August 1, 2017

# Online Appendix to "Cross-border Residential Mortgage Lending: Theory and Evidence from the European Sovereign Debt Crisis", forthcoming in Real Estate Economics

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**Abstract**

This Online Appendix contains supplementary material for the paper "Cross-Border Residential Lending: Theory and Evidence from the European Sovereign Debt Crisis". It starts with the proofs of Lemmas 1, 2, and 3b. Then, we expand on Remark 4 of our theoretical model regarding the role of government guarantees in mortgage finance. We then provide a brief chronology of the European sovereign debt crisis. We also give some facts about the economic impact of this crisis in terms of GDP growth, bond yields, and residential mortgage rates. We then perform some tests that support our argument that year-ends 2009 and 2013 roughly correspond to the period right before the sovereign debt crisis and the period at the end of this crisis, respectively. We also use our novel database to report estimates of the banks' credit squeeze by regions and asset types, as well as the change in residential portfolio weights with respect to banks' total loan portfolios. Here, we also investigate the reasons behind the credit squeeze in residential mortgages. In addition, we consider alternative definitions of flight-to-quality (FTQ) and risky-lending (RL) by disentangling the possibility of flight-home (FH) from these two variables, and provide similar regressions to the ones in the paper using these alternative dependent variables. Also, we provide alternative definitions of FTQ, FH, and RL both in net terms and in terms of a bank's total loan portfolios. We also include a table that contains the list of banks contained in our database. Finally, we provide a list of references specific to this Online Appendix.

# Proofs of Lemmas 1, 2, and 3

**Proof of Lemma 1:** From equilibrium conditions

$$\hat{z}^{\hat{l}_R} + Z_R = 0, R = \mathbf{A}, \mathbf{B} \tag{1}$$

and

$$\hat{\nu}^{\hat{l}_R}\left(\omega_1^{\hat{l}_R} - c\cdot(\phi_A \frac{\omega - \hat{p}_A \hat{z}^{\hat{l}_R}}{\hat{q}_A} + \phi_B \frac{\omega_1^{\hat{l}_R} - \hat{p}_B \hat{z}^{\hat{l}_R}}{\hat{q}_B})\right) = 0, R = \mathbf{A}, \mathbf{B}, \tag{2}$$

the following equality must hold for the marginal bank $\hat{l}_{\mathbf{B}}$ with the capital constraint binding:

$$\hat{q}_B = c\phi_B(1 + (\hat{p}_R Z_R / \omega_1^{l_{\mathbf{B}}})) \tag{3}$$

Also, we can use the market clearing conditions

$$(1 - \hat{l}_{\mathbf{A}})\frac{\omega_1^{l_{\mathbf{A}}} - \hat{p}_A \hat{z}^{\hat{l}_{\mathbf{A}}}}{\hat{q}_B} + (1 - \hat{l}_{\mathbf{B}})\frac{\omega_1^{l_{\mathbf{B}}} - \hat{p}_B \hat{z}^{\hat{l}_{\mathbf{B}}}}{\hat{q}_B} + Y_{\mathbf{B}} = 0 \tag{4}$$

and condition (1) to write:

$$\hat{q}_B = \left((1 - \hat{l}_{\mathbf{A}})(\omega_1^{l_{\mathbf{A}}} + \hat{p}_A Z_A) + (1 - \hat{l}_{\mathbf{B}})(\omega_1^{l_{\mathbf{B}}} + \hat{p}_B Z_B)\right)/(-Y_{\mathbf{B}}) \tag{5}$$

(3) and (5) then imply

$$1 = \frac{\omega_1^{l_{\mathbf{B}}}}{c\phi_B}\left((1 - \hat{l}_{\mathbf{A}})\frac{\omega_1^{l_{\mathbf{A}}} + \hat{p}_A Z_A}{\omega_1^{l_{\mathbf{B}}} + \hat{p}_B Z_B} + (1 - \hat{l}_{\mathbf{B}})\right) \tag{6}$$

Our initial hypothesis is that B-banks' funding cost increases, which is equivalent to saying that these banks obtain less funding in period 1 for the same $\rho_B$, [1] i.e., $\hat{p}_B Z_B$ decreases. Thus, if $\hat{p}_B Z_B$ decreases, $\hat{l}_{\mathbf{B}}$ must increase, assuming that $\hat{l}_{\mathbf{A}}$ decreases (we will verify this assumption next).

[1] Recall that $\hat{p}_B$ is endogenous in our model and $\rho_B$ is a parameter. This approach to asset pricing is the norm in general equilibrium.

Now, let us rewrite the market clearing condition for A-mortgages

$$\hat{l}_{\mathbf{A}} \frac{\omega_1^{l_{\mathbf{A}}} - \hat{p}_A \hat{z}^{\hat{l}_{\mathbf{A}}}}{\hat{q}_A} + \hat{l}_{\mathbf{B}} \frac{\omega_1^{l_{\mathbf{B}}} - \hat{p}_B \hat{z}^{\hat{l}_{\mathbf{B}}}}{\hat{q}_A} + Y_{\mathbf{A}} = 0 \tag{7}$$

and the indifference condition for the A-marginal bank

$$\frac{\delta}{\lambda^{\hat{l}_{\mathbf{A}}} \hat{q}_A} = \frac{\delta \left( \beta(\hat{l}_{\mathbf{A}}) + (1 - \beta(\hat{l}_{\mathbf{A}}))\gamma \right)}{\lambda^{\hat{l}_{\mathbf{A}}} \hat{q}_B + \nu^{\hat{l}_{\mathbf{A}}} c \phi_B} \tag{8}$$

with $\hat{\nu}^{\hat{l}_{\mathbf{A}}} = 0$ as follows, respectively,

$$\hat{q}_A = \left( \hat{l}_{\mathbf{A}} (\omega_1^{l_{\mathbf{A}}} - \hat{p}_A \hat{z}^{\hat{l}_{\mathbf{A}}}) + \hat{l}_{\mathbf{B}} (\omega_1^{l_{\mathbf{B}}} - \hat{p}_B \hat{z}^{\hat{l}_{\mathbf{B}}}) \right) / (-Y_{\mathbf{A}}) \tag{9}$$

$$\hat{q}_B = \hat{q}_A \left( \beta(\hat{l}_{\mathbf{A}}) + (1 - \beta(\hat{l}_{\mathbf{A}}))\gamma \right) \tag{10}$$

(9) and (10) then imply

$$\hat{q}_B = \left( \beta(\hat{l}_{\mathbf{A}}) + (1 - \beta(\hat{l}_{\mathbf{A}}))\gamma \right) \left( \hat{l}_{\mathbf{A}} (\omega_1^{l_{\mathbf{A}}} - \hat{p}_A \hat{z}^{\hat{l}_{\mathbf{A}}}) + \hat{l}_{\mathbf{B}} (\omega_1^{l_{\mathbf{B}}} - \hat{p}_B \hat{z}^{\hat{l}_{\mathbf{B}}}) \right) / (-Y_{\mathbf{A}}) \tag{11}$$

Then, if $\hat{p}_B \hat{z}^{\hat{l}_{\mathbf{B}}}$ decreases (our initial hypothesis), $\hat{q}_B$ decreases (from our initial hypothesis and (3)), and $\hat{l}_{\mathbf{B}}$ increases (as hypothesized above), then $\hat{l}_{\mathbf{A}}$ must decrease, assuming that $\hat{l}_{\mathbf{B}}(\omega_1^{l_{\mathbf{B}}} + \hat{p}_B \hat{z}^{\hat{l}_{\mathbf{B}}})$ increases. Thus, it remains to show that $(\omega_1^{l_{\mathbf{B}}} + \hat{p}_B \hat{z}^{\hat{l}_{\mathbf{B}}})$ does increase. For this, let us rewrite (5) as follows:

$$\hat{l}_{\mathbf{B}} (\omega_1^{l_{\mathbf{B}}} + \hat{p}_B Z_B) = -\hat{q}_B (-Y_{\mathbf{B}}) + (1 - \hat{l}_{\mathbf{A}})(\omega_1^{l_{\mathbf{A}}} + \hat{p}_A Z_A) + (\omega_1^{l_{\mathbf{B}}} + \hat{p}_B Z_B) \tag{12}$$

We conclude that the term $\hat{l}_{\mathbf{B}}(\omega_1^{l_{\mathbf{B}}} + \hat{p}_B Z_B)$ must decrease when $\hat{q}_B$ decreases, $\hat{l}_{\mathbf{A}}$ increases, and $\hat{p}_B Z_B$ decreases. ■

