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Gap-filling government debt maturity choice

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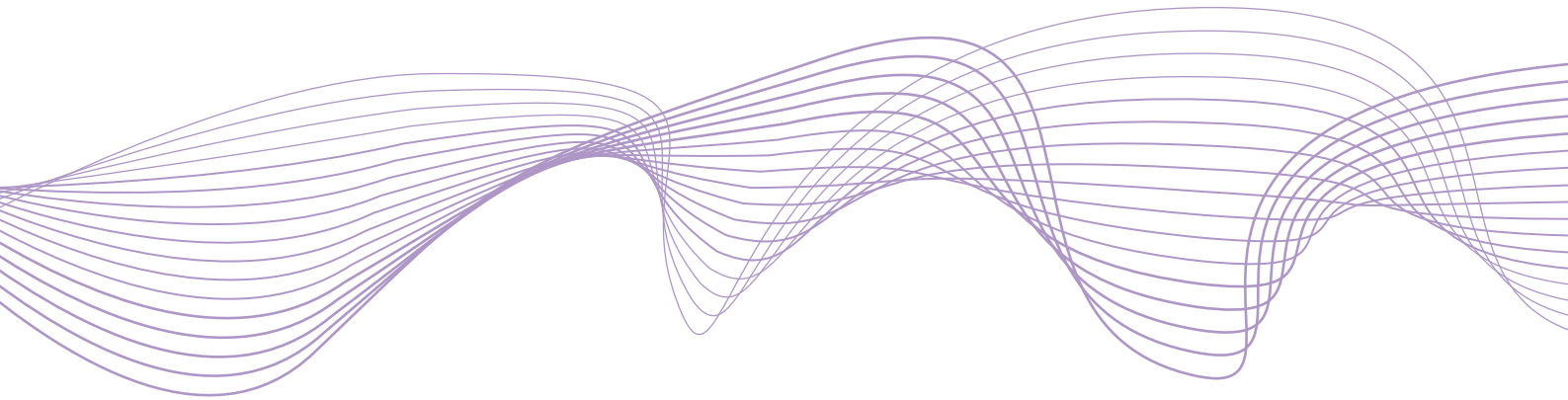

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Abstract

Do governments strategically choose debt maturity to fill supply gaps across maturities? Building on a new panel data set of more than 9,000 individual Eurozone government debt issues between 1999 and 2015, I find that governments increase long-term debt issues following periods of low aggregate Eurozone long-term debt issuance, and vice versa. This gap-filling behavior is more pronounced for (1) less financially constrained and (2) higher rated governments. Using the ECB's three-year LTRO in 2011-2012 as an event study, I find that core governments filled the supply gap of longer maturity debt, which resulted from peripheral governments accommodating banks' short-term debt demand for "carry trades". This gap-filling implies that governments act as macro-liquidity providers across maturities, thereby adding significant risk absorption capacity to government bond markets.

Keywords: Financial Stability, Government Bond Market, Liquidity Provision, Market Segmentation
JEL Classification: E58, E62, G11, H63

1 Introduction

Governments actively decide on their debt maturity structure by issuing debt across maturities. The maturity structure of government debt portfolios is important as it affects creditor losses in debt restructurings, long-term interest rates, exposure to fluctuating funding costs, debt sustainability levels, and consequently governments' vulnerability to crises (e.g., Kim (2015), Beetsma et al. (2016), and Asonuma et al. (2017)). There are a number of established theories of government debt maturity choice, but these theories predominantly focus on funding costs and funding needs (e.g., Cole and Kehoe (2000), Arellano and Ramanarayanan (2012), and Aguiar et al. (2016)). An alternative explanation is strategic behavior. One of the leading theories for strategic maturity choice from the corporate debt literature is gap-filling (Greenwood, Hanson, and Stein (2010), hereafter GHS (2010)). According to gap-filling, governments' debt issues would fill supply gaps across maturities, which result from varying aggregate government financing patterns.[1] However, gap-filling has so far only been studied for corporates (GHS (2010), Badoer and James (2016), and Foley-Fisher et al. (2016)). Governments' gap-filling would nevertheless be of particular importance, because governments acting as macro liquidity providers would add significant risk absorption capacity to government bond markets.

In this paper, I investigate whether gap-filling is also an important determinant of maturity choice in the government bond market. I use the Eurozone as a unique laboratory, as multiple governments share the same institutional setup, but separately choose debt maturity. After analyzing gap-filling over the full sample period, I address possible endogeneity concerns in an event study by exploiting changes in peripheral governments' maturity choice (induced by peripheral banks' "carry trades") following the ECB's three-year LTRO in 2011-2012.[2] In this setup, I examine three related questions: First, do governments engage in gap-filling maturity choice? Second, how does governments' gap-filling vary over time? And third, for which types of governments is gap-filling more pronounced?

I hypothesize that gap-filling maturity choice also occurs in the government bond market, because investors prefer the high quality and liquidity of government bonds (Krishnamurthy and Vissing-Jorgensen (2012), hereafter KVJ (2012)). Rather than

[1] According to the gap-filling theory, governments have a preference for a specific diversification of their debt maturity. However, aggregated supply changes combined with investors' preference for long-term debt and arbitrageurs' limited availability of capital can lead to a relative price change between short- and long-term debt. To reduce expected funding costs, governments are willing to adjust their supply of long-term debt.

[2] "Carry trades" constitute of purchasing high-yielding (peripheral) government bonds funded by cheap ECB funding, and depositing these (peripheral) government bonds as collateral at the ECB (see, for example, Acharya and Steffen (2015)).

substituting government debt with corporate debt within a country (as in GHS (2010)), investors seem to prefer substituting government debt across countries. In the Eurozone, investors can easily substitute government debt across multiple countries for the following four reasons: (1) a common currency is shared across governments, (2) monetary policy is centralized across governments, (3) credit quality is similar across multiple governments, and (4) financial regulation is largely identical across governments. In addition, financial regulation and central bank open market operations grant government debt preferential treatment–thereby further incentivizing investors to purchase government debt. Most importantly, financial regulation grants reduced (up to zero) capital charges and no large exposure limits to government debt. And the ECB classifies government debt as first category collateral in its open market operations, independent of their actual liquidity. Finally, substitution with corporate debt is much more restricted in Europe compared to the U.S., because European corporations fund themselves mainly through bank debt rather than bond debt.

Importantly, gap-filling should be most pronounced for governments' long-term (greater than 10 years) bond issues, because of higher duration risk capital for arbitrageurs (Badoer and James (2016)). As price volatility rises with a bonds maturity due to higher discounting of future cash flows, regulatory capital requirements usually increase with maturity. Moreover, a large class of investors with long-term liabilities, such as life insurance companies and pension funds, prefers purchasing long-term government debt as maturity matching is most effective to reduce capital requirements and comply with financial regulation.

In the cross-section, gap-filling should be more pronounced for less financially constrained and higher rated governments. Less financially constrained governments might engage more aggressively in gap-filling, due to their higher flexibility to adjust the maturity structure of their debt issues (GHS (2010)). Higher rated governments might undertake gap-filling more aggressively, as investors prefer the high quality of government bond securities (KVJ (2012)).

To empirically analyze governments' gap-filling, I construct a new panel data set of 9,098 individual debt issues of 15 Eurozone governments between 1999 and 2015 from Bloomberg. To my knowledge, I am the first to compile such a large data set of European government debt issues. For the event study, I also collect data on individual bond auctions and hand-collect data on debt issuance announcements for a smaller set of governments around the ECB's three-year LTRO in 2011-2012. This granular issuance- and auction-level data allows me to precisely observe governments' debt maturity choice. Importantly, it also allows me to split debt issues

in multiple maturity buckets as in Badoer and James (2016) and analyze gap-filling purely on a flow basis–that is using fluctuations in the flow of aggregate Eurozone government long-term debt issues to explain the flow of an individual government's debt issues across maturities.[3] In comparison, previous gap-filling studies use the stock of long-term U.S. government debt to explain the flow or the stock of long-term U.S. corporate debt. As a result of strict budget rules for governments in the Eurozone, total debt issuance amounts within a period are fixed by governments' maturing debt and budget deficits. Compared to corporates that can also adjust total debt issuance amounts, Eurozone governments are restricted to adjusting the debt issues' maturity composition only.

My government bond data shows that deal characteristics of government debt issues are very similar across countries. In addition, governments frequently issue debt across maturities, enabling governments to easily shift debt issuance amounts across the maturity spectrum. Overall, total issuance amounts are predominantly short-term (up to one year, on average 50.5%), and long-term (greater than ten years, on average 18.7%). Finally, and important for analyzing gap-filling, there is substantial variation in aggregate Eurozone government long-term debt issuance over time.

In a first step, I examine whether governments engage in gap-filling. Consistent with gap-filling, I find that governments significantly increase long-term debt issues (and significantly reduce short-term debt issues) following periods of low aggregate Eurozone long-term government debt issuance, and vice versa. Governments perform gap-filling by shifting almost euro-for-euro between short-term and long-term debt issues, leaving medium-term maturity buckets largely unaffected. Controlling for government-level seasonality in debt issuance across all maturity buckets shows that gap-filling is a temporary deviation from established debt issuance pattern.

In a second step, I investigate the variation of governments' gap-filling over time. According to the gap-filling theory, gap-filling only occurs under partially segmented markets and limits to arbitrage. Partial segmentation might have increased as a result of harmonizing EU insurance regulation (Solvency II), as it strengthened insurer's incentives for maturity matching. Limits to arbitrage might have become more relevant since the last two financial crises and subsequent increases in financial regulation. Consistent with the gap-filling theory, I only find governments' gap-filling behavior after the start of harmonizing EU insurance regulation in late 2009.

In a third step, I examine the cross-section of governments' gap-filling. As discussed above, gap-filling might be more pronounced for less financially constrained

[3]My results are also robust to controlling for the stock of outstanding long-term debt.

and higher rated governments. I find evidence consistent with these two cross-sectional predictions. In particular, when I sequentially group governments across different dimensions of financial constraints, I find significantly larger gap-filling for governments with lower indebtedness, smaller size, lower financing needs, lower budget deficits, and higher future economic growth.

The main concern with my gap-filling results is that governments might have coordinated their debt supply, instead of responding to investor's maturity-specific demand. To address this endogeneity concern, I exploit peripheral governments increase in shorter maturity debt issuance to accommodate banks demand for "carry trades" following the ECB's three-year LTRO in 2011-2012. These adjustments effectively resulted in a largely unexpected temporary negative credit supply shock of longer maturity Eurozone government debt. Consistent with gap-filling, I find that core governments responded by temporarily increasing longer maturity debt issues by 16.5%-points to fill the supply gap. Measures of excess demand in governments' longer maturity bond auctions, and changes in the slope of governments' yield curve are consistent with core governments responding to investor demand. In robustness checks, I also provide evidence that the gap-filling result is (1) not driven by confounding events during the Eurozone crisis; (2) not driven by restricted maturity choices of peripheral governments; (3) not driven by investor demand for safe assets; and (4) constitutes a deviation from governments' pre-announced issuance patterns.

These temporary adjustments in the maturity structure of debt issuances following the ECB's three-year LTRO resulted in significant financial implications. In aggregate, the average residual maturity of total outstanding debt of peripheral and core governments diverged by 0.6 years in the LTRO-period, and did not converge thereafter. Further, peripheral governments' debt rollover requirements until 2016 increased by 51.4bn EUR (or 3.3% of GDP) for Italy and 49.1bn EUR (or 4.7% of GDP) for Spain. In contrast, funding cost reduced by just 0.07% of GDP for Italy (with a budget deficit of 2.9% of GDP) and 0.05% of GDP for Spain (with a budget deficit of 10.4% of GDP) compared to not adjusting their debt maturity structure in response to the ECB's three-year LTRO. Consequently, peripheral governments exploited banks "carry trade" demand as a temporary relief on debt rollover, despite its negative implications for future debt rollover amounts. In contrast, core governments' gap-filling of long-term debt permanently reduced debt rollover requirements by 74.2bn EUR (or 1.1% core governments GDP). In sum, these maturity adjustments permanently stabilized core governments' debt portfolios, while it permanently destabilized peripheral governments' debt portfolios.

My analysis contributes to three strands of the literature. First, my paper con-

tributes to the literature on segmented bond markets across maturities (e.g. Vayanos and Vila (2009), Greenwood and Vayanos (2014)) and the interaction of debt maturity choices between corporates and the government (for example, GHS (2010), Badoer and James (2016), and Foley-Fisher et al. (2016)). This literature shows that segmented bond markets across maturities can arise from investors' preferred habitat for specific maturities, which induces corporates to strategically fill maturity-specific supply gaps of government debt. In contrast, my paper is the first to investigate gap-filling also in the government bond market. In addition, I study gap-filling outside the U.S., and also analyze the cross-section of governments' gap-filling.

Second, my paper adds to the literature studying the determinants of governments' debt maturity choice (for example, Arellano and Ramanarayanan (2012), Broner et al. (2013), and Bai et al. (2015)).[4] In summary, these empirical papers typically concentrate on the effect individual country-specific credit market conditions, such as the spread, and investigate debt maturity choice in emerging economies. In contrast, I focus on interactions in governments' maturity choice across multiple governments. In addition, my study is the first to systematically analyze the determinants of governments' debt maturity choice across Europe and carefully controls for a variety of country-level credit market and macroeconomic conditions.

Third, my paper also contributes to the recent literature on the effects of unconventional monetary policies on government bond markets (for example, Joyce and Tong (2012), Eser and Schwaab (2016), and Krishnamurthy et al. (2017)). These papers predominantly investigate the effect on bond prices and CDS spreads, ignoring the effect on bond quantities. My paper is the first to investigate the effects of an unconventional monetary policy on bond quantities. In addition, my paper shows that adjustments on bond quantities of directly affected governments can induce strategic interactions of other governments.

The paper proceeds as follows. Section 2 introduces the institutional setting. Section 3 describes the data and presents summary statistics. Section 4 empirically investigates gap-filling in the government bond market. Section 5 addresses endogeneity concerns in an event study using the ECB's three-year LTRO. Section 6 concludes and draws some policy implications.

[4]Other papers explore the optimal maturity structure of entire debt portfolios and their implications on optimal taxation and insurance against fiscal shocks, among others, Barro (1979), Lucas and Stokey (1983), Angeletos (2002), Buera and Nicolini (2004), and Debortoli et al. (2017).

2 Institutional setting

2.1 Government debt management

The task of governments' borrowing and debt management is performed by government debt management offices (DMOs). Despite a strong interdependence of debt management with the remaining fiscal policy and monetary policy, DMOs in the Eurozone are separated from other parts of fiscal policy and operate independently from monetary policy. Guided by a micro portfolio approach of debt management, DMOs main objective constitutes a classical Markov problem: to reduce government's financing costs over a medium to long horizon, while limiting fiscal risks (that are fluctuating funding costs, and rollover risks).[5] A key element to achieve this objective is debt maturity.

This objective, however, inherits a trade-off on debt maturity. Due to the monetary premium for short-term government debt, funding costs for shorter maturities are usually cheaper than for longer maturities. Yet, as shorter maturity debt has to be refinanced more frequently than longer maturity debt, higher total annual issuance amounts increase governments' exposure to fluctuating funding costs and rollover risk. As a result of this trade-off, governments usually diversify their debt maturity structure and issue debt with both shorter and longer maturities.[6]

In addition, DMOs additionally aim to achieve resilient secondary market liquidity for main benchmark maturities (for example, one, three, five, or ten year bonds). To ensure deep secondary markets, regular debt issues in each benchmark maturity are required, which might potentially conflict with the maturity trade-off of its main objective. Specifically, once credit market conditions change, governments might be slow to adjust the maturity of debt issues to ensure deep secondary market liquidity.

The DMOs' debt maturity decisions are operationalized in their funding strategy. Therein, government's total borrowing requirements (comprised of debt redemptions and primary surplus/deficit) are exogenous to the DMO, as they are a result of past debt issuance decisions and current financing needs decided by the remaining fiscal policy. Consequently, the DMO decides on the allocation of this fixed amount across the maturity spectrum. To ensure predictability of debt issues and sufficient demand

[5] See the "Revised Guidelines for Public Debt Management" by the IMF and the World Bank from 2014: https://www.imf.org/external/np/pp/eng/2014/040114.pdf

[6] DMOs can also alter this trade-off by entering into interest rate swaps. However, issuing long-term debt and entering into interest rate swaps to pay lower short-term yields increases the volatility of debt servicing costs. In the Eurozone, DMOs' outstanding interest rate swaps are at most small, and over time DMOs partially even inter into offsetting interest rate swap positions. Also, there is anecdotal evidence that increases in interest rate expenditures resulting from interest rate swaps are more difficult to communicate to the Ministry of Finance.

by investors at each auction, DMOs in the Eurozone announce information of their funding strategy in advance. A general overview is provided at the annual level, where the DMO announces its predicted annual funding requirements, maturity(-range) specific auction dates, and partially the intended aggregated annual issuance amount of money market (up to one year maturity) and capital market (above one year maturity) debt issues. In contrast to emerging market debt issuances where auction dates are dependent on credit market conditions, for Eurozone governments the date of government bond auctions is therefore exogenous to credit market conditions around the auction date. Despite pre-determined auction dates (and for some DMOs also indications on the respective maturity), regular debt issues across the maturity spectrum and variations in issue amounts allow DMOs to maintain a high degree of freedom on their overall maturity choice at this stage. Usually at a quarterly level, DMOs determine auction- or issuance-level specific targets on debt issuance amounts, which to a large degree determine governments' debt maturity choice. While, DMOs officially keep the option to adjust their funding strategy depending on market conditions and funding requirements. Historically however, debt issues have rarely been canceled and realized debt issues are often similar as planned. Consequently, DMOs in the Eurozone determine their debt maturity choice largely at a quarterly level.

