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Bank Exposures and Sovereign Stress Transmission*

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Abstract

Using novel monthly data for 226 euro-area banks from 2007 to 2015, we investigate the determinants of banks' sovereign exposures and their effects on lending during and after the crisis. Public, bailed-out and poorly capitalized banks responded to sovereign stress by purchasing domestic public debt more than other banks, consistent with both the "moral suasion" and the "carry trade" hypothesis. Public banks' purchases grew especially in coincidence with the largest ECB liquidity injections, which therefore reinforced the "moral suasion" mechanism. Bank exposures significantly amplified the impact of sovereign stress on bank lending to domestic firms, as well as on lending by foreign subsidiaries of stressed-country banks to firms in non-stressed countries. Altogether, our evidence connects this amplification effect and its cross-border transmission to the moral suasion exerted by domestic governments on banks during the crisis.

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1. Introduction

The euro-area debt crisis and its aftermath are a natural testing ground to assess the role of banks' exposures in the transmission of sovereign stress to the credit market. In this paper, the evidence generated by the crisis is used to address two closely related research questions: first, how did banks change their public debt holdings in response to sovereign stress, and how did their response vary depending on their characteristics? Second, did their different sovereign exposures amplify the transmission of stress to their lending? To answer these questions, we draw on a unique data set covering 226 euro-area banks at monthly frequency from 2007 to 2015. Exploiting the heterogeneity in banks' characteristics allows us to test competing hypotheses regarding the response of their sovereign exposures to sovereign stress. Furthermore, exploiting the bank-specific dynamics of exposures enables us to quantify their contribution to the transmission of sovereign stress to lending. We establish two main results.

First, publicly owned and recently bailed-out banks reacted to sovereign stress by purchasing significantly more domestic public debt than other banks, and boosted their purchases especially at the time of the two large liquidity injections by the ECB in December 2011 and March 2012. Since public and recently bailed-out banks are more likely to yield to political pressure than other banks, the evidence is consistent with their public debt purchases during the crisis being driven by the respective government's pressure—the "moral suasion" hypothesis.[1] The low funding costs due to the ECB liquidity injections appear to have reinforced this mechanism: the estimates imply that, at the time of these injections, stressed-country public banks increased their sovereign debt holdings by 17% more than private banks. We also find that stressed-country banks with low regulatory capital bought more domestic public debt than other banks, in line with the view that they engaged in yield-seeking behavior to gamble for resurrection—the "carry trade" hypothesis. The two hypotheses appear to have about the same explanatory power and to apply to almost completely disjoint sets of banks in our sample.

Second, stressed-country banks with larger sovereign exposures cut lending more deeply than less exposed banks when sovereign stress increased, and expanded lending more when sovereign stress abated. The granular nature of our data enables us to estimate precisely the amplification effect associated with sovereign exposures: a 1-standard-deviation drop in the price of government bonds reduced the loan growth of the median domestic bank by

1 This hypothesis is formalized by Uhlig (2013), who shows that fiscally vulnerable governments have an incentive to allow domestic banks to hold home risky bonds, in order to borrow more cheaply, while non-vulnerable governments will impose tighter regulation. Battistini, Pagano, and Simonelli (2014) argue that sovereign stress heightens this incentive, generating a positive relationship between sovereign yields and banks' holdings of domestic debt, and refer to this prediction as the "moral suasion" hypothesis, a label also used in subsequent work.

1.4 percentage points, which is 20% of the standard deviation of loan growth. This amplification mechanism can account for the entire drop in lending by the average bank in stressed countries at the peak of the sovereign crisis, that is, between mid-2010 and mid-2012.

In principle, domestic customers may reduce their demand for lending at times of sovereign stress, thereby introducing an omitted-variable bias in our lending regressions. The unconsolidated nature of our banks' balance-sheet data helps us to address this endogeneity concern: we investigate whether losses on sovereign debt incurred by parent banks in stressed countries affected their foreign subsidiaries' loans to firms in non-stressed countries, whose demand for credit should not respond to sovereign stress. The sovereign exposures of the parent banks turn out to affect the lending of their foreign subsidiaries, to an extent that is comparable to that found for lending to domestic firms by the respective parent banks. This indicates that our estimates of the amplification effect are not driven by demand-side factors. Beside addressing endogeneity concerns, these estimates have substantive economic implications: they show that banks' sovereign exposures amplify the impact of sovereign debt repricing not only on their domestic but also on their foreign lending, and thereby contribute to the international transmission of sovereign stress.

Another possible concern is that banks' losses on sovereign holdings may not be exogenous in our lending regressions, for instance because banks with larger sovereign holdings have clients whose solvency is more sensitive to sovereign risk. To this purpose, we build on the previous findings that public ownership and bailout events are key determinants of banks' sovereign exposures, and interact these variables with sovereign repricing to construct instruments for banks' losses on sovereign holdings. The exclusion restriction required for the validity of these instruments is that the loans of public and bailed-out banks react differently to sovereign stress only because they have larger sovereign exposures: this restriction would be violated if the customers of public and bailed-out banks became riskier at times of sovereign stress. We show instead that for these banks the fraction of impaired loans does not increase more than for other banks at the time of sovereign stress, thus supporting the exclusion restriction. The instrumental variable (IV) regressions confirm the amplification effect of sovereign exposures on stressed-country bank lending. These IV estimates indicate that this amplification mechanism can be traced back to the moral suasion exerted by governments on banks during the crisis, underscoring the tight connection between the two research issues addressed by our analysis.

Our paper is related to a large literature on the drivers of domestic sovereign exposures during sovereign crises. Indirect evidence on such drivers was first provided by Acharya and Steffen (2015), who document that the loadings of bank stock returns on sovereign debt returns are higher for low-capitalized and recently bailed-out banks. They interpret these findings as evidence for the "carry trade" and "moral suasion" hypotheses, respectively. This interpretation is warranted if factor loadings proxy for banks' sovereign exposures, but not if these loadings were to reflect just banks' dependence on public bailout guarantees: the stocks of less capitalized banks and recently bailout banks may be more sensitive to public debt returns simply because they depend more on the government as backstop. Instead, our month-by-month observations of banks' sovereign holdings enable us to directly estimate the impact of sovereign stress on the portfolios of banks with different characteristics.

Ongena, Popov, and van Horen (2016) find that stressed-country domestic banks bought more sovereign debt than foreign banks when the domestic government's financing needs were particularly high. De Marco and Macchiavelli (2014) report that banks with

sizeable government ownership or politically appointed directors feature more home-biased sovereign portfolios than privately owned and managed banks. These findings are consistent with the "moral suasion" hypothesis. Instead, Buch, Koetter, and Ohls (2016) report evidence supporting the "carry trade" hypothesis using granular information on German banks. Finally, Horváth, Huizinga, and Ioannidou (2015) test both hypotheses, but in separate regressions, so that from their estimates it is unclear whether both would have explanatory power in a nested specification.

Other papers investigate whether central bank liquidity fueled the purchase of sovereign debt by banks. Drechsler *et al.* (2016) document that less capitalized banks bought more domestic sovereign debt after the extraordinary liquidity provision by the ECB in December 2011 and March 2012. However, Peydró, Polo, and Sette (2017) find that more—not less—capitalized Italian banks bought high-yield bonds when monetary policy softened, countering the idea that liquidity injections encouraged banks' carry trades. Ongena, Popov, and van Horen (2016) find that domestic and public banks engaged in larger sovereign debt purchases but these were not fueled by the ECB liquidity injections. In contrast with their evidence, we document that the ECB liquidity injections in 2011 and 2012 amplified the "moral suasion" channel, since they appear to have enabled public banks to buy more sovereign debt. Instead, we find no evidence that these liquidity injections reinforced the "carry trade" channel, by making poorly capitalized banks more inclined to buy stressed public debt.

Our paper is also related to the literature on the transmission of sovereign stress to lending activity. Gennaioli, Martin, and Rossi (2014a) present a model in which sovereign defaults reduce private lending by undermining the balance sheets of domestic banks, the more so the larger their holdings of government debt, and test these predictions on cross-country evidence; they also test them on bank-level data in a companion paper (Gennaioli, Martin, and Rossi, 2014b). Becker and Ivashina (2014) use company data on bank borrowing and bond issuance to show that European companies were more likely to replace bank loans with bond issues when banks in their country held more domestic sovereign debt and when that debt was risky. De Marco (2017) and Popov and Van Horen (2014) show that the euro-area banks with larger sovereign exposures in the EBA stress tests participated to the syndicated loan market less than banks with lower exposures, and raised their lending rates more sharply.[2] All these studies suffer from the lack of accurate time series of bank-level data for banks' sovereign exposures. Gennaioli, Martin, and Rossi (2014b) rely on banks' total bond holdings, which lump domestic government bonds together with non-domestic bonds. The other three studies use data on sovereign exposures drawn from the EBA stress tests, and thus refer only to (at most) four dates and to a small sample of systemically important banks.

To identify the transmission of sovereign stress to lending via banks' sovereign exposures, it is important to control for the demand for loans by firms. The recent contributions by Acharya *et al.* (2015) and Carpinelli and Crosignani (2017) achieve such identification following the methodology proposed by Khwaja and Mian (2008): they analyze the change in loans issued to the same firm by banks with different exposures to sovereign risk. In our study, we control for loan demand in other ways, since we do not have bank–firm matched loan data. However, our data are more complete in terms

2 De Marco (2017) documents this finding also using yearly balance-sheet data on bank loans, besides syndicated loan data.

of coverage of banks, countries, and time, as they refer to a sample of banks providing about 70% of total euro-area lending, and track bank-level sovereign exposures and lending policies throughout the crisis and after its abatement, rather than at specific dates and for a segment of the credit market. In contrast, Acharya *et al.* (2015) measure bank lending with data on syndicated loans, which account for just 10% of total euro-area lending and cater mostly to large, established corporations, while Carpinelli and Crosignani (2017) focus only on Italian banks.

The structure of the paper is as follows. Section 2 describes the data, illustrating the variation in bank-level exposures and presenting some stylized facts. Section 3 analyzes the determinants of banks' domestic sovereign exposures. Section 4 examines whether these exposures influenced the impact of sovereign stress on bank lending. Section 5 concludes.

2. Data and Stylized Facts

This section describes our data and sets out some stylized facts about euro-area banks' holdings of domestic sovereign bonds and their relationship with bank lending. These not only help to gauge the correlations in the data at aggregate level but also point to the additional insights that can be gleaned from bank-level data.

Our analysis is based on a unique, proprietary data set of balance-sheet items (BSI) at bank level (Individual Balance-Sheet Items or IBSI), which is regularly updated by the ECB. We use monthly observations on the main balance-sheet indicators (assets and liabilities) from June 2007 to February 2015. The sample contains a total of 226 unconsolidated banks in eighteen euro-area countries (Table I), the highest coverage being in the largest countries: Germany (sixty), France (thirty-two), Italy (twenty-four), and Spain (twenty-three). The banks are observed at unconsolidated level: 119 group head banks, 49 domestic subsidiaries, and 59 foreign subsidiaries (some affiliated to UK or Danish groups).[3]

These data are merged with data on bank share ownership from Bankscope and hand-collected data about bailout dates from the EU Commission state aid database. The data include monthly observations of the benchmark 10-year and 5-year sovereign yields and survey-based consensus yield forecasts at 3-month and 12-month horizons. Yields for euro-area countries are drawn from Datastream; survey-based forecasts are from Consensus Economics and are available only for France, Germany, Italy, the Netherlands, and Spain. For details on data definitions and sources, see the Appendix.

The representativeness of the sample is shown in Table II, which reports main assets (defined as total assets less derivatives), loans to non-financial corporations and holdings of government bonds for the banks in our data set as a fraction of the national aggregate, drawn from the ECB BSI database. On average, for the main variables our data cover about

3 Our analysis is based on the IBSI data release of April 15, 2015, which contained data for 252 banks. Of these, we removed twenty-six banks featuring one or more of the following: (i) less than 12 months of observations were available for loans and exposures; (ii) loans equal to zero for the entire sample (with at most sparse spikes); (iii) frequent and extreme jumps in exposures or loans. Of the removed banks, two are Finnish, five French, five German, two Irish, two Italian, five Latvian, one is from Luxembourg, one Slovenian, and three are Spanish. We also remove all negative values of domestic sovereign holdings, equity, main assets, and lending.

Table I. Distribution of the banks by country and ownership

For each country, the table reports the total number of individual banks and their breakdown according to the country in which they operate and domestic or foreign ownership.

	Total	Domestic banks		Foreign banks
		Head banks	subsidiaries	
Austria	9	6	2	1
Belgium	10	3	0	7
Cyprus	5	4	0	1
Estonia	4	1	0	3
Finland	5	3	0	2
France	32	8	20	4
Germany	60	39	13	8
Greece	6	4	2	0
Ireland	11	3	1	7
Italy	24	15	4	5
Luxembourg	10	3	0	7
Malta	4	3	0	1
Netherlands	10	7	0	3
Portugal	6	4	0	2
Slovakia	3	0	0	3
Slovenia	4	2	0	2
Spain	23	14	6	3
Total	226	119	48	59

70% of the corresponding country aggregate. The bottom row of the table shows that weighting country coverage by GDP does not change the results.

Our data are far more representative of the euro-area banking system than those used in previous studies, along several dimensions. First, our sample has data for the sovereign exposures of 226 banks, compared with at most 91 banks in the pre-2014 EBA stress test data, and for 93 months, compared with the few snapshots of the EBA stress tests. Second, as illustrated in Table II, our bank loan data cover almost 70% of the corresponding national lending aggregates, compared with the 10% coverage of the syndicated loan data used by Popov and Van Horen (2014), De Marco (2017), and Acharya *et al.* (2015).

