Bond Supply Expectations and the Term Structure of Interest Rates

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Abstract

In this paper we study the impact of current and expected bond supply on Italian and German government bond yields. We find that the news of expected supply of government bonds influence German yields, but not Italian yields. The opposite is true for current supply which is priced only in Italian bonds. The accuracy of news on expected supply appears to drive the result. If accuracy is high, expected supply is considered to be more informative than current supply and the former is the only one with a price impact. If accuracy is low, only current supply is considered informative and embedded in traded prices. We also investigate the puzzle of the large amount of German bonds trading consistently below the deposit rate of the European Central Bank since 2015. We argue that this is not caused by the ECB's unconventional monetary policies, but by the expectation of a sharp contraction in the expected supply of German short-term debt. Our findings support term-structure models that account for imperfect asset substitutability and preferred-habitat investors and provide first empirical evidence of the impact of supply expectations on interest rates.

JEL codes: E43, E41, E51, E52, E58.
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1 Introduction

Does forward-looking information on the amount of Government bonds in circulation drive changes in the term-structure of interest rates in Europe? According to arbitrage-free models and to the expectations hypothesis bond supply should not affect bond yields (Cox et al., 1985). However, models that consider the presence of preferred-habitat investors and imperfect substitutability between assets entail this possibility (Vayanos and Vila, 2009).

In our paper we use time-series data to estimate how Italian and German bond yields are affected by current and future expected Government debt. Our empirical evidence points to a link between the future level of bond supply and interest rates whenever agents have detailed information regarding future auctions by the Government. In that case, the current level of supply has no effect on the term-structure. However, the current outstanding amount of Government bonds in the market is the only reliable measure of supply whenever investors hold only scarce details on future auctions by the Treasury. We also provide an empirical explanation for the puzzle of government debt trading below the European Central Bank deposit rate. In fact, A large amount of short and medium-term German bonds has been trading consistently below the deposit rate of the European Central Bank since 2015. Given the long-term focus of the Public Sector Purchase Program (PSPP), we are able can rule out any direct impact of this program on the yields at the short-end of the term-structure. We argue that this issue can be explained by looking at the expected amount of short-term bonds that will be issued in future months by the German Treasury. The expected limited amount of these securities creates a local scarcity effect that keeps bond yields at historical low levels and well below the deposit rate. For example, our results suggest that a 1 percent increase in the expected amount of short-term debt to GDP ratio decreases the spread between German bonds and the deposit rate of the Central Bank by around 10-15 basis points, depending on our specification, whenever the spread is negative.

Our contributions to the literature are as follows. First, to the best of our knowledge, we are the first to explore the empirical relationship between expected bond supply and interest rates. Second, we contribute to the literature by showing how future scarcity of short-term bonds impacts the yield curve. While our paper is related to previous studies linking supply, unconventional monetary policies and interest rates, we do not specifically address the impact of Quantitative Easing in Europe. Instead, we cover a longer sample period and we examine the information stemming from bond auctions and Treasury press releases. We study Germany and Italy, two European economies with sizable and liquid bond markets. Interestingly, these two countries feature very different policies regarding the amount of released information on their bond issuance plans. Whereas Italy publishes the issuance schedule with auction dates and bond types but not nominal issue sizes, Germany publishes detailed press releases about forthcoming auctions throughout the year. We take advantage of the specific information released by the German Treasury to build a new and detailed variable of expected supply, defined as the overall amount of debt that would be outstanding in the future if the Treasury followed exactly the issuance planning communicated at the time of each press release. Germany and Italy are also two of the main benchmarks for core and peripheral European countries, driven by different macroeconomic and financial effects throughout our sample. This allows us to assess how supply can differently affect interest rates in two different environments.

Our work fits within a growing strand of literature relating interest rates and fixed-income quantities. The foundations of this literature lead back to the work of Tobin (1958, 1969), in which a shock to the stock of available assets has to change its expected returns in order to restore equilibrium. Another early contribution from Modigliani and Sutch (1966) refers to the existence of preferred-habitat investors in certain segments of the yield curve. A more recent influential work by Vayanos and Vila (2009) formalizes a no-arbitrage model of the yield curve in which two types of agents trade across the term-structure: preferred-habitat investors that demand only bonds at specific maturities and risk-averse arbitrageurs that trade along all the yield curve and render it arbitrage-free. In this setup, changes in supply impact the required rate of return requested by arbitrageurs to absorb a change in quantities and duration risk. Our paper is also strictly related to the theoretical model developed by Greenwood et al. (2015), in which expectations about future changes in supply due to expected purchases by the Central Bank affect spot and forward rates. There is also a large body of empirical literature investigating the relationship between supply and the possible channels through which it may affect interest rates. For example, Greenwood and Vayanos (2014) find that supply affects both spot rate and future returns through the risk premia. Krishnamurthy and Vissing-Jorgensen (2012) find that the overall amount of outstanding Treasuries has an effect bond safety and liquidity, thus driving the spread between Treasuries and corporate bonds. A lot of empirical work has also been devoted to estimate the financial and macroeconomic impact of large-scale asset purchase programs that took place in the last decade in western economies. Most of these studies distinguish between the stock and flow effects on interest rates. Stock effects are defined as the permanent effect on yields determined by the announcement of the program implementation, while flow effects relate to the change in prices due to the actual purchases by the Central Bank. Among others, D' Amico and King (2013), Krishnamurthy and Vissing-Jorgensen (2011), Gagnon et al. (2011) and Joyce et al. (2011) estimate the impact of these programs in the U.S and in the United Kingdom with an event-study approach. The literature regarding the impact of Quantitative Easing in Europe is more limited, because the European Central Bank lagged among its peers in adopting a similar policy. However, a growing number of studies on the ECB's APP have been published in the last few years (For example Altavilla et al. (2015), De Santis and Holm-Hadulla (2017) Gambetti and Musso (2017), Koijen et al. (2016), Blattner and Joyce (2016), Wieladek and Garcia Pascual (2016) study how the Public Sector Purchase Programme (PSPP) affected financial and macroeconomic variables).

The paper is organised as follows. Section 2 describes how we construct our measures of supply. Section 3 illustrates our identification strategy. Section 4 reports and discusses our empirical results. Section 5 shows the robustness tests we undertake to validate our findings. Section 6 concludes.

2 Bond Supply Measures

We download data on bond supply from the German and Italian Treasury web sites. Our sample covers the period from January 2005 to December 2017. We collect detailed information on each fixed-rate and zero-coupon government bond issued in this time period (ticker, issue date, maturity date, coupon rate, auction average price, bid-to-cover ratio and face value outstanding). In this way, we are able to reconstruct the total amount of bond supply at each point in time during our sample. For Italian bonds, we also correct the outstanding amount of each bond whenever it is modified by an exchange auction. An exchange auction happens whenever a portion of the total amount outstanding of a bond is bought back from the Treasury in exchange for another security issued in the past and with a different maturity. Usually, the objective of an exchange auction is trading a seasoned bond that is close to maturity with another one that has a longer time until redemption. We take into account exchange auctions because, even though they have a minor impact on the overall amount of government debt, they still modify both the total amount of supply and the average duration of debt.

Following Greenwood and Vayanos (2014) we construct a maturity-weighted measure of debt for each country:

$$MWD_{i,t} = \frac{\sum_{\tau=0}^{30} D_{i,t}^{\tau} \tau}{GDP_{i,t}}$$

where

$$D_{i,t}^{\tau} = Pr_{i,t}^{\tau} + C_{i,t}^{\tau}.$$

$Pr_{i,t}^{\tau}$ and $C_{i,t}^{\tau}$ are the aggregate principal and coupon payments that are due τ years from time t for country i. We choose this as our main measure of supply because, according to Greenwood and Vayanos (2014), maturity-weighted debt-to-GDP dominates several other measures of debt when forecasting bond returns.

We also build a new measure of future expected supply for each country. To the best of our knowledge, we are the first to study the relationship between interest rates and a future expected quantity. We assume that agents incorporate all the publicly available forward-looking information in order to price assets. We define the future expected value of supply as:

$$E[MWD_{i,t+k}] = \frac{\sum_{\tau=0}^{30} E[D_{i,t+k}^{\tau}\tau|I_{i,t}]}{GDP_{i,t}}$$

where $E[D_{i,t+k}^{\tau}\tau|I_{i,t}]$ is the expected value of total principal and coupon payments due τ years from $t+k$ months ahead for country i conditional on the information available at time t, $I_{i,t}$. We build the best possible proxy forexpected supply given the information known by investors at each point in time. In order to estimate this variable, we look at how each Treasury Department organises press-releases regarding their bond issuance plan. The quantity and quality of forward-looking information released by Italy and Germany is quite different.

The German Treasury issues several press releases throughout the year[1]. The first release takes place in December, when the Treasury states the issuance plans for the next calendar year with the expected notional amount of every auction for each bond. There are also communications at the end of every quarter that state changes in the upcoming

[1] All the press-releases for the German Treasury can be downloaded at `https://www.deutsche-finanzagentur.de/en/press/press-releases/`

auctions. Consider, for example, the press release of September 23rd 2014, in which the Treasury announced that due to lower required funding for the federal budget, the fourth quarter auctions for the 6-months and 12-months Treasury Discount Papers (announced the previous December) were cancelled.

