

Central Bank Interventions, Demand for Collateral, and Sovereign Borrowing Costs*

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Abstract

We analyze the effect of unconventional monetary policy, in the form of collateralized lending to banks, on sovereign borrowing costs. Using our unique dataset on monthly security- and bank-level holdings of government bonds, we document that Portuguese banks increased substantially their holdings of domestic public debt during the allotment of the three year Long-Term Refinancing Operations (LTRO) of the European Central Bank. We argue that domestic banks engaged in a carry trade, which involved the purchase of high-yield bonds with short maturities that could be pledged as collateral for low cost and long-term borrowing from the ECB. This significant increase in bond holdings was concentrated in shorter maturities, as these were especially suited to mitigate funding liquidity risk. The resulting steepening of the sovereign yield curve and the timing and characteristics of government bond auctions suggest a strategic response by the debt management agency. We develop a theoretical framework to study intermediary portfolio choice during the LTRO allotment period that is able to explain the patterns that are observed in the data. We also document several novel stylized facts on the dynamics of banks' balance sheets during a sovereign debt crisis.

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1 Introduction

The importance of financial intermediaries for the macroeconomy has become evident in the last decade. The collapse of the US subprime mortgage market and the subsequent increase of peripheral European government yields impaired the respective financial sectors, which in turn transmitted the shock to the real sector and contributed to long-lasting recessions.¹ In response, central banks throughout the world engaged in unprecedented interventions to improve banks' financial conditions and help restore business activity and employment in the real economy. Understanding banks' portfolio choices before, during and after the crisis, as well as the transmission of central bank policies is therefore key to design effective prudential regulation and lender-of-last-resort (LOLR) interventions.

We document the portfolio choices of Portuguese banks from 2005 to mid-2014, focusing, in particular, on the recent European Central Bank (ECB) three-year Long Term Refinancing Operations (vLTRO).² This decade is a very rich laboratory, as it encompasses three very different macroeconomic environments: (i) the pre-crisis period, when, albeit in stagnant economic conditions³, there were no doubts regarding the solvency of the Portuguese government and of domestic financial institutions; (ii) the crisis period, when peripheral government yields rose to record high levels; and (iii) the period that follows the three-year vLTRO, when the ECB provided extraordinary long term funding to banks. Portugal is an ideal candidate for our analysis as it has been severely hit by the crisis – the 10-year Portuguese bond spread reached more than 16% at the peak of the crisis – and its economy is heavily dependent on bank lending.⁴ Our novel dataset combines a wealth of disaggregated information at the monthly frequency, and results from the combination of two datasets: (i) Detailed balance sheet composition of all monetary and financial institutions regulated as such by the Portuguese central bank (Banco de Portugal, henceforth BdP); (ii) ISIN-level data on the holdings of Portuguese sovereign debt by all financial institutions in the country, including non-monetary institutions.⁵

¹See Brunnermeier and Sannikov (2014), He and Krishnamurthy (2013), and Gertler and Kiyotaki (2010) for macroeconomic models with a financial sector. Ivashina and Scharfstein (2010) and Chodorow-Reich (2014b) present evidence on the negative real effects of the 2008 financial crisis. Bocola (2014), Popov and van Horen (2013), and Acharya et al. (2014a) present evidence on the negative real effects of the European sovereign debt crisis.

²We refer to the three-year operations as *very* Long-Term Refinancing Operations, in order to distinguish them from the regular three-month open market operations that the ECB also classifies as LTRO.

³See Blanchard (2007) for a description of the stagnant state of the Portuguese economy in the first decade of the 21st century. Reis (2013) updates this account with the impact of the financial and sovereign debt crises.

⁴Antão and Bonfim (2008) look at the corporate debt structure of Portuguese firms, and find that bank lending accounted for 64% of total corporate credit in 2007.

⁵Non-Monetary Financial Institutions is the designation used by the ECB to broadly denote all financial companies that do not accept deposits from the public. These include insurance companies, pension funds,

Our contribution is twofold. First, we document the evolution of balance sheet composition of the universe of monetary and financial institutions that operate as banks in Portugal. To our knowledge, we are the first ones to undertake this descriptive exercise as lack of available data forced previous studies to focus on the limited sample of banks subject to the European Banking Authority (EBA) stress tests. We find that banks' total assets and leverage increased during the crisis period and decreased after the ECB activated the vLTROs. On the other hand, private lending contracted during both the crisis and post-crisis periods, and this decrease was primarily driven by lending to non-financial firms. Finally, with respect to the government bond portfolio, we show that holdings were constant between January 2005 and May 2009 and then increased seven-fold until mid-2012, driven by purchases of domestic government bonds.

Second, we study the effect of vLTRO on the government's cost of borrowing. The vLTRO consisted of two allotments of collateralized lending by the ECB to banks at the unprecedented maturity of three years. Banks that sought to borrow from vLTRO had to post eligible collateral on pre-determined dates (allotment dates). vLTRO was announced on 8 December 2011 and funds were allotted on 21 December 2011 and 29 February 2012. We find that (i) the first allotment consisted mainly of roll over of previous (shorter-term) ECB borrowing, (ii) holdings of government bonds increased between the two allotments, and (iii) these purchases explain the amount borrowed from the LOLR at the second allotment. Banks were lacking collateral at the time of vLTRO announcement and were not able to gather sufficient collateral to get *new* borrowing on the first allotment. We show that, between the two allotments, banks scrambled to obtain eligible collateral in the form of government bonds, in order to access the second and last vLTRO allotment. The timing and magnitude of these purchases is strongly suggestive of their value as collateral to tap the lender of last resort facility. This suggests that financial institutions with access to the ECB liquidity facilities took advantage of a profitable "collateral" trade that consisted of purchasing government bonds with maturity less or equal than three years (the maturity of the vLTRO) and pledging them at the LOLR in exchange of a cheap three year loan. With this policy design, the ECB mitigated banks' funding risk as bonds with maturity less than three years would be converted into cash that could then be used to repay the ECB loan at maturity. On the other hand, bonds with maturity in excess of three years still subjected banks to several types of risks (market and funding liquidity) by the time the loan matured. The interaction between the different constraints faced by banks and the ECB intervention generated an expansion in demand for government debt, with a preference for shorter-maturity government bonds. Indeed, during the intra-allotment period, the Portuguese yield curve became steeper, with yields at a horizon lower than three years decreasing, and yields above three years increasing. We develop a theoretical framework that formalizes this intuition, rationalizes these stylized facts, and yields two additional empirical implications, confirmed in the data: (i) following the central bank operation, the

brokerages, etc.. In Portugal, there are three types of monetary financial institutions: banks, credit unions, and money market mutual funds.

sovereign curve steepens, and (ii) the government accordingly adjusts the composition of its bond issuance.

Related Literature. Our paper is related to four strands of literature. First, we contribute to the growing body of literature inspired by the recent Euro crisis that analyzes the role of linkages and feedback loops between the sovereign and the financial sector. [Acharya et al. \(2014b\)](#) model a loop between the sovereign and the financial sector credit risk and find evidence of the two-way feedback from CDS prices. [Bolton and Jeanne \(2011\)](#) present a model where diversification of banks' holdings of sovereign bonds leads to contagion. In the absence of fiscal integration, risky governments issue too much debt as they do not fully internalize the costs of default. [Broner et al. \(2010\)](#) add a meaningful role for secondary markets to an otherwise traditional sovereign default model and show that repatriation is a punishment for increased default probability. The increasing holdings of government bonds by European banks have been documented by [Acharya and Steffen \(2015\)](#), who show that large and undercapitalized banks engaged in a carry trade going long peripheral government bonds while funding their positions in wholesale funding markets. [Drechsler et al. \(2014\)](#) and [Becker and Ivashina \(2014\)](#) suggest that this behavior is consistent with risk-shifting and moral suasion, respectively. [Crosignani \(2014\)](#) shows that these two hypotheses are intertwined, as governments have an incentive to keep domestic banks undercapitalized. [Uhlig \(2013\)](#) also shows that regulators might allow banks to hold risky domestic bonds, thus shifting sovereign default losses to the common central bank.

Empirically, we contribute to the literature analyzing the portfolio choice of European banks by documenting the large increase in domestic government bond holdings as well as of total assets and leverage during the crisis. Compared to previous studies, our comprehensive dataset allows us to describe the cross-section of the universe of Portuguese banks, crucially including the smaller entities that are neither publicly traded nor included in stress tests. Until now the literature employed: (i) European Banking Authority stress test data where only approximately 60 systemically important banks were included (approximately 20 from the periphery, 4 from Portugal); or (ii) Bankscope data, where the nationality of the bond portfolio is not disclosed.⁶ These datasets tend to include only large and publicly listed banks, ignoring privately-owned banks and subsidiaries of foreign banks, which make up a substantial fraction of the banking sector in Portugal. To our knowledge, the only studies that used comparable datasets are [Buch et al. \(2013\)](#) and [Hildebrand et al. \(2012\)](#), both focused on Germany. They find that worse-capitalized banks hold more government bonds and that banks shifted investments to securities that are eligible to be posted as collateral at the ECB. Compared to these two papers, we focus on a peripheral country whose financial sector was severely hit by the crisis and, therefore, targeted by the lender-of-last-resort intervention. Even though we focus on the portfolio of sovereign debt, our stylized facts on lending to the private sector in the pre-vLTRO period are also related to the literature on the transmission of sovereign debt

⁶See [Acharya and Steffen \(2015\)](#) and [Gennaioli et al. \(2014a\)](#) for studies that use this data.

shocks to the real sector, through the contraction of credit supply.⁷

Second, our findings on the impact of vLTRO on portfolio choice relate to the vast literature on the transmission of monetary policy through the financial sector. In their seminal paper, [Kashyap and Stein \(2000\)](#) focus on the bank lending channel of conventional monetary policy. Like [Chodorow-Reich \(2014a\)](#) for the case of the US, we focus our attention on an unconventional monetary policy measure, where the ECB fulfills its role as a lender of last resort. The transmission of vLTRO to private lending is studied, among others, by [Andrade et al. \(2014\)](#). Our data on assets and liabilities is not granular enough to discuss the transmission of vLTRO to private lending. Our paper is closer to [Drechsler et al. \(2014\)](#), who study the collateral pledged at the ECB in the pre-vLTRO period and show that banks' usage of the lender of last resort is associated with risk-shifting behavior. [Trebesch and Zettelmeyer \(2014\)](#) study the effect on government bond prices and ECB behavior in mid-2010, when the European Central bank decided to buy government bonds in the secondary market under the "Securities Market Program". Compared to this contribution, we focus on a different type of intervention (collateralized borrowing as in vLTROs), aimed at relaxing banks' liquidity constraints.

Third, our analysis of the behavior of domestic banks, and the banking sector's demand for domestic sovereign debt also relates to the equally large literature on sovereign debt management. Our findings have implications for the link between the management of sovereign debt, and the performance of unconventional monetary policy. [Bai et al. \(2015\)](#) show that countries react to crises by issuing debt with shortened maturity and promised payments closer to maturity (payments are more back-loaded). Issuance of shorter maturity government bonds during periods of sovereign distress has been also documented by [Broner et al. \(2013\)](#), who show that, for emerging economies, borrowing short term is cheaper than borrowing long term, especially during crises. [Arellano and Ramanarayanan \(2012\)](#) document the same pattern in emerging markets and show that maturity shortens as interest rate spreads of government debt rise. In their model, short term debt is more effective at providing incentives to repay while long term debt is an hedge against fluctuations in interest rate spreads.

Finally, our analysis relates to the emerging literature on the interaction and coordination of fiscal and monetary policies during the financial crisis. [Greenwood et al. \(2014\)](#) present evidence that the US Treasury behaved strategically during the Federal Reserve's Quantitative Easing programme, taking advantage of the reduction in longer-term yields to increase the maturity of its debt. This evidence is consistent with the behavior predicted by the trade-off model of optimal maturity of government debt developed by [Greenwood et al. \(forthcoming\)](#).

⁷Both [Ivashina and Scharfstein \(2010\)](#) for the case of Lehman Brothers, as well as [Acharya et al. \(2014a\)](#), [Bofondi et al. \(2013\)](#), and [Popov and van Horen \(2013\)](#) for the case of the European sovereign crisis document negative real effects of banks' exposure to risky government bonds, namely through reduced lending to non-financial institutions. [Almeida et al. \(2014\)](#) also show the aforementioned negative effect through credit rating downgrades.

We contribute to the literature on policy coordination in two ways: first, we show evidence that the Portuguese Treasury also behaved strategically, taking advantage of investor’s preference for short-term debt that arises from liquidity and collateral constraints. Second, we show that programs that involve providing incentives for private investors to acquire government debt can have the opposite effect of programs where assets are directly purchased by institutions such as central banks. In particular, while direct asset acquisition programs such as QE tend to flatten the yield curve, indirect acquisition programs such as the vLTRO interact with investors’ constraints to steepen the yield curve. This has consequences for the strategic reaction of the fiscal authority, who chooses to tilt the maturity structure of its issuances towards the longer end in the first case, and towards the shorter end in the second, so as to take advantage of the respective decreases in yields.

The rest of the paper proceeds as follows: Section 2 describes the data and offers some novel stylized facts on the evolution of the financial sector throughout the three distinct periods in our sample. Section 3 provides some institutional background on the main ECB unconventional interventions that are the focus of this paper. Section 4 develops and presents a theoretical framework that analyzes bank portfolio choice and government debt issuance in response to the ECB’s unconventional monetary policy measures. Section 5 empirically studies the behavior of banks around the vLTRO period, documenting some of the empirical predictions of the model. Section 6 studies the behavior of sovereign borrowing costs and government bond issuances around the vLTRO period. Section 7 concludes.

2 Data and Stylized Facts

In this Section, we briefly describe the Portuguese macroeconomic conditions during the period 2005-2014 and the proprietary dataset from BdP. We then use the latter to illustrate the evolution of assets and liabilities of Portuguese banks during the sample period. The reader is referred to [Appendix C](#) for figures and to [Appendix A](#) for more details on variables and dataset construction.

2.1 Macroeconomic Conditions

Portugal was severely hit by the European debt crisis. The top panel of [Figure C.1](#) shows, for the period 2005-2014, the time series of the Portuguese 10-Year government bond yield (solid blue line) and the spread between the 10-Year Portuguese government bond and the German benchmark (dashed green line).⁸ From both time series it is evident that, starting

⁸The results are similar if we instead use 5-Year USD denominated CDS spreads.

in mid-2009, the Portuguese sovereign credit risk evolved from being virtually riskless to a yield of 16.6% in January 2012. The medium panel shows that the higher credit risk has been associated with an increased government debt burden, both in level (m EUR, solid blue line) and as a percentage of GDP (dashed red line). Portuguese GDP, which had grown until 2009, started declining thereafter. Moreover, from the onset of the crisis, a larger share of public debt has been held by domestic banks. The bottom panel of the figure shows that banks have been historically owning approximately 10% of Portuguese public debt and that this ratio doubled during the crises. [Figure C.2](#) shows the evolution of the sovereign yield curve slope between January 2008 and February 2014 where the slope is defined as the difference between 30Y yield (10Y yield in the lower panel) and various short-term yields. Both panels depict an inverted yield curve between mid-2011 and mid-2012.

2.2 Dataset Description

We use two proprietary datasets from Banco de Portugal (BdP), the Portuguese central bank. These datasets are monthly panels from January 2005 to May 2014.⁹

The first dataset contains monthly information on the composition of the balance sheets of all monetary and financial institutions regulated by BdP. The full sample contains 82 banks, 10 savings institutions, and 13 money market funds. An observation consists of the value held in a given month, by a given institution, of an asset in a specific category vis-à-vis all counterparties in a given institutional sector and geographical area.¹⁰ This dataset allows us to determine, for example, the value of all non-equity securities whose issuer was the German central government, that were held by bank i in January 2006. Observations are measured in book value.

The second dataset contains monthly ISIN-level data of all holdings of government debt by

⁹Despite differences in coverage, we find that the two datasets are overwhelmingly consistent with each other, see [Appendix A](#) for details.

¹⁰More specifically, the different dimensions for which data are available are: (i) Asset category: banknotes and coins, loans and equivalent (with repricing date 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, Estonia, Finland, France, Greece, Netherlands, Ireland, Italy, Latvia, Luxembourg, Malta, Slovakia, European Monetary Union excluding Portugal, Non-EMU Countries, European Central Bank; (iii) 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, 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, capital and reserves.

domestically regulated institutions. The universe of entities of this second dataset is larger than that of the first, as it includes all non-monetary financial institutions such as mutual funds, hedge funds, brokerages, and pension funds (among others). For each institution, we have data on book, face, and market value of all holdings of Portuguese government debt (as well as debt of major public companies) at the ISIN level. We cross this dataset with bond-level information such as yield, duration, maturity, coupon and amount issued, obtained from Bloomberg.¹¹

2.3 Stylized Facts

We begin our analysis by focusing on the first dataset, which encompasses the universe of monetary and financial institutions in Portugal. We present the main facts that emerge from the data. This dataset includes three types of institutions: banks, savings institutions, and money market funds. Most of the institutions are classified as banks; savings institutions comprise agricultural credit unions, mostly small regional institutions; finally, and as in other European countries, the Portuguese money market mutual fund sector is relatively undeveloped and these institutions are few and small.

We choose not to follow this functional classification, and instead adopt one based on size and nationality. We classify institutions in three categories:

- **Big:** the four largest banks in Portugal that account for an average of 65% of total assets, and 70% of total government bond holdings throughout the sample.
- **Foreign:** all banks that are either subsidiaries of or wholly owned by foreign banks. This category consists mainly of small banks, also including some significantly sized banks resulting from the acquisition of major domestic banks by large global banks. This category consists of an unbalanced panel of 52 institutions.
- **Others:** all other domestic banks. While many of these are small banks, this category still includes some sizable institutions that borrowed nontrivial amounts from the European Central Bank. It includes an unbalanced panel of 35 institutions.

The classification of banks as foreign or domestic is undertaken manually, by crossing information from several sources (ECB, SNL Financial) as well as by analyzing self-reported institutional information.

As mentioned in the introduction, we divide the long sample in three periods: (i) the pre-crisis period from January 2005 to April 2009, when government bond yields were close to the German 10-year benchmark (see first panel of [Figure C.1](#)); (ii) the crisis period from May

¹¹We are able to match more than 98% of the value of the dataset with Bloomberg.

2009 to November 2011, when Portuguese sovereign spreads increased from 4% to 14% and the share of government debt held by domestic banks also increased from 10% to 20% (see bottom panel of [Figure C.1](#));¹² (iii) the unconventional monetary policy period starting in December 2011, when the European Central Bank (ECB) announced two three-year vLTRO allotments. Throughout this section, we superimpose vertical lines on all plots, coinciding with the dates that separate these periods (May 2009 and December 2011). Later, we will further partition the vLTRO period into the intra-allotment period (between the two allotments of December 2011 and February 2012) and the post-vLTRO period, after the second and last allotment. Section 3 discusses the vLTRO operation in greater detail.

We now proceed to document, in greater detail, the evolution of the main components of both sides of the balance sheet and leverage. Table 1 presents a snapshot of the balance sheet composition of the banks in our sample at three dates: the early stages of the crisis (May 2009), the month of the vLTRO announcement and first allotment (December 2011), and the most recent data period (May 2014).¹³

2.3.1 Asset Side

Total Assets. [Figure C.3](#) shows the evolution of total assets during the period 2005-2014. First, we note that the Portuguese banking sector is very concentrated, with the four Big banks holding around 60% of total assets in the sample at any point in time. The other categories seem to have roughly stable shares, the Foreign category being slightly larger until the very end of the sample. In general, assets are slow-moving and inverse U-shaped, except for other domestic banks, for which they are strictly increasing at an apparently constant trend. For big banks, assets grow at a constant trend until peaking around the vLTRO period, and decreasing thereafter. For Foreign banks, assets are increasing in the early sample. Growth accelerates during the crisis, and assets peak shortly after the LTRO.

Lending. [Figure C.4](#) illustrates total lending (top panel) and private lending (to non-financial firms and households; bottom panel). We do not present any geographical disaggregation for lending since lending to non-domestic counterparties is very small (on average 2% of total lending over the sample). As the largest component of assets, the behavior of lending is very similar, presenting very slow moving and U-shaped dynamics. It peaks during the crisis period: June 2010 for Big banks, June 2011 for Foreign, and November 2009 for Others. This contrasts with assets, which keep growing throughout the crisis period and peak only after the vLTRO. Lending seems to behave in a very stable manner across categories, the only noticeable change of pattern relating to Foreign banks at the end of the sample. Big

¹²May 2009 is also the month when concerns regarding the capitalization of domestic banks first arise, and the government creates a €4 bn recapitalization fund

¹³[Table B.1](#) reproduces Table 1 for January 2005.

