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The "greatest" carry trade ever? Understanding eurozone bank risks ☆

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ABSTRACT

We show that eurozone bank risks during 2007–2013 can be understood as carry trade behavior. Bank equity returns load positively on peripheral (Greece, Italy, Ireland, Portugal, Spain, or GIIPS) bond returns and negatively on German government bond returns, which generated carry until the deteriorating GIIPS bond returns adversely affected bank balance sheets. We find support for risk-shifting and regulatory arbitrage motives at banks in that carry trade behavior is stronger for large banks and banks with low capital ratios and high risk-weighted assets. We also find evidence for home bias and moral suasion in the subsample of GIIPS banks.

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1. Introduction

The sovereign debt crisis that began in Europe in 2009 cast doubt on the solvency of European banks that incurred substantial mark-to-market losses and impairments on their peripheral (Greece, Italy, Ireland, Portugal, Spain, or GIIPS) sovereign bond holdings. Since mid-2008, government bond yield spreads between pairs of European countries, for example, between German bunds and GIIPS bonds, widened considerably, mirroring the economic divergence between them across the region (Fig. 1).[3] This divergence has challenged the survival of the eurozone. In 2011 alone, banks on average lost 40% of their market value and afterwards shed billions of euros in assets in an effort to increase regulatory capital ratios.

In this paper, we show that banks' risks during the 2007–2013 period can be understood as a form of carry trade. With access to short-term unsecured funding in wholesale markets, banks appear to have undertaken long peripheral sovereign bond positions. On the upside, the bank would pocket the carry, that is, the spread between long-term peripheral sovereign bonds and banks' short-term funding costs. On the downside, which materialized, the spreads between the two legs of the trade diverged even further, resulting in significant losses for banks and leading to concerns about their solvency and liquidity. In essence, this carry trade reflects a bet that eurozone countries would converge economically, resulting in a convergence of the spread involving its two legs. We show that carry trade behavior has in fact been pervasive among European banks.

We investigate the causes of the European banking crisis and argue that banks' substantial share price decline can be explained in part by banks anticipating the survival of the eurozone, choosing to hold peripheral sovereign bonds and financing their investments in short-term wholesale markets. Correlations between the bond yields of Germany (or France) and peripheral sovereign bond yields were above 95% in 2005 but became negative in 2010 when markets were more reluctant to finance banks' investments in risky sovereign debt. This led to a flight into longer-term core European (particularly German) government bonds. In other words, the banks lost on both sides of the carry trade.[4]

At the core of our analysis are the publicly listed banks that were part of different stress tests and assessments by the European Banking Authority (EBA) over the March 2010 to June 2012 period, when detailed information about European banks' sovereign bond holdings was released. Importantly, our sample of banks includes eurozone banks, as well as banks of countries that are part of the European Union (EU) but outside the eurozone. As these banks are less affected by actions from the European Central Bank (ECB) or other distortions within the eurozone, they constitute an interesting benchmark against which we evaluate the behavior of eurozone banks.

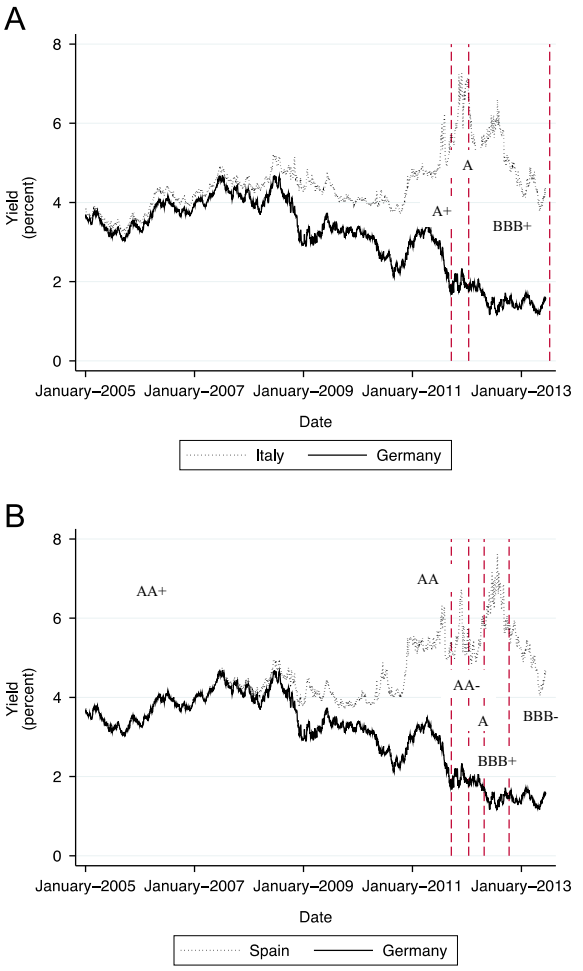

Fig. 1. Pairwise comparison of government bond yield spreads. The figure shows the time series of 10-year government bond yields comparing Italian and German 10-year government bond yields (Panel A) and Spanish and German 10-year government bond yields (Panel B) since January 2005. Vertical lines indicate rating downgrades by Standard & Poor's. Panel A: Italian and German 10-year government bond yields. Panel B: Spanish and German 10-year government bond yields.

Our data show that European banks entered the stress test period in 2010 with a substantial exposure to GIIPS sovereign debt that overall remained remarkably constant until June 2012. More important, GIIPS banks and (in particular) non-GIIPS (eurozone and non-eurozone EU) banks appear to have actively managed their sovereign bond portfolios by increasing their exposures to the periphery even as yield spreads on these countries' debt widened between March and December 2010. Our analysis indicates that parts of these purchases were financed with proceeds from selling, for example, German and French sovereign debt.

Except for these reporting dates, micro-level data of sovereign bond positions are not available on a high-frequency basis. Banks could also be exposed to sovereign bond risk other than through direct bond positions [e.g., through credit default swap (CDS) positions and counterparty

[3] For almost a decade prior to this, the 10-year sovereign bond yields for these countries hovered around the 4% benchmark, with a small yield spread difference between core and peripheral European countries.

[4] Dexia SA (Dexia) and the Bank of Cyprus provide two quintessential examples of such behavior as they invested heavily in these carry trades, as described in the Online Appendix.

exposure in derivatives transactions with governments, as well as indirectly though exposures to other financial institutions engaging in carry trades]. Given this limitation and to link bank risk to both the investment leg and the funding leg of the carry trade, we estimate banks' exposure to sovereign debt using the sensitivity of banks' equity returns to sovereign bond returns.[5]

We find that European banks load positively on GIIPS sovereign bonds and negatively on German bund returns, which indicates that banks financed long-term peripheral bonds with short-term debt in a carry trade. We show that factor loadings on GIIPS sovereign bond returns relate to banks' actual sovereign bond holdings, not non-sovereign exposures (to firms, households, and real estate). Moreover, banks with more short-term funding exposure, through US money market funds (MMFs)[6] and other wholesale funding sources, have more negative factor loadings on German bunds. Interestingly, we find that MMFs withdraw particularly from weakly capitalized institutions, highlighting how liquidity and solvency risk interact.

We analyze three channels through which banks' carry trade behavior can be explained: (1) regulatory capital arbitrage and risk shifting by undercapitalized banks, (2) home bias of peripheral banks, and (3) suasion by domestic sovereigns to maintain asset exposures. The regulatory capital arbitrage motive arises due to Basel II regulations, which assign a zero-risk weight for investments in sovereign debt.[7] The governments themselves could have had incentives to preserve the zero-risk weight to be able to continue to borrow.[8] Undercapitalized banks, that is, banks with low Tier 1 capital ratios, have incentives to increase short-term return on equity by shifting their portfolios into the highest-yielding assets with the lowest risk weights in an attempt to meet regulatory capital requirements without having to issue economic capital (regulatory capital arbitrage).[9]

Moreover, riskier banks could shift from safer into riskier government bonds by placing a bet on their own survival (risk shifting). This action would likely shift risk into the states of the world (government defaults) where they are likely to experience bank runs, as argued by Diamond and Rajan (2011). While the regulatory arbitrage incentive would be stronger for both GIIPS and non-GIIPS banks, the risk shifting incentive would be stronger for the domestic banks of GIIPS countries, which would increase the home bias of these countries over time.

The premise behind the moral suasion hypothesis is that peripheral governments force domestic banks to absorb more of their own sovereign debt because overall demand is weak and to reduce sovereign bond yields. This hypothesis also implies an increase in home bias over time. The above discussion suggests that these hypotheses are not mutually exclusive. For example, there can be an increase in home bias and an increase in moral hazard and regulatory arbitrage at the same time.

We bring these hypotheses to the data in a variety of tests. We conduct falsification tests and find that carry trade behavior is specific to banks, not to hedge funds or industrial firms, and are also specific to European banks but not to US banks that do no benefit from zero risk weights. Importantly, we show that non-eurozone EU banks have significant exposures to the GIIPS sovereign debt, suggesting that motives other than home bias or moral suasion can help to explain our findings. We also repeat our tests in consecutive subperiods and show that the exposure of non-GIIPS eurozone and non-eurozone EU banks decreases over time, while GIIPS banks' factor loadings increase, which is consistent with an increase in home bias of GIIPS banks. We also find an increase in home bias of non-GIIPS eurozone and non-eurozone EU banks with respect to their own domestic sovereign debt. The loadings on German bunds are significantly lower for GIIPS banks in the first half of 2012, suggesting that the long-term refinancing operations (LTRO) injections by the ECB in December 2011 and February 2012 reduced the funding risk of GIIPS banks.

We show that large banks and banks with a high short-term leverage, high risk-weighted assets, and low Tier 1 ratios have more exposure to peripheral sovereign debt. The results of a subsample test of GIIPS versus non-GIIPS banks delineate the risk-shifting motive, particularly by the GIIPS banks. The regulatory arbitrage motive, however, is stronger in the non-GIIPS banks. Moreover, moral hazard by undercapitalized banks is an important determinant of banks' carry trade behavior, even during periods when home bias is increasing.

We also analyze banks that have or have not been bailed out by their governments. We find that GIIPS banks that have been bailed out had higher peripheral sovereign bond exposure, consistent with moral suasion among GIIPS banks. In summary, we find evidence that regulatory capital arbitrage and home bias (due to risk shifting and moral suasion) are important to understanding European banks' sovereign bond exposures.

Our paper is related to the literature investigating the yield-chasing investment behavior of non-bank financial institutions due to agency frictions (Becker and Ivashina, 2014a, 2014b; and Kacperczyk and Schnabl, 2013). We show that European banks pursue high economic risk and return investing in high-yielding long-term government debt financed with low-yielding short-term wholesale funds as a response to risk shifting and regulatory capital

[5] To further strengthen our methodology, we relate our estimates to actual portfolio holdings throughout the paper.

[6] The dependence on US MMFs by European banks for US dollar funding potentially poses a threat to their (short-term) liquidity and could be transmitted to other financial institutions or the real economy (Chernenko and Sunderam, 2012; Ivashina et al., 2012).

[7] The Capital Requirement Directive assigns a zero-risk weight for "exposures to Member States' central government […] denominated and funded in the domestic currency of that central government" (Hannoun, 2011). That is, despite (even little) differences in country ratings, EU member banks (i.e., eurozone and non-eurozone) are allowed to reduce the capital they hold against these positions to zero.

[8] The more entangled the financial sector and the governments become, the more costly the government default would be due to collateral damage in the form of bank runs and disruption of interbank and repo markets (Broner, Martin, and Ventura, 2010; Acharya and Rajan, 2013; Bolton and Jeanne, 2011).

[9] See Acharya, Engle, and Pierret (2014) for a formal derivation of this perverse incentive when banks disregard the risks that arise from earning returns on capital subject to a risk-weight based capital requirement scheme.

arbitrage incentives.[10] Regulatory capital arbitrage is a broader theme in other papers that investigate banks' investment and financing decisions (Acharya, Schnabl, and Suarez, 2011; Acharya, Engle, and Pierret, 2014 and Boyson, Fahlenbrach, and Stulz, 2013).

Our paper is directly related to the literature on the relation between sovereign and bank risk. Battistini, Pagano, and Simonelli (2014) find that banks increase the home bias in their portfolios when systemic risk increases, which contributes to the segmentation of the eurozone sovereign bond market. Giannetti and Laeven (2013) provide evidence for home bias in syndicated lending practices following the global financial crisis. Crosigniani (2014) develops a model to show why governments leave their banking sector undercapitalized to ensure their future debt capacity. We show that the increase in home bias of GIIPS banks can be explained by moral hazard and the moral suasion of their governments.

Our paper relates more broadly to the literature on the effects of credit supply on the sovereign debt crisis (Popov and van Horen, 2014; Acharya, Eisert, Eufinger, and Hirsch, 2014; Becker and Ivashina, 2014a, 2014b; De Marco, 2014). While we focus on banks' incentives to increase sovereign bond exposures, in the conclusion of our paper, we also present evidence consistent with a crowding out of corporate lending providing a channel how the sovereign debt crisis affects the real sector.

