Collateral Haircuts and Bond Yields in the European Government Bond Markets*

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Abstract

Analyzing a novel collateral haircut dataset, this paper investigates the relations between the collateral haircuts and the yields of Euro-area central government bonds. The empirical analysis shows that investors demand higher yields for bonds with higher collateral haircuts. The importance of collateral haircuts on bond yields remains robust after controlling for the variations in credit quality, market liquidity and the effects of the European sovereign debt crisis.

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1 Introduction

Modern implementations of monetary policies rely heavily on the injections of central bank money into the banking system. Central banks typically lend funds to financial institutions on the basis of adequate collateral. An organization which faces funding constraints could use securities in their inventory as collateral to borrow money[1]. However, they might not be given the full amount of funds. Instead, the financier determines a certain haircut (or margin), that is, the fraction of the investment value that the organization cannot borrow and has to raise from their own funds[2]. The amount of the haircut which depends on the assessment made by the financier on the riskiness of the collateral varies across different securities and over time. An important question arises whether the haircuts imposed by the central banks could have any impact on the prices of the underlying securities traded in the secondary markets.

A fast growing body of literature is dedicated to the relation between funding constraint and asset prices. The theory put forth by Garleanu and Pedersen (2011) suggests that securities with higher margins are typically more capital intensive. Since funding shocks affect the risks of holding the securities, those with higher margin constraints should be required higher returns. In another theoretical study, Chapman, *et al.* (2011) argue that haircuts imposed by central banks can affect decisions made by market participants. Lowering haircuts will relax funding constraints faced by investors and induce further investments. Other authors (See Buiter and Sibert, 2005; Nyborg, 2017) argue that securities with lower haircuts are inherently more attractive, because they can be translated into central bank funds at a higher rate. From the empirical front, the evidence on the links between collateral haircuts and

[1]These lending activities often takes place via a repurchase (repo) agreement. A repurchase transaction is a collateralized lending agreement which involves a simultaneous sale and repurchase of a security in a future date.

[2]Market practitioners and the regulators are particularly interested in the importance of collateral haircuts (or margin) in financial markets. See, for example, "Collateral damage", The Economist, October 17, 2015; "ECB haircuts are trimmed, ABStylish", Financial Times, July 29 2010; "Fed Eyes Margin Rules to Bolster Oversight", Wall Street Journal, Jan 10, 2016.

asset prices remain very limited. In an effort to measure the impacts of the lending facilities implemented by the Federal Reserves in the U.S. during the financial crisis, Ashcraft, *et al.* (2010) document a positive relation between the required asset returns and the central bank haircuts.

This study investigates the relations between funding constraints and bond prices (and thus, yields) in the context of the European government bond market. We contribute to the literature by examining collateral-specific haircut characteristics of a large cross-section of European government bonds both during and after the European sovereign debt crisis. Our analysis concentrates on the European government bond markets because of a number of important reasons. First, the European government bond market still remains one of the biggest and most liquid market for securities issued by the central governments. In 2015, the total trading volume for government bonds is 5.9 trillion USD in Europe compared with 6 trillion USD in the U.S.[3]. Second, government bonds are often used as collateral, for instance, by eligible credit institutions to obtain financing from the European Central Bank (ECB) via their open market operations. In 2016, they accounted for about 42% of the total outstanding amount of the ECB's acceptable collateral pool (See Bindseil *et al.*, 2017). Third, there exists a direct link between haircuts imposed by the ECB and those in the private funding market, for instance, the European interbank repurchase (repo) market[4]. In particular, Nyborg (2017) calculates that 93 percent of securities in the General Collateral basket of Eurex's Repo market share the same haircuts as those in the ECB's list of eligible assets. Therefore, the central bank haircuts will have direct impacts on the variations of haircuts in the private repo markets as well as the trading activities of government bonds in the secondary markets.

[3]These figures are obtained from SIFMA for the U.S., and MarketAxess for Europe.

[4]The link between ECB's haircut policies and the private funding market is widely covered in the financial press. See, for example, "ECB's changes to covered bond haircuts will increase CPT issuers' repo funding costs", Moody's, Mar 8, 2018; "SME financing: ECB aims to kill two birds with one haircut", Euromoney, Jul 1, 2013;

The empirical investigation focuses on whether the differences in collateral haircuts influence the cross-sectional variations in bond yields. Although euro-area government bonds are denominated in the same currency and remain subject to the same jurisdiction of the European Central Bank, they vary significantly in terms of multiple issuers, the maturity spectrum, the coupon rates and yields. Beber *et al.* (2009) show that differences in credit quality and market liquidity explain the differences in bond yields. Following Garleanu and Pedersen (2011), we argue that bond yield can also be affected by an alternative source of friction, that is, funding constraint. This study uses collateral haircuts to capture funding constraints and examines how haircuts explain bond yields after controlling for the joint effects of credit quality and market liquidity.

We obtain the collateral haircut dataset from the European Central Bank. The data includes bond-specific haircut details of a large cross-section of securities in the central bank's list of eligible assets over the period from May 10, 2010 to Mar 30, 2017. The haircut data is also supplemented with bond price and credit-default swap data from Bloomberg[5]. This data includes the daily bid and ask prices that reflect consensus quotes among market participants and are recorded from the Bloomberg Terminal. This paper focuses on fixed-rate government bonds from the ten euro-area government bonds with the remaining maturities ranging from one to thirty years. The final data employed in the empirical analysis includes more than 881,000 bond-day observations.

Our empirical analysis shows a positive relation between funding constraint and bond yields. In particular, 1 percent difference in the haircuts across bonds leads to a 3.42 basis point difference in bond yields. The effect is sizable and corroborates the theoretical predictions put forth by Garleanu and Pedersen (2011) that investors demand higher compensation for bonds with higher haircuts. We show that the contributions of funding constraint to the variance of yield spreads on average range between 4.8 percent and 18.27 percent and vary

[5] Bloomberg's fixed-income and credit data is widely used by market practitioners and in academic work (See, for instance, Longstaff, 2004; Chen *et al.*, 2007).

across countries. Additionally, the importance of funding constraints to bond yields remains significant during and after the European sovereign debt crisis and remain robust after controlling for the differences in credit quality, market liquidity, the country effects and the exposures to other market-wide liquidity factors.

