Supplementary Material

In this appendix, we present a model of the collateral trade (section A); develop an additional simple model of the collateral trade taking into account that the central bank may trigger margin calls (section B); illustrate the dataset construction (section C); illustrate the ECB collateral framework (section D); present additional figures (section E); and present additional tables (section F).

A Model of the Collateral Trade

In this section, we develop a stylized model of the collateral trade. We first characterize the equilibrium in the absence of an LOLR, and then introduce a facility that can be used by banks to purchase sovereign debt at different maturities. We show that the model is able to generate the empirical predictions that we test, in the context of an optimizing agents, partial equilibrium framework.

Model Setup The economy lasts for two periods, $t = 0, 1$, and is populated by a continuum of domestic banks, international investors, and a government. At the beginning of $t = 0$, banks can borrow from the ECB and invest in short- and long-term bonds. short-term bonds and ECB borrowing both mature at $t = 1$, while long-term bonds do not.

International investors have downward sloping demand curves for short- and long-term bonds at $t = 0$. At $t = 1$, they have a stochastic valuation for long-term bonds, which determines their price.

Banks are risk-neutral and care about their profits at $t = 1$, which are given by the value of long-term debt $q_L^1 b_L$ (where b_L are units and q_L^1 is the stochastic price), the value of maturing short-term b_S, and the value of LTRO repayments $R€$, where € is the amount borrowed from the ECB and R is the ECB interest rate. We introduce the following liquidity constraint in the bank's problem: we assume that the revenues from sovereign bond trading must be sufficient to cover ECB repayments; otherwise, the bank needs to access international funding markets, which is costly. We assume that the bank pays a cost $\kappa > 1$ per unit borrowed in these funding markets. Expected profits at $t = 1$ are therefore given by

$$\mathbb{E}\pi_1 = \mathbb{E}\left\{q_L^1 b_L + b_S - R€ + \kappa \min[0, q_L^1 b_L + b_S - R€]\right\} \tag{1}$$

Banks face a budget constraint at $t = 0$, stating that the value of purchased debt cannot exceed available resources ω plus ECB borrowing,

$$q_S b_S + q_L b_L \leq \omega + € \tag{2}$$

We assume that government bonds are in fixed supply at $t = 0$, given by B_S, B_L. At $t = 0$, international investors have demand curves of the type

$$b_i^* = \beta_i + \frac{\alpha_i}{q_i}, i = \{L, S\}$$

At $t = 1$, we assume that these investors have a random valuation for long-term debt, given by $q_L^1 \sim F[\underline{q}, \bar{q}]$, that generates a perfectly elastic demand, pinning down the price. We also assume that $\beta_i < B_i, i = \{L, S\}$.

Banks choose $(b_S, b_L, €)$ to maximize 1 subject to 2. We make two simplifying assumptions:

1. Accessing international funding markets is prohibitively costly, $\kappa \to \infty$.

2. The lower bound of the support for international investors' valuation is zero, $\underline{q} = 0$.

The first assumption is equivalent to assuming a form of infinite risk-aversion for the bank, and it effectively imposes that the bank avoids having a shortfall between bond portfolio revenues and ECB repayments in any state of the world, in particular for the worst possible realization of q_L^1,

$$\underline{q} b_L + b_S - R€ \geq 0 \tag{3}$$

The second assumption is not essential for our results, but it greatly simplifies the algebra. It implies that the liquidity constraint takes the following form

$$b_S - R€ \geq 0$$

Bank Portfolio Problem Let $\mu = \mathbb{E} q_L^1$. We can then write the bank's Lagrangian as

$$\mathcal{L} = \mu b_L + b_S - R€ + \lambda[\omega + € - q_L b_L - q_S b_S] + \eta[b_S - R€]$$

The bank's first-order conditions are

$$b_L : \mu - \lambda q_L = 0$$

$$b_S : 1 - \lambda q_S + \eta = 0$$

$$€ : -R + \lambda - \eta R = 0$$

And the market-clearing conditions are

$$b_i + b_i^* = B_i, i = \{L, S\}$$

Case 1: No LTRO Let us assume first that there is no LTRO facility, so that € $= \eta = 0$. Define $\mathcal{B} = B_S + \mu B_L$ as the stock of "discounted" government debt. Then, we can show that the equilibrium is as follows:

$$\begin{aligned}
q_S &= \frac{\omega + \alpha_S + \alpha_L}{\mathcal{B} - \beta_S - \mu\beta_L} \\
q_L &= \mu\frac{\omega + \alpha_S + \alpha_L}{\mathcal{B} - \beta_S - \mu\beta_L} \\
b_S &= \frac{(\omega + \alpha_L)(B_S - \beta_S) - \alpha_S\mu(B_L - \beta_L)}{\omega + \alpha_S + \alpha_L} \\
b_L &= \frac{(\omega + \alpha_S)\mu(B_L - \beta_L) - \alpha_L(B_S - \beta_S)}{\mu(\omega + \alpha_S + \alpha_L)}
\end{aligned}$$

We can show that the slope of the yield curve is given by

$$\begin{aligned}
\text{slope} &= \frac{1}{q_L} - \frac{1}{q_S} \\
&= \frac{\mathcal{B} - \beta_S - \mu\beta_L}{\omega + \alpha_S + \alpha_L}\left(\frac{1}{\mu} - 1\right)
\end{aligned}$$

Case 2: LTRO, Liquidity Constraint Binding Let us now assume that the ECB introduces the LTRO facility and that banks borrow enough such that their liquidity constraint binds. This implies that $\eta > 0$. We can then characterize the equilibrium as

$$
\begin{aligned}
q_S &= \frac{1}{R} \\
q_L &= \frac{\omega + \alpha_L}{B_L - \beta_L} \\
b_S &= B_S - \beta_S - \alpha_S R \\
b_L &= \frac{\omega}{\omega + \alpha_L}(B_L - \beta_L) \\
\text{€} &= \frac{B_S - \beta_S}{R} - \alpha_S \\
\eta &= \frac{\mu(B_L - \beta_L)}{R(\omega + \alpha_L)} - 1
\end{aligned}
$$

And we can show that the slope is given by

$$
\text{slope} = \frac{B_L - \beta_L}{\omega + \alpha_L} - R
$$

Finally, a sufficient condition for the liquidty constraint to bind is to have

$$
\mu \frac{B_L - \beta_L}{\omega + \alpha_L} > R
$$

Testable Predictions

Recall that the main predictions that we test empirically are the following:

1. Banks buy high-yield government bonds to borrow at the LOLR.

2. The LOLR causes purchases of high-yield short-term government bonds.

3. The sovereign yield curve steepens.

While Prediction 1 is borne by design, we can show that the LTRO equilibrium generates Predictions 2 and 3.