	May 2009			Dec 2011			May 2014		
	Big	Others	For	Big	Others	For	Big	Others	For
No. banks	4	35	41	4	32	35	4	37	34
Mean assets	74.8	2.5	2.7	88.8	2.9	3.6	75.4	2.6	2.9
Median assets	78.7	0.57	0.78	95.1	0.38	0.91	78.2	0.44	0.47
Cash	.00	.00	.00	.00	.00	.00	.00	.00	.00
Securities	.24	.18	.10	.34	.20	.11	.35	.27	.12
Govt	.02	.01	.00	.05	.06	.02	.07	.12	.03
Dom Govt	.02	.01	.00	.04	.06	.02	.06	.09	.01
Lending	.69	.71	.83	.59	.67	.84	.58	.64	.82
Individuals	.27	.20	.18	.23	.17	.22	.24	.14	.23
Non-fin.	.25	.18	.33	.20	.18	.32	.20	.14	.27
Other	.07	.11	.08	.07	.12	.05	.07	.08	.05
Deposits	.69	.64	.79	.57	.56	.81	.57	.47	.71
MFI	.34	.24	.59	.24	.17	.58	.19	.13	.49
Private	.32	.37	.19	.29	.36	.21	.34	.31	.17
ECB	.00	.01	.00	.09	.06	.01	.09	.05	.03
> 2y ECB	.00	.00	.00	.04	.02	.00	.09	.03	.02
Repo	.00	.02	.00	.02	.01	.01	.01	.01	.01
Securities	.18	.05	.01	.22	.04	.01	.19	.03	.01
Other Liab.	.05	.06	.07	.04	.06	.04	.04	.05	.07
Equity	.08	.23	.13	.07	.26	.12	.10	.39	.18

Table 1: Balance Sheet Composition. This table shows the composition of balance sheets of all monetary and financial institutions regulated by the BdP, drawing from [Kashyap and Stein \(2000\)](#) (excluding wholly owned subsidiaries and money market funds). Mean and median assets are expressed in €bn, while all asset and liability categories are expressed as a fraction of total assets. Subsidiaries are dropped for the three categories. [Table B.1](#) in [Appendix B](#) repeats the same analysis for January 2005.

banks represent roughly 60% of total lending across the sample, and lending to the private non-financial sector (households and firms) represents around 60-70% of total lending.

Government Debt Holdings. [Figure 1](#) plots the evolution of total government bond holdings (top panel) and domestic government bond holdings (bottom panel). We can conclude the following: (i) Total government bond holdings are stable between January 2005 and May 2009. After this date, they increase for all categories; (ii) The increase is steady for domestic banks (Big and Others);¹⁴ (iii) While the growth in holdings decelerates right before the first vLTRO (December 2011), it quickly picks up for domestic banks; (iv) The increase in

¹⁴Foreign banks peak in August 2010, and then reduce their holdings to pre-May 2009 levels.

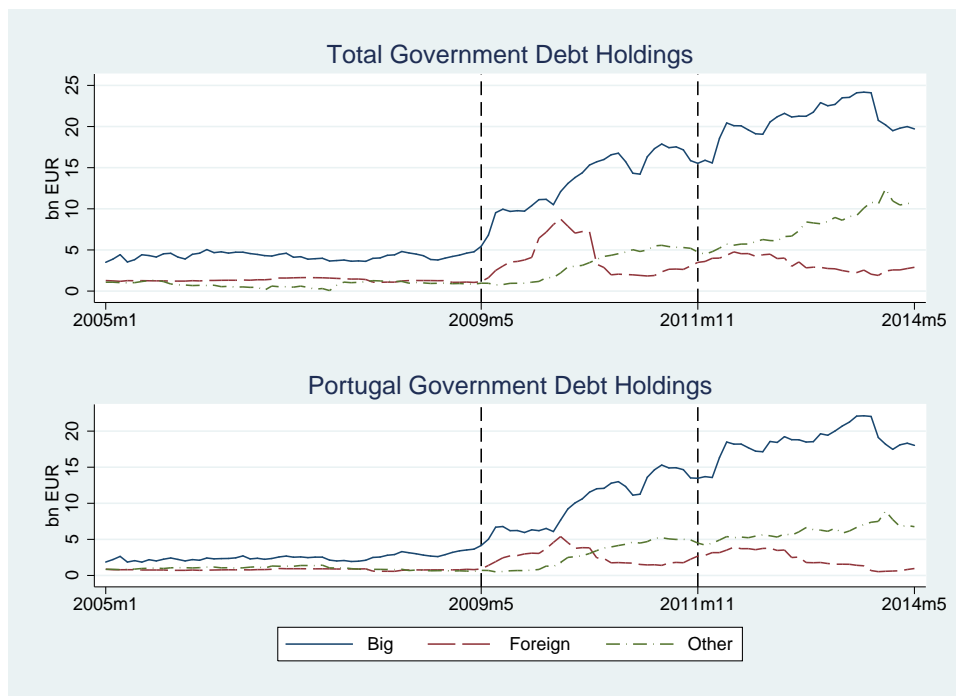


Figure 1: Government Bond Holdings. This figure plots total government bond holdings (top panel) and domestic (Portugal) government bond holdings (bottom panel), for the three categories in our classification (Big, Foreign, Others). Total government bond holdings for an institution are defined as the value, in a given month, of all securities except equity (at all maturities) whose counterparties are central governments. Domestic government bond holdings have the Portuguese central government as the counterparty.

total government holdings throughout the sample is driven mostly by an increase in holdings of domestic government debt. Domestic institutions are overwhelmingly responsible for this increase (€25 bn vs. €0.09 bn for foreign institutions); (v) While total holdings of domestic debt are very similar across domestic and foreign institutions up to mid-2010, domestic banks start accumulating domestic government debt at a very quick pace from that period onwards, while foreign banks reduce their exposures; (vi) Big banks increase their exposure to non-domestic debt from 2009 onwards, but reduce their exposures to pre-crisis levels by the end of 2011. Small domestic banks and foreign banks increase their holdings of non-domestic debt very quickly from 2011 onwards.¹⁵ (vii) The behavior of non-domestic debt holdings seems to be entirely driven by holdings of non-domestic GIIPS, as Figure C.5 illustrates.

Figure C.6 shows the evolution of residual maturity of government bond holdings for the subsamples of entities that have access to the LOLR (mostly banks) and entities that do not have access to the LOLR. This latter group is the set of all institutions that are included in

¹⁵The increase starts only in 2012 for small banks

the government bond holdings dataset, but not in the monetary and financial institutions one. Both subsamples increased the residual maturity in the first part of the crisis period and then decreased it in the years leading to vLTRO announcement. [Figure C.7](#) shows the total stock and the residual maturity of the Portuguese public debt, for comparison and reference.

Other Assets. [Figure C.8](#) plots the evolution of holdings of securities excluding government debt. The top panel considers non-equity securities, while the bottom panel refers to equity securities. Equity holdings are relatively stable and display an increasing trend, driven by Big banks. Other securities display a strong positive trend, also driven by large banks, that starts in early 2008. The behavior of these holdings mirrors that of total assets, peaking right after the vLTRO and decreasing thereafter.

2.3.2 Leverage and Liabilities

We now turn to the right side of the balance sheet and illustrate the evolution of leverage and liabilities.

Book Leverage. The evolution of book leverage, defined as assets divided by book equity is illustrated in [Figure C.9](#). Leverage displays a countercyclical pattern. In early 2009, large and foreign banks appear to delever, but leverage once again starts increasing in late 2009, peaking in December 2011, particularly for these categories. In the post-vLTRO period, leverage decreases for all categories. Domestic banks seem to be less levered, on average, than foreign banks. This may, however, reflect accounting effects since most foreign banks are subsidiaries of large global banks.

Liabilities. [Figure C.10](#) decomposes the evolution of liabilities in retail (top panel) and wholesale (bottom panel). Retail liabilities include deposits, at different maturities, whose counterparties are neither MFI's nor central banks. The counterparties are thus non-financial firms, households, and the government. Wholesale liabilities, on the other hand, include deposits owned by MFI's as well as repurchase agreements and securities (bonds and commercial paper). Retail liabilities are dominated by the large banks, reflecting their market power in the retail banking industry. They steadily increase until the beginning of the crisis, when they stabilize, and start increasing again until the vLTRO. The stabilization that follows may be a consequence of generalized deleveraging. This can also be observed for wholesale liabilities, on which both smaller and foreign institutions are much more reliant. They are generally slow-moving and inverse U-shaped, peaking before the vLTRO, and capturing the same overall trend as for lending.

The greater reliance of smaller institutions on what we define as wholesale funding may appear to contradict the conventional wisdom that larger banks tend to have a comparative advantage in raising funding from non-retail sources (see [Kashyap and Stein \(2000\)](#)). Two broad facts help us justify this: first, this reliance comes mostly on the form of deposits by other MFI's, and not via non-deposit debt instruments. Second, this is consistent with the high level of market concentration in the Portuguese retail deposit market, and the fact that smaller

banks, unable to compete with the larger established banks for retail deposits, tend to be more specialized in their activities and less retail oriented.

The behavior of these broad funding aggregates hides some heterogeneity in their composition, however. To illustrate this, [Figure C.11](#) plots the evolution of deposits whose counterparties are MFI's. The bottom panel shows a significant decreasing trend on deposits by foreign MFI's held at domestic banks, beginning with the crisis. This reflects loss of access to international funding markets.¹⁶ The magnitude of this decrease is considerable, when accounting for the fact that deposits by foreign MFI's were approximately 33% of assets for large banks in May 2009. The top panel, on the other hand, plots deposits by domestic MFI's, and shows an increasing trend, with a significant surge in the middle of the crisis. The magnitudes are, however, considerably smaller.

3 Institutional Framework

Having documented that the behavior of banks seems to change significantly after the vLTRO, we use this section to provide a more detailed description of the conventional and unconventional policy measures that the ECB employs to implement monetary policy in the Eurozone.

The Eurosystem's regular open market operations are conducted through repurchase agreements: banks can borrow from the monetary authority by pledging collateral in exchange for cash loans.¹⁷ In particular, regular open market operations consist of one-week and three-month liquidity providing facilities, called main refinancing operations (MROs) and longer-term refinancing operations (LTROs), respectively. On 8 December 2011, as the Eurozone crisis deteriorated even further, the European Central Bank announced two unprecedented "very" long-term LTROs (vLTROs), which provided three-year funding to participating banks. The remainder of this section describes the regular open market operations (MROs and LTROs) as well as the two vLTROs.¹⁸

¹⁶[Boissel et al. \(2014\)](#) show that the Portuguese private repo market shut down in April 2011, as soon as the Portuguese government officially requested international assistance.

¹⁷The difference with respect to U.S.-style open market operations (liquidity supplied through purchases of Treasury bonds) goes back to the Statute of the European System of Central Banks (ESCB), which states, in Article 18, that "the ECB and the national central banks may (i) operate in the financial markets by buying and selling outright (spot and forward) or under repurchase agreement and by lending or borrowing claims and marketable instruments, whether in euro or other currencies, as well as precious metals; (ii) conduct credit operations with credit institutions and other market participants, with lending being based on adequate collateral." Source: [Statute of the ESCB](#). For more details on the architecture of the European monetary policy, see [Mercier and Papadia \(2011\)](#).

¹⁸The ECB adopted other non-standard monetary policy operations: (i) US dollar liquidity-providing operations, (ii) three covered bond purchase programs, (iii) purchases of government bonds in the secondary

3.1 Regular Open Market Operations

The regular open market operations are conducted through repo auctions with maturity of one or two weeks (MROs) and three-months (LTROs).

The one or two weeks MROs are the main policy tool, accounting for approximately 75% of the overall liquidity provided by the monetary authority in normal times. MROs are designed as a variable rate tender, i.e. banks submit bids in terms of a volume and a price (the bid rate), subject to a minimum bid rate set by the ECB. ECB then allocates a pro rata amount at the marginal rate.¹⁹ MROs are designed to support the maturity and liquidity transformation roles of banks and to signal, through the bid rate, the central bank’s monetary policy stance.

On the other hand, the three month LTROs are designed to provide “a good opportunity for smaller counterparties, which have limited or no access to the interbank market, to receive liquidity for a longer period”. The tender, conducted with variable-rate, a relatively small and pre-announced allotment, and no reservation price is designed to minimize the impact on market rates, with the monetary authority acting as a price taker.

In a world with frictionless markets, the LTROs are a redundant policy tool, since banks could simply access and rollover the shorter-term MROs, while hedging the interest rate risk using financial instruments. If hedging is costly, however, LTROs become an attractive option for banks that want to increase and diversify the maturity of their funding while ensuring themselves against interest rate risk and liquidity risk (namely the risk of losing access to shorter-term lending). Interestingly, in October 2002, banks were consulted by the ECB on whether to eliminate LTRO. Banks almost unanimously rejected the proposal in January 2003, arguing that LTRO played an important role in their liquidity management, allowing them to diversify the maturity of liabilities.²⁰ Banks also argued that “LTRO plays an important role in credit institutions’ liquidity contingency plans”, i.e. their plans for obtaining liquidity during times of general market tension or when faced with individual liquidity problems. Accordingly, the ECB strengthened the supply of longer term funding with 6-month and 12-month LTROs, starting in late 2010 and throughout 2011.²¹

market under the Securities Market Programme, (iv) a series of targeted longer-term refinancing operations (TLTROs), (v) the ABS purchase program, and (vi) the “Expanded Asset Purchase Programme”. These measures are not the focus of this paper.

¹⁹See [Eisenschmidt et al. \(2009\)](#) for a detailed description.

²⁰See [ECB \(2002\)](#) and [ECB \(2002\)](#) for details on the consultation and its rejection by participating banks.

²¹The ECB provided three 6-month LTROs allotted in April 2010, May 2010, and August 2011. In addition, a 12-month maturity LTROs was allotted in October 2011.



Figure 2: Timeline of the vLTRO. This figure shows the timeline of the vLTRO facility. The announcement (8Dec11) is followed by two allotment dates (21Dec11 and 29Feb12).

3.2 Very Long-Term Refinancing Operations

On 8 December 2011, the ECB announced “measures to support bank lending and money market activity”.²² The most important of these measures was the announcement of two three-year maturity long-term refinancing operations (vLTROs) with the option of early repayment after one year. Compared to standard LTROs, the two vLTROs also relaxed the collateral eligibility requirements. In previous operations, the collateral was required to have a AAA rating from two agencies. Such restriction was replaced by requiring a second-best rating of a single A. The two operations were conducted with full allotment, meaning that there was no limit to the loan a bank could get, provided that it posted enough eligible collateral. The interest rate was very low, based on the overnight rate during the loan period, which was around 1% at the time of announcement. Participating banks had to pledge eligible collateral to get funding. The LOLR evaluated the pledged collateral using a publicly available schedule. This schedule assigned an haircut, based on the collateral rating, asset class, and residual maturity. For example, a covered bond rated AAA with residual maturity of 8 years had an haircut of 6.5, requiring the bank to pledge 106.5 in collateral to obtain a loan with a face value of 100. Figure 2 shows the timeline of the two vLTROs. The first operation (vLTRO1) was allotted on 21 December 2011 and the second operation (vLTRO2) on 29 February 2012. On 6 September 2012 the ECB decided to expand the eligible collateral to “debt instruments denominated in currencies other than the euro, namely the US dollar, the pound sterling and the Japanese yen, and issued and held in the euro area”. On 18 July 2013, the ECB updated the haircut applicable to eligible collateral.

²²Source: [ECB Website](#), 8 December 2011 Press Release.

PANEL A	Tot tapped (bn €)	No. banks
vLTRO1	19.9	13
vLTRO2	26.2	18

PANEL B	Tot tapped (bn €)			No. banks			
	MRO	LTRO	ECB Total	MRO	LTRO	ECB Total	Total Assets
Nov-11	37.7	7.4	45.1	14	9	14	552.1
Dec-11	24.4	1.1	45.3	15	5	16	551.9
Feb-12	25.9	1.1	46.8	14	5	15	559.9
Mar-12	8.2	1.0	55.3	13	4	18	557.2

Table 2: Borrowing from the LOLR. These tables show the number of banks and the amount borrowed during various ECB operations. The top panel shows the gross amount tapped (bn €) and banks that accessed the two vLTROs of December 2011 and February 2012. The second panel shows, at four different dates, the total amount borrowed by Portuguese banks under standard open market operations interventions, namely MRO, and LTRO. The third column shows the total borrowing (MRO, LTRO and vLTRO) from ECB. The last column illustrate total assets (bn €). [Table B.2](#) in [Appendix B](#) shows the same statistics for the subsamples of Big Four, Foreign, and Rest.

3.3 Borrowing From ECB

[Figure 3](#) plots the evolution of all liabilities whose counterparties are either BdP or the ECB. In the Eurosystem, open market operations are conducted through the balance sheets of the national central banks, and so the BdP is effectively the only counterparty. The top panel plots total borrowing from the LOLR and confirms the previous claims of loss of access to funding markets in the starkest manner: borrowings jump in late 2009 and early 2010, confirming the substitution of private wholesale for central bank funding. The bottom panel plots long-term borrowings (with maturity exceeding 2 years). These are the vLTRO1 and vLTRO2, accessed in December 2011 and February 2012, respectively. Note that the effective net uptake of vLTRO1 is almost non-existent, with long-term borrowing increasing substantially, but total borrowing remaining essentially unchanged. The same is not true for the vLTRO2, which corresponds to a significant increase in total borrowing.

[Table 2](#) illustrates aggregate borrowing from the ECB by Portuguese banks. The top panel shows the amount tapped and the number of banks that accessed each vLTRO allotment. The bottom panel shows, for four dates, the amount borrowed during standard open market operations, i.e. MRO and LTRO. These numbers mirror our analysis of [Figure 3](#), which shows that total ECB borrowing is relatively stable until the second allotment of the vLTRO. Crucially, it was stable between the two allotments.

While the top panel shows a positive uptake of both vLTROs (€19.9 bn and €26.2 bn), the bottom panel shows that Total ECB Borrowing was flat around vLTRO1, suggesting that

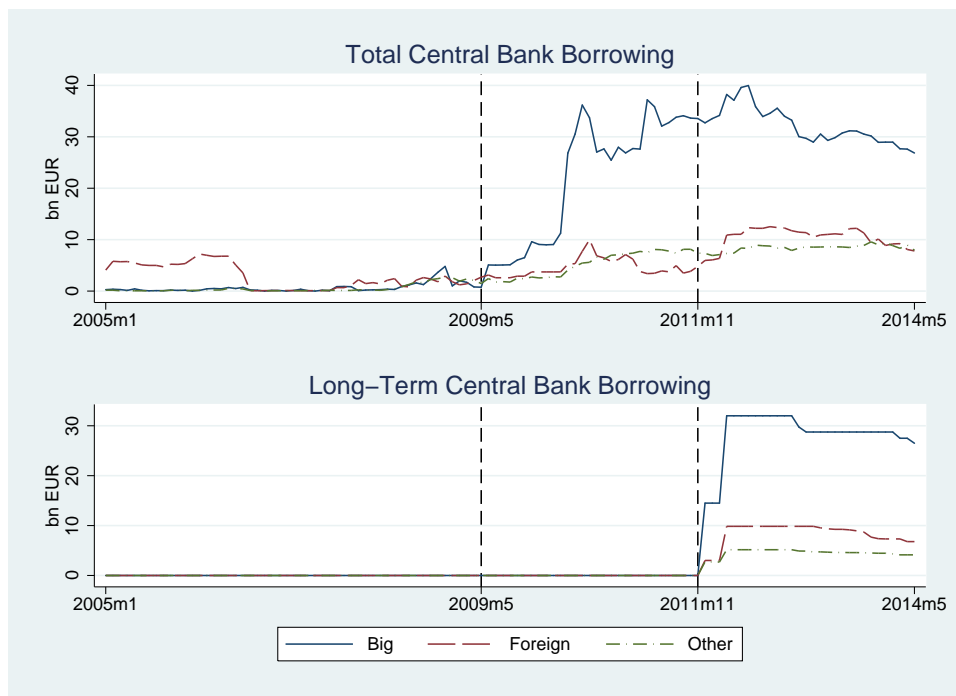


Figure 3: Central Bank Borrowing. This figure plots the evolution of liabilities (primarily time deposits) whose counterparty is either the BdP or the ECB. The top panel plots the evolution of all central bank borrowings, while the bottom panel plots the evolution of long-term central bank borrowings, with maturity exceeding 2 years (the vLTROs).

vLTRO1 was used to roll over previous central bank funding (MRO and LTRO) at the better vLTRO terms.

3.4 Bank Behavior During vLTRO

How did banks react to the announcement of the two vLTROs? After the 8 December announcement banks had two weeks to prepare for vLTRO1 and almost three months for vLTRO2. Having a substantial share of their eligible assets already pledged at the LOLR, institutions had few weeks to gather eligible collateral to take advantage of the one-time three-year liquidity facility provided by the LOLR. Not surprisingly, vLTRO2, giving participants more time to gather collateral, saw greater participation.²³

From the previous sections, it is evident that the vLTRO program had a significant long-term impact on the trend of several bank variables: assets, which had been steadily growing until this period started decreasing. Measures of retail and wholesale funding stopped growing and

²³vLTRO1 was tapped by 523 banks for € 489 bn and vLTRO2 was tapped by 800 banks for € 529 bn.

