excess or shortfall. RWA floored at 2013 levels.

(B) Market risk

Scope: All financial assets and liabilities assessed at fair value (positions in HfT, AfS and designated at fair value through profit and loss portfolios), including counterparty

credit risk. Hedge accounting portfolios. Securitizations held at fair value.

Methodology: Simplified approach: bankspecific reduction in NTI based on historical variation. Comprehensive approach: revaluation of positions based on market risk parameters. CVA haircuts for OTC derivatives. Default of largest counterparty (excl. CCP, market infrastructure, sovereign).

RWA impact: RWA increase for VaR, SVaR and CRM capital charges due to predefined assumptions (constant RWA for banks using simplified approach; VaR replaced by SVaR for banks using comprehensive approach, fixed scaling for CRM). IRC and CVA increase due to worsened risk parameters.

(C) Sovereign risk

Scope: (direct debt exposures as well as indirect exposures to central and local governments). Assessed at fair value (HFT, AFS, fair value through profit and loss) and amortized cost positions.

Methodology: All fair value positions: application of market risk methodology for impact of changes in market prices. Regulatory banking book positions: application of credit risk methodology for impairment estimates based on rating migration defined by ESRB/ECB.

RWA impact: RWA increase due to worsened risk parameters in IRB and STA.

(D)Securitization risk

Scope: Securitization and securitization positions assessed at fair value (HfT, AfS, designated at fair value through profit and loss) and amortized cost positions. ABCP (incl. ABCP liquidity lines) excluded but subject to either the regular RWA treatment or market risk methodology. Methodology: Increase of RWA depending on risk profile of the positions (three risk buckets). Impairment estimates for positions not held for trading. Application of market risk methodology for fair value positions. RWA impact: RWA increase for all securitization positions based on predefined risk buckets.

C.3 Economic Hypothesis

C.3.1 Model of Glasserman and Kang (2014)

Regulators' objective is to stabilize the market by minimizing the risk in the bank's portfolio y while allowing the bank an adequate rate of return at time t=1:

$$\min_{y} \quad y^T \Sigma y$$
$$\text{s.t.} \quad \mu^T y \geq l$$

for some $l > 0$. It's equivalent[38] to solve the following maximization under regulation constraints at t=1:

$$\max_{y} \quad \mu^T y$$
$$\text{s.t.} \quad \sqrt{y^T \Sigma y} \leq \eta$$

Solving the objective function under regulation constraints, from the regulators' point of view the optimal banks' portfolio should be:

$$\Rightarrow y_1^* = \frac{\eta}{\sqrt{\mu^T \Sigma^{-1} \mu}} \Sigma^{-1} \mu$$

The optimal portfolios under regulations can be implemented by imposing a required capital ratio on banks. Banks' assets are assigned to different risk-weights w according to different categories of the asset[39]. At t=1 their objective function under regulation constraints becomes:

$$(BC) \max_{x} \quad \mu^T x - \frac{\gamma}{2} x^T \Sigma x$$
$$s.t. \quad x^T w \leq K$$
$$\Rightarrow x_1^* = \frac{1}{\gamma} \Sigma^{-1} \mu - \frac{(w^T \Sigma^{-1} \mu - \gamma K)^+}{w^T \Sigma^{-1} w} \frac{1}{\gamma} \Sigma^{-1} w$$

[38] Under the assumption that the return of x is normally distributed. Regulators' minimization of banks probability of default can be transformed into the minimization problem of risk level.

[39] More details can be found in the Basel III

C.3.2 My extension of the model

The objective function for all types of banks at t=1 becomes:

$$\max_{x} \quad \pi(\mu^T x - \frac{\gamma}{2} x^T \Sigma x) + (1-\pi)P$$
$$\begin{cases} \pi = 1 & if \quad x^T w \leq K \\ \pi \in [0,1) & if \quad x^T w > K \end{cases}$$

If $x_1 = \frac{K}{w}$ on the binding constraint, I have $V_1 = \mu^T x_1 - \frac{1}{\gamma} x^T \Sigma x = \mu^T (\frac{K}{w}) - \frac{1}{\gamma} (\frac{K}{w})^T \Sigma (\frac{K}{w})$;

If $x_1 = x_0^*$, the expected value becomes $V_2 = \pi(\mu^T x_0^* - \frac{1}{\gamma} x_0^{*T} \Sigma x_0^*) + (1-\pi)P$.

At the optimal, there are two possible cases: Case (1) $V_1 > V_2$ and Case (2)$V_1 > V_2$

C.3.3 Regulatory Arbitrage

Suppose that the risk weight w is linear to the risk of the asset σ: $w = c\sigma$, where $\sigma = (diag(\Sigma))^{\frac{1}{2}}$[40] and c is a constant. From the previous optimal solution, we have:

$x_1^* = \frac{1}{\gamma}\Sigma^{-1}\mu - \frac{(w^T\Sigma^{-1}\mu - \gamma K)^+}{w^T\Sigma^{-1}w}\frac{1}{\gamma}\Sigma^{-1}w$

Replace $w = c\sigma$, then we have:

$x_1^* = \frac{1}{\gamma}\Sigma^{-1}\mu - \frac{(w^T\Sigma^{-1}\mu - \gamma K)^+}{w^T\Sigma^{-1}w}\frac{1}{\gamma}\Sigma^{-1}w$

$x_1^* = \frac{1}{\gamma}\Sigma^{-1}\mu - \frac{(c\sigma^T\Sigma^{-1}\mu - \gamma K)^+}{c\sigma^T\Sigma^{-1}c\sigma}\frac{1}{\gamma}\Sigma^{-1}c\sigma$

$x_1^* = \frac{1}{\gamma}\Sigma^{-1}(\mu - \frac{(c\sigma^T\Sigma^{-1}\mu - \gamma K)^+}{c\sigma^T\Sigma^{-1}c\sigma}\sigma)$

$x_1^* = \frac{1}{\gamma}\Sigma^{-1}(\mu - \frac{(c\sigma^T\Sigma^{-1}\mu - \gamma K)^+}{cM^{-1}}\sigma)$

$\Rightarrow x_1^* = \frac{1}{\gamma}\Sigma^{-1}(\mu - \rho\sigma)$

Where $(c\sigma^T\Sigma^{-1}\mu - \gamma K)^+$ is a scalar function of K and denote ρ as the function of K and c. If the constraints are binding, x_1^* is not linear to $x_0^* = \frac{1}{\gamma}\Sigma^{-1}\mu$ any more, i.e., the regulations imposed on banks change the optimal investment scheme of constrained banks. In the real economy, the risk weight $w = c\bar{\sigma}$ is linear to the standard deviations of the asset categories $\bar{\sigma}$, that is to say, it is not a continuous variable. Banks can always chose $x_1^{'}(\neq x_1^*)$ to take more risk.

[40] $\Sigma = \sigma M \sigma^T$, M is the correlation matrix of assets