**Proof of Lemma 2:** Conditions (3) and (5) imply

$$c\phi_B \left( 1 + \frac{\hat{p}_R Z_R}{\omega_1^{l_{\mathbf{B}}}} \right) = \left( (1 - \hat{l}_{\mathbf{A}})(\omega_1^{l_{\mathbf{A}}} + \hat{p}_A Z_A) + (1 - \hat{l}_{\mathbf{B}})(\omega_1^{l_{\mathbf{B}}} + \hat{p}_B Z_B) \right) / (-Y_{\mathbf{B}})$$

Then, a decrease in $\omega_1^{l_{\mathbf{B}}}$ implies a decrease in $\hat{l}_{\mathbf{B}}$ , assuming that $\hat{l}_{\mathbf{A}}$ increases. This assumption is satisfied for our system of equilibrium equations. As in Lemma 1, we can use (9) and (10), and write condition (11), which in turn implies that if both $\omega_1^{l_{\mathbf{B}}}$ and $\hat{l}_{\mathbf{B}}$ decrease, $\hat{l}_{\mathbf{A}}$ must increase. ■

**Proof of Lemma 3:** From the indifference conditions for the A-marginal bank (8) and the B-marginal bank

$$\frac{\delta}{\lambda^{\hat{l}_{\mathbf{B}}}\hat{q}_A} = \frac{\delta\left(\beta(\hat{l}_{\mathbf{B}}) + (1-\beta(\hat{l}_{\mathbf{B}}))\gamma\right)}{\lambda^{\hat{l}_{\mathbf{B}}}\hat{q}_B + \nu^{\hat{l}_{\mathbf{B}}}c\phi_B} \tag{13}$$

and assumptions $\nu^{\hat{l}_{\mathbf{A}}} = \nu^{\hat{l}_{\mathbf{B}}} = 0$ and $\zeta > 0$, we have that $\beta(\hat{l}_{\mathbf{A}}) + (1-\beta(\hat{l}_{\mathbf{A}}))\gamma = \beta(\hat{l}_{\mathbf{B}}) + (1-\beta(\hat{l}_{\mathbf{B}}))(\gamma+\zeta)$. Thus, changes in $\hat{l}_{\mathbf{A}}$ and $\hat{l}_{\mathbf{B}}$ are such that either both $\hat{l}_{\mathbf{A}}$ and $\hat{l}_{\mathbf{B}}$ increase, or both $\hat{l}_{\mathbf{A}}$ and $\hat{l}_{\mathbf{B}}$ decrease. The following is an equilibrium. From market clearing equation (7), we have that, if funding decreases for B-banks (i.e., $\hat{p}_B Z_B$ decreases) and both $\hat{l}_{\mathbf{A}}$ and $\hat{l}_{\mathbf{B}}$ decrease, then $\hat{q}_A$ must decrease. Then, indifference condition (8) with $\nu^{\hat{l}_{\mathbf{A}}} = \nu^{\hat{l}_{\mathbf{B}}} = 0$ and $\zeta > 0$ implies that $\hat{q}_B$ must decrease. This is compatible with market clearing equation (4) as long as the increase in $(1-\hat{l}_{\mathbf{A}})$ and $(1-\hat{l}_{\mathbf{B}})$ is small compared to the fall in funding $\hat{p}_B Z_B$. ■

# Remark 4: Government guarantees in mortgage finance

Unlike in the US, securitization is not a major source of mortgage funding in any of the EU countries. However, European governments do guarantee residential mortgage funding in other ways, both explicitly and implicitly. Here, we argue that there are no reasons to incorporate differences in mortgage guarantees across countries in our model and regressions given the particularities of the government guarantees system in Europe.

First, the primary source of mortgage funding in the EU is from bank deposits and, to a lesser extent, covered bonds (see Min (2012)). Thus one might argue that differences in deposit guarantees across countries could have an impact on cross-border mortgage lending. In reality, however, there is substantial similarity among member states in the level of deposit coverage. On October 7, 2008, the EU Finance Ministers of all member states agreed to increase coverage for deposits to at least €100,000 within a year. At this coverage level, as the Amendment of the Directive on Deposit Guarantee Schemes (15.10.2008) points out, 90% of all eligible deposits were covered.[2] As a result, we dismiss differences in deposit guarantees across countries as a

[2] http://europa.eu/rapid/press-release_IP-08-1508_en.htm?locale=en

factor significant enough to be included in our theoretical model and regressions.

Second, a "too-big-to-fail" guarantee implicitly ensures the non-depository liabilities of some European banks (henceforth "TBTF" banks), including covered bonds. As argued by Bijlsma and Mocking (2013), TBTF banks have lower funding costs since their creditors are protected by the government. In turn, lower funding costs give these banks a competitive edge over other banks, providing an incentive to take risk because market discipline by investors decreases. This distorts investment decisions and makes banks too risky. In addition to controlling for the bank's funding costs in our regressions, we also highlight here an important Autumn 2008 decision at the EU level in which member states "agreed to take the necessary action to recapitalize and guarantee banks", an "unprecedented action . . . coordinated at the European level on an ad-hoc basis".[3] The existence of an implicit government guarantee common to all EU countries suggests that we cannot attribute any significant difference in TBTF government guarantees across EU countries.

## A brief chronology of the sovereign debt crisis

The European sovereign debt crisis sparked in early 2010 when Greek bond yields skyrocketed following bad news concerning the health of the Greek's government finances. On February 25, 2010, the IMF delivered a grim assessment of Greece's finances, on April 11 the EMU agreed on an unprecedented bailout plan for Greece, and on April 27 Standard & Poors (S&P) downgraded Greek's sovereign debt rating below investment grade to junk bonds. After that, the crisis spread to other European countries. Portuguese, Spanish, and Irish sovereign debt ratings were subsequently downgraded.

In September 2011, the international alarm over a Eurozone crisis grew when S&P downgraded Italy's sovereign rating as well as the rating of seven Italian banks. By then, concerns extended to the European banking sector. Funding costs rose most for those banks loaded with GICIPS sovereign bonds. GICIPS bonds became the new toxic asset of this crisis.[4] Tensions

[3]See http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52009DC0561. In addition, on May 9, 2010, right at the beginning of the sovereign debt crisis, the 27 EU member states agreed to create the European Financial Stability Facility (EFSF), a legal instrument aiming at preserving financial stability—including Eurozone countries in financial troubles—by recapitalizing banks or buying sovereign debt.

[4]To build on the analogy with the Great Recession, recall that the toxic assets during that time were US subprime mortgage-backed securities. Banks with high exposures to subprime mortgages found it difficult, if not impossible, to access funding liquidity.

rapidly transmitted to the repo market, and repo exchanges, such as LCH Clearnet, raised repo haircuts on lower-rated sovereign bonds.[5] Sovereign bonds were the main collateral for European banks for obtaining funding in repurchase agreements (or repos), and repos were the main tool for these banks for funding their asset purchases.[6] This was true even in the worst years of the sovereign debt crisis. For example, large European banks were still funding 66 percent of their assets in wholesale funding markets, which was twice the level of US or Asian banks (Hordahl and King 2008, and FSB 2012). Banks in GICIPS countries were the most exposed to GICIPS bonds.

Our database, constructed from the EBA's stress tests, shows that GICIPS banks' exposure to GICIPS bonds came mainly from their holdings of home-country sovereign debt. For example, we find that in 2009, the percentage of home-country long-term sovereign debt owned by home-banks was 94% for Greece, 65% for Ireland, 79% for Italy, 72% for Portugal, and 83% for Spain. In addition, our database reveals that by the end of 2009, banks in GICIPS countries were far more exposed to GICIPS bonds (in absolute terms) than banks in core European countries, suggesting that funding problems hit GICIPS banks more severely than banks in safe countries during the sovereign debt crisis.

The sovereign debt crisis was the perfect storm because it hit those countries with an undercapitalized banking sector. In Table 1, we can see that the *average* core Tier 1 capital ratio was significantly smaller for B-banks than for A-banks at the onset of this crisis. Interestingly, the standard deviation for the Tier 1 ratio in the B region was relatively small, suggesting that a large fraction of B-banks had significant lower core Tier 1 capital ratios. In the A region, on the other hand, the standard deviation was significantly higher, suggesting that some banks in that region were also undercapitalized.

A hallmark of the sovereign debt crisis was the unprecedented intervention of the European Central Bank (ECB), which injected more than 1 trillion euros into European financial entities

[5]For example, LCH Clearnet, the second largest clearer of bonds and repos in the world, providing services across 13 government debt markets, increased haircuts on Irish sovereign collateral from 0% to 45% in a short period of time. Putting aside default risk considerations, this increment means that, for every €100 of Irish collateral pledged in repo, a healthy German bank could only get €55 of funding.