The Italian Treasury employs a very different policy regarding press-releases on future auctions[2]. In fact, press releases are issued only at the end of each quarter, and only provide an indication of the Government's intentions over the next three months. The Treasury states its intentions regarding new issues and re-openings only for bonds between 2 and 10 year maturity. However, the actual face value of each bond issue is not indicated and the Treasury only communicates the minimum total amount that will be offered. Furthermore, there is no forward-guidance for auctions of short-term bonds (below 1 year maturity), bonds with maturity over 10 years and off-the run bonds. Thus, investors have full information on scheduled German bond auctions, but only partial information on scheduled Italian bond auctions. In both countries, press-releases with information on the issuance schedule for the following are published in December. Agents though don't have any information on auctions that will take place after the end of the current calendar year and they need to wait until the new annual auction schedule is released. We use the following approach for constructing a proxy for the expected supply conditional on all the information available at time t, $E[D^{\tau}_{t+k}\tau|I_t]$:

- For Germany, $E[D^{\tau}_{t+k}\tau|I_t]$ is defined as the amount of maturity-weighted supply that would be outstanding at the end of the year, according to the information available at each point in time. So, we download every single press-release to estimate the amount of supply that would be outstanding at the end of each year if there were no changes to the Treasury's planning in the next k months. Whenever a new press-release with changes to planned auctions becomes public, we adjust the measure

[2]Press-releases for the Italian Treasury can be found at http://www.dt.tesoro.it/it/debito_pubblico/emissioni_titoli_di_stato_interni/programma_trimestrale_emissione/

to account for the changes in supply due to cancelled auctions, new auctions that were not announced or changes in face value offered on planned auctions. We also assume that the amount of coupon payments due in the future and starting $t + k$ months ahead will be based on market conditions that are observable at time t.

- For Italy, $E[D^{\tau}_{t+k}\tau|I_t]$ is computed as the amount of maturity-weighted supply that is expected to be outstanding at the end of the next quarter. This relies on two assumptions. First, we assume that investors know the amount of supply that will be outstanding at the end of the quarter for bonds with maturities between 2 and 10 year. Second, since there is no information about bonds of other maturities, we assume that there will be no aggregate change in the supply of these bonds. Hence, the supply at the start of the quarter for both short-term bonds and bonds with maturity above 10 years is the best proxy for the amount that will be outstanding at the end of the quarter.

We also download data on the amount Government bonds purchased by the European Central Bank during the Public Sector Purchase Program (PSPP) that started in March 2015. We obtain the total purchases and average remaining duration of the ECB holdings for both countries. We build a maturity-weighted measure of debt held by the European Central Bank as:

$$MWQE_{i,t} = \frac{\sum_{t=0}^{n} Holdings_{i,t} * \bar{M}_{i,t}}{GDP_{i,t}}$$

where $\sum_{t=0}^{n} Holdings_{i,t} * \bar{M}_{i,t}$ is the overall PSPP bond holdings for each country i at time t multiplied by their average residual maturity.

We express our supply variables in nominal values for two reasons. First, as Greenwood and Vayanos (2014) point out, interest rate changes have a mechanical effect on the overall supply if this is expressed in market values. A decrease in bond prices would decrease maturity weighted debt, thus creating a spurious negative relationship between yields and supply. Second, we could theoretically estimate a market value of expected debt based on interest rates observed ex-post, but those same interest rates would not be available in the market at the time in which details about future value of outstanding debt would become available to investors.

Finally, we are interested in studying potential scarcity effects at the short-end of the German term-structure of interest rates. We define the expected amount of short-term bonds outstanding as:

$$E[Debt_{t+k}^{\tau<2}] = \frac{\sum_{\tau=0}^{2} E[D_{t+k}^{\tau}|I_t]}{GDP_t}$$

where $\sum_{\tau=0}^{2} E[D_{t+k}|I_{i,t}]$ is the sum of the expected outstanding amount of German bonds at the end of the year with original maturity below 2 years, based on the information available at time t. We also take advantage of some specific features of the PSPP to make sure that our measure is a reliable estimate of the net outstanding amount of short-term debt. In fact, at the start of the program, the ECB could not purchase neither bonds with remaining maturity below 2 years nor bonds that traded below the deposit rate. Since short-term German bonds have been trading below this threshold consistently since the start of the PSPP, we know that our measure of short-term supply is a good estimate of the total amount of bonds available to investors. Even if the implementation aspects slightly changed in January 2017, allowing the ECB to buy bonds with yields below the deposit rate, we believe the purchases in this maturity bucket were limited. Nonetheless, in our robustness tests we also restrict our sample and define our variable slightly differently to check the consistency of our results. We split the variable into specific supply buckets (less than one year maturity supply, between one and two years supply) and regress the specific spread on that splitted variable.

Table A.1 in the appendix lists the main variables used in our empirical analysis and specifices their sources, while in Table 1we provide summary statistics for yields, various supply proxies and other variables used in our empirical analysis. Not surprisingly, the mean of Italian maturity-weighted debt to GDP (7.3) is twice as big as the German maturity-weighted debt to GDP (3.2). The standard deviation of maturity-weighted debt for Italy is ten times larger than the standard deviation of maturity-weighted debt for Germany. Table 2 shows the correlations in levels and first difference between the main variables in our study. The top panel shows that our measure of expected supply is more correlated to 10 and 5 year spreads than current supply, both in levels and in first difference. Looking at Italy, the correlations are very similar in levels, while current supply is more correlated to yield spreads than expected supply in first difference. Finally, Figure 2 plots separately the short-term (blue-dashed line) and long-term(red line) supply curves of German bonds. Short-term debt increases sharply towards the end of 2009 and then steadily decreases reaching very low levels in October 2017. The situation is even more dramatic if we look at bonds below 1 year maturity, where the total amount outstanding decreased from around Eur 100 billion before 2010 to about Eur 10 billion at the end of 2017. In the last part of the sample, we can observe the effect of the ECB purchases on long-term debt.

3 Identification

We estimate the following monthly regressions of yields on current and expected future supply separately for both countries:

$$y_{i,t}^{(\tau)} - y_{i,t}^{(1)} = \alpha + \beta_1 MWD_{i,t} + \beta_2 MWQE_{i,t} + \beta_3 t + \epsilon_{i,t} \quad \forall \tau > 1 \tag{1}$$

$$y_{i,t}^{(\tau)} - y_{i,t}^{(1)} = \alpha + \beta_1 E[MWD_{i,t+k}|I_{i,t}] + \beta_2 MWQE_{i,t} + \beta_3 t + \epsilon_{i,t} \quad \forall \tau > 1 \tag{2}$$

where $y_{i,t}^{(\tau)} - y_{i,t}^{1}$ is the spread between the τ year and the 1-year bond and t is a time trend. Our baseline regressions are in the spirit of Greenwood and Vayanos (2014), but we augment the specification by using an expected value of supply as independent variable. We also run a horse-race regression in which we jointly estimate the contribution of both current and future expected supply to the yield spread:

$$y_{i,t}^{(\tau)} - y_{i,t}^{(1)} = \alpha + \beta_1 MWD_{i,t} + \beta_2 E[MWD_{i,t+k}|I_{i,t}] + \beta_3 MWQE_{i,t} + \beta_4 t + \epsilon_{i,t} \quad \forall \tau > 1. \quad (3)$$

We adjust standard errors to account for autocorrelation. Obviously, yield spreads may depend on other variables besides supply and expected supply. Thus we use a parametric approach and estimate an AR(1) process for regression residuals. We also estimate the regressions with robust-standard errors.

To address endogeneity concerns, we also adopt an instrumental variables approach. Endogeneity could arise from the fact that the Government could choose the structure of its debt to minimize interest payments. The Treasury could have an incentive to shift towards issuing a higher percentage of long-term bonds if the spread between long and short-term interest rates decreased, due for example to a higher demand for bonds with longer maturity.We focus our instrumental variables approach on equation (1) for Italy and (2) for Germany. We choose Debt to GDP and its square as instruments for Maturity Weighted Debt for Italy, while we use the future expected Debt to GDP for future expected German supply. Our approach is consistent with the one proposed by Krishnamurthy and Vissing-Jorgensen (2012).

3.1 Identification of Scarcity Effects

We also focus our analysis on short and medium-term German Bonds. We define $s_t^{(\tau)}$ as the yield spread between the τ year bond and the ECB deposit rate and estimate a threshold model for yield spread changes as follows:

$$\Delta_4 s_t^{(\tau)} = \alpha + \beta_1 \Delta_4 E[Debt_{t+k}^{(\tau<2)}] \mathbb{1}_{(s_{t-4}^{(\tau)}>0)} + \beta_2 \Delta_4 E[Debt_{t+k}^{(\tau<2)}] \mathbb{1}_{(s_{t-4}^{(\tau)}<0)} + \sum_{j=3}^{n} \beta_j \Delta_4 X_j + \epsilon_t$$

where $\Delta_4 s_t^{(\tau)}$ is the spread change over a four-week period, $E[Debt_{t+k}^{(\tau<2)}]$ is the expected supply of Government Debt with original maturity below 2 years and X_j is a matrix of control variables. $\mathbb{1}_{(s_{t-4}^{(\tau)}>0)}$ and $\mathbb{1}_{(s_{t-4}^{(\tau)}<0)}$ are two indicator functions that assume value of one whenever the lagged spread is positive and negative, respectively. We estimate our model with Newey and West (1987) standard errors allowing for 8 lags. We also consider an alternative specification and assume an AR(1) process for the regression residuals and estimate the extended model with robust standard errors. We control mainly for flight-to-safety effects, since German governments bonds might be prone to an increase demand at times of high market stress, given their status of safe-haven.

