

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

Matteo Crosignani

Miguel Faria-e-Castro

Luís Fonseca

NYU Stern

NYU

Bank of Portugal and LBS

August 2015

Abstract

We analyze the effect of unconventional monetary policy, in the form of collateralized lending to banks, on the demand for government bonds. Using our unique dataset on security-level holdings of public debt, we document that Portuguese banks purchased domestic bonds during the allotment of the eurozone three year Long-Term Refinancing Operations. Participating banks engaged in a “collateral trade” by purchasing high-yield short-term bonds that could be pledged at the central bank. The resulting steepening of the sovereign yield curve and the timing and characteristics of government bond auctions are consistent with a strategic response by the debt management agency.

JEL: G21, G28, H63, E58

*The opinions expressed are those of the authors and do not necessarily reflect the views of Banco de Portugal or of the Eurosystem. We are extremely grateful to Nuno Alves and Diana Bonfim for their support and the team of the Statistics Department at Banco de Portugal for helping us access and interpret the data. We thank Viral Acharya, Rui Albuquerque, Geraldo Cerqueiro, Eduardo Davila, Miguel Ferreira, Michel Habib (discussant), Victoria Ivashina, Sydney Ludvigson, Steven Ongena, Carlos Parra (discussant), Thomas Philippon, Carla Soares, Marti Subrahmanyam, Pedro Teles, and seminar participants at NYU, NYU Stern, Banco de Portugal, 2015 ECB Forum on Central Banking, London Business School TADC, Second Belgrade Young Economists Conference, Ninth Meeting of the Portuguese Economic Journal, IGCP (Portuguese Treasury and Debt Management Agency), Católica Lisbon, University of Minho, University of Porto, and Nova SBE for valuable feedback and advice. Miguel Faria-e-Castro is grateful to Banco de Portugal for the hospitality. Matteo Crosignani is grateful for the support of the Macro Financial Modeling Group dissertation grant from the Alfred P. Sloan Foundation. All errors are our own. Corresponding authors: Matteo Crosignani (mcrosign@stern.nyu.edu), Miguel Faria-e-Castro (miguel.castro@nyu.edu), and Luís Fonseca (lfonseca@london.edu).

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 the transmission of central bank policies is therefore key to design effective regulation and lender-of-last-resort (LOLR) interventions.

In this paper, we study the transmission of unconventional monetary policy to sovereign borrowing costs. Our laboratory is Portugal in 2011-2012, during the implementation of the European Central Bank's (ECB) 3-year Long Term Refinancing Operation. 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.² 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) security-level data on the holdings of Portuguese sovereign debt by all financial institutions in the country,

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.

²[Antão 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.

including non-monetary institutions.³

In December 2011, the ECB announced an extraordinary measure that consisted of collateralized lending to banks at the unprecedented maturity of three years, the 3-Year Long Term Refinancing Operation (vLTRO). These funds were distributed in two allotments. Banks that sought to borrow from the vLTRO had to post eligible collateral on pre-determined dates (the allotment dates). The vLTRO was announced on 8 December 2011, and the allotment dates were 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, (iii) these purchases help explain the amount borrowed from the ECB at the second allotment, (iv) the vLTRO announcements stimulated demand for shorter term government debt by 18 percentage points of amounts issued, and long-term debt by around 2 percentage points. Banks were lacking collateral at the time of vLTRO announcement and were not able to gather sufficient collateral to obtain *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 for a cheaper 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

³Non-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, for example, insurance companies, pension funds, and brokerages.

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 ECB loan matured.

The interaction between the different constraints faced by banks and the ECB intervention led to an expansion in demand for government debt that was tilted towards shorter-maturity government bonds. We develop a theoretical framework that formalizes this intuition and yields two additional empirical implications that are consistent with the data: (i) following the central bank operation, the sovereign curve steepens, and (ii) the government accordingly adjusts the composition of its bond issuance. We then compare two approaches to unconventional monetary policy: the vLTRO-style, or long-term collateralized lending to financial intermediaries, and the QE-style, long-term purchases of assets in secondary markets. We show that these may have different implications for aggregate variables, such as the yield curve and the aggregate maturity gap in the economy.

Our contribution is twofold. First, to our knowledge, this is the first attempt to evaluate the impact of unconventional monetary policy on sovereign borrowing costs. Our results suggest that LOLR policies can influence the government debt portfolio composition of financial intermediaries and therefore exacerbate the link between the sovereign and domestic financial sectors. Second, in contrast to quantitative easing (QE), we show that vLTRO-like operations might cause a yield curve steepening. Due to the granularity and specificity of our data, we cannot replicate our analysis for other troubled eurozone sovereigns. However, we do present some evidence that other peripheral countries experienced aggregate effects that are similar to the ones we report for Portugal. Moreover, the importance of vLTRO-like policies has grown beyond the eurozone, with similar policies being implemented in countries such as Russia and China. In Russia, the central bank (CBR) conducted a vLTRO-style policy in July 2013, dubbed “Russia QE” by the press. This policy was implemented through collateralized

lending by the CBR to banks at an unprecedented maturity of 12 months.⁴ The implicit objective of this operation was not to stimulate demand for sovereign debt but rather for corporate debt, as well as to reduce demand pressures for short-term funding. In China, vLTRO-style loans have been offered by the People’s Bank of China (PBoC), in exchange of collateral in the form of bonds issued by Chinese local governments as collateral.⁵ The policy seems to be primarily aimed at assuaging liquidity problems faced by local banks, as well as to minimizing the impact of a potential rollover crisis by over-indebted local governments. In this respect, it is adopted in a context that is very similar to the one faced by the ECB in late 2011.

Related Literature Our paper is related to four strands of literature. First, we contribute to the growing body of literature analyzing 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 and [Broner et al. \(2010\)](#) show that public debt repatriation through secondary markets is a punishment for increased default probability. In context of the eurozone crisis, the increasing holdings of government bonds by European banks have been documented by [Acharya and Steffen \(2015\)](#), who show that large and

⁴The Duma had previously allowed the central bank to increase maturity at its own discretion. In addition, the collateral base was expanded to encompass securities that were not accepted in private money markets. See [FT Alphaville \(2013\)](#).

⁵While the financial press has repeatedly referred to this policy as the “Chinese QE”, this characterization is incorrect in light of the distinctions we made above. Popular commentators argue that this policy is aimed at stimulating demand for local government debt; while the PBoC has always engaged in collateralized lending to banks as part of its regular conduct of monetary policy, it is the first time that it accepts this type of debt is collateral. Besides, the maturity is unprecedented. See [FT Alphaville \(2015\)](#) for an informal description of this program.

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 \(2015\)](#) 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. 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 either: (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.

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,

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

[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. \(2014\)](#), who find a positive impact on lending by French banks. 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. [Trebesh 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. [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 a hedge against fluctuations in interest rate spreads. Our paper proposes an alternative explanation for the reliance of sovereigns on short-term public bonds as the debt agency faces high demand for short term bonds as these are the best suited asset class to pledge at the central

bank.

Fourth, 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 QE 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. \(forthcoming\)](#). We contribute to the literature on policy coordination in two ways: first, we show discuss evidence that suggests that the Portuguese Treasury might also have behaved strategically, taking advantage of investor’s preference for short-term debt that arises from liquidity and collateral constraints. Second, we discuss the fact that programs involving incentives for private investors to acquire government debt can have very different effects than programs where assets are directly purchased by public 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. In [Section 2](#), we illustrate the data and provide some institutional background on the conduct of monetary policy in the eurozone. In particular, we describe the vLTRO in detail and present two related stylized facts. In [Section 3](#), we develop a theoretical framework that provides a narrative linking the two facts while yielding additional empirical implications. In [Section 4](#), we take advantage of the granularity of the dataset to test the model implications. In [Section 5](#), we compute aggregate effects and discuss the impact of vLTRO on sovereign borrowing costs and the government’s bond

issuance strategy. [Section 6](#) concludes.

2 Data and Institutional Setting

In this section, we first describe the dataset and the institutional setting and then present two stylized facts that motivate our analysis.

2.1 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. We complement these with mutual fund portfolio data that is obtained from the website of the Portuguese Securities Market Commission (CMVM). This is a monthly panel ranging from January 2005 to September 2013, after which it becomes a quarterly panel (available until September 2014).

The first dataset from BdP contains monthly information on the composition of the balance sheets of all monetary and financial institutions regulated by BdP. The unbalanced panel contains information on 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.⁷ This dataset allows us to determine, for example, the value of all non-equity securities

⁷More 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

whose issuer was the German central government, that were held by bank i in January 2006. Observations are measured in book value. [Crosignani et al. \(2015\)](#) describes this dataset in more detail and analyzes the evolution of the balance sheets for the Portuguese monetary financial sector during the full sample period.

The second dataset contains monthly security-level data of all holdings of government debt by 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 security (ISIN) level. We cross this dataset with bond-level information such as yield, residual maturity, and amount issued, obtained from Bloomberg.⁸

The CMVM dataset contains information on the portfolio holdings of all Portuguese mutual funds. This information helps us add detail about institutions already present in our securities dataset, and add entities that did not have Portuguese government debt throughout this period.

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.

⁸We are able to match more than 98% of the value of the dataset with Bloomberg.