[6]See Bottazzi, Luque and Pascoa (2012) for a general equilibrium model of repo and rehypothecation, and Luque (2017) for a general equilibrium model of cross-border lending in which banks finance their loan purchases through repo. Luque (2017) complements our work by taking a further step for understanding how shocks to repo funding and leverage induce banks to reallocate credit by geographic region and asset type

| | **mean** | **sd** | **min** | **max** |
|---|---|---|---|---|
| Tier 1 ratio in region A | 10.20 | 4.49 | 5.00 | 28.42 |
| Tier 1 ratio in region B | 7.85 | 1.92 | 4.00 | 10.53 |
| Tier 1 ratio in region C | 7.50 | 2.28 | 5.00 | 10.53 |
| Tier 1 ratio in region D | 12.08 | 0.25 | 11.82 | 12.33 |
| Tier 1 ratio in region E | 9.95 | 1.32 | 8.00 | 12.45 |

Table 1: This table reports banks' average core Tier 1 ratio in year-end 2009, sorted by the bank group. For each bank group, we take the average of core Tier 1 capital ratios among those banks in our sample that belong to the specific bank group in question. In addition to the averages, we also report the standard deviations, minimums, and maximums for each bank group and each point in time.

in two unprecedented 3-year Long Term Refinancing Operations at interest rates as low as 1% (December 22 2011 and February 29 2012). In addition, on March 25, 2013, a €10 billion international bailout was announced for Cyprus, in return for Cyprus agreeing to close the country's second-largest bank, the Cyprus Popular Bank, which was heavily exposed to Greek debt. In the meantime, the ECB continued pursuing a policy of low interest rates and, although these and other measures helped alleviate the tensions in the interbank market, the economic recovery did not start materializing until the end of 2013.

## Economic impact of the sovereign debt crisis

The economic impact of the sovereign debt crisis in the GICIPS region was brutal and contrasts with the mild impact of this crisis on core European countries. To get some inisght on these differences, we took Austria, Belgium, Finland, France, Germany, Luxembourg, and the Netherlands as the set of core European countries, and found that in 2011, the GICIPS countries experienced an average -1.57% Gross Domestic Product (GDP) growth rate, while the average GDP growth rate for the set of selected core European countries was 3% (see Table 2). When looking at the average 10-year sovereign bond yield in 2011, we find an average rate of 8.21% among the GICIPS countries and only a 2.95% average rate among the set of core European countries (see Table 3). Table 2 reports the average GDP growth rate in 2011 of countries in each region. Table 3 reports the average 10-year sovereign yield in 2011 of countries in each region. For both tables, in addition to the averages, we also report the standard deviations, minimums, and maximums for each region. We obtained our data for both GDP and bond yields from Eurostat.

Sovereign bond yields are a proxy for mortgage rates, so it is reasonable to argue that residential mortgage rates were also substantially higher in the GICIPS countries than in the core countries. Table 4, which reports the average growth rate of residential mortgage rates between 2010 and 2013 of countries for each bank group, confirms this. There, we see that the average growth rate of mortgage rates between 2010 and 2013 was 15.90% among the GICIPS countries and -11.73% among the core countries. In addition, we find that the correlation coefficient of residential mortgage rates between GICIPS countries and core countries was low (0.1). This contrasts with the high correlation coefficient (0.87) between our set of selected core countries

|  | **mean** | **sd** | **min** | **max** |
|---|---|---|---|---|
| Region A | 3.00 | 0.78 | 1.65 | 3.66 |
| Region B | -1.57 | 3.45 | -8.87 | 2.79 |
| Region C | 1.11 | 0.70 | 0.61 | 2.10 |
| Region D | 3.28 | 1.48 | 1.81 | 4.76 |
| Region E | 1.84 | 0.61 | 1.28 | 2.73 |

Table 2: This reports the average GDP growth rate in 2011 of countries in each region.

| | **mean** | **sd** | **min** | **max** |
|---|---|---|---|---|
| Region A | 2.95 | 0.41 | 2.61 | 4.18 |
| Region B | 8.21 | 3.91 | 5.42 | 15.75 |
| Region C | 4.97 | 0.00 | 4.97 | 4.97 |
| Region D | 6.80 | 0.84 | 5.96 | 7.64 |
| Region E | 2.85 | 0.23 | 2.61 | 3.14 |

Table 3: This table reports the average 10-year sovereign yield in 2011 of countries in each region.

and other safe European non-euro countries (Denmark, Sweden, and the United Kingdom), and also between core countries and a group of eastern European countries (Bulgaria, Czech Republic, Hungary, Poland, and Romania), with a correlation coefficient of 0.95 for the latter pair of country groups. We report the correlation coefficients of residential mortgage rates among bank groups for the period 2010-2013 in Table 5 (see below for other tables of correlation coefficients between countries within bank groups A and B).[7]

Finally, we report in Table 6 the correlation coefficients of residential mortgage rates between countries within group A. Table 7 does the same but between countries within group B. Both Tables 6 and 7 use data from European Mortgage Federation National Experts.

## Year-end 2009 and year-end 2013 as appropriate points in time for our empirical analysis

An important question, relevant for our empirical analysis, is whether our two points in time, year-ends 2009 and 2013, roughly correspond to the period right before the sovereign debt crisis and the period at the end of this crisis, respectively. We address this question in this subsection.

Several empirical studies identify the first quarter of 2010 as the beginning of the European sovereign debt crisis. In particular, Tamakoshi and Hamori (2015) find a structural break date in both the mean and volatility of the 1-year Greek sovereign index return in April 2010, when the European sovereign debt crisis intensified and the Greek bond was downgraded to junk status. In addition, Filoso et al. (2016) identify May 2010 as a break date for Greece, Italy, and Spain using daily values of 10-year public bonds' interest rates. In addition, Filoso et al. (2016) showed that the crisis worsened after summer 2011, as the European authorities hastened the restructuring of Greek sovereign debt, and also that the crisis improved only during summer 2012, when the ECB Governing Council approved a program for the purchase of sovereign bonds. Thus, given these findings, we can regard year-end 2009 as a moment in time right before the sovereign debt crisis started.

[7] Both Tables 4 and 5 use data from European Mortgage Federation National Experts (information on residential interest rates for Iceland, Liechtesnstein, and Norway (in group E) not reported).

| | mean | sd | min | max |
|---|---|---|---|---|
| A | -11.73% | 9.77% | -29.31% | -0.50% |
| B | 15.90% | 18.52% | -14.62% | 36.70% |
| C | -17.98% | 11.98% | -35.41% | -3.06% |
| D | -17.90% | 12.25% | -33.47% | -1.33% |
| E | -1.75% | 25.30% | -20.18% | 27.09% |

Table 4: This table reports the average growth rate of residential mortgage rates between 2010 and 2013 of countries for each bank group.

| | A | B | C | D | E |
|---|---|---|---|---|---|
| A | 1.00 | | | | |
| B | 0.10 | 1.00 | | | |
| C | 0.99 | 0.00 | 1.00 | | |
| D | 0.95 | 0.13 | 0.96 | 1.00 | |
| E | 0.87 | 0.29 | 0.87 | 0.83 | 1.00 |
| | 0.83 | -0.37 | 0.84 | 0.69 | 0.56 |

Table 5: This table reports the correlation coefficients of residential mortgage rates among bank groups for the period 2010-2013.

| | Austria | Belgium | Finland | France | Germany | Luxembourg | Netherlands |
|---|---|---|---|---|---|---|---|
| Austria | 1 | | | | | | |
| Belgium | 0.6667 | 1 | | | | | |
| Finland | 0.6476 | 0.3374 | 1 | | | | |
| France | 0.962 | 0.5348 | 0.4665 | 1 | | | |
| Germany | 0.8233 | 0.9474 | 0.6086 | 0.6713 | 1 | | |
| Luxembourg | 0.7911 | 0.1349 | 0.8129 | 0.764 | 0.4291 | 1 | |
| Netherlands | 0.9474 | 0.8626 | 0.5143 | 0.8857 | 0.9305 | 0.5614 | 1 |

Table 6: This table reports the correlation coefficients of residential mortgage rates between countries within group A.

| | Greece | Ireland | Cyprus | Italy | Portugal | Spain |
|---|---|---|---|---|---|---|
| Greece | 1.00 | | | | | |
| Ireland | 0.20 | 1.00 | | | | |
| Cyprus | 0.18 | 0.59 | 1.00 | | | |
| Italy | -0.26 | 0.44 | 0.90 | 1.00 | | |
| Portugal | 0.30 | 0.57 | 0.99 | 0.84 | 1.00 | |
| Spain | 0.45 | 0.64 | 0.96 | 0.74 | 0.98 | 1.00 |

Table 7: This table reports the correlation coefficients of residential mortgage rates between countries within group B.