2.2 Investor demand for government debt

As government bonds are a large part of bond market in general, various investors demand government debt. In the primary market, each government restricts the number of banks (so-called primary dealers) that are allowed to bid in government bond auctions. These banks, however, usually receive orders from other investors so that also other investors have indirect access to debt issues in the primary market. Additionally, all investors can buy and sell government bonds in secondary markets.

Since the aftermath of the global financial crisis in 2007-2009, new regulatory reforms further stipulated banks, and insurance companies to purchase government bonds. For banks, new liquidity regulation under Basel III (the liquidity coverage ratio, and net stable funding ratio) requires banks to hold government bonds as liquidity reserves. Further, as high quality government bonds possess minimal credit risk and high liquidity, banks usually use it as collateral for short-term borrowing. And despite evidence on its credit risk from the European sovereign debt crisis, government bonds continue to hold zero-risk weight in banks regulatory capital calculations and government debt is exempt from concentration limits. For European insurers, the new Solvency II regulation also exempts government bonds from credit

and concentration risk under the standard formula in the solvency capital requirements (SCR) calculation.[7] In addition, Solvency II particularly incentivizes insurers to purchase government debt with specific maturities. Specifically, assets that perfectly match the maturity of liabilities are exempt from interest rate risks in the computation of insurers' capital requirements. Given that longer maturity liabilities pose particularly high interest rate risk due to their high discounting effect, insurers are particularly incentivized to purchase long-term government debt. This is particularly the case for life insurance companies, where interest rate risk resulting from maturity mismatches of assets and liabilities are often the largest component of capital requirements.

The transition to the low yield environment further reinforced these incentives. Lower yields increase asset values as future bond payments are discounted less, so that capital charges for asset holdings - that are usually proportional to assets values - correspondingly increase. As lower yields also increase the present value of long-term liabilities and widen existing duration mismatches between assets and liabilities, falling long-term interest rates even induce insurance companies to increase purchases of long-term government bonds at rising prices (Domanski et al. (2017)).

These regulatory reforms incentivize large classes of investors to buy governments bonds, so that aggregated demand for government debt might have become more inelastic. Moreover, inelastic demand might have been particularly developed for longer maturity government bonds, given insurers changed incentives to match the maturity of long-term liabilities to reduce regulatory capital requirements. An increase in the average duration of outstanding government debt in Europe from six to seven years between 2008 and 2016 provides indicative evidence for increased demand for long-term European government debt.[8]

3 Data and descriptive statistics

3.1 Data

To analyze interactions in governments' maturity choice, I collect data on government's individual bond issuances between January 1999 and September 2015 for 15 Eurozone governments: Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and

[7] Nevertheless, SCR computed by internal models have to account for sovereign risk.

[8] See "The bond market is transformed: fewer vigilantes; more forced buyers" in the Economist on Oct 22nd, 2016.

Spain.[9] The starting year of the sample differs across governments, and depends on the date when governments joined the Eurozone.[10] Data on individual government bond issuances into the primary market are collected from Bloomberg, and contains information on the usual characteristics of government bond issuances. I exclude from my analysis bond issuances that are tied to specific infrastructure projects, that are issued by fully owned public corporations owned by the central government (for example, energy companies, nationalized banks, transportation companies) and government investment funds, and that are obtained as part of ESM financial assistance programs.[11] I exclude these bond issuances, because the maturity choice is likely to be aligned with the time horizon of specific investment or financing decisions, and/or the maturity choice was likely determined to a large degree outside the scope of the central government.

I restrict my sample to central government debt issuances, because strategic maturity choices most likely occur at the highest level of government for two reasons. First, as central government debt in the Eurozone is usually the majority of total government debt, DMOs at the central level consequently issue most of the total governments' debt. Second, strategic maturity choices might be more pronounced at the central level compared to multiple local governments. For example, at the local level debt issues might be more inclined to match maturities of investment projects, and maturity choice might be less sophisticated than at the center. In addition, focusing on central government debt in a multi-country setting ensures cross-country comparability (see De Broeck and Guscina (2011)). Despite limiting my analysis to central government debt, the maturity structure remains however very similar than those reported for total government debt in the ECB's Statistical Data Warehouse (SDW).

My focus on Eurozone governments stems from their unique institutional setup that allows me to investigate gap-filling in the government bond market. The Eurozone currently consists of 19 governments, which predominantly issue debt denominated in euro and are close substitutes in the Eurozone government bond market. Many countries are of high credit quality, and government bond markets are very liquid; two major bond characteristics preferred by investors (KVJ (2012)). In ad-

[9]These are all current Eurozone governments besides Estonia, Latvia, Lithuania, and Luxembourg, which all have zero or very low levels of central government debt and consequently only sporadically issue central government bonds. Also, Latvia (2014) and Lithuania (2015) only joined the Eurozone at the end of the sample period.

[10]The following governments joined the Eurozone after their inception in 1999: Greece (2001), Cyprus (2008), Malta (2008), Slovenia (2007), and Slovakia (2009).

[11]Correspondingly, I exclude periods, in which governments did not have access to financial markets.

dition and as discussed above, financial regulation provides investors with different incentives to purchase government debt rather than substituting with (high quality) corporate debt. Also, the ECB classifies government debt as first category collateral in its open market operations, and only accepts euro-denominated government debt as collateral. Correspondingly, the start of my sample period is motivated by the start of the Eurozone, which abolished national currencies of Eurozone governments and thus increased the substitutability of Eurozone government debt.

To address endogeneity concerns in the event study, I also collect data on individual debt auction results and government's debt issuance announcements for a smaller set of governments around the ECB's three-year LTRO in 2011-2012. Specifically, I collect data on individual debt auction results for France, Germany, Italy, and Spain and hand-collect data on debt issuance announcements for Germany and Italy between 2010 and 2014. Also, I expand the bond issuance database by central government bonds issued prior to 1999 and maturing in 2012 or thereafter for computing outstanding debt maturity profiles.

My government bond data base is complemented by government-level data on macroeconomic conditions from Datastream and Bloomberg at quarterly, or yearly frequency. These variables are the government's debt/GDP ratio, the total change in the debt/GDP ratio in the previous four quarters, total real GDP growth during the previous four quarters, the countries consumer price inflation (CPI) during the prior year, a recession dummy computed based on two subsequent quarters of negative GDP growth, and a non-investment grade rating dummy based on S&P's long-term local currency government rating. In addition, I complement the dataset with data on credit market conditions from Bloomberg at the quarterly, or daily frequency. These credit market condition measures are the term structure measured as the yield differential between 10-year and 6-month government debt, the yield level as measured by the governments' 6-month yield, and the yield spread of 10-year government debt securities to 10-year German bunds. For the cross-sectional analysis, I also collect data on a countries size as measured by its GDP, and governments' budget deficit at quarterly, respectively yearly frequency. To examine gap-filling behavior, my measure for the supply of aggregated Eurozone long-term government debt is the log of the aggregated deal amounts (converted to euro) of Eurozone government debt issuances with maturities above ten years (hereafter AMT10).

The benefits of the AMT10 measure is that it precisely captures the new supply of long-term Eurozone government debt to investors. As discussed above, long-term government debt is more likely to be held to maturity by investors, so that new supply of long-term Eurozone government debt substantially influences the

availability of long-term Eurozone government debt in the market. Investors - such as life insurance companies that aim to invest new premiums from customers in government bonds to match long-term liabilities - create demand for new long-term Eurozone government debt. Further, the supply of new government long-term debt issues varies substantially over time (see Figure 1), which is contained in the AMT10 measure. A potential drawback of the AMT10 measure is that it does not reflect the total supply of outstanding Eurozone long-term government debt. Nevertheless, total supply of Eurozone long-term government debt is relatively stable over time and variations predominantly arise due to new Eurozone government long-term debt issuances. To address this concern in the empirical analysis below, I include country-year fixed effects in robustness specifications to control for the changing level of government-level outstanding long-term debt over time (the results continue to hold).

3.2 Descriptive statistics

The main data set contains 9,098 government debt issuances from Bloomberg between January 1999 and September 2015. Table I shows summary statistics of deal characteristics, issuer characteristics, market characteristics, and the number of individual governments across five maturity buckets. The maturity buckets reflect major issuance maturities of government securities and are similar than those used by Broner et al. (2013). Panel A of Table 1 highlights that long-term (above 10 years) debt issues comprise only 677 debt issues (or 7.44% of total debt issues), however the mean issuance amount is four times larger than short-term (up to one year) debt issues. In addition, consistent with the monetary premium for short-term government debt, Eurozone governments predominantly issue short-term (6,406 debt issues, or 70.41% of total debt issues). Also as described above, deal characteristics are generally very similar across Eurozone governments. For example, 87% of total long-term debt issues are denominated in euro and about 95% of total long-term issues are not puttable or callable (and thus repay at final maturity).

[Insert Table 1 near here]

Panel B of Table 1 shows issuer characteristics. Consistent with Eurozone governments being unable to dilute nominal debt with higher inflation as monetary policy in the Eurozone is not set at individual governments national level (but centrally at the ECB), mean inflation is about 1.8% for both short-term and long-term debt issues. Consistent with mitigation of rollover risk and hedging motives, medium-term

and long-term debt issues tend to be more pronounced for higher indebted governments. Moreover, as shown in Panel C of Table 1 displaying market characteristics, medium-term to long-term debt issues increase with a higher term structure of the yield curve. For example, the mean term premium is about 30bp higher for long-term debt issues compared to short-term debt issues. In contrast, theory predicts that a higher term premium should lead to reduced long-term debt issues in order to save interest expenditures, and this behavior is documented for example by Broner et al. (2013) for governments in emerging markets. Overall, these summary statistics suggest that while issuer characteristics appear to influence governments' maturity choice in line with theoretical predictions, the term structure might affect governments' maturity choice opposite to theoretical predictions.

[Insert Table 2 near here]

To further investigate debt issuance behavior at the government-level, Panel A of Table 2 displays the frequencies of government debt issues across maturity buckets at the government-level. Consistent with the aggregated results discussed above, all governments issue the largest number of bonds in the short-term segment, but higher indebted governments such as Belgium, Greece and Portugal issue a relatively larger number of long-term bonds compared to lower indebted governments such as Finland and the Netherlands. Further, governments regularly issue debt as indicated by the high number of individual debt issues across governments. The median (mean) annual number of debt issues is 28 (46). To condense the maturity choice of governments at a quarterly frequency in line with governments' interval of maturity choice, I compute quarterly government-level shares of debt issues for each maturity bucket. This aggregation also accounts for variations in deal amounts across multiple debt issues within a quarter. On average, governments issue twelve bonds per quarter, but usually do not issue debt in each maturity bucket every quarter. Panel B of Table 2 reports the results of 3,645 government-quarter-maturity bucket observations, of which 2,014 are comprised of at least one debt issue (and 1,631 without any debt issue). On average, 50.54% of the total issuance amount is short-term. Also, and consistent with the larger deal amounts for long-term debt, 18.65% of the total debt issuance amount across all governments is on long-term debt issues (compared to 7.44% of the total number of long-term debt issues). Moreover, long-term debt issuances are clustered. On average, long-term debt issues occur only every second quarter, but once governments issue long-term debt, one fourth of issuance quarters contain more than half of the total quarterly debt issuance amount. In sum, long-term debt issues are a substantial part of governments' total

debt issuances and vary substantially across governments and within governments over time.

4 Empirical analysis

4.1 Gap-filling debt maturity choice

In this section, I empirically test for gap-filling in the government bond market. According to gap-filling, governments' debt issues would fill supply gaps across maturities, which result from varying aggregate government funding patterns. As argued above, gap-filling should be more pronounced for governments long-term (greater than ten years) debt issues, because of higher duration risk capital for arbitrageurs and higher inelastic demand from life insurance and pension companies. The gap-filling hypothesis is therefore that governments increase their issuance of long-term debt following periods of low aggregate Eurozone government long-term debt issuance.

To test the gap-filling hypothesis, I investigate the determinants of governments' debt issuance across different maturity buckets. Specifically, I estimate Tobit models with the following latent variable regression

$$\begin{aligned} ShareIssue_{i,m,t} = &\alpha + \beta_1 \cdot AMT10_{t-1} + \beta_2 \cdot TermStructure10y6m_{i,t-1} \\ &\beta_3 \cdot Yield6m_{t-1} + \beta_4 \cdot SpreadToGermany10y_{i,t-1} \\ &+ \gamma \cdot X_{i,t-1} + e_{i,m,t} \qquad \forall m \in M, \end{aligned} \tag{1}$$

where $ShareIssue_{i,m,t}$ is the share of debt issues of government i in quarter t in maturity segment m, which can be one of the five maturity buckets introduced above (with maturity ranges of (0,1] year, (1,3] years, (3,5] years, (5,10] years, and (10,...) years). The Tobit models take into account that the dependent variable is bounded between zero and one, and jointly estimates governments' decision to issue in a specific maturity segment as well as the issuance share. The key independent variable of interest is $AMT10_{t-1}$, which is the log of the aggregated Eurozone governments' long-term debt issue amount in the previous quarter. Consistent with the gap-filling hypothesis and governments' time interval of maturity choice, $AMT10$ is lagged by one period and therefore predetermined in period t, which suppresses contemporaneous issuance adjustments. Other country-specific credit market conditions are the slope of the government yield curve ($TermStructure10y6m_{i,t-1}$), the level of government short-term yields ($Yield6m_{i,t-1}$), and the long-term credit spread to Germany ($SpreadToGermany10y_{i,t-1}$), which are all lagged by one period consis-

tent to governments' time interval of maturity choice. Further, $X_{i,t-1}$ contains a set of lagged country-level macroeconomic variables affecting governments' current maturity choice, such as the level of indebtedness, and the change in indebtedness over the previous four quarters. Standard errors are heteroscedasticity robust and clustered at the country-level.

[Insert Table 3 near here]

Table 3 presents the set of Tobit model regression results. As shown, supply changes in aggregated Eurozone long-term debt affect governments' maturity choice non-linearly. Consistent with gap-filling, the coefficient estimate for AMT10 on long-term debt issues is negative and statistically significant at the 1%-level (see column (5)). Also, the coefficient for AMT10 on short-term debt issues is positive and statistically significant at the 1%-level (see column (1)), and both coefficient estimates of AMT10 are very similar in absolute magnitude. The coefficient estimate of AMT10 on debt issues in the remaining three maturity buckets is mostly close to zero and not statistically significant, besides for debt issues with (3,5] year maturities at the 10%-level. Consequently, governments engage in gap-filling by increasing long-term debt issues following periods of low aggregate Eurozone government debt, and vice versa.

Turning to other credit market conditions, I find that governments increase debt issues in the three intermediate maturity buckets during periods of a high term structure, while short-term debt issues are reduced (see columns (2)-(4)). This finding stays in contrast to theoretical models in which governments increase short-term issues in times of high term premia, when hedging fluctuating interest rates with long-term debt becomes more expensive (see for example Arellano and Ramanarayanan (2012)). An alternative explanation being consistent with my finding is that higher term premia stipulate increased investor demand for medium-term government debt, and governments cater this demand. Further, and consistent with only relative prices between short-term and long-term debt affecting governments maturity trade-off, the level of governments short-term yields does not affect short-term and long-term debt issues. Further, higher 10-year credit risk compared to Germany reduces governments' long-term debt issuance (see column (5)). This finding is consistent with investors reducing long-term funding to governments, when their credit quality deteriorates relative to Germany.

Also, the effects of macroeconomic conditions are broadly in line with theory. Consistent with theories of mitigating rollover risk, debt issues in the two maturity buckets greater than five years increase with the level of indebtedness (see

columns (4) and (5)). Similarly, long-term debt issues increase (and short-term debt issues decrease) following positive changes in the level of governments' indebtedness. Conversely, deleveraging governments reduce long-term and increase short-term issuances, which is consistent with theories of incentivizing quicker paths to lower government debt levels (Aguiar et al. (2016)). In sum, I find strong evidence for governments' gap-filling and the effects of both credit market conditions and macroeconomic conditions are predominantly in line with theoretical predictions.

One concern of this gap-filling result might be that the dependent variable captures only the absolute share of debt issues, rather than temporary deviations. To alleviate this concern, I estimate OLS models of governments' debt issues across my five maturity buckets with different fixed effects.[12] For brevity, I only discuss the results here, but report the results for short-term and long-term debt issues in Table A. 3 in the Appendix. In the different regression specifications, I sequentially include year, quarter, country-quarter, and country-year fixed effects to control for unobserved (country-level) time-invariant effects such as country-level specific issuance pattern, or (country-level) demand trends over time. Consistent with the Tobit model results, governments' gap-filling behavior continues to hold under all OLS model specifications. Specifically, the coefficient estimates of the AMT10 variable for long-term debt issues are negative, very similar in magnitude across all specifications, and also statistically significant at least at the 5%-level across all specifications (see Panel (b)). This gap-filling effect is also economically highly significant. A decrease from the 75th-percentile to the 25th-percentile of the AMT10 variable increases the share of governments' long-term debt issuance by between 5.04%-points to 6.55%-points across all specifications, which compares to a mean quarterly share of long-term debt issuance of 18.65%-points. Also consistent with the Tobit models results, governments' gap-filling results in a shift between long-term and short-term debt issues. The coefficient estimates on AMT10 for short-term debt issues are positive, similar in absolute economic magnitude than for long-term issues, and statistically significant at least at the 1%-level (besides for the most saturated specification being at the 5%-level) (see Panel (a)). In addition, as country-year fixed effects control for the stock of country-level long-term debt, my gap-filling result based on the flow of new debt issues can also be interpreted to hold for the stock of Eurozone government long-term debt. Overall, these results show the robustness of the gap-filling result and imply that governments' gap-filling constitutes a deviation from established debt issuance pattern.