2.2 Borrowing from the ECB

The Eurosystem’s open market operations are conducted through collateralized loans: banks can borrow from the monetary authority by pledging collateral in exchange for cash loans.⁹

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. MROs are the main policy tool, accounting for approximately 75% of the overall liquidity provided by the monetary authority in normal times.¹⁰ MROs are designed to support the maturity and liquidity transformation roles of banks and to signal 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”. In a world with frictionless markets, 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 such as swaps. 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 and liquidity risk (namely the risk of losing access to shorter-term lending).¹¹

⁹The 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 \(2011\)](#).

¹⁰See [Eisenschmidt et al. \(2009\)](#) for a detailed description.

¹¹Interestingly, 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



Figure 1: Timeline of the vLTRO. This figure illustrates the timeline of the vLTRO facility. The announcement (8 December 2011) is followed by two allotment dates (21 December 2011 and 29 February 2012).

Very Long-Term Refinancing Operations On 8 December 2011, as the eurozone experienced dire macroeconomic conditions, the European Central Bank announced two unprecedented “very” long-term LTROs (vLTROs), which provided three-year funding to participating banks (with the option of early repayment after one year) to “support bank lending and money market activity”.¹² 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.¹³ The interest rate was very low, based on the overnight rate during the loan period, which was around 1%¹ at the time of announcement and expected to remain low.

in their liquidity management, allowing them to diversify the maturity of liabilities (see [ECB \(2002\)](#) and [ECB \(2002\)](#) for details on the consultation and its rejection by participating banks). 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.

¹²Before vLTRO, the ECB strengthened the supply of longer term funding with extraordinary 6-month and 12-month LTROs. Three 6-month LTROs were allotted in April 2010, May 2010, and August 2011 and one 12-month maturity LTROs was allotted in October 2011. The 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 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. The announcement of the vLTRO can be found at the [ECB Website](#)

¹³Compared to previous operations, the two vLTROs also relaxed the collateral eligibility requirements.

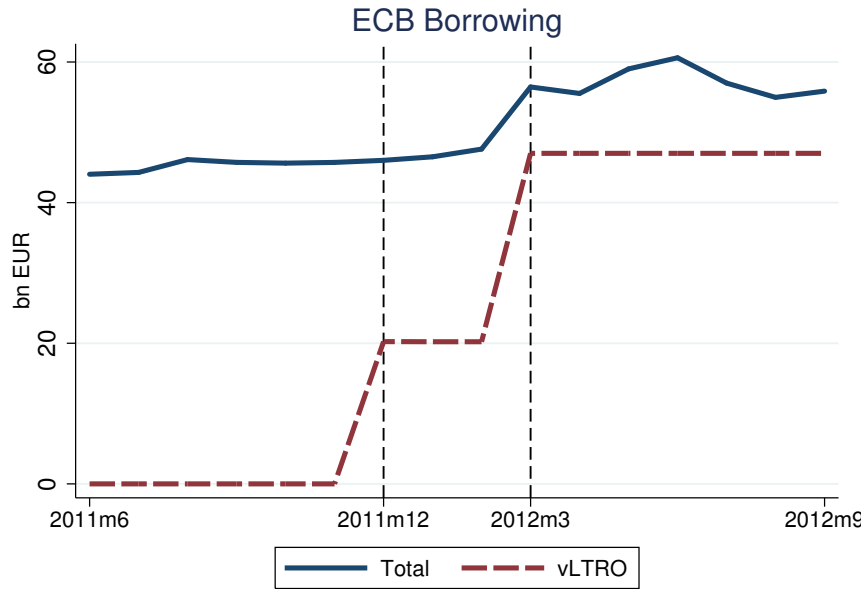


Figure 2: Central Bank Borrowing. This figure plots the evolution of total ECB borrowing (blue solid line) and long-term ECB borrowing (red dashed line) from June 2011 to September 2012 by Portuguese banks. Borrowing is defined long-term if its maturity exceeds two years. Long-term borrowing from the ECB coincides with the vLTROs for this sample period.

Participating banks had to pledge eligible collateral to get funding. The lender of last resort (LOLR) evaluated the collateral using a publicly available schedule. This schedule assigned an haircut, based on ratings, 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 euros in collateral to obtain a loan with a face value of 100 euros. [Figure 1](#) 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.

2.3 vLTRO and new ECB borrowing

Figure 2 plots the evolution of all liabilities whose counterparty is the ECB for Portuguese banks between June 2011 and September 2012. The dashed line shows long-term borrowings (with maturity exceeding 2 years), namely vLTRO1 and vLTRO2, accessed in December 2011 and February 2012, respectively. Note the different behavior of banks at the two uptakes: the effective net uptake (“new” borrowing) 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 B.1 in Appendix B disentangles short- and long-term borrowing from the ECB and reports the number of banks with positive debt from the LOLR. During the first allotment, banks reduced their short-term ECB borrowing by €19.9 bn and 16 banks tapped vLTRO for €20.2 bn. Total ECB borrowing is essentially unchanged between November 2011 and December 2011 confirming that the aggregate *net* uptake of the first allotment was basically zero. In contrast, total ECB borrowing jumps from €47.6 bn to €56.4 bn around the second allotment with banks obtaining €26.8 bn funding from vLTRO2.¹⁴

2.4 vLTRO and the demand for collateral

We now take turn to the evolution of domestic government bonds held by banks in the period between the two allotments (intra-allotment period). Figure 3 compares banks (that

¹⁴A total of 18 banks were borrowing from the ECB in November 2011. All of them access at least one the vLTROs (15 of them tap vLTRO1 and all of them tap vLTRO2). In total, 16 tap vLTRO1 and 23 tap vLTRO2. The remaining banks are institutions that accessed the vLTRO but were not borrowing from the ECB before.

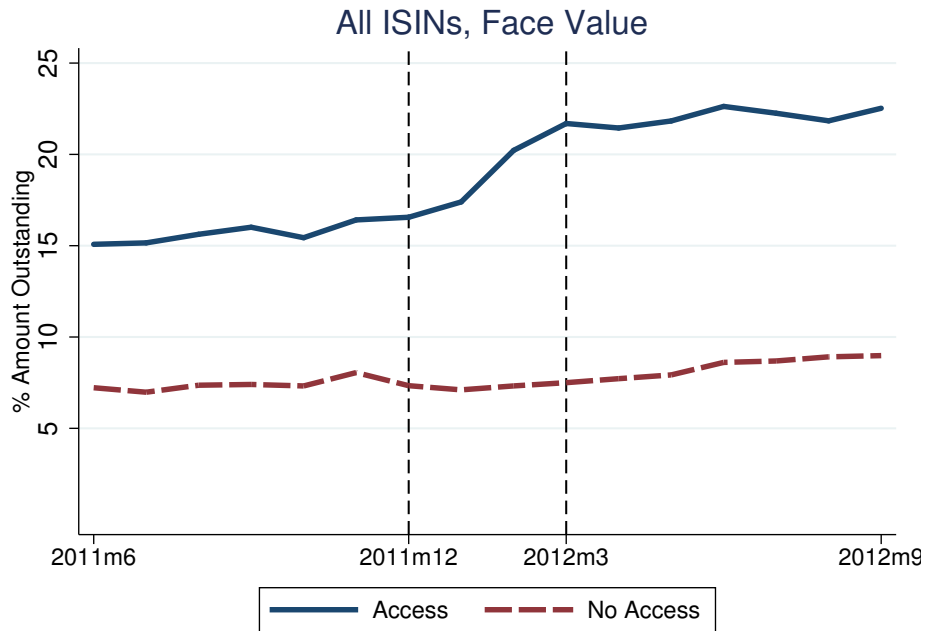


Figure 3: Holdings of Domestic Government Debt, vLTRO period. This figure plots the evolution of the quantity of domestic government bonds held by banks (solid blue line) and non-banks (dashed red line), around the vLTRO period. Quantity is measured as the total face value divided by the total amount outstanding.

could tap vLTRO) and non-banks (that were excluded from vLTRO) from June 2011 to September 2012. The vertical lines correspond to each of the two allotments, December 2011 and March 2012.¹⁵ We plot the total face value of holdings by each category, divided by the total face value issued in that month. From the figure, it emerges that the behavior of non-banks hardly changed around the vLTRO period while banks increased their holdings significantly *between* the two allotments. This behavior is markedly different from the one

¹⁵The 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.

that is observed before the first and after the second allotments.

3 Theoretical Background

Having shown that (i) vLTRO2 accounted for the entire new vLTRO borrowing in the operation and (ii) institutions with access to the LOLR increased their government bond holdings in the intra-allotment period, we now provide a narrative linking these two facts while yielding additional empirical implications. Our hypothesis is that banks, having a substantial share of their eligible assets already pledged at the LOLR in November 2011, did not have available collateral to tap vLTRO1. They instead used this facility to rollover previous ECB borrowing at the better terms of the vLTRO. Crucially, banks had only two weeks to prepare for vLTRO1 and almost three months for vLTRO2. Hence, in the intra-allotment period they gathered eligible collateral to take advantage of the one-shot three-year liquidity facility provided by the LOLR. Not surprisingly, vLTRO2, giving participants more time to gather collateral, saw greater participation (both at the intensive and extensive margins).

In this section, we develop a simple model to illustrate the reaction of banks' portfolio choice to the availability of such funding opportunity, and its general equilibrium effects. In particular, we show (i) how a decrease in borrowing costs can have an asymmetric impact on bond yields at different maturities due to liquidity and collateral constraints and (ii) how a decrease in borrowing costs for investors can lead to a steepening of the yield curve. In the following sections, we test the validity of our narrative by taking advantage of the granularity of our dataset.