4 Results

We start the empirical analysis by investigating the importance of current bond supply versus expected supply for explaining yield spreads. Table 3 shows the result of regressions of current and future expected supply on yield spreads. The second and the ninth Columns of Panel A and Panel B report the coefficients of current and expected maturity-weighted supply for both countries. The outcome is completely different depending on the country we consider. For example, the coefficients of current maturity-weighted supply are not significant for any maturity for German yields. However, future expected maturity-weighted supply carries significant coefficients at all maturities. We get completely opposite results for Italy. In fact, current maturity-weighted debt shows significant coefficients for Italy, while future expected maturity-weighted supply has no impact on yield spreads.

Looking at the economic significance of our results, current maturity-weighted supply carries a coefficient of 0.005 (t=2.38) on the 10 year yield spread for Italy. Thus, an increase of one standard deviation in current supply would increase the spread between the 10 year and the 1 year bond by around 50 basis points. Results are doubled for expected future supply for Germany. More specifically, an increase of one standard deviation in future expected supply (coefficient=0.011, t=1.99) would increase the spread between the 10 and the 1 year German yield by around 110 basis points. We can compare these results with estimates of the impact of the PSPP program the ECB implemented in Europe from March 2015 (it was announced in January 2015). If we look at the first year and a half of purchases , the ECB bought around âĆň160 billion of Italian government bonds. Assuming an average duration of around 5 years and a GDP of âĆň1.6 trillions, the decrease in current maturity-weighted supply would be 0.16*5/1.6=0.5. This magnitude would decrease the yield spread by around 25 basis points.

The same calculation for Germany has more caveats. In fact, we would have to estimate the expected amount and average maturity of purchases that was anticipated by market participants before the program even took place. This is a daunting task, in the sense that it is complicated to assess when agents incorporated information on future purchases. While the announcement of the program may have had a sizable impact, it is also possible that the PSPP was anticipated even before the announcement date. According to Gambetti and Musso (2017), the announcement of the Public Sector Purchase Programs was anticipated, up to a certain extent, by market participants. However, there were uncertainties about the total size of the program, that could only be estimated by investors. Assuming that agents could have had an imperfect estimate of the amount and maturity of the purchases in the first part of the PSPP (for example around âĆň200 billion with an average duration of 5 years for German Government bonds) and with a GDP of âĆň3.2 trillions, hence a decrease in expected maturity-weighted supply would be 0.31 (0.2*5/3.2). This would imply a total decrease of the yield spread by around 200 basis points. While almost in line with the estimates of Greenwood and Vayanos (2014), our estimates of the impact of current supply on yield spreads for Italy is somewhat smaller compared to other estimates of the impact of the PSPP, while it is of bigger magnitude than expected for the expected German supply. This dissonance could be due to the intrinsic difference in the two variables, with one being a measure of the present outstanding amount of government bonds, while the second one being a forward-looking measure. It is also possible that we overestimate the impact of the PSPP on German bonds, because in our calculation we assume that agents have a reliable estimate of specific features of the program months in advance, which is unlikely.

Moreover, columns 4 and 11 of Panel A and B of Table 3 report the coefficients related to maturity weighted purchases by the ECB. The variable measures the impact of actual purchases (the flow effect) on yield spreads. Coefficients are not significant for both countries at any maturity. At first sight, this may seem inconsistent. However, the existing literature (for example D' Amico and King (2013)) estimates that flow effects have a limited impact on yields compared to stock effects (the impact at the announcement). Flow effects are also transitory and converge to zero a few days after the actual purchases. Therefore, our monthly time-series regressions may not be well equipped to capture this flow effect that could be observed at higher frequencies. Panel C of Table 3 reports the results of the horse-race regressions between current and expected maturity-weighted supply. Consistent with our results in Panel A and B of the same Table, our measure of expected maturity-weighted supply dominates current supply for Germany, while current supply flushes out expected supply for Italy. The magnitude of the coefficients is similar to our base-case, so adding current supply or expected supply for Germany and Italy respectively does not add any information to our baseline specifications.

In order to check the consistency of our results, we add serveral controls to our baseline specifications. We check the robustness of future expected supply for Germany, while we focus our attention on current supply for Italy. Table A.2 and Table A.3 in the Appendix report the results for both countries. First, in column 3 we add controls for credit and liquidity risk. Credit and liquidity conditions may drive interest rates, especially in times of high market stress, for example during the Financial Crisis and, more specifically, during the Sovereign Debt Crisis that happened in Europe between 2010 and 2012. Next, in column 4 we add a control for risk aversion in the equity market and a dummy for the Sovereign Crisis. Moreover, in columns 5 and 6 we add two macroeconomic controls. Macroeconomic variables such as GDP and inflation could affect interest rates through the risk premium, such as shown in Ludvigson and Ng (2009) and Joslin et al. (2014). We control for output growth and inflation risk in Columns 5 and 6. Our results remain significant after controlling for all these factors.

Panel A and B of Table 5 show the results of our instrumental variables estimation. Columns 8-13 report the coefficients of the first stage regressions. The t-stat of our instruments are highly significant and the R-squared are around 0.90 for all regressions. Compared to our base case in Table 3 we add the lag of the yield spread as an additional exogenous independent variable. T-statistics are computed with Newey and West (1987) standard errors and allowing for lags of up to 12 months. Columns 2-7 of both tables report the second stage regressions for both countries. The size of the coefficients of the second stage is similar to the ones of our base case, confirming the main results. More specifically, the second stage regression for the 10 year yield spread shows an estimated coefficient of 0.007 (0.005 for the OLS) for Italian current supply, while it shows a coefficient of carries a coefficient of 0.008 (0.01 for the OLS) for the German expected supply.

4.1 Scarcity Effects

Table 6 shows the results of the threshold model we estimate to assess the impact of scarcity effects whenever German short-term bonds trade at lower yields than the ECB deposit rate. Columns 2-6 estimate the model with Newey and West (1987) standard errors allowing for 8 months of lag. Adding more lags does not seem to alter our results. Instead, columns 7-11 assume an AR(1) process for regression residuals. In this case, we also use robust standard errors. The two different estimations carry similar results, with the latter being more conservative in terms of t-stats and magnitude of the coefficients. For instance, the coefficient of 0.19 (t=7.6) in Column 3 implies that a 1 percent decrease in the expected short-term debt to GDP (more or less half of the variable standard deviation) widens the spread between the 1 year bond and the short rate by 19 basis points whenever the lagged spread is negative. The correspondent coefficient of 0.134 in Column 8 (t=2.88) means that a 1 percent decrease in expected short-term debt to GDP widens the same spread by almost 14 basis points. In both specifications we find the stronger effect around the 1 year maturity, with the size and the significance of the coefficients declining moving towards longer maturities. Furthermore, the impact of expected short-term debt on the spread between government bonds and the deposit rate is negligible whenever the spread is positive (first row of Table 6). The only maturity in which the expected outstanding amount of short-term debt seems to have an impact on the spread is at 4 year maturity. However, this could be due to the limited amount of days in which 4 year bonds traded below the deposit rate. In our robustness tests, we apply the model to different sample periods and we also change how we calculate our measure of expected supply. In all our specifications, the results are significant and robust. To the best of our knowledge, we are the first to find a link between the amount of German bonds that have been trading below the ECB deposit rate and the expected amount of short-term bond supply.

We also control our model for flight-to-safety effects, because an increased demand for German Bonds during times of high market stress and risk aversion may drive downward movements of interest rates on safe-haven markets. We add 4-week changes in stock market volatility and in the German CDS Spread as controls for flight-to-safety. Indeed, we find a negative relationship between our controls and German yields, confirming the presence of a flight-to-safety effect in our sample. The coefficients of Row 3 and 4 of Table

6 are negative and significant, especially when we control for higher risk aversion in the equity market. However, our variable of interest is still significant, even after controlling for this effect.

5 Robustness Tests

We perform a number of robustness tests on our baseline specifications. First, we estimate the same horse-race regression of Table 3 in first difference. We compute the t-statistics with Newey and West (1987) standard errors allowing for up to 12 lags. The results in Table 4 are very similar to our regressions in levels, even if somewhat weaker.

We also check for possible effects of the Securities Market Program (SMP) on the overall supply stock for Italy. We then modify our maturity-weighted debt by the amount and the average maturity of the purchases during the SMP. We define

$$MWD_{ITA,SMP} = \frac{\sum_{\tau=0}^{30} D_t^{\tau}\tau - D_{SMP} * \overline{M}_{SMP}}{GDP_t}$$

where D_{SMP} is the total amount of government bond purchases and $\overline{M}_{SMP}$ is the average maturity of the purchases during the program. Table A.4 in the Appendix shows the results of our baseline regression with this modified variable. Results are largely unaffected, with the coefficients of current supply in Column 2 still significant.

We also control for quarterly and annual effects of future expected supply on interest rates. Since the main press releases happen at the end of each quarter, it is possible that the impact on interest rates of our forward-looking measure is concentrated in those months. For Germany, we also check for annual effects, because the most important announcement regarding future auctions takes place every December. We interact a quarterly dummy with our measure of future expected supply. In the case of Germany, we also interact our variable with a yearly dummy. The results are shown in Table A.5. In C olumns 5 and 6 of the Table we show that the interaction terms are not significant. We also perform an F-test between the coefficients of the interaction with our variable of expected supply in Column 9. Quarterly and yearly dummies do not affect our baseline results that remain significant and are largely unchanged.