[12]Even though the setup would continue to justify non-linear regression models, the incidental parameters problem in the Tobit model (see, e.g. Greene (2004)) justifies a linear model to include several fixed effects.

4.2 Time-variation of gap-filling

In the previous subsection, I showed that governments engage in gap-filling debt maturity choice. Next, I analyze variations in governments' gap-filling over time. The theoretical gap-filling result from GHS (2010) builds on two key ingredients for governments' gap-filling: (1) partially segmented bond markets, and (2) limits to arbitrage. Partial segmentation of bond markets across maturities might have significantly increased since the start of harmonizing EU insurance regulation (Solvency II) on November 25, 2009, which reinforced insurers' incentive to match the maturity of its liabilities with government bonds. These matching incentives particularly affected life insurance companies' preferred habitat for long-term government debt, as matching the maturity of long-term liabilities is most efficient to reduce regulatory capital requirements. With insurance companies being the largest group of institutional investors in Europe with almost EUR 10 trillion of assets under management in 2014 according to Insurance Europe, these changed incentives might have significantly increased the segmentation of Eurozone government bond markets across maturities. In addition, limits to arbitrage might have increased over the same period as a result of banks reduced capitalizations due to the global financial crisis and Eurozone crisis, and tighter financial regulation in response to these crises.

To investigate possible variations in gap-filling over time, I use the start of harmonizing EU insurance regulation (Solvency II) as a cut-off to split the sample periods in two subperiods. Specifically, the first subperiod covers 1999 to 2009, and the second subperiod covers 2010 to 2015. Consistent with the gap-filling theory, I hypothesize that governments' gap-filling did not occur during the first subperiod with lower inelastic demand for long-term government debt and lower limits to arbitrage. Further, I conjecture that gap-filling occurred during the second subperiod with higher inelastic demand for long-term government debt and higher limits to arbitrage.

[Insert Table 4 near here]

Table 4 provides estimates of Tobit models for short-term (up to one year) and long-term (greater than ten years) government debt issues for each subperiod. As hypothesized and shown in column (2), gap-filling did not occur during the first subperiod from 1999-2009. The coefficient estimate for AMT10 on long-term debt issues is close to zero and statistically insignificant.[13] Instead, governments reduced long-term debt issuance, when the level of short-term funding costs increased. That

[13] I also do not find governments' gap-filling in the subperiod from 2007:q2-2009:q4 covering lower capitalization of banks during the Global financial crisis.

is, the coefficient estimate for the six-month government yield is negative and statistically significant at the 5%-level. However, and as hypothesized, governments engaged in gap-filling during the second subperiod from 2010-2015. The coefficient estimate for AMT10 on long-term debt issues is negative, almost double the magnitude compared to results across the entire sample period, and statistically significant at the 1%-level (see column (3)). In addition, the coefficient estimate of AMT10 on short-term debt issues is positive and statistically significant at the 1%-level (and the non-reported coefficient estimates of AMT10 for the three intermediate maturity ranges are close to zero and statistically insignificant).[14] Consequently, governments engage in gap-filling by shifting between long-term and short-term debt issuances, leaving intermediate maturity debt issues unchanged. In contrast to the first subperiod, long-term debt issuance is not affected by changes in the level of short-term yields. Instead, and consistent with catering investor demands, governments increase the issuance of long-term debt, when the term premium is high. Overall, these results show that gap-filling occurred only since 2010 and appears to be driven insurers inelastic demand for long-term government debt.

One concern might be that the gap-filling result in the 2010-2015 subperiod is driven by interactions in maturity choice between peripheral and core governments, for example as a result of peripheral governments reduced access to long-term funding during the Eurozone crisis. I counter this concern in two steps. First, I test governments' gap-filling behavior separate for core and peripheral governments over the entire 2010 to 2015 subperiod. Second, I estimate gap-filling across all governments after the Eurozone crisis (with a sample period from 2012:q4 to 2015:q3). For brevity, I discuss the results here and refer to Tables A. 4 and A. 5 in the Appendix. First, and similar to results for the 2010-2015 subperiod, both core and peripheral governments engaged in gap-filling behavior in the 2010 to 2015 period. The estimated coefficients on AMT10 for long-term debt issues are negative, very similar in magnitude between peripheral and core governments, and statistically significant at the 1%-level. Second, the gap-filling result also holds for the time-period after the Eurozone crisis. The coefficient estimate on AMT10 for long-term debt issues is negative, has very similar magnitude as in the other specifications and is statistically significant at the 1%-level. Overall, these results confirm the robustness of governments' gap-filling debt maturity choice in the 2010-2015 subperiod.

[14]These and all the following results are robust to excluding time periods affected by the introduction of the ECB's QE program in early 2015.

4.3 Cross-section of gap-filling

In the previous two sub-sections, I showed that governments engage in gap-filling, but only during the 2010-2015 subperiod. Next, I analyze for which types of governments gap-filling is more pronounced. As discussed above, gap-filling should be more pronounced for less financially constrained and higher rated governments. Less financially constrained governments might engage more aggressively in gap-filling, as they have higher flexibility to adjust the maturity structure of their debt issues (GHS (2010)). Higher rated governments might undertake gap-filling more aggressively, as investors prefer the high credit quality of government bond securities (KVJ (2012)).

To investigate cross-sectional variations, I estimate Tobit models of governments' long-term debt issues across different subsamples of governments in the 2010-2015 subperiod. Governments' financial constraints are captured along five dimensions: indebtedness, size, funding needs, budget deficit, and future economic growth. Governments' credit quality is measured by its S&P's long-term local currency rating. Sample splits are defined as equal or above median within the same quarter (or year) in the panel of Eurozone governments, except for funding needs being defined within a government over time as specified in Ongena et al. (2016) and budget deficits are split above and below 3% corresponding to budget deficit limit in the Maastricht Criteria.

[Insert Table 5 near here]

Table 5 shows estimates of Tobit models for long-term debt issues for subsamples of governments sequentially split across their indebtedness, size, funding needs, budget deficit, future economic growth, and rating. Consistent with theoretical predictions, I find that less financially constrained governments engage more aggressively in gap-filling. That is, governments' gap-filling is more pronounced when indebtedness is low, country size is small, funding needs are low, budget deficits are below the Maastricht criteria, and future economic growth is high (see columns (1), (3), (5), (7), and (9)). All coefficient estimates on AMT10 are negative, economically significant, and about three to four times (one half to one third higher than) the magnitude for more financially constrained governments across indebtedness and size (funding needs, budget deficit, and economic growth). These coefficient estimates on AMT10 are also statistically significant at the 1%-level, expect for funding needs at the 5%-level. Additionally, while less pronounced, gap-filling is still an important determinant of higher financially constrained governments' maturity choice. The coefficient estimate on AMT10 is negative, and statistically significant at least

at the 5%-level for the subsamples of financially higher constraint governments (see columns (2), (4), (6), (8), and (10)). Consequently, less financially constrained governments possess a higher flexibility to issue their debt and possess a higher degree of freedom to structure their maturity profile of their outstanding debt.

Finally, and also consistent with theory, I find more pronounced gap-filling for higher rated governments. In the subsample of higher rated governments the coefficient estimate of AMT10 on long-term debt issues is negative, about one and a half times the magnitude for lower rated governments, and statistically significant at the 1%-level (see column (11)). The coefficient estimate on AMT10 on long-term debt issues for lower rated governments is also negative, and statistically significant at the 5%-level (see column (12)). Overall, I find that gap-filling is more pronounced for less financially constrained, and higher rated governments.

5 Event Study

Even though my government debt issuance data enables me to precisely capture governments' maturity choice that is consistent with gap-filling behavior, endogeneity problems from unobserved coordination of governments' debt maturity choice across countries remain. Specifically, individual governments might want to avoid concentrated maturity profiles of aggregated Eurozone government debt to mitigate rollover risk and limited access to capital market in case of a systematic shock to Eurozone governments (similar to Choi et al. (forthcoming)). Under this alternative explanation, changes in governments' debt maturity choice would be the result of coordinated supply, rather than a response to investor's maturity-specific demand. To address this concern, I exploit changes in peripheral governments' maturity choice (induced by peripheral banks' "carry trades") following the ECB's three-year long-term refinancing operations (LTRO) in 2011-2012 as a large, and largely unexpected negative credit supply shock of long-term government debt possibly affecting core governments maturity choice.

[Insert Figure 2 near here]

As discussed in detail below and illustrated in Figure 2, the ECB aimed to support bank lending and market liquidity when providing its largest liquidity provision ever to mostly weakly capitalized, peripheral banks. Peripheral banks used the ECB's liquidity to gamble for resurrection by entering into "carry trades" that matched the maturity of the ECB's three-year liquidity – that is, purchasing short-term peripheral government debt and depositing it as collateral at the ECB. As a

response, peripheral governments increased short-term debt issuance to accommodate banks temporary collateral demand to mitigate their rollover risk during the Eurozone crisis. Given unchanged total debt issuance amounts, peripheral governments' adjustments in maturity choice induced a temporary negative credit supply shock of long-term Eurozone government debt. The corresponding gap-filling hypothesis is that core governments temporarily increased their issuance of longer maturity debt to fill this supply gap.

A concern might be that the ECB launched its large-scale liquidity provision to Eurozone banks to ease refinancing risks for peripheral governments during the escalation of the Eurozone crisis (in particular for non-EFSF/ESM program countries Italy, and Spain). However, Article 123 of the Treaty on the Functioning of the European Union (TFEU) prohibits the ECB from monetary financing of governments. In addition, even if the ECB might have intended that its large-scale liquidity provision improves peripheral governments refinancing conditions, the intervention is likely to be exogenous to core governments' maturity choices. Further, while financial market participants might have expected that the ECB lengthens its LTRO maturity compared to previous LTROs, the ECB's choice of granting liquidity for three years was still to a large degree incidental, and exogenous to core governments maturity choices. Consequently, the ECB's three-year LTRO constitutes a suitable event to investigate core governments' gap-filling behavior.

5.1 The ECB's three-year long-term refinancing operations

As a response to funding pressures of European banks caused by their exposure to risky Eurozone sovereign debt in the second half of 2011, the ECB announced on December 8, 2011 two unpreceded loans to banks in its three-year long-term refinancing operations (LTRO).[15] These three-year LTROs were an addition to the ECB's existing lending to banks under its main refinancing operations (MRO). The three-year LTRO's conditions were equivalent to the ECB's MROs, except for granting liquidity for three years.[16] Specifically, the ECB's LTRO liquidity was granted unconditional to bank lending, the lending interest rates was floating at the MRO rate (tied to ECB policy rate), collateral and haircut conditions were more favorable than in the private markets, and lending was full allotment (no borrowing quantity limits for banks). These loan conditions were identical across all banks.

[15]The official ECB goal was to add "additional enhanced credit support measures to support bank lending and liquidity in the euro area money market." See https://www.ecb.europa.eu/press/pr/date/2011/html/pr111208_1.en.html

[16]The MRO loan maturity is one week. Another type of prior ECB loans are LTRO loans with three month maturity.

As the ECB introduced full allotment in its MROs only in October 2008, uptake of the ECB's new three-year loans reduced banks uncertainty about potential future amount limits on the ECB MROs. In addition, both three-year loans included repayment options after one year, so that banks had flexibility about the duration of their ECB funding.[17]

Following the LTRO announcement, the ECB conducted two three-year LTRO allotments on December 21, 2011 (LTRO1), and on February 29, 2012 (LTRO2). Under LTRO1 523 banks borrowed EUR 489.2bn and under LTRO2 800 banks borrowed EUR 529.5bn. Banks were allowed to substitute new liquidity with existing ECB borrowing facilities (MROs, 3-month LTROs, 12-month LTRO[18]) so that in the week of LTRO1 the net increase in borrowing was EUR 210.0bn and in the week of LTRO2 the net increase in borrowing was EUR 310.6bn.[19] Yet, despite banks partial substitution of LTRO liquidity with existing ECB borrowing, the two LTRO loans significantly eased banks funding pressure and considerably reduced the uncertainty of banks funding due to the lengthened maturity. Consistent with the ECB's three-year LTRO being more favorable for weakly capitalized banks (see Drechsler et al. (2016)), banks in peripheral countries picked up more than two thirds of the total LTRO1 and LTRO2 loans.

5.2 Banks maturity-specific demand for government debt

The large-scale liquidity provision under the ECB's three-year LTRO allowed undercapitalized peripheral banks to gamble for resurrection by engaging in "carry trades" (e.g. Acharya and Steffen (2015)).[20] "Carry trades" constitute of purchasing high-yielding peripheral government debt funded by cheap ECB funding, and depositing these peripheral government debt as collateral at the ECB. Purchasing bonds for "carry trades" with maturities of up to three years were particularly attractive to

[17]Banks aggregate repayments from January 25, 2013 to June 27, 2013 added up to 205.8bn EUR (101.7bn EUR) for the first (second) three-year LTRO, which is consistent to a substantial part of banks "carry trades" being conducted with short-term (up to one year) peripheral government debt issues. These debt issues accounted for the largest share of peripheral governments' debt issuance adjustments following the ECB's three-year LTRO as discussed in subsection 5.3 below. For details on LTRO repayments see https://www.ecb.europa.eu/pub/pdf/other/mb201307_focus04.en.pdf?33a710426a010fe7968e0adb8a012839

[18]The ECB allotted 3-month LTROs in April 2010, May 2010, and August 2011, and a 12-month LTRO in October 2011. Banks were allowed to switch liquidity from the 12-month LTRO with the three-year LTRO1 liquidity and shifted EUR 45.7bn.

[19]See https://www.ecb.europa.eu/mopo/pdf/mb201203en_box3.pdf?08c66bbcc045b15e9ae0e7038518274d

[20]Peripheral banks' exposure to its domestic sovereign debt during the Eurozone crisis also increased due to "moral suasion" (see for example Ongena et al. (2016), and Altavilla et al. (2017)). However, the "moral suasion" channel - in comparison to the "carry trade" channel - is independent from the maturity structure of government bond purchases by banks.

banks, as these matched the ECB funding maturity and consequently reduced banks liquidity and market risk (Crosignani et al. (2017)). While the yield spread on the "carry trades" was identical across all banks, incentives to engage in "carry trades" were very different between weakly capitalized banks in peripheral Eurozone countries and well-capitalized banks in core Eurozone countries. For weakly capitalized banks in peripheral Eurozone countries these "carry trades" were particularly attractive, as under-capitalized banks did not bear the entire downside risk of the trade due to the limited liability of equity. In addition, peripheral banks purchases of domestic peripheral government debt increased sovereign-bank linkages and consequently raised the likelihood of domestic bailouts of the banking system (Farhi and Tirole (forthcoming)). Consequently, "carry trades" allowed weakly capitalized peripheral banks to gamble for resurrection. In contrast, well-capitalized banks in core Eurozone countries were fully exposed to the downside risk of "carry trades" and their exposure to peripheral government debt did not affect their domestic bailout probability.

[Insert Table 6 near here]

Table 6 reports country-level holdings of banks peripheral government debt holdings before and after the inception of the ECB's three-year LTRO. Changes in banks' peripheral government debt holdings between December 2011 and June 2012 are consistent with the above described asymmetric incentives for under-capitalized peripheral and well-capitalized core banks. Specifically, banks in peripheral Eurozone countries increased their holdings of GIIPS (Greece, Italy, Ireland, Portugal, and Spain) government debt (see also Crosignani et al. (2017)), while banks in core Eurozone countries reduced their holdings of GIIPS government debt. Also, increases by banks in peripheral countries are larger by a factor of six compared to decreases of banks in core countries, indicating that Eurozone banks in aggregate increased their demand for peripheral government debt. Consistent with peripheral banks "carry trades" demand, banks in peripheral Eurozone countries particularly increased their holdings of GIIPS government debt up to three years, while banks in core Eurozone countries reduced GIIPS government debt holdings similarly across maturities.

[Insert Figure 3 near here]

Further, changes in the slope of peripheral governments' yield curves following the announcement of the ECB's three-year LTRO are also consistent with a sharp increase in demand for shorter maturity peripheral government debt (see Figure 3, Panel A). The term premium – that is the difference between the 10-year yield

and the 1-year yield – increased between the announcement of the ECB's three-year LTRO on December 8, 2011 and the second allotment on February 29, 2012 by 320bps for Italy, and 274bps for Spain, mainly resulting from reductions of the 1-year yield. Overall, both changes in banks holdings of peripheral government debt and changes in the slope of peripheral government yield curves following the announcement of the ECB's three-year LTRO indicate a large, and sudden increase in demand for short-term peripheral government debt.

[Insert Figure 4 near here]

In contrast, relative demand changes across maturities for Eurozone core governments rotated oppositely after the announcement of the ECB's three-year LTRO – indicating a sudden increase in the demand for longer maturity core government debt. Specifically, the term premia for core governments decreased between December 8, 2011 and February 29, 2012 – for example by 28bps for Germany, and 18bps for France – and continued to decline until the ECB president Draghi's "whatever it takes speech" on July 26, 2012 to a total of 72bps for Germany, and 57bps for France (see Figure 3, Panel B). In addition, rotating demand across maturities for core government debt is also observed in core governments' debt auctions. Excess demand (measured in the bid-to-cover ratio) in government debt auctions decreased for shorter maturities and increased for longer maturities for Germany and France during the LTRO-period (see Figure 4). In sum, after the announcement of the ECB's three-year LTRO demand for longer maturity core government debt increased significantly.