3.1 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. This consists of zero-coupon bonds maturing 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 of the asset is uncertain. This will be the only source of uncertainty in the model, making the price of long-term debt at $t = 1$ uncertain. The timeline of the model and the sequence of events is depicted in [Figure 4](#).

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

$$\mathcal{U} = \mathbb{E}_0[\pi_2] \tag{1}$$

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 (which can potentially be negative), and can either rebalance their long-term debt portfolio, b'_L , or store/borrow resources d . When $d \geq 0$, banks store resources at a unit return between $t = 1$ and $t = 2$. When $d < 0$, banks borrow from external funding markets at a unit cost $\kappa > 1$. We can write profits at $t = 2$ as

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

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.¹⁶ The bank faces a budget constraint, and a collateral constraint for money market borrowing. The budget constraint at $t = 0$ is

$$W_0 + \text{€} = q_S b_S + q_L b_L + c \tag{2}$$

And the collateral constraint on external borrowing states that total borrowing € cannot exceed a weighted average of the value of pledgeable assets,

$$\text{€} \leq (1 - h_L) q_L b_L + (1 - h_S) q_S b_S \tag{3}$$

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

¹⁶We 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.

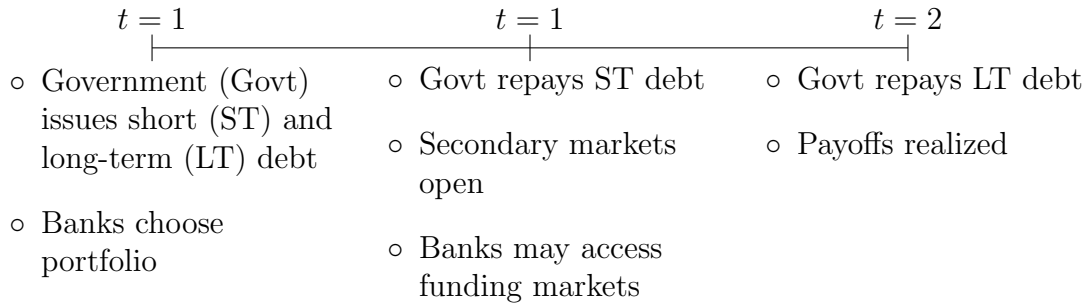


Figure 4: Timeline for the Model

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.

3.2 Characterizing the Equilibrium

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 describe the detailed solution to the banks' problem in periods $t = 1$ and $t = 0$ in [Appendix A](#). We let $\kappa \rightarrow \infty$, the costs of accessing funding markets at $t = 1$ to become prohibitive. While stark, this assumption captures a motive to hold liquid reserves at any point in time (due to regulatory constraints, for example) and simplifies considerably the solution to the model.

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

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

An equilibrium in this model is a pair of prices (q_S, q_L) , $t = 0$ bank policies $(b_L, b_S, c, \mathbb{E})$, 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, $\epsilon = \delta = \eta = 0$, 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

$$\begin{aligned}\omega &= h_S q_S \gamma + h_L q_L (1 - \gamma) \\ q_S &= \frac{1}{R + \delta h_S} \\ q_L &= \frac{\tilde{q}}{R + \delta h_L}\end{aligned}$$

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

$$\begin{aligned}q_S &= \frac{1}{R} \\ q_L &= \frac{\tilde{q} + \eta \underline{q}}{R(1 + \eta)}\end{aligned}$$

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,

$$\begin{aligned}q_S &= \frac{1}{R} \frac{h_L(\gamma + \underline{q}(1 - \gamma)) - (1 - h_L)R\omega}{\gamma(h_L - h_S)} \\ q_L &= \frac{1}{R} \frac{(1 - h_S)R\omega - h_S(\gamma + \underline{q}(1 - \gamma))}{(1 - \gamma)(h_L - h_S)}\end{aligned}$$

The above proposition defines regions for the equilibrium depending on the value of $R\omega$. If the value of this term 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 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 can use our stylized model to analyze the general equilibrium effects of banks' portfolio choice on prices. 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 haircuts are constant, and the haircut on short-term debt is smaller, $h_S < h_L$.¹⁷

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

¹⁷During 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.

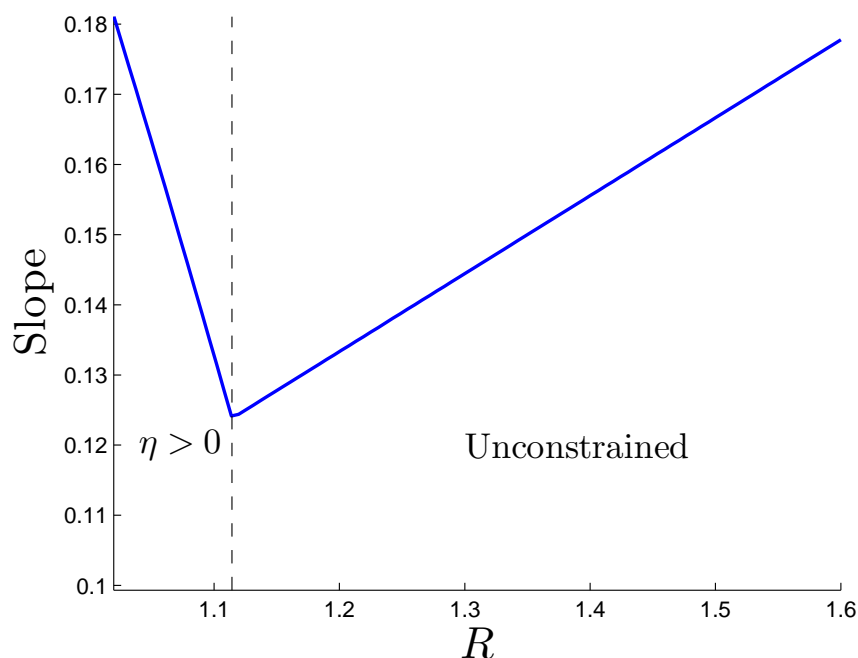


Figure 5: Slope of the Yield Curve, Model. This figure plots the slope of the Treasury’s yield curve as a function of borrowing costs R . The dashed line indicates the transition from an unconstrained equilibrium to one where the liquidity constraint binds, $\eta > 0$.

to one where banks are constrained, and thus have a preference for short-term debt.

Figure 5 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. 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.

4 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. 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.¹⁸ 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

¹⁸Without 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.

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, 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.¹⁹

Second, due to the fact that the described trade consists of purchasing an asset that is pledgeable as collateral to raise 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.²⁰

We now proceed in three steps. First, we present evidence suggesting that a combination of surprise and collateral constraints meant that the first allotment was mostly rollover of previous short-term debts, consistent with the aggregate statistics illustrated in [Section 2](#). Second, we show that the pattern of purchase of government bonds changed significantly during the intra-allotment period, and that these bond purchases explain a significant part

¹⁹Compared to other asset classes (e.g., covered and uncovered bank bonds, asset backed securities, etc.), euro denominated government bonds have also a preferential treatment as they carry a zero risk weight.

²⁰To formalize this reasoning, we present a very simple model of liquidity risk that illustrates the main trade-offs inherent to bond maturity in the Online Appendix. The model presents conditions under which a portfolio manager prefers to invest in shorter term bonds even in the absence of any time discounting. The reason is that in an environment where raising liquidity is costly, the risk of margin calls dominates the benefit from investing in an asset with a higher expected return.

of the cross-sectional variation of new borrowing at the second allotment. Third, we discuss potential alternative explanations.

4.1 vLTRO1 and Rollover

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 available collateral to access 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 6](#) 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 shows that there was no significant changes in total borrowing as a percentage of assets, in spite of considerable variation in vLTRO uptakes, and that vLTRO1 was essentially used to replace (rollover) shorter term debt.

4.2 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 to prepare themselves. This allowed them to gather the necessary collateral during this

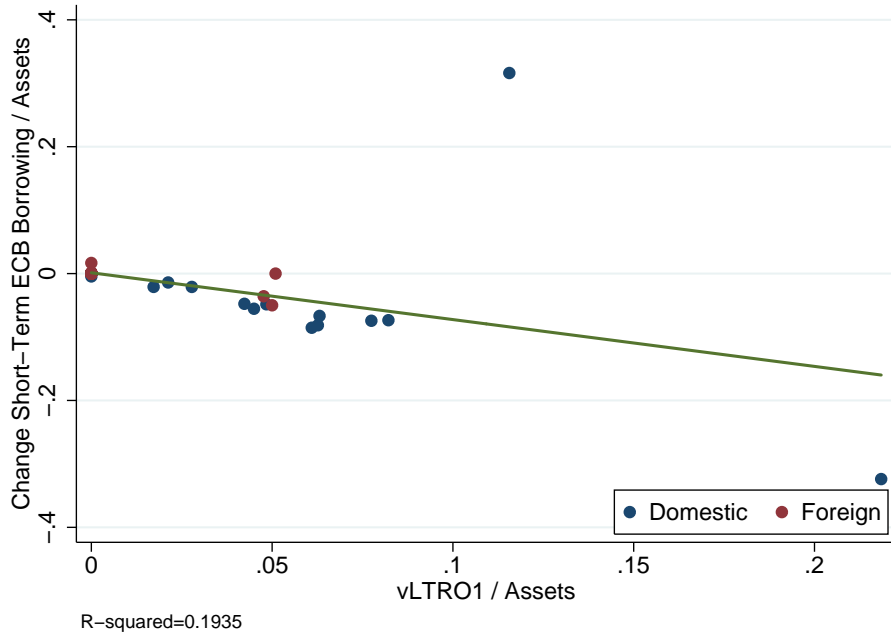


Figure 6: vLTRO1 Changes in Total and Short-term Borrowing from the ECB. The figure plots total vLTRO1 uptake against the change in short-term ECB borrowing between November 2011 and December 2011, as a percentage of assets in November 2011.

period, and consequently increase their net borrowings during the second allotment. We claim that this increased demand for collateral manifested itself through increased holdings of domestic government debt, driven by the carry trade motive 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).

$$\text{vLTRO2}_i^R = -\Delta \text{Short-Term ECB Borrowing}_{i,\text{Feb12-Mar12}} \tag{4}$$

The main requirement of this assumption is that there are 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.²¹ This assumption allows us to identify the

²¹Strictly speaking, we are also implicitly assuming that the entire stock of vLTRO1 borrowing is also being

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, (4), 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,

$$\text{vLTRO2}_i^N = \alpha + \beta\Delta C_{i,\text{Nov11-Feb12}} + \epsilon_i \tag{5}$$

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 December 2011 and February 2012.