To the best of our knowledge, there are no papers that study the existence of a structural break for the end of the sovereign debt crisis. To shed light on this issue, we first computed the average 10-year bond yields for Greece, Ireland, Italy, Portugal, and Spain in different time periods.[8] We find that the average yields became substantially smaller after year-end 2013 compared to the crisis and pre-crisis periods for all countries except for Greece (see Table 8)).

Because Greek yields remained higher after year-end 2013 than in the pre-crisis period, we ran the Zivot-Andrews (1992) test to search for a structural break date on 10-year Greek bond yields. The Zivot-Andrews (1992) test consists of a unit-root testing procedure that allows us to test for the existence of a date break in the trend function under the alternative hypothesis that there is no break. This test circumvents the problem of data-mining (i.e., searching at each date if there is a break) and has good aymptotic properties. The procedure runs sequential tests using the full sample and different dummy variables for each possible break period (the breakpoint is endogenous). The break is detected where the t-statistic is lower. Because our objective is to find a "minimum" (for the end of the crisis), we ran the Zivot-Andrews (1992) test for the period that goes from the beginning of March 2012 (at the peak of the sovereign debt crisis) to the end of December 2016 (the last date of our sample). This test reveals the existence of a structural break date on December 24, 2013 with a t-statistic of -4.357 (which implies significance of 10%). Thus, we conclude that year-end 2009 can be regarded as a moment in time close to the end of the sovereign debt crisis.

# Sizing Up Changes in Cross-Border Residential Lending

## Credit squeeze

Table 9 reports the difference between year-end 2013 exposures and year-end 2009 exposures (in millions of EUR) by exposure type and country group. These numbers provide a conservative first approximation (lower bound) of the credit squeeze by region and portfolio loan type. In total, for our sample of 69 representative banks, the reduction in banks' credit supply amounts to more

[8]We computed these averages using daility data from Datastream. The corresponding yields for Cyprus are not provided in Datastream.

| | Jan 02-Dec 16 | Jan 02-Mar 10 | Apr 10-Feb 12 | Mar 12-Dec 13 | Jan 14-Dec 16 |
|---|---|---|---|---|---|
| Greece | 2.36 | 1.49 | 2.71 | 2.65 | 2.11 |
| Ireland | 0.69 | 1.43 | 2.03 | 1.53 | 1.07 |
| Italy | 1.01 | 1.44 | 1.56 | 1.55 | 0.65 |
| Portugal | 1.49 | 1.43 | 2.09 | 2.04 | 1.09 |
| Spain | 1.02 | 1.40 | 1.60 | 1.64 | 0.62 |

Table 8: This table reports the average 10-year bond yields for Greece, Ireland, Italy, Portugal, and Spain for the following time periods: (i) January/1/2002 (after the adoption of the euro for all euro countries, including Greece) - December/31/16 (last date of our sample); (ii) January/1/2002 (after the adoption of the euro for all euro countries, including Greece) - March/30/2010 (the onset of the sovereign debt crisis); (iii) April/01/2010 (the onset of the sovereign debt crisis) - February/30/2012 (the peak of the sovereign debt crisis); (iv) March/1/2012 (the peak of the sovereign debt crisis) - December/31/2013 (the end of 2013, which corresponds to our second data point from the EBA's stress tests); and (v) January/1/2014 (the first date after year-end 2013) - December 31/2016 (the last date of our sample).

than €10.8tr. Of this, at least €2.7tr corresponds to the "periphery" B-banks and at least €4.8tr corresponds to "core" A-banks. In addition, of the €10.8tr total credit squeeze, we find that at least €3.2tr corresponds to residential exposures.[9] These are very high numbers considering that the ECB's 3-year LTRO loans in 2012—the so-called "big bazooka"—were just €1tr.

We also used our database to size up the residential credit squeeze by region. In total, B-banks' residential mortgage exposures in their respective home countries decreased by €560bn, whereas banks in countries outside the B region reduced their B residential mortgage exposures by €80bn. Thus, the residential mortgage credit squeeze in the B region was larger than €0.6tr. The residential credit squeeze in the A region was €0.9tr — a shift in allocation approaching the scale of the ECB's unprecedented €1tr in 3-year LTRO loans by the beginning of 2012. Although the squeeze in the A region was slightly higher than in the B region, one must keep in mind that the aggregate Gross Domestic Product (GDP) of countries in the A region is four times higher than the GDP of countries in the B region.

To put in perspective the €0.6tr reduction in residential credit in the B region, we took data from the European Mortgage Federation National Experts, and found that the overall market size of residential loans in GICIPS countries by the end of 2009 was €1.3tr. Thus, the €0.6tr retrenchment in residential mortgage credit is approximately half of the overall market size of residential loans in GICIPS countries.

## What factors are behind the very dramatic decline in outstanding bank mortgage credit?

To answer this question, we look at the following suspects:

- **Curtailment of new lending**: To get a better understanding of the relationship between the credit squeeze in residential loans and the squeeze in total credit, we sorted banks by

[9] In addition, Table 9 shows that the credit squeeze in corporate loans was even higher than for residential loans (€4.6tr and €3.2tr, respectively). The squeeze in the credit sector may explain the escalation in unemployment observed in Spain during the sovereign debt crisis period. See Weiss and Stiglitz (1981) for a seminal paper on credit rationing and unemployment, and Benmelech et al. (2011) for an illustration of the economic importance of this channel; see also Broner et al. (2014) for a model that rationalizes how a reduction of productive investments due to more purchases of public debt may have deepened the recession in a context of constrained domestic creditors.

| **Country group** | **Residential** | **Commercial** | **Sovereign** | **Institution** | **Corporate** | **Total** |
|---|---|---|---|---|---|---|
| A | -1,139,202 | -342,614 | -52,846 | -1,263,824 | -1,989,532 | -4,788,018 |
| B | -887,419 | -224,980 | 91,499 | -399,967 | -1,336,726 | -2,757,593 |
| C | -4,706 | -3,664 | -215 | -8,372 | -20,398 | -37,356 |
| D | -7,427 | -1,513 | -3,998 | -1,245 | -11,044 | -25,227 |
| E | -1,187,608 | -379,590 | -72,718 | -361,966 | -1,247,300 | -3,249,181 |
| Total | -3,226,362 | -952,362 | -38,277 | -2,035,373 | -4,605,000 | -10,857,375 |

Table 9: This table estimates the change in banks' exposures between year-end 2013 and 2009 by loan type - residential mortgages, commercial mortgages, sovereigns, financial institutions, and corporations - in million EUR terms. For example, the amount -1,139,202 represents the total decrease in residential mortgage credit between year-end 2013 and year-end 2009 for the set of A-banks in our sample.

percentiles (0%-25%, 25%-50%, 50%-75%, and 75%-100%) and computed the correlations between these two variables for each percentile. We did this exercise for our set of 69 banks, as well as for bank groups A and B. We report the resulting correlations in Table 10. There, we can appreciate a decreasing positive correlation for the set of B-banks as we move from the first percentile (banks with the lowest reduction in total credit) to the last percentile (banks with the highest reduction in total credit). Roughly speaking, the relationship between the squeeze in residential mortgage credit and the squeeze in total credit is less intense for those B-banks with a larger squeeze in all loan types. Yet, we find small correlation coefficients (between 0.05 and 0.12), so this result should be taken with precaution. In Table 10, we also see that there is no clear pattern for the other sets of banks (all banks and A-banks).

- **Funding cost and core Tier 1 capital:** In addition, we correlated the credit squeeze in residential loans with variables such as funding cost and core Tier 1 capita, but found no clear pattern.

- **Losses**: Unfortunately, in our database, constructed with the EBA's stress tests, we are not able to disentangle "losses through foreclosures" from total bank losses. Keeping this shortcoming in mind, we correlated the change in residential exposures between 2009 and 2013 with net losses (losses minus profits), and found evidence of an increasing negative relationship for all bank groups, suggesting that banks with more losses experienced a larger reduction in residential mortgage lending. However, correlation coefficients were very small (between 0.06 and -0.02), suggesting a weak or even nonexistent correlation pattern between these two variables.[10]

- **Shift to non-bank lending sources:** Unfortunately, our database, constructed with the EBA's stress tests, does not allow us to identify non-bank lending sources. It only provides information on banks' exposures to residential and commercial mortgages, sovereign bonds, loans to financial institutions, and corporate loans.

[10]Results can be provided by the authors upon request.

| *Change in total lending* | All banks | A-banks | B-banks |
|---|---|---|---|
| 0%-25% | 0.01 | 0.00 | 0.12 |
| 25%-50% | 0.00 | 0.11 | 0.10 |
| 50%-75% | 0.06 | 0.08 | 0.08 |
| 75%-100% | 0.05 | 0.07 | 0.05 |

Table 10: This table reports the correlation coefficients for each bank group and percentile group corresponding to the banks' change in residential mortgage lending between 2009 and 2013 (in euros), and the change in total lending (including all loan types) between 2009 and 2013.