5.3 Governments' supply response

Next, I examine governments' response in their maturity choice of debt issues to the these changes in investor's maturity-specific demand for peripheral and core Eurozone government debt following the announcement of the ECB's three-year LTRO. As I will show below, peripheral governments accommodated peripheral banks "carry trade" demand for shorter debt maturities by reducing the supply of long-term debt. The corresponding gap-filling hypothesis is that core governments responded to this negative credit supply shock of long-term Eurozone government debt by filling the gap of longer maturity government debt.

[Insert Figure 5 near here]

In a first step, I analyze aggregate changes in the maturity structure of peripheral and core governments' debt issues in response to the ECB's three-year LTRO.

Therefore, I compute the average maturity of all debt issues for both peripheral and core governments over time by weighting individual debt maturities by their notional issuance amount denominated in euro. Figure 5 shows that the average maturity of debt issues of peripheral and core governments shows a parallel trend before and after the LTRO-period, with core governments issuing debt with slightly shorter debt maturity compared to peripheral governments. However, during the LTRO-period the average maturity of debt issues diverged between peripheral and core governments. Consistent with peripheral governments accommodating peripheral banks demand for "carry trades", peripheral governments reduced their maturity of debt issues by 0.8 years to 2.6 years in the LTRO-period. Consistent with core governments' gap-filling of longer maturity government debt, core governments increased their average maturity of debt issues by 2.2 years to 5.1 years in the LTRO-period.

This rotation of peripheral and core governments' maturity structure of debt issues is also observed when analyzing the fraction of debt issues with maturities above three years over time (see Figure A.1 in the Appendix). Further and consistent my gap-filling results above, core governments decreased short-term (up to one year) debt issues to fill the gap of longer maturity government debt (see Figure A. 2 in the Appendix).

In a second step, I investigate peripheral and core governments' maturity choices following the ECB's three-year LTRO in a regression setting. The baseline form of the regression I estimate is as follows:

$$\begin{aligned} ShareIssue_{i,m,t} = &\beta_1 \cdot (Peripheral_i \cdot LTRO_t) + \beta_2 \cdot (Core_i \cdot LTRO_t) \\ &+ \gamma \cdot X_{i,m,t} + e_{i,m,t} \qquad \forall m \in M \end{aligned} \tag{2}$$

The dependent variable $ShareIssue_{i,m,t}$ is the share of debt issues of government i in quarter t and maturity segment m, which can either be up to three years or greater than three years. These two maturity buckets are aligned according to the maturity of the ECB's three-year LTRO to reflect banks incentive to mitigate liquidity risk. The two key interaction terms in the regression are $(Peripheral_i \cdot LTRO_t)$ and $(Core_i \cdot LTRO_t)$. $Peripheral_i$ is an indicator variable equal to one if government i is a peripheral government, and $Core_i$ is an indicator variable equal to one if government i is a core government. $LTRO_t$ is an indicator variable equal to one if quarter t falls into the LTRO-period from 2012:q1 to 2012:q3. To ensure that peripheral governments' maturity choices are not affected by exclusion from capital markets and ongoing ESM-programs, I restrict peripheral governments to Italy and Spain. Core governments are Austria, Belgium, Finland, France, Germany, and the

Netherlands, and the sample period is 2010:q1 to 2014:q3.[21] I further sequentially include different fixed effects, such as country, country-maturity, country-quarter, and maturity-quarter fixed effects. Standard errors are heteroscedasticity robust and clustered at the government level.

[Insert Table 7 near here]

Table 7 reports the regression results. In all specifications, I find economically and at the 1%-level statistically significant coefficient estimates for changes of peripheral and core governments' maturity choices during the LTRO-period. That is, consistent with accommodating peripheral banks "carry trade" demand, peripheral governments increased their share of debt issues up to three years by 19.9%-points in the LTRO-period (the average share of debt issues up to three years is 52.3% outside the LTRO-period) (see column (1)). Correspondingly, peripheral governments' share of debt issues with maturities greater than three years reduced by 19.9% (see column (2)). Consistent with gap-filling, core governments increased their share of debt issues above three years by 14.5%-points in the LTRO-period (see column (2)). These maturity adjustments by core governments are equivalent to an increase of 44.8%, when compared to the mean share of debt issues greater than three years of 32.4%-points outside the LTRO-period. These regression results are also robust to sequentially including two-way fixed effects of country, maturity, and quarter.[22] Overall, this event study shows that core governments' gap-filling of longer maturity debt is a response to investor's maturity-specific demand for government debt.

5.4 Financial implications of governments' supply response

The results above indicate that both peripheral and core Eurozone governments significantly altered their maturity structure of debt issues following the ECB's three-year LTRO. In this sub-section, I investigate the financial implications of these temporary maturity adjustments. Specifically, I focus government debt managers' primary maturity trade-off between funding needs and funding costs.

[Insert Figure 6 near here]

[21] This sample period is aligned to the gap-filling subperiod 4.2, but excludes periods affected by the introduction of the ECB's Q.E. program. The results shown below are robust to extending the sample period until 2015:q3.

[22] The results are also robust to analyzing governments' debt maturity choice at a monthly, or yearly frequency, and aggregating debt issues at the government-level in the pre-LTRO- and LTRO-period as suggested by Bertrand et al. (2004).

Figure 6 reveals that peripheral and core governments' temporary maturity adjustments following the ECB's three-year LTRO lead to a permanent effect on their overall debt maturity structures. The average residual maturity of total outstanding debt increased from 7.1 to 7.3 years across core governments and decreased from 6.8 to 6.4 years across peripheral governments from December 31, 2011 to September 30, 2012, while the average residual maturities show a parallel trend both before and after the LTRO-period. These maturity adjustments resulted in core governments' debt portfolios becoming less fragile due to lower future rollover requirements, while peripheral governments' debt portfolios became more fragile due to higher future rollover requirements.

To illustrate the effects on individual governments' debt rollover requirements, I next plot each government's debt maturity profile as at December 31, 2012. Therein, I highlight changes resulting from the introduction of the ECB's three-year LTRO. To compute the counterfactual – the debt maturity profile without the ECB's three-year LTRO effect –, I take a government's debt maturity profile as at December 31, 2011, and rescale the amount of debt issues in the LTRO-period to the maturity-bucket specific average share of debt issues from 2010 and 2011. The difference between the actual and counterfactual debt maturity profile is highlighted as the ECB's three-year LTRO effect.

[Insert Figure 7 near here]

Consistent with changes to the average residual maturity of total outstanding debt, I find that debt maturity profiles of peripheral governments shifted towards shorter maturities. In contrast, debt maturity profiles of core governments shifted towards long-term maturities. As shown in Figure 7, total debt rollover requirements until 2016 increased by 51.4bn EUR (or 3.3% of 2012 GDP) for Italy and 49.1bn EUR (4.7% of 2012 GDP) for Spain due to the ECB's three-year LTRO effect. Correspondingly, debt rollover requirements particularly for long-term debt (maturing after 2021) significantly reduced for Italy (30.1bn EUR) and Spain (50.0bn EUR). As shorter maturity debt is usually rolled over into debt with similar maturities, peripheral governments' debt rollover requirements are likely to increase also beyond 2016.

Consistent with gap-filling, debt maturity profiles of core governments' show that their increased debt issuance with maturities after 2021 filled the gap left by peripheral governments. In total, core governments increased their outstanding debt maturing after 2021 by 74.2bn EUR (or 1.1% of aggregated core governments 2012 GDP). Consequently, core government's gap-filling was almost euro-for-euro,

replacing 93% (74.2bn EUR out of 80.1bn EUR) of the reduced long-term debt issuance by peripheral governments. Consistent with the gap-filling results across the longer time period above, core governments mainly reduced short-term debt issues maturing in 2013 by -52.6bn EUR (or -0.84% of aggregated core governments 2012 GDP).

Consistent with the cross-sectional results above, gap-filling was more pronounced for less financially constrained and higher rated governments. Finland as a AAA-rated, small, and lowly indebted country engaged most aggressively in gap-filling, increasing long-term debt issues maturing after 2021 by 4.2% of GDP. Austria as a AA+-rated, small, and then similarly indebted country as France and Germany increased long-term debt issues maturing after 2021 by 3.1% of GDP (compared to 0.8% of France (AA+-rated), and 0.9% of Germany (AAA-rated)). In sum, core governments' gap-filling lead to a permanent prolongation of their debt maturity profiles and consequently reduced future debt rollover requirements – particularly for less financially constrained and higher rated governments.

Finally, I investigate the effect of governments' adjusted debt maturity structure on governments funding costs. As yield curves were upward sloping in the LTRO-period (see Figure 3), peripheral governments might have significantly reduced their funding costs by increasing their issuance of shorter debt maturities. In contrast, core governments might have only possessed the ability to fill the gap of long-term bonds due to their capacity to pay higher funding costs.

Based on the same assumptions as for computing a governments' debt maturity profile without the ECB's three-year LTRO effect above, I also compute the resulting changes in governments' funding costs due to their maturity adjustments in the LTRO-period. My analysis reveals that core governments' gap-filling increased their funding costs by just 0.1bn EUR to 0.4bn EUR in 2012 (or between 0.01% to 0.12% of a core government's GDP), which compares to an average core government budget deficit of 2.9%. Consequently, core governments permanently lengthened their debt maturity profiles and reduced future debt rollover requirements at relatively low additional costs. Peripheral governments shift to shorter debt maturities reduced the funding costs for Italy and Spain by 1.1bn EUR (or 0.07% of GDP) and 0.5bn EUR (0.05% of GDP) in 2012, respectively. These funding costs reductions are also very small when compared to the Italy's and Spain's 2012 budget deficits of 2.9% and 10.4% of GDP, respectively. In sum, this evidence on changes in funding needs and funding costs is consistent with peripheral governments' main motive to adjust their debt maturity structure following the ECB's three-year LTRO being a temporary relief on debt rollover during the Eurozone crisis, despite its negative

implications for future debt rollover requirements.

5.5 Robustness

Placebo test: ECB's first targeted long-term refinancing operation

A major concern of employing the ECB's three-year LTRO in 2011-2012 as an event study to investigate governments' gap-filling behavior might be confounding events during the Eurozone crisis. To alleviate this concern, I perform a placebo test based on another large-scale ECB liquidity provision dated after the Eurozone crisis. Specifically, I exploit the introduction of the ECB's first target long-term refinancing operations (TLTRO1) announced on June 5, 2014. The TLTRO1 intervention was very similar to the three-year LTRO, besides making liquidity provisions to banks conditional to bank lending.[23] This conditionality consequently also prohibited banks to use ECB liquidity for "carry trades", which induced peripheral governments to accommodate demand for shorter maturity peripheral government debt and subsequently led to core governments gap-filling following the ECB's three-year LTRO in 2011-2012. Another important difference is that in 2014 peripheral banks had a much higher level of capitalization, so that they would have been fully exposed to the downside risk of the "carry trades" compared limited downside risk following the three-year LTRO in 2011-2012. In addition, in 2014 peripheral sovereigns were more resilient compared to 2011-2012 so that increased bank-sovereign linkages would not have affected banks domestic bailout probability. In sum, the conditions that induced peripheral banks to engage in "carry trades" in 2011-2012 were largely eliminated by mid-2014. Consequently, I hypothesize that (peripheral) banks did not alter their demand for shorter maturity peripheral government debt following the inception of the TLTRO1 so that both peripherla and core Eurozone governments' maturity choices remained unaffected by the introduction of the TLTRO1.

Liquidity provisions under the ECB's TLTRO1 were allotted on eight allotments dates between September 24, 2014 to June 29, 2016, with the majority of the liquidity injection (384.1bn EUR out of 432.0bn EUR, or 88.9%) being allotted in the first four allotments until June 24, 2015.[24] All liquidity provisions matured on September 26, 2018 so that the loan maturity for the first four allotments amounted to four, or slighly below four years. Correspondingly, I use four years as the maturity cut-off between shorter and longer maturity debt and 2014:q4 to 2015:q3 as the TLTRO1-period (and a sample period from 2010:q1 to 2015:q3) for the placebo test.

[Insert Table 8 near here]

[23] See https://www.ecb.europa.eu/press/pr/date/2014/html/pr140605_2.en.html

[24] See https://www.ecb.europa.eu/mopo/implement/omo/html/index.en.html

Table 8 reports estimation results and shows that following the inception of the ECB's TLTRO1 program both peripheral and core governments maturity choice remained unchanged. Specifically, the magnitude of the estimated coefficients on the TLTRO1-period are close to zero and statistically insignificant for both peripheral and core governments' shorter and longer maturity debt issues (see columns (1), and (2)). These results also continue to hold when controlling for two-way fixed effects of country, maturity, and quarter. Correspondingly, liquidity allotments under the ECB's TLTRO1 did not affect peripheral and core governments maturity choices. Overall, this placebo test provides evidence that the ECB's three-year LTRO in 2011-2012 led to peripheral banks "carry trades", which resulted in peripheral governments accommodating their demand for shorter maturity debt and core governments to fill the gap of longer maturity debt.

Restricted maturity choices for peripheral governments?

Another possible concern might be that investors restricted peripheral governments access to the longer maturity bond market by reducing their demand. Consequently, investors might have instead directly demanded core governments' longer maturity debt, rather than core governments filling the gap of longer maturity Eurozone government bonds.

Different pieces of evidence reject this concern. First, my analysis is restricted to Italy and Spain as peripheral governments, which had continuous access to the (longer maturity) bond market throughout the Eurozone crisis (compared to Greece, Ireland, and Portugal, which were partially excluded from financial markets). Second, during the LTRO-period, Italy and Spain issued on average 27.6% of their debt above three years every quarter, indicating that a substantial share of debt was refinanced with longer maturities. Third, excess demand for Italian and Spanish longer maturity bond auctions during the LTRO-period increased compared to the pre-LTRO period - indicating that investor's demand for long-term peripheral government debt remained unserved (see Figure 8). In sum, this evidence indicates that in the LTRO-period Italian and Spanish longer maturity debt issues were not restricted by investors.

[Insert Figure 8 near here]

Demand for safe assets

Another possible concern might be that investors demanded safe Eurozone government long-term assets during the acceleration of the Eurozone crisis. Consequently, investors might have predominantly demanded long-term government debt

of Germany - rather than across all core governments - due to its relative safety, size and liquidity (He et al. (2016a), and He et al. (2016b)). Then, Germany's provision of safe long-term assets – rather than core governments' gap-filling – would have led to increased provision of long-term debt by core governments.

Different pieces of evidence reject this concern. First, investors increased their demand for longer maturity government debt similarly across all core governments, rather than exclusively for Germany. Yield curves for all core governments continuously flattened after the announcement of the ECB's three-year LTRO (see Figure 3), and increases in excess demand in longer maturity debt auctions were similar in France compared to Germany (see Figure 4). Second, all core governments – rather than exclusively Germany – increased their issuance of long-term debt in the LTRO-period (see Figute 7). Relative increases in the provision of long-term debt were even larger for Austria and Finland compared to Germany. These graphical observations are also confirmed in regression analyses, when estimating core governments gap-filling in the LTRO-period excluding Germany (see Table A. 6 in the Appendix). The estimated regression coefficients for core governments increase in longer maturity debt issuance in the LTRO-period is almost identical in magnitude compared to the regression specification including Germany and statistically significant at the 5%-level. Overall, different pieces of evidence reject that demand for safe asset as the underlying channel for core governments increased provision of long-term government debt in the LTRO-period.

Deviations from debt issuance announcements

A final concern might be that observed changes in the maturity structure of debt issues following the three-year LTRO might have been the result of intended supply adjustments, rather than government's response to changes in investors' maturity-specific demand. To alleviate this concern, I analyze deviations between governments' announced and realized debt auctions. Based on expected demand by investors, governments publicly announce their planned future debt auctions. Nevertheless, governments also publicly communicate that they maintain the flexibility to deviate from their debt issuance announcements, if refinancing requirements or market conditions change. Consequently, deviations between governments' announced and realized debt auctions following the three-year LTRO identify supply adjustments caused by unexpected changes in investors' maturity-specific demand.

To compute deviations between governments' announced and realized debt auctions, I hand-collect data on debt auction announcements from Italy and Germany between 2010:Q1 and 2014:Q3. Representing both peripheral and core Eurozone

governments, both countries frequently issue debt across the maturity spectrum and publicly provide detailed debt auction announcements around the ECB's three-year LTRO.[25] To obtain a matched data set of announced and realized debt auctions, I map announced debt auctions (via ISIN, auction date, and maturity date) to the corresponding realized debt auction. Then, I compute auction-level measures that relate realized debt auction amounts to announced amounts. Specifically, I compute the realized debt auction amount relative to the announced debt issues' minimum final outstanding amount for Italy, and relative to the announced debt auction target amount for Germany. Supply changes caused by investors changed maturity-specific demand are then identified based on realized debt auctions during the LTRO-period that were announced prior to the inception of the three-year LTRO. Consistent to the findings above, I hypothesize that Italy reduced issuance amounts of longer maturity debt auctions during the LTRO-period, while Germany increased issuance amounts of longer maturity debt auctions to fill the gap.

