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Abstract

Wide and volatile interest rate spreads in the 2007-2009 financial crisis could represent concerns over asset liquidity or issuer solvency. To precisely identify the contribution of these two effects on sovereign bond and interbank spreads, I propose a model-free measure of euro-area market liquidity that captures all liquidity information impounded in bond yields. I find that credit and liquidity are independently important in risk spreads; the role of liquidity dominates in the interbank market, while its relative importance in sovereign bond spreads varies substantially by country. I exploit variation in sovereign bond returns over countries, maturities and time to directly test liquidity risk pricing; the possibility that liquidity could be negatively correlated with marginal utility. I find that liquidity risk premia are large and significant, evidencing the importance of a liquidity channel missed by measures that capture only instantaneous liquidity.

Mind the Gap: Disentangling Credit and Liquidity in Risk Spreads

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Abstract

Wide and volatile interest rate spreads in the 2007-2009 financial crisis could represent concerns over asset liquidity or issuer solvency. To precisely identify the contribution of these two effects on sovereign bond and interbank spreads, I propose a model-free measure of euro-area market liquidity that captures all liquidity information impounded in bond yields. I find that credit and liquidity are independently important in risk spreads; the role of liquidity dominates in the interbank market, while its relative importance in sovereign bond spreads varies substantially by country. I exploit variation in sovereign bond returns over countries, maturities and time to directly test liquidity risk pricing; the possibility that liquidity could be negatively correlated with marginal utility. I find that liquidity risk premia are large and significant, evidencing the importance of a liquidity channel missed by measures that capture only instantaneous liquidity.

The 2007-2009 financial crisis was marked by an unusual widening of risk spreads and increased volatility in asset prices. Changing credit or liquidity conditions were two possible causes of the substantial variation in bond yields, as discussed by many recent paper such as the models of Heider and Hoerova (2009) and Heider, Hoerova and Holthausen (2015). Researchers have proposed theoretical models in which liquidity can have an important effect on bond yield spreads, especially during a crisis; Acharya and Skeie (2011), Favero, Pagano and von Thadden (2010) and Manganelli and Wolswijk (2009). However, different manifestations of liquidity have differing implications for policy and practitioners, and the effects of liquidity and credit are hard to measure. There is a growing literature that argues that traditional measures of liquidity, such as bid-ask spreads, do not capture all liquidity effects. For example, Jankowitsch, Mösenbacher and Pichler (2006) find that conventional liquidity indicators are inadequate for accurately estimating euro-area sovereign bond premia. See also Friewald, Jankowitsch and Subrahmanyam (2012) and Dick-Nielsen, Feldhütter and Lando (2012) in the corporate bond market.

The first goal of this paper is to propose a new measure of liquidity that captures both instantaneous and forward-looking liquidity in interest rates. The measure is constructed directly from asset prices; it is the difference in yields between two duration-matched bonds that share an identical credit guarantee from the German federal government, but differ in market liquidity. Specifically, I compare the German federal government bond yield with the yield of its less-liquid KfW (Kreditanstalt für Wiederaufbau) agency counterpart. I refer to this yield differential as the K-spread. I argue that the K-spread's construction ensures that it fully captures the liquidity effects impounded in asset prices since that is the remaining difference between these two yields; some liquidity channels are missed by model-driven measures, such as the bid-ask spread, or by liquidity characteristics, such as trading volume. In particular, the yields that form the K-Spread liquidity measure price forward-looking liquidity risk,

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something that is not captured by liquidity characteristics or by instantaneous liquidity measures alone. For instance, a bond could have low transactions costs today, but still have high liquidity risk.

The second goal of this paper is to use this measure to explain variation in euro-area sovereign bond yields and unsecured interbank borrowing rates, two interest rates that are closely related through the use of bonds as collateral in secured interbank money markets.[1] Beyond the expected path of future short-horizon interest rates, it is unclear to what extent the movements in these rates are driven by credit, reflecting compensation for heightened default risk – see Afonso, Kovner and Schoar (2011), Filipović and Trolle (2013), Taylor and Williams (2009), Beber, Brandt and Kavajecz (2009), and McAndrews, Sarkar and Wang (2008) – or by poor liquidity (Michaud and Upper (2008), Acharya and Skeie (2011)), especially at times of market stress when these effects are potentially large.