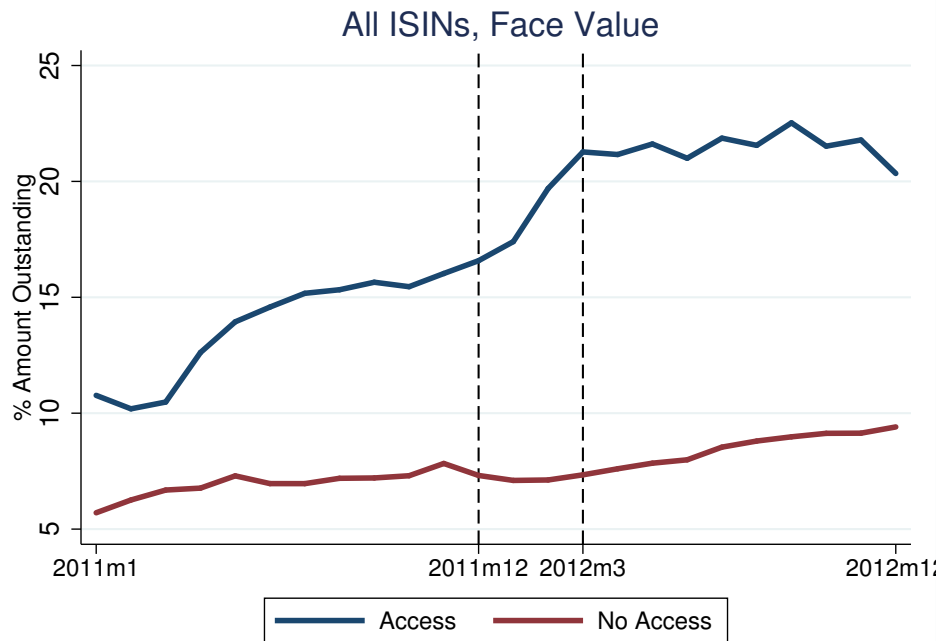


Figure 4: Holdings of Domestic Government Debt, vLTRO period. This figure plots the evolution of the quantity of domestic government bonds held by banks and non-banks, around the vLTRO period. The quantity is measured as the total face value divided by the total amount outstanding.

started declining, respectively. This reduction in the size of balance sheets was reflected in a declining trend for book leverage.

We take a closer look at the evolution of some observable bank characteristics around the vLTRO allotment period. We start by documenting that the quantity – measured in face value – of domestic government bonds held by banks increased sharply in the period between the two allotments. Figure 4 compares the evolution of the quantity of domestic government bonds held by banks (that could tap vLTRO) and non-banks (that were excluded from vLTRO) throughout 2011 and 2012. The vertical lines correspond to each of the two allotments, December 2011 and March 2012.²⁴ Two striking facts that emerge from the figure are: (i) the behavior of non-banks hardly changed around the vLTRO period, and (ii) banks increased their holdings significantly *between* the two allotments. This behavior is significantly different from the one that is observed before the first and after the second allotments.

²⁴The allotment took place on the last day of February 2012, but the funds were only effectively made available one day later, thus vLTRO uptakes are only reflected in March 2012.

3.4.1 Dissecting Bank Demand in the Cross-Section of Securities

Which bonds were bought the most during the intra-allotment period? To answer this question, we classify bonds in six groups based on their residual maturity in December 2011: 0-1 years, 1-3 years, 3-5 years, 5-7 years, 7-10 years, and more than ten years. This classification reflects the ECB’s haircut policy: for each government bond pledged, the central bank assigns an haircut based on bond rating and residual maturity. As Portuguese bonds with different maturities have, at any point in time, the same rating, there is a one-to-one mapping between residual maturity and the “collateral buckets” used by the ECB.²⁵

Let $H_{i,j,t}^k$ denote the holdings of ISIN j by institution i of type k at time t . The intra-allotment ISIN- and bank-level change of holdings is given by

$$\Delta H_{i,j}^k = H_{i,j,\text{Feb12}}^k - H_{i,j,\text{Nov11}}^k$$

Let J^n be the set of ISINs with residual maturity falling in ECB bucket n as of 1 December 2011. For example, J^2 corresponds to the second ECB bucket – the bucket of ISINs with residual maturity between one and three years as of 1 December 2011.²⁶ To study which maturity buckets were purchased the most, we need to normalize holdings by the amount issued of each ISIN j , which we denote by AMT_j . We then analyze separately changes in holdings of three types of institutions, k : (i) banks that borrowed from the second allotment of the vLTRO (T), (ii) banks that, even having access, decided not to borrow from the second allotment of the vLTRO (NT), and (iii) non-banks that did not have access to the vLTRO (NA). For each investor category, $k \in \{T, NT, NA\}$, and for each collateral bucket $n \in \{1, \dots, 6\}$, we compute the following measure

$$\Delta H_n^k = \frac{\sum_{j \in J^n} \Delta H_{i,j}^k}{\sum_{j \in J^n} AMT_{i,j}}$$

Figure 5 shows the change in holdings ΔH_n^k for each of the six ECB buckets n and for each type of investor k . Banks that tapped the second vLTRO allotment (T) bought more bonds with maturity equal or less than three years both compared to other financial institutions, as well as compared to other government bond maturities. Interestingly, this finding is driven by purchases of government bonds with maturity equal or less than one year and, in particular,

²⁵These buckets apply to all securities *eligible* as collateral at the Eurosystem. The ECB maintains on its website an updated list of eligible ISINs. For government bonds this list of ISINs essentially matches the securities that are available in the market: all government bonds in our dataset whose information we were able to match with Bloomberg were eligible as collateral throughout, before and after the allotments. In addition, each collateral bucket is also divided in two subgroups, one for fixed coupon bonds and one for zero coupon bonds. We ignore this distinction as there is little variation in the applied haircut in this dimension.

²⁶The ISINs issued in the intra-allotment period are manually allocated to the correct ECB bucket.

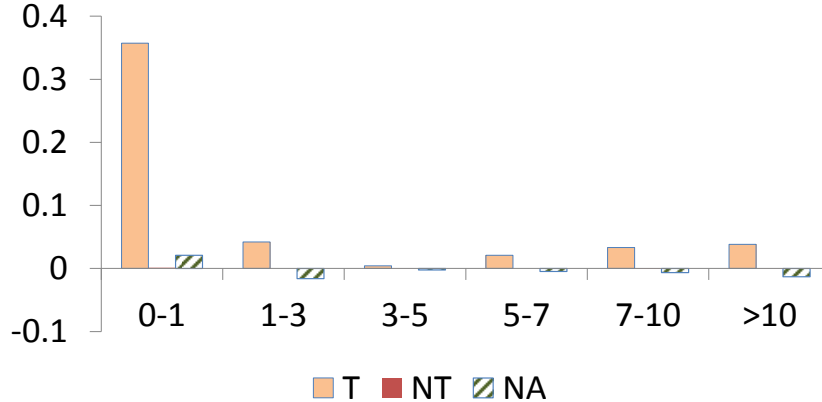


Figure 5: Purchases by Residual Maturity. This figure shows the change in holdings ΔH_n^k , between November 2011 and March 2012, of government bonds in each of the ECB-residual maturity buckets $n \in N$ and for each category of investors $k \in K$. We exclude bonds maturing during the period. [Figure C.14](#) in Appendix C shows the results of the same exercise excluding bonds that mature and are issued in the intra-allotment period.

by short-term bonds issued during the intra-allotment period.

Demand for Newly Issued Bonds. We now look at this differential behavior through the lens of a standard difference-in-differences regression. We take full advantage of the richness of the dataset, and use the panel of holdings of government bonds to compare the behavior of entities that had access to the vLTRO (our treatment group) to that of entities that did not have access (our control group). We employ the following specification,

$$H_{i,t,[t-\tau,t]}^{k,new} = \alpha_i + \gamma_t + \beta vLTRO_t \times Access_i + \epsilon_{i,t} \quad (1)$$

The dependent variable, $H_{i,t,[t-\tau,t]}^{k,new}$, measures holdings of bonds by entity i of type k at time t that were issued in the period $[t - \tau, t]$. $vLTRO_t$ is a dummy that is equal to one if month t is in the intra-allotment period (December 2011-February 2012), and is zero otherwise. $Access_i$ is a dummy that is equal to 1 if entity i has access to the central bank’s liquidity facilities, and zero otherwise. This specification also includes entity- and time-level fixed effects.

[Table 3](#) presents the regression results. The first column defines a bond as “newly issued” if issued between t and $t - 3$ and the second column defines a bond as “newly issued” if issued between t and $t - 4$. We find that entities with access to the vLTRO increased their demand for newly issued bonds by 2% compared to entities with no access to the facility. Certainly, entities in the treatment and control groups (banks and non-banks, respectively) are different along several dimensions. The inclusion of entity and time fixed effects controls for time-invariant entity characteristics and time-varying aggregate factors (e.g., macroeconomic

	$\Delta H_{i,t,[t-3,t]}^k$	$\Delta H_{i,t,[t-4,t]}^k$
vLTRO \times Access	0.0193** (0.00829)	0.0220** (0.0104)
Time FE	✓	✓
Entity FE	✓	✓
N	31619	31619
adj. R^2	0.160	0.180

Table 3: vLTRO and Purchases of Newly Issued bonds. This table presents the estimation results for the specification in (1). The dependent variable in the first (second) column are the holdings of Portuguese government bonds at time t that were issued between time $t - 3$ ($t - 4$) and t . *Access* is a dummy variable equal to one if the institution is a bank, and therefore had access to the facility and zero otherwise. *vLTRO* is a dummy equal to 1 for months from November 2011 to February 2012, included. Standard errors, clustered at the institution type level k , are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

conditions such as bond yields). Since access to vLTRO is an attribute of banks and not other types of investors, we cluster standard errors at the investor type level k in order to correct for potential correlation of purchases of newly issued bonds within entities in the same investor type group.

4 Theoretical Background

In this section, we develop a very simple and stylized model that illustrates the mechanisms that we believe to have been at work during the intra-allotment period. We use the model to show how a decrease in borrowing costs can have an asymmetric impact on bond yields at different maturities due to liquidity and collateral constraints. In particular, we show how a decrease in borrowing costs for investors can lead to a steepening of the yield curve.

4.1 Setup

The economy lasts for three periods, $t = 0, 1, 2$. It is populated by a continuum of domestic banks, international investors and the government. At the beginning of $t = 0$, the government issues short and long-term debt. These assets mature at $t = 1$ and $t = 2$, respectively. This debt is initially purchased by domestic banks. Banks care only about their payoffs at the end of $t = 2$, when all assets have matured. At $t = 1$, short-term debt matures and banks can rebalance their long-term debt portfolios. International investors may purchase this long-term debt, but their valuation is uncertain. This makes the price of long-term debt at $t = 1$ uncertain, and will be the only source of uncertainty in the model. The timeline of the model and the sequence of events is depicted in [Figure 6](#).

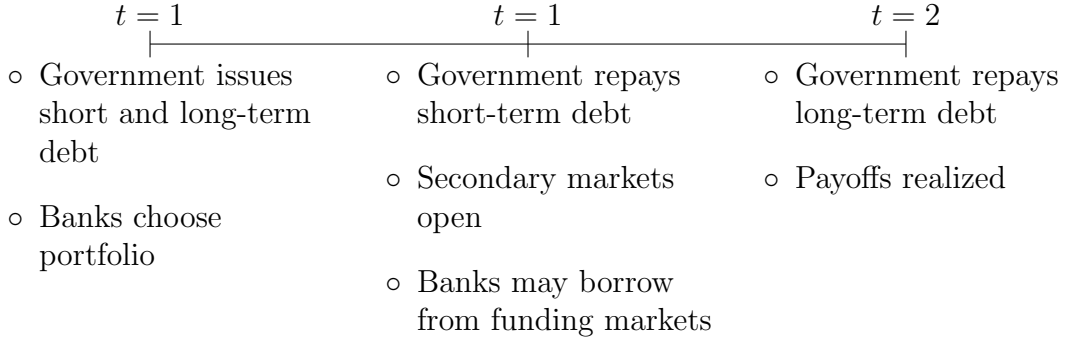


Figure 6: Timeline for the Model

Banks Banks are risk-neutral, and care only about their profits at the end of $t = 2$

$$\mathcal{U} = \mathbb{E}_0[\pi_2] \quad (2)$$

where π_2 are profits at $t = 2$, that arise from portfolio choices made at $t = 1$. Banks enter this period with available resources W_1 (this can be a negative number, as it will be soon clear), and can either rebalance their long-term debt portfolio, b'_L , or store/borrow resources d . When $d \geq 0$, banks are able to store resources at a unit return between $t = 1$ and $t = 2$. When $d < 0$, banks are borrowing from external funding markets at a unit cost $\kappa > 1$. We can then write profits as

$$\pi_2 = b'_L + d \{ \mathbf{1}[d \geq 0] + \kappa \mathbf{1}[d < 0] \}$$

and the resource constraint for banks at $t = 1$ is

$$q_1 b'_L + d = W_1$$

where q_1 is the price of long-term debt at $t = 1$. Available resources W_1 come from choices made at $t = 0$. At the initial period, banks solve a more sophisticated portfolio allocation problem: they can purchase short-term bonds b_S , long-term bonds b_L , store cash c , or borrow from money markets/lender of last resort € . Both short-term bonds and cash yield a unit return, while money market borrowing has a unit cost of R . This means that

$$W_1 = b_S + q_1 b_L + c - R\text{€}$$

At $t = 0$, the bank has some level of resources $W_0 > 0$ available.²⁷ The bank faces a budget constraint, and a collateral constraint for money market borrowing. The budget constraint at

²⁷We can think of this wealth as being available funds from short-term investments that have just matured, i.e. $W_0 = D + E - L$, where D, E, L are deposits/debt, equity and loans/non-pledgeable assets, respectively.

$t = 0$ is

$$W_0 + \mathbb{E} = q_S b_S + q_L b_L + c \quad (3)$$

And the collateral constraint on external borrowing states that total borrowing \mathbb{E} cannot exceed a weighted average of the value of pledgeable assets,

$$\mathbb{E} \leq (1 - h_L) q_L b_L + (1 - h_S) q_S b_S \quad (4)$$

where the only pledgeable assets are government debt, of any maturity, and h_L, h_S are the haircuts on long and short-term debt, respectively. This collateral constraint is a modeling device to account for the fact that most wholesale and central bank borrowing is undertaken through repurchase agreements, and public debt is a prime source of collateral for these contracts.

International Investors International investors are risk-neutral, deep-pocketed traders who operate in secondary markets for long-term debt at $t = 1$. They are willing to purchase any amount of debt, generating a perfectly elastic demand curve. There is, however, uncertainty regarding their outside option or valuation, $a \sim F$. At $t = 1$, they are willing to purchase long-term debt if and only if they break even, thus pinning down the price. They purchase debt if and only if

$$q_1 \leq a$$

We assume that F , the distribution for a , has support $[\underline{q}, \bar{q}]$, where $\bar{q} < 1$ (so that interest rates are always strictly positive).

Government/Treasury The treasury manages public debt issuances for the government. We assume that the government seeks to issue a face value of B at $t = 0$, and the Treasury issues a fraction γ of short-term debt, and a fraction $1 - \gamma$ of long-term debt. These fractions are taken as exogenous, and there is no strategic behavior on the part of the fiscal authority for the moment.

4.2 Bank's Portfolio Choice

There are three markets: long-term debt at $t = 1$ and $t = 0$, and short-term debt at $t = 0$. At $t = 1$, the market for long-term debt features international investors on the buy side, and domestic banks on the sell side. In equilibrium, the price must equal the inverse return on international investors' outside option,

$$q_1 = a$$

We solve the banks' problem backwards, starting at $t = 1$. At this period, the bank chooses how to rebalance its long-term debt portfolio, and whether to store/borrow from funding markets,

$$\begin{aligned} & \max_{b'_L, d} [b'_L + d \{ \mathbf{1}[d \geq 0] + \kappa \mathbf{1}[d < 0] \}] \\ & \text{s.t.} \\ & W_1 = q_1 b'_L + d \end{aligned}$$

Using the budget constraint, note that setting $d \geq 0$ is equivalent to setting

$$b'_L \leq \frac{W_1}{q_1}$$

In this case, the bank's payoff at $t = 2$ is equal to

$$\pi_2|_{d \geq 0} = b'_L + W_1 - q_1 b'_L$$

Since $q_1 < 1$, the bank seeks to set b'_L as high as possible. Will it ever set b'_L such that $d < 0$? In this case, the payoff is

$$\pi_2|_{d < 0} = b'_L + \kappa W_1 - \kappa q_1 b'_L$$

We will assume that funding costs are high enough that $\kappa q_1 > 1$, in which case the optimal policy is to set $b'_L = 0$, and so $d < 0$ is inconsistent with optimality. The bank still runs the risk of borrowing: assuming it cannot short-sell long-term bonds, $b'_L \geq 0$, the bank needs to borrow whenever $W_1 < 0$. This occurs when

$$b_S + q_1 b_L + c - R\mathbb{E} < 0$$

Note that it occurs whenever the value of the portfolio is low enough due to a low realization of q_1 , or whenever the bank has borrowed enough at $t = 0$, that is, $R\mathbb{E}$ is high. In such case, the value of the payoff is

$$\pi_2|_{d < 0, b'_L = 0} = \kappa W_1 < 0$$

We can then characterize the bank's strategies at $t = 1$, given q_1 , as

$$\begin{aligned} b'_L &= \begin{cases} b_L + \frac{b_S + c - R\mathbb{E}}{q_1} & \text{if } q_1 \geq \frac{R\mathbb{E} - c - b_S}{b_L} \\ 0 & \text{otherwise} \end{cases} \\ d &= \begin{cases} 0 & \text{if } q_1 \geq \frac{R\mathbb{E} - c - b_S}{b_L} \\ b_S + q_1 b_L + c - R\mathbb{E} & \text{otherwise} \end{cases} \end{aligned}$$

Note then that the expected value of $t = 2$ profits at $t = 0$ can be written as

$$\mathbb{E}_0[\pi_2] = \int_{\underline{q}}^{\frac{R\mathbb{E} - c - b_S}{b_L}} \kappa [b_S + q_1 b_L + c - R\mathbb{E}] dF(q_1) + \int_{\frac{R\mathbb{E} - c - b_S}{b_L}}^{\bar{q}} \left[b_L + \frac{b_S + c - R\mathbb{E}}{q_1} \right] dF(q_1)$$

The bank's problem at $t = 0$ is then,

$$\begin{aligned} & \max_{b_L, b_S, c, \epsilon} \mathbb{E}_0[\pi_2] \\ & \text{s.t.} \\ & W_0 + \epsilon = q_S b_S + q_L b_L + c \\ & \epsilon \leq (1 - h_L) q_L b_L + (1 - h_S) q_S b_S \end{aligned}$$

In order to illustrate the forces at play, we now assume that $\kappa \rightarrow \infty$: the costs of financing in the intermediate period are prohibitive. The bank is infinitely averse to seeking out funding in the intermediate period, and will therefore adjust its $t = 0$ decisions to avoid any shortfall. We believe that, while stark, this assumption captures the motive for holding liquid asset reserves at any point in time. Additionally, it simplifies considerably the solution and characterization of the model.

For $\kappa \rightarrow \infty$, we can restate the bank's problem as follows: the objective function now becomes

$$\mathbb{E}_0[\pi_2] = \int_{\underline{q}}^{\bar{q}} \left[b_L + \frac{b_S + c - R\epsilon}{q_1} \right] dF(q_1) = b_L + (b_S + c - R\epsilon) \mathbb{E}_0 \left[\frac{1}{q_1} \right]$$

and the bank faces an additional (liquidity) constraint, imposing a zero shortfall in the second period even for the worst realization of q_1

$$b_S + c + \underline{q} b_L - R\epsilon \geq 0$$

Letting (λ, δ, η) denote the Lagrange multipliers on the budget, collateral and liquidity constraints, respectively, and defining

$$\tilde{q} \equiv \mathbb{E}_0 \left[\frac{1}{q_1} \right]^{-1}$$

as the expected value of the price of the long-term bond at $t = 1$ adjusted by a Jensen term, we can write the first-order conditions for the bank's problem as

$$\begin{aligned} \tilde{q} - q_L[\lambda - \delta(1 - h_L)] + \underline{q}\eta &\leq 0 \perp b_L \geq 0 \\ 1 - q_S[\lambda - \delta(1 - h_S)] + \eta &\leq 0 \perp b_S \geq 0 \\ 1 - \lambda + \eta &\leq 0 \perp c \geq 0 \\ -R + \lambda - \delta - \eta R &\leq 0 \perp \epsilon \geq 0 \end{aligned}$$

4.3 Characterizing the Equilibrium

An equilibrium in this model is a pair of prices (q_S, q_L) , $t = 0$ bank policies $(b_L, b_S, c, \mathcal{E})$, and $t = 1$ bank policies $(b'_L(q_1), d(q_1))$, such that policies solve the optimization problems for banks at the respective periods, and all markets clear: the secondary market for long-term debt at $t = 1$, and the primary markets for short and long-term debt at $t = 0$.

We focus on equilibria with strictly positive yields, $q_S, q_L < 1$. From bank optimality, this means that cash is always a strictly dominated asset, $c = 0$. From the bank's optimality conditions, notice that there are two factors that may motivate a preference for short, over long-term debt from the bank's perspective: the first is if short-term debt commands a more favorable haircut, $h_S < h_L$. This preference is scaled by the multiplier on the collateral constraint, δ . The second is that short-term debt allows for better liquidity management, since it yields a certain cash-flow of 1 in the second period, while long-term debt yields a worst-case payoff of $\underline{q} < 1$. This preference is scaled by the multiplier on the liquidity constraint, η .

Assuming that $b_S, b_L > 0$, and so that both first-order conditions bind, we can write the slope of the yield curve as

$$\frac{1}{q_L} - \frac{1}{q_S} = (\lambda - \delta) \left[\frac{1}{\tilde{q} + \underline{q}\eta} - \frac{1}{1 + \eta} \right] + \delta \left[\frac{h_L}{\tilde{q} + \underline{q}\eta} - \frac{h_S}{1 + \eta} \right]$$

Notice first that if none of these constraints bind, $\delta = \eta = 0$, the bank prices debt at each maturity using a traditional unconstrained arbitrage condition that equates inter-period returns,

$$\frac{1}{q_S} = \frac{\tilde{q}}{q_L} = \lambda$$

where λ measures the marginal cost of funds for the bank. If any of the constraints is active, however, the bank's preference is tilted towards short-term debt. This means that, for the same quantities of outstanding debt, the price of short-term debt increases relative to the price of long-term debt. Thus the yield curve becomes steeper.