This paper contributes to the recent literature on the importance of funding constraints in determining liquidity and asset prices in financial markets (See Comerton-Forbe *et al.*, 2010, Fontaine and Garcia, 2011, Hu *et al.*, 2013, for instance). Jylha (2017) shows that a reduction in margin requirements initiated by the Securities and Exchange Commission led to an increase in trading volume, lower bid-ask spread and price impacts for index options. Moinas *et al.* (2017) suggest that collateral haircuts can explain the exposures of market liquidity to funding constraints, and vice versa. Dufour *et al.*, (2019) demonstrate the link between the rareness or specialness of the collateral in the private repo market and the liquidity of the Italian government bonds in the secondary market. Bekkum *et al.* (2017) demonstrate that changes in the European Central Bank's collateral framework, particularly the inclusion of residential mortgage-backed securities, significantly increase loan supply and lower interest rates applied on new securities issued. Examining unique data containing haircut details for each collateral, this study shows that the cross-sectional variations in the government bond yields are not only affected by credit quality and market liquidity but also by the differences in collateral haircuts.

The study is useful for financial market participants and policy makers. The analysis shows that the central bank's collateral policies can significantly affect the trading activities of securities in the secondary markets. This evidence is especially relevant in view of the new global margin regulation for non-centrally cleared over-the-counter derivatives[6]. In

[6] From Sep 1, 2016, the Bank for International Settlements (BIS) introduced a global framework for initial and variation margin requirements applied for non-centrally cleared over-the-counter (OTC) derivatives. This is a key policy put forth by the Group of Twenty (G20) and is aimed at reducing systematic risk in non-centrally cleared OTC derivatives by ensuring adequate collateral in the event of losses caused by default of a counterparty.

particular, changes in margin requirements can affect trader's capital and the provision of liquidity in financial markets.

The rest of the paper is organized as follows. Section 2 discusses collateral eligibility and haircuts in the euro area. Section 3 describes the empirical framework employed to investigate the impacts of collateral haircuts on market liquidity and bond yields in this study. Section 4 describes the data used in this study and reports preliminary summary statistics. Section 5 presents the main empirical results and performs robustness checks. A final section concludes.

2 Eligible assets and collateral haircuts in the Euro area

In their conduct of monetary policies, the European central bank and the national central banks in the euro area, or the eurosystem, lend funds to financial institutions on basis of adequate collateral (Further explanations of the central bank collateral framework can be found in Nyborg, 2017 and Bindseil *et al.*, 2017). The assets eligible for these operations can be classified in five haircut categories[7]: (1) Central government and central bank debts; (2) Local and regional government debts, jumbo covered bonds, agency and supranational debt instruments; (3) Traditional covered bonds and corporate debts; (4) Unsecured bank bonds; and (5) Asset-backed securities. All eligible assets must have acceptable rating[8] from certain external rating agencies which include Standard & Poor (S&P), Fitch, Moody's, and Dominion Bond Rating Services (DBRS). As of 2016, the list of eligible assets exceeds 38,000 individual securities and is publicly disclosed on daily basis from the European Central Bank.

The European Central Bank determines the degree of haircut for each collateral. Collateral haircuts depend on the issuer groups, the residual maturity of the asset, the coupon

[7] Prior to Oct 1, 2013, the ECB uses the phrase "liquidity categories" to refer to "haircut categories".

[8] Credit rating provides an independent assessment of the credit worthiness of the issuer to repay the interest plus the principal.

structure and the credit quality of the issuer. An important feature of the haircut policy is that haircuts for each collateral are set independently from the counterparty. As long as the counterparty meets the eligibility criteria for participation in the eurosystem, their individual credit risk does not affect the amount of haircut applied. This property allows the central bank funds to be equally accessible to a broad set of counterparties.

Bonds issued by central governments remain an important category of eligible assets and account for a large proportion of the total value of the collateral pool. Despite their importance, the collateral haircuts imposed on government bonds are not necessarily lower than those of other assets such as covered bank bonds or asset-backed securities (See Bindseil *et al.*, 2017). This is because different factors mentioned above determine haircuts as well as the presence of legal restrictions that prevent the central bank from providing government bonds with special treatments relative to securities from issuers in the private sectors.

According to Bindseil *et al.* (2017), the profile of the collateral pool has experienced significant changes following the developments in financial markets since Aug 2007. The list of eligible assets has been widened as more securities such as fixed-term deposits or marketable debts in certain foreign currencies are accepted to be used as collateral. During the financial crisis, the minimum credit quality for eligible assets was lowered from A- (on Standard & Poor's scale) to BBB-. In addition, certain government bonds such as Greece received minimum credit quality threshold exceptions with additional haircut requirements. These measures were aimed at mitigating the eurosystems against financial risks while still allowing a wide range of assets eligible to be used by counterparties.

3 Empirical methodology

This section first introduces the method to calculate bond yields and the yield spread. The discussion then moves on to an empirical approach to measure the impacts of collateral haircuts on the cross-sectional variations of bond yields.

3.1 Excess bond yields

This paper seeks to investigate the impacts of collateral haircuts on bond yields. Due to the absence of yield information in the data, the yield-to-maturity is obtained from bond price based on the Newton-Raphson procedure and by minimizing the squared yield errors from the equation[9]:

$$Q_t = \sum_{i=1}^{n} \frac{Coupon}{(1+y_t/h)^i} + \frac{ParValue}{(1+y_t/h)^n}, \tag{1}$$

where $Q_t$is the end-of-day mid-quote price plus accrued interest at time t, y_t is the bond yield-to-maturity, h is the coupon frequency, $Coupon$ is the bond coupon, $ParValue$ is the redemption value, n is the number of remaining coupon periods until maturity. The Macaulay duration of each bond can be computed as follows:

$$D_t = \left(\sum_{i=1}^{n} i \frac{Coupon}{(1+y_t/h)^i} + n \frac{ParValue}{(1+y_t/h)^n} \right) /Q_t, \tag{2}$$

Once the yields are obtained for each bond and day, we need to control for the behaviors of the term structure of interest rates that affect bond yields. Following Beber*et al.* (2009), we adopt the parametric model introduced by Nelson and Siegel's (1987) and Svensson (1994) with the spot rates defined as follows:

$$z_{TTM} = \beta_0 + (\beta_1 + \beta_2) \left[\frac{1-e^{-TTM/\tau_1}}{TTM/\tau_1} \right] - \beta_2 e^{-TTM/\tau_1} + \beta_3 \left[\frac{1-e^{-TTM/\tau_2}}{TTM/\tau_2} - e^{-TTM/\tau_2} \right], \tag{3}$$

where TTM is the time to maturity, β_i and τ_i are the parameters of the model. This term structure model is estimated by the European Central Bank for the Standard & Poor's AAA-rated (or equivalent) bonds on a daily basis and we obtain the model parameters from the European Central Bank over the whole sample period[10]. Following Dufour and Nguyen

[9] We have compared our bond yield estimates and the yield information for a sample of government bonds contained in the MTS database (See www.mtsmarkets.com). We find that the yield differences between these two sources are small and are typically less than one basis point.