The paper proceeds as follows. In Section 2, we explain the data sources and some descriptive statistics. In Section 3, we provide portfolio-level evidence on sovereign bond exposures. In Section 4, we discuss our carry trade exposure estimates from multifactor models and various robustness tests to demonstrate their validity. In Section 5, we relate our carry trade estimates to bond holdings as reported by the EBA and measures of short-term funding risk. In Section 6, we explore bank incentives for carry trades. We present concluding remarks in Section 7.

2. Data and descriptive statistics

This section describes our data set and provides summary statistics related to sovereign bond holdings of European banks and bank characteristics.

2.1. Data sources

To investigate banks' carry trade behavior, we construct a data set containing all public European banks included in the EBA stress tests.[11] The EBA has been responsible for stress tests and capitalization exercises that have been conducted in the European banking market since 2010, covering more than 60% of total EU banking assets. The results of these tests together with detailed information about banks' sovereign bond holdings were published for the following reporting dates: March 2010, December 2010, September 2011, December 2011, and June 2012. Our sample has banks from 19 EU countries, 13 eurozone countries, and 6 non-eurozone EU countries.

We collect daily market data (such as bank stock prices, bank and sovereign CDS spreads, and ten-year benchmark government bond yields) from Bloomberg. We also collect financial information such as size, short-term funding, and capitalization from SNL Financial and company reports. Stock returns and balance sheet characteristics are reported in euros. We collect monthly information from the iMoneyNet database about the holdings of US MMFs in European banks' commercial paper and repurchase agreements (repos). As a consequence of the recent financial crisis, MMFs have to report monthly mark-to-market net asset value (NAV) per share of their portfolios on Form N-MFP since October 2010.

2.2. Summary statistics

In Table 1, we provide descriptive statistics for the returns of GIIPS sovereign bonds and as German ten-year government bonds. Panel A shows mean daily bond returns during the 2007–2013 period. Greek government bonds have the highest negative return and the highest variance, followed by Portugal and Ireland. All three countries were bailed out by the European Commission (EC), the International Monetary Fund (IMF), and the ECB.[12] Germany exhibits positive daily returns with a small variance.

Panel B (Panel C) of Table 1 reports bond return correlations between 2001 and 2006 (2007 and 2013). In the 2001–2007 period, bond returns are almost perfectly correlated. This demonstrates that investors perceived these countries as being almost identical despite their major economic differences. The government bond returns in Greece and Germany, for example, had a correlation of 0.99. This changed significantly as the sovereign debt crisis unfolded. Between 2007 and 2013, the bond return correlation among the GIIPS countries declined, while the correlation between GIIPS and German bond returns became negative, which shows the divergence within the eurozone and the flight-to-quality.[13]

Panel A of Table A3 lists the averages of key variables for each bank. *Log-Assets* is the natural logarithm of total book assets. *ST-LVG* is short-term debt divided by total debt. *RWA/Assets* is risk-weighted assets divided by book assets. *Tier 1* is the Tier 1 capital divided by *RWA*. $\Delta MMF/Assets$ is the monthly withdrawal by US MMF scaled by book assets. On average, 33% of the total debt is short-term debt and banks have a Tier 1 ratio of 10.15%. Panel B of

[10] The theoretical literature supports the interpretation as to agency costs (e.g., Jensen and Meckling, 1976; Furlong and Keeley, 1987, 1989; Keeley, 1990; Hellman, Murdock, and Stiglitz, 2000).

[11] Table A2 includes a list of these banks. We exclude four banks either because of data availability or because the bank is part of a banking group of which the parent owns the vast majority of stocks. These are Raiffeisenbank International AG, Österreichische Volksbanken AG, Hypo Real Estate, and Irish Life and Permanent.

[11] Greece entered the bailout program in May 2010; Ireland and Portugal in February and June 2011, respectively.

[13] We further explore the time series characteristics of GIIPS bond yields. The time series are non stationary but first differences are. GIIPS bond yields are thus integrated of the order of 1 [I(1)]. We test the co-integration relation between, for example, Italian government bond and German government bond yields and find no co-integrating relation in the period starting in the fourth quarter of 2009.

Table 1
Descriptive statistics on return correlations.
Panel A of Table 1 contains descriptive statistics of daily returns for the January 2007 to June 2013 period. Panel B shows correlations of ten-year sovereign bond returns in Greece, Italy, Portugal, Spain, Ireland, and Germany during the January 2001–December 2006 period and Panel C during the January 2007–June 2013 period.

Panel A: Descriptive statistics of daily sovereign bond returns (bps)

Country	Mean	Standard deviation	Minimum	50th percentile	Maximum
Greece	−3.28	441.98	−2,449.13	−3.82	14,220.73
Italy	−0.08	73.88	−445.76	0.00	755.06
Portugal	−1.36	150.59	−1,868.39	−1.77	1,549.32
Spain	−0.34	80.01	−404.87	−0.47	837.14
Ireland	−0.07	93.50	−672.63	0.57	976.10
Germany	1.38	49.60	−224.44	0.97	252.22

Panel B: Sovereign bond return correlations (2001–2006)

	Greece	Italy	Portugal	Spain	Ireland	Germany
Greece	1.00					
Italy	1.00	1.00				
Portugal	0.97	0.96	1.00			
Spain	1.00	1.00	0.97	1.00		
Ireland	0.99	0.99	0.97	0.99	1.00	
Germany	0.99	0.99	0.97	0.99	0.99	1.00

Panel C: Sovereign bond return correlations (2007–2013)

	Greece	Italy	Portugal	Spain	Ireland	Germany
Greece	1.00					
Italy	0.66	1.00				
Portugal	0.95	0.78	1.00			
Spain	0.82	0.80	0.84	1.00		
Ireland	0.69	0.53	0.76	0.59	1.00	
Germany	−0.82	−0.35	−0.68	−0.58	−0.29	1.00

Table A3 reports the bond holdings of GIIPS banks versus non-GIIPS banks. Sovereign bonds correspond to 8.69% (1.2%) of total assets of GIIPS (non-GIIPS) banks and domestic sovereign bonds account for 83.9% (50.97%) of GIIPS (non-GIIPS) banks' sovereign bond portfolios. Panel C of Table A3 provides time series characteristics of banks' stock returns and CDS prices observed on a daily basis. The average daily realized return is −8.75 basis points (bps) and the average five-year CDS spread is 113 bps.

3. How did banks manage their GIIPS exposures? Evidence from micro-level data

This section provides descriptive statistics of sovereign bond holdings of banks and univariate test to investigate banks' carry trade behavior and to disentangle the different hypotheses outlined above.

3.1. Descriptive statistics of sovereign bond holdings

To start our investigation, we exploit the micro-level data disclosed by the EBA. We use micro-level data of sovereign bond holdings by banks mainly because of data availability. Banks also have exposures through loans to both state-owned enterprises and the governments of peripheral countries. Our analysis thus understates the true level of the sovereign debt exposure of banks in the sample and, consequently, the extent to which carry trades took place.

Panel A of Table 2 reports European banks' exposures to GIIPS sovereign bonds, as well as German and French sovereign bonds at the five reporting dates for GIIPS banks and non-GIIPS (eurozone and non-eurozone EU) banks.

While European banks entered the sovereign debt crisis with a substantial exposure to peripheral sovereign debt, we observe an increase in GIIPS and non-GIIPS banks' exposure to Spanish, Italian, and, to some extent, Portuguese sovereign debt between March and December 2010, when yield spreads widened (see Fig. 1). Non-GIIPS banks increased their total exposure to Spanish sovereign debt more than GIIPS banks in absolute euro amounts. Thus, banks were not passively caught by the emergence of the sovereign debt crisis, and bond positions cannot be explained by bank inertia.

Table 2.1 in the Online Appendix shows that Irish and Portuguese sovereign bonds were largely purchased by domestic banks and that non-eurozone EU banks, in particular, reduced their exposures to Irish sovereign bonds in 2010. In fact, non domestic GIIPS banks even sold Irish and Portuguese debt to some extent. Thus, we observe a home bias with respect to those countries that were hit first by the sovereign debt crisis. These results indicate that carry trades were mainly focused on the largest peripheral economies (i.e., Italy and Spain).

Table 2 reports that GIIPS and non-GIIPS banks substantially reduced their exposures to GIIPS sovereign debt by 29% (45%) between January and December 2011. Non GIIPS banks almost entirely wrote-down their Greek sovereign bond positions due to the private sector

Table 2
Summary statistics of sovereign bond holdings of European banks.

This table reports summary statistics of sovereign bond holdings as reported by the European Banking Authority (EBA) for all publicly listed banks. Reporting dates are March 2010, December 2010, September 2011, December 2011, and June 2012. Panel A reports aggregated holdings in Greek, Italian, Portuguese, Spanish, and Irish sovereign bonds, as well as German and French sovereign bonds. We distinguish between non-GIIPS eurozone, non-eurozone European Union (EU) and GIIPS banks. Panel B reports changes in sovereign bond holdings between January and June 2012 at the country level. Changes are reported by bond maturity (≤ 3 years, >3 years). GIIPS = = Greece, Italy, Ireland, Portugal, and Spain.

Panel A: GIIPS Sovereign Bond Holdings (March 2010-June 2012, in € million)

Reporting Date	Greece	Italy	Portugal	Spain	Ireland	Germany and France
Non-GIIPS eurozone banks						
March 2010	24,509	75,600	7,767	13,417	2,477	142,389
December 2010	24,886	97,729	8,513	25,761	3,254	262,052
September 2011	20,231	72,521	7,360	18,771	2,814	233,920
December 2011	14,889	44,250	4,614	13,034	2,463	191,505
June 2012	1,595	47,445	2,886	12,099	2,024	205,736
Non-eurozone EU banks						
March 2010	4,874	12,077	2,808	6,544	6,610	105,082
December 2010	2,897	27,335	2,911	12,643	1,706	110,923
September 2011	1,538	23,814	1,902	7,869	993	120,679
December 2011	2,466	18,231	1,691	5,989	1,044	108,725
June 2012	77	15,285	1,662	5,525	917	109,244
GIIPS banks						
March 2010	60,570	154,635	14,144	148,627	6,201	33,862
December 2010	57,665	171,196	18,848	163,162	11,352	28,867
September 2011	2,747	164,082	19,021	147,459	10,775	29,480
December 2011	2,585	153,923	15,467	115,594	10,487	33,568
June 2012	146	189,508	20,544	127,847	11,938	29,410

Panel B. Changes in GIIPS Sovereign Bond Holdings (Jan–June 2012)

Country	GIIPS (€ million)		Italy (€ million)		Spain (€ million)	
	≤ 3 years	>3 years	≤ 3 years	>3 years	≤ 3 years	>3 years
Non-GIIPS eurozone banks						
Austria	−583	−10	−473	−4	−100	1
Belgium	−940	−555	−137	−232	−814	−189
Cyprus	−2,672	−2,116	30	−27	0	−5
Germany	−3,063	−283	−48	767	56	−588
France	492	−3,788	4,009	−881	345	231
Malta	−2	−2	0	0	0	0
Netherlands	−27	−95	230	−187	−319	142
Non-eurozone EU banks						
Denmark	137	130	158	151	−31	8
Hungary	0	0	0	0	0	0
Norway	0	0	0	0	0	0
Sweden	−27	−51	11	−6	−13	0
UK	−3,042	−3,101	−1,468	−1,791	−956	528
GIIPS banks						
Ireland	1,511	119	1	15	−30	0
Italy	27,355	7,261	**28,643**	**7,782**	−65	−271
Portugal	3,215	36	−1	65	−19	27
Spain	7,446	5,268	1,531	−2,450	**6,032**	**6,579**

involvement (PSI) in the first half of 2012. However, their exposures to the other peripheral countries remained largely unchanged.[14]

GIIPS banks (and Italian and Spanish banks, in particular) substantially increased their peripheral sovereign bond holdings during the first half of 2012, which is consistent with both the moral hazard and the moral suasion hypotheses (Panel B, Table 2). The majority of these bond purchases had maturities of three years or less. In December 2011 and February 2012, the ECB channeled €1 trillion into the banking system using non-standard monetary policy measures, namely, three-year LTROs at an initial interest rate of 1%. In other words, the ECB reduced the funding pressure and extended the carry trades of these banks.

3.2. Univariate tests

In this subsection, we examine which channels are at work. Initially, we compare the percentage changes in Italian, Spanish, Greek, and overall GIIPS sovereign bond holdings of domestic and nondomestic banks between the EBA reporting periods.

[14] We also observe an increase in exposure to non-peripheral (in particular, German and French) government debt during the March 2010–June 2012 period, which is driven by non-GIIPS banks and consistent with a flight-to-quality behavior.