We proceed to characterize the equilibrium in terms of thresholds over the ratio of available resources to the face value of government debt $\omega \equiv \frac{W_0}{B}$ and the initial cost of borrowing R . The following proposition illustrates the possible regimes that can arise depending on the model's parameters.

Proposition 1. *The equilibrium is characterized as follows:*

1. For $R\omega \geq \gamma + \tilde{q}(1 - \gamma)$, banks do not borrow, $\mathcal{E} = \delta = \eta = 0$, and prices satisfy

$$q_S = \frac{\omega}{\gamma + \tilde{q}(1 - \gamma)}$$

$$q_L = \frac{\tilde{q}\omega}{\gamma + \tilde{q}(1 - \gamma)}$$

2. For $R\omega \in [\min\{(\tilde{q} - \underline{q})(1 - \gamma), h_S\gamma + h_L\tilde{q}(1 - \gamma)\}, \gamma + \tilde{q}(1 - \gamma)]$, banks borrow, $\epsilon > 0$, but no constraints are binding, $\delta = \eta = 0$, and prices satisfy

$$q_S = \frac{1}{R}$$

$$q_L = \frac{\tilde{q}}{R}$$

3. For $R\omega \in [(\tilde{q} - \underline{q})(1 - \gamma), h_S\gamma + h_L\tilde{q}(1 - \gamma)]$, the collateral constraint binds, $\delta > 0$, but the liquidity constraint does not, $\eta = 0$. Prices solve the following system

$$\omega = h_S q_S \gamma + h_L q_L (1 - \gamma)$$

$$q_S = \frac{1}{R + \delta h_S}$$

$$q_L = \frac{\tilde{q}}{R + \delta h_L}$$

4. For $R\omega \in [h_S\gamma + h_L\tilde{q}(1 - \gamma), (\tilde{q} - \underline{q})(1 - \gamma)]$, the liquidity constraint binds, but the collateral constraint does not. Prices satisfy

$$q_S = \frac{1}{R}$$

$$q_L = \frac{\tilde{q} + \eta \underline{q}}{R(1 + \eta)}$$

where

$$\eta = \frac{(\tilde{q} - \underline{q})(1 - \gamma)}{R\omega} - 1$$

5. For $R\omega < \min\{(\tilde{q} - \underline{q})(1 - \gamma), h_S\gamma + h_L\tilde{q}(1 - \gamma)\}$, both the liquidity and the collateral constraints bind. Prices satisfy,

$$q_S = \frac{1}{R} \frac{h_L(\gamma + \underline{q}(1 - \gamma)) - (1 - h_L)R\omega}{\gamma(h_L - h_S)}$$

$$q_L = \frac{1}{R} \frac{(1 - h_S)R\omega - h_S(\gamma + \underline{q}(1 - \gamma))}{(1 - \gamma)(h_L - h_S)}$$

The above proposition defines regions for the equilibrium depending on the value of $R\omega$: the costs of external financing times the ratio of available resources to the face value of government debt. If this product is very high, banks do not borrow and simply price government debt out of their initially available resources. This can be the case when resources are ample (ω is high), or when borrowing costs are prohibitive (R is high).

Once either R or ω decrease, banks start borrowing. There is a region when constraints do not bind, and banks simply borrow to purchase short-term and long-term debt at risk-neutral

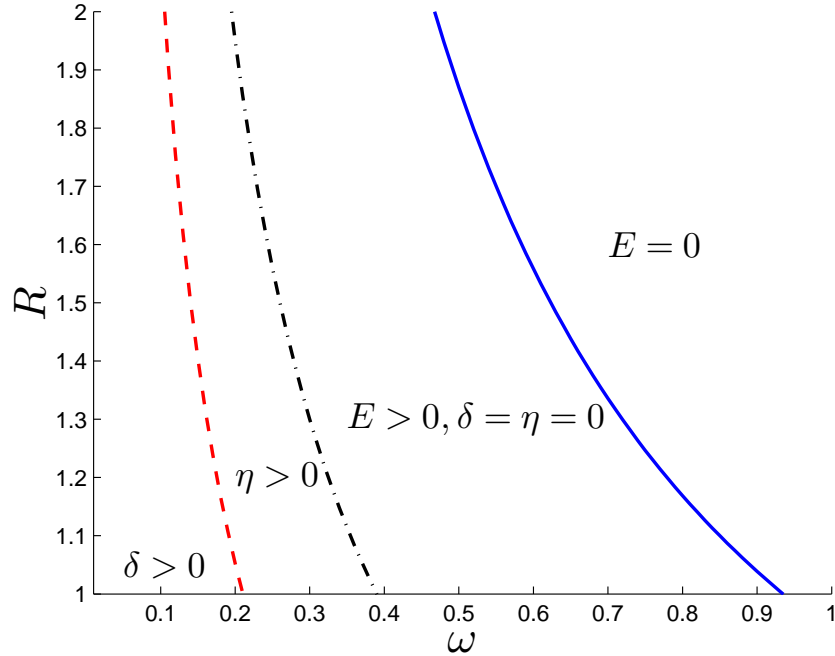


Figure 7: Equilibrium Regimes in the (ω, R) space. The figure plots the equilibrium regions described in Proposition 1 in the (ω, R) space. The region above the solid blue line corresponds to no borrowing, $\epsilon = 0$. The region between the solid blue and the dash-dotted black line corresponds to unconstrained borrowing. The region between the dash-dotted black and dashed red lines corresponds to the liquidity constraint binding, but not the collateral constraint. Finally, the region to the left of the red line corresponds to both the liquidity and the collateral constraints binding.

prices: there is complete pass-through of the costs of external financing to government yields. If either R or ω decrease further, one or more constraints start binding. For these regions, since either $\delta > 0$, or $\eta > 0$, or both, there will be a preference for short-term debt. This means that a transition from one of the previous regions will be associated with a larger increase (or smaller decrease) in the price of short-term debt, relative to long-term debt. That is, with a steepening of the yield curve.

We present the equilibrium regions in Figure 7, in the (ω, R) space.²⁸ To the right of the solid blue line, the bank does not borrow. Between the solid blue and the dashed-dotted black lines, the bank borrows but no constraints bind. Our choice of parameters is such that the liquidity constraint binds first, between the dashed-dotted black and the dashed red lines. To the left of the red line, both constraints bind.

²⁸We choose $\gamma = 0.35$, since roughly 35% of all outstanding debt had a maturity lower than 3 years at the time of the second allotment. We also set $\bar{q} = 0.9$, reflecting average 10-year yields of 10% around the vLTRO period, $\underline{q} = 0.3$, and the haircuts $h_S = 0.055$, $h_L = 0.105$ reflect those practiced by the ECB.

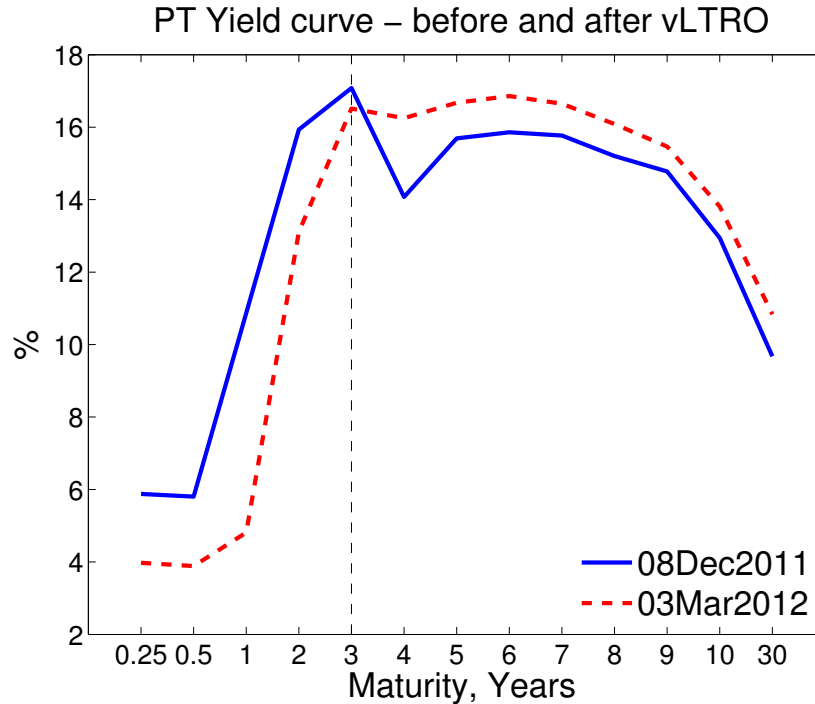


Figure 8: Portugal Yield Curve, pre and post vLTRO. This figure plots the yield curve (interpolated for missing maturities) on December 8, 2011 and March 3, 2012. December 8 is the date of the announcement of the vLTRO, and February 29 is the date of the second allotment. The horizontal axis of maturities is measured in years.

4.3.1 The Yield Curve and the vLTRO

During the intra-allotment period, the Portuguese sovereign yield curve rotated, and became steeper. This is illustrated in Figure 8, which plots the yield curve for different maturities (in years) on the date of the announcement of the vLTRO, and some days after the second allotment. A striking fact is that the yields of all bonds with maturity smaller than the vLTRO (3 years) decreases, while the yields on the bonds with maturity greater than the vLTRO increased: we did not see a parallel shift of the yield curve, but rather a rotation around the 3 year maturity, that left the yield curve steeper.

We use our stylized model to argue that this observation is consistent with the constrained regime. We do this by letting the pre-allotment period correspond to a situation with dire wholesale funding conditions, high interest rate R_0 , while the allotment period corresponds to an improvement of these conditions, $R_1 < R_0$, a lower interest rate on wholesale funding. While Portuguese banks could potentially borrow in wholesale markets at longer maturities, the interest rate was prohibitive. We thus model the vLTRO as a decrease on the interest rate for wholesale funding at a maturity that is large enough such that it matches (or exceeds) the maturity of some of the assets that can be pledged as collateral (short-term bonds, which we interpret as bonds with maturity shorter than three years). We maintain throughout that

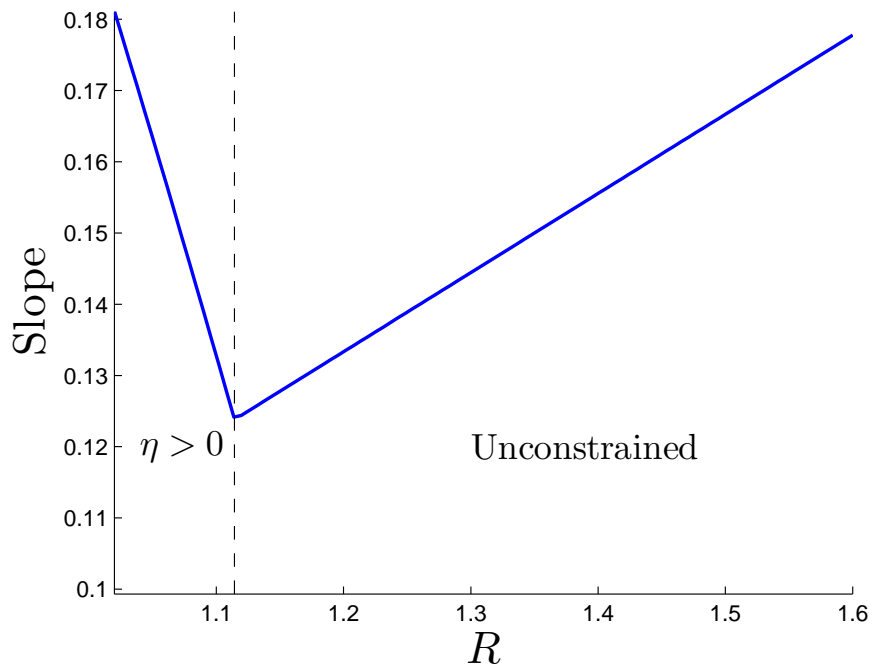


Figure 9: Slope of the Yield Curve, Model. This figure plots the slope of the Treasury’s yield curve as a function of borrowing costs R . The dashed line indicates the transition from an unconstrained equilibrium to one where the liquidity constraint binds, $\eta > 0$.

haircuts are constant, and the haircut on short-term debt is smaller, $h_S < h_L$.²⁹

In our model, for the same ω , if the decrease in R is large enough, the economy can experience a change in regime: in particular, the economy can switch from an unconstrained equilibrium to one where banks are constrained, and thus have a preference for short-term debt.

Figure 9 plots the slope of the yield curve as a function of R . For high levels of R , the bank is unconstrained, and the slope of the yield curve behaves in the usual manner: if borrowing costs decrease, the slope decreases (yields become more compressed). However, if the decrease in R is large enough so as to bring the economy to an equilibrium where liquidity (or collateral) constraints bind, the sign of the relationship inverts: due to the preference for short-term debt induced by the constraint, a decrease in borrowing costs can actually *increase* the slope of the yield curve.

This effect illustrates the reason why programs that rely on private institutions absorbing risk can be fundamentally different from programs that involve institutional actors (such as

²⁹During the intra-allotment period, the haircuts applied by the Eurosystem to Portuguese bonds ranged from 5.5% for bonds with maturity less than one year to 10.5% for bonds with maturity greater than ten years.

the ECB) absorbing the same risk, such as Quantitative-Easing style programs. A program such as QE would be associated with a flattening of yield curves, while a program in which risk is absorbed by constrained private agents can generate a steepening of yield curves. The following sections empirically explore the behavior of private agents in greater detail, as well as evidence of strategic response by the treasury, which we leave unmodelled.

5 Empirical Analysis

In this section, we present empirical evidence to argue that the rapid increase of holdings of government debt between the two allotments was driven by a “collateral trade” motive that induced a higher demand for collateral in the form of domestic government debt. We argue that the vLTRO provided banks, particularly domestic ones, with an attractive opportunity that consisted of investment in high-yield short-maturity domestic sovereign bonds, that were then pledgeable at the LOLR. Two features, in particular, made this trade extremely attractive.

First, from the perspective of a domestic bank, this was a particularly safe trade when used to invest in short-term debt. By short-term, we mean bonds with a maturity that is inferior to the maturity of the ECB loan. In a world where there are implicit guarantees by the government and a substantial degree of sovereign-bank linkages, banks and sovereigns tend to default at the same time. Due to risk-shifting, government debt thus offers a better return to domestic banks than to foreign ones, and public debt tends to be repatriated. This is the logic underlying several theoretical models, such as that of [Gennaioli et al. \(2014b\)](#). The only states of the world that may lead banks not to deem domestic sovereign debt as a safe asset are those in which the price of the purchased bonds may change, thereby affecting the bank’s capacity to repay the ECB loan or resulting in the ECB issuing a margin call to the bank.³⁰ Thus, while the bank disregards the (direct) credit risk of the sovereign, the bond still exposes the buyer to funding liquidity risk. If the bank engages in this trade using long-term bonds, with maturity exceeding that of the ECB loan, it will be highly exposed to funding liquidity and margin risk: if those bonds drop in price during the term of the ECB loan, not only the bank may receive a margin call, but the bond itself may be worth less at the time the loan expires. Either of these situations force the bank to raise additional funds to either meet the margin call or repay the loan, which might be costly and increases uncertainty regarding liquidity management. If bonds have a term that is shorter than the loan, however, the risk associated with the margin call is lower, and the bond matures - becomes cash - before the loan is due. This still results in a margin call, which the bank can cover with the newly available funds,

³⁰Without the option of early repayment - which only occurs after one year - banks are required to either pledge additional collateral or place cash in margin call deposits at the ECB should the collateral drop in value. According to the ECB Risk Control Framework, marketable assets that are used as collateral are marked to market daily.

and so entails much less risk. Besides, it results in an additional profit for the bank since the bond yield was greater than the borrowing cost in the first place.

Second, due to the fact that the described trade involves purchase of an asset that is pledgeable as collateral to raise the funds, banks were able to take leveraged positions: the purchase of the asset relaxes the borrowing constraint, up to the haircut. This is consistent with the increase in new, net borrowing from the vLTRO that is observed at the second allotment, after banks have gathered new collateral.

A Simple Model of Margin Calls and the Collateral Trade To formalize this reasoning, we present a very simple model of liquidity risk that illustrates the main trade-offs inherent to bond maturity. 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

$$\begin{aligned} y_S &= \frac{1}{\eta} \\ y_M &= \frac{1}{\eta^2} \\ y_L &= \frac{\alpha \rho^- + (1 - \alpha) \rho^+}{\eta^2} \end{aligned}$$

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 vLTRO 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.³¹

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 given by

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

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

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

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 at the shorter term.³²

³¹Basically, the investor can save for a net return of zero and borrow for a net cost of r .

³²Our analysis is robust to adding an additional period, so that the investor would obtain a certain payoff from the long-term bond. This would, however, still entail funding risk at loan maturity, since the investor

We now proceed as follows: first, we present evidence that suggests that a combination of surprise and collateral constraints meant that the first allotment was mostly rollover of previous short-term debts. We then formally show that the pattern of purchase of government bonds changed significantly during the intra-allotment period, and that bond purchases explain a significant part of the cross-sectional variation of new borrowing at the second allotment. This is not true for other forms of collateral, such as non-domestic sovereign or private bonds. The purchase of new collateral allowed banks to undertake new borrowing and keep their liquidity risk under control, while profiting from the carry trade. We also present evidence that most of these purchases were concentrated in short-term government bonds. Finally, we present some alternative explanations and argue they are not consistent with the patterns observed in the data.

5.1 vLTRO1 as a Surprise

The first allotment was mostly used to rollover outstanding short term debt at longer maturities. This, along with the fact that there were only two weeks between the announcement of the vLTRO program on the 8 December, and the first allotment on the 21 December, suggests that: (i) the announcement was a surprise, and (ii) banks had little time to prepare themselves for the first allotment. If all assets that were eligible as collateral were already being used to borrow from the LOLR, the lack of time to accumulate more eligible collateral should manifest itself by low levels of new net borrowing, and high levels of rollover of short-term debt.

Indeed, this is what the data suggests. [Figure 10](#) presents two scatter plots. The left panel shows vLTRO1 uptake against total change in ECB borrowing (including both short and long-term borrowings), and it shows that there were no significant changes in total borrowing as a percentage of assets (except for two domestic outliers), in spite of considerable variation in vLTRO uptakes. The right panel, on the other hand, plots vLTRO1 uptake against changes in short-term ECB borrowing, and illustrates that there is a negative relationship between the two. The slope of the fitted regression line is very close to -1 , and most institutions except for two outliers are very close to this line. This is a non-parametric way to illustrate that vLTRO1 was essentially used to replace (rollover) shorter term debt.

5.2 vLTRO2 and the Demand for Collateral

While vLTRO1 could be considered a surprise, the same is not true of the second allotment: having been announced on the 8 December, banks had almost three months, until 29 February

would need to either sell the bond (as in our set-up) or raise costly external funds to repay the loan.

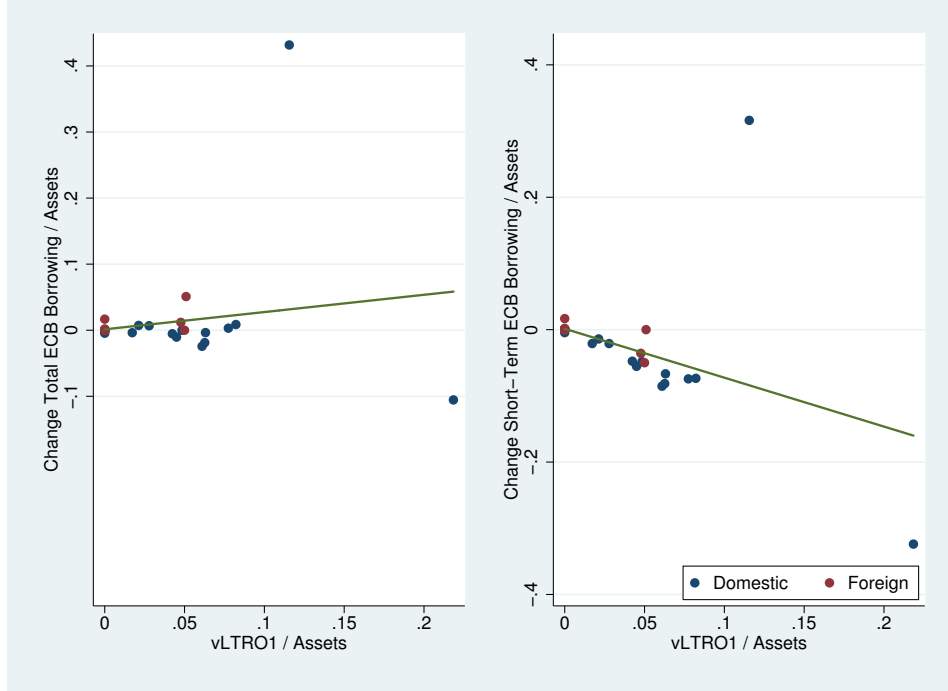


Figure 10: vLTRO1 changes in total and short-term borrowing from the ECB. The left panel plots total vLTRO1 uptake as a percentage of assets in November 2011 in the horizontal axis, and total change in ECB borrowing between November 2011 and December 2011, as a percentage of assets in November 2011, in the vertical axis. The right panel plots total vLTRO1 uptake against the change in short-term ECB borrowing between November 2011 and December 2011.

to prepare themselves. This allowed them to gather the necessary collateral during this period, and consequently increase their net borrowings during the second allotment. We claim that this increased demand for collateral manifested itself primarily through increase holdings of domestic government debt, driven by the carry trade motive that was described above. The channel that we propose is can then be summarized as follows,

$$\text{vLTRO Announcement} \Rightarrow \text{Demand for Collateral} \uparrow \Rightarrow \text{Demand for Govt}^{\text{PT}} \uparrow$$

Our hypothesis is testable to the extent that increased holdings of eligible collateral should generate an increase in net borrowing at the time of the vLTRO2 allotment. To help us formalize our argument, let C_i be a measure of eligible collateral held by bank i , and ΔC_i be the change in the amount of collateral held by bank i between the vLTRO announcement and the vLTRO2 allotment. vLTRO uptake for a particular bank i can be decomposed in two components: a “rollover” component that corresponds to the part of the total uptake that is used to transform already-existing ECB borrowings in longer-term debt, and a “new borrowing” component that corresponds to new borrowings that are unrelated to rollover,

$$\text{vLTRO2}_i = \text{vLTRO2}_i^N + \text{vLTRO2}_i^R$$

As described in previous sections, the vLTRO and the shorter-term ECB open market operations, the MRO and the LTRO, had essentially the same collateral requirements. Banks could rollover all their short-term borrowings with no visible variation in the pool of eligible collateral, $\Delta C_i = 0$. This suggests that any variations in the pool of eligible collateral C_i between the vLTRO allotments should be a good predictor of the new borrowings component.