Eligible collateral at the ECB falls in two broad asset classes: marketable assets and non-

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.

marketable assets. The first comprises debt instruments such as unsecured bonds, asset-backed securities, and covered bank bonds. The second class includes fixed-term deposits from eligible monetary policy counterparties, credit claims (bank loans), and non-marketable retail mortgage-backed debt instruments.²² The vLTRO period was characterized by an expansion of the eligible collateral. On the day of the announcement of the operations, the ECB also announced collateral availability by allowing riskier asset-backed securities and allowing national central banks (NCBs) to temporarily allow additional credit claims that satisfy their specific criteria, as long as the risks of this acceptance were assumed by the NCB.²³

We include these as regressors in addition to changes in Portuguese government bond holdings. We decompose these into price and quantity changes to control for the changes in the prices of holdings, since our argument is based on increases in quantities.²⁴ Let the face value of the holdings of a bond j held by bank i in period t that we obtain from the securities dataset be denoted by $q_{i,j,t}$. Since we also have information on the market value of these

²²See section 6 of [ECB \(2011\)](#) for additional details on the eligibility of assets as collateral in the Eurosystem.

²³On February 9, twenty days before the second allotment, BdP detailed the criteria for Portugal regarding these additional credit claims. Portfolios of mortgage-backed loans and other loans to households, as well as of loans to non-financial corporations became increasingly pledgeable as collateral. The expansion of these rules also suggests banks were collateral scarce at the time of the first allotment. Although we do not have asset-level data on the holdings of these classes of assets by banks, we rely on aggregate measures of pledged collateral for each bank. These measures include non-marketable assets whose risk was borne by the Eurosystem, additional credit claims (ACCs), government guaranteed bank bonds (GGBBs) issued from a government fund expanded around the time of the troika intervention in mid-2011, and other marketable assets. These can be interpreted as borrowing constraints, since the amounts account for haircuts. [Figure C.1](#) in the Appendix plots the aggregate amounts for the Portuguese monetary financial system. Between the end of December and the end of February, when the second allotment took place, the pledged amounts of Portuguese government bonds, as well as GGBB increased significantly. It is also visible that banks started using ACCs as soon as they were allowed, in February, but only after the vLTROs were they used as significant sources of collateral.

²⁴For Portuguese government bonds, we are not considering changes in haircuts.

holdings, $p q_{i,j,t}$, we can calculate the price as $p_{i,j,t} = \frac{p q_{i,j,t}}{q_{i,j,t}}$. We then decompose the total change in the market values of holdings as:

$$\Delta p q_{i,j,t} = p_{i,j,t} q_{i,j,t} - p_{i,j,t-1} q_{i,j,t-1} \quad (6)$$

By adding and subtracting $p_{i,j,t} q_{i,j,t-1}$ and simplifying, we can obtain the following decomposition

$$\Delta p q_{i,j,t} = \underbrace{p_{i,j,t} \Delta q_{i,j,t}}_{\text{Qty change}} + \underbrace{\Delta p_{i,j,t} q_{i,j,t-1}}_{\text{Price change}} \quad (7)$$

We can compute explicitly each of the terms, and include them separately in the regression. This allows us to isolate, for each bond and for each institution, the change in portfolio value that arose from an actual increase in holdings or from valuation gains. These terms are measured in euros, and are therefore easily aggregated across bonds for each institution. Letting $P_{i,t} = \sum_{j \in J} p_{i,j,t}$ and $Q_{i,t} = \sum_{j \in J} q_{i,j,t}$, we estimate equation 5 as follows

$$\begin{aligned} \Delta \text{Total ECB Borrowing}_{i,\text{Mar12}-\text{Feb12}} = & \alpha + \beta_1 P_{i,\text{Feb12}} \Delta Q_{i,\text{Feb12}-\text{Nov11}} + \\ & + \beta_2 \Delta P_{i,\text{Feb12}-\text{Nov11}} Q_{i,\text{Feb12}} + \\ & + \beta_3 X_{i,\text{Feb12}-\text{Nov11}} + \epsilon_i \end{aligned} \quad (8)$$

where $X_{i,\text{Feb12}-\text{Nov11}}$ represents additional measures of collateral. We divide each of the changes in value by total assets in February 2012, to scale the change by the size of the institution. [Table 1](#) presents the results.

Columns (1) and (3) present the result for the whole sample, while columns (2) and (4) include only domestic institutions. The first two columns include only changes in quantities and prices for Portuguese bonds between November 2011 and February 2012, while the

Dependent variable: $\Delta\text{Total ECB Borrowing}_{\text{Feb12-Mar12}}$				
	(1)	(2)	(3)	(4)
GovtPT Qty change	0.146 (0.212)	0.184** (0.0681)	0.369*** (0.0637)	0.241*** (0.0670)
GovtPT Price change	✓	✓	✓	✓
Other collateral			✓	✓
Sample	Full	Domestic	Full	Domestic
N	71	36	71	36
adj. R^2	0.034	0.653	0.915	0.699

Table 1: Demand for Collateral. This table presents the results of specification (8). 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 quantities and prices of holdings of Portuguese government bonds, and changes in other sources of collateral such as additional credit claims, government guaranteed bank bonds and other marketable assets between December 2011 and February 2012, divided by assets in February 2012. Even-numbered columns include only domestic institutions. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

last two columns include additional collateral measures, such as additional credit claims, government guaranteed bank bonds and other marketable assets.²⁵ These results suggest that the banks in our sample relied substantially on the acquisition of domestic government bonds as a means to access new borrowings from the second vLTRO allotment, even after we take into account the collateral eligibility expansion during this period. This expansion on collateral eligibility criteria also serves as another reason for why we choose to focus on government bonds as an asset, since they were one of the few sources of collateral whose eligibility criteria was not changed during this period, while still being an essential source of collateral for financial institutions.

²⁵Non-marketable assets in the shared-risk framework were not a significant source of collateral during this period.

4.3 Potential Alternative Explanations

4.3.1 Stigma

Stigma, and not the collateral demand dynamics that we focus on, is a potential explanation for the borrowing behavior that we observe between the first and second allotments. There is an old and vast literature on stigma associated with borrowing from the lender of last resort that is too large to be reviewed here.²⁶ The idea is that borrowing from standing facilities, such as the discount window that is operated by the Federal Reserve in the U.S., may be seen as signalling funding and liquidity problems and may raise concerns regarding the health of the institution.

If banks initially perceived borrowing from the vLTRO as a bad signal during the first allotment, but such fears were dispelled by wide participation, this could potentially explain why they avoided borrowing in the first allotment, but undertook positive net borrowing during the second allotment.

We first note that while net uptakes were very small in the first allotment, gross uptakes were substantial. As we documented, banks engaged in substantial gross uptakes during the first allotment in order to roll over previous shorter-term borrowing. Concerns regarding stigma usually belie the LOLR's concern for protecting the privacy of participants in standing facilities: indeed the ECB never published the identities of the banks that participated in the vLTRO. We note, however, using anecdotal evidence from press articles around the allotment dates that there was substantial self-reporting by participating banks. At the time

²⁶See [Peristiani \(1998\)](#), [Furfine \(2001\)](#), [Furfine \(2003\)](#). For more recent studies, see [Ennis and Weinberg \(2013\)](#) and [Armantier et al. \(2013\)](#).

of the allotment, most large banks issued public statements explicitly stating the quantities that were borrowed from the vLTRO. Most statements described access to a new funding source as a significant positive shock. This suggests that stigma was not an issue for this unconventional liquidity provision operation.²⁷

4.3.2 Window Dressing

5 Aggregate Impact and General Equilibrium Effects

5.1 Quantifying the Impact on Demand

Having established that domestic government debt was an important source of collateral during the intra-allotment, we now show empirically that: (i) the vLTRO *announcement* led to an increase in demand for government debt; (ii) this increase was concentrated in shorter maturities, as our model predicts; and (iii) we try to quantify the impact of the announcement.