Descriptive statistics for the main variables are shown in Panel A of Table III, and for bank characteristics in Panel B. As in the subsequent analysis, the statistics are computed separately for two groups of countries: "stressed" (Cyprus, Greece, Ireland, Italy, Portugal, Slovenia, and Spain) and "non-stressed" (Austria, Belgium, Estonia, Finland, France, Germany, Luxembourg, Malta, the Netherlands, and Slovakia). We define as "stressed"—that is, subject to high sovereign stress—countries whose 10-year sovereign yield exceeded 6% (or, equivalently, four points above the German yield) for at least one quarter in our sample period.

Table III reveals that banks in these two groups of countries behaved quite differently in several respects. First, their domestic sovereign exposures (the ratio of government debt holdings to main assets) are greater in stressed countries (4.9%) than in non-stressed ones (3.8%), while the opposite applies to non-domestic euro-area exposures (1% versus

Table II. Sample representativeness

For each country, the table shows the aggregate values of main assets, loans to non-financial corporations (NFCs) and holdings of government debt in our dataset in January 2015 as percentages of the same variables in the aggregate data reported in the BSI statistics of the ECB.

	Ratio of IBSI aggregates to BSI totals (%)		
	Main assets	Loans to non-financial corporations	Bank holdings of sovereign debt
Austria	40	38	50
Belgium	72	81	84
Cyprus	73	87	86
Estonia	87	90	74
Finland	85	82	86
France	74	68	87
Germany	64	48	74
Greece	92	91	85
Ireland	38	74	66
Italy	63	59	48
Luxembourg	34	69	36
Malta	30	81	77
Netherlands	87	89	91
Portugal	69	70	66
Slovakia	55	57	63
Slovenia	54	50	69
Spain	84	86	86
Average	64	72	71
Weighted average	69	64	73

2.2%).[4] Hence, in stressed countries the sovereign debt portfolios of banks are more "home-biased" than in non-stressed countries. (Unfortunately, we cannot measure the diversification of sovereign debt portfolios more precisely, because our data do not break non-domestic exposures down by sovereign issuer.) Second, banks accumulated domestic sovereign debt twice as fast in stressed as in non-stressed countries (2% versus 1% on a quarterly basis). Third, in stressed countries loans to firms are a larger fraction of bank assets than in non-stressed countries but grow less.

However, in both groups of countries there is considerable dispersion in the sovereign exposures of banks, as well as in the growth of bank sovereign holdings and lending to firms. Sovereign exposures feature substantial variation both over time and cross-sectionally: in the stressed countries, their overall standard deviation is 4.9%, the same

4 Banks' sovereign holdings are partly at market prices and partly at book values. They are marked to market if the bank classes them in its "trading book" (i.e., either "available for sale" or "held for trading"). They are at book values if the bank classes them in its "banking book" (i.e., "held to maturity"). Our data do not contain the breakdown between these two components. In the forty-five euro-area banks present in the EBA stress test data, trading-book sovereigns account for 59% of the total for banks in stressed and 48% in non-stressed countries.

Table III. Descriptive statistics

The table presents the mean, median, and standard deviation of banks' monthly sovereign exposures, loans to firms (Panel A), and characteristics (Panel B). The stressed countries are Cyprus, Greece, Ireland, Italy, Portugal, Slovenia, and Spain; the non-stressed countries are Austria, Belgium, Estonia, Finland, France, Germany, Luxembourg, Malta, the Netherlands, and Slovakia. Domestic sovereign exposures are domestic sovereign debt as a fraction of the corresponding bank's main assets. Bank lending is the bank loans to non-financial corporations as a fraction of the corresponding banks' main assets. Bank lending growth and sovereign holdings growth are the quarterly growth rates (in percent) of bank loans to non-financial companies and of their sovereign holdings. Leverage ratio is the ratio of banks' total assets to their equity capital. *T*1/RWA is the ratio of Tier-1 common equity to risk-weighted assets. Public is the fraction of banks' shares owned by local or national government or publicly controlled institutions (Fondazioni in Italy, Fundaciones and Cajas in Spain, and Sparkasse and Landesbank in Germany). Bailout equals 1 starting in the quarter in which a bank was bailed out (unless acquired in the two subsequent quarters), and 0 before that date.

Panel A. Domestic exposures, bank lending, and interest rates (%)

	Stressed countries			Non-stressed countries		
	Mean	Median	Standard deviation	Mean	Median	Standard deviation
Domestic sovereign exposures (%)	4.9	4.0	4.9	3.8	1.7	6.6
Non-domestic sovereign exposures (%)	1.0	0.0	3.5	2.2	0.6	3.8
Bank lending to firms (%)	25.3	25.3	14.0	15.7	13.1	12.6
Bank lending growth (%)	−0.4	−0.3	12.5	0.2	0.3	10.8
Sovereign holdings growth (%)	1.9	0.0	23.1	1.0	0.0	20.1

Panel B. Bank characteristics

	Stressed countries			Non-stressed countries		
	Mean	Median	Standard deviation	Mean	Median	Standard deviation
Assets (billion euro)	72.1	41.0	93.2	89.0	35.5	137.5
Leverage ratio	22.1	10.3	116.0	29.0	17.4	172.8
*T*1/RWA (%)	9.4	9.3	2.7	10.1	9.9	3.4
Deposit/liabilities (%)	66.7	68.9	16.9	64.3	67.7	24.8
Public	24.3	0.0	38.4	22.9	0.0	40.7
Bailout	0.1	0.0	0.3	0.1	0.0	0.2

value as their mean; in the non-stressed countries, it is 6.6%, with a mean of 3.8%. The growth rate of domestic sovereign holdings is more volatile, its standard deviation being 23.1% in stressed countries and 20.1% in non-stressed ones. Both values are very large compared with the respective means of 1.9% and 1%. Both between-banks and within-bank variation in these variables are central to our empirical strategy.

Panel B shows that the average bank in the two groups of countries has similar characteristics: it is quite large, highly leveraged (more so in the non-stressed countries), yet with

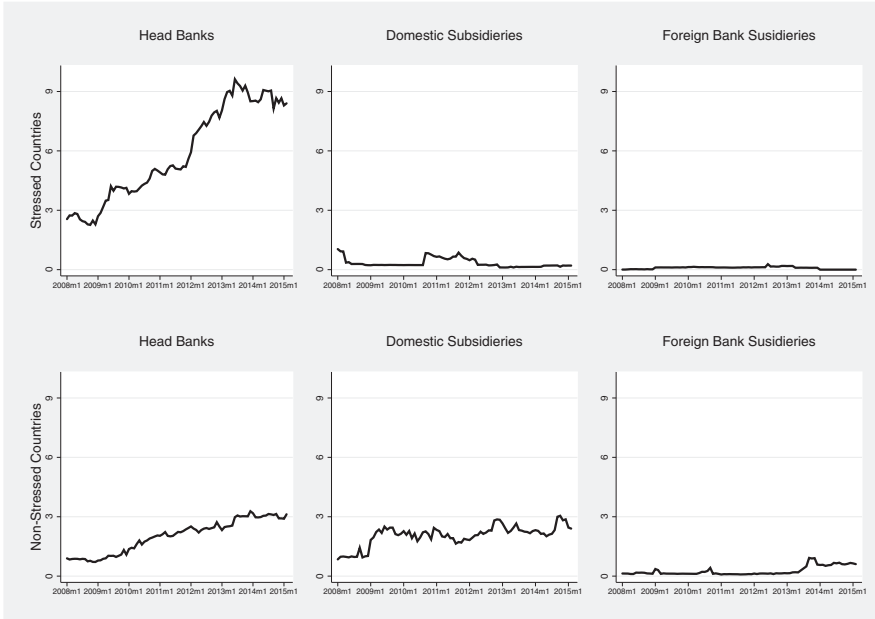

Figure 1. Median domestic sovereign exposure of head banks, domestic and foreign subsidiaries, monthly values. Domestic sovereign exposure is the ratio of domestic sovereign debt holdings to main assets (total assets less derivatives).

high regulatory capital ratios (9.4% in the stressed and 9.9% in the non-stressed countries), and mainly reliant on deposit funding (about two-third in both sets of countries). Also, government intervention in the banks of the two groups is similar, with average public stakes of 24% and 23%, respectively (public ownership being defined as shareholdings of local or national government and of publicly controlled institutions); and the frequency of observations referring to bailed-out banks is 10% for both sets of countries (bailout being a dummy equal to 1 during and after a bailout, and 0 otherwise).

Figures 1–3 add a dramatic time dimension to two stylized facts that emerge from Table III, namely the rapid growth of banks' domestic sovereign exposures and the sharp decline in the loan-to-asset ratio in stressed countries, in striking contrast with the experience of non-stressed countries. Figure 1 shows that the different pattern of sovereign exposures between the two groups of countries is driven by the exposures of the head banks: the median domestic subsidiary in the stressed countries and the median foreign subsidiary in both groups have virtually no sovereign exposures, reflecting the fact that a banking group's securities portfolio is typically managed by the head bank.[5]

Figure 2 shows the pattern of median domestic sovereign exposures and loan–asset ratios for stressed countries from July 2007 to February 2015; Figure 3 shows the corresponding pattern for non-stressed countries. Besides confirming that domestic sovereign exposures increased much more sharply in stressed countries, the figures illustrate the

5 We are grateful to Rony Hamaui for pointing out this fact to us, based on his managerial experience at Intesa Sanpaolo.

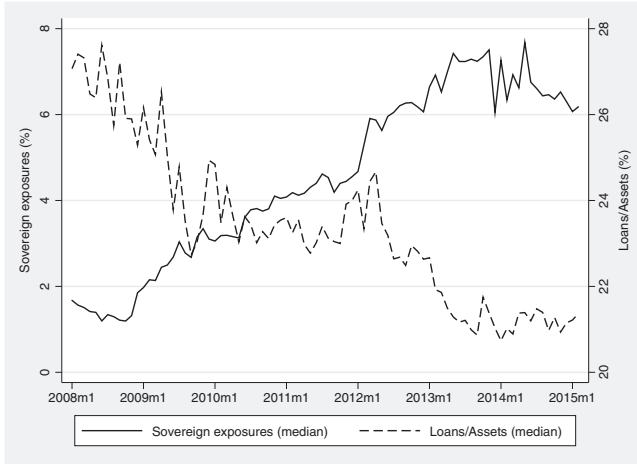

Figure 2. Domestic sovereign exposure and loan–asset ratio of the median bank in stressed countries, monthly values. Sovereign exposure is the ratio of domestic sovereign holdings to main assets; loan–asset ratio is lending to non-financial corporations divided by main assets.

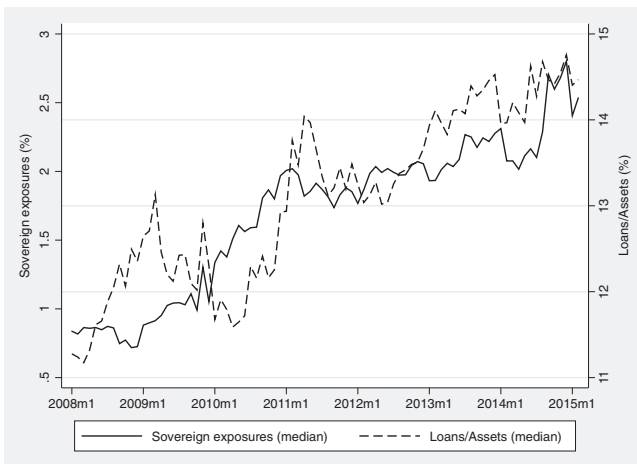

Figure 3. Domestic sovereign exposure and loan–asset ratio of the median bank in non-stressed countries, monthly values. Sovereign exposure is the ratio of domestic sovereign holdings to main assets; loan–asset ratio is lending to non-financial corporations divided by main assets.

completely different dynamics of the median bank's loan-to-asset ratio. Figure 2 shows that in stressed countries, loans to non-financial corporations are correlated negatively with sovereign exposures: over the sample period, the median bank's domestic exposure increases from 1% to 6% of assets, while its corporate lending falls from 28% to about 20% of main assets, the sharpest drop coming in the second half of 2012. In late 2014, the loan–asset ratio begins to stabilize, in line with the improvement in aggregate lending in the stressed countries. Figure 3 shows a completely different picture for the non-stressed countries: except for the first 2 years of the sample, the loan–asset ratio of the median bank is positively

correlated with its domestic sovereign exposures, and both variables have a distinct positive trend.

Of course, these different correlations between sovereign exposures and bank lending at the time-series, aggregate level do not, as such, establish causation: in principle, the negative correlation in stressed countries could reflect either the "crowding out" of private lending by sovereign debt in banks' balance sheets or diminished demand for loans leading banks to substitute them with sovereign debt. However, as we shall see, bank-level data help to pin down the direction of causality, exploiting bank-level heterogeneity in the response of sovereign exposures (Section 3) and of lending (Section 4) to sovereign stress.

3. Determinants of Banks' Sovereign Exposures

The descriptive evidence set out above highlights the cross-sectional and time-series variation in banks' domestic sovereign exposures. Some of this variation is accounted for by three characteristics of the banks: fraction of public share ownership, government–bailout history, and regulatory capital ratio. This section documents that these three characteristics correlate not only with differences in sovereign exposures, but also with the way banks vary their exposures when faced with domestic sovereign stress: public ownership, previous occurrence of a bailout, and low capitalization are associated with a greater tendency to increase holdings of distressed government debt in the face of a drop in its price.