To test this hypothesis, we rely on the following identification assumption: the rollover component of the vLTRO is equal to any change in short-term borrowings from the ECB that is observed around the time of the allotment (between February 2012 and March 2012).

$$\text{vLTRO2}_i^R = \Delta \text{Short-Term ECB Borrowing}_{i,\text{Feb12-Mar12}} \quad (5)$$

The main requirement of this assumption is that there be no changes in short-term ECB borrowing at the time of the allotment that are completely unrelated to rollover. That is, we are excluding the possibility that banks could have reduced (or increased) their shorter-term borrowings from the ECB for reasons that are completely unrelated to the vLTRO at the time of the allotment. We believe this to be a relatively mild assumption, since vLTRO should (weakly) dominate any other sources of LOLR.³³ This assumption allows us to identify the new borrowings component of the vLTRO. To see this, note that we can decompose the change in total ECB borrowings between February and March 2012 as

$$\Delta \text{Total ECB Borrowing}_i = \text{vLTRO2}_i + \Delta \text{Short-Term ECB Borrowing}_{i,\text{Feb12-Mar12}}$$

Imposing our assumption, (5), we obtain

$$\Delta \text{Total ECB Borrowing}_{i,\text{Feb12-Mar12}} = \text{vLTRO2}_i^N$$

Since all changes in short-term borrowing around the allotment are assumed to correspond to the rollover component, we can measure the net uptake component of the vLTRO by looking directly at changes in total ECB borrowing around this period. With this fact in mind, we test our hypothesis by regressing the new borrowings component of vLTRO on the change in eligible collateral. We consider the following specification,

$$\text{vLTRO2}_i^N = \alpha + \beta \Delta C_{i,\text{Nov11-Feb12}} + \gamma' X_{i,\text{Nov11}} + \epsilon_i \quad (6)$$

³³Strictly speaking, we are also implicitly assuming that the entire stock of vLTRO1 borrowing is also being rolled over in this operation, since we identify vLTRO2 borrowing as the change in long-term borrowing from the ECB between February and March 2012.

where the left-hand side is the new borrowings component of vLTRO2, as measured by the change in total ECB borrowing between February and March 2012, scaled by total assets in February 2012. The right-hand side includes a measure of the change in total eligible collateral between November 2011 and February 2012, and bank-level controls. The change in collateral is measured starting in November 2011, since observations are end-of-month and the vLTRO announcement took place in early December.

Eligible collateral at the ECB falls in three broad asset classes: bonds, asset-backed securities and covered bank bonds. Although we do not have security-level data on the holdings of these classes of assets by banks, we can still rely on more aggregate measures that are taken from the balance sheet of banks. We include separately as regressors changes in holdings of the following categories of assets: Portuguese government bonds, government bonds from GIIPS excluding Portugal, government bonds from other countries, and holdings of non-equity non-government securities,

$$\Delta C_i = \Delta \text{Govt}_i^{\text{PT}} + \Delta \text{Govt}_i^{\text{IGS}} + \Delta \text{Govt}_i^{\text{Other}} + \Delta \text{Other Securities}_i$$

where $\Delta y_i = y_{i,\text{Feb12}} - y_{i,\text{Mar12}}$. These four categories encompass all classes of assets that are pledgeable at the ECB that we can observe from balance sheet data. While we can measure variations in the total amounts in each class, we cannot account for internal changes in composition: for example, we cannot observe if banks acquire eligible ABS by selling non-eligible ABS with the same book value. Even though this bank would be accumulating eligible collateral, this transaction would not be captured by our measure if it is not reflected in an increase in observed book value for the class that includes ABS. We divide each of the changes in value by total assets in February 2012, to scale the change by the size of the institution.

As for controls, we consider nationality, leverage and size. [Table 4](#) presents the results. For robustness, we present the same specification on a sample with domestic banks only.

Column (1) includes the change in holdings of Portuguese government bonds as the only regressor. Columns (2)-(3) include the other measures of collateral as well as controls. No other measure of the change in eligible collateral is significant. The change in the quantity of domestic government bonds is always significant at the 5% level, and our specification explains 73% of the variation in new borrowings for the sample of domestic banks. This suggests that the banks in our sample, especially domestic ones, relied substantially on the acquisition of domestic government bonds as a means to access new borrowings from the second vLTRO allotment. Not only are our results statistically, but also quantitatively significant: we can interpret the coefficient in column (2) as saying that for each euro of exposure acquired against the Portuguese sovereign, the average bank was able to obtain 25 cents of new borrowing from the central bank.

While simple to interpret, we believe that our results may underestimate the impact of collateral acquisition on new borrowing. This is primarily due to the fact that four MRO's took place during the intra-allotment period, and uptake of these short-term operations could reflect some of the new borrowing. If banks gradually acquired collateral during the intra-allotment

	Dependent variable: $\Delta\text{Total ECB Borrowing}_{\text{Feb12-Mar12}}$		
	(1)	(2)	(3)
$\Delta\text{Gov}^{\text{PT}}$	0.201** (0.085)	0.246*** (0.089)	0.236*** (0.026)
$\Delta\text{Gov}^{\text{IGS}}$		-0.360 (1.754)	-0.103 (0.512)
$\Delta\text{Gov}^{\text{Other}}$		0.137 (8.603)	0.745 (2.492)
$\Delta\text{Other Securities}$		-0.009 (0.077)	0.001 (0.022)
Controls		✓	✓
N	71	67	36
adj. R^2	0.062	0.075	0.699
Sample	Full	Full	Domestic

Table 4: Demand for Collateral. This table presents the results of specification (6). The dependent variable is the change in total ECB borrowing between February 2012 and March 2012, scaled by total assets in February 2012. The regressors show changes in book value holdings of Portuguese government bonds, GIIPS excluding Portugal government bonds, other government bonds, and other non-equity, non-government securities between December 2011 and February 2012, divided by assets in February 2012. Controls in column (3) include the log of assets in February 2012, the log of leverage in February 2012, a foreign dummy, and interactions of all the regressors with foreign dummies. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

period, they would be able to increase their borrowing at the short-term open market operations, knowing that they would be able to rollover this liquidity at a longer maturity during the second allotment. Therefore, it would be expectable that banks would frontload some of their new borrowing using these short-term operations. Ideally, we would account for this frontloaded new borrowing by taking the change in total ECB borrowing between December 2011 and March 2012 as the dependent variable on specification 6. However, this would mean that the period over which the change of the dependent variable is taken (Dec11-Mar12) would overlap with the period over which the independent variables are taken (Nov11-Feb12), thus raising endogeneity concerns.

To address this question, we propose an alternative specification that takes advantage of the fact that our dataset is a panel,

$$\Delta\text{Total ECB}_{i,t} = \alpha_i + \gamma_t + \beta\Delta C_{i,t-1} + \gamma'X_{i,t-1} + \epsilon_{i,t} \quad (7)$$

The dependent variable is the change in total ECB borrowing by bank i at month t . Since we take the change of total ECB borrowing, we are purging rollover effects and only measuring new net borrowing. Crucially, this measure captures any frontloaded new net borrowing that may have taken place through short-term open market operations (regardless of whether it was rolled over later in time). The independent variable is the change in our measure of collateral, in the previous month. The timing addresses reverse causality (that banks are

	Dependent variable: $\Delta\text{Total ECB}_{i,t}$				
	(1)	(2)	(3)	(4)	(5)
$\Delta\text{Gov}_{i,t-1}^{\text{PT}}$	1.355***	1.028***	1.347***	1.349***	1.349***
	(0.127)	(0.064)	(0.127)	(0.128)	(0.130)
$\Delta\text{Gov}_{i,t-1}^{\text{PT}} \times \text{Foreign}_i$				-0.624	-0.635
				(2.198)	(2.224)
$\Delta\text{Gov}_{i,t-1}^{\text{IGS}}$					0.999
					(2.313)
$\Delta\text{Gov}_{i,t-1}^{\text{IGS}} \times \text{Foreign}_i$					-0.537
					(2.386)
$\Delta\text{Gov}_{i,t-1}^{\text{Other}}$					3.123
					(10.42)
$\Delta\text{Gov}_{i,t-1}^{\text{Other}} \times \text{Foreign}_i$					2.260
					(46.76)
$\Delta\text{Other Securities}_{i,t-1}$					0.030
					(0.069)
$\Delta\text{Other Securities}_{i,t-1} \times \text{Foreign}_i$					-0.020
					(0.140)
Bank FE	✓		✓	✓	✓
Time FE		✓	✓	✓	✓
N	288	288	288	288	288
adj. R^2	0.379	0.478	0.377	0.374	0.359
Sample	Full	Full	Full	Full	Full

Table 5: Demand for Collateral, Panel. This table presents the results of specification (7), for the intra-allotment time period, between November 2011 and March 2012. The dependent variable is the change in total ECB borrowing between t and $t-1$, scaled by total assets at $t-1$. The regressors are changes between $t-1$ and $t-2$, scaled by assets at $t-2$, of: face value holdings of Portuguese government bonds, book value holdings of GIIPS sovereign bonds excluding Portugal, book value holdings of other sovereign bonds, and book value holdings of non-equity, non-sovereign securities. All regressors are interacted with a Foreign dummy. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

increasing their holdings of pledgeable assets due to the fact that they are borrowing funds), since bank i cannot use the funds borrowed at t to purchase collateral at $t-1$. Lastly, we include bank (α_i) and time (γ_t) fixed effects.

We estimate this specification for the intra-allotment period, from December 2011 to March 2012, the results are presented in Table 5.

Columns (1)-(3) include only the change in the quantity of government debt in the previous month, for different combinations of fixed effects: bank only, time only, bank and time, respectively. The coefficient is always highly significant and of similar magnitude. Column (4) adds an interaction with a foreign dummy, and column (5), our preferred specification, includes the change in the other measures of collateral. This barely affects the magnitude and standard errors of the coefficient on government debt. In particular, no other collateral class seems to

	Dependent variable: $\Delta\text{Total ECB}_{i,t}$				
	(1)	(2)	(3)	(4)	(5)
$\Delta\text{Gov}_{i,t-1}^{\text{PT}}$	0.082** (0.039)	0.085** (0.039)	0.079** (0.039)	0.079** (0.040)	0.075* (0.040)
$\Delta\text{Gov}_{i,t-1}^{\text{PT}} \mathbb{1}[t \in \text{Intra-Allotment}]$	0.952*** (0.051)	0.943*** (0.049)	0.950*** (0.051)	0.951*** (0.052)	0.957*** (0.052)
$\Delta\text{Gov}_{i,t-1}^{\text{PT}} \mathbb{1}[t \in \text{Post-Allotment}]$	-0.121** (0.058)	-0.133** (0.057)	-0.125** (0.058)	-0.124** (0.059)	-0.118** (0.059)
Bank FE	✓		✓	✓	✓
Time FE		✓	✓	✓	✓
Foreign Interactions				✓	✓
Other Collateral					✓
N	3171	3171	3171	3171	3171
adj. R^2	0.263	0.274	0.263	0.263	0.272
Sample	Full	Full	Full	Full	Full

Table 6: Demand for Collateral, Panel, Full Sample. This table presents the results of specification (8), between May 2009 and May 2014. The dependent variable is the change in total ECB borrowing between t and $t - 1$, scaled by total assets at $t - 1$. The regressors are changes between $t - 1$ and $t - 2$, scaled by assets at $t - 2$, of: face value holdings of Portuguese government bonds, book value holdings of GIIPS sovereign bonds excluding Portugal, book value holdings of other sovereign bonds, and book value holdings of non-equity, non-sovereign securities. Additionally, we interact the change in Portuguese bond holdings with time dummies for the intra-allotment (December 2011 - March 2012) and post-allotment (April 2012 - May 2014) periods. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

have had a significant impact on future changes in ECB borrowing.

To illustrate that the vLTRO period does indeed correspond to a change in behavior, we estimate a variation of 7 over the entire crisis and post-vLTRO periods, from May 2009 to May 2014, given by

$$\begin{aligned} \Delta\text{Total ECB}_{i,t} = & \alpha_i + \gamma_t + \beta_0 \Delta C_{i,t-1} + \beta_1 \Delta\text{Gov}_{i,t-1}^{\text{PT}} \times \mathbb{1}[t \in \text{Intra-Allotment}] \\ & + \beta_2 \Delta\text{Gov}_{i,t-1}^{\text{PT}} \times \mathbb{1}[t \in \text{Post-Allotment}] + \epsilon_{i,t} \end{aligned} \quad (8)$$

where $\mathbb{1}[t \in \text{Intra-Allotment}]$ is a dummy that is equal to 1 during the intra-allotment period (December 2011 to March 2012), and $\mathbb{1}[t \in \text{Post-Allotment}]$ is a dummy equal to 1 during the post-allotment period (April 2012 to May 2014). Results are shown in Table 6.

Our results confirm the change in behavior during the intra-allotment period.³⁴ Before the vLTRO period, there was some significant relationship between government bond purchases

³⁴The results are very robust to regressions over the respective subsamples.

and central bank borrowing. This relationship becomes one order of magnitude stronger during the intra-allotment period, and becomes negative after the allotment. This supports our claim that a scramble for collateral took place during the intra-allotment period: that banks engaged in unprecedented purchases of government bond in order to access the LOLR facilities.

5.3 Alternative Explanations

We now try to address some alternative explanations for the above results. We focus on two conventional narratives. The first is the well-established risk-shifting view: that banks used the newly provided ECB liquidity to increase their leverage, and their exposure to the respective risky sovereigns. The second is the so-called Sarkozy Trade, the notion that banks in the periphery were liquidity constrained, and the provision of “new money” by the ECB would provide them with the liquidity to purchase bonds from the respective sovereigns and therefore help stabilizing yields.³⁵ While a similar argument, and consistent with our results in several ways, the Sarkozy Trade is a subtle version of reverse causality.

5.3.1 Risk-Shifting

It is well-documented in the literature that the increased exposure to domestic sovereigns throughout the crisis period was driven by risk-shifting motives, with undercapitalized banks further increasing their leverage by purchasing sovereign bonds (see [Acharya and Steffen \(2015\)](#)). It is then natural to ask whether bond purchases during the intra-allotment period are being driven by a risk-shifting motive. To answer this question, we check whether undercapitalized (more leveraged) banks purchase more bonds than better capitalized banks. We focus on the following specification

$$\Delta y_i = \alpha + \beta_0 \text{Domestic}_i + \beta_1 \text{Leverage}_{i,t-1} + \beta_2 \text{Domestic}_i \text{Leverage}_{i,t-1} + \gamma X_i + \epsilon_{i,t} \quad (9)$$

where *Leverage* is the log of leverage (asset/book equity), *Domestic* is a dummy equal to one if the financial institution is Portuguese, and *X* is a vector of controls. The dependent variable is the change in government bond holdings in the intra-allotment period.³⁶ [Table 7](#) shows the results using for different dependent variables: (i) total government bonds (market value), (ii) Portuguese government bonds (market value), (iii) Portuguese government bonds (face value), and (iv) peripheral non-Portuguese government bonds (market value) during the period November 2011 to February 2012. Under the risk-shifting hypothesis the coefficient of

³⁵See [FT Alphaville](#), December 15 2011.

³⁶The results from this specification are consistent with unreported results using a monthly panel version of this specification during the period November 2011 to February 2012.

	ΔGovt	ΔGovt^{PT}	$\Delta\text{GovtNom}^{PT}$	ΔGovt^{IGS}
$\text{Domestic}_i \times \text{Leverage}_{i,t-j}$	0.00520 (0.0270)	0.00476 (0.0272)	0.00014 (0.00631)	0.00064 (0.00283)
$\text{Leverage}_{i,t-j}$	0.000397 (0.0158)	0.00013 (0.0160)	0.00012 (0.00371)	0.00025 (0.00166)
Domestic_i	0.0347 (0.0814)	0.0397 (0.0821)	-0.00099 (0.0191)	-0.00495 (0.00854)
Controls	✓	✓	✓	✓
N	65	65	65	65
adj. R^2	0.201	0.179	0.038	0.214

Table 7: Risk-Shifting Hypothesis. This table tests whether risk-shifting is driving the purchases of government bonds in the intra-allotment period. The dependent variables are respectively the growth rate of (i) total government bonds (market value), (ii) Portuguese government bonds (market value), (iii) Portuguese government bonds (face value), and (iv) peripheral non-Portuguese government bonds (market value) during the period November 2011 to February 2012. *Domestic* is a dummy equal to one if the bank is a Portuguese bank and zero otherwise; *Leverage* is the log of leverage (asset/book equity) in November 2011. Controls include: repurchase agreements, liabilities other than repurchase agreements and nor securities, and total assets. Controls are quantities in November 2011. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the interaction term should be positive for Portuguese bonds as highly levered and domestic banks should drive the accumulation of these securities. We do not find evidence of this risk-shifting motive in our sample.

5.3.2 The Sarkozy Trade: Reverse Causality

At the time of its announcement, the vLTRO was lauded by the then President of France Nicolas Sarkozy as an opportunity to provide liquidity for banks to purchase domestic sovereign debt (the statements were made in the context of France and Italy), helping relieve pressures on yields and contractions in demand. While this narrative is similar to the one we advance, it relies on a subtle form of reverse causality. According to the Sarkozy Trade, the net new borrowing from the ECB should *cause* bond purchases, while our argument is the converse: that new purchases of bonds *cause* the new uptake from the ECB. The reason why this distinction may be subtle and not immediately obvious has to do with the fact that both narratives are consistent with a carry trade that consists of sovereign debt purchases, funded by the vLTRO.

We use the timing of the events to argue against the Sarkozy Trade flow of causality. This theory presupposes that due to liquidity constraints, the arrival of new funds should lead to an increase in purchases of sovereign debt. Assuming that the ECB is the only source of new funds, a plausible assumption if we take the supply of deposits as fixed and that

wholesale funding markets were closed to Portuguese banks at the time, the change in total borrowing from the ECB should then cause the purchase of government bonds. This timing is inconsistent with what we observe in the data: taking the second allotment as the only major widespread increase of total ECB borrowing, we do not observe a significant increase in government bonds holdings in the months after the second allotment. In fact, we observe the opposite: that bond purchases increased *before* the new borrowing.

This suggests that, if anything, banks were collateral- rather than liquidity-constrained at the time of the vLTRO announcement. Still, collateral constraints could still be consistent both with the absence of new borrowings and the Sarkozy Trade. Under this view, banks would increase their pool of collateral during the intra-allotment period, borrow new funds at the second allotment, and then purchase even more bonds *after* the second allotment, using the newly available funds.

Under this theory, we should then observe a large increase in government bond holdings after the second allotment, which was characterized by large amounts of new borrowings. We formally show that this is not the case. Under the alternative hypothesis, large net uptakes at vLTRO2 should cause the accumulation of domestic government bond holdings after the vLTRO2. We test this claim with the following specification,

$$\Delta\text{Gov}_{i,\text{Mar12-Jun12}}^{PT} = \alpha + \beta\text{vLTRO2}_i + \gamma'X_i + \epsilon_i \quad (10)$$

that is, we regress the change in holdings of Portuguese government bonds in the months after the second allotment on the amount that was borrowed during that allotment, as well as bank-level controls (size, leverage, and nationality).³⁷ The results are presented in [Table 8](#) and show that, if anything, banks that borrowed the most were the ones that decreased their holdings the most in the post-allotment period.

Columns (1)-(2) present the results using as a regressor the change in long-term ECB borrowing between February and March 2012 (total vLTRO borrowing in the second allotment, net of rollover from the first allotment). The impact is significant and negative: if anything, banks that borrowed from the second allotment reduced their face value exposure to the Portuguese sovereign in the following months. For robustness, columns (3)-(4) replace the regressor for the change in total ECB borrowing in the same period, and the results are similar. If anything, the magnitudes increase when controls are included in the regression.

Our results are also robust to using a panel specification,

$$\Delta\text{Gov}_{i,t}^{PT} = \alpha_i + \gamma_t + \beta\Delta\text{Total ECB Borrowing}_{i,t-1} + \epsilon_{i,t} \quad (11)$$

³⁷We use June 2012 as the end period since three large Portuguese banks received government assistance during this month. Our results are robust to extending the period.