[Insert Table 9 near here]

Table 9 provides evidence that peripheral governments catered investors' "carry trade" demand for shorter term maturities following the ECB's three-year LTRO and core governments filling the gap of longer maturity government debt. Italy reduced the amount of each longer maturity debt auctions by on average 11.07% (or EUR 1,220mn) of the announced minimum final outstanding debt issuance amount in the LTRO-period (column (2)). With a mean longer maturity debt auction amount of EUR 2,912mn, this adjustment is economically highly significant, and also statistically significant at the 1%-level. (The issuance amount of shorter maturity debt auctions also reduced, but fewer than for longer maturity debt auctions, while at the same time their frequency increased.) Further, Germany filled the gap of longer maturity Eurozone government debt by deviating from its debt issuance announcements. Specifically, Germany increased the amount of each longer maturity debt auction by on average 7.71% (or EUR 356mn) of the announced target amount in the LTRO-period (column (4)). With a mean longer maturity debt auction amount of EUR 3,710mn, his adjustment is economically highly significant, and also statistically significant at the 1%-level. Also, increases in debt auction amounts compared to pre-announced target amounts occurred exclusively for longer maturity bond auctions in the LTRO-period. Overall, these results investigating governments' de-

[25]Italy announces minimum final outstanding amounts of individual debt issues that are comprised of multiple debt auctions, while Germany announces target amounts of each individual debt auction.

viations between announced and realized debt auctions are consistent to my previous findings and strengthen the identification of governments' gap-filling behavior.

6 Conclusion and policy implications

In this paper, I investigate whether gap-filling is also an important determinant of maturity choice in the government bond market. Consistent with gap-filling, I find that governments increase long-term debt issues following periods of low aggregate Eurozone government long-term debt issuance, and vice versa. This gap-filling behavior is more pronounced for (1) less financially constrained and (2) higher rated governments. I address endogeneity concerns in an event study using the ECB's three-year LTRO, and show that core governments filled supply gaps of longer maturity debt resulting from peripheral governments accommodating peripheral banks short-term debt demand for "carry trades". These maturity adjustments permanently stabilized core governments' debt portfolios, while it permanently increased the fragility of peripheral governments' debt portfolios.

My empirical findings have two important policy implications. First, Eurozone governments act as macro-liquidity providers across maturities, thereby providing significant risk absorption capacity to government bond markets. There is a widespread concern about deteriorated resilience in government bond market liquidity since the global financial crisis.[26] In contrast, governments' gap-filling behavior strengthens the resilience of government bond market liquidity. As ensuring market liquidity is important for the stability of the financial system and the transmission of monetary policy, governments' gap-filling might ultimately contribute to facilitating investments and economic growth in the real economy. Consequently, changes to the financial architecture, such as the creation of a safe government asset and the setup of a sovereign debt restructuring mechanism in the Eurozone, should be designed such that governments continue to be able to provide this risk absorption capacity.

Second, the gap-filling result from my event study of the ECB's three-year LTRO provides evidence for the interaction of unconventional monetary and fiscal policy. Specifically, ECB's large-scale liquidity provision to banks led Eurozone governments to adjust their maturity choices, which heterogeneously affected the stability of core and peripheral governments' debt portfolios. Consequently, being aware of governments' strategic debt issuance responses to central banks' interventions in government bond markets might help to avoid unintended consequences of central

[26] See, for example, BIS (2016), ESRB (2016), and the testimony of the Federal Reserve System by Governor Jerome Powell (2016).

bank interventions. Currently, these considerations appear of particular relevance for the discussion on the size and purpose of central banks asset holdings,[27] as well as central banks decisions on reducing their asset holdings, or tapering quantitative easing programs.

[27]For example, Greenwood et al. (2016) suggest that the Fed should permanently use its balance sheet to provide ample supply of government-provided short-term, safe instruments to improve financial stability.

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Figure 1: Aggregated Eurozone Government Long-Term Debt Issue Amounts

This figure shows the aggregated debt issuance amounts of long-term debt issues by Eurozone governments from 1999:q1 to 2015:q3. Long-term debt issues have maturities greater than ten years. Foreign currency debt issuance amounts have been converted to euro.

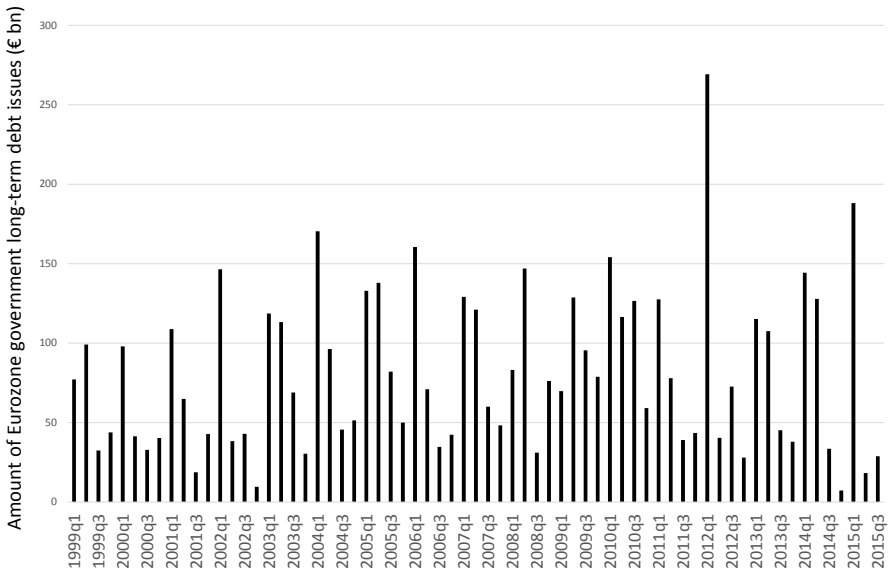


Figure 2: ECB's 3-Year LTRO as Negative Credit Supply Shock of Long-Term Debt

This figure illustrates the channels though which the ECB's three-year LTRO induced a negative credit supply shock to long-term Eurozone government debt.

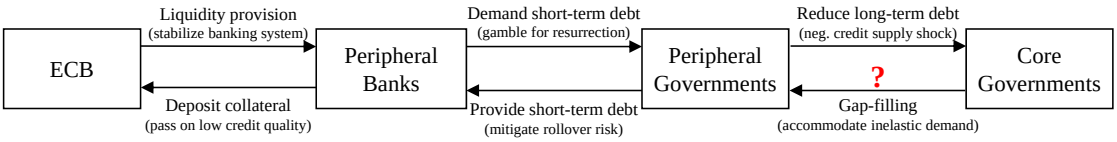
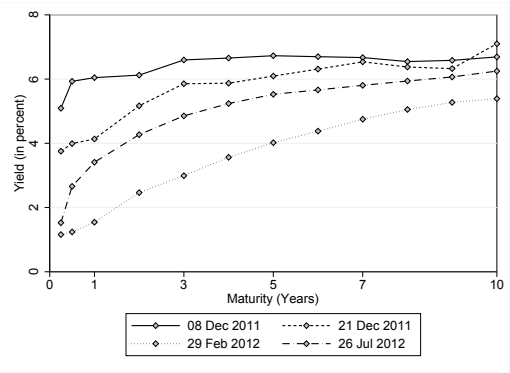


Figure 3: Changes in Government Yield Curves after the ECB's 3-Year LTRO

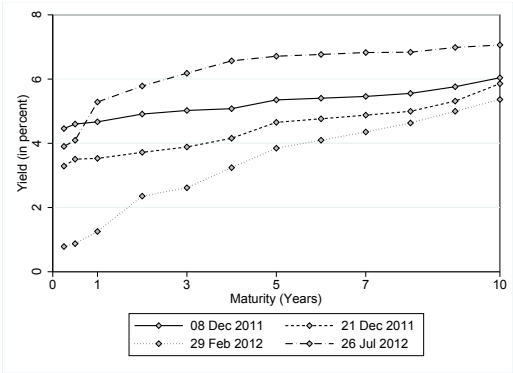
This figure shows snapshots from sovereign yields of peripheral and core governments at four points in time: December 8, 2011 (the announcement day of ECB's three-year LTRO), December 21, 2011 and February 29, 2012 (the two allotment days of the ECB's three-year LTRO), and July 26, 2012 (the day of ECB president Draghi's "whatever it takes" speech). The yield curves show yields of different maturities, ranging from three months to 10 years. Panel A shows the yields for peripheral countries, and Panel B for core countries. Yield data is obtained from Bloomberg.

Panel A: Peripheral Governments

(a) Italy

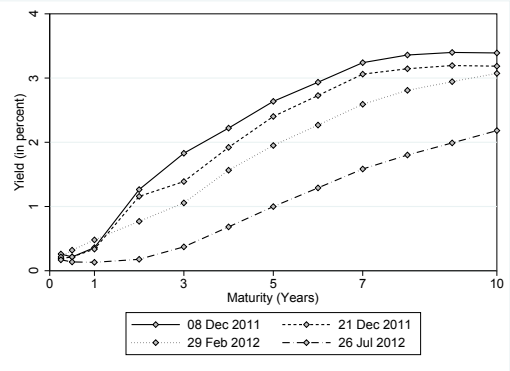


(b) Spain

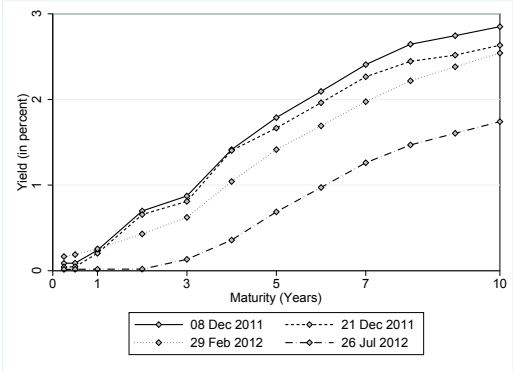


Panel B: Core Governments

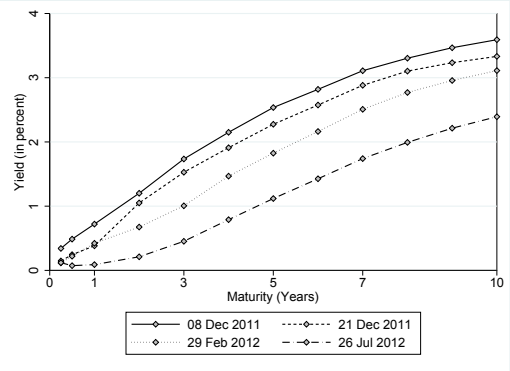
(c) Austria



(d) Finland



(e) France



(f) Germany

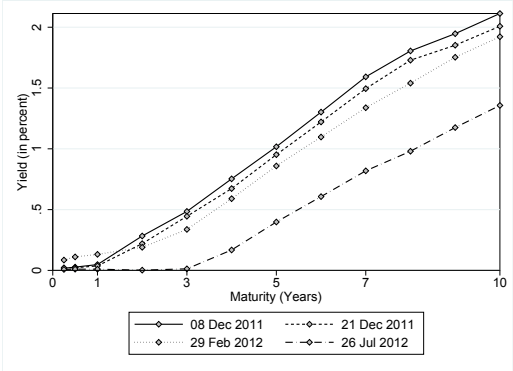
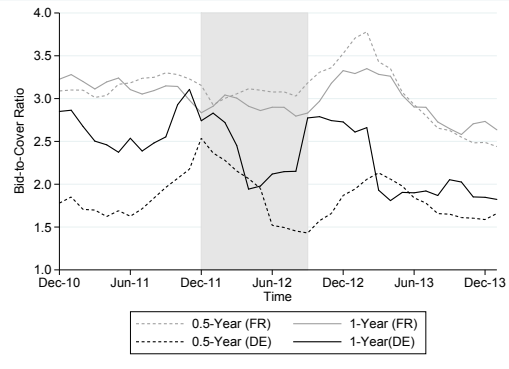


Figure 4: Excess Demand for Core Government Bonds Around ECB's 3-Year LTRO

This figure shows six-month moving averages of selected core governments bid-to-cover ratios of governments debt auctions of different maturities. The bid-to-cover ratio of an individual debt auction is computed as the aggregated bid amount over the total issuance amount. Selected core governments are France and Germany. Shorter maturity debt auctions have maturities of 0.5 years, and 1 year. Longer maturity debt auctions have maturities of 5 years, and 10 years. The grey shaded area depicts the LTRO-period from 2012:q1 to 2012:q3.

(a) Shorter maturity auctions



(b) Longer maturity auctions

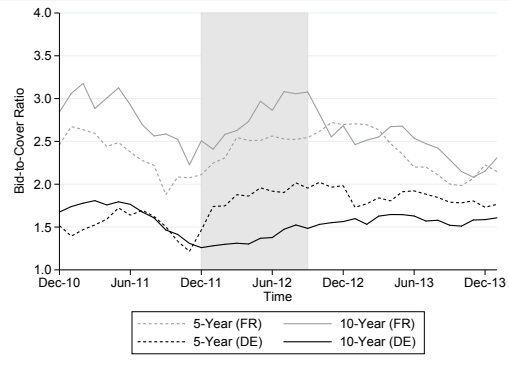


Figure 5: Avg. Maturity of Government Debt Issues Around ECB's 3-Year LTRO

This figure depicts the average maturity of debt issues by government groups around the ECB's three-year LTRO over time. The sample of governments is split into peripheral and core governments. The average maturity is computed as the mean of debt issues across all governments of the respective group. The grey shaded area depicts the LTRO-period from 2012:q1 to 2012:q3.

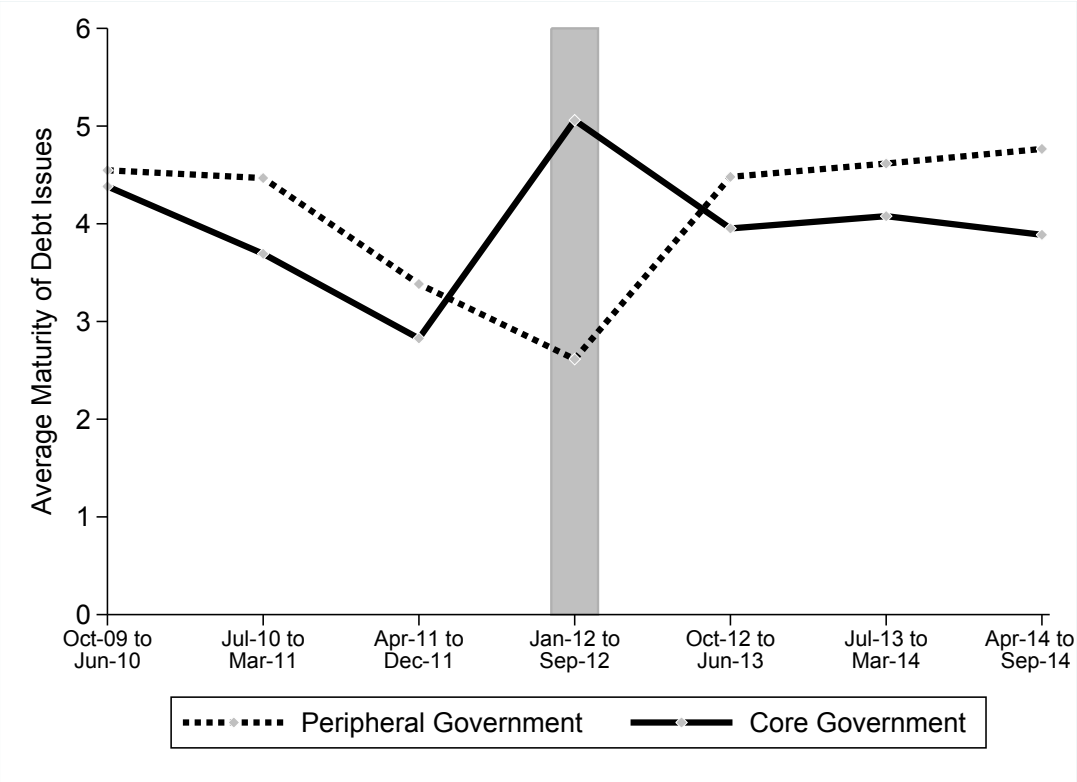


Figure 6: Avg. Residual Maturity of Outstanding Debt Around ECB's 3-Year LTRO

This figure shows the average residual maturity of outstanding debt around the ECB's three-year LTRO between December 31, 2010 and September 30, 2014. The sample of governments is split into peripheral and core Eurozone governments. The average residual maturity of outstanding debt is computed based on the residual maturity of all outstanding government bonds of a government group at a time, weighted by the bonds notional amount. The grey shaded area depicts the LTRO-period (2012:q1-2012:q3).