Prediction 2 To check this prediction, we compare the equilibrium b_S under the LTRO to the equilibrium b_S in the absence of the LTRO:

$$\begin{aligned}\Delta(b_S) &= b_S^{\text{LTRO}} - b_S^{\text{no LTRO}} \\ &= B_S - \beta_S - \alpha_S R - \frac{(\omega + \alpha_L)(B_S - \beta_S) - \alpha_S \mu (B_L - \beta_L)}{\omega + \alpha_S + \alpha_L} \\ &= \alpha_S \left(\frac{\mathcal{B} - \beta_S - \mu \beta_L}{\omega + \alpha_S + \alpha_L} - R \right)\end{aligned}$$

A sufficient condition to have $\Delta(b_S) > 0$ is

$$\mu \frac{B_L - \beta_L}{\omega + \alpha_L + \alpha_S} > R$$

and recall that the sufficient condition for the liquidity constraint to bind was $\mu \frac{B_L - \beta_L}{\omega + \alpha_L} > R$. Therefore, as long as the liquidity constraint is binding, and α_S is small enough,[1] the introduction of the LTRO yields $\Delta(b_S) > 0$ — that is, domestic banks purchase more short-term bonds when the LTRO facility is introduced, at a sufficiently low interest rate. We can

[1]In particular, we need $\alpha_S \leq \frac{\omega + \alpha_L}{R} \left[\mu \frac{B_L - \beta_L}{\omega + \alpha_L} - R \right]$.

also see what happens to the demand for long-term bonds:

$$\begin{aligned}
\Delta(b_L) &= b_L^{\text{LTRO}} - b_L^{\text{no LTRO}} \\
&= \frac{\omega}{\omega+\alpha_L}(B_L-\beta_L) - \frac{(\omega+\alpha_S)\mu(B_L-\beta_L)-\alpha_L(B_S-\beta_S)}{\mu(\omega+\alpha_S+\alpha_L)} \\
&= \frac{\alpha_L}{\omega+\alpha_S+\alpha_L}\left[\frac{1}{\mu}(B_S-\beta_S) - \frac{\alpha_S}{\alpha_L+\omega}(B_L-\beta_L)\right] \\
&\equiv \Phi
\end{aligned}$$

This condition cannot be unambiguously signed. For different model parametrizations, demand for long-term bonds can either rise or fall with the introduction of the LTRO.

Prediction 3 The introduction of the LTRO generates a steepening of the yield curve if and only if

$$\begin{aligned}
\Delta(\text{slope}) &= \text{slope}^{\text{LTRO}} - \text{slope}^{\text{no LTRO}} \\
&= \frac{B_L-\beta_L}{\omega+\alpha_L} - R - \frac{\mathcal{B}-\beta_S-\mu\beta_L}{\omega+\alpha_S+\alpha_L}\left(\frac{1}{\mu}-1\right) \\
&= \frac{(B_L-\beta_L)\left(\mu+\frac{\alpha_S}{\omega+\alpha_L}\right)-(B_S-\beta_S)\left(\frac{1}{\mu}-1\right)}{\omega+\alpha_S+\alpha_L} - R \\
&= \frac{\mathcal{B}-\frac{\Phi}{\alpha_L}}{\omega+\alpha_S+\alpha_L} - R
\end{aligned}$$

It is easy to show that this expression is positive for low enough R and as long as $\mu > \underline{\mu}$ is bounded below. Note also that this condition is more likely to hold when the following occur:

1. Available bank resources ω are lower.

2. The ratio of long-term to short-term government debt (net of foreign demand) $\frac{B_L - \beta_L}{B_S - \beta_S}$ is higher.

Both were arguably true for the case of the Portuguese banking system and maturity structure of sovereign debt around the time of the introduction of the LTRO.

Additionally, notice that a fall in the demand for long-term bonds caused by the introduction of the LTRO, $\Phi < 0$, is *sufficient, but not necessary* for a steepening of the yield curve.

Finally, note that an alternative way to model the LTRO is as a fall in the cost of borrowing at maturities that match those of short-term government bonds, $R \downarrow$. Notice that, as long as banks are liquidity constrained, a fall in R triggers a steepening of the yield curve.

B Model of Margin Calls and the Collateral Trade

Consider a risk-neutral investor that lives for three periods, $t = 0, 1, 2$, and can choose at $t = 0$ to undertake a leveraged investment on either a short-term bond maturing at $t = 1$, a medium-term bond maturing at $t = 2$, or a long-term bond that does not mature in the investor's lifetime. The investor can partially finance this investment with a collateralized loan that matures at $t = 2$. If the value of the collateral falls (or the collateral matures) before the loan is due, the investor is subject to a margin call and needs to raise sufficient liquidity to compensate the lender for this shortfall. We assume that raising liquidity is costly: each unit of liquidity raised at $t = 1$ costs r at $t = 2$.

The bonds are priced by deep-pocketed, risk-neutral investors with discount factor $\eta < 1$. This means that the price of a bond with maturity s is η^s at $t = 0$. At each subsequent period $t = 1, 2$, with probability α, these investors may receive a preference shock that lowers their discount factor permanently by a factor of $\rho^- < \eta$ or raises their discount factor permanently by a factor of $\rho^+ > \eta$. Thus the price of a bond with maturity s at $t = 1$ becomes $(\rho^x\eta)^s$ after shock $x \in \{-, +\}$. This revaluation may trigger a margin call for longer-maturity bonds. We assume that $\alpha\rho^- + (1 - \alpha)\rho^+ < 1$ so that the yield curve is always upward sloping (longer-term bonds are cheaper). This means that the frictionless yields for each of the bonds are

$$y_S = \frac{1}{\eta}$$

$$y_M = \frac{1}{\eta^2}$$

$$y_L = \frac{\alpha\rho^- + (1 - \alpha)\rho^+}{\eta^2}$$

Let us analyze separately the payoffs of investing in a short-, medium- and long-term bond. Let $h \in (0,1)$ denote the haircut on collateral and R the interest rate on the LTRO loan. Since we want to focus on the relative preference for different maturities, and not on the desirability of the carry trade *per se*, we assume that $\eta < 1 + R$ so that an unconstrained carry trade is always profitable at any maturity. We assume that there is storage with return unity.[2]