### Change in portfolio weights

Regarding the change in loan portfolio weights with respect to the overall total portfolio (including all loan types), we report in Table 11 the average weights by bank home regions. This table corroborates the now well-known fact that, taken together, banks in all countries rebalanced their portfolios in favor of sovereign debt (see Popov and Van Horen (2015) and Broner et al. (2014) for seminal contributions on this issue). In addition, we can see that portfolio rebalancing in residential mortgages was not as intense as in the case of corporate exposures. Because the focus of this paper is on residential mortgages, we leave for future research a detailed study of the credit squeeze in other loan types, including corporate exposures.

Table 12 complements our results on the changes in residential portfolio weights in Table 11 with additional information on standard deviation, minimums, and maximums for this loan type. There, we see that exposures to residential mortgages did not change much between year-ends 2009 and 2013 in terms of *total* portfolio weights. We also appreciate a significant difference between minimums and maximums both across bank regions and within regions but for different points in time. Interestingly, from year-end 2009 to year-end 2013, the minimum decreases and maximum increases for banks in region B. This suggests that the set of B-banks became more heterogenous in terms of residential portfolio rebalancing after the onset of the sovereign debt crisis.

## Disentangling FH from FTQ and RL

We define flight-home (FH) in residential loans as the strategy of a bank rebalancing its residential loan portfolio toward its home country. In this section, we disentangle FH from FTQ and RL. For this, we redefine FTQ as the strategy of a bank rebalancing its residential loan portfolio toward a "safe" country, other than its home country if the bank's home country is in the "safe" region; we also redefine RL as the strategy of a bank rebalancing its residential loan portfolio toward any of the B countries, other than its home country if the rebalancing bank is located in a B country.

| | Residential | | Commercial | | Sovereign | | Institution | | Corporate | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2013 | 2009 | 2013 | 2009 | 2013 | 2009 | 2013 | 2009 | 2013 |
| A | 16.78% | 13.02% | 6.17% | 1.20% | 19.94% | 64.66% | 27.14% | 10.34% | 29.96% | 10.79% |
| B | 30.5% | 31.82% | 8.69% | 3.63% | 13.71% | 51.11% | 11.02% | 7.15% | 35.98% | 6.29% |
| C | 16.41% | 15.74% | 1.97% | 3.55% | 19.95% | 73.06% | 18.70% | 7.65% | 42.95% | 0.00% |
| D | 44.56% | 53.88% | 2.48% | 0.06% | 23.56% | 35.71% | 4.85% | 4.63% | 24.52% | 5.73% |
| E | 33.30% | 32.46% | 10.57% | 3.40% | 11.42% | 51.47% | 11.71% | 8.60% | 32.98% | 4.08% |

Table 11: This table estimates the change in banks' loan portfolio weights with respect to the overall total portfolio by loan type (residential, commercial real estate, sovereign, corporate, and lending to financial institutions) and by bank country. Numbers are presented in percentage terms and the columns for both year-ends 2009 and 2013 sum to 100%.

| **Year-end 2009** | **mean** | **sd** | **min** | **max** |
|---|---|---|---|---|
| A | 16.78% | 15.79% | 0.00% | 59.69% |
| B | 30.59% | 12.16% | 13.88% | 60.13% |
| C | 16.41% | 11.03% | 7.30% | 31.93% |
| D | 44.57% | 0.46% | 44.11% | 45.02% |
| E | 33.30% | 15.77% | 13.62% | 65.09% |
| | | | | |
| **Year-end 2013** | **mean** | **sd** | **min** | **max** |
| A | 13.02% | 10.80% | 0.00% | 36.86% |
| B | 31.82% | 16.49% | 6.66% | 72.16% |
| C | 15.74% | 12.35% | 0.18% | 30.39% |
| D | 53.88% | 19.54% | 34.34% | 73.41% |
| E | 32.46% | 17.40% | 10.07% | 81.99% |

Table 12: This table reports the banks' average *residential* portfolio weights (with respect to total assets in portfolio) sorted by the bank group. For each bank group and each point in time (year-end 2009 and year-end 2013), we take the average of residential mortgage portfolio weights (with respect to the total assets in portfolio) among those banks in our sample that belong to the specific bank group in question. In addition to the averages, we also report the standard deviations, minimums, and maximums for each bank group and each point in time.

Formal definitions of our variables of interest follow using variable

$$\pi^i_{j,\theta,t} = \frac{L^i_{j,\theta,t}}{\sum_i L^i_{j,\theta,t}}$$

In particular:

- for a {bank $j$, counterparty country $i$}-pair with {bank $j$'s home country$\neq i$}, $FTQ^{sh,i}_{j,\theta} = 1$ if $\pi^i_{j,\theta,t+1} > \pi^i_{j,\theta,t}$, where $i \in \{A, E, F\}$.
- for a {bank $j$, counterparty country $i$}-pair with {bank $j$'s home country$\neq i$}, $RL^{sh,i}_{j,\theta} = 1$ if $\pi^i_{j,\theta,t+1} > \pi^i_{j,\theta,t}$, where $i \in \{B\}$.
- for a {bank $j$, counterparty country $j$}-pair with {bank $j$'s home country$\neq j$}, $FH^{sh,i}_{j,\theta} = 1$ if $\pi^j_{j,\theta,t+1} > \pi^j_{j,\theta,t}$.

Next, we compare regions in terms of FTQ, FH, and RL bank behaviors as redefined above. Figures 1.a, 1.b, and 1.c illustrate the number of FTQ residential loans, FH residential loans, and RL residential loans by bank region, respectively. The interpretation is in terms of pairs (bank, country counterparty) and exposure to residential mortgage loans.

For the above definitions, we find 19 $FTQ^{sh,i}_{j,\theta}$ pairs {B-bank $j$, safe country counterparty $i$}, where a B-bank $j$ rebalanced its residential loan portfolio toward a country $i$ in the "safe" region. On the other hand, there were 49 $FTQ^{sh,i}_{j,\theta}$ pairs {A-bank $j$, safe country counterparty $i$} for banks in the A region. Because the A region and the B region have 22 and 24 non-nationalized banks, respectively, we conclude that, on average, A-banks had 2.8 times more safe-country counterparties than B-banks in FTQ cross-border residential mortgage lending. However, when looking at the FH numbers, we notice that B-banks had a higher number of FH residential loans than A-banks, both in absolute terms (9 FH loans for B-banks and 7 FH loans for A-banks) and in average terms (0.37 FH loans on average per B-bank and 0.32 FH loans on average per A-bank). The number of $RL^{sh,i}_{j,\theta}$ pairs {bank $j$, risky country $i$}, where a bank $j$ rebalanced its residential loan portfolio toward a country $i$ in the "risky" B region, is 3.6 times higher for A-banks than for B-banks (11 RL loans for A-banks and only 3 for B-banks). Also, on average, A-banks had riskier counterparties than B-banks.

To sum up, we demonstrate a geographical market segmentation of the banks' cross-border residential mortgage lending during the European sovereign debt crisis. A-banks engaged in more FTQ and RL than B-banks (consistent with our results in the main paper with FH embded into FTQ and RL), while B-banks engaged in slightly more FH than A-banks.

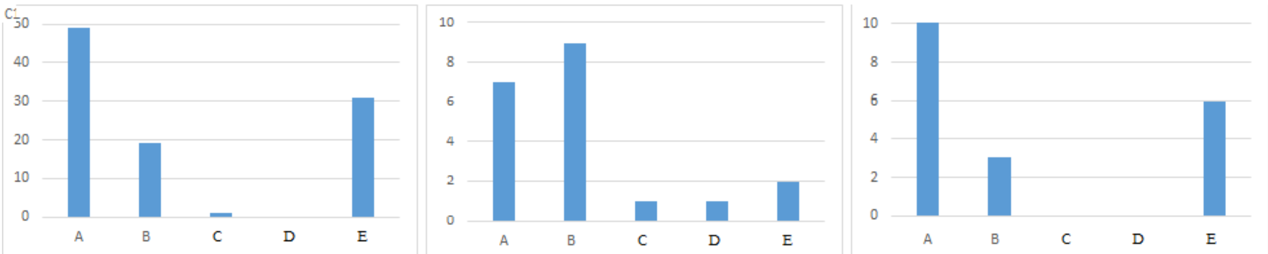
## Regression results for redefined variables $FTQ_{j,\theta}^{sh,i}$, $FH_{j,\theta}^{sh,j}$, and $RL_{j,\theta}^{sh,i}$

We ran three separate logistic models to regress our categorical dependent variables $FTQ_{j,\theta}^{sh,i}$, $FH_{j,\theta}^{sh,j}$, and $RL_{j,\theta}^{sh,i}$ with respect to the independent variables described above. Here $\theta$ stands for "residential loans". Because we are mainly interested in understanding the rebalancing of cross-border residential loans of banks in the A and B groups, we ran these regressions for each of these two groups of banks.[11] Each regression has 459 observations if the set of banks belongs to the A region and 648 if the set of banks belongs to the B region. We report the results of these regressions in Tables 13 and 14, respectively. Notice that, for the FH regressions, we do not include the variable "Domestic-Counterparty GDP growth diff", given that by definition of FH, the difference in GDP growth rate between the bank home country and its counterparty country would be zero. Thus, in the corresponding coefficient we write "n.a.".