As observed in Section 1, according to the "moral suasion" hypothesis, publicly owned banks should be more willing than private ones to surrender to government influence and purchase domestic debt at times of sovereign stress, and foreign banks should be less willing than domestic ones to do so. By the same token, recently rescued banks should be more sensitive to government pressure, their management being typically government-appointed and keenly aware that their survival hinged on a public capital infusion. According to the "carry trade" hypothesis, poorly capitalized banks should purchase more high-yield public debt to gamble for resurrection. In the case of stressed-country banks, domestic debt is invariably also high-yield debt, so that to distinguish between the two hypotheses heterogeneity across banks is essential: indeed, we exploit the fact that at times of stress public and recently bailed-out banks should be more inclined to buy domestic public debt, and undercapitalized banks to buy more of it for yield-seeking motives.[6] In this section, we show that each of these hypotheses accounts for some of the variation of bank sovereign exposures in stressed countries, and that the two groups of banks to which each hypothesis applies are distinct and largely non-overlapping. Before turning to regression analysis, we provide some graphic evidence to illustrate how changes in domestic sovereign exposures correlate with bank characteristics.

Figure 4 shows banks' domestic sovereign exposures according to the type of ownership: the lines labeled "public" and "private", respectively, plot the average exposures of banks above and below the average fraction of public share ownership in the relevant country in 2008. The two vertical dashed lines in both panels of Figure 4 mark the timing of the two

6 In non-stressed countries, domestic debt obviously does not coincide with high-yield public debt, so that for the banks of those countries one could test the "carry trade" hypothesis simply by investigating whether they increase their holdings of foreign debt issued by stressed sovereigns. However, our data do not provide a breakdown of foreign sovereign debt holdings by issuer, and therefore prevent us from implementing this test for non-stressed-country banks.

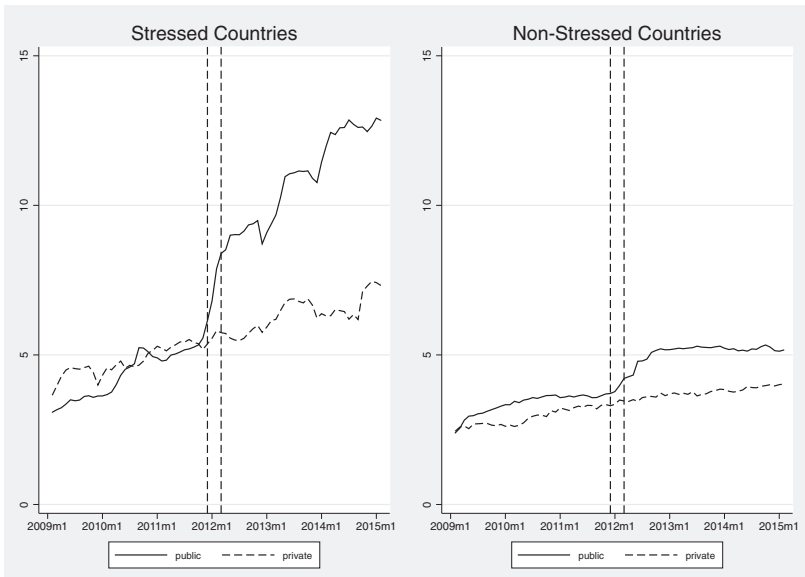

Figure 4. Domestic sovereign exposure and bank ownership, in stressed and non-stressed countries. The line labeled "public" (private) plots the average monthly exposure of banks with a fraction of public ownership above (below) the relevant country average in 2008.

largest injections of liquidity by the ECB during the sovereign crisis, namely, the 3-year very long-term refinancing operations (VLTROs) of December 2011 and March 2012, which provided loans for €489 bn and €529 bn, respectively, to euro-area banks.[7] In the left panel, which refers to the stressed countries, the domestic sovereign exposures of the two groups of banks are very similar until late 2011, but afterwards the banks with greater public ownership increase their domestic sovereign exposures at a much faster pace than the other group: the difference between them grows from nil in 2011 to over 6 percentage points in 2015, consistently with the "moral suasion" hypothesis. The largest increase in public banks' sovereign exposures occurs in coincidence with the two VLTROs, suggesting that these banks used the liquidity provided by the ECB to fund their purchases of domestic public debt and/or bought such debt to pledge it as collateral to obtain liquidity, as found by Crosignani, Faria-e-Castro, and Fonseca (2016) for Portuguese banks. The right panel shows a qualitatively similar pattern in the domestic exposures of non-stressed countries' banks as well, but with a much smaller difference between public and private banks—between 1 and 2 percentage points.

Figure 5 shows that in stressed countries, banks rescued with public funds purchased substantially more domestic government debt in the month before and the year after it, again consistently with the "moral suasion" hypothesis. The line plotted in the two panels is the difference between the average domestic sovereign exposure of the bailed-out and the other banks, measured in the same month and group of countries, over a 2-year window centered on the bailout date (month 0). In stressed countries, the exposure of the bailed-out

7 More precisely, the settlement dates of the two operations were December 22, 2011, and March 1, 2012, respectively.

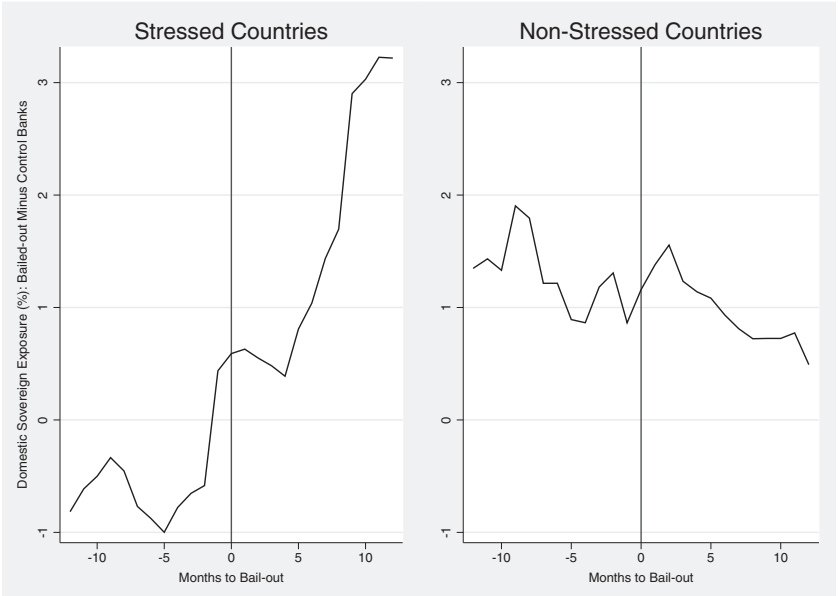

Figure 5. Difference between the average domestic sovereign exposure of bailed-out and control banks, in stressed and non-stressed countries. Control banks are not bailed-out ones. The difference refers to values observed in the same month and the same group of countries. Month 0 is the bailout date.

banks rises on average 3 percentage points above that of the control group over the 12 subsequent months. No such pattern is detectable in non-stressed countries.

Figure 6 explores whether banks with lower regulatory capital (Tier-1 capital scaled by risk-weighted assets, or *T*1/RWA) increased high-yield sovereign holdings more than other banks, consistently with the "carry trade" hypothesis. The left panel refers to stressed countries, the right panel to non-stressed ones. The figure is based on the subsample of banks for which *T*1/RWA data are available in the SNL Financial database (SNL): between 30 and 40 banks in each group, depending on month. In each panel, the lines labeled "high *T*1/RWA" and "low *T*1/RWA" refer to the average domestic sovereign exposure of banks with above-median and below-median *T*1/RWA, respectively. After the 2010 Greek bailout, the stressed-country banks with low capital ratios increased their sovereign exposures more than their better-capitalized peers. Some difference, albeit smaller, is also observable in non-stressed countries.

Taken together, the three figures suggest that stressed-country banks with more public ownership and less regulatory capital increased their sovereign holdings more than other banks at times of sovereign stress, and recently bailed-out banks bought more stressed domestic debt than other banks. That is, this graphic evidence already suggests that both the "moral suasion" and the "carry trade" hypotheses have some explanatory power. Interestingly, the two hypotheses seem to apply to two quite different groups of stressed-country banks: as of the end of 2008, only one of the "low *T*1/RWA" banks in Figure 6—Monte dei Paschi di Siena—also features public ownership above its country median, and therefore belongs to the group of "public" banks in Figure 4.

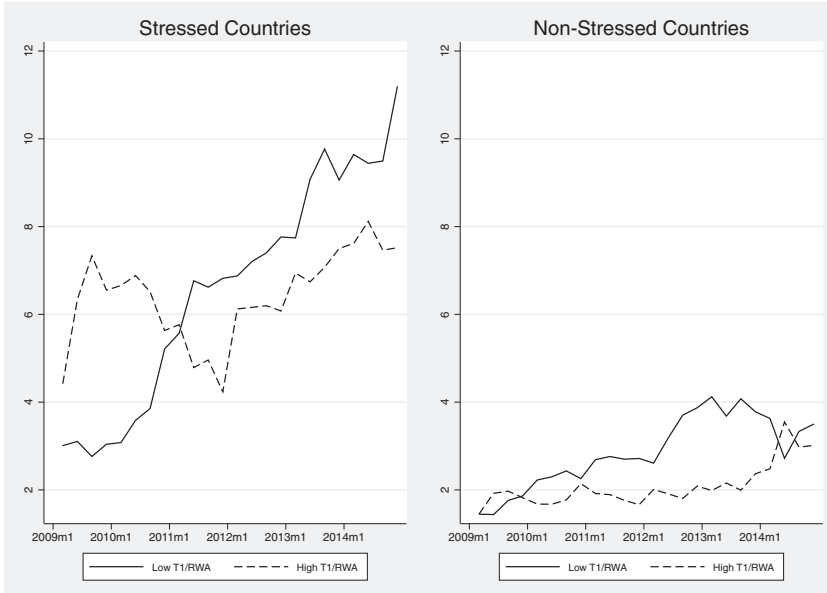

Figure 6. Domestic sovereign exposure and bank regulatory capital in stressed and non-stressed countries, monthly values. The line labeled "High (Low) *T*1/RWA" refers to the average exposure of banks with above-median (below-median) ratio of Tier 1 capital to risk-weighted assets.

To test these two hypotheses with regression analysis, we proceed in two steps. Since the SNL data on *T*1/RWA—needed to test the "carry trade" hypothesis—are only available for a subsample of banks, we first use the full sample to test the "moral suasion" hypothesis only. Next, we restrict the estimation to the subsample for which we have SNL data and test both hypotheses on this smaller sample.

In Table IV, we estimate the following specification:

$$\begin{aligned}\frac{\Delta H_{ijt}}{H_{ijt-1}} = {} & \alpha_{jt} + \gamma_i + \phi_1 \text{Public}_{ijt} \times \frac{\Delta P_{jt}}{P_{jt-1}} + \phi_2 \text{Public}_{ijt} \times \text{VLTRO}_t + \phi_3 \text{Public}_{ijt} \\ & + \phi_4 \text{Bailout}_{ijt} \times \text{VLTRO}_t + \phi_5 \text{Bailout}_{ijt} + \phi_6 F_{ij} \times \frac{\Delta P_{jt}}{P_{jt-1}} \\ & + \phi_7 F_{ij} \times \text{VLTRO}_t + \theta X_{ijt-1} + \eta_{ijt},\end{aligned} \tag{1}$$

where the dependent variable is the quarterly percentage change in domestic sovereign holdings H_{ijt} of bank i in country j and quarter t (Holdings H_{ijt} of debt issued by country j's government differ from exposure, which is defined as the ratio of holdings to main assets, i.e., H_{ijt}/A_{ijt}). In Equation (1), Public_{it} is the time-varying fraction of the bank's shares owned directly or indirectly by local or national government or publicly controlled institutions (Fondazioni in Italy, Fundaciones and Cajas in Spain, and Sparkasse and Landesbank in Germany); $\Delta P_{jt}/P_{jt-1}$ is the percentage change in the price of sovereign j's debt in the previous quarter (computed as the product of the change in the relevant 10-year yield from t–1 to t by the corresponding duration as in De Marco, 2017); VLTRO_t equals 1 in coincidence with the two ECB liquidity injections of December 2011 and March 2012, and 0 otherwise; Bailout_{ijt} equals 1 from the quarter in which bank i was bailed out (unless acquired by

another bank in the two subsequent quarters), and 0 otherwise; F_{ij} equals 1 if bank i is the subsidiary of a foreign bank operating in country j and 0 if it is a domestic head bank or subsidiary. The specification also includes bank-fixed effects γ_i to control for unobserved heterogeneity at bank level and time-country effects α_{jt} to control for country-level factors that may affect bank purchases of sovereign debt, including government debt repricing: the latter enters the specification only via its differential effect on banks with different characteristics. Finally, we include the (lagged) deposit–liability ratio X_{ijt-1} as a further bank-level control. In estimating specification (1), errors are clustered at the bank level, and the quarterly growth rates of sovereign holdings are trimmed at $\pm 100\%$ to eliminate outliers.