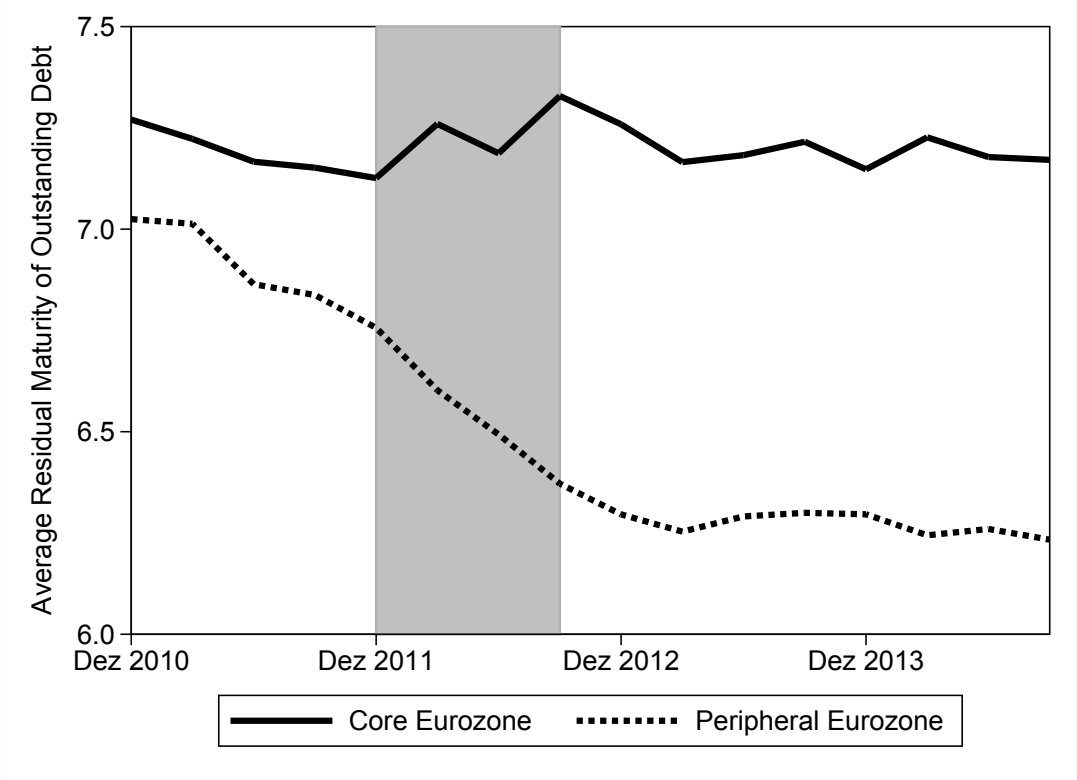
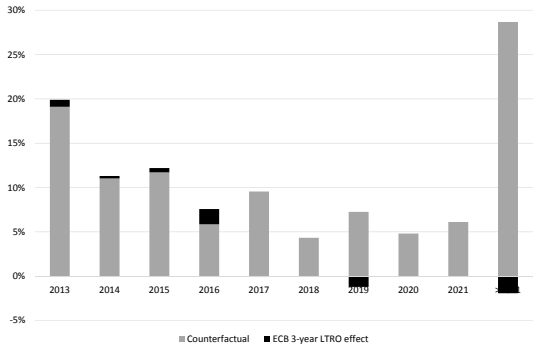


Figure 7: Debt Maturity Profiles and the ECB's 3-Year LTRO Effect

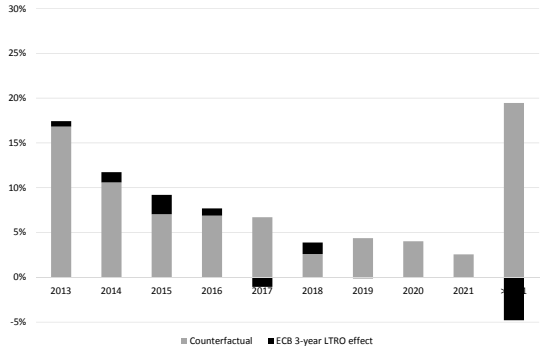
This figure shows the debt maturity profiles of Eurozone governments as at December 31, 2012. The changes resulting governments adjusted maturity choices following the introduction of the ECB's three-year LTRO are highlighted in black. To compute the counterfactual – that is the debt maturity profile without the ECB's three-year LTRO effect –, I take a government's debt maturity profile as at December 31, 2011, and rescale the amount of bond issues in the LTRO-period to the maturity-bucket specific average from the years 2010 and 2011.The difference between the actual and counterfactual debt maturity profile is highlighted as the ECB's three-year LTRO effect. Panel A shows peripheral governments, and Panel B shows core governments.

Panel A: Peripheral Governments

(a) Italy

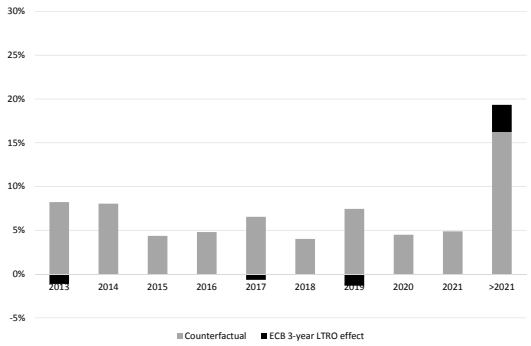


(b) Spain

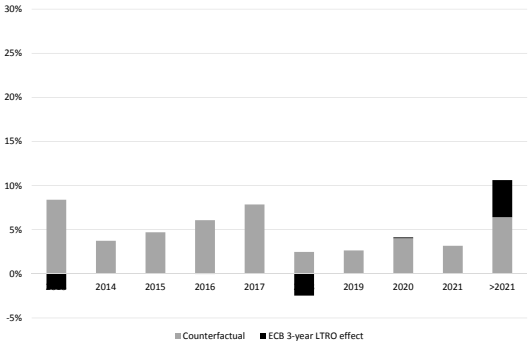


Panel B: Core Governments

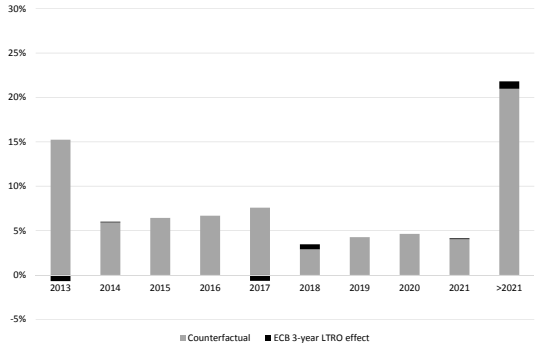
(c) Austria



(d) Finland



(e) France



(f) Germany

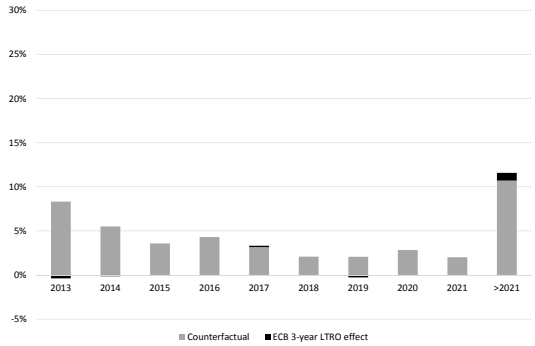
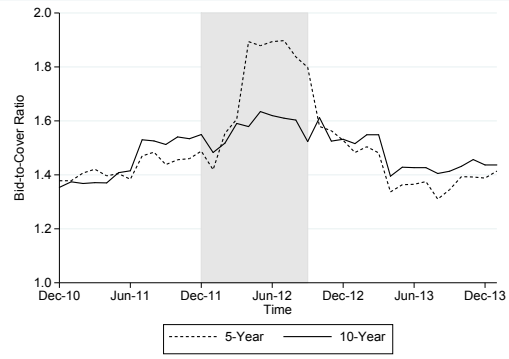


Figure 8: Excess Demand for Peripheral Gov. Bonds Around ECB's 3-Year LTRO

This figure shows six-month moving averages of two peripheral governments bid-to-cover ratios of governments longer maturity debt auctions. The bid-to-cover ratio of an individual debt auction is computed as the aggregated bid amount over the total issuance amount. The two peripheral governments are Italy and Spain. Bid-to-cover ratios of longer maturity debt auctions for maturities of 5 and 10 years are shown. The grey shaded area depicts the LTRO-period from 2012:q1 to 2012:q3.

(a) Longer maturity auctions (Italy)



(b) Long maturity auctions (Spain)

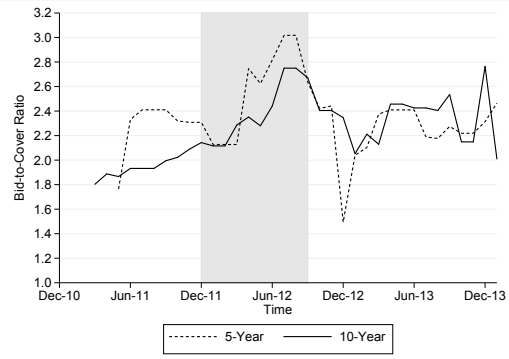


Table 1: Summary Statistics by Maturity of Issue, 1999-2015

This table reports issuance-level summary statistics across the five different maturity buckets. The sample consists of all central government debt issuances by 15 Eurozone governments between 1999:q1 (or their year of joining the Eurozone) and 2015:q3 and is obtained from Bloomberg. Panel A reports summary statistics of individual debt issues. Panel B displays summary statistics of the issuing government at the time of issuance. Panel C reports credit market conditions of the government at the time of issuance.

	(0,1] Years			(1,3] Years			(3,5] Years			(5,10] Years			(10,...) Years		
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N
Panel A: Deal Characteristics															
Years to Final Maturity	0.428	0.256	6,406	1.802	1.914	754	4.121	4.441	533	7.067	6.995	728	16.361	11.455	677
Deal Amount	2.052	0.192	6,406	4.985	2.284	754	3.695	0.728	533	4.359	0.240	728	8.194	2.480	677
Euro Denomination Dummy	0.688	1.000	6,406	0.786	1.000	754	0.636	1.000	533	0.777	1.000	728	0.873	1.000	677
Zero/Fixed Coupon Dummy	0.944	1.000	6,406	0.786	1.000	754	0.707	1.000	533	0.647	1.000	728	0.705	1.000	677
Not Inflation Linked Dummy	1.000	1.000	6,406	1.000	1.000	754	0.979	1.000	533	0.897	1.000	728	0.925	1.000	677
Repayment at Maturity Dummy	0.983	1.000	6,406	0.979	1.000	754	0.977	1.000	533	0.949	1.000	728	0.948	1.000	677
Panel B: Issuer Characteristics															
Non-IG Rating Dummy	0.017	0.000	6,341	0.004	0.000	747	0.002	0.000	533	0.011	0.000	723	0.007	0.000	667
Recession Dummy	0.122	0.000	6,406	0.155	0.000	754	0.182	0.000	533	0.115	0.000	728	0.093	0.000	677
Total GDP 4Q Growth	-0.002	-0.060	6,406	-0.342	-0.081	754	-1.066	-0.907	533	-0.323	-0.275	728	-0.067	-0.181	677
Inflation	1.875	1.868	6,406	2.251	2.239	754	2.136	2.230	533	1.914	1.953	728	1.795	1.932	677
Debt/GDP Ratio	0.548	0.524	6,406	0.530	0.471	754	0.554	0.498	533	0.565	0.524	728	0.611	0.587	677
Total Debt/GDP 4Q Change	0.030	0.024	6,389	0.027	0.017	753	0.041	0.031	532	0.030	0.023	727	0.028	0.022	675
Panel C: Market Characteristics															
AMT10	4.207	4.286	6,333	4.154	4.233	733	4.208	4.286	526	4.207	4.333	718	4.138	4.245	653
Termstructure 10y-6m	1.595	1.655	5,625	1.738	1.740	725	2.103	2.088	501	1.898	1.951	665	1.895	1.951	592
Yield 6m	2.613	2.744	5,625	2.793	3.010	725	2.226	2.133	501	2.404	2.143	665	2.067	2.138	592
Spread to Germany 10y	0.395	0.209	5,625	0.677	0.264	725	0.783	0.277	501	0.551	0.207	665	0.590	0.248	592

Table 2: Maturities by Government, 1999-2015

This table reports the distribution of debt issues by government and across maturity buckets. Panel A presents the frequencies of individual debt issues across 15 Eurozone governments between 1999:q1 (or their year of joining the Eurozone) and 2015:q3, which are obtained from Bloomberg. Panel B displays the mean quarterly share of debt issues across governments, which is computed based on the aggregation of individual debt issues' deal amounts within a government-quarter.

	(0,1] Years	(1,3] Years	(3,5] Years	(5,10] Years	(10,...) Years	Total
Panel A: Frequencies of Individual Debt Issues						
Austria	2,573	50	32	62	59	2,776
Belgium	227	29	56	102	76	490
Cyprus	115	5	9	9	2	140
Finland	368	41	40	25	15	489
France	1,186	67	47	168	105	1,573
Germany	249	67	12	46	46	420
Greece	93	3	18	22	34	170
Ireland	25	1	3	5	11	45
Italy	492	154	84	84	127	941
Malta	581	3	14	42	57	697
Netherlands	212	14	14	12	25	277
Portugal	43	13	5	9	19	89
Slovakia	12	2	5	13	12	44
Slovenia	119	7	7	9	8	150
Spain	111	298	187	120	81	797
Total	6,406	754	533	728	677	9,098
Panel B: Share of Debt Issues (quarterly, in percent)						
Austria	60.13	5.07	2.99	12.13	19.68	100.00
Belgium	66.34	8.07	1.97	6.35	17.28	100.00
Cyprus	67.87	5.75	19.44	6.43	0.51	100.00
Finland	56.09	5.61	10.03	12.83	15.45	100.00
France	67.00	4.96	3.47	7.90	16.68	100.00
Germany	30.97	26.53	3.39	18.26	20.86	100.00
Greece	31.88	2.91	16.09	19.91	29.21	100.00
Ireland	29.07	5.56	5.31	17.72	42.35	100.00
Italy	45.39	19.55	9.58	10.65	14.82	100.00
Malta	58.14	0.70	3.75	13.50	23.91	100.00
Netherlands	71.44	6.49	5.60	6.88	9.59	100.00
Portugal	44.67	11.62	4.18	12.12	27.41	100.00
Slovakia	30.03	1.14	9.83	29.63	29.36	100.00
Slovenia	56.42	9.35	7.11	10.71	16.41	100.00
Spain	18.70	36.08	12.50	12.49	20.23	100.00
Total	50.54	11.87	6.96	11.99	18.65	100.00

Table 3: Gap-Filling Government Debt Maturity Choice, 1999-2015

This table reports Tobit model regression results of governments share of debt issues across five maturity segments, on lagged AMT10 and control variables. The data sample is based on governments individual debt issues from 1999:q1 to 2015:q3 and is obtained from Bloomberg. The dependent variable is a governments' share of debt issues in a maturity segments (0,1], (1,3], (3,5], (5,10], and (10,...) years in a given quarter. The share of debt issues is computed as the aggregated issuance amount in the respective maturity segment over the total issue amount across maturity segments within a quarter. The Tobit model accounts for the share of debt issues being bounded between zero and one. AMT10 is the log of the aggregated amount of long-term (above 10 years) Eurozone government debt issues. Robust standard errors are reported in parenthesis. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

	(1) (0,1] Y	(2) (1,3] Y	(3) (3,5] Y	(4) (5,10] Y	(5) (10,...) Y
model					
L.AMT10	0.096***	-0.024	-0.038*	-0.005	-0.085***
	(0.025)	(0.022)	(0.021)	(0.020)	(0.026)
L.Termstructure 10y-6m	-0.060**	0.051*	0.063***	0.055**	0.033
	(0.028)	(0.027)	(0.023)	(0.023)	(0.031)
L.Yield 6m	0.007	0.057***	0.007	0.002	-0.015
	(0.017)	(0.016)	(0.014)	(0.014)	(0.019)
L.Spread to Germany 10y	0.013	-0.013	-0.027	-0.002	-0.061**
	(0.026)	(0.025)	(0.018)	(0.025)	(0.027)
L.Non-IG Rating Dummy	0.095	-0.098	-1.564	-2.021	0.096
	(0.215)	(0.250)	(.)	(.)	(0.280)
Recession Dummy	0.061	0.027	-0.016	-0.086*	-0.032
	(0.056)	(0.047)	(0.043)	(0.049)	(0.067)
Total Real GDP Q4 Growth	-0.000	-0.006	-0.012*	0.009	0.005
	(0.010)	(0.008)	(0.007)	(0.009)	(0.012)
L.Inflation	-0.049***	0.012	0.028**	0.027**	-0.007
	(0.017)	(0.015)	(0.012)	(0.014)	(0.020)
L.Debt to GDP Ratio	0.147	-0.022	0.068	0.170**	0.209**
	(0.094)	(0.084)	(0.065)	(0.072)	(0.099)
Total Debt to GDP Q4 Change	-0.868***	-0.338	0.307	0.181	0.623*
	(0.294)	(0.284)	(0.240)	(0.252)	(0.346)
Constant	0.242*	-0.143	-0.150	-0.236**	0.255*
	(0.141)	(0.128)	(0.117)	(0.116)	(0.155)
sigma					
Constant	0.416***	0.346***	0.271***	0.326***	0.429***
	(0.015)	(0.018)	(0.022)	(0.016)	(0.019)
Onservations	625	625	625	625	625
Pseudo R^2	0.0435	0.0402	0.0738	0.0492	0.0314

Table 4: Time-Variation of Governments' Gap-Filling

This table reports Tobit model regression results of governments share of short-term (up to one year) and long-term (greater than ten years) debt issues across two subperiods, on lagged AMT10 and control variables. The data sample is based on governments individual debt issues from 1999:q1 to 2015:q3 and is obtained from Bloomberg. The two subperiods span from 1999:q1-2009:q4, and 2010:q1-2015:q3. The dependent variable is a governments' share of debt issues of (0,1] years, or (10,...) years of maturity in a given quarter. The share of debt issues is computed as the aggregated issuance amount of debt issues with maturities in the respective maturity range over the total issue amount across all maturities within a quarter. The Tobit model accounts for the share of debt issues being bounded between zero and one. AMT10 is the log of the aggregated amount of long-term (above 10 years) Eurozone government debt issues. Robust standard errors are reported in parenthesis. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