The logistic regressions in Tables 13 and 14 fit the data pretty well and are absent of severe multicollinearity (or collinearity for short). We achieved a quite high goodness-of-fit ($R^2$) considering the use of a logistic model. For the set of A-banks, we got $R^2 = 26.42\%$ for the FTQ regression, $R^2 = 32.95\%$ for the FH regression, and $R^2 = 18.99\%$ for the RL regression. And for the set of B-banks, we got $R^2 = 39.72\%$ for the FTQ regression, $R^2 = 32.57\%$ for the FH regression, and $R^2 = 46.10\%$ for the RL regression.

With regard to collinearity, notice that it occurs when two or more independent variables are approximately determined by a linear combination of other independent variables in the model. When severe collinearity occurs, the standard errors for the coefficients tend to be very large (inflated), and sometimes the estimated logistic regression coefficients can be highly unreliable. Two commonly used measures to detect severe collinearity are the tolerance and VIF (variance

[11] We use the logistic distribution because it has larger tails than a normal distribution, and hence is a more robust estimation for our type of volatile data. Recall that a logistic econometric model estimates the best fit of a cumulative distribution function of the errors, which are assumed to behave as a joint logistic distribution.




(a) FTQ across regions in residential loans

(b) FH across regions in residential loans

(c) RL across regions in residential loans

Figure 1: These figures illustrate the number of FTQ residential loans, FH residential loans, and RL residential loans by bank region, respectively. The interpretation is in terms of pairs (bank, country counterparty) and exposure to residential mortgage loans with respect to total residential loans in portfolio.

inflation factor). The "collin" program (Stata) provides estimates of these two measures. For this test, the rule of thumb is that a tolerance of 0.1 or less (equivalently VIF of 10 or greater) is a cause for concern. The "collin" test confirms that for our set of independent variables there is no severe collinearity.

## Alternative definitions of FTQ, FH, and RL

### In net terms

One may wonder whether the insights obtained from our previous comparison among lending behaviors would still hold if instead we use alternative definitions of FTQ, FH, and RL that capture potentially offsetting positions within a region. For example, suppose that a Spanish bank increases its residential portfolio weight exposure in Germany by $1\%$ and decreases its residential exposure in France by $1\%$; then we can say that *in net terms* there is no FTQ in residential loans for this bank. However, under the former definitions in gross terms, we would count this as 1 residential loan (B-bank, safe country counterparty). Here, we provide the formal definitions of FTQ, FH, and RL in net terms and also compare the corresponding lending behaviors by bank region. In particular, we show that our previous conclusions do not change if we consider the definitions in net terms. We also find that A-banks engaged in more FTQ and RL than B-banks, and B-banks engaged in slightly more FH than A-banks.

In the paper, definitions were expressed in gross terms because there we are counting pairs $\{$bank, counterparty country$\}$. Here, we provide a different perspective on the magnitudes of FTQ, FH, and RL by considering alternative definitions that capture potentially offsetting positions within a region. For a given point in time $t$, we define the bank $j$'s share of type $\theta$ loans (e.g., residential loans) in region $R$ with respect to its *total residential loans* as follows:

$$\pi^R_{j,\theta,t} = \frac{\sum_{i\in R} L^i_{j,\theta,t}}{\sum_i L^i_{j,\theta,t}}$$

Expression $\pi^R_{j,\theta,t}$ deserves three remarks:

- Region $R$ may consist of one or several regions in the set $\{A, B, C, D, E, F\}$.

| | FTQ A-banks | | | FH A-banks | | | RL A-banks | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | | S.E. | Coef. | | S.E. | Coef. | | S.E. |
| Core Tier 1 ratio | 0.893 | *** | 0.181 | -9.274 | * | 5.581 | 0.219 | | 0.279 |
| Funding costs | -0.242 | | 0.320 | -9.518 | | 6.829 | -0.980 | ** | 0.428 |
| Default exposures to total exposures | -0.506 | | 0.406 | -11.000 | * | 6.745 | -1.721 | *** | 0.524 |
| B-bond exposures to total exposures | -0.415 | *** | 0.155 | -12.118 | | 7.695 | -0.435 | *** | 0.171 |
| Coverage ratio residential loans | 0.023 | ** | 0.011 | 0.567 | | 0.364 | 0.028 | | 0.020 |
| Provisions nondefaulted residential loans | -1.540 | *** | 0.309 | -13.759 | | 9.065 | -0.527 | * | 0.315 |
| Provisions defaulted residential loans | 0.265 | *** | 0.066 | 1.989 | | 1.306 | 0.098 | | 0.086 |
| Domestic - Counterparty GDP growth diff | -0.265 | *** | 0.032 | n.a. | | n.a. | 0.129 | *** | 0.029 |
| Growth BP counterparty | 0.028 | *** | 0.005 | 0.037 | *** | 0.007 | -0.044 | *** | 0.004 |
| Avg. growth house prices counterparty | 0.012 | ** | 0.006 | 0.018 | | 0.016 | -0.014 | | 0.010 |
| Constant | -9.477 | *** | 1.920 | 111.970 | | 73.202 | -2.281 | | 2.519 |

Table 13: Determinants of the FTQ, FH, and RL behaviors in terms of total residential exposures for the subset of A-banks. *** Significant at the 1 percent level; ** Significant at the 5 percent level; * Significant at the 10 percent level. Standard error adjusted for 17 clusters.

| | FTQ B-banks | | | FH B-banks | | | RL B-banks | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coef. | | S.E. | Coef. | | S.E. | Coef. | | S.E. |
| Core Tier 1 ratio | -0.682 | * | 0.358 | -0.234 | | 0.218 | -0.856 | ** | 0.404 |
| Funding costs | 1.981 | ** | 0.899 | 3.730 | * | 1.991 | -0.319 | | 1.100 |
| Default exposures to total exposures | -1.007 | *** | 0.342 | -0.090 | | 0.081 | -0.443 | | 0.304 |
| B-bond exposures to total exposures | -0.222 | ** | 0.113 | -0.018 | | 0.036 | -0.213 | | 0.138 |
| Coverage ratio residential loans | -0.082 | * | 0.045 | -0.049 | | 0.032 | -0.227 | *** | 0.048 |
| Provisions nondefaulted residential loans | -0.233 | | 0.536 | -0.438 | | 0.473 | 0.751 | | 0.518 |
| Provisions defaulted residential loans | 0.569 | *** | 0.203 | 0.168 | ** | 0.078 | 0.024 | | 0.189 |
| Domestic - Counterparty GDP growth diff | -0.275 | *** | 0.058 | n.a. | | n.a. | 0.027 | | 0.366 |
| Growth BP counterparty | 0.042 | *** | 0.008 | -0.045 | *** | 0.016 | -0.086 | ** | 0.045 |
| Avg. growth house prices counterparty | -0.005 | | 0.013 | 0.022 | | 0.019 | -0.006 | | 0.040 |
| Constant | 5.230 | | 4.547 | -10.796 | *** | 3.349 | 6.711 | | 5.116 |

Table 14: Determinants of the FTQ, FH, and RL behaviors in terms of total residential exposures for the subset of B-banks. *** Significant at the 1 percent level; ** Significant at the 5 percent level; * Significant at the 10 percent level. Standard error adjusted for 24 clusters.

- The numerator of $\pi^R_{j,\theta,t}$ includes all bank $j$'s loans in all countries in $R$ at time $t$. Thus, as we move from $t$ to $t+1$, some exposures to certain countries in $R$ may increase, while exposures in other countries in $R$ may decrease in absolute euro terms. Thus, the change in $\sum_{i\in R} L^i_{j,\theta,t+1} - \sum_{i\in R} L^i_{j,\theta,t}$ captures the bank $j$'s net change in region $R$. For the same reason, a change from $\pi^R_{j,\theta,t}$ to $\pi^R_{j,\theta,t+1}$ should also be read in net terms for region $R$.

- The denominator of $\pi^R_{j,\theta,t}$ captures the bank $j$'s *total residential exposures*, irrespectively of loan type and geographical location, at time $t$.