A short-term bond costs η at $t = 0$ and is completely riskless, yielding 1 at $t = 1$. The bank invests by borrowing $h\eta$. Since the collateral matures before the loan, the bank is requested to deposit $h\eta$ at $t = 1$. Since $1 > h\eta$, this margin call is inconsequential and the bank does not need to raise any external liquidity. It receives the margin call deposit at $t = 2$ and repays the loan plus interest. The total profit from this trade is

$$\pi_S = -\eta + h\eta + (1 - h\eta) + [h\eta - (1 + R)h\eta] = 1 - \eta - Rh\eta$$

Given the bank's initial capital, $k < \eta^3$, it can purchase a quantity equal to $\frac{k}{(1-h)\eta}$, and so the profit of this trade is equal to

$$\pi_S = \frac{k}{1-h}\left[\frac{1}{\eta} - 1 - Rh\right]$$

Similarly, we can show that the profits for investing in medium- and long-term bonds are

[2]Basically, the investor can save for a net return of zero and borrow for a net cost of r.

given by

$$\pi_M = \frac{k}{1-h}\left[\frac{1+\alpha r h \rho^- \eta}{\eta^2} - 1 - Rh - \alpha r h\right]$$
$$\pi_L = \frac{k}{1-h}\left[\frac{\alpha\rho^-\eta + (1-\alpha)\rho^+\eta + \alpha r h(\rho^-)^2\eta^2}{\eta^3} - 1 - Rh - \alpha r h\right]$$

We can show that $\pi_L \leq \pi_M$ if

$$\alpha r h \rho^- \eta(1-\rho^-\eta) \geq \alpha\rho^- + (1-\alpha)\rho^+ - 1$$

So that, if the probability of a downwards revaluation (and the magnitude of that revaluation) is high enough, and exceeds the return benefits of investing in a long-term bond, the investor may prefer to invest in a medium-term bond. We can derive similar conditions, under which $\pi_L \leq \pi_S$. They are mainly related to liquidity risk: the short-term investment exposes the bank to no type of liquidity risk whatsoever. The medium-term bond exposes the bank to margin call risk, with probability α. The long-term bond exposes the bank to both margin call *and* funding liquidity risk at the final period, since the bond's payoff (its price on the secondary market) may be uncertain. Since there is no discounting, the unconstrained, risk-neutral investor would simply prefer the bond that offers the ex-ante higher return, which is the long-term bond by assumption. Due to liquidity risk, emanating both from margin calls and uncertain prices at loan maturity, the investor may prefer to invest in shorter-term bonds.[3]

[3] Our analysis is robust to adding an additional period, so that the investor would obtain a certain payoff

C Dataset Construction

Our final dataset is the merger of two proprietary datasets.

1. Monetary and Financial Statistics (MFS), a proprietary dataset from the BdP that includes monthly balance sheet data for all monetary and financial institutions regulated by the BdP. We have data on book values, disaggregated by type of asset/liability, type of counterparty, geographical location of the counterparty, and, for some assets and liabilities, maturity.[4] Monetary and financial institutions are divided in three categories: banks, savings institutions, and money market mutual funds. Most of the institutions are banks; savings institutions is an obsolescent category that applies only to agricultural credit cooperatives. Money market funds are small given the undeveloped nature of the Portuguese market for money funds. More specifically, the different dimensions for which data are available are: (i) asset category: banknotes and coins, loans and equivalent (with repricing dates up to 1 year, 1 to 5 years, more than 5 years), securities except equity holdings (up to 1 year, 1 to 2 years, more than 2 years), equity holdings, physical assets, and other assets (of which derivatives); (ii) counterparty's geographical area: Portugal, Germany, Austria, Belgium, Cyprus, Slovenia, Spain, Es-

from the long-term bond. This would, however, still entail funding risk at loan maturity, since the investor would need to either sell the bond (as in our setup) or raise costly external funds to repay the loan.

[4]Maturity, as classified by the MFS, refers to next residual repricing maturity, or time left until the next repricing date. Lending, for example, is disaggregated as lending with maturity less than 1 year, between 1 and 5 years, and more than 5 years. This measure of maturity does not coincide with contractual residual maturity if the contract is repriced at a frequency lower than its contractual maturity. Due to the institutional characteristics of the Portuguese financial markets, most long-term loans such as mortgages are floating rate loans, indexed to some reference rate such as the Euribor. This means that they are classified as short-term loans in our dataset.

tonia, Finland, France, Greece, the Netherlands, Ireland, Italy, Latvia, Luxembourg, Malta, Slovakia, the European Monetary Union excluding Portugal, non-EMU countries, and the ECB; and (iii) the counterparty's institutional sector: monetary and financial institutions, social security administration, local government, regional government, insurance and pension funds, private individuals, central government, other financial intermediaries, non-financial firms, and other sectors. For the other side of the balance sheet, the counterparty classification is the same, and the liability categories are demand deposits, deposits redeemable at notice (less than 90 days, more than 90 days), other deposit equivalents (less than 1 year, 1 to 5 years, more than 5 years), repurchase agreements, securities (up to 1 year, more than 1 year), other liabilities, and capital and reserves. Crosignani et al. (2015) describes this dataset in more detail and analyzes the evolution of the balance sheets for the Portuguese monetary financial sector during the full sample period.

2. *Sistema Integrado de Estatísticas de Títulos* (SIET), another proprietary dataset from the BdP, which contains monthly information on quantity (face value), book value, and market value for all ISINs that refer to debt instruments issued by the Portuguese central government and a few public companies, and that are owned by financial institutions domiciled in Portugal. This dataset corresponds to the universe of financial institutions in Portugal, conditional on them owning any of these securities. It includes several types of institutions, including monetary and financial institutions, mutual funds, hedge funds, pension funds, and brokerage companies.

For the MFS dataset, we keep the following information for each bank, in each period:

assets, cash and equivalents, lending, lending to households, lending to non-financial firms, holdings of non-equity securities, holdings of government debt, holdings of Portuguese government debt, holdings of GIIPS government debt, holdings of equity securities, and other assets. For the other side of the balance sheet: equity and reserves, demand deposits, savings deposits, time deposits, repo, securities, other liabilities, short-term (less than 1 year) borrowing from the central bank, medium-term (1-2 years) borrowing from the central bank, and long-term (more than 2 years) borrowing from the central bank.