We also check whether the results regarding the impact of expected short-term debt on the spread between German Bonds and the deposit rate of the ECB remain significant with different specifications. In Columns 2-6 of Table A.6 we modify our measure of expected short term debt. We calculate separately the specific amount of expected supply below 1 year of original maturity and below 2 years original maturity. We regress the 3 months and the 1 year spread on the expected supply below 1 year, while we regress the 2 year spread on the expected supply with 2 year maturity. Since the German Government does not issue bonds with 3 and 4 years original maturity, we use the expected supply of 2 year bonds as the closest proxy of expected supply for similar bonds. Furthermore, Columns 7-11 show the results if we decrease the sample size from 2010 to 2017, omitting the financial crisis. In fact, the Government might have responded endogenously to the decrease in short-term interest rates by issuing a larger fraction of short-term debt. In this specification the coefficients are doubled compared to the ones in Table 6. In Columns 12-16 we omit 2017. It is possible, in fact, that the ECB purchased some bonds around the two years maturity and below the deposit rate from January 2017. However, our results are largely unaffected if we omit 2017. Finally, we estimate a horse-race threshold regression between current and expected future short-term supply. We also augment this specification with a control for liquidity risk. Table 7 shows the results. Our measure of expected short-term debt flushes out current short-term supply when the spread is negative. This also confirms our previous findings on the intrinsic value of specific forward-looking information compared to the actual quantities observable on the market.

6 Conclusion

This paper provides some evidence on the impact of current and expected supply on government bond yields in the European market. We find that, whenever agents have specific information of future issues from the Government, the current level of supply that is observable in the market does not affect interest rates. Conversely, scarce information regarding the future path of supply makes the current outstanding amount of government bonds the only reliable measure of supply. We also provide an explanation for the sizable amount of German government bonds trading consistently below the deposit rate of the European Central Bank. Our findings are both statistically and economically significant. For example, a standard deviation increase in expected future supply steepens the yield curve by around 110 basis points. The effects are more than halved in terms of current supply. Moreover, one standard deviation increase in expected short-term supply decreases the spread between short-term bonds and the short rate by around 10-15 basis points whenever the spread is negative.

We provide empirical support for portfolio-rebalance and preferred-habitat theories of the term structure of interest rates. Understanding how the channels through which current and expected supply affect interest rates might be useful both for policy-makers and for Treasury Departments. For example, Treasury departments that do not have a specific forward guidance on the future issuance planning could take advantage of this feature in the future. Moreover, the channel of transmission regarding expectations of future supply might be useful for Central Banks in case new large-scale asset purchase programs will be undertaken in the future.

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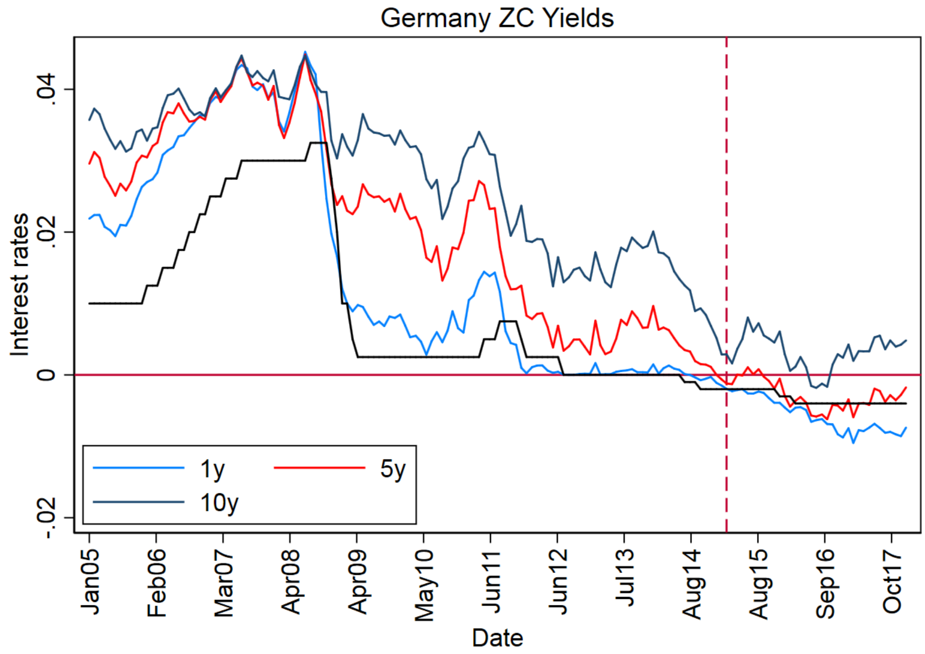
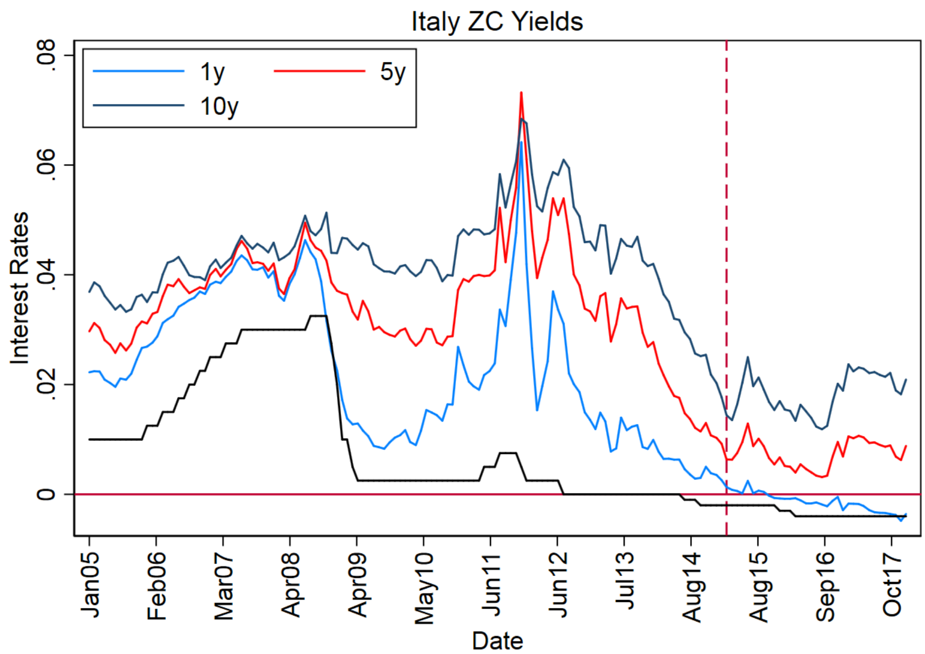


(a) Germany



(b) Italy

Figure 1: German and Italian Zero-Coupon Yields
Italian and German zero-coupon interest rates. The black line represents the ECB deposit rate. The dashed vertical line marks the start of the Public Sector Purchase Program.

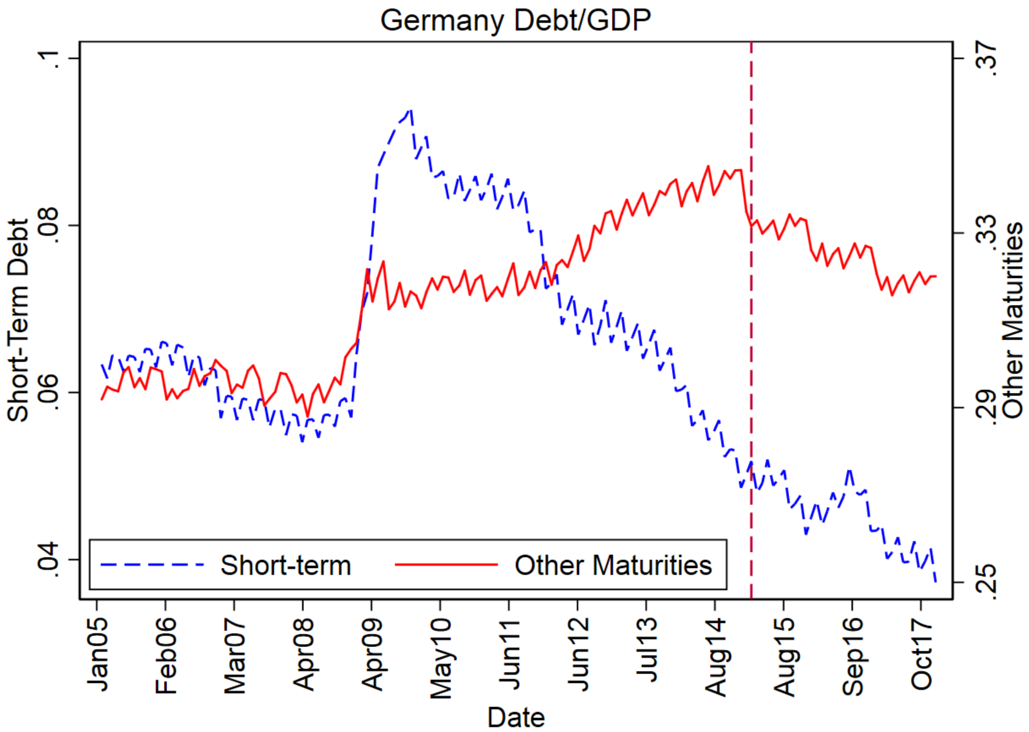


Figure 2: German Short and Long-Term Supply

The figure plots the amount of outstanding german debt divided in two sub-groups. The blue line represents the amount of debt with original maturity below 2 years scaled by GDP, while the red lineis all the remaining maturity scaled by GDP. The dashed vertical line represents the start of the Public Sector Purchase Program. In this graph we do not subtract the amount of purchases from the outstanding amount of debt above 2 years maturity (the red line).