Panel A of Table 3 shows that both domestic and nondomestic banks increased their exposure to Italian, Spanish, and GIIPS sovereign bonds between March and December 2010. In fact, non-Spanish banks even increased their exposure to Spanish bonds significantly more compared with Spanish banks (65 versus 23 percentage points). Exposures to Greek sovereign bonds meanwhile are substantially reduced across all European banks, particularly by non-Greek banks, suggesting that carry trades did not focus on Greek bonds.[15] During 2011, GIIPS sovereign bond exposure is significantly reduced by nondomestic banks relative to domestic banks. This process accelerated after the capital exercise of the EBA in September 2011. Between January and June 2012, nondomestic banks further reduced their peripheral sovereign exposures, whereas domestic GIIPS banks purchased a significant amount of their own sovereign bonds. This activity provides supportive evidence that the home bias of GIIPS banks substantially increased during the sovereign debt crisis.[16]

We also explore moral hazard incentives by undercapitalized banks by regressing changes in sovereign bond holdings on total assets on regulatory capital measures (*Tier 1* and *RWA/Assets* ratios). We interact these measures with indicator variables for GIIPS, non-GIIPS eurozone, and non-eurozone EU banks and report the slope coefficients in Panel B of Table 3. On average, European banks with lower *Tier 1* ratios increase their exposure to GIIPS sovereign bonds between March and December 2010, although the slope coefficients are not significantly different. GIIPS banks with high *RWA/Assets* ratios also increased sovereign bond exposures during the January to June 2012 period. Overall, banks with higher gambling and regulatory arbitrage incentives increase their exposure to GIIPS sovereign debt more relative to other banks.

Several European banks were bailed out by their governments, thereby increasing the influence of regulators over their domestic banks. In Panel C of Table 3, we differentiate between GIIPS (Italian and Spanish) banks that received or did not receive bailout funding (we call them "intervened" after they received funding). We compile data on government interventions using information disclosed on the official EU state-aid websites.[17] On average, intervened banks do not increase their exposure to GIIPS sovereign bonds relative to total assets more than non-intervened banks.[18]

4. Estimating banks' carry trade exposure using market data

In this section, we estimate banks' carry trade exposure using market data and provide a variety of robustness and falsification tests that corroborate our results. We exploit cross-sectional variation in bank characteristics and show that the results hold in subsamples of both GIIPS and non-GIIPS banks.

4.1. Methodology

Unfortunately, high-frequency micro-level data of sovereign bond positions are unavailable. Furthermore, banks could be exposed to sovereign bond risk other than through direct bond positions (e.g., through credit default swap positions or counterparty exposure in derivatives transactions with governments). Given this limitation and to link bank risk to both the investment and funding leg of the carry trade, we use market data to understand banks' carry trade behavior. We use multifactor models in which the sensitivities of banks' stock returns to sovereign bond returns measure their exposure to sovereign debt. To improve these models, we also link our exposure estimates to micro-level portfolio holdings and estimate the regression

$$R_{i,t} = \beta_{0,i} + \beta_{GIIPS,i} R_{GIIPS,t} + \beta_{Germany,i} R_{Germany,t} + \beta_{m,i} R_{m,t} + \sum \gamma Macro + \varepsilon_{i,t}, \quad (1)$$

where $R_{i,t}$ is bank *i*'s daily stock return and $R_{GIIPS,t}$ is the daily return on ten-year government bonds from Greece, Italy, Portugal, Spain, or Ireland. $R_{Germany,t}$ is the daily return on ten-year German government bonds, and $R_{m,t}$ is the daily return of the equity market index in country *m* in which the bank is headquartered. Because of the co-movement of $R_{m,t}$ and the sovereign bond returns of country *m* and Germany, we orthogonalize $R_{m,t}$ to both return series.[19] The ten-year German government bond is an additional risk factor in our model. We include a variety of other macroeconomic state variables (*Macro*) in the model to control for changes in macroeconomic fundamentals that could drive both stock and sovereign bond returns.[20]

[15] Greece effectively lost access to public bond markets in April 2010 when yields over German bunds tripled from 300 bps to 900 bps. About €200 billion of Greek sovereign debt was restructured in March - April 2012 in a debt swap resulting in substantial losses for private investors (private sector involvement).

[16] GIIPS banks simultaneously decreased their German and French sovereign bond holdings in 2010, which indicates that they used the proceeds to finance the purchase of their own sovereign debt. While GIIPS banks decreased German bunds in the first half of 2012, they increased their French government bonds holdings, whose yields substantially increased beginning in late 2011. These results are available upon request.

[17] The data can be obtained here: ⟨http://ec.europa.eu/competition/elojade/isef/index.cfm?clear=1&policy_area_id=3⟩.

[18] Table A2 indicates whether a bank has been bailed out. Unfortunately, we cannot further differentiate between countries as all Greek, Irish, and Portuguese banks in our sample had been bailed out at that time.

[19] Our empirical approach includes all banks as described in Section 2. They are not dropped from the sample if they become delisted due to a merger or because they become insolvent. As long as their equity is actively traded, we estimate their carry trade exposures. Our methodology, therefore, does not suffer from a survivorship bias.

[20] The macroeconomic variables are *VSTOXX*, the change in the volatility index of the European stock market; *TermStructure*, measured as the difference between the yield on a 10-year euro area government bond and the one-month Euribor; *BondDefSpread*, the difference between the yield on 10-year German BBB bonds and yields on 10-year German government debt; *1mEuribor*, the one-month Euribor; Δ*ESI*, the monthly change in the economic sentiment indicator; Δ*IntProd*, the monthly change in the level of industrial production; Δ*CPI*, the change in the rate of inflation measured as the monthly change in the European consumer price index; and Δ*FX-Rate*, the change in the effective exchange rate of the euro, which should pick up any exchange rate effect with respect to

Table 3
Univariate analysis of sovereign exposures using micro-level sovereign bond holding data.

This table provides changes in bond holdings over the four stress tests conducted by the European Banking Authority (EBA). The time periods are March to December 2010, January to September 2011, October to December 2011, and January to June 2012. Panel A reports the percentage change in holdings in Italian, Spanish, Greek, and GIIPS sovereign bonds for domestic versus non-domestic banks. Panel B reports the results regressing the change of GIIPS sovereign bond holdings over total assets on the interaction terms of Tier 1 (RWA/Assets) ratios and indicator variables for GIIPS, non-GIIPS eurozone and non-eurozone European Union (EU) banks. These indicators are also included separately as well as an intercept but the coefficients are not reported. Panel C reports changes in Italian, Spanish, and GIIPS sovereign bond holdings over total assets. We distinguish between banks that have been bailed out during or after the 2007–2009 financial crisis (we call these banks "intervened") and those who were not bailed out. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively. GIIPS = =Greece, Italy, Ireland, Portugal, and Spain.

Panel A: Changes in GIIPS sovereign bond holdings (domestic versus non-domestic banks, in percent)

Time Indicator	Italian sovereign bonds; Italian Bank		Spanish sovereign bonds; Spanish Bank		Greek sovereign bonds; Greek Bank		GIIPS sovereign bonds; GIIPS Bank	
	No	Yes	No	Yes	No	Yes	No	Yes
March–Dec 2010	26.7	29.4	65.3*	23.1	−20.7**	−0.1	10.1	35.8
Jan–Sept 2011	1.9	−8.4	−21.6*	9.1	−24.8	NA	−20.9***	2.2
Oct–Dec 2011	−24.1*	0.5	−14.5	−2.4	−12.5	NA	−25***	−5.0
Jan–June 2012	−3.1**	37.4	−23.9**	22.0	−60.0	NA	−8.5***	29.2

Panel B: Changes in GIIPS sovereign bond holdings by regulatory ratios (univariate tests)

	Dependent variable: *ΔGIIPS Holdings/Assets*			
Regulatory Ratio	March–Dec 2010	Jan–Sept 2011	Oct–Dec 2011	Jan–June 2012
Tier 1 × GIIPS	−0.168***	0.084	0.009	−0.082
Tier 1 × Non-GIIPS Eurozone Banks	−0.227***	0.052	0.022	−0.255**
Tier 1 × Non-Eurozone EU Banks	−0.179***	0.044	0.021	−0.195*
N	46	43	40	40
R^2	21.53%	4.83%	2.47%	32.36%
RWA/Assets × GIIPS	0.018**	0.007	0.000	0.041***
RWA/Assets × Non-GIIPS Eurozone Banks	0.002	0.004	0.004**	0.003
RWA/Assets × Non-Eurozone EU Banks	−0.000	0.008**	0.005**	0.005
N	46	43	40	40
R^2	17.15%	4.46%	3.27%	41.12%

Panel C: Changes in GIIPS sovereign bond holdings (intervened versus non-intervened domestic banks)

	Dependent Variable: *ΔGIIPS Holdings/Assets*					
	Italy		Spain		GIIPS	
Time indicator	Italian Banks		Spanish Banks		GIIPS Banks	
	Not Intervened	Intervened	Not Intervened	Intervened	Not Intervened	Intervened
March–Dec 2010	0.293	0.295	0.224	0.364	0.245	1.161
Jan–Sept 2011	−0.091	−0.073	0.068	0.161	−0.004	0.042
Oct–Dec 2011	−0.052	0.089	−0.017	−0.037	−0.042	−0.055
Jan–June 2012	0.553	0.101	0.078	0.504	0.358	0.250

The estimate of $\beta_{GIIPS,i}$ provides an unbiased estimate of the exposure of bank *i* to GIIPS sovereign debt. A positive factor loading indicates that banks are long long-term peripheral government bonds. $\beta_{Germany,i}$ is an estimate of bank *i*'s short-term funding exposure. The negative factor loading indicates that banks are short long-term German bonds. This reflects a flight to quality of investors who purchase long-term safe (German) government bonds, simultaneously reducing the supply of short-term capital. If long-term bond prices appreciate whenever short-term funding evaporates and banks are exposed to short-term funding, then it appears as if banks were short long-term German bonds. $\beta_{GIIPS,i} > 0$ and $\beta_{Germany,i} < 0$ are consistent with a carry trade behavior by European banks. They appear to have invested in long-term government bonds financed in the short-term wholesale market to maximize the carry between both legs of the trade.

Panel A of Table 4 provides descriptive statistics of the estimated carry trade exposures. We estimate the factor loadings for each quarter and compute unweighted means across banks. The factor loadings of peripheral bonds indicate that European banks had, on average, substantial exposure to the periphery. The large negative loading of German bunds indicates the funding pressure on banks during our sample period due to a flight to quality of

(*footnote continued*)
the euro and currencies in the EU (Battistini et al., 2014). The last variable is designed to capture possible concerns for the stability of the eurozone.

investors. The pre-2007 carry trade estimates show that the exposure estimates were close to zero and sometimes even small and negative before the yield spreads widened in mid-2008.

4.2. Carry trade behavior of European banks

We estimate (1) using pooled ordinary least squares regressions with country fixed effects. We cluster standard errors at two dimensions, bank and quarter, to account for (unobserved but time-variant) variation that is both bank specific in different quarters and common across all banks in the same quarter. The results are reported in Panel B of Table 4. The estimated values of β_{GIIPS} and $\beta_{Germany}$ represent the cross-sectional averages of European banks' carry trade exposure. We analyze the sensitivity of banks' equity to sovereign bond returns using all GIIPS bonds collectively (Model 1). The factor loadings are positive and show, on average, that exposures are largest with respect to Italian government debt. These loadings are (when employed individually) also positive and similar in magnitude (not reported). The R-squared of the model shows that a substantial proportion of the variation in stock returns is explained by these covariates. $\beta_{Germany}$ is negative and large in magnitude, which indicates banks' funding pressure is caused by their exposure to short-term debt.

Model 2 in Table 4 uses a gross domestic product weighted GIIPS Sovereign Bond Index as a measure of banks' exposure to peripheral debt, which is a comprehensive measure of banks' overall exposure to peripheral sovereign debt. We perform robustness tests to support our results. We first construct an index of bond returns using the daily average returns of sovereign bonds from euro area members other than GIIPS countries or Germany or France (*Bond Index*). If banks invested in GIIPS government debt to exploit the highest-yielding sovereign investments, their stock returns should be less sensitive to the return of this index. Model 3 includes *Bond Index* as separate control variable and, as expected, its coefficient is not statistically significant.

The sovereign debt market is characterized by a high degree of collinearity, as shown in Table 1. Principal component analysis (PCA) is a statistical procedure we use to construct different linear combinations of the factor returns that are uncorrelated with each other using the covariance matrix of the returns. We regress the banks' stock return on the first principal component (PC1) and Germany, and we find a positive and significant relation between PC1 and stock returns (Model 4), which is consistent with a carry trade behavior by European banks.

In Model 5 in Table 4, we substitute French for German government bonds and find a negative and significant value for γ_{France}, which is smaller in magnitude compared to the factor loadings of German bunds. This reflects the increasing divergence of yields between French and German government debt that started in 2011. The coefficients of Greece and Italy are even stronger. In Model 6, we include the Fama and French factors, small minus big (*SMB*) and high minus low *(HML)*, however, the results remain unchanged.