At times of sovereign stress, the price of public debt falls; that is, the variable $\Delta P_{jt}/P_{jt-1}$ is negative. The "moral suasion" hypothesis holds that at those times public banks should buy more domestic debt than private ones, and foreign subsidiaries less than domestic banks, so that $\phi_1 < 0$ and $\phi_6 > 0$. Insofar as the ECB liquidity injections enabled public banks to buy more domestic public debt than private and foreign ones, one would also expect $\phi_2 > 0$ and $\phi_7 < 0$. The "moral suasion" hypothesis does not necessarily imply a positive direct effect of public ownership, ϕ_3: public banks are supposed to be more pliant at times of sovereign stress, not to increase their public debt holdings more than other banks at all times. Instead, the "moral suasion" hypothesis requires bailed-out banks to buy more sovereign debt during and after their rescue, compared with other banks in the same country and quarter: $\phi_5 > 0$. Moreover, if ECB liquidity injections contributed to domestic public debt purchases by bailed-out banks, one should find $\phi_4 > 0$. Specification (1) merges elements from the models of "moral suasion" estimated by De Marco and Macchiavelli (2014); Acharya *et al.* (2015); Horváth, Huizinga, and Ioannidou (2015); and Ongena, Popov, and van Horen (2016): the first three studies estimate regressions of sovereign exposures on indicators of political control and government support using EBA stress test data; the fourth focuses on measures of foreign ownership using IBSI data for stressed countries.[8]

The estimates in Table IV show that for stressed countries the coefficient of the interaction between public ownership and the change of sovereign debt prices (ϕ_1) is negative and significant, and the coefficients of the bailout variable (ϕ_5) and of the interaction between foreign ownership and sovereign price changes (ϕ_6) are both positive, although the latter is imprecisely estimated: all these estimates conform to the predictions of the "moral suasion" hypothesis. The estimate of ϕ_1 in Column 3 implies that, in response to a 1% decrease in domestic sovereign debt prices, a 100% publicly owned bank ($\text{Public}_{ijt} = 1$) increased its domestic sovereign holdings by 0.35% more than a 100% private bank ($\text{Public}_{ijt} = 0$); the estimate of ϕ_5 instead implies that bailed-out banks increase their public debt holdings by 6.44% more than other banks. Moreover, the interaction of the VLTRO_t dummy with public ownership has a positive and significant coefficient (ϕ_2), and that with foreign ownership has a negative and significant one (ϕ_7): the 3-year ECB loans in 2011–12 allowed domestic public banks of stressed countries to purchase sovereign debt far in excess of private and foreign banks. The estimates in Column 2 imply that in the two months of the liquidity injections a 100% publicly owned bank increased its domestic debt holdings

8 The specification used by Ongena, Popov, and van Horen (2016) also relies on a different variable to gauge sovereign stress, namely a measure of abnormally large domestic sovereign issuance (high needs), which may induce the government to pressure domestic banks to underwrite larger amounts of its debt.

Table IV. Determinants of sovereign holdings: "moral suasion"

The dependent variable is the growth rate of banks' domestic sovereign holdings in quarter t (defined as the percentage difference between the end-of-period values in quarter t and quarter t–1). The stressed countries are Greece, Ireland, Italy, Portugal, Slovenia, and Spain. The non-stressed countries are Austria, Belgium, Finland, France, Germany, Malta, and the Netherlands. $\Delta P_{jt}/P_{jt-1}$ is sovereign debt repricing, defined as the percentage change of debt prices in country j and quarter t, based on 10-year benchmark yields. Public_{ijt} is the fraction of banks' shares owned by local or national government or publicly controlled institutions (Fondazioni in Italy, Fundaciones and Cajas in Spain, and Sparkasse and Landesbank in Germany). VLTRO equals 1 in December 2011 and March 2012, and 0 otherwise. Bailout_{ijt} equals 1 starting in the quarter t in which bank i in country j was bailed out (unless acquired in the two subsequent quarters), and 0 before quarter t. F_{ij} equals 1 if bank i in country j is a foreign subsidiary and 0 otherwise. All the regressions include the bank-level (lagged) deposit–liability ratio as a further control. The sample ranges from 2008:Q1 to 2014:Q4. Standard errors are clustered at the bank level and shown in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

	Stressed countries			Non-stressed countries		
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Public}_{it} \times \frac{\Delta P_{jt}}{P_{jt-1}}$	−0.37**	−0.29**	−0.35**	−0.04	−0.05	−0.05
	(0.14)	(0.14)	(0.15)	(0.04)	(0.05)	(0.05)
$\text{Public}_{it} \times \text{VLTRO}$	21.03***	16.52***	17.54***	4.10	2.27	1.61
	(6.04)	(5.92)	(5.72)	(3.68)	(3.95)	(4.18)
Public_{it}	4.41	3.99	4.12	5.77	5.93	10.84
	(5.25)	(5.13)	(6.37)	(4.21)	(4.14)	(6.86)
$\text{Bailout}_{it} \times \text{VLTRO}$			−5.41			−10.75
			(5.11)			(8.30)
Bailout_{it}			6.44**			−8.02
			(2.65)			(6.03)
$F_{ij} \times \frac{\Delta P_{jt}}{P_{jt-1}}$		0.19*			−0.06	
		(0.11)			(0.05)	
$F_{ij} \times \text{VLTRO}$		−11.98***			−6.83*	
		(4.29)			(3.83)	
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time × country FE	Yes	Yes	Yes	Yes	Yes	Yes
Only domestic	No	No	Yes	No	No	Yes
Adjusted R^2	0.11	0.11	0.14	0.05	0.06	0.07
Banks	74	74	55	143	143	104
Observations	1892	1892	1401	3706	3706	2719

by 16.52% more than those of a 100% privately owned bank, in stressed countries. In contrast, none of the coefficients is significantly different from zero in the non-stressed countries, except for ϕ_7, which is also negative and marginally significant. Since sovereign solvency was seriously questioned by investors only for stressed countries, the results support the "moral suasion" hypothesis. They broadly agree with the results of De Marco and Macchiavelli (2014) and Horváth, Huizinga, and Ioannidou (2015), but not with those of Acharya *et al.* (2015), who find no evidence of "moral suasion", nor with Ongena, Popov,

and van Horen (2016), who find no significant interaction between the VLTRO and "moral suasion".

In Table V, we expand specification (1) to jointly test the "moral suasion" and the "carry trade" hypothesis, allowing for their respective interactions with the ECB liquidity injections:

$$\begin{aligned}\frac{\Delta H_{ijt}}{H_{ijt-1}} = \alpha_{jt} + \gamma_i + \delta_1 \frac{T1}{\text{RWA}_{ijt-1}} \times \frac{\Delta P_{jt}}{P_{jt-1}} + \delta_2 \frac{T1}{\text{RWA}_{ijt-1}} \times \text{VLTRO}_t + \delta_3 \frac{T1}{\text{RWA}_{ijt-1}} + \\ + \delta_4 \text{Public}_{ijt} \times \frac{\Delta P_{jt}}{P_{jt-1}} + \delta_5 \text{Public}_{ijt} \times \text{VLTRO}_t + \delta_6 \text{Public}_{ijt} \\ + \delta_7 \text{Bailout}_{ijt} \times \text{VLTRO}_t + \delta_8 \text{Bailout}_{ijt}.\end{aligned} \tag{2}$$

According to the "carry trade" hypothesis, weakly capitalized banks (low $T1/\text{RWA}_{ijt-1}$) should increase their sovereign holdings more than better capitalized ones when government debt becomes cheaper ($\Delta P_{jt}/P_{jt-1} < 0$), and resell it more aggressively if and when prices recover ($\Delta P_{jt}/P_{jt-1} > 0$) to realize their profits. Hence, the coefficient of the interaction between $T1/\text{RWA}_{ijt-1}$ and $\Delta P_{jt}/P_{jt-1}$ should be positive: $\delta_1 > 0$. Interestingly, the $T1/\text{RWA}_{ijt-1}$ variable has low correlation with Public_{ijt} and Bailout_{ijt} (0.15 and 0.18, respectively), confirming that the group of poorly capitalized banks is quite distinct from the groups of public and recently bailed-out banks. Specification (2) also allows us to test whether weakly capitalized banks borrowed more from the ECB and used these loans to buy risky sovereign debt, as found by Drechsler *et al.* (2016): this would require the coefficient of the interaction between bank capitalization ($T1/\text{RWA}_{ijt-1}$) and the VLTRO_t to be negative, that is, $\delta_2 < 0$.

It is worth noticing that the "carry trade" hypothesis does not imply that poorly capitalized banks invariably purchase more domestic public debt (i.e., $\delta_3 < 0$): if the price of domestic sovereign debt is stable while that of distressed foreign sovereign debt declines, a yield-seeking bank will bet on foreign sovereign debt, and divest domestic debt. In other words, the hypothesis predicts an increasing home bias in sovereign debt portfolios only for banks in stressed countries, not in non-stressed ones: during the crisis, a yield-seeking German bank would not have invested in German but in Italian or Spanish public debt. However, our data only provide a breakdown between domestic and foreign euro-area sovereign debt holdings, and therefore they allow us to test the "carry trade" hypothesis only for stressed countries: for the banks in non-stressed countries, such testing would require the complete breakdown of their foreign debt portfolio (as in the studies of Buch, Koetter, and Ohls (2016), on German banks and Peydró, Polo, and Sette (2017), on Italian banks). Hence, we estimate Specification (2) only for stressed countries, where our data allow meaningful estimation of the carry-trade coefficients δ_1, δ_2, and δ_3.

Specification (2) also includes the variables present in Specification (1) to capture "moral suasion", except for the interaction between foreign ownership and sovereign debt repricing, since we have no data on the regulatory capital of foreign subsidiaries. The sample includes only the bank-quarter observations for which the SNL database supplies regulatory capital data. The panel is unbalanced, since there are data gaps even for some of the forty-one banks included in the sample.

The estimates of Specification (2) are shown in Table V. The first two columns are for the carry-trade variables only: the sample used in Column 1 includes all domestic banks, while that in Column 2 includes head banks only (that hold most of their groups' sovereign debt). The estimate of δ_1 is positive and significant in both columns. Its estimate in Column

Table V. Determinants of sovereign holdings in stressed countries: "moral suasion" and "carry trade"

The dependent variable is the growth rate of banks' domestic sovereign holdings in quarter t (defined as the percentage difference between the end-of-period values in quarter t and quarter t–1). The stressed countries are Cyprus, Greece, Ireland, Italy, Portugal, Slovenia, and Spain. $\Delta P_{jt}/P_{jt-1}$ is the sovereign debt repricing, defined as the percentage change of government bond prices in country j and quarter t, based on 10-year benchmark yields. $T1/\text{RWA}_{ijt-1}$ is the ratio of Tier-1 common equity to risk-weighted assets of bank i in country j and quarter $t-1$. Public_{ijt} is the fraction of banks' shares owned by local or national government or publicly controlled institutions (Fondazioni in Italy, Fundaciones and Cajas in Spain, and Sparkasse and Landesbank in Germany). VLTRO equals 1 in December 2011 and March 2012, and 0 otherwise. Bailout_{ijt} equals 1 starting in the quarter t in which bank i in country j was bailed out (unless acquired in the two subsequent quarters), and 0 before quarter t. F_{ij} equals 1 if bank i in country j is a foreign subsidiary and 0 otherwise. All the regressions include the bank-level (lagged) deposit–liability ratio as a further control. The sample ranges from 2008:Q1 to 2014:Q4. Standard errors are clustered at the bank level and are shown in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

	Stressed countries		
	(1)	(2)	(3)
$T1/\text{RWA}_{ijt-1} \times \frac{\Delta P_{jt}}{P_{jt-1}}$	7.60***	10.22***	11.36***
	(2.57)	(2.70)	(3.24)
$T1/\text{RWA}_{ijt-1} \times$ VLTRO	−104.86	−65.37	−153.74
	(176.82)	(174.85)	(142.24)
$T1/\text{RWA}_{ijt-1}$	−94.67	−175.02*	−190.03*
	(94.00)	(100.64)	(100.28)
$\text{Public}_{it} \times \frac{\Delta P_{jt}}{P_{jt-1}}$			0.11
			(0.24)
$\text{Public}_{it} \times$ VLTRO			28.24 **
			(11.80)
Public_{it}			3.88
			(5.71)
$\text{Bailout}_{it} \times$VLTRO			4.66
			(5.74)
Bailout_{it}			4.76**
			(2.31)
Bank FE	Yes	Yes	Yes
Time × country FE	Yes	Yes	Yes
Only domestic	No	Yes	Yes
Adjusted R^2	0.14	0.16	0.16
Banks	41	31	31
Observations	686	523	523

2 implies that a 1% decrease in the price of domestic sovereign debt is associated with an increase in sovereign holdings of about 1% for the median bank (which has a regulatory capital ratio of 10%). The estimate of δ_3 is negative and marginally significant in Columns 2 and 3, implying that in stressed countries less capitalized banks increased their domestic sovereign holdings more than better capitalized ones. Both estimated coefficients are

thus in agreement with the "carry trade" hypothesis. The estimate of δ_2 is negative but not significantly different from zero in Columns 2 and 3, implying that in our data the ECB liquidity injections do not appear to have exacerbated carry trades by poorly capitalized banks.

Column 3 shows the estimates for the complete specification (2), comprising both the "carry trade" and the "moral suasion" terms, as well as the corresponding interactions with the ECB liquidity injections of 2011–12, including only group head banks. Both hypotheses are seen to have explanatory power, despite the limited size of this subsample. The carry-trade coefficients δ_1 and δ_3 are virtually the same as in Column 2, and the coefficient δ_8 of the bailout variable and the coefficient δ_5 of the interaction between public ownership and the VLTRO$_t$ both remain positive and significant, and similar in magnitude to the corresponding estimates in Column 3 of Table IV – the only difference being that the coefficient of the interaction between public ownership and sovereign debt repricing is no longer significant, though positive. Indeed, a formal test shows that on the whole the "carry trade" and the "moral suasion" variables have the same explanatory power.[9] The main difference between them lies in their interaction with monetary policy: the ECB liquidity injection appears to have facilitated sovereign debt purchases by public banks rather than by undercapitalized ones, that is, to have fed more into the "moral suasion" than the "carry trade" channel—a finding that no previous study uncovered.