For the SIET dataset, we keep its original structure, a three-dimensional panel (j, i, t), where j is an ISIN, owned by institution i at time t. For each observation, the SIET gives us quantity (face value), market value, and book value. The latter is only available for certain institutions, but we use it only for consistency purposes.

Note that while the datasets intersect, neither is contained in each other: the MFS includes monetary financial institutions that may not own any Portuguese sovereign debt securities and thus are excluded from the SIET dataset, while the SIET dataset includes other types of institutions that are not included in the MFS dataset, such as pension funds.

References

Crosignani, M., M. Faria-e-Castro, and L. Fonseca (2015): "The Portuguese Banking System during the Sovereign Debt Crisis," *Banco de Portugal Economic Studies*, 1, 43–80.

D ECB Collateral Framework and the LTRO

Eligible collateral at the ECB falls in two broad asset classes: marketable assets and non-marketable assets. The first comprises debt instruments such as unsecured bonds, asset-backed securities, and covered bank bonds. The second class includes fixed-term deposits from eligible monetary policy counterparties, credit claims (bank loans), and non-marketable retail mortgage-backed debt instruments. The LTRO period was characterized by an expansion of the eligible collateral. On the day of the announcement of the operations, the ECB also announced collateral availability by allowing riskier asset-backed securities and allowing national central banks (NCBs) to temporarily allow additional credit claims that satisfy their specific criteria, as long as the risks of this acceptance were assumed by the given NCB.

On February 9, 20 days before the second allotment, BdP detailed the criteria for Portugal regarding these additional credit claims. Portfolios of mortgage-backed loans and other loans to households, as well as of loans to non-financial corporations, became increasingly pledgeable as collateral. The expansion of these rules also suggests banks were collateral scarce at the time of the first allotment. Although we do not have asset-level data on the holdings of these classes of assets by banks, we rely on aggregate measures of pledged collateral for each bank. These measures include non-marketable assets whose risk was borne by the Eurosystem, additional credit claims (ACCs), government guaranteed bank bonds (GGBBs) issued from a government fund expanded around the time of the troika intervention in mid-2011, and other marketable assets.

E Additional Figures

Figure E.1: Holdings of Domestic Government Debt, Normalized by Assets. This figure plots the evolution of domestic government bonds held by banks, divided by total assets, from June 2011 to June 2012. The two vertical dashed lines delimit the LTRO allotment period.

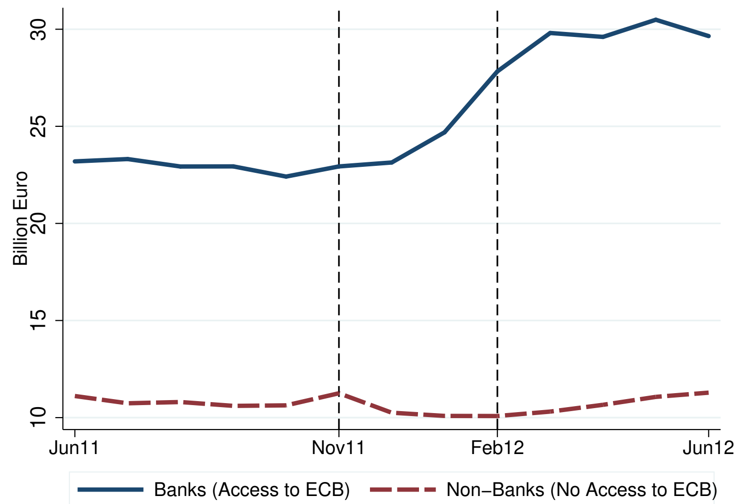

Figure E.2: Holdings of Domestic Government Debt. This figure plots the evolution of domestic government bonds held by banks (solid line) and non-banks (horizontal dashed line) from June 2011 to June 2012. Quantity is measured as the face value in billions of euro. We cannot normalize quantities in the figure by total assets, as we do not observe assets of non-banks. The two vertical dashed lines delimit the allotment period.

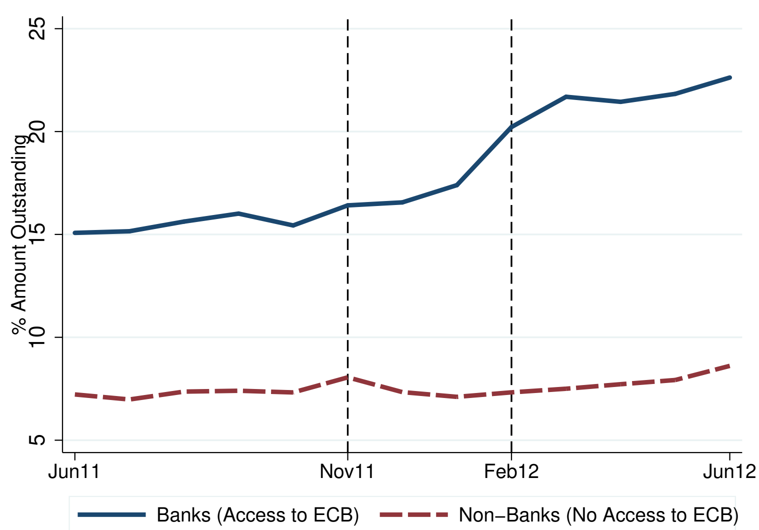

Figure E.3: Holdings of Domestic Government Debt, Normalized by Amount Outstanding. This figure plots the evolution of domestic government bonds held by banks (solid line) and non-banks (dashed line) from June 2011 to June 2012, normalized by the stock of public debt outstanding. The two vertical dashed lines delimit the LTRO allotment period.

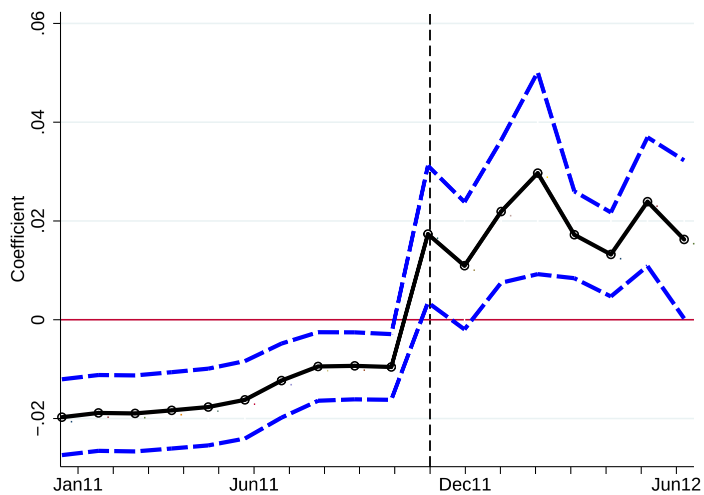

Figure E.4: Placebo Test, Intensive Margin. This figure plots interaction coefficients from a modified version of specification (4), where the interaction term is further multiplied by *Intensity*. The sample period is from January 2011 to June 2012. The horizontal dashed lines delimit the 95% confidence interval. Standard errors are double clustered at the bank-maturity and month levels. The dashed vertical line indicates the last date before the LTRO announcement.