I use the K-spread liquidity measure to estimate market liquidity for the euro-area money market and to decompose the sovereign bond yields of several different euro-area countries. In the sovereign bond market, identification relies on commonality in market liquidity in the cross-section of countries. This assumption draws on work showing that common factors drive liquidity premia across various markets (Chordia, Sarkar and Subrahmanyam (2005) and Brunnermeier and Pedersen (2009)). The K-spread liquidity measure is available because Germany happens to have issued securities with identical credit profiles but very different liquidity. Commonality in liquidity implies that spreads between comparably matched bond pairs of other euro-area countries would be roughly proportional to the K-spread, if they were available. Empirically supporting the assumption of common liquidity, I find that the single K-spread is important in explaining the variation in sovereign bond yields of different euro-area countries; alone, it explains more variation than is captured jointly by several conventional country-specific liquidity measures. For about one-third of the countries in the sample, the contribution of the K-

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[1] Unsecured interbank rates, considered in this paper, are a close substitute to secured interbank rates (repo funding), which are directly affected by the liquidity premia of assets used as collateral.

spread far exceeds that of credit, but there is large variation in the relative importance of liquidity and credit by country.

In the interbank market, I use the K-spread measure of aggregate market liquidity and a new bank-tiering credit measure, which directly reflects default risk in the short-horizon unsecured interbank market, to parse money market interest rates. The tight link between aggregate market liquidity and funding liquidity for institutions is modeled by Brunnermeier and Pedersen (2009) and Bolton, Santos and Scheinkman (2011) to explain market features seen in the early stages of the 2007-2009 financial crisis. I find that the effects of the new bank-tiering credit measure dominate those of bank CDS premia. But, the K-spread liquidity measure is paramount in explaining interbank rates at all maturities, giving empirical evidence of the role of bond market liquidity in funding markets.

The final goal of this paper is to explicitly test the pricing of liquidity *risk*, in order to better understand the nature of the large liquidity contribution identified in interest rates over the crisis in sovereign bond yields and in interbank rates. The concept of liquidity risk is proposed in the theoretical models of Acharya and Pedersen (2005), Pastor and Stambaugh (2003) and Vayanos (2004), representing the possibility that liquidity will dry up in the future at exactly the time when investors' marginal utility is at its highest. However, empirically, there is a lack of consensus on the importance of expected liquidity versus liquidity risk in returns. In corporate bond markets, Lin, Wang and Wu (2011) find that liquidity risk premia can help to explain corporate bond returns, whereas Bongaerts, de Jong, and Driessen (2013) find that liquidity risk is priced in equity markets but not in corporate bond markets.

In the euro-area sovereign bond market, liquidity risk identification comes from the systematic relationship between sovereign bond returns and factor sensitivity to liquidity, by country and maturity, making euro-area sovereign bond data ideally suited to the estimation. Applying a two-step Fama MacBeth procedure to the rich cross section and time series variation of euro-area bonds, I find that

liquidity factor sensitivity across countries is systematically related to expected returns. Large and significant euro-area liquidity risk premia help to explain the sizeable overall liquidity effect in interest rates in the 2007-2009 financial crisis. These results also evidence the forward-looking information impounded in the K-spread liquidity measure, beyond what instantaneous liquidity measures contain.