	1999-2009		2010-2015	
	(1) (0,1] Y	(2) (10,...) Y	(3) (0,1] Y	(4) (10,...) Y
model				
L.AMT10	0.058*	-0.032	0.129***	-0.177***
	(0.033)	(0.037)	(0.038)	(0.040)
L.Termstructure 10y-6m	-0.051	-0.055	-0.064	0.143**
	(0.043)	(0.053)	(0.045)	(0.060)
L.Yield 6m	0.051	-0.091**	0.082	-0.077
	(0.035)	(0.043)	(0.050)	(0.068)
L.Spread to Germany 10y	0.059	-0.130	-0.048	-0.040
	(0.097)	(0.111)	(0.045)	(0.052)
L.Non-IG Rating Dummy			0.240	-0.049
			(0.222)	(0.279)
Recession Dummy	0.085	-0.033	0.008	0.013
	(0.073)	(0.084)	(0.108)	(0.124)
Total Real GDP Q4 Growth	-0.007	0.001	0.004	0.029
	(0.012)	(0.015)	(0.018)	(0.021)
L.Inflation	-0.073***	-0.004	-0.020	-0.001
	(0.024)	(0.025)	(0.029)	(0.038)
L.Debt to GDP Ratio	0.223*	0.148	0.126	0.248
	(0.119)	(0.130)	(0.163)	(0.160)
Total Debt to GDP Q4 Change	-1.258***	0.933*	-0.763	0.561
	(0.392)	(0.503)	(0.465)	(0.503)
Constant	0.247	0.438	0.134	0.347*
	(0.233)	(0.279)	(0.191)	(0.196)
sigma				
Constant	0.404***	0.426***	0.424***	0.408***
	(0.017)	(0.020)	(0.027)	(0.036)
Observations	409	409	216	216
Pseudo R^2	0.0566	0.0316	0.0687	0.1174

Table 5: Cross-Section of Governments' Gap-Filling, 2010-2015

This table reports Tobit model regression results of governments share of long-term (above 10 years) debt issues across different subsamples, on lagged AMT10 and control variables. The data sample is based on governments individual debt issues from 2010:q1 to 2015:q3 and is obtained from Bloomberg. The subsamples separate governments across indebtedness, size, funding needs, budget deficit, economic growth, and rating. The dependent variable is a governments' share of debt issues of (10,...) years of maturity in a given quarter. The share of debt issues is computed as the aggregated issuance amount of debt issues with maturities above 10 years over the total issue amount across all maturities within a quarter. The Tobit model accounts for the share of debt issues being bounded between zero and one. AMT10 is the log of the aggregated amount of long-term (above 10 years) Eurozone government debt issues. Robust standard errors are reported in parenthesis. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

	Indebtedness		Size		Funding needs		Budget deficit		Economic growth		Rating	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	low	high	small	large	low	high	low	high	high	low	high	low
L.AMT10	-0.365***	-0.089**	-0.280***	-0.095***	-0.155**	-0.106**	-0.229***	-0.170***	-0.208***	-0.136**	-0.201***	-0.133**
	(0.097)	(0.044)	(0.086)	(0.028)	(0.074)	(0.051)	(0.070)	(0.052)	(0.051)	(0.063)	(0.053)	(0.055)
L.Termstructure 10y-6m	0.276*	0.067	0.307*	0.083**	-0.078	0.106	-0.011	0.217***	0.261***	0.057	0.120	0.146
	(0.140)	(0.059)	(0.162)	(0.035)	(0.096)	(0.080)	(0.108)	(0.076)	(0.078)	(0.081)	(0.078)	(0.103)
L.Yield 6m	-0.115	-0.089	-0.459**	0.025	-0.170	-0.099	-0.034	-0.077	-0.212**	0.026	-0.054	-0.028
	(0.173)	(0.064)	(0.183)	(0.050)	(0.131)	(0.073)	(0.123)	(0.087)	(0.092)	(0.084)	(0.091)	(0.103)
L.Spread to Germany 10y	-0.050	-0.003	-0.054	0.011	0.166	-0.047	0.040	-0.068	-0.037	-0.079	-0.011	-0.064
	(0.116)	(0.053)	(0.120)	(0.040)	(0.127)	(0.052)	(0.110)	(0.059)	(0.059)	(0.108)	(0.075)	(0.097)
Macroeconomic Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	106	110	106	110	109	107	79	137	124	92	155	61
Pseudo R^2	0.1643	0.1159	0.1492	0.3225	0.1560	0.2130	0.1205	0.1609	0.2150	0.0871	0.1126	0.2311

Table 6: Gov. Debt Holdings of Eurozone Banks Around ECB's 3-Year LTRO

This table reports summary statistics of country-level government debt holdings for publicly listed banks in the Eurozone from the European Banking Authority (EBA) reported in Acharya and Steffen (2015). Panel A reports aggregate holdings in Irish, Italian, Portuguese, and Spanish government bonds of banks in GIIPS countries (GIIPS: Greece, Italy, Ireland, Portugal, and Spain) as of December 2011 and June 2012. Panel B reports changes in GIIPS government bond holdings by banks across different countries between December 2011 and June 2012 at the country level and by bond maturity ($\leq$ 3 years, $>$ 3 years). Changes in GIIPS government bond holdings of banks in core countries are also aggregated across countries. Core countries are Austria, Belgium, France, Germany, and the Netherlands.

	Panel A: GIIPS Sov. Bond Holdings (in EUR million)		Panel B: Change GIIPS Sov. Bond Holdings (in EUR million)	
	Dec 2011	Jun 2012	$\leq$ 3 years	$>$ 3 years
Ireland	10,487	11,938	1,511	119
Italy	153,923	189,508	27,355	7,261
Portugal	15,467	20,544	3,215	36
Spain	115,594	127,847	7,446	5,268
Core	N/A	N/A	-4,121	-4,731

Table 7: Gap-Filling by Core Governments at ECB's 3-Year LTRO

This table reports the estimates of the change in governments' debt maturity choices following the ECB's three-year LTRO announcement. The dependent variable in all specifications is the share of debt issues of maturity (range) m of country i in quarter t. The LTRO-period spans from 2012:q1 to 2012:q3. The first and second row test the changes in the share of short-term ($\leq$ 3 years) and long-term ($>$ 3 years) debt issues separately for core and peripheral countries and include country fixed effects. The third row tests the difference between the changes in the share of short-term ($\leq$ 3 years) and long-term ($>$ 3 years) debt issues separately for core and peripheral countries and includes country-maturity and country-time fixed effects. The fourth row tests the difference between core and peripheral countries difference between the changes in the share of short-term ($\leq$ 3 years) and long-term ($>$ 3 years) debt issues and includes country-maturity, country-time, and maturity-time fixed effects. Standard errors are clustered at the country level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

	$ShareIssue_{i,short,t}$ (1)	$ShareIssue_{i,long,t}$ (2)	$ShareIssue_{i,m,t}$ (3)	$ShareIssue_{i,m,t}$ (4)
Peripheral × LTRO	0.199***	-0.199***	0.199***	0.242***
	(0.029)	(0.029)	(0.028)	(0.030)
Core × LTRO	-0.145***	0.145***	-0.145***	-0.103**
	(0.038)	(0.038)	(0.037)	(0.040)
Peripheral × Long × LTRO			-0.397***	-0.483***
			(0.056)	(0.059)
Core × Long × LTRO			0.290***	0.206**
			(0.075)	(0.079)
R-squared	0.227	0.227	0.344	0.434
Observations	151	151	302	302
Country FE	Yes	Yes		
Country-Maturity FE			Yes	Yes
Country-Quarter FE			Yes	Yes
Maturity-Quarter FE				Yes

Table 8: Placebo Test: No Gap-Filling at ECB's first Targeted LTRO

This table reports the estimates of the change in governments' debt maturity choices following the ECB's first four-year targeted (T)LTRO announcement. The dependent variable in all specifications is the share of debt issues of maturity (range) m of country i in quarter t. The TLTRO1-period spans from 2014:q4 to 2015:q3. The sample period end is extended by three quarters so that the entire sample perios spans from 2010:q1 to 2015:q3. The first and second row test the changes in the share of short-term ($\leq$ 4 years) and long-term ($>$ 4 years) debt issues separately for core and peripheral countries and include country fixed effects. The third row tests the difference between the changes in the share of short-term ($\leq$ 4 years) and long-term ($>$ 4 years) debt issues separately for core and peripheral countries and includes country-maturity and country-time fixed effects. The fourth row tests the difference between core and peripheral countries difference between the changes in the share of short-term ($\leq$ 4 years) and long-term ($>$ 4 years) debt issues and includes country-maturity, country-time, and maturity-time fixed effects. Standard errors are clustered at the country level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

	$ShareIssue_{i,short,t}$ (1)	$ShareIssue_{i,long,t}$ (2)	$ShareIssue_{i,m,t}$ (3)	$ShareIssue_{i,m,t}$ (4)
Peripheral × TLTRO1	-0.012	0.012	-0.012	-0.019
	(0.052)	(0.052)	(0.051)	(0.052)
Core × TLTRO1	0.067	-0.067	0.067	0.059
	(0.038)	(0.038)	(0.037)	(0.037)
Peripheral × Long × TLTRO1			0.025	0.039
			(0.101)	(0.103)
Core × Long × TLTRO1			-0.134	-0.117
			(0.074)	(0.075)
R-squared	0.178	0.178	0.386	0.475
Observations	183	183	366	366
Country FE	Yes	Yes		
Country-Maturity FE			Yes	Yes
Country-Quarter FE			Yes	Yes
Maturity-Quarter FE				Yes

Table 9: Deviations from Debt Issuance Announcements after ECB's 3-Year LTRO

This table reports estimation results of linear regressions on issuance adjustments in government's debt auctions. Issuance adjustments are measured as the realized debt auction amount relative to the announced debt issues' minimum final outstanding amount for Italy (columns (1) and (2)), and relative to the announced debt auction target amount for Germany (columns (3) and (4)). Columns (1) and (3) provide results for multivariate regressions without fixed effects. Columns (2) and (4) provide results for multivariate regressions controlling for maturity segment, tranche, and quarter fixed effects. The relevant variables are indicator variables indicating whether a debt auction was announced prior to the inception of the ECB's three-year LTRO and auctioned during the LTRO-period for short-term (up to three years) and long-term (greater than three years) maturities. The bottom part of the table shows the hypothesis test (H_0: *LTRO x Long-Term – LTRO x Short-Term* = 0) and the hypothesis test's p-value. Robust standard errors are clustered at the maturity segment level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	Italy: Measuring Issuance Adjustments Relative to Announced Minimum Total Debt Issue Amounts		Germany: Measuring Issuance Adjustments Relative to Announced Target Auction Amounts	
	(1)	(2)	(3)	(4)
	Realized over Announced Amount	Realized over Announced Amount	Realized over Announced Amount	Realized over Announced Amount
LTRO x Long-Term	-0.220***	-0.111***	0.089***	0.077***
	(0.024)	(0.022)	(0.019)	(0.020)
LTRO x Short-Term	-0.048	-0.080***	0.017***	0.012
	(0.025)	(0.005)	(0.004)	(0.008)
Maturity Segment F.E.		Yes		Yes
Tranche F.E.		Yes		Yes
Quarter F.E.		Yes		Yes
Observations	222	222	304	304
Adj. R^2	0.319	0.754	0.077	0.118
H_0	-0.171**	-0.030	0.072***	0.065**
p-value	0.002	0.320	0.007	0.018

Appendix

Figure A.1: Longer Maturity Debt Issues Around ECB's 3-Year LTRO

This figure shows the fraction of longer maturity debt issues around the ECB's three-year LTRO. Longer maturity debt issues are debt issues with maturities of (3,...) years. The sample of governments is split into peripheral and core Eurozone governments. Fractions are computed based on aggregated debt issuance amounts across governments within a government group with debt maturities above three years over total debt issuance amounts within the same group. Fractions are computed over the pre-LTRO- (2010:q1-2011:q4), LTRO- (2012:q1-2012:q3), and post-LTRO-period (2012:q4-2014:q3), respectively.

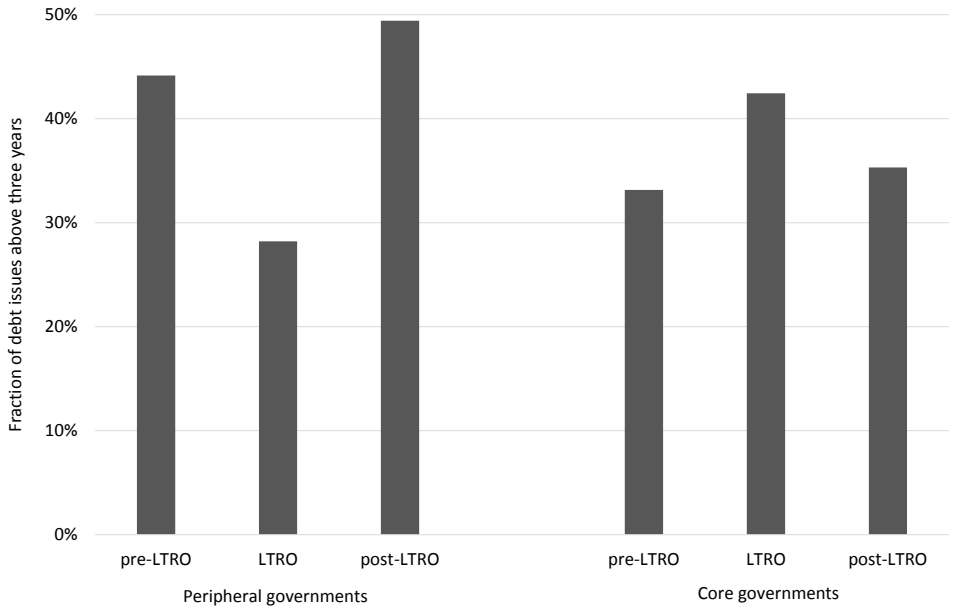
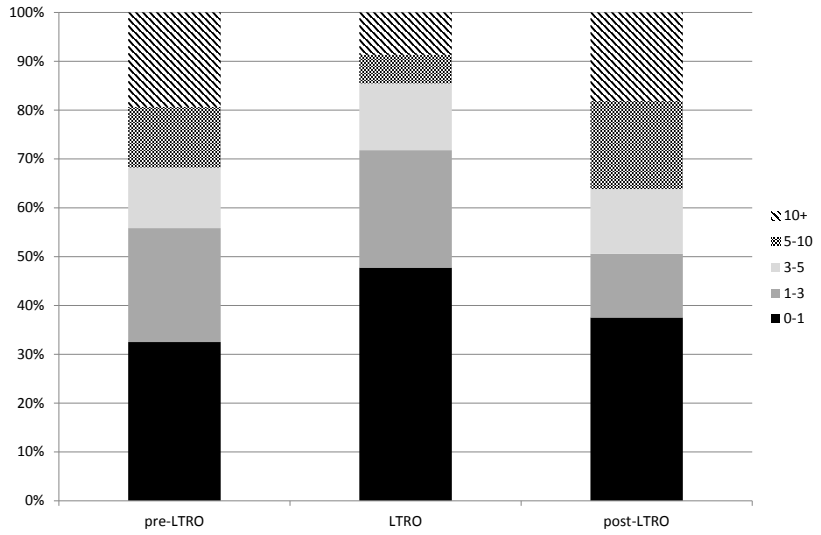


Figure A.2: Maturity Buckets of Debt Issues Around ECB's 3-Year LTRO

This figure shows the fraction of debt issues across five maturity buckets around the ECB's three-year LTRO. Debt issues are split into maturities of (0,1] year, (1,3] years, (3,5] years, (5,10] years, and (10,...) years. Panel A reports results for peripheral Eurozone governments, and Panel B for core Eurozone governments. Fractions are computed based on aggregated debt issuance amounts across governments within a government group with debt maturities in the respective maturity bucket over total debt issuance amounts within the same group. Fractions are computed over the pre-LTRO- (2010:q1-2011:q4), LTRO- (2012:q1-2012:q3), and post-LTRO-period (2012:q4-2014:q3), respectively.

(a) Peripheral Eurozone governments



(b) Core Eurozone governments

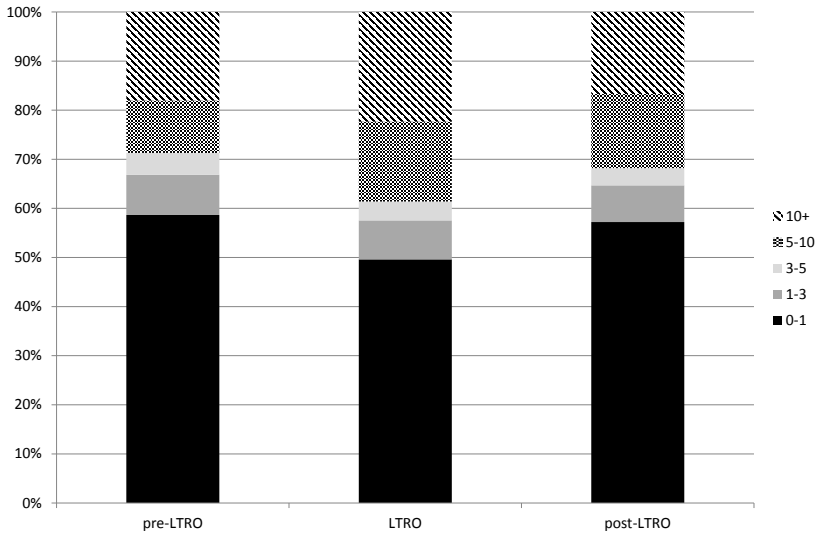


Table A.1: Description of Variables

The table describes all variables and their units of measurement. The variables are split in deal characterstics, issuer characteristics, and market characteristics.