Carry trade exposure should also be reflected in CDS spreads as an important proxy for bank risk and funding costs. We expect to see that CDS spreads reflect a widening of the gap between GIIPS bond and German bund yields, either through an increase in peripheral bond yields or if funding conditions deteriorate. We test this in Models 7 and 8 in Table 4 and use ΔLog (*Bank CDS*) as a dependent variable, which is the change in the natural logarithm of daily bank CDS spreads. Overall, we find strong evidence consistent with carry trade behavior by European banks.[21]

4.3. Subsamples of GIIPS versus non-GIIPS banks

An alternative explanation of our results is an intensification of weak sovereign bank linkages, i.e., banks become weaker when their sovereigns become weaker, which could explain the positive factor loadings on GIIPS sovereign debt. If sovereign risk causes GIIPS banks to be weaker, then non-GIIPS (eurozone and non-eurozone EU) banks should get stronger under the alternative explanation and not get affected in the same manner as GIIPS banks. We test this by splitting our sample into subsamples of GIIPS, non-GIIPS eurozone, German and French, and non-eurozone EU banks.

In Panel A of Table 5, we estimate banks' exposure using the GIIPS Sovereign Bond Index. GIIPS banks have large exposures as expected. But we also identify large and significant exposures of non-GIIPS eurozone and non-eurozone EU banks to peripheral sovereign bonds, which indicates that an intensification of weak sovereign bank linkages is likely not driving our results. Moreover and importantly, non-eurozone EU banks' exposures cannot be explained by home bias or moral suasion, lending support to the moral hazard hypothesis. Similarly, European banks are vulnerable to a flight-to-quality as the sensitivity of their equity returns to changes in German bund returns indicates.

4.4. Falsification tests

We conduct a variety of falsification tests as European banks have different incentives to load up on peripheral sovereign debt compared with, for example, US banks, which have to hold capital against investments in peripheral sovereign debt. Banks in the US were also systematically recapitalized after the US mortgage crisis, whereas European banks are still undercapitalized based on various standards (such as leverage ratios). In addition, US banks cannot use sovereign debt as collateral for liquidity to the same extent as European banks. We thus expect to find smaller estimates on similar tests using US banks. We further investigate returns of hedge funds and industrial

[21] We perform further tests that remain unreported for brevity. We use bond yield changes instead of bond returns. We also construct an equally weighted portfolio of bank stocks from our sample and estimate a time series regression. In separate tests, we exclude broker-dealer banks. These banks could have larger portfolios due to this specific function (Duffie, 2011). Lastly, we use weekly (instead of daily) stock returns. In all tests, our results from Table 4 remain qualitatively unchanged.

firms, which, unlike banks, do not have similar gambling or regulatory capital arbitrage incentives.

We run tests with the following index returns as dependent variables: a value-weighted index of all EBA banks in our sample; a value-weighted index of the one hundred largest U.S. banks based on market values; the HFRX Macro Hedge Fund Index; an equally weighted industrial index formed from the underlying MSCI industrial indices from Italy, Spain, and Portugal (MSCI GIIPS); the MSCI Industrial Germany Index; an equally weighted index of the most important countries in Europe other than Germany and the periphery (France, Netherlands, Norway,

Table 4
Carry trade exposure.

Panel A summary statistics of our carry trade estimates, $\hat{\beta}_{GIIPS}$, $\hat{\beta}_{Italy}$, $\hat{\beta}_{Spain}$, and $\hat{\beta}_{Germany}$. We measure the factor loadings on a quarterly basis for each bank for the January 2007–June 2013 and pre-2007 periods and compute unweighted means. Panel B contains the results of a pooled ordinary least squares regression of daily stock returns of publicly listed banks that participated in the European Banking Authority (EBA) stress tests on sovereign bond returns during the January 2007–June 2013 period. Model 1 is the baseline model from (1). Model 2 uses a value-weighted GIIPS sovereign bond index. Model 3 includes *BondIndex*, the daily average return of sovereign bonds from Euro area members other than GIIPS countries or Germany or France. Model 4 reports the results of a principal component analysis (*PCA*); Model 5 uses French bond returns as the funding leg of the carry trade; Model 6 includes Fama-French factors (*SMB, HML*). Models 7 and 8 report the results of the cross-sectional analyses of bank CDS spread changes on GIIPS bond returns. The dependent variable in both models is ΔLog (Bank CDS). All models include various macro variables: (1) *VSTOXX* is the return of the VSTOXX Index; (2) *TermStructure* is measured as the difference between the yield on a 10-year euro area government bond and the one-month Euribor; (3) *BondDefSpread* is the difference between the yield on ten-year German BBB bonds and yields on ten-year German government debt; (4) *1mEuribor* is measured as the one-month Euribor; (5) Δ*ESI* is the monthly change in the European economic sentiment indicator; (6) Δ*IndProd* is the monthly change in the level of industrial production; (7) Δ*CPI* is the change in inflation measured as the monthly change in the European Consumer Price Index; and (8) Δ*FX-Rate* is the change in the effective exchange rate of the euro. All regressions include country fixed effects. Standard errors are clustered at bank and quarter level. *t*-Statistics are given in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Summary statistics of factor loadings and bond holdings

2007–2013	Number of observations	Mean	Standard deviations	Minimum	50th percentile	Maximum
Non-GIIPS eurozone banks						
$\hat{\beta}_{Italy}$	439	1.67	2.44	−10.13	1.07	16.35
$\hat{\beta}_{Spain}$	439	1.45	1.96	−5.59	1.05	13.43
$\hat{\beta}_{GIIPS}$	439	1.45	2.58	−5.45	0.84	15.08
$\hat{\beta}_{Germany}$	439	−2.57	2.47	−16.33	−2.32	7.61
Non-eurozone EU banks						
$\hat{\beta}_{Italy}$	382	1.66	2.36	−6.45	0.85	12.80
$\hat{\beta}_{Spain}$	382	1.37	1.83	−2.77	0.76	10.33
$\hat{\beta}_{GIIPS}$	382	1.36	2.38	−7.75	0.63	13.33
$\hat{\beta}_{Germany}$	382	−2.66	2.24	−12.74	−2.09	2.61
GIIPS banks						
$\hat{\beta}_{Italy}$	570	1.76	2.42	−13.14	1.28	19.35
$\hat{\beta}_{Spain}$	570	1.50	1.95	−10.84	1.19	16.42
$\hat{\beta}_{GIIPS}$	570	1.58	2.67	−9.26	0.96	21.68
$\hat{\beta}_{Germany}$	570	−2.56	2.42	−21.56	−2.37	10.11
Pre 2007						
Non-GIIPS Eurozone Banks						
$\hat{\beta}_{Italy}$	234	−0.18	5.87	−15.34	1.65	9.66
$\hat{\beta}_{Spain}$	234	0.43	3.89	−11.42	0.32	16.67
$\hat{\beta}_{GIIPS}$	234	−1.19	7.10	−35.67	−0.06	24.02
$\hat{\beta}_{Germany}$	234	−1.02	4.02	−17.43	−0.81	10.45
Non-Eurozone EU Banks						
$\hat{\beta}_{Italy}$	214	−0.47	5.68	−15.91	0.83	12.06
$\hat{\beta}_{Spain}$	214	0.20	3.92	−11.99	0.43	21.26
$\hat{\beta}_{GIIPS}$	214	−0.84	7.31	−27.26	−0.17	37.80
$\hat{\beta}_{Germany}$	214	−0.77	3.94	−19.79	−0.56	11.66
GIIPS banks						
$\hat{\beta}_{Italy}$	321	0.66	7.80	−49.37	1.56	14.64
$\hat{\beta}_{Spain}$	321	0.38	3.78	−25.37	0.25	17.00
$\hat{\beta}_{GIIPS}$	321	−0.83	8.31	−116.30	−0.05	24.23
$\hat{\beta}_{Germany}$	321	−0.85	3.77	−16.87	−0.70	20.98

Panel B: Banks' carry trade behavior estimates

Variables	Baseline model	GIIPS sovereign bond index	Bond index	PCA	Funding leg	Fama and French factors	CDS Five-year	CDS Five-year PCA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\hat{\beta}_{Greece}$	0.019**		0.018**		0.018*	0.018**	−0.128***	
	(2.40)		(2.38)		(1.67)	(2.42)	(−3.38)	
$\hat{\beta}_{Spain}$	0.213**		0.195**		0.615***	0.209**	−0.056	
	(2.57)		(2.55)		(5.28)	(2.52)	(−0.38)	
$\hat{\beta}_{Portugal}$	0.021*		0.022*		0.008	0.022**	−0.089	
	(1.91)		(1.87)		(0.33)	(2.12)	(−1.72)	
$\hat{\beta}_{Spain}$	0.028		0.019		0.016	0.027	−0.213	
	(0.58)		(0.38)		(0.20)	(0.53)	(−1.52)	
$\hat{\beta}_{Ireland}$	0.120***		0.113***		0.090	0.114***	−0.231**	
	(3.38)		(3.13)		(1.39)	(3.39)	(−2.03)	
$\hat{\beta}_{GIIPS}$		0.357***						
		(8.50)						
$\hat{\beta}_{Germany}$	−2.291***	−2.278***	−2.426***	−2.293***		−2.280***	2.347***	2.386***
	(−21.78)	(−21.80)	(−16.95)	(−21.39)		(−21.70)	(5.10)	(4.71)
$\hat{\beta}_{m}$	1.424***	1.426***	1.422***	1.425***	1.329***	1.420***	−0.554***	−0.559***
	(17.14)	(17.04)	(16.92)	(17.19)	(16.69)	(17.28)	(−5.45)	(−5.60)
$\hat{\gamma}_{VSTOXX}$	0.097***	0.098***	0.102***	0.096***	−0.046	0.095***	0.002***	0.002***
	(3.96)	(4.00)	(4.16)	(4.02)	(−0.73)	(3.85)	(3.86)	(3.82)
$\hat{\gamma}_{\Delta TermStructure}$	0.057	0.054	0.055	0.053	0.036	0.114**	0.002	0.002
	(1.34)	(1.19)	(1.28)	(1.19)	(0.81)	(2.57)	(0.56)	(0.60)
$\hat{\gamma}_{BondDefSpead}$	−0.006	−0.006	−0.008	−0.005	−0.010	−0.020	−0.001	−0.001
	(−0.22)	(−0.18)	(−0.29)	(−0.19)	(−0.28)	(−0.82)	(−0.83)	(−0.84)
$\hat{\gamma}_{1mEuribor}$	0.069*	0.065	0.069*	0.066	0.053	0.104***	0.003	0.003
	(1.74)	(1.56)	(1.73)	(1.60)	(1.24)	(2.88)	(0.97)	(0.98)
$\hat{\gamma}_{\Delta ESI}$	0.039***	0.038***	0.038***	0.040***	0.049***	0.018	−0.000	−0.000
	(3.33)	(3.21)	(3.36)	(3.42)	(3.19)	(1.50)	(−0.76)	(−0.93)
$\hat{\gamma}_{\Delta IndProd}$	0.001	0.002	−0.001	0.002	0.006	0.005	0.000	0.000
	(0.06)	(0.07)	(−0.03)	(0.10)	(0.20)	(0.25)	(0.42)	(0.40)
$\hat{\gamma}_{\Delta CPI}$	−0.066	−0.062	−0.063	−0.065	−0.001	−0.116	0.002	0.002
	(−0.66)	(−0.62)	(−0.63)	(−0.65)	(−0.01)	(−1.36)	(0.39)	(0.40)
$\hat{\gamma}_{\Delta FX-Rate}$	−0.000	0.000	−0.000	−0.000	0.001	−0.000	−0.006***	−0.006***
	(−0.06)	(0.02)	(−0.07)	(−0.06)	(0.66)	(−0.25)	(−3.81)	(−3.95)
$\hat{\gamma}_{BondIndex}$			0.246					
			(1.46)					
$\hat{\gamma}_{PCA}$				0.001***				−0.003***
				(9.02)				(−3.53)
$\hat{\gamma}_{France}$					−1.752***			
					(−6.49)			
$\hat{\gamma}_{SMB}$						0.002		
						(0.18)		
$\hat{\gamma}_{HML}$						0.043***		
						(5.21)		
$\hat{\beta}_{0}$	−0.002	−0.002	−0.002	−0.002	−0.001	−0.004***		
	(−1.43)	(−1.27)	(−1.39)	(−1.29)	(−0.90)	(−2.63)	(−0.49)	(−0.51)
N	72,871	72,871	72,871	72,871	72,871	72,871	28,047	28,047
R^2	43.38%	43.32%	43.33%	43.26%	39.64%	43.37%	14.15%	13.91%

Denmark, and Sweden); and the MSCI Industrial UK Index[22] Panel B of Table 5 reports the results. As market return, we include the Euro Stoxx 600 Index for European indices, the Standard & Poor's 500 index for the US banks, and the MSCI World for the HFRX Macro Hedge Fund Index. Model 1 shows the time series estimates for all EBA banks, which reflect our earlier cross-sectional results. We do not find that U.S. banks have statistically significant exposure to peripheral sovereign banks (Model 2). Moreover, the value of $\beta_{Germany}$ is much smaller, which indicates a lower funding exposure. The results in Model 3 are intriguing and show that macro hedge funds are long German bunds, thus effectively taking opposite positions compared with European banks.[23] Models 4–7 show sensitivities of country-specific industry indices to GIIPS and German

[22] We exclude Ireland and Greece from the equally weighted industrial index formed from the underlying MSCI industrial indices from Italy, Spain and Portugal due to missing data in their respective industrial indices.