Table 1: Summary Statistics

The Table summarises the main variables in our sample (2005-2017). ECB Dep. Rate is the interest applied on deposits at the European Central Bank. 2y, 5y, 10y, 30y are zero-coupon yields on 2, 5, 10 and 30 year bonds. MWD is the Maturity-Weighted Debt scaled by GDP. $E[MWD|I_t]$ is the future expected value of Maturity-Weighted Debt scaled by GDP. $MWQE$ is the amount of Maturity-Weighted Purchases by the ECB during the PSPP Program scaled by GDP. $E[STdebt]$ is the expected outstanding amount of German short-term bonds scaled by GDP. Liquidity Risk is the Time-Weighted Bid-Ask Spread from MTS. For both countries, we average across all maturities the intra-day Bid-Ask Spread of each bond displayed in the order book, weighted by the length of time each spread is displayed. Credit Risk is the log of the 5-year us dollar denominated Sovereign CDS Spread. Inflation is monthly inflation. Inflation Risk is the standard deviation of monthly inflation over the past twelve months. Output Growth is the difference between log real GDP in the current quarter and log real GDP in quarter t-4. Stock market volatility is the log of the Vstoxx index. Crisis Dummy is a dummy that assumes the value of 1 between October 2010 and September 2012.

Sample: 2005-2017 (Monthly Data)	**ITALY**				**GERMANY**			
Yields	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
ECB Dep. Rate	0.007	0.01	-0.004	0.0325	0.007	0.01	-0.004	0.0325
2y	0.021	0.016	-0.002	0.069	0.012	0.016	-0.009	0.044
5y	0.029	0.015	0.003	0.073	0.016	0.016	-0.006	0.045
10y	0.038	0.013	0.012	0.068	0.023	0.014	-0.002	0.045
30y	0.045	0.010	0.022	0.067	0.029	0.012	0.004	0.047
Supply								
MWD	7.298	1.177	5.297	8.928	3.199	0.133	2.97	3.42
$E[MWD\|I_t]$	7.273	1.156	5.284	8.789	3.236	0.14	3.022	3.50
$MWQE$	0.196	0.444	0.000	1.651	0.129	0.293	0.000	1.021
D/GDP	0.775	0.146	0.560	0.962	0.384	0.021	0.351	0.420
$E[STdebt]$					0.061	0.016	0.037	0.096
Other Variables								
Liquidity Risk	0.125	0.159	0.016	1.223	0.106	0.060	0.029	0.376
Credit Risk	4.38	1.30	1.74	6.33	2.82	1.03	0.75	4.72
Inflation	0.001	0.010	-0.025	0.025	0.001	0.004	-0.012	0.012
Inflation Risk	0.010	0.003	0.005	0.013	0.004	0.001	0.003	0.005
Output Growth	0.000	0.010	-0.051	0.016	0.005	0.012	-0.065	0.028
Stock Market Vol.	22.81	8.20	11.99	60.68	22.81	8.20	11.99	60.68
Crisis Dummy	0.15	0.36	0.00	1.00	0.15	0.36	0.00	1.00

Table 2: Correlation Matrix

The table shows the correlation matrix between the main variables in our analysis. The top part of the table represents the correlations for Germany, while the bottom part shows the correlation of Italian variables. We report the correlations in levels below the diagonal, while above the main diagonal we show the first-difference correlations. We highlight in bold the correlations between current and expected supply and 10 year and 5 year yield spreads in levels and first difference.

GERMANY

	E[MWD]	MWD	10y	5y	CDS	Crisis D.	Output Gr.	Liquidity
E[MWD]	1.00	0.08	**0.14**	**0.16**	0.08	-0.03	0.10	-0.05
MWD	0.87	1.00	**0.06**	**0.07**	0.08	-0.06	0.08	0.16
10y	**0.76**	**0.64**	1.00	0.89	0.17	-0.01	0.11	0.24
5y	**0.66**	**0.47**	0.94	1.00	0.15	0.01	0.10	0.13
CDS	0.70	0.71	0.69	0.52	1.00	0.16	-0.09	0.27
Crisis D.	0.44	0.38	0.32	0.27	0.57	1.00	-0.04	0.01
Output Gr.	0.02	0.03	-0.04	-0.01	-0.28	0.02	1.00	-0.16
Liquidity	0.10	0.15	0.36	0.27	0.63	0.19	-0.57	1.00

ITALY

	E[MWD]	MWD	10y	5y	CDS	Crisis D.	Output Gr.	Liquidity
E[MWD]	1.00	0.22	**-0.02**	**0.00**	0.00	-0.02	0.09	0.02
MWD	0.99	1.00	**0.14**	**0.11**	-0.19	-0.02	-0.01	-0.17
10y	**0.60**	**0.60**	1.00	0.83	0.10	0.00	0.02	-0.27
5y	**0.45**	**0.44**	0.95	1.00	0.17	0.02	-0.02	-0.01
CDS	0.83	0.81	0.77	0.73	1.00	0.04	-0.06	0.31
Crisis D.	0.18	0.16	0.24	0.39	0.45	1.00	-0.09	0.03
Output Gr.	0.05	0.07	-0.16	-0.27	-0.29	-0.21	1.00	-0.10
Liquidity	0.21	0.19	0.22	0.35	0.53	0.61	-0.40	1.00

Table 3: Current and Expected Debt Supply as a Determinant of Yield Spreads

This table reports monthly regressions of yield spreads on Current and Expected Future Maturity-Weighted Supply for Germany and Italy:

$$y_{i,t}^{(\tau)} - y_{i,t}^{(1)} = \alpha + \beta_1 MWD_{i,t} + \beta_2 E[MWD_{i,t+k}|I_{i,t}] + \beta_3 MWQE_{i,t} + \beta_4 t + \epsilon_{i,t}.$$

Panel A shows the results for the regression of yield spreads on current supply, while Panel B for expected future supply. Panel C reports horse-race regressions in which current and expected supply are estimated together. T-stats are reported in brackets.We estimate all regression models with an AR(1) Process for Residuals and with Robust Standard Errors. Coefficients in bold are significant. *** p<0.01, ** p<0.05, * p<0.1.

Panel A: Current Supply

	GERMANY							ITALY							
Yield Spreads	MWD_{GER}	t-stat	$MWQE_{GER}$	t-stat	α	t-stat	R-squared	MWD_{ITA}	t-stat	$MWQE_{ITA}$	t-stat	α	t-stat	R-squared	Trend
2y	0.0008	[0.56]	0.001	[0.43]	-0.0006	[-0.14]	0.01	**0.002*****	[2.70]	-0.001	[-0.84]	**-0.001****	[-2.11]	0.04	YES
3y	0.001	[0.78]	0.002	[0.66]	0.0001	[0.027]	0.02	**0.002****	[2.22]	-0.0006	[-0.20]	-0.005	[-1.04]	0.02	YES
4y	0.002	[0.85]	0.003	[0.66]	0.0009	[0.12]	0.02	**0.002****	[2.02]	0.0006	[0.16]	-0.004	[-0.64]	0.02	YES
5y	0.002	[0.90]	0.004	[0.70]	0.001	[0.15]	0.02	**0.002****	[1.98]	0.001	[0.24]	-0.003	[-0.53]	0.02	YES
6y	0.002	[0.83]	0.005	[0.76]	0.003	[0.32]	0.02	**0.003****	[2.44]	0.002	[0.33]	-0.006	[-0.91]	0.03	YES
8y	0.003	[0.90]	0.006	[0.79]	0.004	[0.39]	0.03	**0.004****	[2.57]	0.0006‘	[0.11]	-0.011	[-1.26]	0.05	YES
10y	0.002	[0.70]	0.007	[0.77]	0.007	[0.59]	0.02	**0.005****	[2.38]	-0.0002	[-0.03]	-0.014	[-1.21]	0.05	YES
20y	0.004	[1.06]	0.007	[0.64]	0.007	[0.48]	0.03	0.004	[1.58]	0.0003	[0.04]	-0.001	[-0.09]	0.04	YES
30y	0.004	[1.15]	0.007	[0.69]	0.005	[0.33]	0.04	**0.007****	[2.08]	-0.0004	[-0.072]	-0.02	[-1.21]	0.10	YES

Panel B: Expected Supply

	$E[MWD_{GER}\|I_t]$							$E[MWD_{ITA}\|I_t]$							
2y	**0.005****	[2.32]	0.0024	[1.25]	**-0.013****	[-2.05]	0.05	0.001	[0.90]	-0.002	[-1.10]	-0.003	[-0.49]	0.02	YES
3y	**0.006****	[2.16]	0.0036	[1.05]	-0.014	[-1.65]	0.05	0.0007	[0.60]	-0.001	[-0.39]	0.001	[0.25]	0.01	YES
4y	**0.008****	[2.35]	0.0047	[1.00]	**-0.02***	[-1.72]	0.05	0.0013	[0.98]	-0.0001	[-0.01]	0.0007	[0.10]	0.01	YES
5y	**0.01****	[2.39]	0.0055	[0.97]	**-0.022***	[-1.71]	0.06	0.0004	[0.25]	0.0003	[0.06]	0.007	[0.85]	0.01	YES
6y	**0.01****	[2.32]	0.0064	[0.99]	-0.022	[-1.56]	0.06	0.0003	[0.15]	0.0008	[0.14]	0.009	[0.97]	0.01	YES
8y	**0.011****	[2.12]	0.0073	[0.94]	-0.021	[-1.25]	0.05	0.0005	[0.23]	-0.0005	[-0.07]	0.009	[0.82]	0.01	YES
10y	**0.011****	[1.99]	0.0078	[0.90]	-0.02	[-1.12]	0.05	0.0003	[0.12]	-0.002	[-0.22]	0.012	[0.86]	0.02	YES
20y	**0.013****	[2.09]	0.0078	[0.73]	-0.02	[-1.06]	0.05	0.002	[0.66]	-0.001	[-0.13]	0.011	[0.81]	0.02	YES
30y	**0.013****	[2.07]	0.0077	[0.78]	-0.02	[-1.14]	0.06	-0.0004	[-0.17]	-0.003	[-0.47]	0.019	[1.29]	0.04	YES