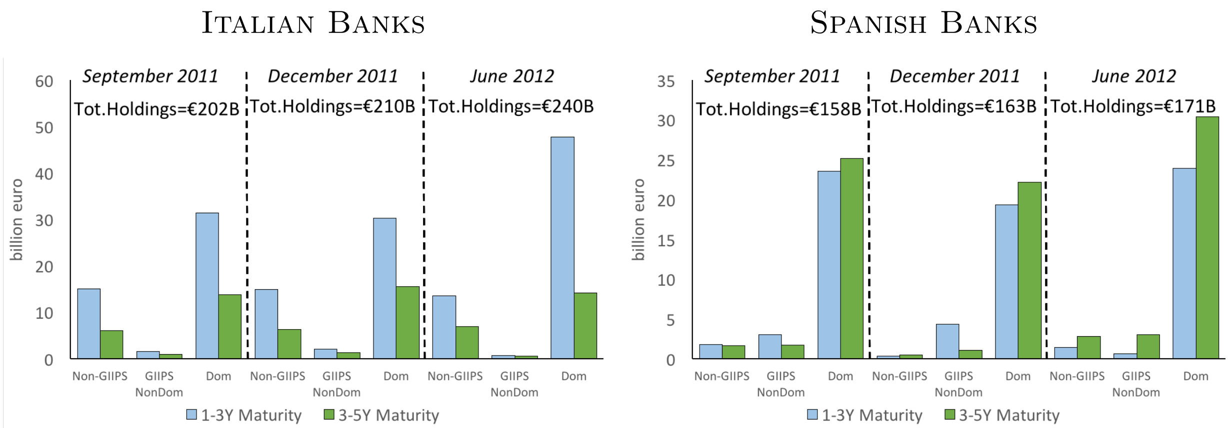

Figure E.5: The Collateral Trade in Italy and Spain: Non-GIIPS, GIIPS Non-Domestic, and Domestic Holdings. This figure shows holdings of sovereign bonds of 1-3Y maturity (blue bars) and 3-5Y maturity (green bars) by Italian banks (left panel) and Spanish banks (right panel) at the time of the three stress tests of September 2011, December 2011, and June 2012. Holdings are in billions of euro and disaggregated into holdings of non-GIIPS, GIIPS non-domestic, and domestic sovereign bonds.

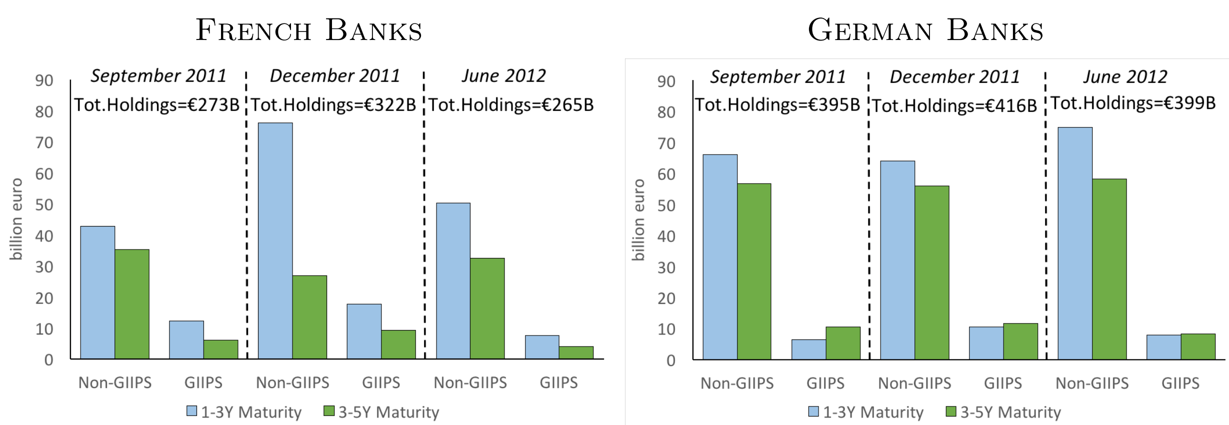

Figure E.6: The Collateral Trade in France and Germany. This figure shows holdings of sovereign bonds of 1-3Y maturity (blue bars) and 3-5Y maturity (green bars) by French banks (left panel) and German banks (right panel) at the time of the three stress tests of September 2011, December 2011, and June 2012. Holdings are measured in billions of euro and disaggregated into holdings of GIIPS and non-GIIPS sovereign bonds.