[10] The parameter estimates of the model can be obtained from the ECB website by following the URL link: www.ecb.europa.eu/stats/financial_markets_and_interest_rates/euro_area_yield_curves/html/index.en.html

(2012), we compute the yield spread between the estimated bond yield and the corresponding rate obtained by matching the bond duration with the European Central Bank's yield curve. We use bond duration to control for the differences in coupon rates that affect the bond price sensitivity to interest rate changes.

3.2 Cross-sectional regressions

This study examines how collateral haircuts explain the cross-sectional variations in expected bond returns. Similarly to Houweling *et al.* (2005), this analysis focuses on bond yields instead of returns because bond yields might serve as a better proxy for the expected returns than realized returns. We control for credit quality and market liquidity which have been shown by Beber *et al.* (2009) to affect bond yields. Due to the liquidity of the instrument, the 5-year credit default swap premium is used as a proxy for credit quality of the issuers while bid-ask spread serves as a proxy for bond market liquidity. Bond yields can be regressed on the explanatory variables in cross-sectional regressions described as:

$$YSPR_{i,t}= \beta_0+\beta_1\left(CDS_{i,t}-CDS_{AVE,t}\right)+\beta_2\left(LIQ_{i,t}-LIQ_{AVE,t}\right)+\beta_3\left(HC_{i,t}-HC_{AVE,t}\right)+\epsilon_{i,t}, \tag{4}$$

where $YSPR_{it}$ is the yield spread over the ECB's yield curve for the bond i at time t with the same duration, β's are the parameters to be estimated, $\epsilon_{i,t}$ is the error term. $\left(CDS_{i,t}-CDS_{AVE,t}\right)$, $\left(LIQ_{i,t}-LIQ_{AVE,t}\right)$ and $\left(HC_{i,t}-HC_{AVE,t}\right)$ are the differences from the cross-sectional averages at time t of credit default swap premium, bid-ask spread and collateral-haircut, respectively. According to Beber *et al.* (2009), the cross-sectional averages are used as the anchor points, because credit quality, market liquidity, and in this case, and haircuts are regarded as relative concepts in the European government bond markets. We expect the β's parameters to be positive, meaning that bond yields increase in lower credit quality, lower market liquidity and higher haircuts. In the Fama and MacBeth (1973)'s approach, the β's parameters can be obtained from the cross-sectional regressions estimated on a daily basis. The coefficient estimate is the average of the T estimates as follows:

$$\widehat{\beta}_{FM} = \sum_{t=1}^{T} \frac{\widehat{\beta}_t}{T}, \tag{5}$$

and the estimated variance of the Fama and MacBeth estimate can be obtained as follows:

$$S_{FM}^2 = \frac{1}{T} \sum_{t=1}^{T} \frac{\left(\widehat{\beta}_t - \widehat{\beta}_{FM}\right)^2}{T-1}, \tag{6}$$

Petersen (2009) compares the standard errors obtained from different empirical methods. In particular, he observes that the standard errors generated from the pooling of cross-sectional and time series data suffer from downward bias due to the correlation of the errors across observations. The Fama-MacBeth standard errors capture the cross-correlations (that is, the correlation between the residual of bond i at time t and that of bond k at time t, e.g. $\epsilon_{i,t}\ \epsilon_{k,t}$) but they are affected by the serial correlation (e.g. the correlation between $\epsilon_{i,t}$ and $\epsilon_{i,j}$). Newey and West (1987) suggest a procedure to correct for the heteroscedasticity and auto-correlation bias in the data by multiplying the covariance of lag j (that is, $\epsilon_t \epsilon_{t-j}$) with the weight $[1 - j/(M+1)]$, where M is the maximum lag. Let X_{it} denote the independent variables for bond i at time t. When the maximum lag is set to be equal to $T-1$, the variance of Newey-West standard error can be obtained as follows:

$$\sum_{i=1}^{N} \left(\sum_{t=1}^{T} X_{it} \epsilon_{it} \right)^2 = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} X_{it}^2 \epsilon_{it}^2 + 2 \sum_{t=1}^{T-1} \sum_{j=1}^{T-t} \left(1 - \frac{j}{T}\right) X_{it} X_{it-j} \epsilon_{it} \epsilon_{it-j} \right), \tag{7}$$

Petersen (2009) shows that Newey-West standard errors are more robust than those obtained from the pooled regressions or the standard Fama and MacBeth's (1973) approach while registering small deviations from the clustered standard errors. Following Dufour and Nguyen (2012), we perform the cross-sectional regressions (equation 4) on a daily basis from May 10, 2010 to Mar 30, 2017 and use the Newey-West procedure for tests of statistical significance.

Once the relationships of credit quality, market liquidity and funding constraint have been established, the analysis focuses on the explanatory powers of these variables on bond yields. Following Beber *et al.* (2009), the contributions of credit quality, market liquidity and funding constraint can be calculated respectively as follows:

$$\begin{aligned} CredCon_i &= \beta_1\overline{(CDS_{i,t} - CDS_{AVE,t})}, \\ LiqCon_i &= \beta_2\overline{(LIQ_{i,t} - LIQ_{AVE,t})} \\ FdCon_i &= \beta_3\overline{(HC_{i,t} - HC_{AVE,t})} \end{aligned} \tag{8}$$

The credit contribution for each bond i is calculated by multiplying the coefficient obtained from the equation (4) with the average difference between the credit quality swap premium of the issuer for bond i and the cross-sectional difference at that time. The contributions for liquidity and funding constraint are calculated similarly. The contribution for each country is obtained from the equal averages of the contributions of each variable across all of the bonds from each country. The proportional contributions of credit quality, market liquidity and funding constraint are calculated as follows:

$$\begin{aligned} CredPC_i &= \frac{|CredCon_i|}{(|CredCon_i| + |LiqCon_i| + |FdCon_i|)}, \\ LiqPC_i &= \frac{|LiqCon_i|}{(|CredCon_i| + |LiqCon_i| + |FdCon_i|)} \\ FdPC_i &= 1 - CredPC_i - LiqPC_i \end{aligned} \tag{9}$$

The proportional contribution of credit quality is the absolute value of the contribution by credit quality divided by the sum of the absolute contribution values of credit quality, liquidity and funding constraint. The proportional contribution by liquidity can be calculated analogously. The proportional contribution by funding constraint is one minus the proportional contributions of credit quality and market liquidity. These proportional contributions indicate how much the yield spreads can be explained by the differences in credit quality, liquidity and funding constraint. According to the "flight-to-quality" or "flight-to-liquidity" literature (See Beber *et al.*, 2009), the investors' aversion to credit (or liquidity) risk is called to be dominant when the proportion contribution of the differences in credit quality (or market liquidity) capture the majority of the variance of bond yields. Thus, if funding constraint matters to bond yields, we expect that collateral haircuts will account for a large proportion contribution to bond yields.