	Dependent variable: $\Delta\text{Gov}_{\text{Mar12-Jun12}}^{\text{PT}}$			
	(1)	(2)	(3)	(4)
vLTRO2	-0.095*** (0.015)	-0.125** (0.017)		
vLTRO2 ^N			-0.068* (0.036)	-0.483*** (0.084)
Controls		✓		✓
<i>N</i>	71	71	71	71
adj. <i>R</i> ²	0.350	0.430	0.036	0.294

Table 8: Testing for Reverse Causality. This table presents the results of specification (10). The dependent variable is the change (quantity) of Portuguese government bond holdings between March 2012 and June 2012, divided by assets in February 2012. The regressors are: the amount borrowed in the second vLTRO allotment divided by assets in February 2012, and the total change in ECB borrowing between February and March 2012, divided by assets in February 2012. Controls include nationality, interaction of nationality with vLTRO2, size and leverage in February 2012. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Dependent variable: $\Delta\text{Gov}_{i,t}^{\text{PT}}$			
	(1)	(2)	(3)	(4)
$\Delta\text{Total ECB Borrowing}_{i,t-1}$	-0.049* (0.028)	0.053** (0.027)	-0.046 (0.029)	-0.056* (0.031)
$\Delta\text{Total ECB Borrowing}_{i,t-1} \times \text{Foreign}_i$				0.076 (0.085)
Bank FE	✓		✓	✓
Time FE		✓	✓	✓
<i>N</i>	513	513	513	513
adj. <i>R</i> ²	0.044	0.007	0.045	0.044
Sample	Full	Full	Full	Full

Table 9: Sarkozy Trade, Panel. This table presents the results of specification (11), for the intra-allotment and immediate post-allotment time periods, between November 2011 and June 2012. The dependent variable is the change in face value of Portuguese government debt holdings t and $t - 1$, scaled by total assets at $t - 1$. The regressors are changes in total ECB borrowing between $t - 1$ and $t - 2$, scaled by assets at $t - 2$, as well as a Foreign interaction. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

where we regress the change in government bond holdings by bank i in month t on the change in total ECB borrowing in the previous month, also including bank and month-level fixed effects. Results are shown in Table 9. Our sample is not exactly the intra-allotment period – we extend it to June 2012. This should work against us, and in favor of the alternative hypothesis if banks only employ the ECB funds to purchase government debt with a lag.

As with our cross-sectional results, the above results show that, if anything, there is a negative relationship between the change in previous month’s borrowing from the LOLR and the change

in the face value holdings of Portuguese government debt. Note that these results refer to exact quantities, and are immune to concerns related to ECB actions impacting bond prices and valuations.

Finally, a channel through which the Sarkozy Trade may be operative (and with which all our results are still fully consistent) is if banks were indeed liquidity-constrained, but the bond purchases preceded the actual borrowing due to the fact that the vLTRO announcement relaxed other funding constraints. If the vLTRO is taken as a signal that the ECB is indeed willing to act as a lender-of-last-resort, wholesale investors may be willing to relax their credit constraints to Portuguese banks, thereby allowing them to raise the funds that enable the purchase of government bonds. We show that this was not the case by looking at the behavior of other liabilities, namely those that are associated with wholesale funding.

We study the impact of wholesale funding on government bond purchases by extending specification (11) and adding non-LOLR funding variables as regressors,

$$\begin{aligned} \Delta \text{Gov}_{i,t}^{PT} = & \alpha_i + \gamma_t + \beta_0 \Delta \text{Total ECB Borrowing}_{i,t-1} + \beta_1 \Delta \text{Retail Funding}_{i,t-1} \\ & + \beta_2 \Delta \text{Wholesale Funding}_{i,t-1} + \beta_3 \Delta \text{Government Funding}_{i,t-1} + \epsilon_{i,t} \end{aligned} \quad (12)$$

These are measures of retail, wholesale, and government funding, respectively. The measure of wholesale funding consists of the change on deposits whose counterparties are financial institutions plus securities and repurchase agreements. These measures explicitly exclude central banks as counterparties. The measure of retail funding consists of the change on deposits whose counterparties are private agents: individuals and non-financial firms. The measure of government funding is equal to total deposits once private counterparties are excluded. These are primarily deposits made by the central and local governments, as well as by public companies and agencies. Results for this specification are shown in [Table 10](#).

As it is clear from the table, adding these alternative measures of funding do not change the results. It does not seem that banks raised funding from external sources to purchase government bonds, as the constraint relaxation hypothesis would suggest. In particular, the inclusion of the government funding variable also excludes concerns that due to political economy reasons, the government could be providing funding to banks so that they would purchase government debt.

5.4 Quantifying the Impact on Demand

Having established that the vLTRO announcement led to an increase in the demand for domestic sovereign bonds, we now attempt to quantify this effect. We conduct the quantitative analysis under the guidance of our theoretical model and preliminary empirical analysis: both suggest that this increased demand was particularly strong at the shorter-end of the maturity structure of government debt. We will therefore analyze the total impact of the vLTRO on the demand for public debt, distinguishing bonds whose maturity is shorter than the maturity of the vLTRO (expiration date on or before February 2015, 36 months after the second allotment)

	Dependent variable: $\Delta\text{Gov}_{i,t}^{\text{PT}}$			
	(1)	(2)	(3)	(4)
$\Delta\text{Total ECB Borrowing}_{i,t-1}$	-0.052* (0.029)	0.050* (0.027)	-0.049* (0.029)	-0.051 (0.035)
$\Delta\text{Retail Funding}_{i,t-1}$	-0.002 (0.015)	0.001 (0.014)	-0.001 (0.015)	-0.063 (0.100)
$\Delta\text{Wholesale Funding}_{i,t-1}$	-0.006 (0.018)	0.003 (0.018)	-0.006 (0.018)	-0.016 (0.033)
$\Delta\text{Government Funding}_{i,t-1}$	0.013 (0.052)	0.022 (0.051)	0.016 (0.052)	0.010 (0.050)
Bank FE	✓		✓	✓
Time FE		✓	✓	✓
Foreign Interactions				✓
N	513	513	513	513
adj. R^2	0.038	0.001	0.039	0.033
Sample	Full	Full	Full	Full

Table 10: Sarkozy Trade, non-ECB Funding, Panel. This table presents the results of specification (12), for the intra-allotment and immediate post-allotment time periods, between November 2011 and June 2012. The dependent variable is the change in face value of Portuguese government debt holdings t and $t - 1$, scaled by total assets at $t - 1$. The regressors are changes in total ECB borrowing between $t - 1$ and $t - 2$, scaled by assets at $t - 2$, changes in retail funding, changes in wholesale funding and changes in government funding. Retail funding is defined as deposits (of any type) whose counterparties are in the non-government, non-financial sectors. Wholesale funding is defined as deposits whose counterparties are in the financial sector, plus repurchase agreements, plus securities. Government funding are deposits whose counterparties are central or local government and public companies/agencies. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

and longer.

To quantify the impact of the vLTRO announcement on the demand for bonds at different maturities, and by different types of institutions, we take advantage of the richness of our data and adopt a triple-difference approach. We study the demand of different bonds, by different entities, over time. We focus on heterogeneity across each of these dimensions: for bonds, we distinguish between short and long-term, where short refers to whether the bond expires before or after the vLTRO borrowing matures; for entities, we distinguish between MFI's, who have access to the vLTRO and Central Bank lending facilities, and non-MFI financial institutions (such as mutual and pension funds); for time, we distinguish between the pre-vLTRO period, the months leading to December 2011, and the post-vLTRO period.³⁸

³⁸We do not distinguish the intra and the post-allotment periods in our analysis for two reasons: i) As we documented, banks that accessed the vLTRO tend to reduce their holdings of government debt in the post-allotment period, so this is a conservative approach; ii) Consistent with our model, banks are likely to renew

We employ the following triple-difference specification,

$$\frac{H_{i,j,t}}{\text{Amount Outstanding}_{j,t}} = \beta \text{vLTRO}_t \times \text{MFI}_i \times \text{Short-Term}_j + \gamma' X_{i,j,t} + \epsilon_{i,j,t} \quad (13)$$

where $H_{i,j,t}$ are holdings (measured in face value) of ISIN j by entity i at month t and $\text{Amount Outstanding}_{j,t}$ is the total face value outstanding of ISIN j at month t . The treatment dummies are: vLTRO_t , equal to 1 after December 2011; MFI_i , equal to 1 if entity i is a MFI (and has access to the vLTRO); and Short-Term_j , equal to 1 if ISIN j expires on or before February 2015, 36 months after the second allotment. $X_{i,j,t}$ includes entity-, ISIN- and time-level controls: it includes all double interactions between the treatment dummies, and either the dummies themselves or entity-, ISIN- and time-level fixed effects.

The results are presented in [Table 12](#). Columns (1)-(2) include the treatment dummies as controls, while columns (3)-(4) include entity-, ISIN- and time-level fixed effects instead. Columns (1) and (3) include the full sample of entities, while columns (2) and (4) restrict the analysis to domestic entities. The results are, overall, very similar across samples and specifications. As a time period, we focus in the one-year period before and after the vLTRO announcement, December 2010 to December 2012.³⁹ Standard errors are clustered at the investor sectoral level.⁴⁰

Across specifications, the only statistically significant results are: i) the triple interaction between the vLTRO, MFI and Short-Term dummies; ii) the interaction between the MFI and the Short-Term dummies, and iii) the interaction between the MFI and the vLTRO dummies. The interpretation of the triple interaction coefficient requires the careful definition of a benchmark. Since we want to study the impact of the vLTRO announcement in the demand for government debt, our preferred analysis consists of asking the following question: by how much did the vLTRO announcement increase the demand for government debt (as a percentage of amount issued)? Given our specification, we can ask this question, separately, for: i) Short and long-term government bonds, ii) MFI's and non-MFI's. For non-MFI's, no impact coefficient is statistically significant, meaning that we find no significant increase in demand, at either maturity, for institutions that have no access to the Central Bank facilities.

their investments in short-maturity bonds as the initially acquired short-term bonds mature and margin calls are issued. Therefore, the vLTRO should lead to a shift in preference towards short-term bonds throughout the following 36 months, until the loan itself expires.

³⁹Our estimates are very robust to changes in the time period, we obtain almost the exact same estimates for the ± 6 months period around the vLTRO announcement in December 2011.

⁴⁰Each entity in our sample is classified according to a functional criterion, in one of the following investor sectors: The investor sectors are: monetary and financial institutions (including money market mutual funds), mutual investment funds and companies (excluding money market mutual funds), venture capital companies, financial brokerage companies, holding companies, other financial intermediaries, mutual guarantee companies, non-depository credit institutions, financial auxiliaries, insurance companies, and pension fund companies.

Table 11: Holdings/Amount Issued, +- 1 year, clustered at investor sector

	Dependent variable: $\frac{H_{i,j,t}}{\text{Amount Outstanding}_{j,t}}$			
	(1)	(2)	(3)	(4)
Short-Term _{<i>j</i>} × MFI _{<i>i</i>} × vLTRO _{<i>t</i>}	0.00290*** (0.0000643)	0.00399*** (0.000145)	0.00290*** (0.0000625)	0.00399*** (0.000143)
Short-Term _{<i>j</i>} × vLTRO _{<i>t</i>}	0.00000387 (0.0000172)	0.00000211 (0.0000258)	-0.000288 (0.000337)	-0.000300 (0.000367)
Short-Term _{<i>j</i>} × MFI _{<i>i</i>}	0.00220*** (0.000399)	0.00386*** (0.000519)	0.00220*** (0.000399)	0.00386*** (0.000519)
MFI _{<i>i</i>} × vLTRO _{<i>t</i>}	0.000351*** (0.0000155)	0.000522*** (0.0000258)	0.000304*** (0.0000145)	0.000528*** (0.0000236)
MFI _{<i>i</i>}	0.000341 (0.000441)	0.000750 (0.000539)		
Short-Term _{<i>j</i>}	-0.000307 (0.000396)	-0.000388 (0.000499)		
vLTRO _{<i>t</i>}	0.00000178 (0.0000143)	0.00000355 (0.0000201)		
Fixed Effects			✓	✓
<i>N</i>	559483	424825	559483	424825
Sample	Full	Domestic	Full	Domestic
adj. <i>R</i> ²	0.005	0.007	0.120	0.125

Table 12: Estimating demand impact. This table presents the results of specification (13). The dependent variable are the holdings of ISIN *j* by entity *i* in month *t* (measured in face value), divided by the total amount outstanding of ISIN *j* at month *t* (also in face value). The regressors are a dummy equal to 1 if the period is after the vLTRO announcement, December 2011, a dummy equal to 1 if the entity is a MFI (with access to the ECB open market operations), and a dummy equal to 1 if the bond is short-term (expires before the vLTRO loan matures, in February 2015). When present, fixed effects are at the ISIN, entity and month levels. The sample is December 2010 to December 2012. Standard errors in parentheses are clustered at the entity’s institutional type level. * p<0.10, ** p<0.05, *** p<0.01.

For MFI’s, on the other hand, we find a significant change in behavior after the vLTRO announcement: MFI’s purchase, on average, more short-term bonds, and purchase more bonds after the vLTRO. On top of these effects, they also purchase more short-term bonds after the vLTRO (the triple interaction term). To get a sense of the quantitative importance of these results, we calculate the aggregate impact of the vLTRO announcement on the demand for government bonds. These calculations are described in [Appendix A.1](#). We find that, on average over short-term ISIN’s, the vLTRO announcement boosted demand by 18 to 24 percentage points of the total amount issued. For long-term bonds, the impact is much more

muted, but still positive: between 2.1 and 2.3 percentage points of the total amount issued. Our results are robust to changes in the sample (for the 12 months around the announcement, our estimates are 15-22 p.p. for short-term bonds, and 1.8-2.1 p.p. for long-term bonds). This suggests that the vLTRO had an economically significant impact on the demand for government debt, especially at short maturities.

Our results are consistent with the observed behavior of sovereign yields around the allotment period: an increase in demand for short-term debt drives shorter maturity yields down. Furthermore, since the relative preference shifts away from longer-term bonds, towards short-term ones, we observe a slight increase in sovereign borrowing costs at longer maturities.

6 Public Debt Management during the Crisis

In the previous sections, we document that the vLTRO caused purchases of sovereign bonds by banks, and these purchases were concentrated at shorter maturities and new issuances. We now turn to analyze the behavior of the government debt agency during the intra-allotment period. In particular, we show that the available evidence is consistent with the treasury acting strategically by issuing securities whose demand was boosted by vLTRO. We turn to describing the refinancing needs and issuance activity of the Portuguese Treasury during the period of interest.⁴¹

Maturing Debt and Rollover. Figure 11 shows the rollover activity of the Portuguese government for each semester from January 2010 to December 2013. The lined blue bars indicate the amount of maturing debt and the green solid bars show the total issuance of new debt in every semester. Around the vLTRO announcement (vertical black dashed line, second semester of 2011), the amount of public debt maturing each semester is roughly constant, approximately €20 bn from 2011 to mid-2012. In particular, during the intra-allotment period, there were four short-term zero-coupon bonds maturing for a total of €13.5 bn.⁴² This contrasts with the behavior of new issuances, which had been steadily decreasing since late 2010, and reaching a minimum during the second semester of 2011 (when only €3.3 bn of new debt were issued). The solid line is the ratio of maturing to newly issued debt, and reaches a minimum during this time period. Its behavior also shows that in spite of roughly constant levels of maturing debt, issuances restarted after the vLTRO, in the first semester of 2012, reaching 2010 levels.

⁴¹Government debt is managed by the *Agência de Gestão da Tesouraria e da Dívida Pública - IGCP*, an autonomous public agency that is in charge of managing consolidated public debt (government debt and debt of some public companies) and is under the supervision of the Ministry of Finance.

⁴²Three of them had a one year maturity and one of them had six-month maturity. The latter had a €2.3 bn. face value.

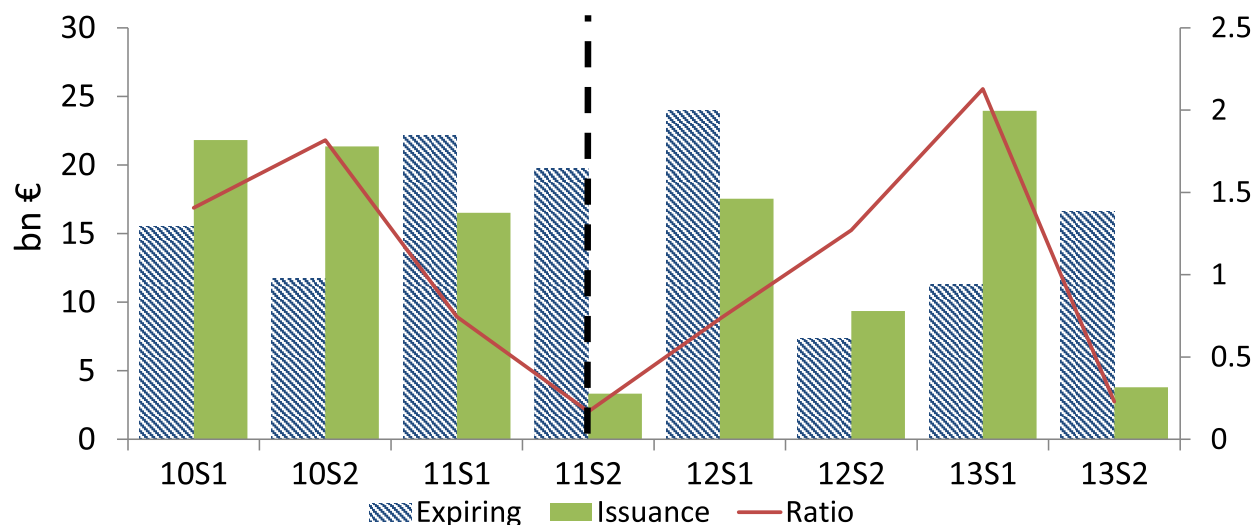


Figure 11: Government Debt Management. This figure plots the amount of public debt expiring (lined blue columns) and the new public debt issued (solid green columns) from 2010S1 to 2013S2. Both quantities are measured in € bn on the primary axis. The red solid line (secondary axis) is the ratio of amount issued over debt maturing. Source: Bloomberg.

During the intra-allotment period, the government issued €7.9 bn through four zero-coupon bonds with maturities of one year (two bonds) and six-months (two bonds). These issuances took place in two days (20 January 2012 and 17 February 2012), and in each of these days, a one-year and a six-month bond were issued. [Table 13](#) shows some statistics for these two auctions. Interestingly, while the issued amount of one-year debt was similar across auctions, the government issued twice as much six-month debt during the first auction. Both 1-year securities had a very similar price across auctions, while the 6-month securities had different yields: the February issue was much cheaper for the government (4.332% compared to 4.74% in January.).

Issuance Characteristics. The ISIN-level data collected from Bloomberg allows us to analyze in greater detail the characteristics of the bonds issued by the Portuguese government throughout our sample. This relates to a growing body of literature that studies the optimal composition of government debt issuances. [Broner et al. \(2013\)](#) show that emerging economies tend to borrow at shorter maturities due to lower costs, and [Arellano and Ramanarayanan \(2012\)](#) motivate the same finding by observing that the incentives to repay, which are particularly important during downturns, are more effectively given by short-term debt. In a recent contribution, [Bai et al. \(2015\)](#) show that, during crises, governments issue shorter-maturity bonds with back-loaded payments. This latter feature allows the government to smooth consumption by aligning payments with future output. [Figure C.13](#) in Appendix C shows the characteristics of Portuguese debt issuances during our sample period. The top panel confirms that the activity, both in terms of number of auctions (black bar) and amount issued (transparent orange bar), resumed in 2012 after only three auctions in the last three quarters of 2011. The bottom panel illustrates, for the period ranging from January 2011 to May 2013,

Issuance Date	Maturity	ISIN	Average Yield (%)	Amount Issued (€bn)
20Jan12	1Y	PTPBTIGE0017	4.986	2.13
20Jan12	6mo	PTPBTHGE0018	4.74	2.34
17Feb12	1Y	PTPBTSGE0015	4.943	2.2
17Feb12	6mo	PTPBTRGE0016	4.332	1.2

Table 13: Intra-Allotment Period Government Bond Issuance. This table shows the characteristics of the securities issued by the government in the intra-allotment period (21Dec11 - 29Feb12). Source: Bloomberg.

the maturity and coupon structure of each issuance. Consistent with the findings of the aforementioned works, the government tends to issue short-term bonds with back-loaded payments during the periods of high volatility and level of bond yields. From March 2011 to October 2012, only zero-coupon bonds were issued (the extreme example of payment back-loading) and there were no auctions for bonds with maturity higher than 2 years.

7 Conclusion

We ask whether central bank interventions, in the form of supply collateralized loans, affect the borrowing costs of the government. To this end we study the ECB 3Y-LTRO in Portugal and find that banks, during the facility allotment period, increased their purchases of domestic government bonds. Using a portfolio choice model with endogenous government bond supply, we show that banks exploited an attractive carry trade opportunity buying bonds with maturity equal or less the maturity of the central bank loan, affecting the yield curve slope. Consistent with this finding the Portuguese government was able to borrow at a cheaper short-term rate, following the 3Y-LTRO.

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Appendix

A Data Appendix

In this section, we provide a more detailed description of the data that we use, and how we transform. As mentioned in the main text, our master dataset results from the merger of two datasets:

1. 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 counterpart, geographical location of counterpart, and, for some assets and liabilities, maturity.⁴³ 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. MMF's are small given the undeveloped nature of the Portuguese money funds market.
2. 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, brokerage companies, etc.