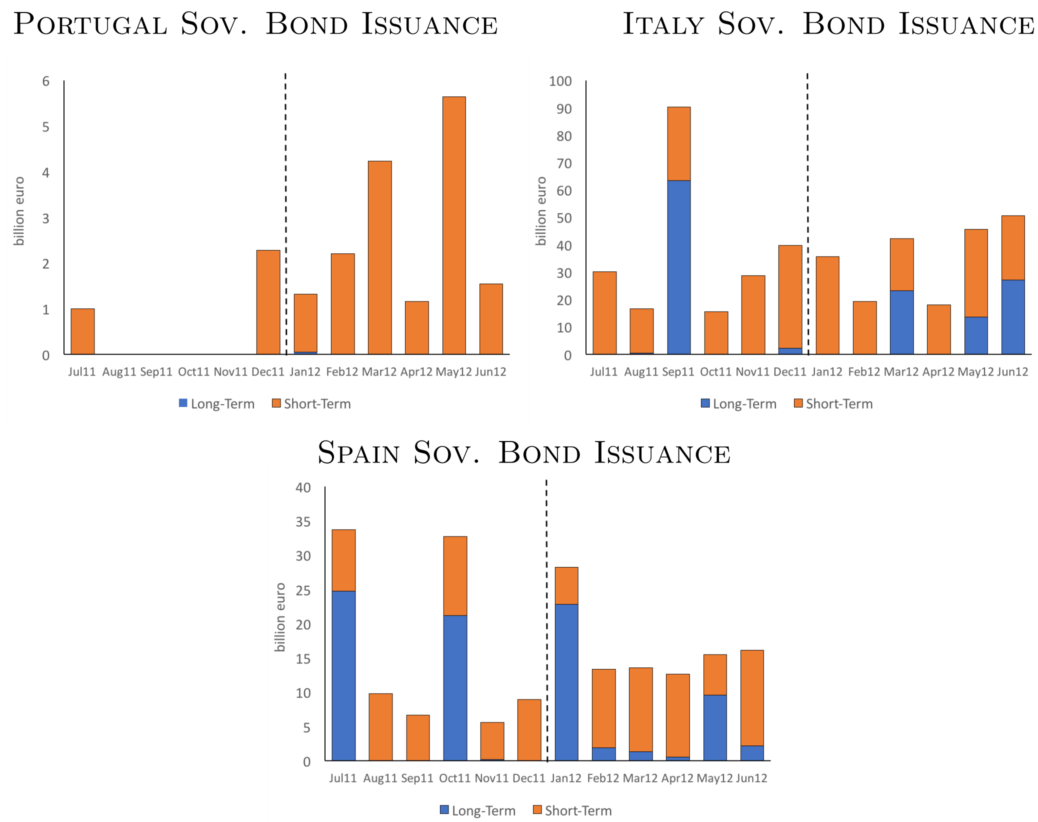

Figure E.7: Public Debt Issuance. This figure shows monthly public debt issuance (billions of euro) in Portugal, Italy, and Spain. The blue (orange) bars correspond to issuance maturing after (before) the LTRO. The vertical dashed line is the LTRO announcement. Source: Bloomberg.

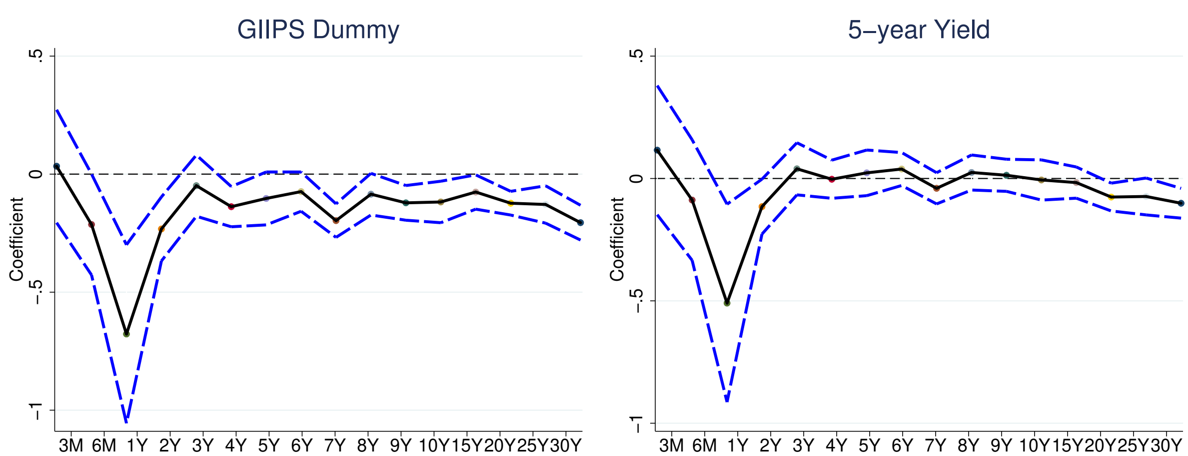

Figure E.8: Yield Curve Steepening, October 2011 1-Year LTRO. This figure plots the $\beta_{(m)}$ estimates of specification (7) as a function of maturity (m). Regressions are estimated separately for each maturity; the sample period is daily from September 27 to October 17, 2011 (the announcement date is October 6); and sample countries are the Netherlands, Portugal, Spain, France, Ireland, Belgium, Germany, Italy, Austria, Finland, Cyprus, Slovakia, and Slovenia. In the left panel, Risk is a dummy equal to 1 for Ireland, Italy, Spain, and Portugal. In the right panel, Risk is the log of the 5-year yield on September 26, 2011. Dashed lines delimit the 99% confidence interval. Standard errors are robust. Source: Bloomberg.

F Additional Tables

	3mo	6mo	1Y	2Y	3Y	5Y	10Y	15Y	30Y
Peripheral Countries									
Italy	0.65	1.47	2.00	3.06	3.72	4.33	5.26	5.47	5.56
Spain	0.27	0.87	1.33	2.08	2.39	3.11	4.24	4.86	5.00
Portugal	2.90	3.53	N/A	12.85	15.32	14.76	11.91	12.52	8.94
Ireland	N/A	N/A	N/A	4.86	N/A	5.39	N/A	6.46	N/A
Greece	N/A	N/A	408.52	N/A	N/A	48.69	30.74	26.58	N/A
Core Countries									
Germany	-1.04	-1.01	-0.94	-0.79	-0.63	-0.15	0.90	1.42	1.48
France	-0.90	N/A	-0.65	-0.25	0.07	0.87	2.07	2.48	2.71
Austria	N/A	N/A	N/A	-0.16	0.16	1.13	2.01	2.40	N/A
Finland	N/A	N/A	-0.95	-0.68	-0.44	0.10	1.34	1.72	N/A
Netherlands	N/A	-1.00	N/A	-0.72	-0.32	N/A	1.27	1.41	1.58

Table F.1: Collateral Trade Spreads. This table shows collateral trade spreads (%) for govenment bonds of each country at different maturities. The collateral trade spread is calculated as the difference between the average daily government bond yields (from December 8, 2011, to February 28, 2012) and the LTRO rate. We use 1% as the LTRO rate, as the rate for main refinancing operations at the time of the policy announcement was 1% and the LTRO rate was fixed as the average rate of the main refinancing operations over the life of the respective operation. N/As correspond to missing data in Bloomberg. Source: Bloomberg.