4 Data and summary statistics

The lists of eligible assets can be obtained on a daily basis from the European Central Bank. The data provide bond-specific details including the international security identification number (ISIN) of the bond, the issuer, the issuing and maturity dates, the denomination of the bond, coupon rate and coupon type and the haircut applied for the bond to be used as collateral. This study focuses on fixed-rate coupon bonds denominated in the euro currency and issued by the central governments of the ten euro-area countries including Austria, Belgium, Finland, France, Germany, Greece, Italy, the Netherlands, Portugal and Spain. To avoid the idiosyncrasies with very short-term and very long-term bonds, the analysis only considers bonds with the residual maturity ranging between one year and thirty years. The collateral data has the sample spanning from May 10, 2010 to Mar 30, 2017.

The collateral data is supplemented with bond price and credit-default swap data obtained from Bloomberg. This data includes details about bond security identification and the end-of-day bid and ask prices on a daily basis over the same sample period. The credit data includes the bid and ask credit default swap rates for each sovereign issuer and denominated in the euro currency. After merging with the collateral data, the mid-price of the bid and ask prices are used to calculate bond yields and the mid-point of the credit default swap rate. For each bond the daily bid-ask spread is calculated as the ask minus the bid price divided by the midpoint of the bid and ask prices. To prepare the data for the analysis, the observations with missing details of collateral haircuts, bond yields and bid-ask spreads are removed. To avoid outliers and control for the effects of reporting errors, we calculate the summary statistics of bond yields and bid-ask spreads on a daily basis for each country and maturity group (that is, 1-2, 2-3 years, 3-5 years, 5-7 years, 7-10 years, 10-15 years, 15-20 years and 20-30 years). Observations are removed when either bond yield or bid-ask spread falls three standard deviation away from the mean statistics of the corresponding maturity group of each country[11]. The final data contains more than 881,000 bond-day observations.

[Figure 1 near here]

Figure 1 reports the average collateral haircut across all of the bonds over the sample period. The average haircut varies from about 2 percent in May 10, 2010 to above 5 percent in Mar 30, 2017. The biggest increase in the average haircut took place in Jul 2013 when haircuts were raised across a large number of assets[12]. During this period, the average haircut nearly doubled from 3 percent to about 5.5 percent.

[Table 1 near here]

Table 1 (Panel A) reports the descriptive statistics of the government bonds by country. This table shows the characteristics of each bond as it first enters in the sample, namely the time to maturity, the coupon rate. The statistics of yield spreads, bid ask spread and collateral haircuts are averaged over the whole sample period. Overall, we have 1,403 unique securities from the ten euro-area countries, among which Germany and France register the highest numbers of bonds. The average maturity of government bonds from Germany, France, Austria and Belgium is about ten years while bonds from those of Greece, Portugal and Finland range between 5 and 6 years. The average age for Finnish bonds is 3.22 years while the average age for bonds from the Netherlands is 12.23 years. German and Finnish bonds register the lowest yield spreads and collateral haircuts while bonds from Greece report the highest yields, bid-ask spreads and collateral haircuts. Panel B shows the descriptive statistics of the bonds over the whole sample period, during the financial crisis (e.g. the

[11] Our results remain qualitatively unchanged if we use two or five standard deviations filters in the data selection.

[12] See the European Central Bank's press release "ECB further reviews its risk control framework allowing for a new treatment of asset-backed securities" on Jul 18, 2013 for further details.

period from May 10, 2010 to Jun 30, 2014) and after the financial crisis. We observe that the average yield spread and the average CDS premium are significantly higher during the financial crisis. The average collateral haircut increases after the financial crisis.

5 Empirical analysis

This section concentrates on how haircuts explain the cross-sectional variations of bond yields. The paper then examines the effects of the European sovereign debt crisis and performs robustness checks.

5.1 Cross-sectional determinants of bond yields

Previous studies (See, for instance, Beber *et al.*, 2009) show that the differences in European government bond yields can be explained by the differences in credit worthiness of the issuers and the liquidity of the securities. This analysis investigates whether funding constraint matters in capturing differences in bond yields in addition to the effects of credit risks and market liquidity. Similarly to Houweling *et al.* (2005), bond yields are used instead of realized returns as bond yields serve as a better proxy of expected returns. In the presence of funding constraints, we expect that investors require higher yields for bonds with higher collateral haircuts.

[Table 2 near here]

Table 2 reports the correlation coefficients across all the bonds over the sample period. We observe that the collateral haircuts are positively related to the sovereign issuer's credit default swap premium and the bond bid-ask spread, indicating that both these variables serve as important inputs for the assessments of collateral haircuts. In addition, yield spreads are positively correlated with the sovereign issuer's credit default swap premium and the bond bid-ask spread. Thus, higher yields are associated with bonds of lower credit quality and with lower market liquidity. Importantly, yields also increase in collateral haircuts. Bonds with higher collateral haircuts experience higher yields.

[Table 3 near here]

Table 3 shows the coefficients and Newey-West heteroscedastic consistent t-statistics (in parentheses) obtained from the cross-sectional regressions. Column (1) shows the result with collateral haircut as the main explanatory variable. The result indicates that yields significantly increase in haircuts. Column (2) confirms the results obtained by Beber *et al.* (2009) that credit quality and liquidity differentials explain the variations in bond yields. The coefficients for credit-default-swap rates and bid-ask spread are positive and significant. That is, 10 basis points higher than the cross-sectional averages of credit default swap and bid-ask spread suggest 2.3 and 5.8 basis points higher in yield spreads, respectively. These results indicate that bonds with lower credit quality and lower liquidity are associated with higher yields. The adjusted R^2 for the two-factor model is 64.3 percent. Column (3) reports the results for the model with collateral haircut serving as the additional determinant to credit quality and market liquidity. The coefficients for bid-ask spread and credit quality differentials remain positive and significant. However, we observe a significant role of collateral haircut in explaining bond yields. Yields increase significantly in bonds with higher collateral haircuts. The coefficient indicates that bonds with one percent higher in collateral haircut than the cross-sectional mean are required 3.42 basis points higher in yields. This effect is sizable and is consistent with the theoretical predictions by Garleanu and Pedersen (2011). This result supports the argument that investors expect higher expected returns for securities subject to tighter funding constraints. The adjusted R^2 for the three-factor model increases to 66.4 percent and indicates that the model is able to explain a large proportion of the variations in yield spreads.