[23] In unreported results, we find that hedge funds are short Italy sovereign bonds. Thus, they effectively bet against the country.

Table 5
Robustness tests.

Panel A contains the results of a pooled ordinary least squares regression of banks' stock returns on the return of a value-weighted GIIPS (Greece, Italy, Ireland, Portugal, and Spain) Sovereign Bond Index and 10-year German bund returns for the January 2007–June 2013 period. We use the following subsamples: all GIIPS banks, all non-GIIPS, eurozone banks, German and French banks, and non-eurozone European Union (EU) banks. All regressions include ten-year German bond returns as the "funding leg" of the carry trade. All regressions further include *VSTOXX*, *TermStructure*, *BondDefSpread*, *1mEuribor*, *ΔESI*, *ΔIndProd*, *ΔCPI*, and *ΔFX-Rate*. All regressions include country fixed effects. *t*-statistics are in parentheses. Standard errors are clustered at bank and quarter level. Panel B reports the results from OLS regressions of daily returns on a value-weighted index of European Banking Authority (EBA) banks, US banks, macro hedge funds (HFRX Macro), and various country-specific industrial indices for the 2007 to June 2013 period. There are: MSCI GIIPS, which is an equally-weighted index formed from the underlying indices for Italy, Spain, and Portugal, MSCI Germany, MSCI Non-GIIPS, which is an equally weighted index of the most important countries in Europe other than Germany or the periphery (France, Netherlands, Norway, Denmark, and Sweden), and MSCI UK. As market return, we include the Euro Stoxx 600 Index (*STOXX 600*) for European indices, the Standard & Poor's 500 (*S&P500*) for the US index and MSCI World for the HFRX Macro Hedge Fund index. The inference variables are the return of a value-weighted GIIPS Sovereign Bond Index and ten-year German bund returns. All regressions include ten-year German bond returns as the "funding leg" of the carry trade. All regressions further include *VSTOXX*, *TermStructure*, *BondDefSpread*, *1mEuribor*, *ΔESI*, *ΔIndProd*, *ΔCPI* and *ΔFX-Rate*. The Newey and West standard errors are adjusted for heteroscedasticity and autocorrelation using eight lags. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Subsamples: GIIPS versus non-GIIPS banks

Variables	GIIPS banks (1)	Non-GIIPS eurozone banks (2)	German and French banks (3)	Non-eurozone EU banks (4)
$\hat{\beta}_{GIIPS}$	0.425***	0.413***	0.383***	0.174***
	(6.25)	(6.64)	(4.49)	(2.64)
$\hat{\beta}_{Germany}$	−2.229***	−2.480***	−2.205***	−2.064***
	(−15.29)	(−11.33)	(−6.53)	(−14.56)
$\hat{\beta}_m$	1.488***	1.422***	1.160***	1.233***
	(15.00)	(8.75)	(5.80)	(12.36)
$\hat{\beta}_0$	−0.006***	−0.004**	−0.000	0.000
	(−2.82)	(−2.03)	(−0.22)	(0.34)
N	33.329	16.866	9186	22676
R^2	43.33%	43.11%	46.09%	45.55%

Panel B: Falsification Tests

Variables	European banks (1)	US banks (2)	HFRX Macro (3)	MSCI GIIPS (4)	MSCI Germany (5)	MSCI Non GIIPS (6)	MSCI UK (7)
$\hat{\beta}_{GIIPS}$	0.340***	−0.063	0.007	0.014	−0.041	0.025	0.003
	(6.51)	(−1.33)	(0.36)	(0.26)	(−0.66)	(0.66)	(0.06)
$\hat{\beta}_{Germany}$	−2.416***	−1.911***	0.087***	0.004	−0.085	−0.002	0.042
	(−31.31)	(−18.25)	(2.75)	(0.06)	(−0.66)	(−0.03)	(0.48)
$\hat{\beta}_m$	1.409***	1.644***	0.004	0.006	0.038	0.304***	0.003
	(21.99)	(13.69)	(0.37)	(0.24)	(0.75)	(10.42)	(0.06)
$\hat{\beta}_0$	−0.000	0.000	−0.000	−0.000	0.000	−0.000	0.000
	(−1.37)	(0.12)	(−0.73)	(−0.70)	(0.45)	(−0.94)	(0.67)
N	1,591	1,523	1,523	1,591	1,591	1,591	1,591
R^2	77.95%	65.83%	0.56%	0.11%	0.15%	12.80%	0.03%

sovereign debt. Overall, the betas are close to zero and insignificant.

5. Factor loadings, sovereign bond holdings, and liquidity risk

In this section, we relate our factor loading estimates to sovereign bond holdings and withdrawals of US money market funds as a measure of funding risk.

5.1. Relating factor loadings to micro-level holding data

Do our factor loadings relate to actual government bond holdings of banks or simply reflect some other underlying economic exposures and linkages? If $\hat{\beta}_{GIIPS}$ reflects higher exposure to GIIPS sovereign bonds, we would expect to find higher $\hat{\beta}_{GIIPS}$ if banks have higher reported holdings. In Panel A of Fig. 2 we plot the factor loadings against average GIIPS holdings (measured between the EBA reporting dates as the sum of the exposures to all peripheral sovereigns) scaled by total assets for GIIPS and non-GIIPS banks. Overall, a positive relation exists between the factor loadings and portfolio holdings.[24]

Non-GIIPS banks could also be affected through contagion because of real sector exposures. We use European banks' real sector exposure as of December 2010, along with sovereign bonds holdings by the EBA in July 2011, and show that direct sovereign bond holdings, not real sector exposure, explain our factor loadings. We report the results in Panels C and D of Appendix Table 4 in the Online Appendix.

[24] We plot these relation between each EBA stress date and show the results in the Online Appendix.

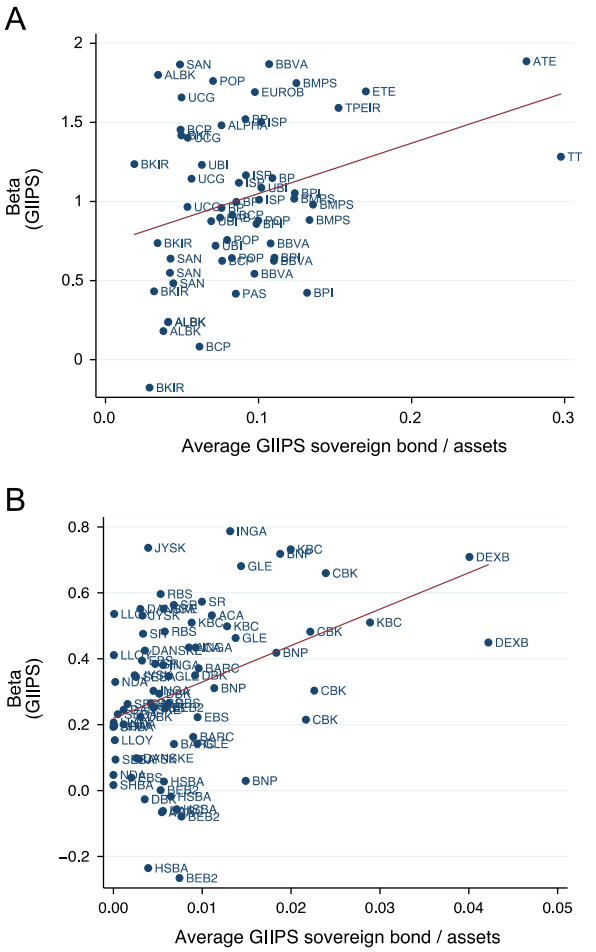

Fig. 2. Factor loadings and bond portfolio holdings. This figure is a scatterplot of the estimated loadings on GIIPS (Greece, Italy, Ireland, Portugal, and Spain) sovereign bonds over the March 2010–June 2012 period on average GIIPS sovereign bond holdings scaled by lagged total assets. Panel A shows this for GIIPS banks and Panel B shows this for non-GIIPS banks. The figure shows ticker symbols of each bank which are defined in Table A2. Panel A: GIIPS Banks. Panel B: Non-GIIPS Banks.

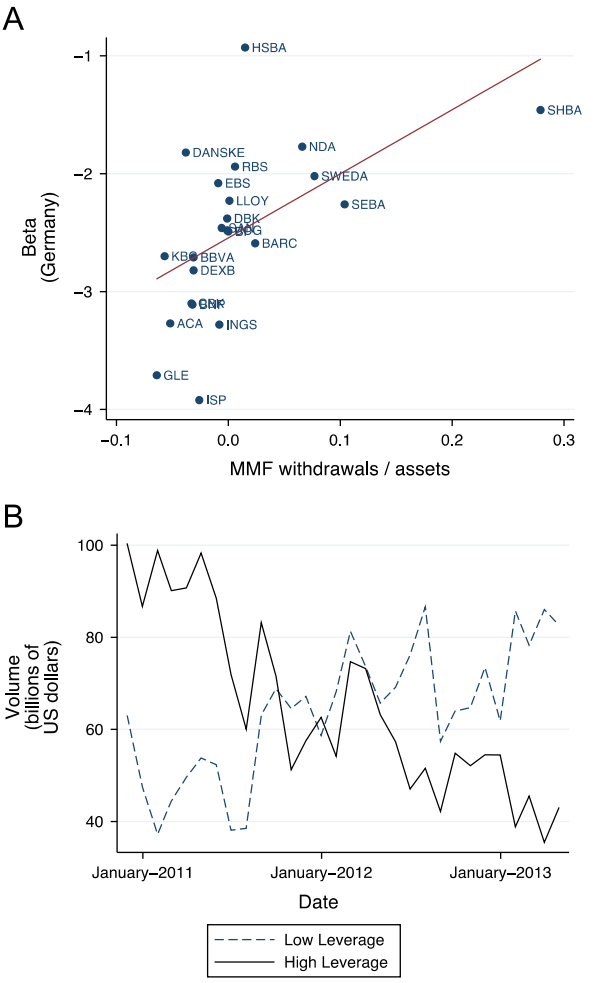

Fig. 3. Cross-sectional differences. Panel A shows $\hat{\beta}_{Germany,i}$ as measured during 2011 plotted against US money market fund (MMF) withdrawals scaled by total assets. The figure shows ticker symbols of each bank which are defined in Table A2. Panel B shows the investments of US MMFs in European banks for well-capitalized banks (low leverage) and weakly capitalized banks (high leverage). We use the firm's market leverage (market LVG) as a measure of bank capitalization. Market LVG is defined as (total assets–book equity+market equity)/market equity. Panel A: Short-term funding risk and MMF withdrawals. Panel B: US MMF withdrawals and bank capitalization.

5.2. *Funding liquidity risk and interaction of liquidity and solvency risk*

Similar to peripheral exposures, we expect to see cross-sectional differences in the factor loadings of German bunds arising from their short-term funding exposure. An important source of funding risk for European banks is their exposure to US MMFs. These funds withdrew about $167 billion in repurchase agreements and commercial paper from European banks in 2011 alone.

We aggregate the monthly US MMF holdings data to the quarter level and estimate quarterly $\hat{\beta}_{Germany,i}$ using (1). We find that the value of $\hat{\beta}_{Germany,i}$ ranges from -3.92 to -0.93. Panel A of Fig. 3 shows the relation between the factor loading estimates and US MMF withdrawals in the cross section of banks in 2011. This correlation is 0.71, which shows that US MMF exposure is an important determinant of banks' liquidity problems.

In Panel B of Fig. 3, we plot the time series of U.S. MMF withdrawals for weakly versus well-capitalized banks. We measure capitalization using a one-year lagged market leverage ratio [defined as (total assets–book equity+market equity)/market equity] and define weakly (well) capitalized banks as those in the upper (lower) quartile of the market leverage ratio The figure looks similar using regulatory or book leverage measures. MMFs withdrew more than 60% of their investments from weakly capitalized institutions after November 2010. However, they more than doubled their investments in well-capitalized banks, which reinforces our earlier conjecture that short-term liquidity risk interacts with solvency risk. The results

further emphasize the divergence in funding opportunities for European banks.[25]

6. Potential explanations for carry trade results

In this section, we investigate home bias, risk shifting and regulatory arbitrage and moral suasion as possible explanations for the carry trade results.

6.1. Home bias

The first channel that could explain banks' carry trade behavior is a home bias of peripheral banks that attempt to accumulate domestic sovereign debt with these actions. Our descriptive results show a rotation of peripheral sovereign debt in banks' portfolios, with non-GIIPS (GIIPS) banks in general reducing (increasing) their exposure to domestic sovereign debt. We test this more formally by estimating Model 1 over various subperiods. We use the non-eurozone EU banks as a benchmark group and include interaction terms in the model of both the returns on the GIIPS Sovereign Bond Index and German bund returns with an indicator variable equal to one if the bank is a GIIPS or a non-GIIPS eurozone bank. $\hat{\beta}_{GIIPS}$ thus reflects the GIIPS sovereign bond exposure of the benchmark group. We chose the time periods between the EBA stress test dates consistent with our descriptive analysis in Tables 2 and 3 and to link our factor loadings to micro-level holding data. The results are reported in Table 6.