Our model suggests that banks with access to the ECB’s liquidity facilities had an incentive to rebalance their collateral portfolios towards the shorter end of the yield curve. We therefore analyze the impact of the vLTRO announcement on the demand for public debt, distinguishing bonds with a residual maturity shorter than the maturity of the vLTRO’s second allotment (expiration date on or before February 2015), which we call “short-term” bonds, and longer.

²⁷Our analysis applies to Portuguese banks only; some core country banks such as Deutsche Bank explicitly voiced stigma concerns regarding vLTRO participation, see [FT Alphaville \(2012\)](#).

To test whether the vLTRO announcement had a differential impact on the demand for bonds with different remaining maturities, and across different types of institutions, we take advantage of the richness of our dataset and adopt a triple-difference approach. We focus on heterogeneity across three dimensions: for securities, 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 the MFI's that can legally access the ECB's open market operations and financial institutions that cannot, such as money market funds and non-MFI financial institutions (e.g. mutual and pension funds, etc.); for time, we distinguish between the pre-vLTRO period, the months before December 2011, and the post-vLTRO period, after the announcement.

We base our analysis in the following triple-difference specification,

$$\frac{H_{i,j,t}}{\text{Amount Outstanding}_{j,t}} = \beta \times \text{vLTRO}_t \times \text{Access}_i \times \text{Short-Term}_j + \gamma' X_{i,j,t} + \epsilon_{i,j,t} \quad (9)$$

where $H_{i,j,t}$ are holdings (measured in face value) of ISIN j by entity i in 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 on and after December 2011; Access_i , equal to 1 if entity i is a MFI with access to the vLTRO; and Short-Term_j , equal to 1 if ISIN j expires on or before February 2015, 3 years after the second allotment. $X_{i,j,t}$ includes entity-, ISIN- and time-level controls: it includes all double interactions between the treatment dummies, as well as entity-, ISIN- and time-level fixed effects.

We run our baseline specification on a six-month window around the vLTRO announcement in December 2011: from June 2011 to May 2012.²⁸ [Table 2](#) shows the results. The first

²⁸We do not include periods on or beyond June 2012, since this is the month when several large Portuguese

	Dependent variable: $\frac{H_{i,j,t}}{\text{Amount Outstanding}_{j,t}}$	
	All Bonds	Issued before Dec2011
Short-Term _j × Access _i × vLTRO _t	0.00220*** (0.0000522)	0.000181** (0.0000649)
Short-Term _j × vLTRO _t	-0.0000587 (0.000108)	0.000160 (0.000139)
Short-Term _j × Access _i	0.00353*** (0.000390)	0.00353*** (0.000390)
Access _i × vLTRO _t	0.000293*** (0.0000583)	0.000293*** (0.0000572)
Period FE	✓	✓
ISIN FE	✓	✓
Entity FE	✓	✓
Sample	Jun2011-May2012	Jun2011-May2012
<i>N</i>	259,272	242,589
adj. <i>R</i> ²	0.126	0.127

Table 2: Estimating demand impact. This table presents the results of specification (9). 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 (MFI's excluding money market funds), and a dummy equal to 1 if the bond is short-term (expires before the vLTRO loan matures, in February 2015). Fixed effects are at the ISIN, entity and month levels. The sample is June 2011 to May 2012. Standard errors in parentheses are clustered at the entity's institutional type level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

column includes all bonds outstanding during the period, while the second column excludes all bonds issued on and after December 2011. By excluding these bonds, we are controlling for potential concerns regarding any strategic response by the debt management agency, and focus only on portfolio rebalancing undertaken through secondary markets. Standard errors

banks access the recapitalization fund offered by the government, a potential confounding factor. [Table B.2](#) shows that our results are robust to changing this window to a smaller period around the operations.

are clustered at the investor sectoral level.²⁹

The first line of the table presents our main result: the triple interaction between the vLTRO, Access and Short-Term dummies is always statistically significant. This establishes that MFI's with access to the ECB's liquidity facilities increased their holdings of ISIN's with maturity shorter than the vLTRO after the announcement of the policy (as a percentage of the total amount outstanding). The magnitude of the coefficient is smaller when bonds issued after the announcement are excluded, suggesting that issuances undertaken after the policy was announced played an important role during this period.

While the second column controls for net supply effects, one could think that there is something particular to short-term bonds that led to their repatriation to the Portuguese financial system after the policy was announced, and that is unrelated to whether an institution can access the ECB's operations or not. Assuming that this repatriation would take place uniformly across different types of financial institutions (i.e. it would affect banks and mutual funds, for example, equally), this possibility is excluded by the fact that, in the second line, the interaction between Short-Term and the vLTRO dummies is not statistically significant. This reveals that non-MFI institutions did not increase their holdings of short-term bonds in a statistically significant manner after the announcement, and that access to the ECB played an important role in establishing this preference.

The third line interacts Short-Term with Access and reveals that banks tend to hold government bond portfolios with shorter maturities than other financial institutions. This is

²⁹Each entity in our sample is classified according to a functional criterion, in one of the following investor sectors: 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.

expectable due to the long investment horizons of some of these financial institutions, such as pension funds. Finally, the fourth line reveals the increase in home bias by banks that was generated by the vLTRO: after the announcement, banks with access tended to increase their holdings of government bonds across maturities. The triple interaction shows that the effect was stronger for short than for long.

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 D](#). We find that, on average over short-term ISIN's, the vLTRO announcement boosted demand by 17.7 percentage points of the amount issued. When bonds issued after December 2011 are excluded, the impact is equal to 3.4 percentage points. For long-term bonds, the impact is smaller but still positive: 2.1 percentage points, regardless of whether bonds issued after December 2011 are excluded or not (no long-term bonds were issued after the announcement in the sample period we consider for the regressions).³⁰ This suggests that the vLTRO had an economically significant impact on the demand for government debt, especially at short maturities.

Intensive Margin Our theoretical framework suggests that the larger the share of vLTRO borrowing, the stronger should be the demand for shorter-term collateral. A natural way to test this hypothesis is to replace the Access dummy for a continuous variable that reflects the intensity of vLTRO borrowing. We define intensity simply as

$$\text{Intensity}_i = \frac{\text{vLTRO}_i}{\text{Assets}_i}$$

³⁰Our results do not change much when we change this sample period: if we consider the 4 months around the announcement (August 2011 to March 2012), we observe an increase of 12.5 p.p. for short-term bonds, 4.5 p.p. when new issuances are excluded, and 1.3 p.p. for long-term bonds.

where $vLTRO_i$ is total long-term borrowing from the ECB at the end of March 2012 by entity i (the first observation that includes the second allotment), and $Assets_i$ is the value of assets of entity i in the same period. This variable simply measures the fraction of assets that are funded by long-term ECB borrowing after the second allotment. We then adapt our baseline specification,

$$\frac{H_{i,j,t}}{\text{Amount Outstanding}_{j,t}} = \beta \times vLTRO_t \times \text{Intensity}_i \times \text{Short-Term}_j + \gamma' X_{i,j,t} + \epsilon_{i,j,t} \quad (10)$$

A problem with this adapted specification is that we measure intensity as total ECB borrowing by the end of the second allotment, three months after the policy has been announced. Naturally, this is an endogenous variable, since increased holdings of government debt after the announcement but before the second allotment affect the pool of collateral owned by the bank and, therefore, how much the bank can borrow. To address this concern, we take advantage of the fact that a large part of vLTRO borrowing was rollover of past ECB borrowing, and instrument vLTRO intensity with total ECB borrowing intensity (ECB borrowing as a percentage of assets) *before* the beginning of the sample. In principle, choosing borrowing intensity before the announcement, say in November 2011, would be enough, but we choose to instrument intensity with a measure that precedes the beginning of the sample to dispel any other endogeneity concerns.

Since our sample starts in June 2011, we choose ECB borrowing as a percentage of assets in May 2011 as an instrument for total vLTRO borrowing. The results are presented in [Table 3](#).³¹ The first column includes all bonds outstanding and issued during the period, while the second column excludes new issuances, after December 2011.

³¹[Table B.3](#) presents the results for the shorter window.

	Dependent variable: $\frac{H_{i,j,t}}{\text{Amount Outstanding}_{j,t}}$	
	All Bonds	Issued before Dec2011
Short-Term $_j \times$ Intensity $_i \times$ vLTRO $_t$	0.0261*** (0.00252)	0.0261*** (0.00256)
Short-Term $_j \times$ vLTRO $_t$	0.000102** (0.0000403)	0.000101** (0.0000409)
Intensity $_i \times$ vLTRO $_t$	0.00597*** (0.00108)	0.00597*** (0.00109)
Period FE	✓	✓
ISIN FE	✓	✓
Entity FE	✓	✓
Sample	Jun2011-May2012	Jun2011-May2012
N	259,272	242,589
F-Statistic	98.14	104.97

Table 3: Estimating demand impact, intensive margin. This table presents the results of specification (10). 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 bond is short-term (expires before the vLTRO loan matures, in February 2015), and an intensity measure that is equal to long-term ECB borrowing divided by total assets in March 2012. This variable is instrumented using total ECB borrowing as a percentage of assets in May 2011, before the beginning of the sample. Fixed effects are at the ISIN, entity and month levels. The sample is June 2011 to May 2012. Standard errors in parentheses are robust (sandwich). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The impact of vLTRO borrowing intensity, as a fraction of assets, on purchases of short-term bonds after the vLTRO announcement is positive and very significant. The third line reveals that vLTRO borrowing led to increased purchases of government bonds overall. A back-of-the-envelope calculation reveals that the aggregate impact of vLTRO borrowing was economically large: for each bank, a 1 p.p. increase of vLTRO borrowing over assets led to an increase in the holdings of short-term bonds of 3 basis points of amount outstanding, and 0.5 basis points for long-term bonds. Computing the aggregate measure of intensity, we find a total impact of 7.6 p.p. of amount outstanding for each short-term ISIN and 1.4 p.p. of

amount outstanding for each long-term ISIN.³²

5.2 Effect on Government Bond Yields

Consistent with the “collateral trade” channel, the Portuguese sovereign yield curve rotated, and became steeper during the intra-allotment period. This is illustrated in [Figure 7](#), 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 (three 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 three year maturity that left the yield curve steeper.