[Table 4 near here]

Table 4 demonstrates the proportion contributions of the three determining variables for each country. We compute the contribution of each variable for each bond and then take the averages of the contributions across the bonds in each country. Credit quality explains 63 percent of the variations in bond yields of Austria while the numbers for liquidity and funding constraint are 27 percent and 9.6 percent. Credit quality is more important for Greece as it explains more than 90 percent of the variations in yield spreads. The proportion contribution of funding constraint is highest with Portuguese government bonds where it explain 18 percent of the variations in yield spreads. These results suggest that funding constraints are important in explaining bond yields and that their contributions to bond yields vary significantly across countries.

5.2 The European sovereign debt crisis

The European sovereign debt crisis severely affects investors' confidence in financial markets and growth in the real economy. This analysis concentrates on the relative importance of credit quality, liquidity and funding constraint to the cross-section of government bond yields during and after the crisis. Following Filoso *et al.* (2017), the sample from May 10, 2010 to Jun 30, 2014 is defined as the period affected by the European debt crisis and the sample from Jul 1, 2014 to Mar 30, 2017 as the period after the crisis[13][14]. The cross-sectional regressions (equation 4) are performed and the variance decompositions (equation 5) are obtained for each period.

[Table 5 near here]

Table 5 (Panel a) reports the regression results for the two sample periods. Compared with the results estimated over the whole sample, the adjusted R^2 for the three-factor model is higher and is about 77 percent. Note that the coefficients for both bid-ask spread and

[13] This classification in the sample period corroborates developments in financial markets. The starting date of the crisis period coincided with the efforts by the European Union and International Monetary Fund to assist Greece in May 2010. The end date of the crisis period took place with the departures of several euro-area countries from international assistance programs for banks, for instance, Spain on Jan 23, 2014 and Portugal on May 4, 2014 (See CNN, Jan 22, 2017 "European Debt Crisis Fast Facts" for further details).

[14] To further motivate the classification of the crisis period, we perform a Chow test on the daily averages of the yield spread across all the bonds with the break point falling on Jun 30, 2014. The F-test statistic obtained from the analysis is 1243.75 (the p-value is less than 0.01) and indicates a structural change in the yield spreads before and after Jun 30, 2014.

credit-default-swap rate are significant and are higher than the estimates obtained after the financial crisis or in the whole sample period, indicating that liquidity and credit quality become more important in explaining variations in bond yields during the crisis. This result corroborates the "flight-to-quality" and "flight-to-liquidity" patterns observed in financial markets and is consistent with the finding in Beber *et al.* (2009) that investors demand higher compensation for credit risk and liquidity risk at times of crisis. The coefficient for collateral haircut remains positive and significant during and after the crisis. This result suggests that funding constraints affect bond yields.

Table 5 (Panel b) shows the explanatory power of the three-variables for the two sample periods. Consistent with the previous results, credit quality and liquidity are more important in explaining bond yields during the financial crisis than after the crisis. For example, the proportional contributions of credit quality and liquidity for Greece are 92.83 percent and 4.49 percent, respectively in the crisis. The contributions of funding constraint for Greek government bonds increase from 2.68 percent during the crisis to 22.24 percent after the crisis. Although credit quality and liquidity remain important for the variations of Italian government bond yields, funding constraint still accounts for a significant proportion of 10.5 percent during the crisis and 26.17 percent after the crisis. The strengths of the coefficient in the cross-sectional regression and the results from the proportion contributions over the sub-sample periods demonstrate that funding constraints explains the variations of bond yields both during and after the European sovereign debt crisis.

5.3 Credit rating and other bond characteristics

Having established the relation between bond yields and funding constraint, we examine whether the effects remain robust after controlling for the importance of credit rating and other bond characteristics. Credit ratings which provide independent assessments of the central government's ability to repay interest and principal obligations are often used as proxy for credit quality. Rating agencies for the euro-area government bonds are provided by agencies including Standard & Poor, Moody's, Fitch and Dominion Bond Rating Services. We obtain the time series of the credit ratings for each country across these agencies from Bloomberg and keep the lowest rating to be conservative. Similarly to Dufour and Nguyen (2012), we use the rating dummy variables A, AA and AAA (A, AA, AAA equals 1 if the bond respectively has A, AA, AAA or equivalent credit rating, and equals 0 otherwise) to capture the effects of credit ratings on bond yields. In addition to credit ratings, bond yields could also be explained by other bond characteristics such as coupon rates and bond maturity. As Bindseil, *et al*. (2017) suggest, these bond characteristics also determine the haircuts imposed by the European Central Bank. Therefore, we add these bond characteristics and rating dummy variables in the empirical model (equation 4) and estimate the regressions over the whole sample period.

[Table 6 near here]

Table 6 reports the regression results with bond characteristics and credit ratings. Column 1 and 2 show the results with bond maturity and coupon rate. Column 3 reports the results with rating dummies while column 4 illustrates the results with all of these variables. We observe that bond yields decrease in bonds with higher credit rating. In particular, bonds with AAA credit rating register 148 basis points lower in yields than those with rating lower than A or equivalent. Bond yields significantly increase in coupon rates and decrease in bond maturities. Importantly, bond yields are positively and significantly related to collateral haircuts. We observe that one percent rise in collateral haircuts leads to an increase of 3.08 basis points in yields and this relation is significant at one percent level. The adjusted R^2 with credit ratings and other bond characteristics is 80.8 percent and indicates that the model captures a large proportion of the variations in bond yields.

5.4 Country effects and the cross-sectional variations of bond yields

Financial market participants are often interested in how country differences affect the variations of bond yields. This analysis uses a dummy variable for each country to capture the country effects. For instance, the dummy variable for France equals one if an observation is related to bonds issued by the French government and zero otherwise. The Germany's bonds are used as benchmark. Therefore, the coefficient obtained for the France dummy variable accounts for the yield spreads between the French and the German government bonds. As the credit default swap (CDS) variable also contains the country effect, the variable is replaced with the country dummy variables in equation (4) and the cross-sectional regressions are performed over the whole sample period.