For example, $\hat{\beta}_{GIIPS\times GIIPS\ Bank}$ reflects the additional exposure of GIIPS banks to peripheral sovereign debt and $\hat{\beta}_{Germany\times GIIPS\ Bank}$ is a measure of GIIPS banks' additional funding risk vis-à-vis non-eurozone EU banks. We find that non-GIIPS eurozone and non-eurozone EU banks also load significantly on peripheral sovereign debt. Moreover, we find that non-GIIPS banks reduce their peripheral sovereign debt exposure between March 2010 and June 2012, which is consistent with our descriptive results. The loadings of non-eurozone EU banks are even insignificant in the first half of 2012. GIIPS banks, by contrast, increase their exposure over the same period, which indicates an increase in home bias by GIIPS banks. Their factor loadings increase from 0.297 (0.291+0.006) to 0.563 (0.001+0.562), which is significant at the 1% level.

The negative and decreasing coefficient of $\hat{\beta}_{Germany}$ shows that the funding problems of German banks rose sharply during the 2010–2011 period. GIIPS banks or non-GIIPS eurozone banks experienced similar funding risks. The interaction terms indicate that GIIPS banks had significantly lower funding risk following the ECB's LTRO injections in 2012 compared with non-GIIPS eurozone banks and the benchmark group of non-eurozone EU banks.

We also investigate the home bias of non-GIIPS banks and introduce two new variables, the exposure of non-GIIPS eurozone banks ($\hat{\beta}_{Home\times non-GIIPS\ Eurozone\ Bank}$) and non-eurozone EU banks ($\hat{\beta}_{Home\times non-Eurozone\ EU\ Bank}$), to their respective domestic sovereign debt. The factor loadings indicate that both groups of banks increase their exposure to their domestic sovereign debt while reducing their exposure to peripheral sovereign debt, which provides support for the home bias hypothesis.

6.2. Risk shifting and regulatory arbitrage

Under the moral hazard hypothesis, undercapitalized banks are more likely to invest in carry trades to comply with regulatory capital requirements (regulatory arbitrage), or shift risk by betting on their own survival (risk shifting) or both. To test this, we use the Tier 1 and *RWA/Assets* ratios to measure banks' capital constraints. Moreover, we include bank characteristics such as bank size (*Log-Assets*) and short-term leverage (*ST-LVG*) to investigate the investment behavior of European banks. In all tests, we use one-year lagged bank characteristics. Table 7 reports the results.

Including the full sample of banks, Model 1 in Table 7 shows that banks with higher *Tier 1* ratios have lower exposure to GIIPS sovereign debt. Tier 1 capital increases if banks have higher *RWA/Assets* ratios or if they decide to hold more economic capital. For a given *RWA/Assets* ratio, the negative coefficient implies higher risk-shifting incentives. Moreover, the positive coefficient on *RWA/Assets* (unlike the sign on *Tier 1*) indicates that regulatory arbitrage is an important motive for banks' investments in risky sovereign debt. Including only one of these variables could result in biased estimates of the coefficients due to confounding effects.[26] Moreover, we find that banks with a high exposure to short-term funding have significantly more exposure to the sovereign debt of GIIPS banks. We show that larger banks (i.e., banks with more international focus, with more wholesale funding, and that are more systemically important) also have larger GIIPS sovereign bank exposures.

We then estimate the regression for subsamples of banks and report the results in Columns 2–5 in Table 7. We find that GIIPS banks with high short-term funding have higher GIIPS sovereign debt and also are more exposed to funding shocks. Importantly, we find that weak capitalization is associated with greater GIIPS sovereign bond exposure only for GIIPS banks. Low Tier 1 ratios do not significantly increase the exposure of other European banks (and only weakly of German and French banks).[27]

[25] We use seemingly unrelated regressions (SUR) to assess the importance of portfolio holdings of sovereign debt and MMF exposure in explaining our factor loadings. Overall, these results, reported in the Online Appendix, support our methodological approach.

[26] In unreported results, we include either *Tier 1* or *RWA/Assets* and find that the coefficient of *Tier 1* is less negative when we do not control for the *RWA/Assets* ratio. This result indicates that the discretionary part of Tier 1 capital is more strongly related to the risk-shifting hypothesis. In other words, not controlling for the *RWA/Assets* ratio understates the risk-shifting effect.

[27] We perform a Wald test under the null hypothesis that the coefficients of the interaction term *GIIPS* × *Tier 1* are not significantly different between the subsamples of GIIPS and German and French

Table 6
Subperiods and home bias.

This table reports the results from regressing bank equity returns on the return of a value-weighted GIIPS (Greece, Italy, Ireland, Portugal, and Spain) Sovereign Bond Index and 10-year German bund returns. We use non-eurozone European Union (EU) banks as a benchmark group and include interaction terms of the returns on the GIIPS Sovereign Bond Index and German bund returns with an indicator variable equal to one if the bank is a GIIPS or a non-GIIPS eurozone bank. Regressions are performed on subperiods that represent the time periods between the four stress tests conducted by the European Banking Authority (EBA). Model 1 reports regression results for the March–December 2010 period; Model 2 for the January–September 2011 period; Model 3 for the October–December 2011 period; and Model 4 for the January–June 2012 period. All regressions include ten-year German bond returns as the funding leg of the carry trade. All regressions further include *VSTOXX*, *TermStructure*, *BondDefSpread*, *1mEuribor*, ΔESI, $\Delta IndProd$, ΔCPI, and $\Delta FX\text{-}Rate$. *t*-Statistics are in parentheses. Standard errors are clustered at the bank level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Variables	March–December 2010 (1)	January–September 2011 (2)	October–December 2011 (3)	January–June 2012 (4)
$\hat{\beta}_{GIIPS}$	0.291***	0.324***	0.216***	0.001
	(5.04)	(5.70)	(3.69)	(0.02)
$\hat{\beta}_{GIIPS\times GIIPS\ Banks}$	0.006	0.251***	−0.110	0.562***
	(0.05)	(3.18)	(−1.11)	(3.96)
$\hat{\beta}_{GIIPS\times Non-GIIPS\ Eurozone\ Banks}$	0.143	0.076	−0.030	0.167
	(0.92)	(0.70)	(−0.19)	(1.48)
$\hat{\beta}_{Germany}$	−2.316***	−2.294***	−2.891***	−2.988***
	(−13.61)	(−10.50)	(−11.24)	(−19.92)
$\hat{\beta}_{Germany\times GIIPS\ Banks}$	0.153	0.511*	0.223	1.085***
	(0.61)	(1.91)	(0.75)	(3.64)
$\hat{\beta}_{Germany\times Non-GIIPS\ Eurozone\ Banks}$	−0.729***	−0.968***	−0.343	−1.028***
	(−3.10)	(−3.51)	(−1.34)	(−3.51)
$\hat{\beta}_{Home\times Non-Eurozone\ EU\ Banks}$	0.186	0.198	0.370**	0.290***
	(0.90)	(1.04)	(2.52)	(2.95)
$\hat{\beta}_{Home\times Non-GIIPS\ Eurozone\ Banks}$	0.986***	1.016***	0.269	1.359***
	(2.94)	(2.95)	(1.24)	(4.81)
$\hat{\beta}_{Non-GIIPS\ Eurozone\ Banks}$	0.000***	0.000*	−0.001***	−0.001***
	(3.26)	(1.73)	(−2.76)	(−8.09)
$\hat{\beta}_{GIIPS\ Banks}$	−0.002***	−0.009***	−0.005	0.000
	(−6.16)	(−6.06)	(−1.40)	(0.14)
$\hat{\beta}_{M}$	1.283***	1.394***	1.703***	1.696***
	(19.05)	(17.13)	(12.53)	(16.45)
$\hat{\beta}_{0}$	−0.000	0.006	0.020	−0.094***
	(−0.05)	(1.19)	(0.61)	(−4.22)
N	10,064	8,914	3,054	5,686
R^2	54.26%	46.04%	46.75%	48.26%

This result provides strong evidence for the moral hazard behavior of GIIPS banks, consistent with the finding reported by Diamond and Rajan (2011).

We also find evidence consistent with regulatory capital arbitrage in the sample of non-GIIPS banks (eurozone and non-eurozone EU), as well as for the German and French banks. Only larger non-GIIPS eurozone, non-eurozone EU, German, and French banks have higher peripheral sovereign debt exposures, which is consistent with the moral hazard behavior of European banks of stronger countries that bailed out their struggling banks.

We finally estimate the regression over various subperiods and report the results in Columns 6–8 in Table 7. The results are again consistent with the interpretation that weakly capitalized banks are more exposed to peripheral sovereign debt. In Online Appendix Table 4, we provide similar analyses regressing GIIPS bond holdings scaled by total assets on our regulatory capital measures and bank characteristics. Overall, these results provide strong support for the moral hazard and regulatory arbitrage hypotheses even during periods when home bias is increasing.

6.3. Moral suasion

A third channel that could explain the higher exposure of European banks to GIIPS sovereign debt could be that peripheral sovereign banks force domestic banks to purchase their own sovereign debt due to limited demand by other investors (moral suasion). The increase in home bias by GIIPS banks that we describe above is consistent with this hypothesis. We test this formally using Models 1–8 from Table 7 and also include a variable *Intervened* that indicates whether or not the bank has been bailed out. We also include interaction terms for both the GIIPS Sovereign Bond Index returns and German bund returns in these models. Table 8 reports the results.

The revised Model 1 in Table 8 shows that intervened banks have lower stock returns, higher GIIPS sovereign bond exposures, and more funding risk. Importantly, we still find evidence for risk shifting and capital arbitrage

(*footnote continued*)
banks. We cannot reject this hypothesis at a meaningful level of confidence.

Table 7
Moral hazard: risk shifting and regulatory arbitrage.

Table 7 reports the results from ordinary least squares regressions of banks' equity returns on the return of a value-weighted GIIPS (Greece, Italy, Ireland, Portugal, and Spain) Sovereign Bond Index and 10-year German bund returns and interaction terms of these returns with various bank characteristics during the 2007 to June 2013 period: *Log-Assets*, *ST-LVG*, *Tier 1*, and *RWA/Assets*. Model 1 reports the results for the full sample and Models 2 and 3 for subsamples of GIIPS and non-GIIPS eurozone banks. Model 4 shows the results for German and French banks, while Model 5 shows the results for the non-eurozone European Union (EU) banks. Models 6–8 report the results of regressions performed on subperiods. Model 6 reports regression results for the March to December 2010 period, Model 7for the January to December 2011 period, and Model 8 for the January to June 2012 period. Bank characteristics are lagged by one year and are included as separate variables, which are omitted for brevity. All regressions include ten-year German bond returns as the funding leg of the carry trade. All regressions further include *VSTOXX*, *TermStructure*, *BondDefSpread*, *1mEuribor*, ΔESI, $\Delta IndProd$, ΔCPI, and $\Delta FX\text{-}Rate$. *t*-Statistics are in parentheses. Standard errors are clustered at the bank and quarter levels. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Variables	All banks (1)	GIIPS banks (2)	Non-GIIPS eurozone banks (3)	German and French banks (4)	Non-eurozone EU banks (5)	March–December 2010 (6)	January–December 2011 (7)	January–June 2012 (8)
$\hat{\beta}_{GIIPS}$	−0.385	0.872	−1.900**	−1.857**	−0.265	−1.272***	−0.253	−0.297*
	(−1.46)	(0.96)	(−2.48)	(−4.29)	(−1.27)	(−4.15)	(−1.49)	(−1.86)
$\hat{\beta}_{GIIPS\times Log-Assets}$	0.039***	−0.032	0.134	0.181*	0.036**	0.057***	0.029***	0.030***
	(2.76)	(−0.57)	(1.54)	(2.39)	(2.41)	(3.85)	(3.10)	(4.09)
$\hat{\beta}_{GIIPS\times ST-LVG}$	0.412**	0.814***	−0.058	0.533	0.083	0.954**	0.468**	0.454**
	(2.23)	(3.43)	(−0.05)	(0.53)	(0.50)	(2.16)	(2.47)	(2.59)
$\hat{\beta}_{GIIPS\times RWA/Assets}$	0.321***	−0.495	0.543***	0.990***	0.213*	0.377***	0.278***	0.315***
	(2.87)	(−1.03)	(4.05)	(7.27)	(1.90)	(3.24)	(3.21)	(3.96)
$\hat{\beta}_{GIIPS\times Tier\ 1}$	−0.021***	−0.023***	0.009	−0.078*	−0.016	0.024	−0.030***	−0.028***
	(−4.33)	(−4.85)	(0.28)	(−2.40)	(−0.89)	(1.26)	(−4.19)	(−3.76)
$\hat{\beta}_{Germany}$	0.190	−3.122*	14.436***	16.155***	−0.943	0.803	−1.080	−0.217
	(0.15)	(−1.86)	(3.87)	(17.32)	(−1.34)	(0.55)	(−0.86)	(−0.13)
$\hat{\beta}_{Germany\times Log-Assets}$	−0.125**	−0.001	−1.140***	−1.142***	−0.074**	−0.102	−0.063	−0.084
	(−2.14)	(−0.01)	(−4.22)	(−10.39)	(−2.15)	(−1.45)	(−0.85)	(−0.97)
$\hat{\beta}_{Germany\times ST-LVG}$	−0.496	−1.896***	−1.875	−2.850	0.101	−2.532*	0.699	1.114
	(−1.18)	(−5.36)	(0.53)	(−1.58)	(0.35)	(−1.77)	(0.81)	(1.20)
$\hat{\beta}_{Germany\times RWA/Assets}$	−0.384	3.067***	−5.649***	−8.765***	−0.750*	−1.387**	−0.696	−0.807
	(−0.51)	(3.07)	(−3.86)	(−25.82)	(−1.68)	(−2.43)	(−1.46)	(−1.66)
$\hat{\beta}_{Germany\times Tier\ 1}$	−0.058*	−0.061	−0.031	0.051**	0.006	−0.011	−0.047	−0.127***
	(−1.69)	(−1.52)	(−0.47)	(2.86)	(0.15)	(−0.15)	(−0.93)	(−2.78)
$\hat{\beta}_0$	−0.005	−0.004*	−0.005	0.003	−0.006***	−0.003	−0.013	−0.102***
	(−1.57)	(−1.76)	(−0.60)	(1.05)	(−4.09)	(−0.66)	(−1.28)	(−6.85)
N	49,880	24,461	8,810	6,081	16,609	7,232	7,044	3,563
R^2	44.27%	47.16%	34.34%	41.75%	48.87%	53.85%	45.10%	49.72%