This novel finding is corroborated by the correlation between the change in banks' domestic sovereign holdings around the VLTRO dates and their liquidity take-up in the VLTROs. As shown in Figure 7, in stressed countries this correlation was larger for public banks than for private ones, the difference being statistically significant at the 2.8% level. This confirms that sovereign debt purchases by public banks were fueled by the 3-year ECB loans of the VLTROs more than those of private banks, in contrast with the findings of Ongena, Popov, and van Horen (2016). Instead, no significant difference in this correlation exists between banks with low and high *T*1/RWA ratio, as shown in Figure 8: in our data, the ECB's liquidity injections do not appear to have exacerbated carry trades by poorly capitalized banks compared with better capitalized ones, in contrast with the results reported by Drechsler *et al.* (2016).[10]

9 To test whether there has been a predominance of one of the two hypotheses, we estimate Specification (1)—for the banks for which SNL data on capital are available—first retaining only the carry-trade variables and then retaining only the moral-suasion ones. We then perform the likelihood ratio test proposed by Vuong (1989) and find that the null hypothesis that the two models have the same predictive power cannot be rejected (p-value = 0.8).

10 It is worth noticing that the evidence by Drechsler *et al.* (2016) on this point is more indirect than ours, and is based on a different specification. They estimate a regression of changes in banks' holdings of distressed sovereign debt on the amount of such debt pledged as collateral with the ECB, and find a positive and significant association only for banks with low credit ratings, which they take to be the less capitalized ones. Their interpretation is that weakly capitalized banks used ECB loans to buy distressed sovereign debt. Our specification, instead, allow a direct test of whether the banks with low *T*1/RWA ratio purchased more sovereign debt during the VLTROs than banks with high *T*1/RWA ratio.

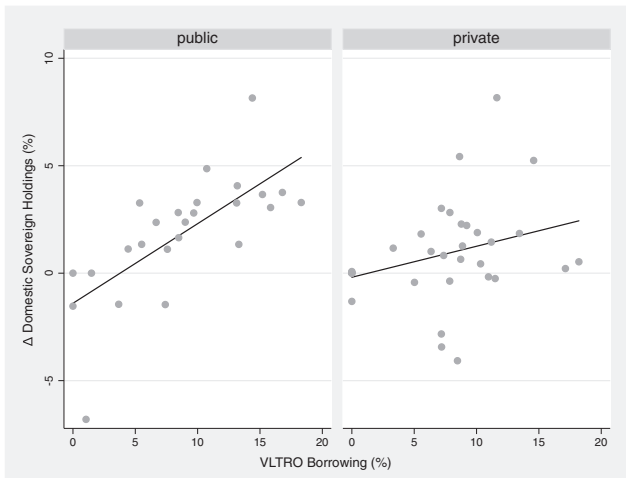

Figure 7. Change in domestic sovereign holdings and VLTRO borrowing, for public and private banks in stressed countries. The figure plots the change in a bank's domestic sovereign holdings from November 2011 to March 2012 against its total VLTRO take-up as of March 2012, scaled by total assets. Public (private) banks are those with public ownership fraction above (below) their country average.

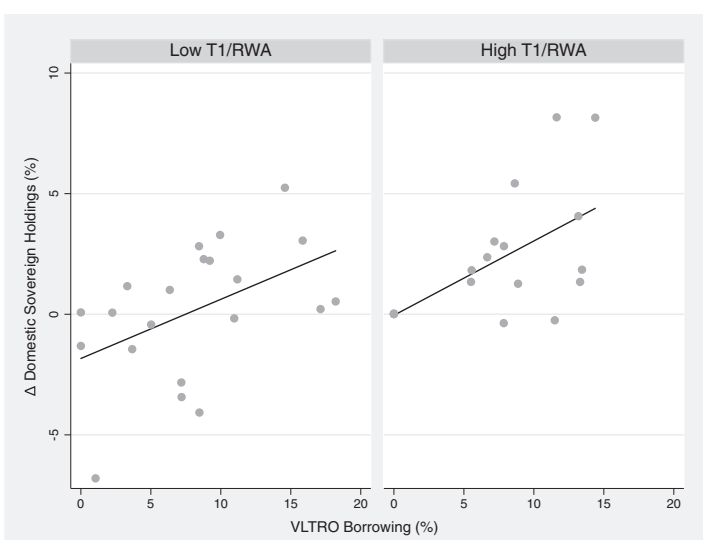

Figure 8. Change in domestic sovereign holdings and VLTRO borrowing, for banks with low and high regulatory capital in stressed countries. The figure plots the change in a bank's domestic sovereign holdings from November 2011 to March 2012 against its total VLTRO take-up as of March 2012. "Low *T*1/RWA" (High *T*1/RWA) are banks with regulatory capital below (above) the median.

To sum up the evidence so far, the descriptive statistics in Section 2 show great heterogeneity in banks' sovereign exposures and in their changes over time. This section shows that sovereign stress increased this heterogeneity, eliciting different responses from banks with different characteristics. In the next section, we inquire whether such heterogeneity is also associated with different responses of banks' lending policies.

4. Sovereign Stress and Bank Lending

In this section, we investigate whether the response of banks' lending to sovereign stress was affected by their holdings of domestic public debt. As noted in Section 1, an increase in sovereign risk may induce the more exposed banks to reduce corporate lending, owing to larger capital losses from sovereign debt repricing. The resulting equity loss increases banks' default risk and pushes them closer to their minimum prudential capital ratio, forcing the weakest to deleverage. An increase in sovereign risk may also disproportionately raise the funding costs of the more exposed banks, forcing them to contract lending. One can expect a symmetric effect when banks' sovereign holdings appreciate, as they did in the stressed countries since mid-2012: in that case, the capital gains on sovereign holdings should amplify the expansion of lending. Since sovereign holdings are a choice variable of banks, an issue of endogeneity may arise in the estimate of this amplification effect. We use the empirical analysis of the previous section to guide us in the choice of relevant instruments to address this endogeneity concern.

Clearly, sovereign stress may also affect banks' loans directly, for instance by inducing banks to change their lending policies or by inducing firms to reduce their demand for credit, quite apart from banks' exposure to government debt: indeed, our specification will control for this direct effect of sovereign stress. However, our focus will be on whether this baseline effect is amplified for heavily exposed banks.

4.1 Bank Lending Regressions

To evaluate the impact of sovereign stress on bank lending, we estimate the following specification:

$$\frac{\Delta L_{ijt}}{L_{ijt}} = \alpha_{jt} + \gamma_i + \left[\left(\beta_1 + \beta_2 \frac{\Delta P_{jt-1}}{P_{jt-2}}\right) D_{ij} + \left(\beta_3 + \beta_4 \frac{\Delta P_{jt-1}}{P_{jt-2}}\right) F_{ij}\right] \mathrm{Exp}_{ijt-1} + \boldsymbol{\theta}' \mathbf{X}_{ijt-1} + \nu_{ijt}, \tag{3}$$

where the dependent variable $\Delta L_{ijt}/L_{ijt}$ is the quarterly growth of the loans granted by bank i to non-financial corporations in country j and quarter t, and $\Delta P_{jt-1}/P_{jt-2}$ is the percentage change in the price of sovereign j's debt in the previous quarter. The reason for lagging the price change in Equation (3) is to allow for a gradual response of lending to capital gains or losses on the sovereign portfolio (although similar estimates are obtained using the contemporaneous price change). The price P_{jt} of the sovereign debt of country j is alternatively the price of 10-year and of 5-year government bonds, computed as the product of the change in the relevant yield from $t-1$ to t and the corresponding duration, as in De Marco (2017). In Specification (3), the loans of domestic and foreign banks are allowed to respond differently to sovereign exposures and capital gains or losses: D_{ij} equals 1 if bank i in country j is domestic and 0 otherwise, and $F_{ij} = 1 - D_{ij}$. The bank-level controls $\mathbf{X}_{ijt-1}$ in Equation (3) are the lagged leverage ratio and deposit–liability ratio, and their interactions with the sovereign debt repricing $\Delta P_{jt-1}/P_{jt-2}$, to control for the differential effect that such repricing may have on banks differing in solvency risk. In estimating Specification (3), errors are clustered at the bank level, and the quarterly growth rates of loans are trimmed at $\pm 100\%$ to eliminate outliers.[11]

11 In the estimation of this specification, we also take into account two breaks in the time series of loans of four Spanish banks (BFA-Bankia, Catalunya Banc, NGC Banco-Banco Gallego, and Banco de Valencia), in November 2012 and January 2013. These breaks are due to restructuring

Table VI shows the estimates of Specification (3) for the stressed countries. In panel A, Columns 1–3 show the estimates obtained when sovereign debt repricing is computed from the yields of 10-year benchmark bonds; Columns 4–6 relate to 5-year yields. In each case, we start from a specification where domestic and foreign banks are constrained to have the same coefficients (Columns 1 and 4), then expand that specification with bank-level controls (Columns 2 and 5), and finally estimate a specification where domestic and foreign banks are allowed to have different coefficients and bank-level controls are included.

In all these specifications, the estimate of β_2 is positive and significantly different from zero, indicating that in stressed countries the domestic banks more exposed to the sovereign responded to public debt repricing by cutting lending more sharply than the less exposed ones; and conversely they expanded their lending more in response to a rise in public debt prices. In contrast, the estimate of β_4 is small and not significantly different from zero, implying that foreign banks with different exposures to their host country's debt did not respond differently to its repricing, probably because the subsidiaries of foreign banks operating in stressed countries had very little exposure to the host country sovereign debt (see Figure 1).

Panel B of Table VI reports the estimates of two specifications where we control for this feature of the data. Since the sovereign portfolio of a banking group is likely to be concentrated at the level of the group head, subsidiaries of domestic banks hold little sovereign debt, as shown in Figure 1. Hence, lending should react only to the value of sovereign debt holdings of the head bank. Panel B of Table VI inquires into this in two different ways. First, we estimate a specification similar to Equation (3) using only data for heads of domestic groups, with sovereign repricing based on 10-year yields in Column 1, and 5-year yields in Column 3. In both cases, the estimate of the interaction coefficient β_2 using only data for head banks is considerably higher than that obtained in Panel A using all banks. The coefficient rises from 1.40 to 2.48 using 10-year debt repricing, and from 0.97 to 1.96 using 5-year debt repricing, and the explanatory power of the regression increases slightly even though the number of observations drops by 42%. Next, in Columns 2 and 4 of Panel B, instead of dropping subsidiaries from the sample, we re-estimate the regression by imputing to domestic subsidiaries the sovereign exposures of their respective parent banks, since subsidiaries' lending decisions may be affected by the capital gains or losses on the securities held by their parent banks. Again the estimate of β_2 exceeds that obtained in Panel A: 2.08 using 10-year debt repricing, and 1.96 using 5-year debt repricing. Hence, the amplification effect is indeed associated with the sovereign exposure of the relevant head bank.

The economic significance of the estimates shown in Table VI is considerable: they imply that in stressed countries a 1-standard-deviation drop in the price of 10-year government bonds (–17%) reduces the loan growth of the median domestic bank by 0.7 percentage points and that of the median domestic head bank by 1.4 percentage points.

and recapitalization by SAREB, the "bad bank" set up by the government to manage the assets transferred by these four banks. To remove the breaks, we regress the loans for these banks on dummy variables corresponding to the two breaks and replace the actual values with the residuals obtained from this regression. We use the same approach to deal with a break for the Slovenian bank Nova Kreditna Banka Maribor in December 2013, when it transferred its bad loans to the Slovenian bad bank.