The yield curve rotation in this period is also present in other peripheral countries like Italy and Spain, suggesting that our analysis might be valid in other similar contexts. [Figure C.2](#) plots yield curves for four eurozone countries, on the date before the vLTRO announcement (December 7, 2011) and the day after the second allotment (March 1, 2012). The upper panels correspond to two core countries, Germany and France, while the lower two panels represent two members of the GIIPS, Italy and Spain. Plots for core countries do not show the yield curve steepening, consistent with the fact that the collateral trade motive is present only if domestic government bonds offer a high enough yield.³³

³²These results are robust to controlling for new issuances, as well as to changing the length of the window around the announcement.

³³These data are taken from Bloomberg, who aggregates secondary market prices using survey data from broker-dealers. Bloomberg does not report any data if a security is not liquid enough on a given day, in which situation prices would be relatively meaningless. Due to the lack of data, we do not present plots for the remaining two GIIPS, Ireland and Greece.

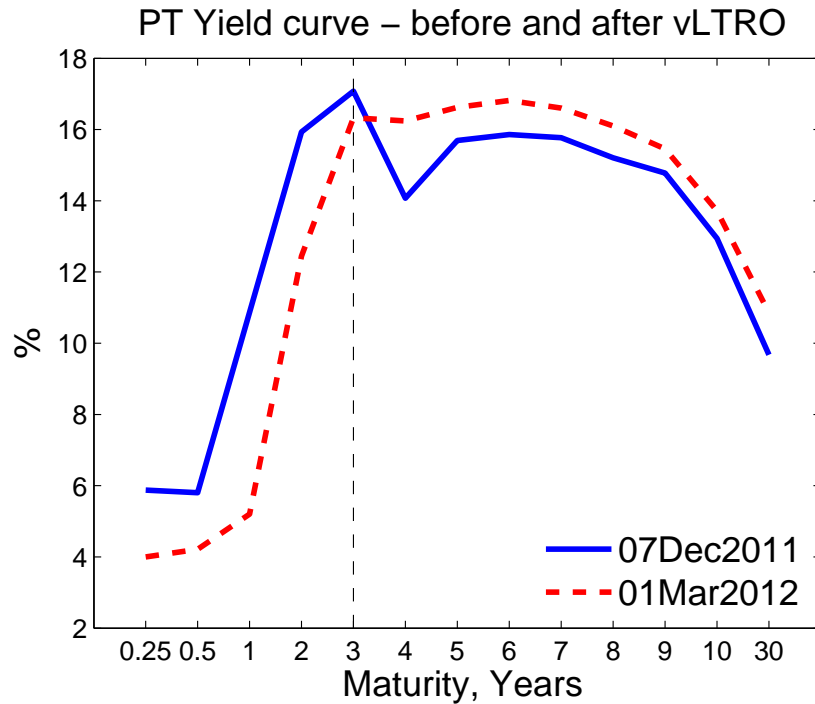


Figure 7: Portugal Yield Curve, pre and post vLTRO. This figure plots the yield curve (interpolated for missing maturities) on December 8, 2011 and March 3, 2012. December 8 is the date of the announcement of the vLTRO, and February 29 is the date of the second allotment. The horizontal axis of maturities is measured in years.

A concern may be that the changes in the yield curve, and the motive for purchasing bonds, may be unrelated to the vLTRO, and instead connected with other unconventional ECB interventions that were active at the time. A prime suspect is the Securities Markets Programme (SMP) launched by the ECB in May 2010; this initiative purchased sovereign bonds in secondary markets. The details of the SMP, such as amounts traded and securities purchased, were never disclosed: the only way through which the total volume of operations was known was through auxiliary open market operations that aimed at sterilizing the impact of the bond purchases.

In the first round of the program, that took place until August 2011, the targeted countries were Greece, Ireland, and Portugal. In the second round, starting in the summer of 2011, the

program focused on the purchase of Italian and Spanish bonds. Thus the focus was not in purchases of Portuguese bonds in the immediate pre- and the intra-allotment periods. Still, the ECB could have caused the observed impact on yield curves if it was purchasing bonds at the short-end of the term structure. [Krishnamurthy et al. \(2014\)](#), in their analysis of ECB bond-purchase programs, show that the average remaining maturity of Portuguese bonds in the SMP portfolio was of about 5 years during 2011, suggesting that most purchases were made at longer maturities. If anything, this effect would work against our results, since the purchase of bonds at longer maturities should flatten, not steepen, the yield curve.

It is also unlikely that this programme influenced agents' behavior during the intra-allotment period, given the shroud of secrecy in which the details of the purchases were involved. Unaware of the type of and quantity of securities that the ECB was purchasing, we do not find it plausible that expectations regarding the program affected substantially the behavior of market participants such as Portuguese banks.

5.3 Public Debt Management

We now look at the behavior of the government debt agency during the intra-allotment period. In particular, we show that the available evidence is consistent with the Portuguese Treasury acting strategically by issuing securities whose demand was boosted by vLTRO.³⁴

³⁴Government 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.

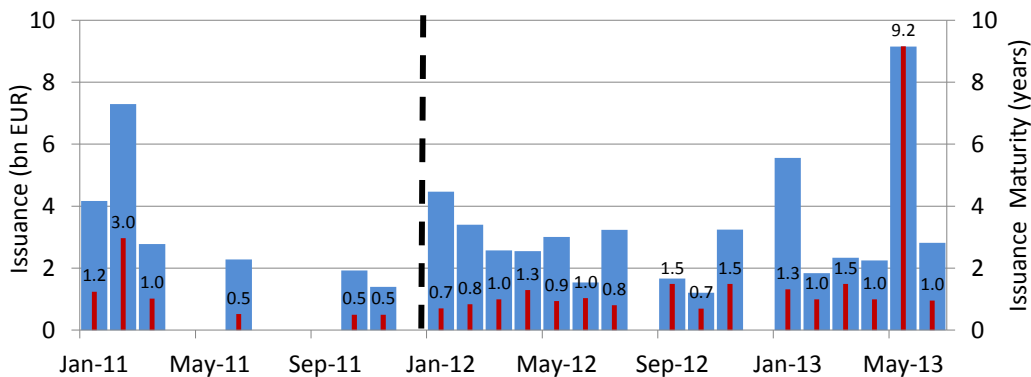


Figure 8: Issuance Volume and Maturity. This figure shows issuance volume and maturity during the period January 2011 - June 2013. Thick bars illustrate monthly issuance volume (bn €, primary axis). Thin bars illustrate volume average maturity of new public debt issuance (years, secondary axis). Maturity and volumes are taken from Bloomberg.

The security-level dataset collected from Bloomberg allows us to analyze in greater detail the characteristics of the bonds issued by the Portuguese government throughout our sample. This exercise relates to a growing body of literature that studies the optimal composition of government debt issuances.³⁵ Figure 8 illustrates, for the period ranging from January 2011 to May 2013, the maturity and volume of monthly public debt issuance. The thick bars show, in billion euros, the amount issued and the thin bars show, in years, the average maturity of monthly issuance.

The figure also documents that the debt agency ramped up debt issuance after the vLTRO announcement. This observation cannot be explained by rollover needs as, before and after the vLTRO, the amount of public debt maturing each semester was roughly constant, approximately €20 bn from 2011 to mid-2012. Interestingly, during the intra-allotment period,

³⁵Broner et al. (2013) show that emerging economics 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.

there were four short-term zero-coupon bonds maturing for a total of €13.5 bn.³⁶ During the intra-allotment period, the government issued €7.9 bn using 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.³⁷

6 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's 3Y-LTRO in Portugal and find that banks increased their purchases of domestic government bonds during the facility allotment period. Using a portfolio choice model, we show that banks exploited an attractive collateral trade opportunity buying bonds with maturity equal or less the maturity of the central bank loan. We argue that this behavior is consistent with the observed changes in the slope of the yield curve, and that the Portuguese government was able to borrow at a cheaper short-term rate following the 3Y-LTRO.

³⁶Three of them had a one year maturity and one of them had six-month maturity. The latter had a €2.3 bn face value.

³⁷The amount issued of one-year debt was similar across auctions, but for six-month debt, 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.).