Table 4: Continued

Panel C: Horse-Race Regressions

GERMANY	MWD_{GER}	t-stat	$E[MWD_{GER}\|I_t]$	t-stat	$MWQE_{GER}$	t-stat	α	t-stat	R-squared	Trend
2y	0.0006	[0.42]	**0.005****	[2.25]	0.003	[1.33]	**-0.015****	[-2.05]	0.04	YES
3y	0.001	[0.64]	**0.006****	[2.10]	0.04	[1.15]	**-0.017***	[-1.77]	0.05	YES
4y	0.001	[0.70]	**0.0081****	[2.29]	0.005	[1.09]	**-0.024***	[-1.87]	0.06	YES
5y	0.002	[0.77]	**0.009****	[2.33]	0.006	[1.06]	**-0.028***	[-1.89]	0.06	YES
6y	0.002	[0.69]	**0.01****	[2.27]	0.007	[1.07]	**-0.028***	[-1.72]	0.06	YES
8y	0.002	[0.76]	**0.01****	[2.06]	0.008	[1.00]	-0.027	[-1.48]	0.05	YES
10y	0.002	[0.58]	**0.011***	[1.95]	0.008	[0.95]	-0.026	[-1.27]	0.05	YES
20y	0.004	[0.93]	**0.013****	[2.02]	0.008	[0.81]	-0.033	[-1.38]	0.06	YES
30y	0.004	[1.03]	**0.013****	[2.01]	0.008	[0.88]	-0.035	[-1.50]	0.07	YES

ITALY	MWD_{ITA}	t-stat	$E[MWD_{ITA}\|I_t]$	t-stat	$MWQE_{ITA}$	t-stat	α	t-stat	R-squared	Trend
2y	**0.002****	[2.39]	0.0007	[0.58]	-0.001	[-0.75]	**-0.013****	[-2.06]	0.05	YES
3y	**0.002****	[2.06]	0.0003	[0.23]	-0.001	[-0.33]	-0.007	[-1.00]	0.02	YES
5y	**0.002***	[1.86]	-0.0001	[-0.08]	4E-04	[0.08]	-0.003	[-0.42]	0.02	YES
6y	**0.003****	[2.29]	-0.0004	[-0.23]	0.001	[0.17]	-0.005	[-0.55]	0.03	YES
8y	**0.005****	[2.37]	-0.0005	[-0.19]	-2E-04	[-0.04]	-0.01	[-0.90]	0.05	YES
10y	**0.005****	[2.18]	-0.0008	[-0.28]	-0.001	[-0.16]	-0.011	[-0.83]	0.05	YES
20y	0.004	[1.43]	0.0008	[0.31]	-0.001	[-0.08]	-0.006	[-0.37]	0.04	YES
30y	**0.008***	[1.92]	-0.0020	[-0.62]	-0.002	[-0.26]	-0.015	[-0.90]	0.10	YES

Table 4:
Current and Expected Supply as a Determinant of Yield Spreads - First Diff. Regressions

Results of the same regressions of Table 3 in first difference. Column 2 reports the coefficients of current maturity-weighted supply (top panel) and future expected maturity-weighted supply (bottom panel) for both countries. T-stats, reported in brackets, are based on Newey-West standard errors with 12 lags. Increasing the number of lags does not alter our results. Coefficients in bold are significant. *** p<0.01, ** p<0.05, * p<0.1.

	GERMANY			**ITALY**		
Yield Spreads	ΔMWD_{GER}	t-stat	R-squared	ΔMWD_{ITA}	t-stat	R-squared
2y	0.000	[0.20]	0	0.001	[1.20]	0
3y	0.001	[0.50]	0.01	**0.002***	[1.68]	0.01
4y	0.002	[0.65]	0.01	**0.002****	[2.04]	0.01
5y	0.002	[0.72]	0.01	**0.002****	[2.14]	0.01
6y	0.002	[0.68]	0.01	**0.003****	[2.49]	0.02
8y	0.003	[0.77]	0.01	**0.004****	[2.21]	0.02
10y	0.002	[0.57]	0.01	**0.004****	[2.03]	0.02
20y	0.004	[1.30]	0.01	0.003	[1.54]	0.01
30y	0.004	[1.42]	0.01	0.006	[1.46]	0.02
	$\Delta E[MWD_{GER}\|I_t]$	t-stat	R-squared	$\Delta E[MWD_{ITA}\|I_t]$	t-stat	R-squared
2y	**0.003***	[1.75]	0.01	0	[-0.43]	0
3y	**0.005***	[1.96]	0.02	0.000	[0.22]	0
4y	**0.007***	[1.78]	0.03	0.001	[0.73]	0
5y	**0.008***	[1.81]	0.03	0.000	[0.04]	0
6y	**0.009***	[1.79]	0.03	-0.000	[-0.05]	0
8y	**0.010***	[1.75]	0.03	-0.000	[-0.05]	0
10y	**0.010***	[1.71]	0.03	-0.001	[-0.19]	0
20y	0.012	[1.609]	0.03	0.001	[0.353]	0
30y	0.012	[1.585]	0.03	-0.002	[-0.809]	0

Table 5: Instrumental Variables Regressions

Instrumental variables regressions of yield spreads on future expected supply for both countries. Compared to our baseline regressions we augment it with $y_{t-1}^{(\tau)} - y_{t-1}^{(1)}$, the lag of the yield spread, as independent variable. Columns 8-14 of Panel A report the first stage regressions for Germany. We instrument Future Expected Maturity Weighted Supply with Expected Debt/GDP. Columns 2-7 of Panel A report the coefficients for the second stage regressions. Columns 8-15 of Panel B report the first stage regressions for Italy. We instrument Current Maturity-Weighted Supply with D/GDP and D/GDP^2. Columns 2-7 of Panel B report the coefficients for the second stage regressions. T-stats are based on Newey-West standard errors with 12 lags. Coefficients in bold are significant. p<0.01, ** p<0.05, * p<0.1.

Panel A: Germany

	Second Stage						First Stage					
	$E[\widehat{MWD}_{GER}]$	$MWQE_{GER}$	α	R-squared	Trend	$y_{t-1}^{(\tau)} - y_{t-1}^{(1)}$	E[D/GDP]	$MWQE_{GER}$	$y_{t-1}^{(\tau)} - y_{t-1}^{(1)}$	Trend	α	R-Squared
2y	**0.003****	**0.001****	**-0.001****	0.81	YES	YES	**5.83*****	-0.06	**-8.86****	-0.0001	**1*****	0.93
t-stat	[2.25]	[2.29]	[-2.23]				[10.69]	[-1.54]	[-2.27]	[-0.23]	[5.18]	
5y	**0.006*****	**0.003*****	**-0.018*****	0.92	YES	YES	**6.02*****	-0.06	**-3.67***	-0.0001	**0.94*****	0.93
t-stat	[3.60]	[3.21]	[-3.54]				[8.42]	[-1.35]	[-1.89]	[0.82]	[3.77]	
8y	**0.006*****	**0.002****	**-0.018*****	0.94	YES	YES	**5.82*****	**-0.07***	-2.08	0.00005	**1.01*****	0.93
t-stat	[2.77]	[2.55]	[-2.71]				[8.35]	[-1.78]	[-1.41]	[0.19]	[4.13]	
10y	**0.008*****	**0.003*****	**-0.025*****	0.93	YES	YES	**5.59*****	-0.08	-1.3	0.0001	**1.09*****	0.92
t-stat	[3.21]	[2.85]	[-3.21]				[8.07]	[0.036]	[-0.89]	[0.52]	[4.47]	
30y	**0.01*****	**0.003*****	**-0.03*****	0.94	YES	YES	**5.43*****	**-0.09*****	-0.81	0.0002	**1.15*****	0.92
t-stat	[3.02]	[2.71]	[-3.03]				[8.44]	[-2.51]	[-0.61]	[0.83]	[5.08]	

Table 6: Continued

Panel B: Italy

	Second Stage						**First Stage**						
	MWD_{ITA}	$MWQE_{ITA}$	α	R-squared	Trend	$y_{t-1}^{(\tau)} - y_{t-1}^{(1)}$	D/GDP	D/GDP^2	$MWQE_{ITA}$	$y_{t-1}^{(\tau)} - y_{t-1}^{(1)}$	α	Trend	R Squared
2y	**0.004****	**0.001****	**-0.02****	0.76	YES	YES	**29.5*****	**-15.4*****	**0.14***	-8.7	0.005	**-6.4*****	0.98
t-stat	[2.29]	[2.17]	[-2.24]				[6.8]	[-5.8]	[1.93]	[-0.94]	[1.4]	[-3.97]	
5y	**0.003****	**0.001****	**-0.015***	0.92	YES	YES	**34.02*****	**-17.6*****	**0.2*****	**-11****	0.001	**-8.15*****	0.98
t-stat	[2.01]	[2.13]	[-1.94]				[8.62]	[-7.6]	[2.67]	[-2.36]	[0.39]	[-5.42]	
8y	**0.006****	**0.002****	**-0.0304****	0.91	YES	YES	**32.6*****	**-16.7*****	**0.19*****	**-7.6****	0.002	**-7.6*****	0.98
t-stat	[2.43]	[2.46]	[-2.37]				[9.19]	[-7.9]	[2.81]	[-2.29]	[0.53]	[-5.65]	
10y	**0.007****	**0.002****	**-0.033****	0.9	YES	YES	**32.9*****	**-16.9*****	**0.2*****	**-7.3****	0.001	**-7.7*****	0.99
t-stat	[2.13]	[2.29]	[-2.09]				[9.1]	[-7.9]	[2.83]	[-2.12]	[0.44]	[-5.61]	
30y	**0.009*****	**0.003****	**-0.044*****	0.89	YES	YES	**27.9*****	**-14.4*****	**0.12****	-1.53	0.005	**-5.82*****	0.98
t-stat	[2.71]	[2.47]	[-2.65]				[9.4]	[-7.18]	[2.1]	[-0.81]	[1.67]	[-5.3]	