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, 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, long-term (more than 2 years) borrowing from the central bank. For each of the MFS institutions, we also manually classify them as to whether they are foreign (i.e. wholly-owned subsidiaries of a foreign company), and as to whether they are subsidiaries. This information is obtained by crossing information with other databases (SNL Financial, Bankscope, Bloomberg), as well as checking the institution's websites.

⁴³Maturity, 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.

For the SIET dataset, we keep its original structure, a three-dimensional panel (j, i, t) , where $j \in J$ is an ISIN, owned by institution $i \in N$ at time $t \in T$. 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 only use it for consistency purposes. Note that while the datasets intersect, neither is contained in each other: the MFS includes monetary financial institutions which may not own any Portuguese sovereign debt security 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, etc.

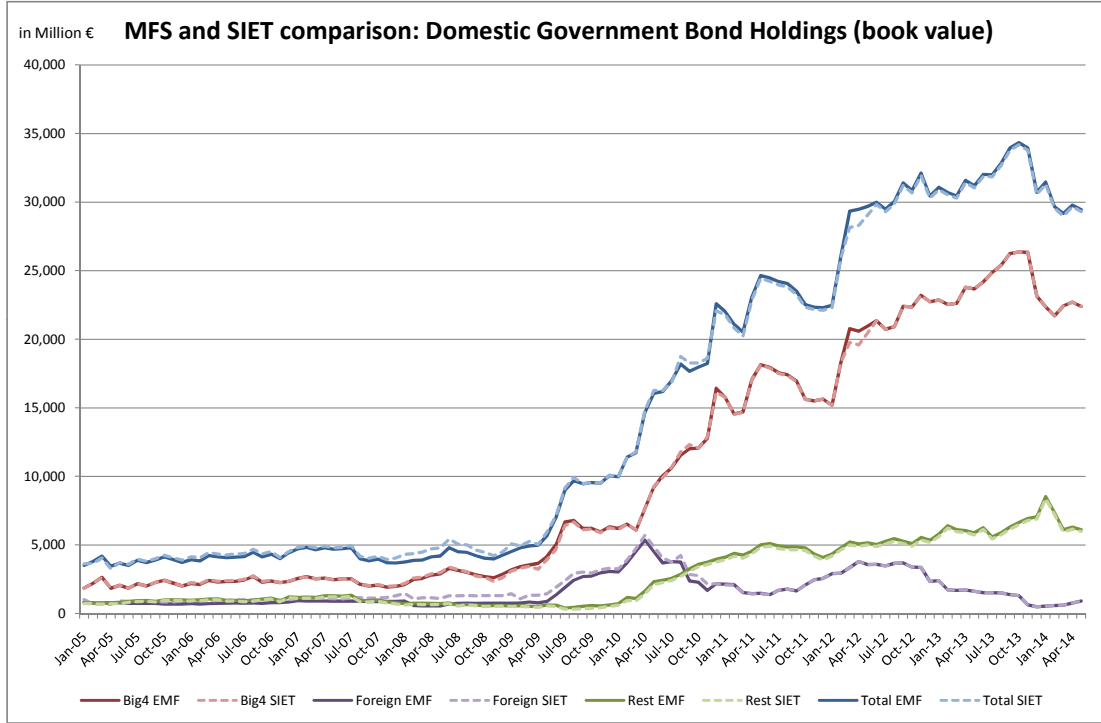


Figure A.1: Holdings of Domestic Government Debt: MFS vs. SIET This figure compares the values of domestic government debt holdings reported for each institution in the MFS and SIET databases, in order to show consistency. The small deviation in March 2012 is attributable to the inclusion of public transport company bonds in the SIET database.

A.1 Estimating the Demand Impact

First, we estimate the demand impact on short-term bonds. Consider an expanded version of specification 13, where we include the statistically significant coefficients,

$$\left(\frac{\hat{H}_{i,j,t}}{\text{Amount Outstanding}_{j,t}} \right) = \hat{\beta}_1 vLTRO_t \times MFI_i \times \text{Short-Term}_j + \hat{\beta}_2 vLTRO_t \times MFI_i + \hat{\beta}_3 MFI_i \times \text{Short-Term}_j$$

We want to compare the demand by MFI's of Short-Term bonds after the vLTRO, to the demand before the vLTRO. The total impact can be computed as

$$\hat{\Lambda}^{\text{Short-Term}} = \hat{\beta}_1 + \hat{\beta}_2$$

We now want to compute the magnitude of the impact as a percentage of total amount outstanding. To achieve this, we write

$$\hat{H}_{i,j,t} = \hat{\Lambda}^{\text{Short-Term}} \times \text{Amount Outstanding}_{j,t}$$

We sum over i to obtain the estimate of the demand impact,

$$\hat{\alpha}_t^{\text{Short-Term}} = \frac{\sum_{i:\text{MFI}_i=1} \hat{H}_{i,j,t}}{\text{Amount Outstanding}_{j,t}} = \hat{\Lambda}^{\text{Short-Term}} \times \left(\sum_{i \in I} \text{MFI}_i \right)$$

We compute the average impact over the period by taking time averages of all variables. The average number of MFI's in our sample is 75 (40 domestic). This implies the following estimates,

$$\begin{aligned} \hat{\alpha}_{\text{Total}}^{\text{Short-Term}} &= 0.2403 \\ \hat{\alpha}_{\text{Domestic}}^{\text{Short-Term}} &= 0.1807 \end{aligned}$$

We can repeat the exercise for long-term bonds. The total impact is now simply equal to

$$\hat{\Lambda}^{\text{Long-Term}} = \hat{\beta}_2$$

Repeating the computations, we obtain

$$\begin{aligned} \hat{\alpha}_{\text{Total}}^{\text{Long-Term}} &= 0.023 \\ \hat{\alpha}_{\text{Domestic}}^{\text{Long-Term}} &= 0.021 \end{aligned}$$

B Additional Tables

	Jan 2005		
	Big	Others	Foreign
No. banks	4	35	40
Mean assets	47.7	1.9	2.1
Median assets	48.1	.39	.36
Cash	.00	.00	.01
Securities	.13	.18	.07
Govt	.02	.02	.01
Dom Govt	.01	.01	.00
Lending	.78	.73	.85
Individuals	.31	.24	.20
Non-fin.	.27	.18	.32
Other	.08	.08	.08
Deposits	.81	.63	.75
MFI	.41	.21	.56
Private	.36	.40	.17
ECB	.00	.00	.00
> 2y ECB	.00	.00	.00
Repo	.00	.03	.01
Securities	.05	.06	.05
Other Liab.	.06	.07	.11
Equity	.08	.21	.13

Table B.1: Composition of Balance Sheet. This figure shows the composition of balance sheets of all monetary and financial institutions regulated by the BdP at January 2005, drawing from [Kashyap and Stein \(2000\)](#). [Figure 1](#) in the main body of the paper shows the same table for May 2009, Dec 2011, and May 2014.

PANEL A		Tot tapped (bn €)	No banks
Big 4	vLTRO1	14.5	4
	vLTRO2	17.5	4
Foreign	vLTRO1	2.9	2
	vLTRO2	6.7	6
Rest	vLTRO1	2.5	7
	vLTRO2	2.1	8

PANEL B		Tot tapped (bn €)			No banks			
		MRO	LTRO	Tot ECB	MRO	LTRO	Tot ECB	Tol Assets
Big 4	Nov11	27.2	6.4	33.6	4	4	4	355.9
	Dec11	17.2	1.0	32.7	4	4	4	355.3
	Feb12	18.7	1.0	34.2	4	4	4	360.2
	Mar12	5.2	1.0	38.2	4	4	4	357.3
For	Nov11	4.8	0.0	4.8	2	0	2	118.4
	Dec11	3.0	0.0	5.8	3	0	4	115.7
	Feb12	3.4	0.0	6.2	2	0	3	117.4
	Mar12	1.1	0.0	10.6	2	0	6	117.5
Rest	Nov-11	5.7	1.0	6.7	8	5	8	77.8
	Dec11	4.2	0.1	6.7	8	1	8	80.9
	Feb12	3.9	0.1	6.4	8	1	8	82.3
	Mar12	1.9	0.0	6.5	7	0	8	82.4

Table B.2: Borrowing from the LOLR (breakdown). This tables illustrate the number of banks and the amount borrowed during various ECB operations. The top panel shows the gross amount tapped (bn €) and banks that accessed the two vLTROs of December 2011 and February 2012. The second panel shows, at four different dates, the total amount borrowed by Portuguese banks under standard open market operations interventions, namely MRO, and LTRO. The third column shows the total borrowing (MRO, LTRO and vLTRO) from ECB. The last column illustrate total assets (bn €). Each table shows the summary statistics for the three subsamples Big Four, Foreign, and Rest.

C Additional Plots

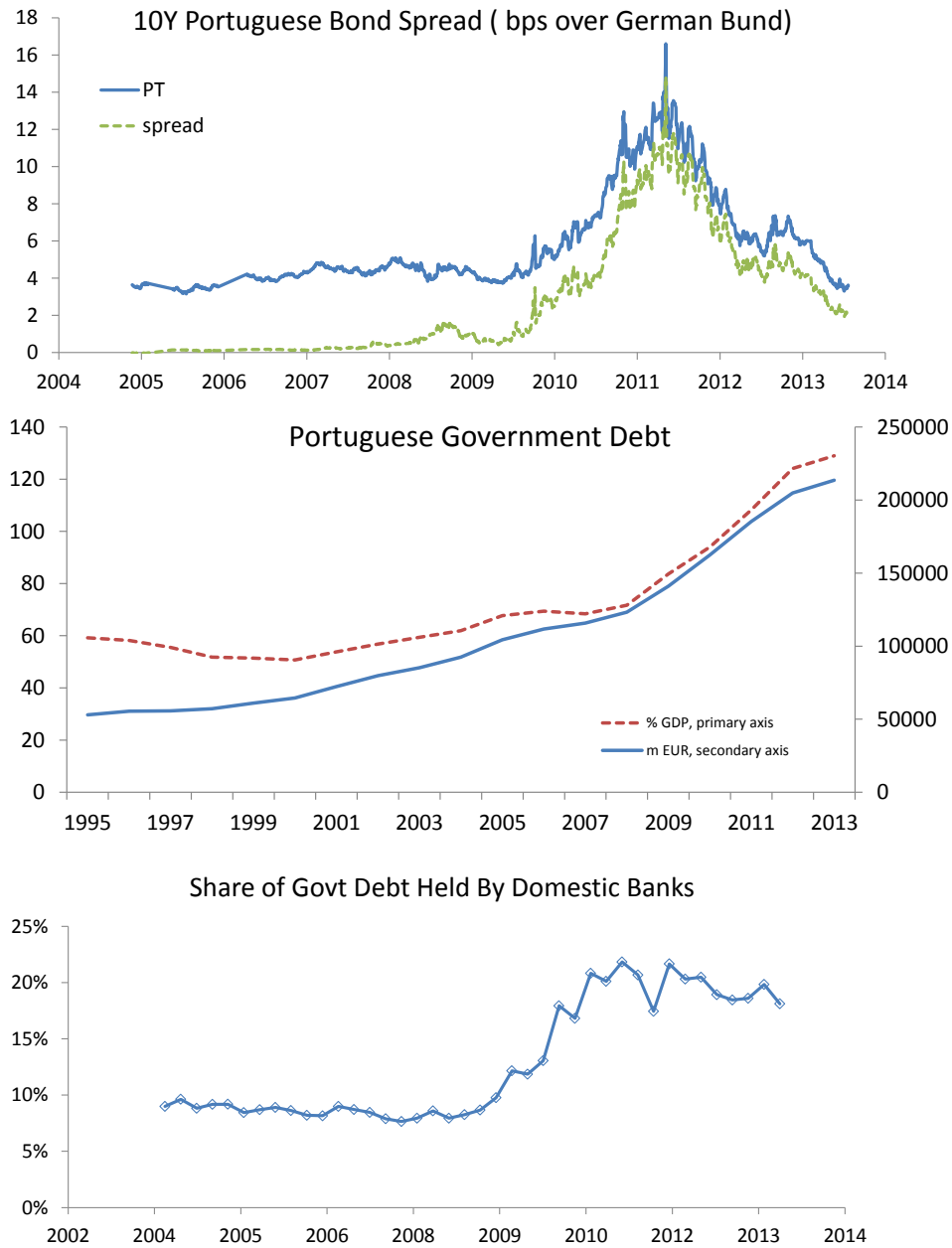


Figure C.1: PT Govt Yield and Debt. The first figure shows the Portuguese 10Y Government Bond Yield (blue solid line) and the spread with the equivalent German benchmark bond (dashed green line). The second figure shows the time series of the level of Portuguese government debt (m EUR, blue solid line) and the time series of the Portuguese government debt level/GDP ratio (percentage, dashed red line). The third and last panel shows the share of gov't debt held by domestic banks in Portugal. Source: Bloomberg, IMF, and Eurostat.

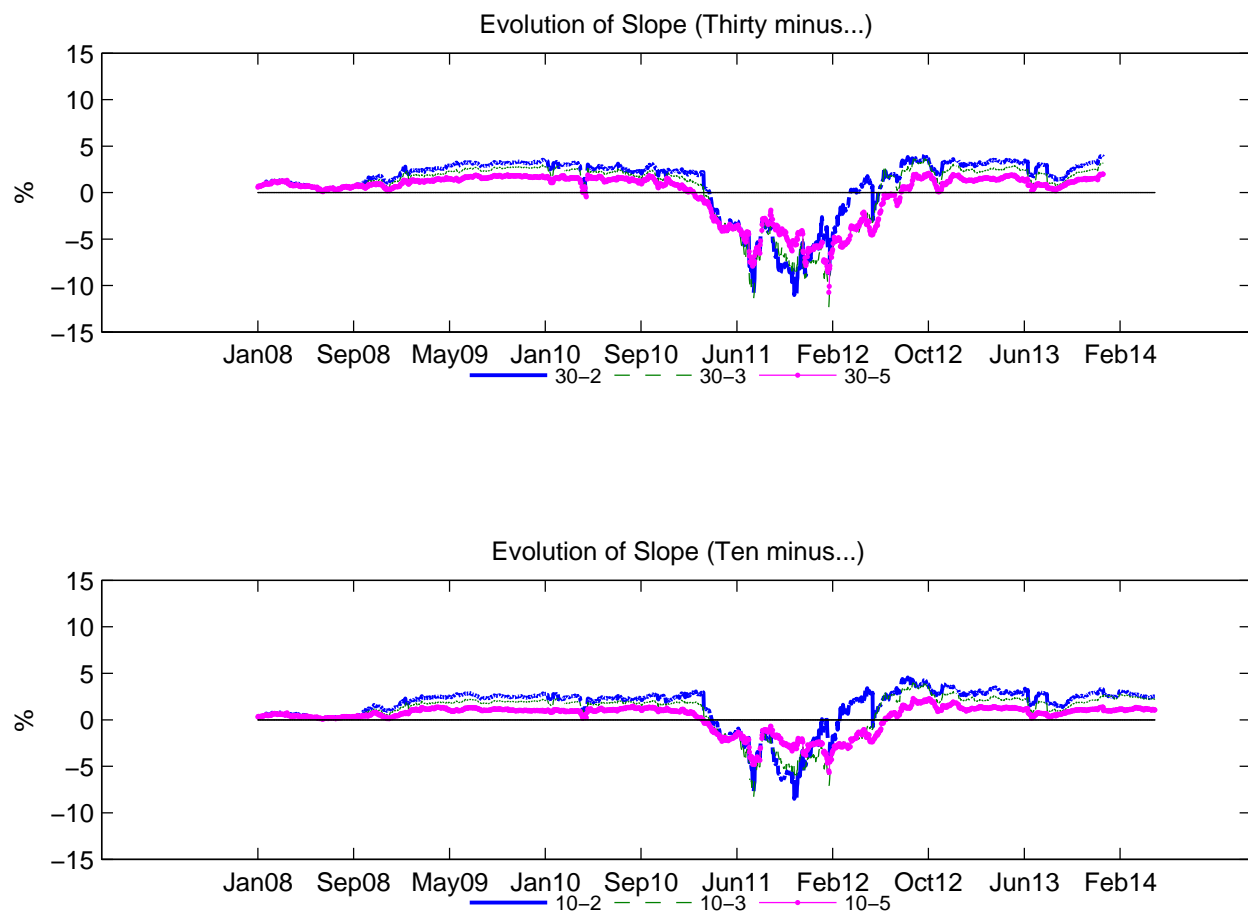


Figure C.2: Yield Curve Slope. This figure shows the slope of the Portuguese yield curve between January 2008 and February 2014. The top panel shows the time series of the spreads between 30Y yields and (i) 2Y yields, (ii) 3Y yields, and (iii) 5Y yields. The bottom panel shows the time series of the spreads between 10Y yields and (i) 2Y yields, (ii) 3Y yields, and (iii) 5Y yields. Source: Bloomberg.

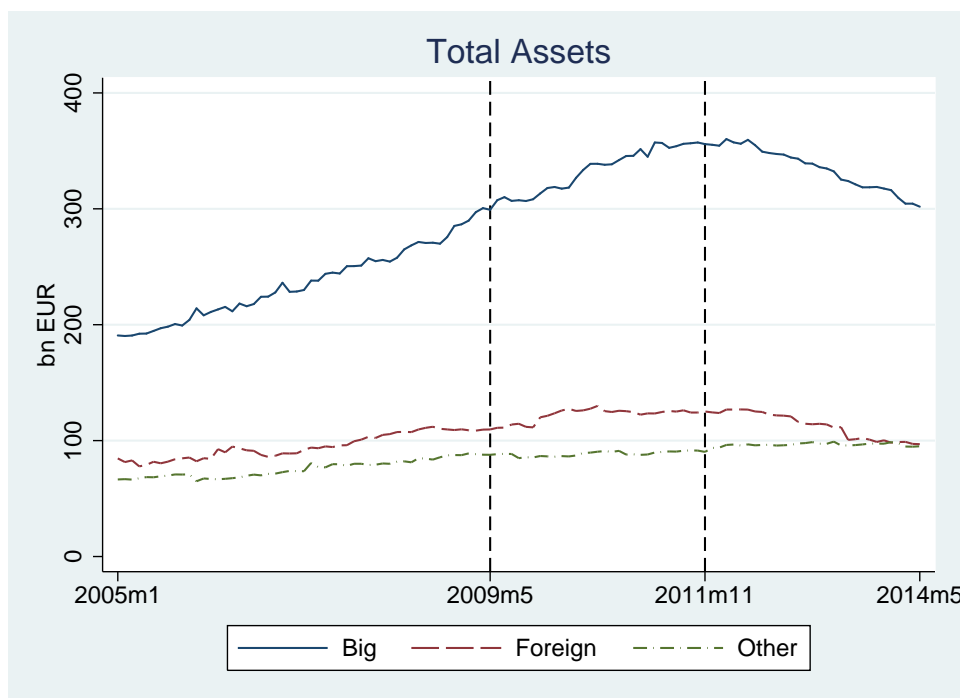


Figure C.3: Total Assets. This figure plots total assets for the three separate categories we consider (Big, Foreign, Others). Total assets consist of cash, lending, securities except equities, equity holdings, physical assets, and other assets (including derivatives). Total assets are computed as the sum of the value in all of these categories, vis-à-vis all (non-overlapping) counterparty geographical areas, for a given bank in a given month.

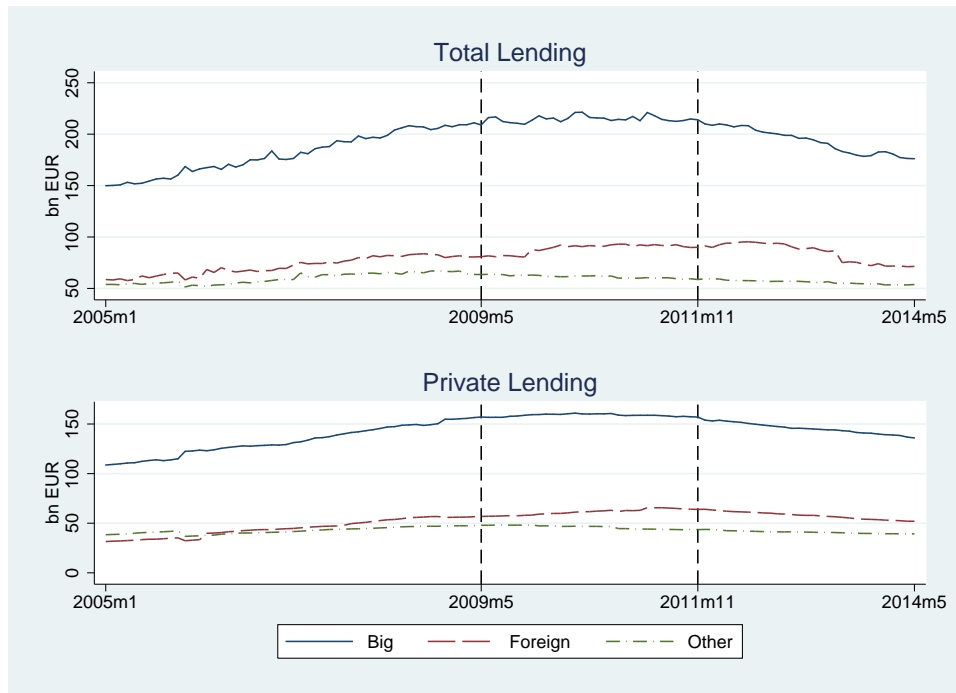


Figure C.4: Lending and Private Lending. This figure plots total lending and private lending, for the three categories in our classification (Big, Foreign, Others). Total lending consists of lending to all counterparties in all geographical areas for a given bank in a given month. Private lending is defined equivalently, but the counterparties are restricted to be non-financial firms and households.