Variable Name	Unit	Description
Panel A: Deal Characteristics		
Years to Final Maturity	Years	Years until final maturity of a debt issue.
Deal Amount	EUR bn	Notional issue amount in prices of 2010; converted to EUR at the exchange rate of the bond issue, if in non-EUR currency.
Euro Denomination Dummy	Dummy	Indicator variable; takes a value of one if debt is issued in EUR currency.
Zero/Fixed Coupon Dummy	Dummy	Indicator variable; takes a value of one if debt is issued as zero or fixed coupon bond.
Not Inflation Linked Dummy	Dummy	Indicator variable; takes a value of one if debt issue is not an inflation-linked security.
Repayment at Maturity Dummy	Dummy	Indicator variable; takes a value of one if debt issue repays at final maturity.
Panel B: Issuer Characteristics		
Qtly. Share of Debt Issues (0,1]Y	%	Quarterly amount of debt issues with maturities up to one year, over the total quarterly amount of debt issues.
Qtly. Share of Debt Issues (1,3]Y	%	Quarterly amount of debt issues with maturities greater than one year but not exceeding three years of maturity, over the total quarterly amount of debt issues.
Qtly. Share of Debt Issues (3,5]Y	%	Quarterly amount of debt issues with maturities greater than three years but not exceeding five years of maturity, over the total quarterly amount of debt issues.
Qtly. Share of Debt Issues (5,10]Y	%	Quarterly amount of debt issues with maturities greater than five years but not exceeding ten years of maturity, over the total quarterly amount of debt issues.
Qtly. Share of Debt Issues (10,...)Y	%	Quarterly amount of debt issues with maturities greater than ten years, over the total quarterly amount of debt issues.

Table A.1: Description of Variables
(continued)

Panel B: Issuer Characteristics		
Non-IG Rating Dummy	Dummy	Indicator variable; takes a value of one if the government has a long-term local-currency credit rating by S&P of BBB- or higher.
Recession Dummy	Dummy	Indicator variable; takes a value of one if the governments last two consecutive quarters had negative GDP growth.
Total GDP 4Q Growth	%	The Countries growth in real GDP during the past four quarters.
Inflation	%	The Countries consumer price inflation (CPI) during the prior twelve month.
Debt/GDP Ratio	Ratio	The countries total government debt over GDP of the previous year.
Total Debt/GDP 4Q Change	Ratio	The total change in the governments' debt/GDP ratio in the previous four quarters.
Peripheral × LTRO	Dummy	Interaction term of indicator variable "Peripheral" that takes a value of one if the country is Italy or Spain; and the indicator variable "LTRO" that takes a value of one if the quarter is included in the ECB's LTRO-period from 2012:q1 to 2012:q3.
Core × LTRO	Dummy	Interaction term of indicator variable "Core" that takes a value of one if the country is Austria, Belgium, Finland, France, Germany, the Netherlands; and the indicator variable "LTRO".
Peripheral × Long × LTRO	Dummy	Interaction term of indicator variable "Peripheral", "Long" that takes a value of one for the share of debt issues with maturities above three years, and "LTRO".
Core × Long × LTRO	Dummy	Interaction term of indicator variable "Core", "Long" and "LTRO".
Peripheral × TLTRO1	Dummy	Interaction term of indicator variable "Peripheral" and the indicator variable "TLTRO1" that takes a value of one if the quarter is included in the ECB's TLTRO1 period from 2014:q4 to 2015:q3.

Table A.1: Description of Variables
(continued)

Panel B: Issuer Characteristics		
Core × TLTRO1	Dummy	Interaction term of indicator variable "Core" and the indicator variable "TLTRO1".
Peripheral × Long × TLTRO1	Dummy	Interaction term of indicator variable "Peripheral", "Long" and "TLTRO1".
Core × Long × TLTRO1	Dummy	Interaction term of indicator variable "Core", "Long" and "TLTRO1".
Panel C: Market Characteristics		
AMT10	Log (EUR bn)	Natural logarithm of the sum of deal amounts of Eurozone government debt issues with maturities above ten years.
Termstructure 10y-6m	%	Difference between the percentage yields of 10-year and 6-month government securities.
Yield 6m	%	The percentage yield of 6-month government securities.
Spread to Germany 10y	%	The Difference between the percentage yields of 10-year government securities and 10-year German government securities.

Table A.2: Government Debt Managers in the Eurozone

The table reports the debt managers of Eurozone governments in the sample. Information on debt managers include the name, institutional position within the government, and website.

Country	Debt Manager	Institutional postion	Website
Austria	Österreichische Bundesfinanzagentur	Part of the Ministry of Finance	www.oebfa.at/en
Belgium	Agence Fédérale de la Dette/Federaal Agentschap van de Schuld	Part of the Federal Public Service Finance	www.debtagency.be/en
Cyprus	Public Debt Management Office	Part of the Ministry of Finance	www.mof.gov.cy/mof/pdmo/pdmo.nsf/index_en/index_en
Finland	Valtiokonttori	State Treasury responsible to the Ministry of Finance	www.statetreasury.fi/en-US
France	Agence France Trésor	Part of the Ministry of the Economy and Finance	www.aft.gouv.fr/
Germany	Bundesrepublik Deutschland - Finanzagentur GmbH	Limited company with the Federal Republic of Germany, represented by the Federal Ministry of Finance, as sole shareholder	www.deutsche-finanzagentur.de/en
Greece	Public Debt Management Agency	Board of Directors is appointed by the Minister of Finance, Agency responsible to the Ministry of Finance	www.pdma.gr/en
Ireland	National Treasury Management Agency	Chairperson is appointed by the Minister of Finance, Agency responsible to the Ministry of Finance	www.ntma.ie
Italy	Dipartimento del Tesoro	Part of the Ministry of Economy and Finance	www.dt.tesoro.it/en/
Malta	Debt Management Directorate	Part of the Treasury Department	treasury.gov.mt/en
Netherlands	Agentschap van de Generale Thesaurie	Part of the Ministry of Finance	english.dsta.nl
Portugal	Agência de Gestão da Tesouraria e da Dívida Pública - IGCP, E.P.E.	Agency supervised by the Finance Minister	www.igcp.pt/en
Slovakia	Agentúry pre riadenie dlhu a likvidity	Agency responsible to the Ministry of Finance	www.ardal.sk/en
Slovenia	Ministrstvo za finance	Part of the Ministry of Finance	www.mf.gov.si/en
Spain	Tesoro Público	Part of the Ministry of Economy, Industry and Competitiveness	www.tesoro.es/en

Table A.3: Gap-Filling Government Debt Maturity Choice (OLS Models), 1999-2015

This table reports OLS model regression results of governments share of short-term and long-term debt issues, on lagged AMT10 and control variables. The data sample is based on governments individual debt issues from 1999:q1 to 2015:q3 and is obtained from Bloomberg. The dependent variable is a governments' share of debt issues in the short-term maturity segments of (0,1] years, and the long-term maturity segments of (10,...) years in a given quarter. The share of debt issues is computed as the aggregated issuance amount in the respective maturity segment over the total issue amount across maturity segments within a quarter. AMT10 is the log of the aggregated amount of long-term (above 10 years) Eurozone government debt issues. Panel A reports results for short-term debt issues, and Panel B reports results for long-term debt issues. Heteroscedasticity-robust and clustered standard errors at the government-level are reported in parenthesis. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

(a) Short-Term Debt Issues

	(1) (0,1] Y	(2) (0,1] Y	(3) (0,1] Y	(4) (0,1] Y	(5) (0,1] Y	(6) (0,1] Y
L.AMT10	0.078***	0.070***	0.069***	0.073***	0.075***	0.071**
	(0.023)	(0.022)	(0.019)	(0.018)	(0.020)	(0.027)
L.Termstructure 10y-6m	-0.036	-0.065	0.009	0.030	0.017	0.010
	(0.033)	(0.061)	(0.055)	(0.053)	(0.056)	(0.057)
L.Yield 6m	0.010	0.042	0.117*	0.088	0.080	0.087
	(0.020)	(0.064)	(0.060)	(0.052)	(0.052)	(0.053)
L.Spread to Germany 10y	-0.007	-0.034	-0.107*	-0.084	-0.078	-0.117
	(0.030)	(0.059)	(0.055)	(0.051)	(0.049)	(0.112)
Macroeconomic Variables	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes	Yes	Yes	
Quarter FE			Yes	Yes		Yes
Country FE				Yes		
Country-Quarter FE					Yes	
Country-Year FE						Yes
Observations	625	625	625	625	625	625
R^2	0.0671	0.0989	0.1635	0.3925	0.4966	0.5557

(b) Long-Term Debt Issues

	(1) (10,...) Y	(2) (10,...) Y	(3) (10,...) Y	(4) (10,...) Y	(5) (10,...) Y	(6) (10,...) Y
L.AMT10	-0.047**	-0.054***	-0.058***	-0.057***	-0.061***	-0.059**
	(0.017)	(0.017)	(0.013)	(0.013)	(0.013)	(0.021)
L.Termstructure 10y-6m	-0.002	0.061	0.011	0.004	0.022	-0.006
	(0.013)	(0.041)	(0.038)	(0.042)	(0.045)	(0.052)
L.Yield 6m	-0.012	0.007	-0.042	-0.039	-0.035	-0.034
	(0.009)	(0.036)	(0.030)	(0.027)	(0.028)	(0.037)
L.Spread to Germany 10y	-0.017	-0.037	0.012	-0.015	-0.018	-0.016
	(0.016)	(0.042)	(0.038)	(0.041)	(0.043)	(0.084)
Macroeconomic Variables	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes	Yes	Yes	
Quarter FE			Yes	Yes		Yes
Country FE				Yes		
Country-Quarter FE					Yes	
Country-Year FE						Yes
Observations	625	625	625	625	625	625
R^2	0.0302	0.0655	0.1376	0.1718	0.3051	0.3288

Table A.4: Gap-Filling by Government Group, 2010-2015

This table reports Tobit model regression results of governments share of debt issues across five maturity segments for different government groups, on lagged AMT10 and control variables. The data sample is based on governments individual debt issues from 2010:q1 to 2015:q3 and is obtained from Bloomberg. The dependent variable is a governments' share of debt issues in a maturity segments (0,1], (1,3], (3,5], (5,10], and (10,...) years in a given quarter. The share of debt issues is computed as the aggregated issuance amount in the respective maturity segment over the total issue amount across maturity segments within a quarter. The Tobit model accounts for the share of debt issues being bounded between zero and one. AMT10 is the log of the aggregated amount of long-term (above 10 years) Eurozone government debt issues. Panel A reports results for peripheral governments, and Panel B reports results for core governments. Robust standard errors are reported in parenthesis. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

(a) Peripheral Governments

	(1) (0,1] Y	(2) (1,3] Y	(3) (3,5] Y	(4) (5,10] Y	(5) (10,...) Y
L.AMT10	0.194***	-0.043	0.041	-0.030	-0.198***
	(0.051)	(0.043)	(0.034)	(0.047)	(0.048)
L.Termstructure 10y-6m	-0.061	0.079	0.037	-0.011	0.005
	(0.091)	(0.071)	(0.053)	(0.070)	(0.075)
L.Yield 6m	0.064	0.072	-0.009	-0.075	-0.098
	(0.075)	(0.068)	(0.055)	(0.078)	(0.086)
L.Spread to Germany 10y	0.034	-0.069	-0.046	0.039	-0.082
	(0.068)	(0.046)	(0.044)	(0.071)	(0.064)
Macroeconomic Variables	Yes	Yes	Yes	Yes	Yes
Observations	73	73	73	73	73
Pseudo R^2	0.2772	0.2981	0.6184	0.2368	0.2803

(b) Core Governments

	(1) (0,1] Y	(2) (1,3] Y	(3) (3,5] Y	(4) (5,10] Y	(5) (10,...) Y
L.AMT10	0.091*	0.012	0.002	-0.001	-0.163***
	(0.051)	(0.040)	(0.052)	(0.044)	(0.058)
L.Termstructure 10y-6m	-0.030	0.016	0.035	-0.010	0.223**
	(0.064)	(0.065)	(0.060)	(0.056)	(0.087)
L.Yield 6m	0.145	-0.067	0.060	0.014	-0.250**
	(0.117)	(0.093)	(0.094)	(0.100)	(0.117)
L.Spread to Germany 10y	-0.077	-0.342**	-0.030	0.063	0.098
	(0.076)	(0.152)	(0.068)	(0.079)	(0.096)
Macroeconomic Variables	Yes	Yes	Yes	Yes	Yes
Observations	143	143	143	143	143
Pseudo R^2	0.0577	0.2189	0.0296	0.0657	0.1168

Table A.5: Gap-Filling After the Eurozone Crisis, 2012:q4-2015:q3

This table reports Tobit model regression results of governments share of debt issues across five maturity segments, on lagged AMT10 and control variables. The data sample is based on governments individual debt issues following the Eurozone crisis (from 2012:q4 to 2015:q3) and is obtained from Bloomberg. The dependent variable is a governments' share of debt issues in a maturity segments (0,1], (1,3], (3,5], (5,10], and (10,...) years in a given quarter. The share of debt issues is computed as the aggregated issuance amount in the respective maturity segment over the total issue amount across maturity segments within a quarter. The Tobit model accounts for the share of debt issues being bounded between zero and one. AMT10 is the log of the aggregated amount of long-term (above 10 years) Eurozone government debt issues. Robust standard errors are reported in parenthesis. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

	(1) (0,1] Y	(2) (1,3] Y	(3) (3,5] Y	(4) (5,10] Y	(5) (10,...) Y
model					
L.AMT10	0.133***	-0.013	-0.032	0.023	-0.170***
	(0.048)	(0.039)	(0.050)	(0.046)	(0.050)
L.Termstructure 10y-6m	-0.012	-0.007	0.065	0.079	-0.006
	(0.091)	(0.071)	(0.077)	(0.085)	(0.118)
L.Yield 6m	0.193	0.071	-0.058	-0.023	-0.410**
	(0.145)	(0.130)	(0.104)	(0.144)	(0.160)
L.Spread to Germany 10y	-0.155	0.026	-0.008	0.038	0.172
	(0.112)	(0.098)	(0.097)	(0.110)	(0.138)
L.Non-IG Rating Dummy	0.445*	-0.147	-1.938	-2.547	-0.114
	(0.243)	(0.252)	(.)	(.)	(0.310)
Recession Dummy	0.104	0.008	-0.028	-0.174	-0.006
	(0.173)	(0.077)	(0.123)	(0.117)	(0.184)
Total Real GDP Q4 Growth	0.055	-0.014	-0.112***	-0.021	0.029
	(0.037)	(0.023)	(0.039)	(0.036)	(0.037)
L.Inflation	0.094	-0.046	-0.189***	-0.022	0.040
	(0.082)	(0.051)	(0.067)	(0.084)	(0.102)
L.Debt to GDP Ratio	0.510*	0.229	-0.129	-0.093	0.333
	(0.275)	(0.198)	(0.212)	(0.300)	(0.290)
Total Debt to GDP Q4 Change	-0.575	-0.416	0.405	-0.400	0.352
	(0.782)	(0.607)	(0.822)	(0.857)	(0.935)
Constant	-0.309	-0.206	0.127	-0.164	0.335
	(0.286)	(0.205)	(0.266)	(0.276)	(0.310)
sigma					
Constant	0.425***	0.309***	0.299***	0.373***	0.431***
	(0.037)	(0.043)	(0.053)	(0.036)	(0.055)
Observations	110	110	110	110	110
Pseudo R^2	0.1028	0.1022	0.2174	0.1029	0.1400

Table A.6: Gap-Filling by Core Gov. (excluding Germany) at ECB's 3-Year LTRO

This table reports the estimates of the change in governments' debt maturity choices following the ECB's three-year LTRO announcement, excluding Germany as core government. The dependent variable in all specifications is the share of debt issues of maturity (range) m of country i in quarter t. The LTRO-period spans from 2012:q1 to 2012:q3. The first and second row test the changes in the share of short-term ($\leq$ 3 years) and long-term ($>$ 3 years) debt issues separately for core and peripheral countries and include country fixed effects. The third row tests the difference between the changes in the share of short-term ($\leq$ 3 years) and long-term ($>$ 3 years) debt issues separately for core and peripheral countries and includes country-maturity and country-time fixed effects. The fourth row tests the difference between core and peripheral countries difference between the changes in the share of short-term ($\leq$ 3 years) and long-term ($>$ 3 years) debt issues and includes country-maturity, country-time, and maturity-time fixed effects. Standard errors are clustered at the country level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

Dependent Variable	$ShareIssue_{i,short,t}$ (1)	$ShareIssue_{i,long,t}$ (2)	$ShareIssue_{i,m,t}$ (3)	$ShareIssue_{i,m,t}$ (4)
Peripheral × LTRO	0.199***	-0.199***	0.199***	0.237***
	(0.029)	(0.029)	(0.028)	(0.030)
Core × LTRO	-0.150**	0.150**	-0.150**	-0.114**
	(0.046)	(0.046)	(0.045)	(0.046)
Peripheral × Long × LTRO			-0.397***	-0.473***
			(0.056)	(0.060)
Core × Long × LTRO			0.300**	0.227**
			(0.090)	(0.093)
R-squared	0.233	0.233	0.353	0.447
Observations	132	132	264	264
Country FE	Yes	Yes		
Country-Maturity FE			Yes	Yes
Country-Quarter FE			Yes	Yes
Maturity-Quarter FE				Yes

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