incentives. We also find that larger banks with more short-term debt and risk-weighted assets have, on average, larger peripheral exposure in the subsample of non-intervened banks. We find evidence consistent with moral suasion in the subsample of GIIPS banks. While intervened banks have higher GIIPS exposure, the interaction term of GIIPS sovereign bond returns with banks' *Tier 1* ratios also enters significantly into the regression. In other words, while regulators can use their influence over intervened banks to attempt to increase the banks' domestic sovereign bond holdings, the banks themselves could be willing to increase their exposure to try to shift risk.

We find that only large banks and banks with high risk-weighted assets from Germany, France, and non-eurozone EU countries have larger GIIPS sovereign bond exposure after controlling for government interventions. These factors, however, do not explain the higher factor loadings of non-GIIPS eurozone banks, on average. The results indicate that even non-eurozone EU banks that are less affected by ECB actions have incentives to increase their exposure to risky sovereign bonds. Regulatory arbitrage seems to be an important incentive. Moreover, the interaction term of intervened banks, along with indicator variables for non-GIIPS eurozone and other EU banks, is still significant even after controlling for moral hazard incentives. A possible interpretation of this result is that the design of European bailout programs that were enforced during the 2007–2009 financial crisis could play an important role in directing bank behavior. European governments bailed out individual domestic banks using debt guarantees, instead of recapitalization. These interventions, which left banking systems severely undercapitalized, could increase banks' moral hazard incentives. We leave this hypothesis for future research.

6.4. Survivorship bias

If the worst performing banks (i.e., those with large peripheral bond holdings) delist during our sample period, this could introduce a survivorship bias into the analysis.

Table 8
Moral suasion.

This table reports the results from ordinary least squares regressions of banks' equity returns on the return of a value-weighted GIIPS (Greece, Italy, Ireland, Portugal, and Spain) Sovereign Bond Index and 10-year German bund returns and interaction terms of these returns with various bank characteristics for the 2007 to June 2013 period: *Log-Assets, ST-LVG, Tier 1,* and *RWA/Assets*. We also include the indicator variable *Intervened*, equal to 1 if the bank as bailed out. We also include interaction terms with GIIPS and German sovereign bond returns. Model 1 shows the results for all banks, Model 2 only for intervened banks. Models 3–6 show the results for GIIPS banks, non-GIIPS eurozone, German, and French banks, and non-eurozone European Union (EU) banks. All regressions include ten-year German bond returns as the funding leg of the carry trade. All regressions further include *VSTOXX, TermStructure, BondDefSpread, 1mEuribor, ΔESI, ΔIndProd, ΔCPI*, and *ΔFX-Rate*. Bank characteristics are lagged by one year and are included as separate variables, which are omitted for brevity. *t*-Statistics are in parentheses. Standard errors are clustered at the bank and quarter level. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% level, respectively.

Variables	All banks (1)	All banks non-intervened (2)	GIIPS banks (3)	Non-GIIPS eurozone banks (4)	German and French banks (5)	Non-eurozone EU banks (6)
$\hat{\beta}_{Intervened}$	−0.001**		−0.001*	−0.004**	−0.002*	−0.000
	(−2.26)		(−1.86)	(−2.45)	(−2.58)	(−0.24)
$\hat{\beta}_{Intervened\times GIIPS}$	0.125***		0.151***	0.197***	−0.011	0.102**
	(3.40)		(5.12)	(7.70)	(−0.23)	(2.20)
$\hat{\beta}_{Intervened\times Germany}$	−0.308*		−0.413*	−0.715**	0.003	−0.146
	(−1.93)		(−1.93)	(−2.81)	(0.01)	(−0.87)
$\hat{\beta}_{GIIPS}$	−0.586**	−0.945	0.270	−1.224**	−1.919***	−0.350
	(−2.39)	(−1.48)	(0.30)	(−2.57)	(−6.69)	(−1.48)
$\hat{\beta}_{GIIPS\times Log-Assets}$	0.045***	0.057**	0.013	0.053	0.188**	0.040***
	(3.38)	(2.17)	(0.23)	(0.96)	(3.46)	(2.83)
$\hat{\beta}_{GIIPS\times ST-LVG}$	0.490***	0.421*	0.848***	0.160	0.504	0.229
	(2.76)	(1.73)	(3.79)	(0.13)	(0.52)	(1.08)
$\hat{\beta}_{GIIPS\times RWA/Assets}$	0.319***	0.577**	−0.565	−0.031	1.050***	0.250***
	(4.42)	(2.14)	(−1.41)	(−0.30)	(4.63)	(5.91)
$\hat{\beta}_{GIIPS\times Tier\ 1}$	-0.019***	−0.007	−0.023***	0.042	−0.082**	−0.022
	(−4.06)	(−0.37)	(−4.43)	(1.47)	(−3.89)	(−1.22)
$\hat{\beta}_{Germany}$	0.438	1.820	−1.732	12.341***	16.162***	−0.929*
	(0.36)	(0.76)	(−1.08)	(4.55)	(17.80)	(−1.83)
$\hat{\beta}_{Germany\times Log-Assets}$	−0.132**	−0.200**	−0.095	−1.028***	−1.145***	−0.073***
	(−2.50)	(−2.12)	(−0.84)	(−5.46)	(−11.93)	(−2.79)
$\hat{\beta}_{Germany\times ST-LVG}$	−0.578	−0.313	−1.839***	2.361	−2.831	−0.023
	(−1.36)	(−0.55)	(−5.42)	(0.70)	(−1.04)	(−0.07)
$\hat{\beta}_{Germany\ x\ RWA/Assets}$	−0.385	−1.005	2.914***	−4.027**	−8.786***	−0.804**
	(−0.54)	(−0.76)	(3.19)	(−2.96)	(−5.38)	(−2.02)
$\hat{\beta}_{Germany\times Tier\ 1}$	−0.057*	−0.087	−0.059	0.010	0.053***	0.014
	(−1.70)	(−1.51)	(−1.50)	(0.23)	(5.22)	(0.42)
$\hat{\beta}_m$	1.382***	1.227***	1.509***	1.272***	1.016**	1.203***
	(15.25)	(15.84)	(12.68)	(5.91)	(4.03)	(11.40)
$\hat{\beta}_0$	−0.007**	−0.003	−0.003	−0.013	−0.001	−0.006***
	(−2.51)	(−1.23)	(−0.94)	(−1.15)	(−0.61)	(−4.87)
N	49,880	30,021	24,461	8,810	6,081	16,609
R^2	44.36%	56.04%	47.25%	34.85%	41.77%	48.91%

We collect information on two GIIPS banks that delisted during the March 2010–June 2012 period. We have micro-level sovereign bond holding data for these two firms: Banco Pastor and Caja de Ahorros del Mediterráneo. Between June 2012 and June 2013, three other GIIPS banks delisted: two Greek banks, TT Hellenic Postbank and ATE, and a Spanish bank, Banca Civica. Two non-GIIPS eurozone banks also delisted during this period: SNS Reaal and LB Berlin.

We further analyze the characteristics of those banks that delist and those that remain stock exchange-listed and ask whether our factor loadings can be explained by banks that delisted during our sample period. We make several important observations. First, none of the non-eurozone EU banks delisted, so a decrease in the sensitivity of their equity returns to GIIPS sovereign bond returns cannot be attributed to riskier banks with larger holdings dropping from our sample.[28]

We also investigate whether the GIIPS sovereign bond holdings of those banks that delisted were larger compared with those that were still listed at the time of delisting within the group of GIIPS banks and non-GIIPS eurozone and non-eurozone EU banks. We find that the average GIIPS sovereign bond holdings of banks that delist relative to total assets were not different compared with the holdings of listed banks at the time these banks delist.

[28] We do not assess the performance of bank stocks. We assess the sensitivity of bank equity returns to sovereign bond returns to evaluate the exposure of banks to these securities. Firms that delist during our sample period are also not excluded from the sample. They are part of the sample as long as they are listed and trade equity.

We conjecture that a survivorship bias would prejudice us against finding evidence for GIIPS sovereign bond exposure in the sample of GIIPS banks. If survivorship bias was a concern, we would expect to observe a decline in factor loadings on GIIPS sovereign bond returns over time when banks with large bond holdings delist. In this case, the average factor loadings would even underestimate the extent of carry trades. More important, however, our analysis over subperiods in Table 6 shows the opposite for the (arguably riskier) GIIPS banks: Factor loadings increase over time. In other tests, we also relate estimated factor loadings to the actual bond holdings of the GIIPS banks and find a significant positive correlation during subperiods. Overall, the evidence indicates that our results are unlikely to be caused by a survivorship bias.

7. Conclusion

In the wake of the 2007–2009 global financial crisis, increasing economic divergence between the core countries of Europe and the periphery caused a surge in the yield spread of peripheral countries and a flight to German bunds. We suggest that European banks designed carry trades as investments in GIIPS government bonds financed with short-term debt and thus they effectively placed bets on convergence within the euro area. However, as the sovereign debt crisis deepened, the market value of European banks significantly declined. In a series of cross-sectional and time series tests, we find that these trades are widespread even among non-eurozone EU banks. We analyze the motives behind the carry trades and find convincing evidence for an increase in the home bias of GIIPS banks. Moreover, we find evidence for bank moral hazard and regulatory capital arbitrage in that large banks, banks with more short-term debt, and undercapitalized banks with high risk-weighted assets are more likely to engage in carry trades employing low risk-weight GIIPS government bonds to earn higher and riskier returns on their diminished economic capital while meeting regulatory capital requirements.

Our empirical findings have several important policy implications. First, undercapitalized banking sectors, such as those found in European countries following the financial crisis of 2007–2009, can lead to subsequent problems through excess risk taking, a theme that is reminiscent of the Japanese banking crisis of the 1990s (Peek and Rosengren, 2005; Caballero, Hoshi, and Kashyap, 2008; Hoshi and Kashyap, 2010). The lack of capital prevents a cleaning-up of European banks' balance sheets and an efficient allocation of credit throughout the economy. Popov and van Horen (2014) report that it has taken European banks much longer to recover in terms of their global syndicated lending than other banks, largely due to their GIIPS holdings.[29]

Second, simply restoring bank capitalization up to regulatory requirements is not sufficient in economic environments in which the regulatory risk weights are out of sync with market fundamentals. Zero-risk weights on sovereign bonds of peripheral countries, being far from being risk-free, do not deserve or require such regulatory capital treatment. Worse, reliance on such outdated risk weights, as in the first two stress tests of 2010 in Europe, could have given undercapitalized banks perverse incentives to shift their portfolios toward assets that had high economic risks and returns. In the case of Europe, this created a strengthening of the nexus between sovereign and financial sectors, making sovereign debt crises in southern periphery countries a pan-European concern.

Third, the ECB's LTRO interventions provided funding to domestic Spanish and Italian banks in an attempt to incentivize and stimulate the buildup of their exposures to their sovereign debt. However, the resulting home bias strengthened the financial sector and the sovereign's nexus in the periphery, implying that a further deterioration of the sovereign's health could lead to a significant peripheral crisis, even if not a fully pan-European one similar in magnitude. This form of ECB funding does not address the problem of bank recapitalization for GIIPS banks and their incentives to load up on sovereign debt, and of their sovereigns to encourage (or not discourage) such home bias, continue unabated.