Table VI. Lending and sovereign exposures in stressed countries

The dependent variable is the growth rate of loans by bank i to non-financial companies in quarter t in stressed country j (Greece, Ireland, Italy, Portugal, and Spain). $\Delta P_{jt-1}/P_{jt-2}$ is the sovereign debt repricing, defined as the percentage change of government bond prices in country j and quarter t–1, based on 10-year yields in Columns 1 – 3 of Panel A and Columns 1–2 of Panel B, and on 5-year yields in Columns 4–6 of Panel A and Columns 3–4 of Panel B. Exp_{ijt-1} is the domestic sovereign exposure of bank i in country j and quarter t–1. Exp.Head_{iht-1} is the indirect exposure of the head bank of subsidiary i operating in country j to the sovereign risk of its home country $h \neq j$, and is set to zero if bank i is a domestic bank of country j, that is, if $h = j$. D_{ij} equals 1 if bank i in country j is domestic and 0 otherwise, and $F_{ij} = 1 - D_{ij}$. The controls are the bank-level (lagged) capital–asset ratio and the lagged deposit–liability ratio, and their interactions with sovereign debt repricing. The sample ranges from 2008:Q1 to 2014:Q4. Standard errors are clustered at the bank level and are shown in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Panel A: Domestic and foreign banks

	10-year debt repricing			5-year debt repricing		
	(1)	(2)	(3)	(4)	(5)	(6)
$\frac{\Delta P_{jt-1}}{P_{jt-2}} \times \text{Exp}_{ijt-1}$	1.38***	1.39***		0.97**	0.97**	
	(0.52)	(0.52)		(0.43)	(0.44)	
$D_{ij} \times \frac{\Delta P_{jt-1}}{P_{jt-2}} \times \text{Exp}_{ijt-1}$			1.45***			1.03**
			(0.52)			(0.46)
$F_{ij} \times \frac{\Delta P_{jt-1}}{P_{jt-2}} \times \text{Exp}_{ijt-1}$			–0.50			–0.20
			(0.80)			(0.54)
Exp_{ijt-1}	10.49	12.08		4.28	6.11	
	(13.68)	(13.87)		(14.64)	(14.49)	
$D_{ij} \times \text{Exp}_{ijt-1}$			19.36			12.61
			(14.96)			(17.14)
$F_{ij} \times \text{Exp}_{ijt-1}$			–41.52			–41.39
			(28.09)			(26.58)
Controls	No	Yes	Yes	No	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time × country FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.08	0.08	0.08	0.08	0.09	0.09
Banks	74	74	74	68	68	68
Observations	1921	1897	1897	1756	1732	1732

Panel B: Domestic banks, using only head banks or imputing their exposures to subsidiaries

	10-year debt repricing		5-year debt repricing	
	(1)	(2)	(3)	(4)
$\frac{\Delta P_{jt-1}}{P_{jt-2}} \times \text{Exp}_{ijt-1}$	2.45**		1.96**	
	(0.98)		(0.91)	
Exp_{ijt-1}	16.35		5.07	
	(16.84)		(16.99)	

(continued)

Table VI. Continued

Panel B: Domestic banks, using only head banks or imputing their exposures to subsidiaries

	10-year debt repricing		5-year debt repricing	
	(1)	(2)	(3)	(4)
$\frac{\Delta P_{jt-1}}{P_{jt-2}} \times$ Exp.Head$_{ijt-1}$		2.05**		1.96**
		(0.79)		(0.78)
Exp.Head$_{ijt-1}$		25.12		12.81
		(17.51)		(16.91)
Controls	Yes	Yes	Yes	Yes
Subsidiary	No	Yes	No	Yes
Bank FE	Yes	Yes	Yes	Yes
Time × country FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.09	0.11	0.10	0.13
Banks	42	53	38	47
Observations	1115	1345	1004	1187

These account, respectively, for 9.7% and 20% of the standard deviation of loan growth (12.7% and 12.2%). Comparable figures are obtained for the effect of the repricing of 5-year government bonds: in that case the amplification effect accounts for 10.1% of the standard deviation of the loan growth of domestic banks and for 23.3% of that of domestic head banks.[12]

Another way to assess the magnitude of this amplification mechanism is to compute the loan growth associated with the change in the value of banks' sovereign holdings over the sample period. Figure 9 plots the cumulated component (dashed line) of the loan growth rate predicted by the interaction term (relying on the estimated coefficient of 2.45, reported in Column 1 of Table VI, Panel B), averaged across the banks operating in stressed countries. The figure also plots actual average loans (solid line) as a benchmark to gauge how far the interaction of bank exposures and sovereign stress helps explain the actual dynamics of lending. The interaction effect is virtually nil until mid-2010, but becomes negative and increasingly large after the Greek bailout in that year (marked by the first vertical line), accounting for the entire drop in lending by the average bank in stressed countries between mid-2010 and mid-2012. After Draghi's "whatever-it-takes" speech in 2012 (the second vertical line), the interaction effect turns positive and rising. Hence, the interaction effect

12 The effect of a 1-standard-deviation rise in the price of 10-year bonds on domestic bank lending is obtained by multiplying its standard deviation (0.17) by the estimate of β_2 in Column 3 of Panel A of Table VI (1.45) and by the median domestic bank's sovereign exposure (0.05), that is, $0.17 \times 1.45 \times 0.05 = 0.012$. Similarly, for domestic head banks we multiply the estimate of β_2 in Column 1 of Panel B of Table VI (2.45) by the median domestic head bank's exposure (5.8%), that is, $0.17 \times 2.45 \times 0.058 = 0.024$. The calculation can be repeated for 5-year bonds taking into account that the standard deviation of their price changes is 0.25, and using the estimates of β_2 in Column 6 of Panel A (1.03) for all domestic banks and in Column 3 of Panel B (1.96) for domestic head banks.

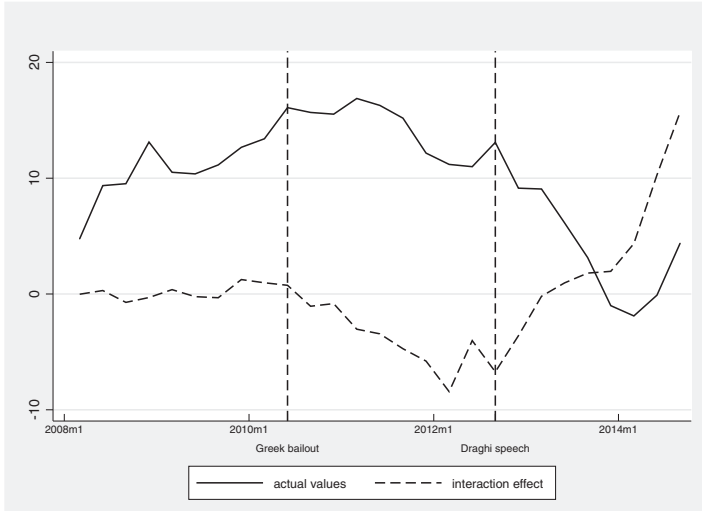

Figure 9. Actual bank lending and estimated amplification effect in stressed countries. The solid line plots actual average loans. The dashed line is the cumulated component of the loan growth rate predicted by the interaction term $(2.45 \times \Delta P_{jt-1}/P_{jt-2} \times \text{Exp}_{ijt-1})$, averaged across banks in stressed countries.

due to sovereign exposures amplifies the fluctuations in loan growth during most of the sample period.

The results reported in Table VI are qualitatively confirmed also when the same specifications are re-estimated for household loans (not reported for brevity). In the case of household loans, the amplification effect of sovereign exposures is considerably smaller than for corporate lending: typically, the estimate of the interaction coefficient β_2 is one-third of the size reported in Table VI. Hence, banks suffering larger losses on their public debt holdings cut back their household loans considerably less than their loans to firms. This "pecking order" may reflect the lower riskiness of household loans, which are generally collateralized by real estate and carry lower prudential risk weights; but it may also reflect the fact that loans to firms have typically shorter maturity than housing mortgages, and thus can be reduced more easily by not rolling them over.

In Table VII the specifications of Table VI are re-estimated for non-stressed countries: the amplification coefficient β_2 is not significantly different from zero for domestic banks, whereas it is positive and significant for foreign banks (Columns 3 and 6 of Panel A); this also explains why it is weakly significant when domestic and foreign banks are pooled together (Columns 4 and 5 of Panel A). Hence, the loans of foreign subsidiaries respond to capital gains or losses on holdings of their host government's debt. This can be explained recalling that these foreign banks are mostly subsidiaries of stressed-country banks, which are more sensitive to the valuation of their securities than banks of non-stressed countries, being more severely equity-constrained.

In summary, the evidence in this section shows that banks' sovereign exposures amplified the impact of sovereign stress on bank lending. In fact, this amplification effect extends to banks' interest rate policy and to their solvency risk, as documented in the working paper version of the present study (Altavilla, Pagano, and Simonelli, 2016). In stressed countries,

Table VII. Lending and sovereign exposures in non-stressed countries

The dependent variable is the growth rate of loans by bank i to non-financial companies in quarter t in non-stressed country j (Austria, Belgium, Estonia, Finland, France, Germany, Luxembourg, Malta, the Netherlands, and Slovakia). $\Delta P_{jt-1}/P_{jt-2}$ is the sovereign debt repricing, defined as the percentage change of government bond prices in country j and quarter t–1, based on 10-year yields in Columns 1–3 of Panel A and Columns 1–2 of Panel B, and on 5-year yields in Columns 4–6 of Panel A and Columns 3–4 of Panel B. Exp_{ijt-1} is the domestic sovereign exposure of bank i in country j and quarter t–1. Exp.Head_{iht-1} is the indirect exposure of the head bank of subsidiary i operating in country j to the sovereign risk of its home country $h \neq j$, and is set to zero if bank i is a domestic bank of country j, that is, if $h = j$. D_{ij} equals 1 if bank i in country j is domestic and 0 otherwise, and $F_{ij} = 1 - D_{ij}$. The controls are the bank-level (lagged) capital–asset ratio and the lagged deposit–liability ratio, and their interactions with sovereign debt repricing. The sample ranges from 2008:Q1 to 2014:Q4. Standard errors are clustered at the bank level and are shown in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Panel A: Domestic and foreign banks

	10-year debt repricing			5-year debt repricing		
	(1)	(2)	(3)	(4)	(5)	(6)
$\frac{\Delta P_{jt-1}}{P_{jt-2}} \times \text{Exp}_{ijt-1}$	0.32	0.34		0.30*	0.29*	
	(0.37)	(0.34)		(0.18)	(0.17)	
$D_{ij} \times \frac{\Delta P_{jt-1}}{P_{jt-2}} \times \text{Exp}_{ijt-1}$			0.02			0.06
			(0.57)			(0.27)
$F_{ij} \times \frac{\Delta P_{jt-1}}{P_{jt-2}} \times \text{Exp}_{ijt-1}$			0.55**			0.43***
			(0.24)			(0.10)
Exp_{ijt-1}	–9.91	–13.49		–14.08	–17.48	
	(13.43)	(13.33)		(14.27)	(14.14)	
$D_{ij} \times \text{Exp}_{ijt-1}$			–10.50			–12.12
			(14.09)			(14.48)
$F_{ij} \times \text{Exp}_{ijt-1}$			–17.94			–24.27
			(29.07)			(29.33)
Controls	No	Yes	Yes	No	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time × country FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.06	0.07	0.07	0.07	0.08	0.08
Banks	147	146	146	143	142	142
Observations	3923	3888	3888	3859	3826	3826

Panel B: Domestic banks, using only head banks or imputing their exposures to subsidiaries

	10-year debt repricing		5-year debt repricing	
	(1)	(2)	(3)	(4)
$\frac{\Delta P_{jt-1}}{P_{jt-2}} \times \text{Exp}_{ijt-1}$	0.96		0.46	
	(0.87)		(0.40)	

(continued)

Table VII. Continued

Panel B: Domestic banks, using only head banks or imputing their exposures to subsidiaries

	10-year debt repricing		5-year debt repricing	
	(1)	(2)	(3)	(4)
Exp_{ijt-1}	–23.81		–26.70	
	(16.52)		(17.84)	
$\frac{\Delta P_{jt-1}}{P_{jt-2}} \times \text{Exp.Head}_{ijt-1}$		0.75		0.38
		(0.80)		(0.38)
Exp.Head_{ijt-1}		–21.66		–24.23
		(14.98)		(16.27)
Controls	Yes	Yes	Yes	Yes
Subsidiary	Yes	No	Yes	No
Bank FE	Yes	Yes	Yes	Yes
Time × country FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.14	0.10	0.15	0.10
Banks	73	104	72	103
Observations	1992	2771	1976	2755

more exposed banks raised their loan rates more in response to sovereign stress, and decreased them more once stress abated. Moreover, sovereign exposures amplified the transmission of risk from governments to banks: in stressed countries, the CDS premia of more exposed banks were more correlated with the CDS premia of domestic sovereign debt than the CDS premia of less exposed banks.

4.1.a. Endogeneity

The estimates in Tables VI and VII might be biased and inconsistent due to endogeneity problems. First, they may be driven by omitted variables, in particular those capturing the role of the demand for credit. At times of sovereign stress, firms may cut back on investment, and thus reduce their loan demand. This could engender spurious correlation if banks with larger sovereign exposures happen to have customers whose business is more sensitive to sovereign stress, so that when public debt prices fall sharply they suffer a larger drop in loan demand by their customers. Second, the results could be driven by reverse causality if the banks that face a larger drop in loan demand (due to the composition of their customer base) substitute public debt for loans in their asset base: if so, causality would run from the change in corporate loan demand to banks' sovereign debt holdings.

To address the issue of omitted variables, we investigate how lending by foreign subsidiaries of stressed-country banks operating in non-stressed countries responds to the repricing of the sovereign portfolio of their head bank. The idea is that the repricing of sovereign debt in stressed countries was external to the credit markets of non-stressed countries, and thus it can be viewed as an exogenous shock to loan supply in the latter, along the lines of Peek and Rosengren (2000); Klein, Peek, and Rosengren (2002); Chava and Purnanandam (2011); Puri, Rocholl, and Steffen (2011) and Schnabl (2012). The domestic sovereign

exposures of head banks in stressed countries should amplify the shock to their foreign subsidiaries' lending: for example, the loans granted by Italian banks operating in Germany should respond to the depreciation of Italian sovereign debt to an extent that depends on the Italian sovereign holdings of their parent bank in Italy. This change in lending should not be affected by spurious correlation, as corporate loan demand in Germany should not respond to sovereign stress in Italy.[13]

Hence, we estimate the following specification:

$$\frac{\Delta L_{ijt}}{L_{ijt}} = \alpha_{jt} + \gamma_i + \left(\beta_1 + \beta_2 \frac{\Delta P_{ht-1}}{P_{ht-2}}\right) \text{Exp.Head}_{ijt-1} + \boldsymbol{\theta}' \mathbf{X}_{ijt-1} + \nu_{ijt}, \tag{4}$$

where the dependent variable is the growth rate of loans by bank i to non-financial corporations in non-stressed country j. The index h denotes the bank's "home" country: bank i may be either a domestic country-j bank (in which case $h = j$) or the foreign subsidiary of a bank based in stressed country h (in which case $h \neq j$). The sample comprises subsidiaries of banks based in Italy and Spain that operate in Austria, Belgium, Germany, Luxembourg, and Slovakia, as well as domestic banks based in these countries. $\Delta P_{ht-1}/P_{ht-1}$ measures the price change of the sovereign debt of the home country $h \neq j$ in quarter t–1. Exp.Head_{ibt} is the indirect exposure of subsidiary i operating in country j to the sovereign risk of its home country $h \neq j$ (i.e., the domestic exposure of the subsidiary's parent bank), and is set to zero if bank i is a domestic bank of country j, that is, if $h = j$. The bank-level controls $\mathbf{X}_{ijt-1}$ are Exp_{ijt-1} and $\Delta P_{jt-1}/P_{jt-2} \times \text{Exp}_{ijt-1}$, where Exp_{ijt-1} is the direct exposure of bank i (whether domestic or subsidiary of a foreign bank) operating in country j to the sovereign debt of country j in quarter t–1: these variables control for the effect of exposure to the "host" country's sovereign risk and the effect of its repricing on bank i's lending.