[Table 7 near here]

Table 7 reports the estimates and Newey-West adjusted t-statistics (in parentheses) obtained from the cross-sectional regressions with the country dummy variables. Column (1) shows the results without bond haircuts and Column (2) reports results with collateral haircuts included in the regressions. The coefficients of the country dummy variable are all positive and significant at one percent level, suggesting that German bonds are often traded at the lowest yields compared with those from other countries. For instance, the yield spreads between the German and Spanish bonds average 121.41 basis points and 124.77 basis points, respectively in the cross-sectional regression models without and with collateral haircuts. The results also show that the coefficients for collateral haircuts remain positive and significant as the country dummy variables are added to the model. The adjusted R^2 of the model with collateral haircut is about 69.7 percent.

5.5 Robustness checks

Studies in financial market microstructure suggest a link between funding liquidity and asset prices. In particular, empirical works (See Brunnermeier *et al.,* 2008; Fontaine *et al.*, 2015;

Hu *et al.* 2013) use market-wide measures to capture systematic movements in funding conditions. This analysis seeks to examine the relation between funding constraints and bond yields after controlling for the asset pricing effects of the aggregate funding liquidity measures. We obtain the exposures (or betas) of the yield spreads of each bond to the innovations of each funding liquidity measure. These exposures are added to the equation (4) and the cross-sectional regressions are performed over the whole sample period.

The first funding liquidity measure is the equity option implied volatility index, the vStoxx index, which contains information from the option prices of the Dow Jones Euro Stoxx 50 equity index. Brunnermeier *et al.* (2008) show that the implied volatility index from equity option markets captures periods of funding constraints in financial markets and help explain the systematic variations in currency returns. Another proxy for funding liquidity is the spread between the Euro interbank offered rate (Euribor) and the overnight index swap rate (OIS) both with the maturity of one week. As discussed extensively in the previous literature (see, for instance, Taylor and Williams, 2009; Baba and Packer, 2009), the variations in the Euribor-OIS spread reflect changes in default/counterparty risk and or interbank liquidity conditions.

[Table 8 near here]

Table 8 reports results from the cross-sectional regressions with the aggregate funding liquidity measures. Column (1) shows the estimates and Newey-West adjusted t-statistics (in parentheses) of the regressions with the exposures of the funding liquidity measures added to the equation (4). Column (2) shows the results with the country dummy variables. The coefficients of the two funding liquidity measures are positive and significant in both of these specifications. Note that the coefficients of collateral haircuts remain positive and significant at one percent level. Thus, 1 percent rise in collateral haircut is associated with an increase of 3.38 basis points in yields. The adjusted R^2 of the model with country dummy variables is about 83.4 percent. These results show that the model captures a majority of the cross-sectional variations in yield spreads.

Our analysis contributes to the debate in the literature about the role of factor exposures (i.e. loadings or betas) versus characteristics in asset pricing. Studies (See Brunnermeier *et al.,* 2008; Fontaine and Garcia, 2015; Hu *et al.,* 2013) show that the exposures to funding liquidity factors explain the variations of asset returns. However, empirical works by Daniel and Titman (1997) and Chordia, *et al.* (2015) suggest that security or firm characteristics might be better predictors of stock returns. Our results show that both factor loadings and characteristics matter. Importantly, funding constraints explain the variations in bond yields after controlling for the exposures to other aggregate funding liquidity factors.

6 Conclusions

This paper examines a cross-section of government bonds from ten euro-area countries and the haircuts applied to these securities when used as collateral for funds from the eurosystem over the period from May 10, 2010 to Mar 30, 2017. We document the existence of a positive and significant relationship between collateral haircuts and yield spreads after controlling for the effects of credit quality and market liquidity. The importance of collateral haircuts remains robust after controlling for the effects of the European sovereign debt crisis, the country dummy variables and the exposures to market-wide funding liquidity measures.

Taken together, our findings suggest that funding constraints matter in explaining the variations of asset prices. We support the theoretical argument in Garleanu and Pedersen (2011) that the uncertainty due to funding liquidity affects the risk of holding securities, and therefore, investors require extra compensation for holding bonds with higher funding liquidity risks. In particular, we show that funding constraints explain bond yields even after controlling for the exposures to market-wide funding liquidity variables. Our study also supports the liquidity spiral arguments discussed by Brunnermeier and Pedersen (2009) and that central banks can influence the impacts of funding constraints on market liquidity and asset prices. A wholistic collateral policy can be adopted to improve the funding conditions faced by market participants.

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Figure 1: This figure presents the evolution of the average collateral haircut across the ten euro-area government bonds on a daily basis from May 10, 2010 to Mar 30, 2017. We focus on fixed-rate coupon bonds with the residual maturity ranging from one year to thirty years.

Table 1: **Descriptive Statistics of Euro-area Government Bonds**

The table reports the average characteristics of the ten Euro-area government bond markets. We only consider fixed-rate coupon bonds with maturity between one year and thirty years and issued by the euro-area central government from May 10, 2010 to Mar 30, 2017. In the table, *No.* denotes the total number of bonds for each country, *Rating* is is the sovereign rating in May 2010, *YSPR* is the end-of-day miquote bond yield spread (in basis points) over the matched yield obtained from the European Central Bank's yield curve, *YTM* is the time to maturity (in years), *Duration* is the weighted maturity (in years) of bond discounted cash flows, *BAS* is the bond quoted bid-ask spread (in basis points), *CP* is the coupon rate (in %), *Age* is the number of years since the issuing date, *CDS* is the 5-year credit default swap premium (in basis points), *HC* is the collateral haircut (in %). Financial crisis is the period between May 10, 2010 and Jun 30, 2014.

Descriptive Statistics per Country

Country	No.	Rating	YSPR	YTM	Duration	Age	CP	BAS	CDS	HC
Austria	184	AAA	31.63	10.22	8.55	6.27	0.51	34.01	40.36	4.39
Belgium	168	AA	37.06	9.48	7.51	6.65	1.46	46.89	71.69	3.68
Finland	17	AAA	1.41	6.45	5.68	4.73	3.03	5.85	32.27	2.34
France	316	AAA	6.54	10.77	9.04	8.46	0.82	53.49	49.50	4.41
Germany	267	AAA	-4.69	9.8	7.98	7.92	0.9	53.26	21.84	3.98
Greece	30	BB	1285.12	6.45	4.62	5.91	4.69	76.01	2402.85	22.18
Italy	86	A	116.22	6.97	5.41	6.39	1.42	53.03	169.38	3.46
Netherlands	82	AAA	10.56	8.26	7.39	11.35	1.19	65.27	28.58	3.62
Portugal	28	A	332.23	5.2	4.09	6.78	4.34	43.87	380.74	8.23
Spain	225	AA	165.83	8.07	7.19	7.78	1.03	69.76	158.15	3.83