LHS Var.: LTRO2	(1)	(2)	(3)	(4)	(5)
ΔGovt (Face Value)		1.089***		0.933***	
		(0.010)		(0.091)	
ΔGovt (Market Value)			1.207***		1.034***
			(0.009)		(0.098)
ΔGGBB	1.575***	2.012***	2.060***	1.196**	1.229**
	(0.300)	(0.260)	(0.200)	(0.583)	(0.553)
ΔACC	0.935***	0.800***	0.800***	0.837***	0.838***
	(0.320)	(0.038)	(0.037)	(0.031)	(0.030)
ΔOtherMarketable	1.062**	0.793***	0.792***	0.802***	0.801***
	(0.441)	(0.047)	(0.046)	(0.036)	(0.035)
Total $\text{Collateral}_{\text{Nov11}}$				0.218*	0.221*
				(0.131)	(0.125)
Observations	68	68	68	68	68
R-squared	0.187	0.941	0.943	0.960	0.962

Table F.2: Banks' Buy-and-Borrow Behavior, Robustness. This table presents the estimation results for versions of specification (1). Columns (4) and (5) correspond to Columns (1) and (2) of Table 1 in the main text. The dependent variable is total uptake at LTRO2 normalized by total assets in November 2011. Independent variables include changes in holdings of central bank eligible collateral between November 2011 and February 2012, and the stock of eligible collateral in November 2011. Eligible collateral includes domestic government bonds, government guaranteed bank bonds (GGBB), additional credit claims (ACC), and other marketable securities. All variables are normalized by bank assets in November 2011. All independent variables are haircut-adjusted. Robust standard errors are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

LHS Var.: LTRO2	(1)	(2)	(3)	(4)	(5)
Δ Govt (Face Value)		0.822***		0.738***	
		(0.174)		(0.219)	
Δ Govt (Market Value)			1.013***		0.948***
			(0.207)		(0.184)
Δ GGBB	2.662**	2.698**	2.763**	1.715**	1.762**
	(1.126)	(1.157)	(1.139)	(0.694)	(0.666)
Δ ACC	0.859***	0.820***	0.815***	0.864***	0.859***
	(0.049)	(0.051)	(0.051)	(0.049)	(0.049)
Δ Other Marketable	0.793***	0.790***	0.790***	0.813***	0.813***
	(0.048)	(0.052)	(0.052)	(0.049)	(0.050)
Total $\text{Collateral}_{\text{Nov11}}$				0.250*	0.254*
				(0.139)	(0.133)
Δ Cash	-0.625	0.522	0.405	2.485	2.451
	(5.441)	(2.910)	(2.943)	(2.845)	(2.747)
Δ Non-Govt Bonds	-0.931***	-0.234*	-0.155	-0.135	-0.031
	(0.053)	(0.135)	(0.140)	(0.200)	(0.142)
Δ Equity Holdings	0.006	-0.129	-0.143	-0.336*	-0.357**
	(0.140)	(0.123)	(0.121)	(0.170)	(0.155)
Δ Non-PT Govt Bonds	-0.750***	-0.062	0.022	-0.288	-0.185
	(0.258)	(0.300)	(0.307)	(0.309)	(0.292)
Δ Lending	-0.884***	-0.222*	-0.146	-0.124	-0.025
	(0.041)	(0.124)	(0.130)	(0.193)	(0.137)
Δ Book Equity	0.791***	0.131	0.054	0.148	0.050
	(0.152)	(0.206)	(0.214)	(0.213)	(0.170)
Δ Securities Issued	0.051	-0.445	-0.514	-0.470	-0.555
	(1.046)	(1.012)	(1.014)	(0.622)	(0.620)
Δ Demand Deposits	0.772***	0.196*	0.124	0.131	0.040
	(0.086)	(0.115)	(0.120)	(0.176)	(0.129)
Δ Saving Deposits	1.721**	0.631	0.362	0.387	0.088
	(0.683)	(0.742)	(0.737)	(0.531)	(0.501)
Δ Time Deposits	0.935***	0.234*	0.154	0.137	0.033
	(0.040)	(0.133)	(0.138)	(0.206)	(0.145)
Δ Repo Borrowing	0.398*	0.071	0.032	-0.011	-0.062
	(0.216)	(0.320)	(0.346)	(0.227)	(0.257)
Balance Sheet Controls	✓	✓	✓	✓	✓
Observations	68	68	68	68	68
R-squared	0.935	0.947	0.948	0.968	0.970

Table F.3: Banks' Buy-and-Borrow Behavior, Robustness. This table presents the estimation results for versions of specification (1) that include bank-level controls. The dependent variable is total uptake at LTRO2 normalized by total assets in November 2011. Independent variables include changes in holdings of central bank eligible collateral between November 2011 and February 2012, the stock of eligible collateral in November 2011, and changes in balance sheet components (assets and liabilities). Eligible collateral includes domestic government bonds, government guaranteed bank bonds (GGBB), additional credit claims (ACC), and other marketable securities. The bank-level controls are changes in balance sheet variables. Assets include: cash, non-sovereign bond holdings, equity holdings, non-domestic sovereign bond holdings, and loans. Liabilities include: book equity, securities issued, demand deposits, saving deposits, time deposits, and repos. All variables are normalized by bank assets in November 2011. The collateral independent variables are haircut-adjusted. Robust standard errors are in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$.

LHS Var.: $\widetilde{\text{Holdings}}_{i,m,t}$	(1)	(2)	(3)	(4)	(5)
Post	0.323*	0.081*			
	(0.154)	(0.044)			
Post × Short			0.245**	0.245**	0.242*
			(0.104)	(0.104)	(0.128)
Bank FE	✓	✓	✓		
Maturity FE	✓	✓	✓	✓	
Time FE			✓		
Bank-Time FE				✓	✓
Bank-Maturity FE					✓
Specification	(3a)	(3b)	(4)	(4)	(4)
Sample Bonds	Short-Term	Long-Term	Full Sample	Full Sample	Full Sample
Observations	2,478	2,478	4,956	4,956	4,950
R-squared	0.346	0.524	0.258	0.337	0.686

Table F.4: LTRO and Government Bond Purchases, Alternative Clustering. This table presents the results of specifications (3a) in column (1), (3b) in column (2), and (4) in columns (3)-(5). The dependent variable is the share of total public debt outstanding of maturity m held by bank i divided by the assets of bank i relative to the assets of the financial sector. Independent variables include a Post dummy equal to 1 on and after December 2011 and a Short dummy equal to 1 if the government bond portfolio matures on or before February 2015. Column (1) and column (2) include only bonds maturing on or before or after February 2015, respectively. The sample period includes 12 months and runs at a monthly frequency from June 2011 to May 2012. The sample includes only banks. Standard errors double clustered at the bank and month levels are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