We can say that a bank engages in FTQ in residential loans in net terms when $\pi^R_{j,\theta,t+1} > \pi^R_{j,\theta,t}$ and $R = \{A, E, F\}$. When this happens, the FTQ dummy variable (in shares), denoted by $FTQ^{sh,net}_{j,\theta}$, takes a value equal to 1, and 0 otherwise. Similarly, we write the corresponding definition for RL as follows: $RL^{sh,net}_{j,\theta} = 1$ if $\pi^B_{j,\theta,t+1} > \pi^B_{j,\theta,t}$.[12]

Table 15 represents, for different groups of countries, the fraction of banks in each region whose lending behaviors satisfy these definitions. For the sake of exposition, we refer to these lending behaviors in net terms as "FTQ (net)" and "RL (net)". Observe that it is not possible to rewrite the FH definition in net terms because each bank only has 1 counterparty (its own home country). Therefore, in Table 15, when revisiting FH in terms of the percentage of banks per region rebalancing their residential portfolios toward home, we will use the same definition of FH as before, namely, $FH^{sh,j}_{j,\theta} = 1$ if $\pi^j_{j,\theta,t+1} > \pi^j_{j,\theta,t}$.

We obtain the following insights from Table 15. On the one hand, for the set of A countries, which contains 22 representative non-nationalized banks, 50% of the banks exhibited an $FTQ^{sh,net}_{j,\theta}$ in cross-border residential mortgage lending, 32% rebalanced their portfolio weight on residential loans toward their respective home countries ($FH^{sh,j}_{j,\theta}$), and 18% are characterized by risky lending behavior in residential loans ($RL^{sh,net}_{j,\theta}$).

The other important group of banks examined in this paper was B, which contains 24 non-nationalized banks. For this group, $FTQ^{sh,net}_{j,\theta}$ in cross-border residential mortgage lending oc-

[12]The analysis could go one step further and consider portfolio rebalancing in net terms with the region R being composed of both safe and risky countries. If, for example, there were positive net rebalancing towards safe countries, we would say that the bank engaged in FTQ in net terms for the whole universe of counterparties. Although reasonable from a statistical standpoint, this stricter definition does not capture the fact that a bank can be engaged in both FTQ and RL and that both of these lending behaviors should be identified in our analysis. Thus, for our discussion of alternative definitions of lending behaviors in net terms, we stick to the above definitions $FTQ^{sh,net}_{j,\theta}$ and $RL^{sh,net}_{j,\theta}$.

| **Flight_type** | **Region A** | **Region B** | **Region C** | **Region D** | **Region E** |
| --- | --- | --- | --- | --- | --- |
| FTQ (net) | 0.50 | 0.250 | 0.333 | 0.000 | 0.615 |
| FH (net) | 0.318 | 0.375 | 0.333 | 0.500 | 0.154 |
| RL (net) | 0.182 | 0.125 | 0.000 | 0.000 | 0.308 |

Table 15: This table reports, for different groups of countries, the fraction of banks in our sample that exhibit $FTQ^{sh,net}_{j,\theta}$, $FH^{sh,j}_{j,\theta}$, and $RL^{sh,net}_{j,\theta}$ lending behaviors in residential mortgages.

curred for 25% of B-banks, half of what we observe for the set of A-banks (50%). This result is consistent in relative terms with the numbers reported in Figure 1.a, setting aside the obvious differences between the definitions in "gross" and "net" terms. On the other hand, the percentage of banks in the B region that engaged in $RL_{j,\theta}^{sh,net}$ in their residential loan exposure was 13%, again smaller than for the set of A-banks (18%) and thus consistent in relative terms with the numbers reported in Figure 1.c (aside from, again, the obvious differences in definitions). These two results confirm that A-banks were characterized by more FTQ and RL than were the B-banks, consistent with the results found in the paper using different definitions of FTQ and RL.

For the $FH_{j,\theta}^{sh,j}$ behavior in residential loans, we noticed that the percentage of B-banks engaged in FH was higher than for A-banks (38% versus 32%, respectively). As expected, these numbers are consistent with those reported in Figure 1.b: 9 FH loans in the B region (Figure 1.b) out of 24 B-banks yields 37.5% of banks engaged in FH (Table 15). Similarly, 7 FH loans in the A region (Figure 1.b) out of 22 A-banks yields 31.8% of banks engaged in FH (Table 15).

**In terms of the bank's total loan portfolio**

As discussed in the paper, the definitions of FTQ, FH, and RL in terms of total residential exposures are useful for capturing the first order effects of rebalancing *within* residential mortgage holdings. However, it is also interesting to consider the alternative definitions of FTQ, FH, and RL in terms of "residential mortgage portfolio shares relative to the overall bank loan holdings". The main difference is in the denominator of $\pi_{j,\theta,t}^{i}$. Now, we define the bank $j$'s share of type $\theta$ loans in country $i$ with respect to its total loan portfolio as:

$$\pi_{j,\theta,t}^{i} = \frac{L_{j,\theta,t}^{i}}{\sum_{\theta,i} L_{j,\theta,t}^{i}}$$

Formal definitions of our variables of interest follow. First, we denote by $FTQ_{j,\theta}^{sh,i}$ the FTQ dummy variable—in shares ($sh$)—that equals 1 when $\pi_{j,\theta,t+1}^{i} > \pi_{j,\theta,t}^{i}$, where $i \in \{A, E, F\}$, i.e.,

- for a $\{$bank $j$, counterparty country $i\}$-pair with $\{$bank $j$'s home country$\neq i\}$, $FTQ_{j,\theta}^{sh,i} = 1$ if $\pi_{j,\theta,t+1}^{i} > \pi_{j,\theta,t}^{i}$, where $i \in \{A, E, F\}$.

Similarly, we write the corresponding definitions for RL and FH as follows:

- for a {bank $j$, counterparty country $i$}-pair with {bank $j$'s home country$\neq i$}, $RL_{j,\theta}^{sh,i} = 1$ if $\pi_{j,\theta,t+1}^{i} > \pi_{j,\theta,t}^{i}$, where $i \in \{B\}$.

- for a {bank $j$, counterparty country $j$}-pair with {bank $j$'s home country$\neq j$}, $FH_{j,\theta}^{sh,i} = 1$ if $\pi_{j,\theta,t+1}^{j} > \pi_{j,\theta,t}^{j}$.

Because in our database $L_{j,\theta,t}^{i}$ is expressed in terms of Exposure-At-Default (EAD), the definition of $\pi_{j,\theta,t}^{i}$ captures the marked-to-market debt exposure level held in the bank's portfolio with respect to the bank's total portfolio exposures. Thus, $\pi_{j,\theta,t}^{i}$ represents the bank's asset $\theta$ credit exposure "share" in geographical region $j$ at time $t$, and can be understood in terms of portfolio risk exposure in a given geographical region.

For the above definitions, we find 9 $FTQ_{j,\theta}^{sh,i}$ pairs {B-bank $j$, safe country counterparty $i$}, where a B-bank $j$ rebalanced its residential loan portfolio toward a country $i$ in the "safe" region. On the other hand, there were 35 $FTQ_{j,\theta}^{sh,i}$ pairs {A-bank $j$, safe country counterparty $i$} for banks in the A region. Because the A region and the B region have 22 and 24 non-nationalized banks, respectively, we conclude that, on average, A-banks had 3.8 times more safe-country counterparties than B-banks in FTQ cross-border residential mortgage lending. However, when looking at the FH numbers, we notice that B-banks more than doubled the number of A-banks' FH residential loans in absolute terms (9 FH loans for B-banks and only 4 FH loans for A-banks). These numbers are consistent in average terms (0.37 FH loans on average per B-bank and 0.18 FH loans on average per A-bank). The number of $RL_{j,\theta}^{sh,i}$ pairs {bank $j$, risky country $i$}, where a bank $j$ rebalanced its residential loan portfolio toward a country $i$ in the "risky" B region, is four times higher for A-banks than for B-banks (8 RL loans for A-banks and only 2 for B-banks). Thus, on average, A-banks had riskier counterparties than B-banks.

These results are consistent with the results found in our main analysis of the paper using different definitions of FTQ and RL.

The definitions of FTQ, FH, and RL in terms of the bank's total loan portfolio are interesting because they allow us to get a big picture of how changes in residential exposures correlate with changes in other loan types (e.g., institutions, corporations, commercial mortgages, and sovereign debt) when we take the bank's total loan portfolio into account. To see this, consider a simple economy with two loan types, say loan type I and loan type II, and two countries, a safe country and a risky country. A-bank's portfolio is then composed as follows: (% loan type I in safe country, % loan type II in safe country, % loan type I in risky country, % loan type II in risky country), such that the sum of all its components equals 1. For example, consider a bank with portfolio (0.25, 0.25, 0.25, 0.25). If the portfolio becomes (0.5, 0, 0, 0.5), then we say that the banks does FTQ in loan type I and RL in loan type II. We would then expect a positive correlation coefficient between FTQ in loan type I and RL in loan type II. It is also possible to observe positive correlations between different lending behaviors for the same loan type. For example, if the portfolio becomes (0.5, 0, 0.5, 0), we say that the bank rebalances its portfolio toward type I loans in both the safe and the risky countries, and the correlation between $FTQ_{type\ I}$ and $RL_{type\ I}$ would be positive.