References

- ACHARYA, V., T. EISERT, C. EUFINGER, AND C. HIRSCH (2014a): “Real Effects of the Sovereign Debt Crisis in Europe: Evidence from Syndicated Loans,” *Working Paper*.
- ACHARYA, V. AND S. STEFFEN (2015): “The Greatest Carry Trade Ever? Understanding Eurozone Bank Risks,” *Journal of Financial Economics*, 115.
- ACHARYA, V. V., I. DRECHSLER, AND P. SCHNABL (2014b): “A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk,” *The Journal of Finance*, 69, 2689–2739.
- ANDRADE, P., C. CAHN, H. FRAISSE, AND J.-S. MESONNIER (2014): “Can the Provision of Long-Term Liquidity Help to Avoid Credit Crunch? Evidence from the Eurosystem’s LTROs,” *Working Paper*.
- ANTÃO, P. AND D. BONFIM (2008): “Capital Structure decisions in the Portuguese corporate sector,” *Economic Bulletin and Financial Stability Report Articles, Economics and Research Department, Banco de Portugal*.
- ARELLANO, C. AND A. RAMANARAYANAN (2012): “Default and the Maturity Structure in Sovereign Bonds,” *Journal of Political Economy*, 120, 187–232.
- ARMANTIER, O., E. GHYSELS, A. SARKAR, AND J. SHRADER (2013): “Discount Window Stigma during the 2007-2008 Financial Crisis,” Tech. rep., Federal Reserve Bank of New York.
- BAI, Y., S. T. KIM, AND G. P. MIHALACHE (2015): “The Maturity and Payment Schedule of Sovereign Debt,” .
- BECKER, B. AND V. IVASHINA (2014): “Financial Repression in the European Sovereign Debt Crisis,” *Working Paper*.

- BOCOLA, L. (2014): “The Pass-Through of Sovereign Risk,” 2014 Meeting Papers 1286, Society for Economic Dynamics.
- BOLTON, P. AND O. JEANNE (2011): “Sovereign Default Risk and Bank Fragility in Financially Integrated Economies,” *IMF Economic Review*, 27, 162–194.
- BRONER, F., , A. MARTIN, AND J. VENTURA (2010): “Sovereign Risk and Secondary Markets,” *American Economic Review*, 100, 1523–1555.
- BRONER, F., G. LORENZONI, AND S. SCHMUKLER (2013): “Why Do Emerging Economies Borrow Short Term?” *Journal of the European Economic Association*, 11, 67–100–142.
- BRUNNERMEIER, M. K. AND Y. SANNIKOV (2014): “A Macroeconomic Model with a Financial Sector,” *American Economic Review*, 104, 379–421.
- BUCH, C. M., M. KOETTER, AND J. OHLS (2013): “Banks and sovereign risk: A granular view,” Discussion Papers 29/2013, Deutsche Bundesbank, Research Centre.
- CHODOROW-REICH, G. (2014a): “Effects of Unconventional Monetary Policy on Financial Institutions,” *Brookings Papers on Economic Activity*, 48, 155–227.
- (2014b): “The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008-09 Financial Crisis,” *Quarterly Journal of Economics*, 129, 1–59.
- CROSIGNANI, M. (2015): “Why Are Banks Not Recapitalized During Crises?” *Working Paper*.
- CROSIGNANI, M., M. FARIA-E-CASTRO, AND L. FONSECA (2015): “The Portuguese Banking System during the Sovereign Debt Crisis,” *Banco de Portugal Economic Studies*, 1, 43–80.
- DRECHSLER, I., T. DRECHSEL, D. MARQUES-IBANEZ, AND P. SCHNABL (2014): “Who Borrows from the Lender of Last Resort?” *Working Paper*.

- ECB (2002): “Public Consultation: Measures to Improve the Efficiency of the Operational Framework for Monetary Policy,” .
- (2011): *The Implementation of Monetary Policy in the Euro Area*, general Documentation on Eurosystem Monetary Policy Instruments and Procedures.
- EISENSCHMIDT, J., A. HIRSH, AND T. LINZERT (2009): “Bidding Behaviour in the ECB’s Main Refinancing Operations During The Financial Crisis,” *Working Paper*.
- ENNIS, H. M. AND J. A. WEINBERG (2013): “Over-the-counter loans, adverse selection, and stigma in the interbank market,” *Review of Economic Dynamics*, 16, 601 – 616.
- FT ALPHAVILLE (2012): “Deutsche Bank voices stigma concerns about LTRO,” .
- (2013): “Russia’s LTRO (or LTROski, if you insist),” .
- (2015): “A Chinese LTRO: the trouble with market based financing continues,” .
- FURFINE, C. (2001): “The reluctance to borrow from the Fed,” *Economics Letters*, 72, 209 – 213.
- (2003): “Standing Facilities and Interbank Borrowing: Evidence from the Federal Reserve’s New Discount Window,” *International Finance*, 6, 329–347.
- GENNAIOLI, N., A. MARTIN, AND S. ROSSI (2014): “Banks, Government Bonds, and Default: What do the Data Say?” .
- GERTLER, M. AND N. KİYOTAKI (2010): “Financial Intermediation and Credit Policy in Business Cycle Analysis,” in *Handbook of Monetary Economics*, ed. by B. M. Friedman and M. Woodford, Elsevier, vol. 3 of *Handbook of Monetary Economics*, chap. 11, 547–599.

- GREENWOOD, R., S. G. HANSON, J. S. RUDOLPH, AND L. SUMMERS (2014): “Government Debt Management at the Zero Lower Bound,” Tech. rep., Hutchins Center Working Paper No. 5.
- GREENWOOD, R., S. G. HANSON, AND J. C. STEIN (forthcoming): “A Comparative-Advantage Approach to Government Debt Maturity,” *Journal of Finance*.
- HE, Z. AND A. KRISHNAMURTHY (2013): “Intermediary Asset Pricing,” *American Economic Review*, 103, 732–70.
- HILDEBRAND, T., J. ROCHOLL, AND A. SCHULZ (2012): “Flight to Where? Evidence from Bank Investments During the Financial Crisis,” *Working Paper*.
- IVASHINA, V. AND D. SCHARFSTEIN (2010): “Loan Syndication and Credit Cycles,” *American Economic Review*, 100, 57–61.
- KASHYAP, A. K. AND J. C. STEIN (2000): “What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?” *American Economic Review*, 90, 407–428.
- KRISHAMURTHY, A., S. NAGEL, AND A. VISSING-JORGENSEN (2014): “ECB Policies involving Government Bond Purchases: Impact and Channels,” Mimeo.
- MERCIER, P. AND F. PAPADIA (2011): “The Concrete Euro. Implementing Monetary Policy in the Euro Area,” *Oxford University Press*.
- PERISTIANI, S. (1998): “The Growing Reluctance To Borrow At The Discount Window: An Empirical Investigation,” *The Review of Economics and Statistics*, 80, 611–620.
- POPOV, A. AND N. VAN HOREN (2013): “The impact of sovereign debt exposure on bank lending: Evidence from the European debt crisis,” DNB Working Papers 382, Netherlands Central Bank, Research Department.

TREBESCH, C. AND J. ZETTELMAYER (2014): “ECB Interventions in Distressed Sovereign Debt Markets: The Case of Greek Bonds,” CESifo Working Paper Series 4731, CESifo Group Munich.

UHLIG, H. (2013): “Sovereign Default Risk and Banks in a Monetary Union,” *German Economic Review*, 15, 23–41.

A Theory Appendix

A.1 Bank Portfolio Choice

In this appendix, we describe the solution to the bank's problem in the model in [Section 3](#).

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 $\kappa \underline{q} > 1$, 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

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

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

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,

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

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

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

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

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

Letting (λ, δ, η) denote the Lagrange multipliers on the budget, collateral and liquidity con-

straints, 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

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

B Additional Tables

	Tot tapped (bn €)			No. banks			Total Assets
	Short	vLTRO	ECB Total	Short	vLTRO	ECB Total	
Nov-11	45.7	--	45.7	18	--	18	552.1
Dec-11	25.8	20.2	46.0	19	16	21	551.9
Feb-12	27.4	20.2	47.6	18	15	20	559.9
Mar-12	9.4	47.0	56.4	16	23	23	557.2

Table B.1: Borrowing from the lender of last resort. This table shows the amount borrowed and the number of borrowing banks for the different types of ECB open market operations during the allotment periods. The first three columns show the amount borrowed from: shorter term operations (MRO's and LTRO's), vLTRO, and total ECB borrowing around the months of the first and second vLTRO allotment. The following three columns show the number of banks participating in each type of operation. The final column is the value of total assets in bn €.