The results for this specification are shown in Table VIII, where debt price changes refer to 10-year debt in Columns 1–2 and to 5-year debt in Columns 3–4, either without or with bank-level controls. In all cases, the estimate of the amplification coefficient β_2 is positive, significant, and comparable to that estimated in Panel B of Table VI for the loan growth of the head banks: when price changes refer to 10-year debt, β_2 is estimated to be 3.26 for "lending abroad" by stressed-country subsidiaries in Table VIII and 2.48 for "lending at home" by the corresponding head banks in Table VI; the estimates are even closer for 5-year debt, β_2 being 1.71 for "lending abroad" by subsidiaries in Table VIII, and 1.96 for "lending at home" by head banks in Table VI.

Hence, the response of loans granted abroad by subsidiaries of stressed-country banks to the repricing of the home country debt held by their head banks is very similar to the response of the domestic loans of those head banks themselves. This indicates that the amplification coefficients estimated in Table VI capture a shift in bank loan supply and not a shift in firms' loan demand.

A second endogeneity concern is that lending itself may affect the size of lagged sovereign exposures, generating reverse causality: for instance, banks with larger sovereign holdings may have clients whose solvency is particularly sensitive to sovereign risk, and therefore may substitute lending with public debt at times of sovereign stress. If so,

13 Bofondi, Carpinelli, and Sette (2013) adopt a symmetric strategy to identify the effect of sovereign stress on the supply of loans in Italy: they compare the loans extended by Italian and foreign banks to the same customers in Italy, and show that during the sovereign crisis Italian banks reduced their lending by more than foreign ones.

Table VIII. Lending by stressed-country subsidiaries operating in non-stressed countries

The dependent variable is the growth rate of loans to non-financial companies issued by bank i based in country h (the "home" country) operating in non-stressed country j. Bank i may be either a domestic country j bank (in which case $j = h$) or the subsidiary of a bank based in stressed country h (in which case $j \neq h$). The stressed countries are Italy and Spain; the non-stressed countries are Austria, Belgium, Germany, Luxembourg, and Slovakia. $\Delta P_{ht-1}/P_{ht-2}$ measures the repricing of sovereign debt of the home country $h \neq j$ in quarter t–1, based on 10-year yields in Columns 1–2, and on 5-year yields in Columns 3–4. Exp.Head_{iht} is the indirect exposure of the head bank of subsidiary i operating in country j to the sovereign risk of its home country $h \neq j$, and is set to zero if bank i is a domestic bank of country j, that is, if $h = j$. The bank-level controls are Exp_{ijt-1} and $\Delta P_{jt-1}/P_{jt-2} \times \text{Exp}_{ijt-1}$, where Exp_{ijt-1} is the exposure of bank i (whether domestic or a subsidiary of a foreign bank) operating in country j to the sovereign debt of host country j in quarter t–1. The sample ranges from 2008:Q1 to 2014:Q4. Standard errors are clustered at the bank level and are shown in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

	10-year debt repricing		5-year debt repricing	
	(1)	(2)	(3)	(4)
$\frac{\Delta P_{bt-1}}{P_{bt-2}} \times \text{Exp.Head}_{ibt-1}$	3.26**	3.34**	1.71**	1.76**
	(1.32)	(1.36)	(0.70)	(0.72)
Exp.Head_{ibt-1}	–72.28	–74.25	–70.84	–72.88
	(49.72)	(50.55)	(47.42)	(48.19)
Controls	No	Yes	No	Yes
Bank FE	Yes	Yes	Yes	Yes
Time × country FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.07	0.07	0.07	0.07
Banks	82	82	82	82
Observations	2278	2278	2278	2278

Ordinary Least Squares (OLS) would over-estimate the amplification of the drop in lending due to sovereign exposures. In principle the bias may go in the opposite direction: if at times of sovereign stress banks want to reduce corporate lending, they need less collateral to borrow from the central bank or the interbank money market, and therefore may also reduce their sovereign holdings. Whatever its direction, the bias should be attenuated by the fact that in our specification the sovereign exposure of bank i is measured one quarter before its loan growth. However, in principle banks could change their sovereign holdings in anticipation of future changes in loan growth. In this case, rather than measuring the extent to which losses or gains on sovereign holdings impact lending, the estimates might be capturing how expected changes in lending impact sovereign exposures.

To address this potential reverse causality, recall the evidence in Section 3 that publicly owned banks increase their domestic sovereign holdings more than privately owned banks in response to sovereign stress, and that bailouts are followed by increases in domestic sovereign holdings. This suggests that these two variables—public ownership and occurrence of a bank bailout, both interacted with sovereign repricing—are relevant instruments of the interaction term $\text{Exp}_{ijt-1} \times \Delta P_{jt-1}/P_{jt-2}$ in our specification. For the variables $\text{Public}_{ijt-1} \times \Delta P_{jt-1}/P_{jt-2}$ and $\text{Bailout}_{ijt-1} \times \Delta P_{jt-1}/P_{jt-2}$ to be also valid instruments, they must satisfy

Table IX. Lending and sovereign exposures of domestic banks: IV estimates

The dependent variable is the growth rate of loans by domestic banks to non-financial companies in quarter t in stressed countries (Greece, Ireland, Italy, Portugal, and Spain). $\Delta P^{10}_{jt-1}/P^{10}_{jt-2}$ and $\Delta P^{5}_{jt-1}/P^{5}_{jt-2}$ measure the percentage change of government bond prices in country j and quarter t–1, respectively, for 10-year and 5-year debt. Exp_{ijt-1} is the domestic sovereign exposure of domestic bank i in country j and quarter t–1, defined as the ratio of sovereign debt holdings to main assets. The controls are the bank-level (lagged) capital–asset ratio and the lagged deposit–liability ratio, and their interactions with sovereign debt repricing. All regressions in this table are estimated by IV, using $\text{Bailout}_{ijt-1} \times \Delta P_{jt-1}/P_{jt-2}$ and $\text{Public}_{ijt} \times \Delta P_{jt-1}/P_{jt-2}$ as instruments for $\text{Exp}_{ijt-1} \times \Delta P_{jt-1}/P_{jt-2}$. Bailout_{ijt} equals 1 starting in the quarter t in which bank i in country j was bailed out (unless acquired in the two subsequent quarters), and 0 before quarter t. Public_{ijt} is the fraction of banks' shares owned by local or national government or publicly controlled institutions (Fondazioni in Italy, Fundaciones and Cajas in Spain, and Sparkasse and Landesbank in Germany). The sample ranges from 2008:Q1 to 2014:Q4. Standard errors are clustered at the bank level and are shown in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

	Stressed countries		Non-stressed countries	
	(1)	(2)	(3)	(4)
$\text{Exp}_{ijt-1} \times \frac{\Delta P^{10}_{jt-1}}{P^{10}_{jt-2}}$	3.65**		–1.43	
	(1.42)		(2.95)	
$\text{Exp}_{ijt-1} \times \frac{\Delta P^{5}_{jt-1}}{P^{5}_{jt-2}}$		3.46*		0.04
		(1.90)		(1.05)
Exp_{ijt-1}	4.25	–30.21	–0.90	–11.85
	(20.34)	(39.64)	(20.54)	(18.48)
Banks	54	48	104	104
First-stage F-test	17	34	2	3
Observations	1396	1238	2822	2819

the exclusion restriction that lending by publicly owned and bailed-out banks does not react differently to sovereign stress compared with lending by other banks, unless they have different domestic sovereign exposures. In other words, their exposure must be the only factor determining their differential response to sovereign stress. This exclusion restriction would be violated if at times of sovereign stress the customers of public and recently rescued banks were to become comparatively riskier, so that these banks would be more inclined to curtail lending than other banks. To verify whether this is the case, we estimate an auxiliary regression whose dependent variable is the ratio of impaired loans to gross loans, based on SNL data for thirty-five banks in stressed countries and forty-three banks in non-stressed ones. The explanatory variables include the Bailout_{ijt-1} and Public_{ijt-1} variables, and their interactions with $\Delta P_{jt-1}/P_{jt-2}$. The estimates (shown in Table AII in the Appendix) indicate that the coefficients of the two instruments ($\text{Public}_{ijt-1} \times \Delta P_{jt-1}/P_{jt-2}$ and $\text{Bailout}_{ijt-1} \times \Delta P_{jt-1}/P_{jt-2}$) are not significantly different from zero: at times of sovereign stress, the fraction of impaired loans does not tend to increase more for public and recently bailed-out banks, which lends credibility to the exclusion restriction made in Table IX.

Table IX shows the IV estimates of Specification (3), restricted to domestic banks (i.e., setting $D_{ij}=1$ and $F_{ij}=0$), as obviously there are no domestic bailouts of foreign banks. For stressed countries the estimate of β_2 is still positive and significant, while for non-stressed countries it is still not significantly different from zero. Indeed, the IV estimate of β_2 for stressed countries exceeds its OLS counterpart: the endogeneity bias appears to lead to an underestimate of the amplification mechanism. For stressed-country banks, the *F*-statistics testing the power of the instruments are 17 and 34 in the regressions based on 10-year and 5-year bond prices, respectively. Beside addressing endogeneity concerns, these IV estimates have a substantive implication: they show that the amplification of shocks to lending due to domestic sovereign exposures can be traced back to the moral suasion exerted by governments on banks during the crisis.

In summary, the evidence indicates that neither omitted variables nor reverse causality are serious concerns for the estimates shown in previous tables.

4.1.b. Unexpected sovereign repricing

The foregoing estimates show that in stressed countries bank loans dropped in response to the depreciation of sovereign debt and rose in response to its appreciation, in proportion to the relevant bank's exposure. Insofar as these price changes are anticipated, however, banks will switch in advance from corporate loans to sovereign debt; that is, they can be expected to buy sovereign debt when its price is unusually low—an effect that is indeed documented in Section 3. In this case, the estimate of β_2 would conflate the impact of the appreciation of given sovereign exposures and that of the concomitant response of exposures to the expected appreciation. In order to study the first of these two effects by itself, the previous specification is re-estimated replacing sovereign debt repricing with its unexpected component.

We have data on survey-based consensus forecasts of 10-year yields (Y^E_{jt}) for Germany, France, the Netherlands, Italy, and Spain, so for these five countries we can compute time series of "yield surprises", $(Y_{jt}-Y^E_{jt})/Y_{jt-1}$. Since these surprises cannot be transformed into unexpected price changes owing to the non-linearity of the price–yield relationship, in Table X we estimate a variant of Specification (3) in which the change in the price of sovereign debt $\Delta P_{jt-1}/P_{jt-2}$ is replaced by yield surprises. The interaction between domestic yield surprises $(Y_{jt}-Y^E_{jt})/Y_{jt-1}$ and a bank's domestic exposure Exp_{ijt} measures the bank's capital loss from the unexpected repricing of its domestic sovereign holdings. Notice that as the repricing is unanticipated, the bank cannot have modified its sovereign holdings to take advantage of it. To take into account that banks may adjust their lending policy to such an unexpected capital loss with a delay, in the regression this interaction variable is lagged by one quarter with respect to the bank's loan growth, as with the analogous interaction variables in previous specifications.