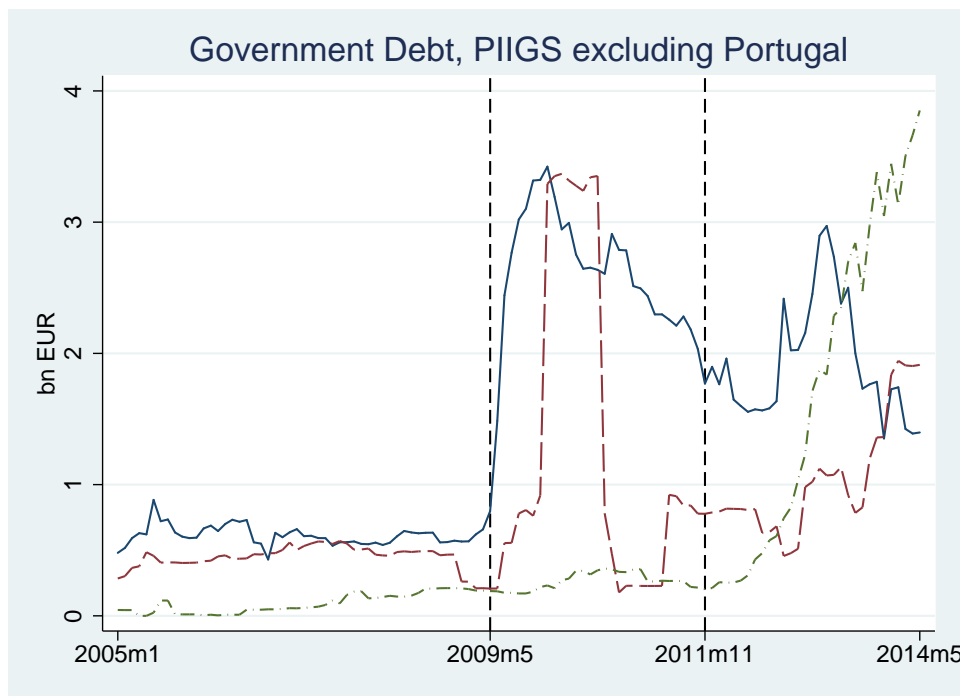


Figure C.5: Government Bond Holdings of GIIPS excluding Portugal. This figure plots total government bond holdings of periphery countries excluding Portugal, for the three categories in our classification (Big, Foreign, Others). Total government bond holdings for an institution are defined as the value, in a given month, of all securities except equity (at all maturities) whose counterparties are the central governments of Ireland, Italy, Greece and Spain.

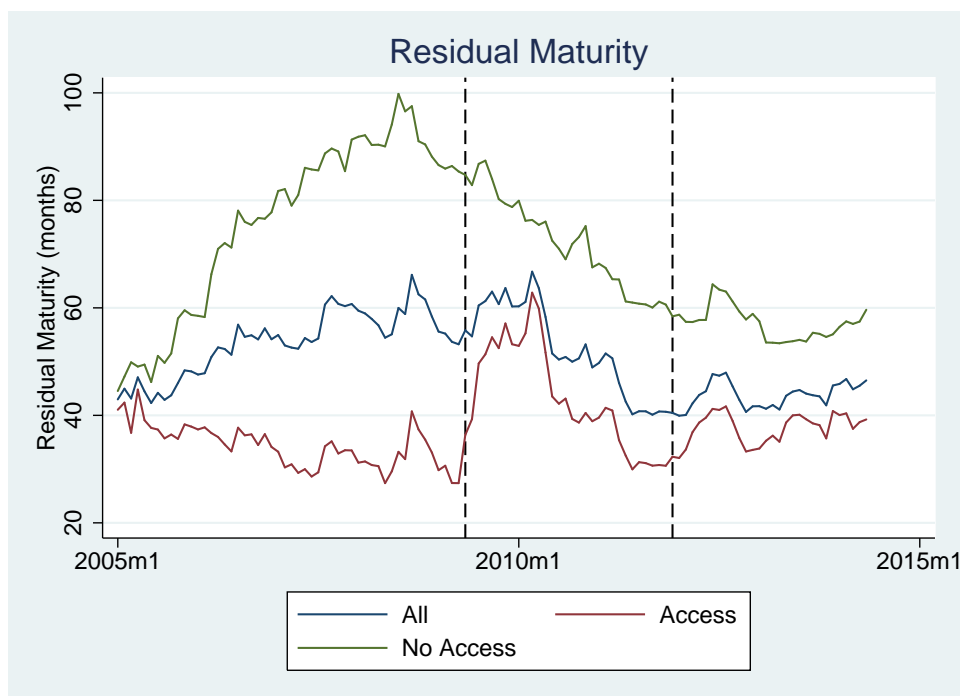


Figure C.6: Maturity of Domestic Government Bond Holdings. This figure plots the evolution of maturity of holdings of Portuguese government bonds for the subsamples of entities that have access to the LOLR (red line), entities that do not have access to the LOLR (blue line), and the entire sample. Maturity is measured as months to maturity.

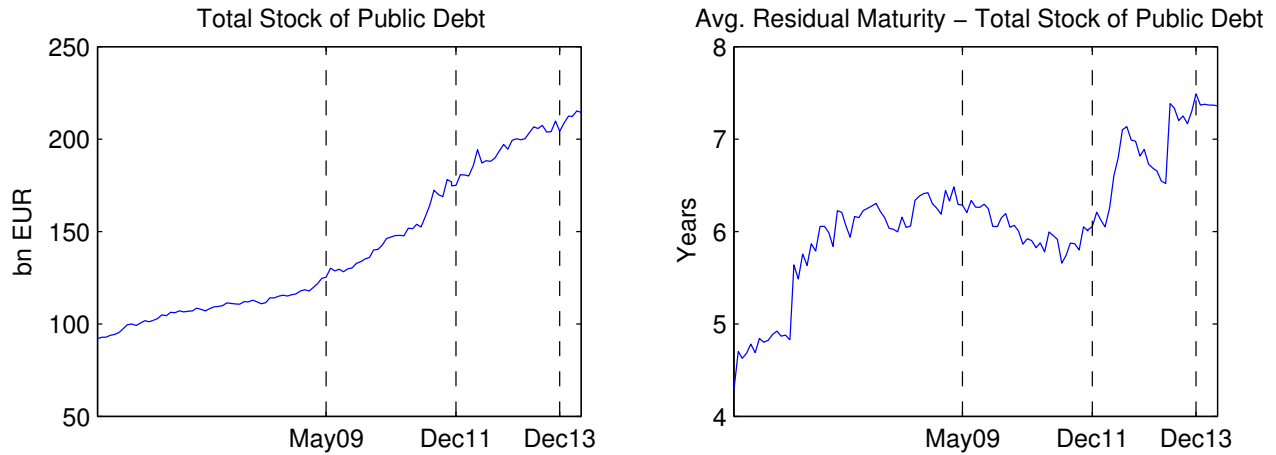


Figure C.7: Portuguese Debt Characteristics. This figure shows the evolution of the amount outstanding, and average residual maturity of the total stock of Portuguese public debt. Source: IGCP (Portuguese Public Debt Agency).

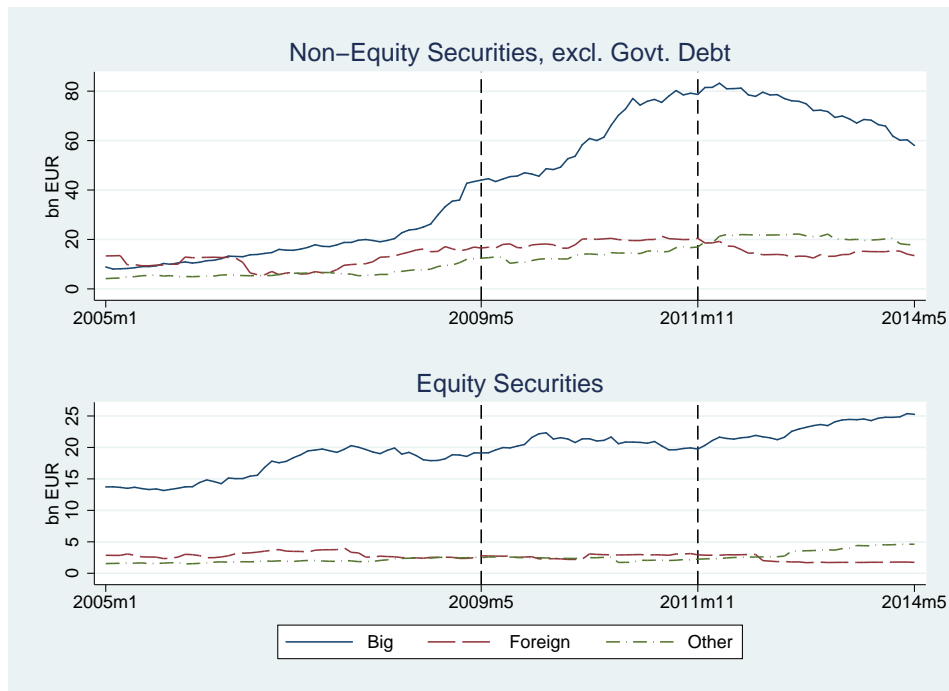


Figure C.8: Other Assets. This figure plots securities excluding equities and government debt (top panel) and equity holdings (bottom panel), for the three categories in our classification (Big, Foreign, Others).

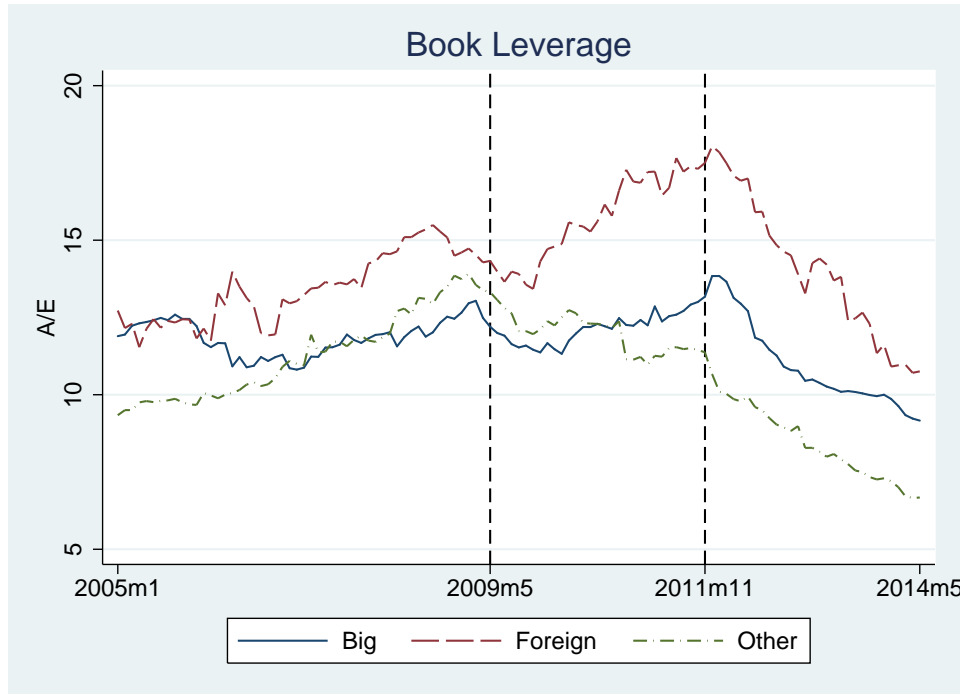


Figure C.9: Leverage. This figure plots the evolution of leverage (defined as assets over equity). Leverage is not weighted, so that total leverage for a category i is computed as the sum of assets of banks in that category divided by the sum of book equity for banks in that category.



Figure C.10: Liabilities. This figure plots the evolution of retail and wholesale liabilities in the top and bottom panels, respectively. Retail liabilities are defined as deposits whose counterparties are neither monetary and financial institutions nor the central bank. Wholesale liabilities include deposits whose counterparties are MFI's, as well as repurchase agreements, and securities.

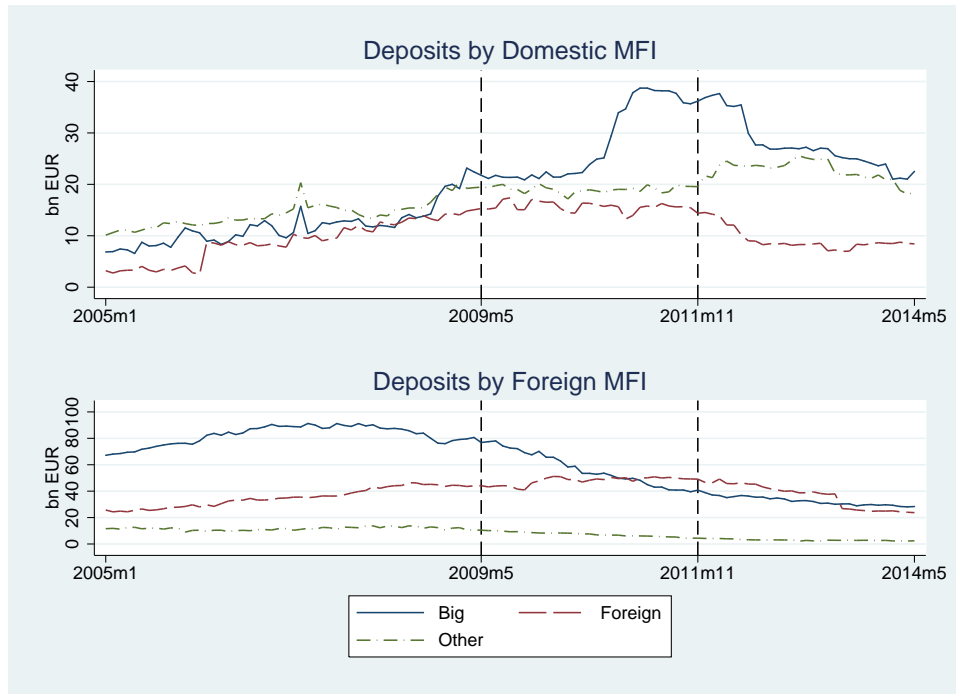


Figure C.11: Deposits by MFI's. This figure plots the evolution of deposits whose counterparties are MFI's. The top panel corresponds to deposits by domestic MFI's, while the bottom panel presents deposits by foreign MFI's.

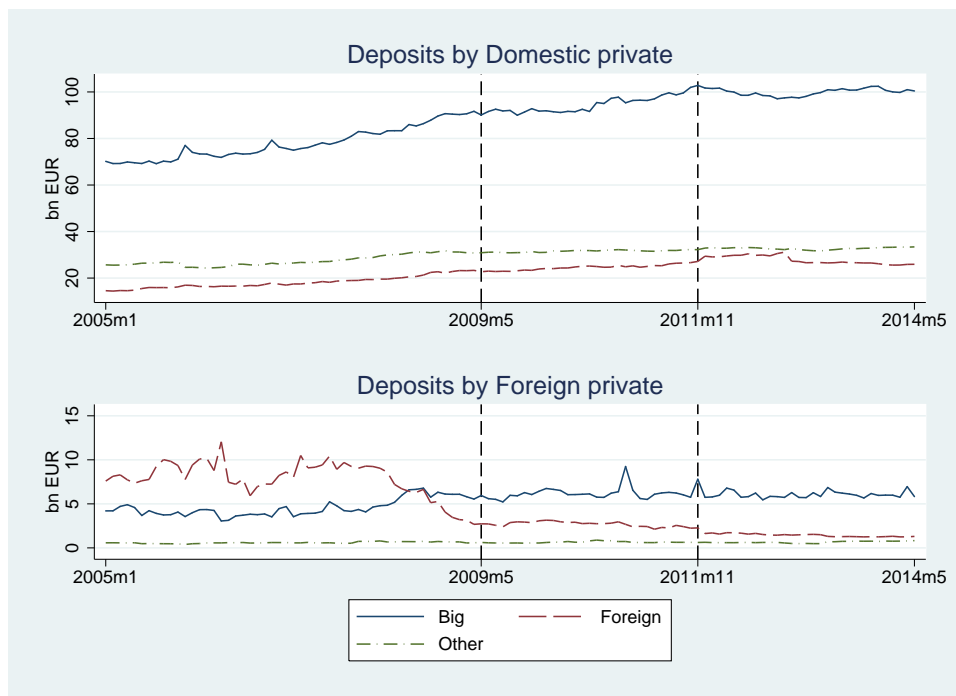


Figure C.12: Deposits by non-MFI Private Agents. This figure plots the evolution of deposits whose counterparties are non-financial private firms and households. The top panel corresponds to deposits by domestic privates, while the bottom panel presents deposits by foreign privates.

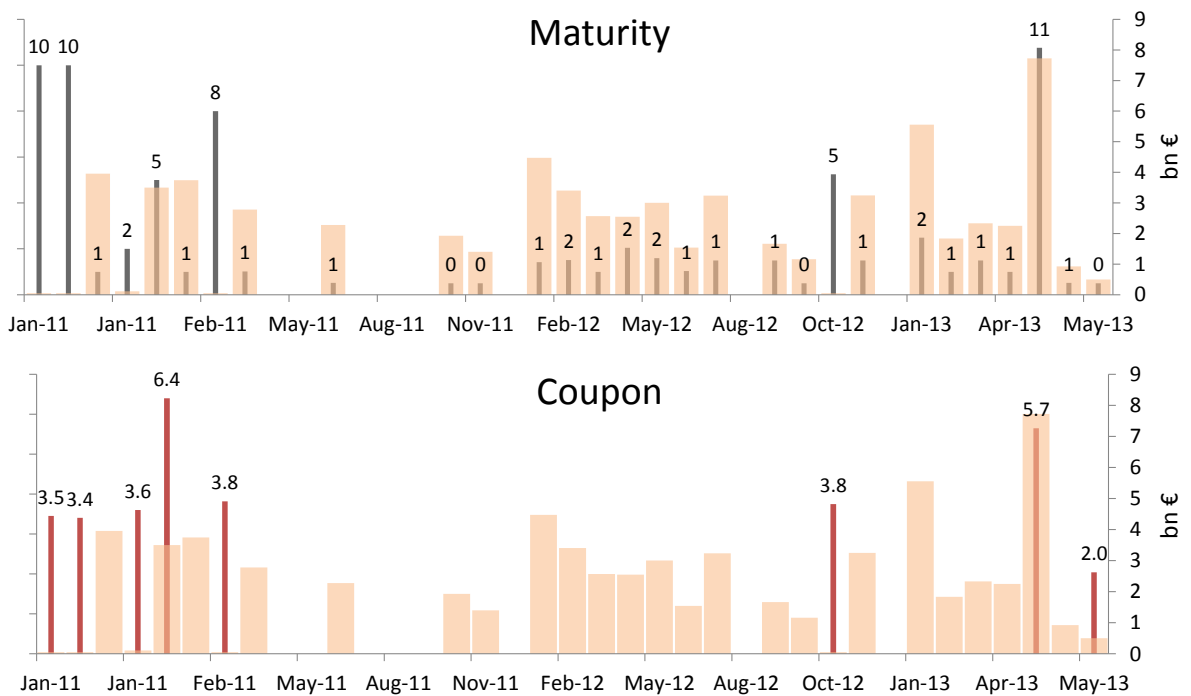


Figure C.13: Issuance Characteristics. This figure shows the issuance activity and maturity and coupon structure of bonds. The first panel shows the maturity (dark gray bars) of each issuance and the amount issued. The second panel shows the coupon rate (dark red bars) of each issuance and the amount issued. The latter, in both panels, is measured in €bn (y-axis) and illustrated by transparent orange bars.

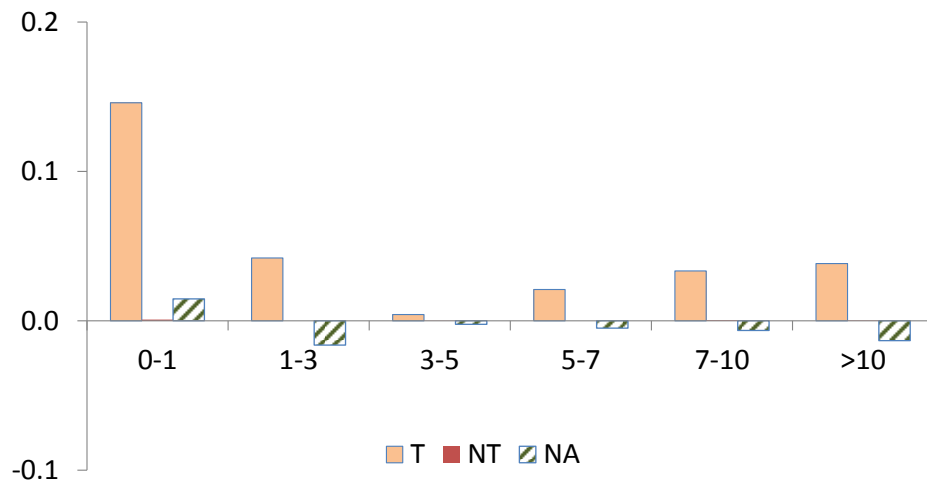


Figure C.14: Purchases by Residual Maturity. This figure replicates [Figure 5](#) excluding bonds both matured and issued in the intra-allotment period. It shows the change in holdings ΔH_n^k , between November 2011 and March 2012, of government bonds in each of the ECB-residual maturity buckets $n \in N$ and for each category of investors $k = \{T, NT, NA\}$.