Table 6: Scarcity Effects in the German Market

Weekly 4-week changes threshold regressions of the form:

$$\Delta_4 y_t^{(\tau)} = \alpha + \beta_1 \Delta_4 E[STdebt_{t+k}] \mathbb{1}_{(y_{t-4}^{(\tau)}>0)} + \beta_2 \Delta_4 E[STdebt_{t+k}] \mathbb{1}_{(y_{t-4}^{(\tau)}<0)} + \sum_{j=3}^{n} \beta_j \Delta_4 X_j + \epsilon_t$$

where the dependent variable is the spread between the τ year bond and the deposit rate of the European Central Bank. The Independent variable $E[STdebt_{t+k}]$ is the outstanding amount of government debt with original maturity below 2 years scaled by GDP. X_j denotes a matrix of controls. Columns 2-6 report the coefficients assuming Newey-West standard errors with 8 lags. Columns 7-10 assume an AR(1) process for residuals and robust standard errors. Coefficients in Bold are significant. *** p<0.01, ** p<0.05, * p<0.1.

Four Week Changes

VARIABLES	3m	1y	2y	3y	4y	3m	1y	2y	3y	4y
Δ_4E[STD] if Spr>0	**-0.10***	0.013	0.083	0.1	**0.17*****	-0.025	0.03	0.07	0.095	**0.14*****
	[-1.93]	[0.18]	[0.84]	[1.02]	[2.82]	[-0.57]	[0.64]	[1.09]	[1.61]	[3.66]
Δ_4E[STD] if Spr<0	**0.12*****	**0.19*****	**0.17*****	**0.16*****	**0.092****	**0.082****	**0.134*****	**0.09***	0.07	0.021
	[4.75]	[7.06]	[7.40]	[6.16]	[2.45]	[2.00]	[2.88]	[1.82]	[1.51]	[0.77]
Δ_4Stock Market Vol.	**-0.002***	**-0.002*****	**-0.002*****	**-0.002*****	**-0.002*****	**-0.0007****	**-0.001*****	**-0.0014*****	**-0.0015*****	**-0.0018*****
	[-1.85]	[-2.71]	[-3.68]	[-3.88]	[-4.11]	[-2.23]	[-3.37]	[-4.40]	[-4.99]	[-5.77]
Δ_4CDS	-0.002	**-0.002***	**-0.001***	**-0.001***	-0.001	-0.0002	-0.0003	-0.0004	**-0.0005***	**-0.0007****
	[-1.64]	[-1.69]	[-1.92]	[-1.84]	[-1.51]	[-0.43]	[-0.70]	[-1.22]	[-1.68]	[-2.28]
α	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	[-0.90]	[-0.80]	[-0.65]	[-0.66]	[-0.54]	[-0.49]	[-0.54]	[-0.47]	[-0.43]	[-0.38]
SE	NW(8)	NW(8)	NW(8)	NW(8)	NW(8)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)
Obs.	667	667	667	667	667	667	667	667	667	667
R-Squared	0.17	0.2	0.15	0.14	0.13	0.02	0.06	0.05	0.06	0.09

Table 7: Expected Short-Term Supply vs Current Short-Term Supply

Columns 2-6 reports the coefficients of the same model described in Table 6, but we augment the regression with the outstanding amount of current short-term debt and with Liquidity Risk. We let current short-term supply have different region coefficients according to the threshold we choose (the deposit rate of the ECB). T-stats are based on Newey-West standard errors allowing for 8 lags. Coefficients in bold are significant. *** p<0.01, ** p<0.05, * p<0.1.

	Four Week Changes				
VARIABLES	**3m**	**1y**	**2y**	**3y**	**4y**
Δ_4E[STD] if Spr>0	**-0.090***	0.028	0.093	0.102	**0.172*****
	[-1.83]	[0.39]	[0.93]	[0.99]	[2.83]
Δ_4E[STD] if Spr<0	**0.130*****	**0.194*****	**0.174*****	**0.161*****	**0.086****
	[3.98]	[6.05]	[6.68]	[5.10]	[2.04]
Δ_4[STD] if Spr>0	-0.048	-0.05	-0.032	0.008	0.017
	[-0.77]	[-0.98]	[-0.67]	[0.19]	[0.32]
Δ_4[STD] if Spr<0	0.089	0.058	0.089	0.011	**-0.126****
	[1.32]	[0.67]	[0.80]	[0.10]	[-1.97]
Δ_4Stock Market Vol.	**-0.002***	**-0.002*****	**-0.002*****	**-0.002*****	**-0.002*****
	[-1.95]	[-2.95]	[-3.64]	[-3.62]	[-3.84]
Δ_4CDS	**-0.002***	**-0.002***	**-0.001***	-0.001	-0.001
	[-1.69]	[-1.72]	[-1.83]	[-1.64]	[-1.26]
Δ_4Liquidity Risk	**-0.011***	**-0.008***	-0.005	-0.005	-0.004
	[-1.81]	[-1.69]	[-1.55]	[-1.25]	[-0.91]
α	-0.000	-0.000	-0.000	-0.000	-0.000
	[-0.86]	[-0.73]	[-0.54]	[-0.65]	[-0.58]
SE	NW(8)	NW(8)	NW(8)	NW(8)	NW(8)
Obs.	667	667	667	667	667
R-Squared	0.23	0.22	0.16	0.14	0.13

A Appendix

Table A.1: Variables Description

Sample: 2005-2017	**Source**	**Ticker ITA**	**Ticker GER**
Yields			
ECB Deposit Rate	Bloomberg	EUORDEPO Index	EUORDEPO Index
2y	Bloomberg	I04002Y Index	I04002Y Index
5y	Bloomberg	I04005Y Index	I04005Y Index
10y	Bloomberg	I040010Y Index	I04010Y Index
30y	Bloomberg	I040030Y Index	I04030Y Index
Supply	**Source**		
MWD	National Treasuries, Authors' Estimate		
$E[MWD\|I_t]$	National Treasuries Press Releases, Authors' Estimate		
$MWQE$	European Central Bank, Authors' Estimate		
D/GDP	National Treasuries, Authors' Estimate		
$E[STdebt]$	National Treasuries, Authors' Estimate		
Other Variables	**Source**	**Ticker ITA**	**Ticker GER**
Liquidity	MTS	Authors Estimate	Authors Estimate
log (CDS)	Bloomberg	ITALY CDS USD SR D14 Corp	GERMAN CDS USD SR D14 Corp
Inflation	Bloomberg	ITCPEM Index	GRCP2HMM Index
Inflation Risk	Bloomberg, Authors Estimate	ITCPEM Index	GRCP2HMM Index
Output Growth	FRED Database, Authors Estimate	CLVMNACSCAB1GQ1T	CLVMNACSCAB1GQDE
Stock Market Vol.	Bloomberg	V2X Index	V2X Index
Crisis Dummy	Authors Estimate		

Table A.2: Robustness Tests for Germany

Regressions of the form:

$$y_t^{(\tau)} - y_t^{(1)} = \alpha + \beta_1 E[MWD_{t+k}|I_t] + \beta_2 MWQE_t + \beta_3 t + \sum_{i=3}^{n} \beta_i C_t + \epsilon_{i,t}$$

where C_t is a matrix of controls. Column 2 reports the coefficients of expected supply in our base case. Column 3 adds controls for credit and liquidity risk. Column 4 adds controls for stock market volatility and a dummy for the sovereign crisis. Column 5 and 6 add a control for Output Growth and Inflation risk, respectively. The dependent variables are 2, 5, 10 and 30 year yield spreads. All control variables are defined in Table 2. We model the error process as an AR(1) and we use robust standard errors. T-stats are in brackets and coefficients in bold are significant. *** p<0.01, ** p<0.05, * p<0.1.

GERMANY

$E[MWD_{GER}\|I_t]$	Base Case	Credit Risk Liquidity Risk	Stock Market Vol. CrisisDummy	Output Growth	Inflation Risk
2y	**0.005****	**0.005****	**0.005****	**0.005****	**0.007*****
t-stat	[2.32]	[2.24]	[2.15]	[2.16]	[2.72]
R-squared	0.05	0.05	0.05	0.04	0.06
5y	**0.01****	**0.01****	**0.01****	**0.01****	**0.01*****
t-stat	[2.39]	[2.39]	[2.33]	[2.17]	[2.77]
R-squared	0.06	0.01	0.01	0.01	0.12
10y	**0.011****	**0.011****	**0.012****	**0.011****	**0.018*****
t-stat	[1.99]	[2.09]	[2.19]	[1.99]	[2.82]
R-squared	0.05	0.12	0.13	0.14	0.16
30y	**0.013****	**0.014****	**0.015****	**0.015****	**0.024*****
t-stat	[2.07]	[2.24]	[2.41]	[2.32]	[3.37]
R-squared	0.06	0.12	0.13	0.13	0.15

Table A.3: Robustness Tests for Italy

Regression of the form:

$$y_t^{(\tau)} - y_t^{(1)} = \alpha + \beta_1 MWD_t + \beta_2 MWQE_t + \beta_3 t + \beta_i C_t + \epsilon_{i,t}.$$

Column 2 reports the coefficients of current supply in our base case. The other columns add the same controls used in Table A.2. We estimate an AR(1) process for regression residuals. T-stats in brackets are robust to heteroskedasticity. Coefficients in bold are significant.p<0.01, ** p<0.05, * p<0.1.