(a)

Cross-sectional Statistics

	All Sample			During the Financial Crisis			After the Financial Crisis		
	Mean	Median	Std	Mean	Median	Std	Mean	Median	Std
YSPR	62.74	21.53	201.41	128.95	22.20	354.73	38.47	21.33	84.55
YTM	9.40	6.67	7.62	6.42	4.40	6.56	10.49	7.98	7.70
Duration	8.29	6.20	6.43	5.19	3.30	5.84	9.30	6.62	6.81
Age	7.65	6.22	5.69	8.33	7.32	5.71	7.41	5.54	5.67
CP	1.07	0.00	1.83	1.55	0.00	2.10	0.90	0.00	1.69
CDS	316.30	60.69	828.59	414.45	86.05	1016.04	193.52	27.14	430.70
BAS	52.27	21.35	67.70	42.24	16.65	60.50	55.96	23.37	69.80
HC	4.30	3.00	3.93	3.64	2.50	4.08	4.54	4.00	3.84

(b)

Table 2: **Cross-sectional Correlations**

The table reports Pearson correlation coefficients for bonds issued by the ten Euro-area governments over the period from May 10, 2010 to Mar 30, 2017. In the table, *YSPR* is the spread between bond yield and the matched yield obtained from the European Central Bank's yield curve of the same maturity, *CDS* is the 5-year credit-default-swap rate on the sovereign issuer, *BAS* is the bid-ask spread, *HC* is the collateral haircut. *** denotes the significance at 1% level.

	YSPR	CDS	BAS	HC
YSPR	1			
CDS	0.724***	1		
BAS	0.365***	0.212***	1	
HC	0.591***	0.643***	0.385***	1

Table 3: **Cross-sectional Regressions**

The table reports the estimates and Newey-West adjusted t-statistics (in parentheses) of the cross-sectional regression:

$$YSPR_{j,t} = \beta_0 + \beta_1(CDS_{j,t} - CDS_{AVE,t}) + \beta_2(LIQ_{j,t} - LIQ_{AVE,t}) + \beta_3(HC_{j,t} - HC_{AVE,t}) + e_{j,t},$$

where as $YSPR_{j,t}$ is the yield spread of bond j at time t over the matched yield obtained from the European Central Bank's yield curve with the same duration. $CDS_{j,t}$ is the 5-year credit default swap premium of the issuer of bond j, $CDS_{AVE,t}$ is the average CDS across all issuers at time t. $LIQ_{j,t}$ is the bid-ask spread of bond j, $LIQ_{AVE,t}$ is the average bid-ask spread across all bonds at time t. $HC_{j,t}$ is the valuation haircuts of bond j, $HC_{AVE,t}$ is the average valuation haircut across all bonds at time t. $AdjRSQ$ is the adjusted R-square of the regression. We perform the cross-sectional regressions on a daily basis from May 10, 2010 to Mar 30, 2017 and use the time-series of the estimates for tests of statistical significance. Column 1 reports the results with collateral haircut acting as the main explanatory variable, Column (2) reports the results with bid-ask spread and credit default swap acting as the explanatory variables. Column (3) reports the results of all variables. *, **, *** denotes the significance at 10%, 5%, and 1% level.

Variable	(1)	(2)	(3)
Intercept	108.65(30.72)***	108.62(36.12)***	108.66(36.26)***
HC	53.76(25.49)***		3.42(4.55)***
CDS		0.23(25.83)***	0.22(23.29)***
BAS		0.58(27.21)***	0.54(21.25)***
Adj RSQ	0.412	0.643	0.664

Table 4: **Explanatory Power of Credit Quality, Liquidity and Funding Constraints by Country**

The table reports the average yield spread, *YSPR* (in basis points) and the proportional contributions of the credit, liquidity and funding differentials on the variations of yield spread on a country by country basis. We first perform the cross-sectional regressions as in Table 3. The contributions of the credit, liquidity and funding constraint of bond i can be calculated as:

$$CredCon_i = \beta_1(CDS_{i,t} - CDS_{AVE,t}),$$

$$LiqCon_i = \beta_2(LIQ_{i,t} - LIQ_{AVE,t})$$

$$FdCon_i = \beta_3(HC_{i,t} - HC_{AVE,t}).$$

The proportional contributions to the variations of bond yields due to credit, liquidity and funding constraint of bond i are respectively computed as follows:

$$CredPC_i = \frac{|CredCon_i|}{(|CredCon_i|+|LiqCon_i|+|FdCon_i|)},$$

$$LiqPC_i = \frac{|LiqCon_i|}{(|CredCon_i|+|LiqCon_i|+|FdCon_i|)},$$

$$FdPC_i = 1 - CredPC_i - LiqPC_i.$$

We perform the regressions and estimate the proportional contributions over the whole sample from May 10, 2010 to Mar 30, 2017. The proportional contributions are averaged across all the bonds in the same country and are multiplied by 100.

Country	YSPR	Credit	Liquidity	Funding
Austria	31.63	63.33	27.05	9.62
Belgium	37.06	44.99	38.57	16.44
Finland	1.41	58.81	31.73	9.46
France	6.54	56.49	32.51	11.00
Germany	-4.69	63.64	28.62	7.74
Greece	1285.12	90.88	4.33	4.80
Italy	116.22	58.92	29.10	11.99
Netherlands	10.56	61.71	30.54	7.75
Portugal	332.23	52.41	29.32	18.27
Spain	165.83	54.92	34.63	10.46

Table 5: **European Sovereign Debt Crisis**

The table (Panel a) reports the coefficients and Newey-West adjusted t-statistics (in parentheses) from the cross-sectional regression:

$$YSPR_{j,t} = \beta_0 + \beta_1(CDS_{j,t} - CDS_{AVE,t}) + \beta_2(LIQ_{j,t} - LIQ_{AVE,t}) + \beta_3(HC_{j,t} - HC_{AVE,t}) + e_{j,t},$$

The regressions are performed over the two sub-sample periods: the crisis period (from May 10, 2010 to Jun 30, 2014) and after the-financial-crisis period (from Jul 1, 2014 to Mar 30, 2017) . *, **, *** denotes the significance at 10%, 5%, and 1% level., respectively. Panel (b) reports the average yield spread, *YSPR* (in basis points), proportional contributions for credit-default swap, bid-ask spread and collateral haircut for each country over the two sub-sample periods, the crisis and after the-crisis period. The proportional contributions are defined in Table 4 and are multiplied by 100.