Finally, our results highlight the link between asset-side risk and the short-term funding problems of banks. The Basel III framework addresses the liquidity problems of banks by requiring them to comply with new liquidity ratios. However, if sovereign bonds count as being liquid, banks have similar incentives to load-up on these assets as when they had zero-risk weights for capital requirements. Going forward, it will be important to investigate how bank solvency and liquidity risk interact. When assets held by banks are risky, this generates funding problems for these banks if they heavily rely on short-term wholesale funding. The months following the third European stress test showed some relief for non-GIIPS banks' funding conditions. For the first time, regulators stressed sovereign risk and eventually required banks to increase their regulatory capital, which has been addressed at least by some banks issuing new equity. Non-GIIPS banks also broadly reduced their risky sovereign debt positions. This indicates that banks' incentives to accumulate risky assets is driven by low capital requirements and similar regulatory arbitrage of Basel III liquidity requirements will have to be addressed by the regulators.

Appendix A

See Tables A1–A3.

[29] In Appendix VI in the Online Appendix, we show that increasing reliance on the domestic banking sector for absorbing government bonds generates a crowding out of corporate lending when the banking sector is undercapitalized, such as in Italy and Spain. Schoenmaker (2013) also suggests that weak banks reduced corporate lending while increasing their holdings of risky peripheral sovereign debt.

Table A1
Variable definitions.

Variable	Definition
GIIPS Banks	Indicator variable equal to one if bank is from Greece, Italy, Ireland, Portugal, or Spain (GIIPS)
Non-GIIPS Eurozone Banks	Indicator variable equal to one if bank is from a non-GIIPS but eurozone country
Non-Eurozone EU Banks	Indicator variable equal to one if bank is from a non-eurozone but European Union (EU) country
BondIndex	Daily average return of sovereign bonds from euro area members other than GIIPS countries or Germany or France
PC1	First principal component (PC1), the linear combination of GIIPS bond returns with the highest eigenvalue
Germany	Daily returns on ten-year government bonds issued by Germany
France	Daily returns on ten-year government bonds issued by France
Intervened	Indicator variable equal to one if the bank has been bailed out by its government before
Log-Assets	Natural logarithm of total book assets
ST-LVG	Short-term debt divided by total debt
RWA/Assets	Risk-weighted assets divided by total assets
Tier 1	Tier 1 capital divided by risk-weighted assets
Bank Stock Return	Realized return is the bank's equity return, in percent
Bank CDS	Five-year credit default swap (CDS) spread of European banks, in basis points (bp)
ΔLog(Bank CDS)	ΔLog(Bank CDS) is the change in the log of daily CDS spreads
$\hat{\beta}_i$	Estimated factor loadings from cross-sectional regressions from banks' stock returns on ten-year government bond returns from country *i* (Greece, Italy, Ireland, Portugal, Spain, or Germany)
$\hat{\beta}_{GIIPS}$	Estimated factor loadings from cross-sectional regressions from banks' stock returns on gross domestic product weighted GIIPS Sovereign Bond Index returns
$\hat{\beta}_{Home}$	Estimated factor loadings from cross-sectional regressions from banks' stock returns on ten-year domestic government bond returns
ΔMMF	Monthly withdrawal by US money market mutual funds in millions of euros
ΔMMF/Assets	*ΔMMF* scaled by total book assets
Macro-State Variables & Indices	
Stock Index "m"	Residual from the regression of the domestic stock market's daily log returns on daily domestic sovereign bond and German bund returns
STOXX600	Daily return of the Euro STOXX 600 Index
S&P 500	Daily return of the Standard & Poor's 500 index
VSTOXX	Daily return of the VSTOXX Index for the European stock market
TermStructure	Term Structure is the slope of the term structure of interest rates measured as the difference between the yield on a ten-year euro area government bond and the one-month Euribor
BondDefSpread	Bond default spread; difference between the yield on ten-year German BBB bonds and yields on ten-year German government debt
1mEURIBOR	One-month Euribor, level of the short-term risk-free interest rate measured as the one-month Euribor
ΔFX-Rate	Change of the nominal effective exchange rate of the euro
ΔESI	Change in European economic sentiment; monthly change in the economic sentiment indicator obtained from opinion surveys conducted by the European Central Bank
ΔIndProd	Change in level of industrial production; monthly change in the level of industrial production
ΔCPI	European Consumer Price Index is the change in inflation measured as the monthly change in the European Consumer Price Index
Fama and French factors	
SMB	Small minus big
HML	High minus low
Time Indicator	
March–Dec. 2010	Indicates time period between March 2010 and December 2010
Jan–Sept. 2011	Indicates time period between January 2011 and September 2011
Oct–Dec. 2011	Indicates time period between October 2011 and December 2011
Jan–June 2012	Indicates time period between January 2012 and June 2012

Table A2
List of banks.
This table is a list of all public banks included in the European Banking Authority (EBA) stress tests sorted by asset size as of December 31, 2011, as well as their EBA identification (ID), country of residence, and information indicating whether the bank has been bailed out.

Bank	EBA ID	Ticker	Country	Intervened	Total assets
Non-GIIPS eurozone banks					
BNP Paribas SA	FR013	BNP	France	Yes	1,800,139
Deutsche Bank AG	DE017	DBK	Germany		1,649,000
Crédit Agricole SA	FR014	ACA	France	Yes	1,536,873
Société Générale SA	FR016	GLE	France	Yes	1,235,262
ING Groep N.V.	NL047	INGA	Netherlands	Yes	1,080,624
Commerzbank AG	DE018	CBK	Germany	Yes	549,661

Table A2 (*continued*)

Bank	EBA ID	Ticker	Country	Intervened	Total assets
KBC Group NV	BE005	KBC	Belgium	Yes	241,306
Dexia SA	BE004	DEXB	Belgium	Yes	223,383
Erste Group Bank AG	AT001	EBS	Austria	Yes	199,876
SNS Real	NL050	SR	Netherlands	Yes	124,785
Landesbank Berlin Holding AG	DE027	BEB2	Germany		118,298
Cyprus Popular Bank Public Co. Ltd.	CY006	CPB	Cyprus	Yes	33,762
Bank of Cyprus Public Company Limited	CY007	BOCY	Cyprus	Yes	30,357
Bank of Valletta Plc	MT046	BOV	Malta		7,258
Nova Kreditna Banka Maribor d.d.	SI058	KBMR	Slovenia	Yes	4,830
Non-eurozone EU banks					
HSBC Holdings Plc	GB089	HSBA	United Kingdom	Yes	1,938,843
Barclays Plc	GB090	BARC	United Kingdom	Yes	1,576,893
Royal Bank of Scotland Group Plc	GB088	RBS	United Kingdom	Yes	1,235,155
Lloyds Banking Group Plc	GB091	LLOY	United Kingdom	Yes	1,017,838
Nordea Bank AB	SE084	NDA	Sweden		630,434
Danske Bank A/S	DK008	DANSKE	Denmark	Yes	432,611
DNB ASA	NO051	DNBNOR	Norway		285,751
Svenska Handelsbanken AB	SE086	SHBA	Sweden		281,016
Skandinaviska Enskilda Banken AB	SE085	SEBA	Sweden		280,455
Swedbank AB	SE087	SWEDA	Sweden	Yes	205,508
PKO Bank Polski SA	PL052	PKO	Poland		47,435
Jyske Bank A/S	DK009	JYSK	Denmark		35,124
OTP Bank Nyrt.	HU036	OTP	Hungary	Yes	34,742
Sydbank A/S	DK010	SYDB	Denmark		19,826
FHB Jelzalogbank Nyrt	HU111	FHB	Hungary	Yes	2,585
GIIPS banks					
Banco Santander SA	ES059	SAN	Spain		1,115,638
UniCredit SpA	IT041	UCG	Italy		926,838
Intesa Sanpaolo SpA	IT040	ISP	Italy		673,472
Banco Bilbao Vizcaya Argentaria, SA	ES060	BBVA	Spain		599,482
Bankia	ES061	BKIA	Spain	Yes	269,159
Banca Monte dei Paschi di Siena SpA	IT042	BMPS	Italy	Yes	218,887
Banco Sabadell SA	ES065	SAB	Spain		163,441
Banco Popular Español SA	ES064	POP	Spain	Yes	147,852
Unione di Banche Italiane SCpA	IT044	UBI	Italy		132,434
Bank of Ireland	IE038	BKIR	Ireland	Yes	132,137
Banco Popolare Società Cooperativa	IT043	BP	Italy	Yes	126,043
Allied Irish Banks, Plc	IE037	ALBK	Ireland	Yes	122,516
National Bank of Greece SA	GR031	ETE	Greece	Yes	104,799
Espirito Santo Financial Group SA	PT055	ESF	Portugal	Yes	87,574
Banco Comercial Português SA	PT054	BCP	Portugal	Yes	82,007
EFG Eurobank Ergasias SA	GR030	EUROB	Greece	Yes	77,586
Caja de Ahorros del Mediterráneo	ES083	CAM	Spain	Yes	75,532
Banca Cívica SA	ES071	BCIV	Spain		71,827
Piraeus Bank SA	GR033	TPEIR	Greece	Yes	70,408
Alpha Bank AE	GR032	ALPHA	Greece	Yes	58,357
Bankinter SA	ES069	BKT	Spain	Yes	55,136
Banco BPI SA	PT056	BPI	Portugal	Yes	42,694
Banco Pastor SA	ES074	PAS	Spain	Yes	30,376
ATEbank SA	GR034	ATE	Greece	Yes	28,818
TT Hellenic Postbank SA	GR035	TT	Greece	Yes	16,396

Table A3
Descriptive statistics.

This table provides summary statistics on bank characteristics, bond holdings, and market characteristics. The sample covers all publicly listed banks that participated in the European Banking Authority (EBA) stress tests and capitalization exercises, as well as bond holdings as reported by the EBA. Panel A shows bank characteristics calculated at the bank level. Panel B shows summary statistics on bond holdings calculated at the reporting dates. Panel C shows summary statistics on bank and market characteristics. All variables are defined in Table A1.

	Number of observations	Mean	Standard deviation	Minimum	50th percentile	Maximum
Panel A: Bank characteristics						
Log-Assets	56	12.03	1.51	7.91	11.92	14.53
ST-LVG	44	0.33	0.11	0	0.32	0.63
RWA / Assets	56	0.49	0.17	0.17	0.52	0.76
Tier 1(percent)	56	10.15	2.8	5.97	9.63	23.98
ΔMMF/Assets (percent)	25	0.12	0.73	−1.52	0.18	1.44

Table A3 (*continued*)

	Number of observations	Mean	Standard deviation	Minimum	50th percentile	Maximum
Panel B. Bond Holdings						
GIIPS Banks						
GIIPS (percent assets)	70	8.69%	4.79%	0.67%	8.44%	29.59%
Non-GIIPS (percent assets)	70	0.93%	1.22%	0.00%	0.58%	5.32%
GIIPS (percent total sovereign bonds)	75	88.11%	14.81%	48.70%	93.09%	100.00%
Non-GIIPS (percent total sovereign bonds)	75	11.89%	14.81%	0.00%	6.91%	51.30%
Domestic (percent total sovereign bonds)	86	83.90%	16.04%	24.32%	89.79%	100.00%
Non-GIIPS banks						
GIIPS (percent assets)	145	1.21%	2.32%	0.00%	0.45%	20.33%
Non-GIIPS (percent assets)	145	6.63%	5.05%	0.00%	4.88%	25.13%
GIIPS (percent total sovereign bonds)	145	15.87%	23.08%	0.00%	7.86%	99.93%
Non-GIIPS (percent total sovereign bonds)	145	84.13%	23.08%	0.07%	92.14%	100.00%
Domestic (percent total sovereign bonds)	154	50.97%	30.57%	0.00%	45.42%	100.00%
Panel C: Time series characteristics						
Daily Bank Stock and CDS Returns						
Bank Stock Return (bps)	1,613	−8.75	351.96	−1771	−3.17	2143
Bank CDS (bps)	1,336	112.76	87.49	6.01	97.56	440.27
ΔLog (Bank CDS) (bps)	1,336	29.12	529.65	3,258.00	20.69	3,293
STOXX 600 (bps)	1,591	−2.41	143.61	−792.97	2.10	941.00
VSTOXX (bps)	1,613	1.93	625.09	−2,491.85	−51.46	3,276.75
S&P 500 (bps)	1,523	0.00	154.54	−946.97	6.97	1,095.79
TermStructure (%)	1,613	2.12	1.39	−0.78	2.83	3.76
BondDefSpread (%)	1,613	2.09	1.04	0.74	1.82	5.67
1mEuribor (%)	1,613	1.79	1.68	0.11	0.93	5.20
FX-Rate	1,613	104.91	4.72	94.45	104.94	114.26
Monthly Time Series Variables						
SMB	76	−0.10	2.10	−4.64	−0.09	4.85
HML	76	−0.24	2.58	−4.61	−0.44	7.45
ΔESI	76	−0.30	2.17	−6.50	−0.10	4.70
ΔIndProd	76	−0.15	1.12	−3.49	0.08	2.15
ΔCPI	76	−0.01	0.30	−1.10	0.00	0.80

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