ITALY

MWD_{ITA}	Base Case	Credit Risk Liquidity Risk	Stock Market Vol. CrisisDummy	Output Growth	Inflation Risk
2y	**0.002*****	**0.003*****	**0.003*****	**0.003*****	**0.003*****
t-stat	[2.70]	[3.31]	[3.41]	[3.66]	[3.78]
R-squared	0.04	0.36	0.39	0.41	0.44
5y	**0.002****	**0.003*****	**0.004*****	**0.004*****	**0.003*****
t-stat	[1.98]	[2.89]	[3.07]	[3.07]	[2.69]
R-squared	0.02	0.1	0.12	0.12	0.13
10y	**0.005****	**0.006*****	**0.006*****	**0.006*****	**0.006*****
t-stat	[2.38]	[3.32]	[3.50]	[3.50]	[3.35]
R-squared	0.05	0.21	0.23	0.23	0.22
30y	**0.007****	**0.005****	**0.005*****	**0.005*****	**0.005*****
t-stat	[2.08]	[2.55]	[2.72]	[2.74]	[2.74]
R-squared	0.1	0.39	0.4	0.41	0.4

Table A.4: The Effect of the ECB's Securities Market Program

The Table shows the results of regressions of yield spreads on current Italian supply modified by the purchases conducted by the ECB during the Securities Market Program. Column 2 shows the coefficients of the modified supply variable. T-stats are in brackets. We assume an AR(1) process for residuals. T-stats in brackets are based on robust standard errors. Coefficients in bold are significant. p<0.01, ** p<0.05, * p<0.1.

Yield Spread	MWD_{ITA}	t-stat	$MWQE_{ITA}$	t-stat	α	t-stat	R-squared	Trend
2y	**0.002****	[2.37]	-0.002	[-1.11]	**-0.007***	[-1.73]	0.03	YES
5y	**0.002***	[1.85]	0.001	[0.19]	-0.002	[-0.34]	0.02	YES
10y	**0.005****	[2.18]	-0.001	[-0.15]	-0.011	[-0.97]	0.04	YES
30y	**0.007***	[1.84]	-0.002	[-0.31]	-0.02	[-0.98]	0.09	YES

Table A.5: Quarterly and Annual Interactions

This Table reports the coefficients of regressions of yield spreads on current and expected future supply for both countries. The independent variables include interactions between expected future supply and quarterly and yearly dummies. Quarterly dummies assume value of 1 in March, June, September and December. For Germany, we also control for a Yearly dummy that assumes the value of 1 only in December. Regression residuals are estimated according to an AR(1) process. We also use robust standard-errors. Column 2 reports the coefficients for current supply, Column 3 for expected future supply. Columns 4 and 5 report the coefficients of the interaction terms. Column 9 reports the p-value of the F-test between Expected supply and the interaction terms. T-stats are in brackets and coefficients in bold are significant.

GERMANY

Yield Spreads	MWD_{GER}	$E[MWD_{GER}\|I_t]$	Quarterly Dummy	Yearly Dummy	α	R-squared	Trend	$\beta_2+\beta_3$
2y	-0.0007	**0.004***	**0.0001****		-0.008	0.07	YES	0.055
t-stat	[-0.38]	[1.89]	[2.34]		[-1.11]			
5y	0.0007	**0.008***	0.0001		-0.021	0.07	YES	0.088
t-stat	[0.21]	[1.70]	[1.18]		[-1.38]			
10y	0.002	**0.011***	0		-0.027	0.05	YES	0.096
t-stat	[0.53]	[1.67]	[-0.17]		[-1.41]			
30y	0.004	**0.013***	0		-0.03	0.07	YES	0.076
t-stat	[0.92]	[1.78]	[0.01]		[-1.56]			
2y	0.0004	**0.005****		0	**-0.014****	0.05	YES	0.02
t-stat	[0.23]	[2.33]		[0.43]	[-2.03]			
5y	0.002	**0.009***		0	**-0.028***	0.06	YES	0.063
t-stat	[0.62]	[1.86]		[-0.08]	[-1.84]			
10y	0.002	**0.011***		0	-0.027	0.05	YES	0.094
t-stat	[0.59]	[1.69]		[-0.27]	[-1.53]			
30y	0.005	0.013*		-0.0001	**-0.037***	0.07	YES	0.08
t-stat	[1.163]	[1.78]		[-0.60]	[-1.71]			

ITALY

Yield Spreads	MWD_{ITA}	$E[MWD_{ITA}\|I_t]$	Quarterly Dummy	α	R-squared	Trend	$\beta_2+\beta_3$
2y	**0.003****	0.0002	0.0000	**-0.013****	0.06	YES	0.89
t-stat	[2.08]	[0.12]	[0.64]	[-2.09]			
5y	**0.004****	-0.001	0	-0.004	0.04	YES	0.57
t-stat	[2.03]	[-0.58]	[1.18]	[-0.53]			
10y	**0.008****	-0.003	0.0001	-0.012	0.07	YES	0.52
t-stat	[2.04]	[-0.64]	[1.07]	[-0.94]			
30y	**0.009***	-0.003	0.0001	-0.016	0.1	YES	0.5
t-stat	[1.71]	[-0.68]	[0.60]	[-0.94]			

Table A.6: Scarcity Effects with Different Specifications

Columns 2-6 reports the coefficients of the same model described in Table 6, but we define a specific $E[STdebt_{t+k}]$ for each maturity up to 2 years. More specifically, in Column 2 and 3 we use the amount of bonds with original maturity (Bubills) below 1 year, while in Column 4 we define $E[STdebt_{t+k}]$ as the amount of bonds with 2 years original maturity (Schatz). Since the German Treasury does not issue 3 and 4 year bonds we use the amount of bonds with 2 year maturity even in Columns 5 and 6. Columns 7-11 restrict the sample from 2010 to the end of 2017, while Columns 12-16 exclude 2017. We model the error process as an AR(1). T-stats in brackets are based on robust standard errors. Coefficients in bold are significant. *** p<0.01, ** p<0.05, * p<0.1.

Four Week Changes

	Specific Maturities					**2010-2017**					**2005-2016**				
VARIABLES	3m	1y	2y	3y	4y	3m	1y	2y	3y	4y	3m	1y	2y	3y	4y
Δ_4E[STD] if s_{t-4} >0	0.052	0.077	-0.032	0.06	**0.20***	-0.03	-0.017	0.004	0.047	0.074	-0.03	0.03	0.067	0.09	**0.14*****
	[0.89]	[1.18]	[-0.35]	[0.74]	[1.90]	[-0.71]	[-0.45]	[0.09]	[0.85]	[1.18]	[-0.57]	[0.63]	[1.08]	[1.60]	[3.65]
Δ_4E[STD] if s_{t-4} <0	**0.089***	**0.15*****	**0.56*****	**0.64***	-0.21	**0.16****	**0.22*****	**0.25*****	**0.19*****	**0.13***	**0.08****	**0.13*****	**0.09***	0.07	0.02
	[1.94]	[2.82]	[3.08]	[1.69]	[-1.13]	[2.29]	[3.78]	[4.08]	[2.61]	[1.79]	[1.99]	[2.88]	[1.82]	[1.51]	[0.75]
Δ_4Stock Market Vol.	**-0.0006****	**-0.001*****	**-0.001*****	**-0.001*****	**-0.002*****	-0.0002	**-0.0005****	**-0.001*****	**-0.001*****	**-0.0015*****	**-0.001****	**-0.001*****	**-0.0014*****	**-0.001*****	**-0.002*****
	[-2.19]	[-3.34]	[-4.58]	[-4.85]	[-5.68]	[-1.12]	[-2.05]	[-3.21]	[-3.77]	[-4.44]	[-2.09]	[-3.29]	[-4.23]	[-4.81]	[-5.58]
Δ_4CDS	-0.0002	-0.0003	-0.0004	**-0.0005***	**-0.0006***	**-0.001*****	**-0.001*****	**-0.001*****	**-0.002*****	**-0.002*****	-0.0002	-0.0003	-0.0004	-0.0005	**-0.001****
	[-0.43]	[-0.69]	[-1.29]	[-1.68]	[-1.92]	[-3.12]	[-3.02]	[-3.28]	[-3.05]	[-3.37]	[-0.33]	[-0.63]	[-1.14]	[-1.59]	[-2.20]
α	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001	-0.0000	-0.0001	-0.0001	-0.0001	-0.0002	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	[-0.45]	[-0.54]	[-0.44]	[-0.52]	[-0.43]	[-0.16]	[-0.46]	[-0.56]	[-0.75]	[-0.80]	[-0.54]	[-0.57]	[-0.50]	[-0.46]	[-0.43]
SE	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)	AR(1)
Obs.	667	667	667	667	667	412	412	412	412	412	620	620	620	620	620
R-squared	0.02	0.05	0.06	0.06	0.07	0.06	0.1	0.12	0.11	0.12	0.02	0.06	0.05	0.06	0.09