	Dependent variable: $\frac{H_{i,j,t}}{\text{Amount Outstanding}_{j,t}}$	
	All Bonds	Issued before Dec2011
Short-Term _j × Access _i × vLTRO _t	0.00160*** (0.0000375)	0.000439*** (0.0000450)
Short-Term _j × vLTRO _t	-0.00000439 (0.0000481)	0.000122 (0.000104)
Short-Term _j × Access _i	0.00378*** (0.000389)	0.00378*** (0.000389)
Access _i × vLTRO _t	0.000188*** (0.0000440)	0.000188*** (0.0000436)
Period FE	✓	✓
ISIN FE	✓	✓
Entity FE	✓	✓
Sample	Aug2011-Mar2012	Aug2011-Mar2012
<i>N</i>	169,494	162,663
adj. <i>R</i> ²	0.129	0.129

Table B.2: Estimating demand impact, 4-month window. This table presents the results of specification (9). 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 (MFI's excluding money market funds), and a dummy equal to 1 if the bond is short-term (expires before the vLTRO loan matures, in February 2015). Fixed effects are at the ISIN, entity and month levels. The sample is August 2011 to March 2012. Standard errors in parentheses are clustered at the entity's institutional type level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	Dependent variable: $\frac{H_{i,j,t}}{\text{Amount Outstanding}_{j,t}}$	
	All Bonds	Issued before Dec2011
Short-Term _j × Intensity _i × vLTRO _t	0.00981*** (0.00310)	0.00981*** (0.00312)
Short-Term _j × vLTRO _t	0.000147*** (0.0000463)	0.000146*** (0.0000466)
Intensity _i × vLTRO _t	0.00403*** (0.00126)	0.00403*** (0.00127)
Period FE	✓	✓
ISIN FE	✓	✓
Entity FE	✓	✓
Sample	Aug2011-Mar2012	Aug2011-Mar2012
<i>N</i>	169,494	162,663
F-Statistic	79.24	83.43

Table B.3: Estimating demand impact, intensive margin. This table presents the results of specification (10). 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 bond is short-term (expires before the vLTRO loan matures, in February 2015), and an intensity measure that is equal to long-term ECB borrowing divided by total assets in March 2012. This variable is instrumented using total ECB borrowing as a percentage of assets in May 2011, before the beginning of the sample. Fixed effects are at the ISIN, entity and month levels. The sample is August 2011 to March 2012. Standard errors in parentheses are robust (sandwich). * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

C Additional Plots

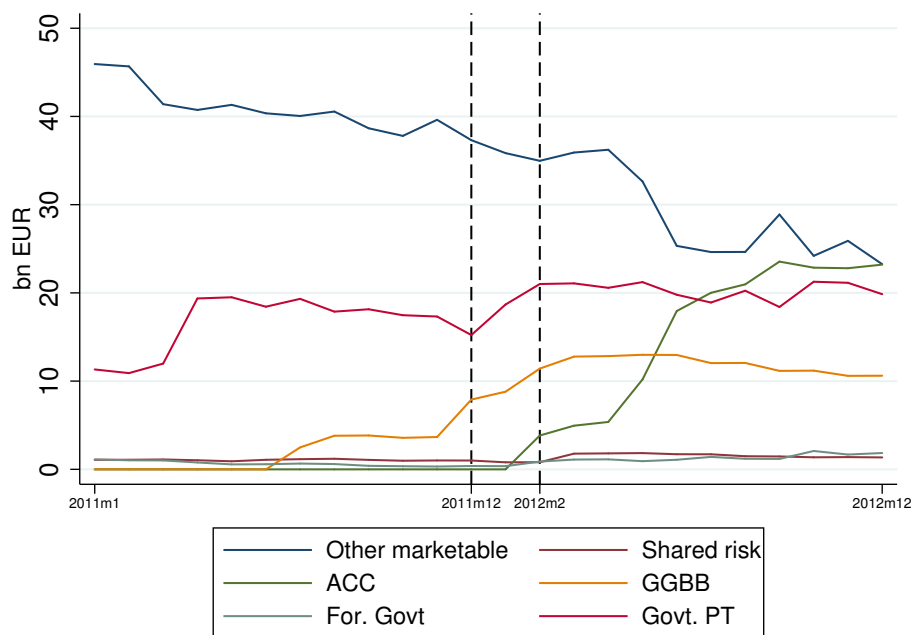


Figure C.1: Pledged collateral by type of eligible asset. The figure plots aggregates amounts of assets pledged as collateral with the Eurosystem, discounted by haircuts. The categories included are exhaustive and include, for marketable assets: Portuguese Government Bonds, Foreign Government Bonds, GGBBs and other marketable assets; for non-marketable assets: ACCs, shared risk framework non-marketable assets.

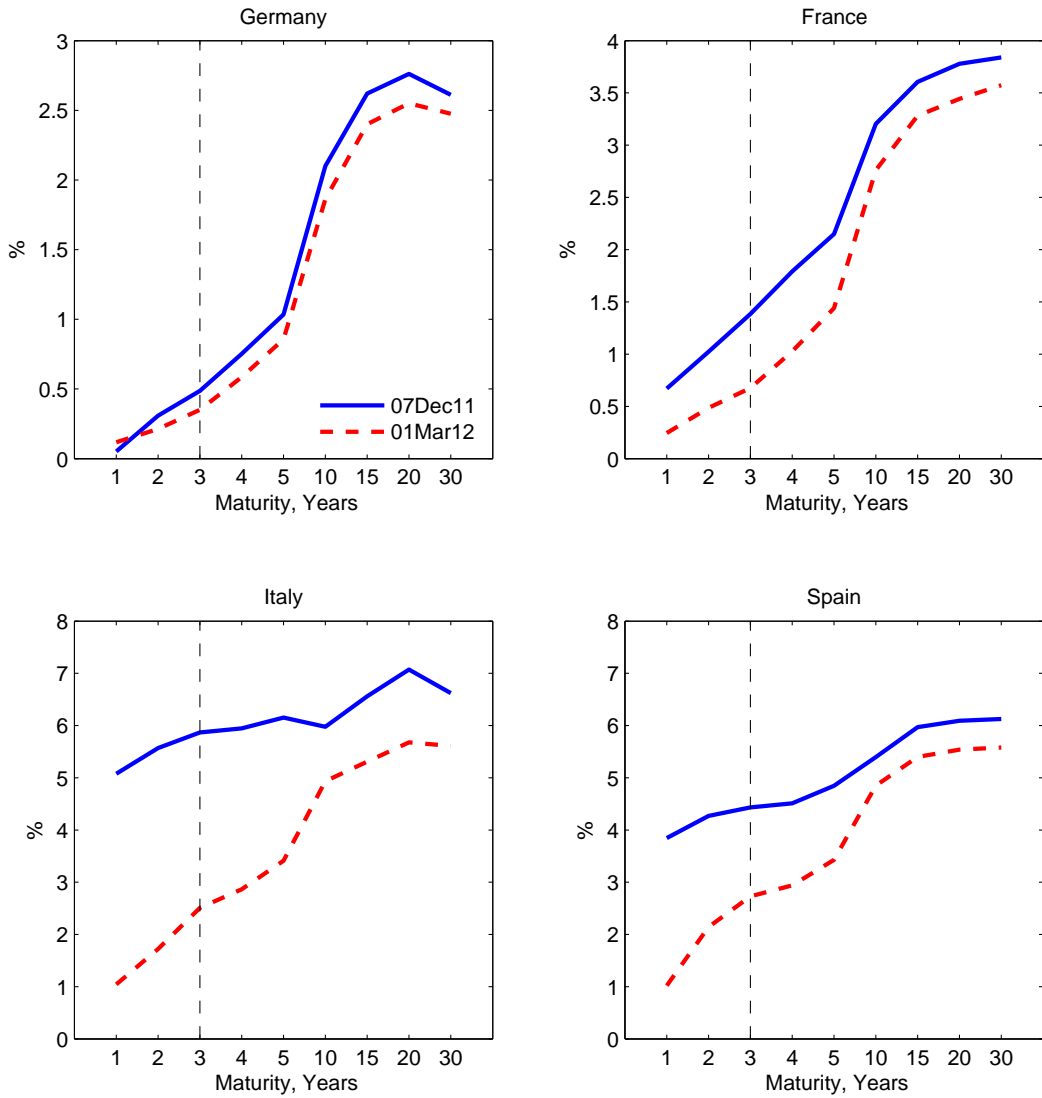


Figure C.2: Yield Curves around the vLTRO. This figure plots the 1-30 year yield curves for four eurozone countries, on the day before the vLTRO announcement (solid blue), and on the day after the second allotment (dashed red). The two upper panels are core countries, Germany and France. The two lower panels are periphery countries, Italy and Spain. Data taken from Bloomberg, based on a daily survey of broker-dealers on secondary debt markets. The dashed vertical line corresponds to 3 year maturity - the same maturity as the vLTRO loan.

D Estimating the Demand Impact

D.1 Aggregate Impact

First, we estimate the demand impact on short-term bonds. Consider an expanded version of specification 9, where we include the statistically significant coefficients,

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

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 number of MFI's with Access in our sample (in the 12-month window) is 71. This implies

the following estimates,

$$\hat{\alpha}_{\text{Total}}^{\text{Short-Term}} = 0.1770$$

$$\hat{\alpha}_{\text{Supply}}^{\text{Short-Term}} = 0.0337$$

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 $\hat{\alpha}_{\text{Total}}^{\text{Long-Term}} = 0.0208$ and $\hat{\alpha}_{\text{Supply}}^{\text{Long-Term}} = 0.0208$

D.2 Intensive Margin

When computing the intensive margin impact of vLTRO borrowing, we proceed in a similar way. We obtain the following estimates from specification 10,

$$\left(\frac{\hat{H}_{i,j,t}}{\text{Amount Outstanding}_{j,t}} \right) = \hat{\beta}_1 \times \text{vLTRO}_t \times \text{Intensity}_i \times \text{Short-Term}_j$$

$$+ \hat{\beta}_2 \text{vLTRO}_t \times \text{Intensity}_i + \hat{\beta}_3 \text{vLTRO}_t \times \text{Short-Term}_j$$

The total impact is then

$$\hat{\Lambda}_{\text{Intensity}}^{\text{Short-Term}} = \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3$$

Then, summing across banks and respective intensities, we obtain $\hat{\alpha}_{\text{Intensity}}^{\text{Short-Term}} = 0.0762$ and

$$\hat{\alpha}_{\text{Intensity}}^{\text{Long-Term}} = 0.0141$$