Cross-sectional Regressions

Variable	Crisis	After crisis	Difference
Intercept	155.02(41.32)***	38.17(44.53)***	116.85
HC	2.97(2.25)***	3.95(23.25)***	-0.98
CDS	0.30(24.64)***	0.08(40.39)***	0.22
BAS	0.86(16.79***	0.25(29.11)***	0.61
Adj RSQ	0.77	0.51	

(a)

Proportional Contributions to Bond Yields

Country	Crisis				After the crisis			
	YSPR	Credit	Liquidity	Funding	YSPR	Credit	Liquidity	Funding
Austria	35.73	58.15	35.41	6.44	30.93	37.11	34.33	28.55
Belgium	63.43	65.64	28.07	6.29	29.85	17.19	44.37	38.44
Finland	-0.27	67.09	28.09	4.82	2.20	29.50	42.64	27.87
France	21.49	62.96	30.73	6.31	0.16	28.39	40.95	30.67
Germany	-3.87	66.18	28.97	4.85	-5.03	39.64	37.29	23.07
Greece	1489.01	92.83	4.49	2.68	663.80	74.35	3.41	22.24
Italy	183.02	44.64	44.86	10.50	109.40	44.85	29.98	25.17
Netherlands	16.15	67.02	28.01	4.97	6.89	36.73	41.34	21.93
Portugal	504.50	54.84	32.91	12.25	164.02	42.46	23.15	34.39
Spain	251.40	42.82	47.04	10.14	125.70	41.95	35.88	22.17

(b)

Table 6: **Cross-sectional Regressions with Credit Rating and other Bond Characteristics**

The table reports the estimates and Newey-West adjusted t-statistics (in parentheses) of the cross-sectional regressions. AAA, AA, A are dummy variables which take the value of one if the issuer of the bond is correspondingly awarded AAA, AA, A or equivalent rating and takes the value of zero, otherwise. Maturity is the bond remaining maturity and Coupon is the coupon rate. Adj RSQ is the adjusted R-square of the regression. The regressions are performed on daily basis from May 10, 2010 to Mar 30, 2017. Column (1) and Column (2) reports the results with bond characteristics including maturity and coupon rates acting as the explanatory variables. Column (3) reports the results with rating dummy variables and Column (4) shows the results with all of these variables. *,**, *** denotes the significance at 10%, 5%and 1% level, respectively.

Variable	(1)	(2)	(3)	(4)
Intercept	161.35(22.75)***	156.03(22.27)***	221.44(38.35)***	251.44(31.31)***
HC	4.04(16.48)***	3.56(12.68)***	3.88(6.36)***	3.08(17.01)***
CDS	0.20(24.78)***	0.21(2513)***	0.19(19.08)***	0.18(22.53)***
BAS	0.54(22.64)***	0.60(22.24)***	0.30(19.03)***	0.33(23.07)***
Maturity	-22.35(-13.76)***	-22.473(-13.8)***		-18.61(-12.49)***
Coupon		3.61(14.74)***		1.40(7.67)***
AAA			-155.02(-27.12)***	-148.62(-31.15)***
AA			-144.27(-28.53)***	-137.74(-32.35)***
A			-15.62(-4.2)***	-13.96(-4.39)***
Adj RSQ	0.679	0.686	0.792	0.808

Table 7: **Cross-sectional Regressions with Country dummy variables**

The table reports the estimates and Newey-West adjusted t-statistics (in parentheses) of the cross-sectional regression with the country dummy variables added as explanatory variables. Germany serves as the benchmark. Adj RSQ is the adjusted R-square of the regression. The regressions are performed on daily basis from May 10, 2010 to Mar 30, 2017. Column (1) reports the results with bid-ask spread and the country dummy variables acting as the explanatory variables. Column (2) reports the results with collateral haircuts, bid-ask spread and the country dummy variables. *, **, *** denotes the significance at 10%, 5%, and 1% level, respectively.

Variable	(1)	(2)
Intercept	-6.04(-6.06)***	-4.93(-4.87)***
HC		5.55(25.68)***
BAS	0.33(40.29)***	0.22(24.23)***
Austria	46.12(63.03)***	43.52(67.31)***
Belgium	36.82(90.24)***	38.13(95.8)***
Finland	23.85(89.47)***	27.89(90.66)***
France	4.561(7.87)***	2.27(4.06)***
Greece	327.70(17.14)***	197.17(12.94)***
Italy	116.14(99.93)***	122.02(110.91)***
Netherlands	4.19(17.82)***	7.22(34.5)***
Portugal	185.22(70.82)***	152.85(61.72)***
Spain	121.41(142.35)***	124.77(143.55)***
Adj RSQ	0.678	0.697

Table 8: **Cross sectional Regressions with other Funding liquidity Measures**

The table reports the estimates and Newey-West adjusted t-statistics (in parentheses) of the cross-sectional regression with the funding liquidity measures added as explanatory variables to equation in Table 5. CDS is the 5-year credit default swap premium of the issuer of bond, BAS is the end-of-day bid-ask spread of the bond, HC is the collateral haircut of the bond. The funding liquidity measures include VOL, the vStoxx index based on the option prices of the Dow Jones Euro Stoxx 50 equity index, Euribor or the spread between Euribor and Overnight Index Swap. We first obtain the exposures (or betas) of the yield spreads on the innovations of the funding liquidity measures. We then add these exposures as the explanatory variables in the cross-sectional regressions described in Table 5. The regressions are performed on daily basis from May 10, 2010 to Mar 30, 2017. Adj RSQ is the adjusted R-square of the regression. Column (1) reports the results with exposures to funding liquidity measures. Column (2) reports the results with the country dummy variables. Germany serves as the benchmark. *, **, *** denotes the significance at 10%, 5%, and 1% level, respectively.

Variable	(1)	(2)
Intercept	113.10(35.84)***	-8.02(-10.39)***
HC	3.23(8.88)***	3.38(2.03)***
CDS	0.25(23.95)***	
BAS	0.55(22.44)***	0.29(24.16)***
Euribor	3.02(1.99)***	6.02(2.9)***
VIX	12.04(17.82)***	3.49(5.45)***
Austria		43.23(37.66)***
Belgium		66.19(30.68)***
Finland		24.31(57.37)***
France		14.89(16.62)***
Greece		862.44(18.87)***
Italy		209.93(38.09)***
Netherlands		12.78(35.07)***
Portugal		438.97(25.81)***
Spain		208.17(52.17)***
Adj RSQ	0.706	0.834