The estimates in the first three columns of Table X refer to stressed countries. In Columns 1 and 2, domestic and foreign banks are pooled: the two specifications differ by the absence or presence of bank-level controls, that is, the (lagged) capital–asset ratio, the lagged deposit–liability ratio, and their interactions with sovereign yield surprises. In Column 3, as in the previous tables, the estimates are allowed to differ between domestic and foreign banks. Columns 4–6 show the estimates of the same specifications for banks operating in non-stressed countries. On the whole, the results confirm those of the previous tables, based on the realized repricing of domestic sovereign debt: the estimated coefficient of the interaction term is negative (as expected) and significant for stressed-country banks

Table X. Lending, sovereign exposures, and yield surprises

The dependent variable is the growth rate of loans by bank *i* to non-financial companies in country *j* and quarter *t*. The stressed countries are Italy and Spain. The non-stressed countries are France, Germany, and the Netherlands. $(Y_{jt} - Y_{jt}^{E})/Y_{jt-1}$ is the unexpected percentage change (surprise) in the domestic 10-year benchmark sovereign yield in quarter *t*, computed as the average of the three monthly surprises in quarter *t*. Exp_{ijt} is the domestic sovereign exposure of bank *i* in country *j* and quarter *t*, defined as the ratio of sovereign debt holdings to main assets. D_{ij} equals 1 if bank *i* in country *j* is domestic and 0 otherwise, and $F_{ij} = 1 - D_{ij}$. The controls are the bank-level (lagged) capital–asset ratio and the lagged deposit–liability ratio, and their interactions with sovereign yield surprises. The sample ranges from 2008:Q1 to 2014:Q4. Standard errors are clustered at the bank level and are shown in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

	Stressed countries			Non-stressed countries		
	(1)	(2)	(3)	(4)	(5)	(6)
$\frac{Y_{jt-1}-Y_{jt-1}^{E}}{Y_{jt-2}} \times \text{Exp}_{ijt-1}$	−1.85**	−1.83**		−0.22	–0.11	
	(0.75)	(0.77)		(0.42)	(0.35)	
$D_{ij} \times \frac{Y_{jt-1}-Y_{jt-1}^{E}}{Y_{jt-2}} \times \text{Exp}_{ijt-1}$			−1.89**			0.04
			(0.88)			(0.36)
$F_{ij} \times \frac{Y_{jt-1}-Y_{jt-1}^{E}}{Y_{jt-2}} \times \text{Exp}_{ijt-1}$			−1.07*			–1.58
			(0.62)			(1.37)
Exp_{ijt-1}	–2.09	–0.51		–15.79	−19.99*	
	(14.03)	(13.85)		(12.92)	(11.90)	
$D_{ij} \times \text{Exp}_{ijt-1}$			3.42			−21.37*
			(17.60)			(12.38)
$F_{ij} \times \text{Exp}_{ijt-1}$			–28.62			17.00
			(26.09)			(29.35)
Controls	No	Yes	Yes	No	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time × country FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.10	0.10	0.10	0.09	0.10	0.10
Banks	47	47	47	102	101	101
Observations	1195	1190	1190	2742	2709	2709

but not for those in non-stressed countries. Further, it is considerably larger and more precisely estimated for domestic banks than for foreign ones operating in stressed countries. The main difference with respect to the previous results is that the coefficient estimate is non-negligible and significantly different from zero at the 10% level also for foreign banks operating in stressed countries: despite their limited exposure to their host countries' sovereign risk, these banks too appear to have reacted to unexpected losses and gains on their holdings of local sovereign debt.

5. Conclusions

Exploiting the substantial cross-sectional and time-series variation in individual banks' domestic sovereign exposures, this paper jointly addresses two questions that various recent studies of the euro-area crisis have attacked separately. First, did banks with different

characteristics change their public debt holdings differently in response to sovereign stress and to its abatement after 2012? Second, were larger sovereign exposures associated with more forceful transmission of sovereign stress to banks' lending policies, and was such an amplification causally related to banks' sovereign exposures? The two questions are clearly related, since sovereign holdings and lending are jointly chosen by banks. Indeed, studying them together allows us to build on our analysis of the determination of sovereign exposures to identify relevant instruments to address endogeneity in our lending regressions.

Our findings answer both of the above questions in the affirmative. First, in stressed euro-area countries, publicly owned and less strongly capitalized banks reacted to sovereign stress by increasing their holdings of domestic public debt more than other banks, which suggests that their portfolio choices were influenced both by government's moral suasion and by their own search for yield. Domestic public debt purchases by public banks in stressed countries were also facilitated by the ECB's 3-year refinancing operations of 2011–12.

Second, banks' domestic sovereign exposures in the stressed countries were associated with a statistically significant and economically relevant amplification of sovereign stress transmission to corporate lending, which cannot be attributed to spurious correlation or reverse causality. Indeed, this amplification effect of sovereign stress also spills over abroad: the repricing of sovereign debt in stressed countries induced the subsidiaries of stressed-country banking groups to reduce lending in non-stressed countries. Altogether, this evidence connects the amplification effect of sovereign exposures and its cross-border transmission with the "moral suasion" exerted by domestic governments on banks during the crisis.

These findings are important for banking regulation: currently, euro-area prudential regulation gives strong preferential treatment to sovereign debt over bank loans, treating it as risk-free for purposes of capital charges and imposing no concentration limit on holdings. This encourages banks to invest in high-yield sovereign debt rather than lending to firms and households and, as shown in this paper, strengthens the impact of sovereign stress on lending. To make matters worse, in the euro-area countries affected by sovereign stress during the crisis, banks' domestic sovereign exposures have remained considerably larger than they were at the inception of the crisis: between 2013 and 2017, the domestic exposure of the median bank in these countries has been about three times as large as it was in early 2010. This raises the concern that a future resurgence of sovereign stress—possibly in connection with tapering of large-scale asset purchases by the ECB—might trigger commensurately larger effects on bank lending.

Appendix

Table AI. List of variables, definitions, and sources

Variable	Symbol	Definition	Source	Units
Ownership	Public_{ij}	Fraction of bank equity held in country j and quarter t by local or national government or by publicly controlled institutions (Fondazioni in Italy, Fundaciones and Cajas in Spain, and Sparkasse and Landesbank in Germany).	Bankscope and authors' calculations	
Sovereign debt price change	$\Delta P_{jt}/P_{jt-1}$	Percentage change of 10- or 5-year debt prices in country j and quarter t.	Datastream and authors' calculations	
Foreign subsidiary dummy	F_{ij}	Dummy variable equal to 1 if bank i in country j is a foreign subsidiary and 0 otherwise.	ECB	
Bailout dummy	Bailout_{ijt}	Dummy variable equal to 1 starting in the quarter t in which bank i in country j was bailed out (unless acquired in the two subsequent quarters), and 0 before t.	EU Commission—State Aid Database	
Sovereign holding growth rate	Sovereign holding growth	Percentage growth rate of banks' sovereign holdings in quarter t.	IBSI–ECB and authors' calculations	
Tier-1 common equity over risk-weighted assets	$T1/\text{RWA}_{ijt-1}$	Ratio between Tier-1 common equity and risk-weighted assets of bank i in country j and quarter t–1.	SNL	
Domestic sovereign exposures	Exp_{ijt}	Ratio between domestic sovereign debt holdings and main assets (total assets minus derivatives) of bank i in country j and quarter t–1.	IBSI–ECB	
Domestic dummy	D_{ij}	Dummy variable equal to 1 if bank i in country j is domestic and 0 otherwise.	ECB	
10-year government yield	Y_{jt}	10-year benchmark government bond yield in country j and quarter t	Datastream	
10-year government yield forecast	Y_{jt}^{E}	Consensus estimate of the 10-year government yield of country j for quarter t made by professional forecasters at the end of quarter t–1.	Consensus economics	
Surprise in sovereign yield	$(Y_{jt} - Y_{jt}^{E})/Y_{jt-1}$	Unexpected percentage change (with respect to consensus forecast) in the domestic sovereign yield of country j in quarter t.	Authors' calculations	%

(continued)

Table AI. Continued

Variable	Symbol	Definition	Source	Units
Bank lending growth		Percentage growth rate of loans granted by bank i in country j to non-financial companies in quarter t.	IBSI–ECB and authors' calculations	%
Domestic sovereign exposure of head banks	Exp.Head_{iht}	Indirect exposure of subsidiary i operating in country j to the sovereign risk of its home country $h \neq j$, arising from the sovereign holdings of its head bank. Set to zero if bank i is a domestic bank of country j, i.e., if $h = j$.	IBSI–ECB and authors' calculations	
Bank loan–asset ratio		Bank loans to non-financial corporations as a fraction of main assets.	IBSI–ECB	
Deposit–liabilities ratio		Ratio of bank's deposits to its total liabilities.	IBSI–ECB	

Table AII. Banks' non-performing loans, public ownership, and bailouts

The dependent variable is the ratio of non-performing loans to total loans of bank i in country j and quarter t. The stressed countries are Ireland, Italy, and Spain. The non-stressed countries are Austria, Belgium, Finland, France, Germany, and the Netherlands. Public_{ijt} is the fraction of banks' shares owned by local or national government or publicly controlled institutions (Fondazioni in Italy, Fundaciones and Cajas in Spain, and Sparkasse and Landesbank in Germany). VLTRO_t equals 1 in December 2011 and March 2012, and 0 otherwise. Bailout_{ijt} equals 1 starting in the quarter t in which bank i in country j was bailed out (unless acquired in the two subsequent quarters), and 0 before quarter t. $\Delta P^{10}_{jt-1}/P^{10}_{jt-2}$ and $\Delta P^{5}_{jt-1}/P^{5}_{jt-2}$ measure the percentage change of government bond prices in country j and quarter t–1, respectively, for 10-year and 5-year debt. The sample ranges from 2008:Q1 to 2014:Q4. Standard errors are clustered at the bank level and are shown in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

	Stressed countries		Non-stressed countries	
	(1)	(2)	(3)	(4)
Bailout_{ijt-1}	0.01	0.01	0.05	0.05
	(0.03)	(0.03)	(0.03)	(0.03)
Public_{ijt-1}	−0.00	−0.00	0.00*	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
$\text{Bailout}_{ijt-1} \times \frac{\Delta P^{10}_{jt-1}}{P^{10}_{jt-2}}$	0.00		0.00	
	(0.00)		(0.00)	
$\text{Public}_{ijt-1} \times \frac{\Delta P^{10}_{jt-1}}{P^{10}_{jt-2}}$	0.00		0.00	
	(0.00)		(0.00)	
$\text{Bailout}_{ijt-1} \times \frac{\Delta P^{5}_{jt-1}}{P^{5}_{jt-2}}$		−0.00		0.00
		(0.00)		(0.00)
$\text{Public}_{ijt-1} \times \frac{\Delta P^{5}_{jt-1}}{P^{5}_{jt-2}}$		0.00		0.00
		(0.00)		(0.00)
Banks	33	33	30	30
Observations	300	287	351	351

References

Acharya, V., Eisert, T., Eufinger, C., and Hirsch, C. (2015): Real effects of the sovereign debt crises in Europe: evidence from syndicated loans. Unpublished.

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

Altavilla, C., Pagano, M., and Simonelli, S. (2016): Bank exposures and sovereign stress transmission. ECB Working Paper No. 1969.

Battistini, N., Pagano, M., and Simonelli, S. (2014): Systemic risk, sovereign yields and bank exposures in the euro crisis, *Economic Policy* 29, 205–241.

Becker, B. and Ivashina, V. (2014): Financial repression in the European sovereign debt crisis. Swedish House of Finance Research Paper No. 14-13.

Bofondi, M., Carpinelli, L., and Sette, E. (2013): Credit supply during a sovereign debt crisis. Bank of Italy Working Paper No. 909.

Buch, C. M., Koetter, M., and Ohls, J. (2016): Banks and sovereign risk: a granular view, *Journal of Financial Stability* 25, 1–15.

Carpinelli, L. and Crosignani, M. (2017): The effect of central bank liquidity injections on bank credit supply. Unpublished.

Chava, S. and Purnanandam, A. (2011): The effect of banking crisis on bank-dependent borrowers, *Journal of Financial Economics* 99, 116–135.

Crosignani, M., Faria-e-Castro, M., and Fonseca, L. (2016): The (unintended?) consequences of the largest liquidity injection ever. Unpublished.

De Marco, F. (2017): Bank lending and the European sovereign debt crisis, *Journal of Financial and Quantitative Analysis*, forthcoming.

De Marco, F. and Macchiavelli, M. (2014): The political origin of home bias: the case of Europe. Unpublished.

Drechsler, I., Drechsel, T., Marques-Ibanez, D., and Schnabl, P. (2016): Who borrows from the lender of last resort? *Journal of Finance* 71, 1933–1974.

Gennaioli, N., Martin, A., and Rossi, S. (2014a): Sovereign default, domestic banks, and financial institutions, *Journal of Finance* 69, 819–866.

Gennaioli, N., Martin, A., and Rossi, S. (2014b): Banks, government bonds, and default: what do the data say? Unpublished.

Horváth, B., Huizinga, H., and Ioannidou, V. (2015): Determinants and valuation effects of the home bias in European banks' sovereign debt portfolios. CEPR Working Paper No.10661.

Khwaja, A. I. and Mian, A. (2008): Tracing the impact of bank liquidity shocks: evidence from an emerging market, *American Economic Review* 98, 1413–1442.

Klein, M., Peek, J., and Rosengren, E. (2002): Troubled banks, impaired foreign direct investment: the role of relative access to credit, *American Economic Review* 92, 664–682.

Ongena, S., Popov, A., and van Horen, N. (2016): The invisible hand of the government: moral suasion during the European sovereign debt crisis. DNB Working Paper 505.

Peek, J. and Rosengren, E. (2000): Collateral damage: effects of the Japanese bank crisis on real activity in the US, *American Economic Review* 90, 30–45.

Puri, M., Rocholl, J., and Steffen, S. (2011): Global retail lending in the aftermath of the US financial crisis: distinguishing between supply and demand effects, *Journal of Financial Economics* 100, 556–578.

Peydró, J. L., Polo, A., and Sette, E. (2017): Monetary policy at work: security and credit application registers evidence. Unpublished.

Popov, A. and Van Horen, N. (2014): Exporting sovereign stress: evidence from syndicated bank lending during the euro area sovereign debt crisis. Review of Finance 19, 1825–1866.

Schnabl, P. (2012): The international transmission of bank liquidity shocks: evidence from an emerging market, *Journal of Finance* 68, 897–932.

Uhlig, H. (2013): Sovereign default risk and banks in a monetary union, *German Economic Review* 15, 23–41.

Vuong, Q. (1989): Likelihood ratio tests for model selection and nonnested hypotheses, *Econometrica* 57, 307–333.