LHS: $\text{Holdings}_{i,m,t}/\text{AmtOutstanding}_{m,t}$	(1)	(2)	(3)	(4)	(5)
Post	0.371**	0.047*			
	(0.157)	(0.024)			
Post × Short			0.329**	0.329**	0.324**
			(0.149)	(0.129)	(0.140)
Bank FE	✓	✓	✓		
Maturity FE	✓	✓	✓	✓	
Time FE			✓		
Bank-Time FE				✓	✓
Bank-Maturity FE					✓
Specification	(3a)	(3b)	(4)	(4)	(4)
Sample Bonds	Short-Term	Long-Term	Full Sample	Full Sample	Full Sample
Observations	2,478	2,478	4,956	4,956	4,950
R-squared	0.402	0.507	0.285	0.375	0.679

Table F.5: LTRO and Government Bond Purchases, Alternative Dependent Variable. This table presents the results of specifications (3a) in column (1), (3b) in column (2), and (4) in columns (3)-(5). The dependent variable is the share of total public debt outstanding of maturity m held by bank i. Independent variables include a Post dummy equal to 1 on and after December 2011 and a Short dummy equal to 1 if the government bond portfolio matures on or before February 2015. Column (1) and column (2) only include bonds maturing on or before and after February 2015, respectively. The sample period includes 12 months and runs at a monthly frequency from June 2011 to May 2012. The sample includes only banks. Standard errors double clustered at the bank-maturity and month levels are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

LHS Var.: $\frac{\text{GovtBondHoldings}_{i,m,t}/\overline{\text{Amount Outstanding}}_m}{\text{Assets}_{i,t}/\overline{\text{Total Assets}}}$	(1)	(2)	(3)	(4)	(5)
Post	0.363**	0.077**			
	(0.151)	(0.031)			
Post × Short			0.289*	0.289**	0.286**
			(0.136)	(0.115)	(0.129)
Bank FE	✓	✓	✓		
Maturity FE	✓	✓	✓	✓	
Time FE			✓		
Bank-Time FE				✓	✓
Bank-Maturity FE					✓
Specification	(3a)	(3b)	(4)	(4)	(4)
Sample Bonds	Short-Term	Long-Term	Full Sample	Full Sample	Full Sample
Observations	2,478	2,478	4,956	4,956	4,950
R-squared	0.303	0.525	0.222	0.299	0.592

Table F.6: LTRO and Government Bond Purchases, Alternative Dependent Variable (2). This table presents the results of specifications (3a) in column (1), (3b) in column (2), and (4) in columns (3)-(5). The dependent variable is the share of total public debt outstanding of maturity m held by bank i divided by the assets of bank i relative to the assets of the financial sector. The amount outstanding in each maturity m and the assets of the financial sector are taken at their mean between December 2011 and February 2012. Independent variables include a Post dummy equal to 1 on and after December 2011 and a Short dummy equal to 1 if the government bond portfolio matures on or before February 2015. Column (1) and column (2) include only bonds maturing on or before and after February 2015, respectively. The sample period includes 12 months and runs at a monthly frequency from June 2011 to May 2012. The sample includes only banks. Standard errors double clustered at the bank-maturity and month levels are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

LHS Var.: $\widetilde{\text{Holdings}}_{i,m,t}$	(1)	(2)	(3)	(4)	(5)	(6)
Post × Intensity	0.086***	0.019*				
	(0.028)	(0.009)				
Post × Short × Intensity			0.067**	0.067**	0.067*	0.067*
			(0.027)	(0.027)	(0.034)	(0.034)
Bank FE	✓	✓	✓			
Time FE	✓	✓	✓			
Maturity FE	✓	✓	✓	✓		
Bank-Time FE				✓	✓	✓
Bank-Maturity FE					✓	✓
Time-Maturity FE						✓
Specification	(7a)	(7b)	(7c)	(7c)	(7c)	(7c)
Sample Bonds	Short-Term	Long-Term	Full	Full	Full	Full
Observations	2,466	2,466	4,932	4,932	4,932	4,932
R-squared	0.409	0.548	0.361	0.401	0.702	0.707

Table F.7: LTRO and Government Bond Purchases: Intensive Margin, Alternative Clustering. This table presents the results of specifications (7a), (7b), and (7c). The dependent variable is the share of total public debt outstanding of maturity m held by bank i divided by the assets of bank i relative to the assets of the financial sector. Columns (1) and (2) include only bonds maturing on or before February 2015 and after February 2015, respectively. Columns (3)-(6) include all bonds. Independent variables include a Post_t dummy equal to 1 on and after December 2011, a Short_m dummy equal to 1 if the government bond portfolio matures on or before February 2015, and an Intensity_i variable equal to LTRO borrowing divided by assets in November 2011. The sample period includes 12 months and runs at a monthly frequency from June 2011 to May 2012. The sample includes only banks. Standard errors double clustered at the bank-maturity and month levels are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Variable (BS)	**Unit**	Sample: No Trade **Nov11 Mean**	Sample: Trade> 0 **Nov11 Mean**	Sample: Trade> 0 $\boldsymbol{corr(BS, Trade)}$
Number of Banks		54	15	
Total Assets	bn euro	2.4	29.4	−53.2 %
Leverage	A/E	6.0	11.0	−21.1 %
Securities	% Assets	10.6	25.4	41.8 %
Govt. Bonds	% Assets	2.3	6.3	51.6 %
Lending to Firms	% Assets	27.7	17.2	−35.1 %
Lending to Households	% Assets	21.9	15.5	−19.9 %
Securities Issued	% Assets	1.7	9.8	−27.7 %
ECB Borrowing	% Assets	1.7	9.4	30.8 %
Deposits	% Assets	29.8	30.7	−14.3 %
Short-term Funding	% Assets	57.7	59.8	26.4 %

Table F.8: Bank Characteristics and Government Bond Purchases. This table shows bank characteristics and collateral trade activity. The third (fourth) column shows cross-sectional means in November 2011 for the group of banks with zero (strictly positive) collateral trade activity. The fifth column shows the correlation between each balance sheet variable and the collateral trade activity in the subsample of institutions that have strictly positive collateral trade activity. Collateral trade activity is defined as government bond purchases between November 2011 and February 2012, divided by assets in November 2011. Securities are holding of securities except equities. Short-term funding refers to securities issued with a maturity of less than one year, short-term deposits, and repurchase agreements. In the last column, total assets is the natural logarithm of total assets.