In Table 16 we report the correlation coefficients between lending strategies in terms of the bank's total loan portfolio for our sample of 64 non-nationalized banks.[13] We get the following insights from this exercise. First, FTQ in residential mortgages was highly correlated with FTQ in other loan exposures (with correlations between 0.35 and 0.55), while, in contrast, correlation with the other two lending behaviors (FH and RL) was small or even negative.

Second, banks that rebalanced toward the risky region (RL) in residential loans were also rebalancing toward that region in other loan types—in particular loans to B corporations and B financial institutions (with correlation coefficients 0.35 and 0.39, respectively). Correlations between RL in residential loans and FTQ in several loan types were small (0.23 or less, even negative), whereas correlations between RL in residential loans and FH in all loan types were negative.

Third, those banks that rebalanced their residential portfolios toward home (FH) were not likely to engage in any FTQ or RL, as evidenced by the corresponding negative correlation coefficients (except RL in commercial mortgages, which had a positive but small correlation coefficient). FH in residential loans was also little correlated with other FH loan types, and in some cases the correlation coefficient was negative (e.g., sovereigns and corporations).

Putting these findings in perspective, we discover high segmentation in the cross-border residential lending market during the European sovereign debt crisis, where banks that flew to quality

[13]For this exercise, we generate variables FTQ, FH, and RL for the other loan types similar to the ones corresponding to residential exposures.

(A, E, F) engaged in little risky lending (in the B region), and vice versa. In addition, banks that rebalanced their residential portfolios toward home (FH) were less likely to rebalance their loan portfolios either to the safe region (FTQ) or to the risky region (RL).[14]

[14]We produced tables similar to Table 16, but using the bank subsamples corresponding to regions A and B, and did not find important differences with respect to the whole sample of 64 banks.

| | FTQ residential mortgages | FH residential mortgages | RL residential mortgages |
|---|---|---|---|
| **FTQ Financial Institutions** | 0.55 | -0.25 | -0.01 |
| **FTQ Corporations** | 0.52 | -0.15 | 0.23 |
| **FTQ Residential Mortgages** | 1.00 | -0.20 | 0.22 |
| **FTQ Commercial Mortgages** | 0.54 | -0.15 | -0.14 |
| **FTQ Sovereigns** | 0.35 | -0.37 | 0.19 |
| **RL Financial Institutions** | 0.00 | 0.00 | 0.39 |
| **RL Corporations** | 0.20 | -0.13 | 0.35 |
| **RL Residential Mortgages** | 0.22 | 0.00 | 1.00 |
| **RL Commercial Mortgages** | 0.02 | 0.13 | 0.13 |
| **RL Sovereigns** | 0.27 | -0.33 | 0.25 |
| **FH Financial Institutions** | -0.01 | 0.20 | -0.03 |
| **FH Corporations** | -0.10 | -0.08 | -0.05 |
| **FH Residential Mortgages** | -0.20 | 1.00 | 0.00 |
| **FH Commercial Mortgages** | 0.02 | 0.15 | -0.16 |
| **FH Sovereigns** | 0.09 | -0.42 | -.04 |

Table 16: Correlation among FTQ, FH, and RL (in terms of the bank's total loan portfolio), and across loan types, for the 64 non-nationalized banks

# Online Appendix List of References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| | LIST OF BANKS IN OUR DATABASE |
|---|---|
| **Bank ID** | **Bank name** |
| AT001 | ERSTE BANK GROUP (EBG) |
| AT002 | RAIFFEISEN BANK INTERNATIONAL (RBI) |
| AT003 | OESTERREICHISCHE VOLKSBANK AG |
| BE004 | DEXIA/Belfius* |
| BE005 | KBC BANK |
| CY007 | BANK OF CYPRUS PUBLIC CO LTD |
| DK008 | DANSKE BANK |
| DK009 | JYSKE BANK |
| DK010 | SYDBANK |
| DK011 | NYKREDIT |
| FI012 | OP-POHJOLA GROUP* |
| FR013 | BNP PARIBAS |
| FR014 | CREDIT AGRICOLE |
| FR015 | BPCE |
| FR016 | SOCIETE GENERALE |
| DE017 | DEUTSCHE BANK AG |
| DE018 | COMMERZBANK AG |
| DE019 | LANDESBANK BADEN-WURTTEMBERG |
| DE020 | DZ BANK AG DT. ZENTRAL-GENOSSENSCHAFTSBANK |
| DE021 | BAYERISCHE LANDESBANK |
| DE022 | NORDDEUTSCHE LANDESBANK -GZ- |
| DE023 | HYPO REAL ESTATE HOLDING AG, MUNCHEN |
| DE025 | HSH NORDBANK AG, HAMBURG |
| DE027 | LANDESBANK BERLIN AG |
| DE028 | DEKABANK DEUTSCHE GIROZENTRALE, FRANKFURT |
| DE029 | WGZ BANK AG WESTDT. GENO. ZENTRALBK, DDF |
| GR030 | EFG EUROBANK ERGASIAS S.A. |
| GR031 | NATIONAL BANK OF GREECE |
| GR032 | ALPHA BANK |
| GR033 | PIRAEUS BANK GROUP |
| HU036 | OTP BANK NYRT. |
| IE037 | ALLIED IRISH BANKS PLC ** |
| IE038 | BANK OF IRELAND ** |
| IE039 | IRISH LIFE AND PERMANENT * |
| IT040 | INTESA SANPAOLO S.p.A |
| IT041 | UNICREDIT S.p.A |
| IT042 | BANCA MONTE DEI PASCHI DI SIENA S.p.A |
| IT043 | BANCO POPOLARE - S.C. |
| IT044 | UNIONE DI BANCHE ITALIANE SCPA (UBI BANCA) |
| LU045 | BANQUE ET CAISSE D'EPARGNE DE L'ETAT |
| MT046 | BANK OF VALLETTA (BOV) |
| NL047 | ING BANK NV |
| NL049 | ABN AMRO BANK NV ** |

| | |
|---|---|
| NL050 | SNS BANK NV * |
| NO051 | DNB NOR BANK ASA |
| PL052 | POWSZECHNA KASA OSZCZEDNOSCI BANK POLSKI S.A. (PKO BANK POLSKI) |
| PT053 | CAIXA GERAL DE DEPOSITOS, SA |
| PT054 | BANCO COMERCIAL PORTUGUES, SA (BCP OR MILLENNIUM BCP) |
| PT056 | BANCO BPI, SA |
| SI057 | NOVA LJUBLJANSKA BANKA D.D. (NLB d.d.) |
| SI058 | NOVA KREDITNA BANKA MARIBOR D.D. (NKBM d.d.) |
| ES059 | BANCO SANTANDER S.A. |
| ES060 | BANCO BILBAO VIZCAYA ARGENTARIA S.A. (BBVA) |
| ES061 | BFA-BANKIA* |
| ES062 | CAJA DE AHORROS Y PENSIONES DE BARCELONA (LA CAIXA) |
| ES064 | BANCO POPULAR ESPANOL, S.A. |
| ES065 | BANCO DE SABADELL, S.A. |
| ES068 | GRUPO BMN |
| ES069 | BANKINTER, S.A. |
| ES072 | CAJA DE AHORROS Y M.P. DE ZARAGOZA, ARAGON Y RIOJA (IBERCAJA) |
| ES073 | MONTE DE PIEDAD Y CAJA DE AHORROS DE RONDA, CADIZ, ALMERIA, MALAGA, ANTEQUERA Y JAEN (UNICAJA) |
| SE084 | NORDEA BANK AB (PUBL) |
| SE085 | SKANDINAVISKA ENSKILDA BANKEN AB (PUBL) (SEB) |
| SE086 | SVENSKA HANDELSBANKEN AB (PUBL) |
| SE087 | SWEDBANK AB (PUBL) |
| GB088 | ROYAL BANK OF SCOTLAND GROUP plc ** |
| GB089 | HSBC HOLDINGS plc |
| GB090 | BARCLAYS plc |
| GB091 | LLOYDS BANKING GROUP plc ** |

Table 17: List of 69 representative banks in our sample derived by matching the year-end 2009 and year-end 2013 EU-wide stress test databases. The * symbol means that the bank was nationalized between 2010 and 2013. The symbol ** means that the bank was nationalized before year-end 2009.