Identifying the default and market liquidity components in interest rates is important for investors' portfolio allocation decisions — investors with the longest investment horizons should prefer to hold higher yielding assets if these elevated yields represent compensation for poor liquidity, but not necessarily if they represent a greater risk of default. Further, the K-spread can be traded to earn the "liquidity spread" while hedging against credit fluctuations; an investor could form a portfolio with a long KfW bond position and a corresponding short German federal bond position. The default-versus-liquidity decomposition is also important for policymakers. If a spike in interest rates primarily represents the effects of poor liquidity today, then policy actions to improve market functioning, such as direct market intervention, could help to dampen the liquidity frictions. If it largely reflects a liquidity risk premium, then a more moderate policy tool, such as a statement of intent, may help to avoid potential escalation. On the other hand, if rate movements largely represent heightened risk of default, then only actions aimed at improving the solvency of the banks/sovereigns in question will ultimately succeed.

The plan for the remainder of this paper is as follows. Section 1 introduces the framework. Section 2 introduces the data and the empirical measures. Section 3 parses the relative euro-area sovereign bond yields into liquidity and credit components. Section 4 identifies market liquidity and credit effects in interbank interest rates. Section 5 tests the pricing of liquidity risk premia in the cross-section of euro-area sovereign bond yields. Section 6 concludes with the paper's contributions and implications.

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1.   A Simple Framework

This section describes a simple structural model that isolates the risk component in interest rates in order to precisely identify credit and liquidity effects in euro-area interest rates, which then frames the empirical analysis of Sections 3 through 5.

1.1   *The Common Component in Euro-Area Interest Rates*

Upon the introduction of the single euro currency in 1999, the European Central Bank (ECB) became independently responsible for managing a common path of short-term interest rates for all euro-area member countries jointly. The expected future path of euro-area monetary policy anchors the entire term structure of euro-denominated interest rates, yet it is not directly observable. In this paper I focus on explaining the variation in rates that is unrelated to the riskfree term structure.

During normal times, limited variation in the risk components of rates can make identification challenging. However, substantial crisis-driven movements in market liquidity (the ease with which a security is traded) and credit (the possibility that a financial instrument pays off below its face value) present a unique opportunity to cleanly identify their separate effects in interest rates. Varying interpretations of the relative contribution of these two effects in euro-area interest rates has fueled a heated debate, ongoing since the crisis. This disagreement motivates the disentangling of these influences in this paper.

There are two classes of interest rates, at different maturity points, that this analysis parses into components related to default and market liquidity: (1) euro-area sovereign bond yields and (2) euro interbank borrowing rates (EURIBOR). Both classes of interest rates share a common euro-area term structure. A key difference in these two classes of interest rates is that, at a single maturity point, there is a well-defined cross-section of sovereign bonds yields among the different euro-area countries,

whereas there is a single representative euro-area interbank market rate, EURIBOR. This is largely because the sovereign debt securities of one country are not fungible with those of another country, even if the terms and risks of the individual securities are otherwise identical, and thus there is no single benchmark sovereign interest rate. Each government independently guarantees its own debt issuance, which comprises the securities of each country's distinct sovereign bond market. Meanwhile, all euro currency is guaranteed by a single entity, the European Central Bank (ECB). EURIBOR represents the single shared interbank market rate at which large euro-area banks borrow some notional amount of euro currency from one another, uncollateralized, for a specified term that is less than or equal to one year.[2] EURIBOR is typically comprised of the average expected overnight interbank interest rate until maturity of the loan, plus a term premium. However, poor market liquidity or compensation for default risk may also influence unsecured interbank borrowing rates.

This paper explores the influence of market liquidity and default risk on EURIBOR and sovereign bond yields. For both of these classes of interest rates, market conditions and the potential for default influence the risk component in interest rates that is outside of the riskfree term structure. In section 2, I will define the particular credit and liquidity measures used to estimate these effects.

1.2   Isolating the Risk Component in Sovereign Bond Yields

First for the euro-area sovereign bond market, consider a model in which sovereign yields are expressed as a function of three components: the riskfree rate, expected default and market liquidity. The model relates individual country yields at each maturity to credit and liquidity influences as follows:

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[2] EURIBOR is a survey rate of unsecured interbank euro borrowing rates compiled by the European Money Markets Institution (formerly called the European Banking Federation) for eight maturities, from overnight- to one-year. LIBOR, also a survey of interbank borrowing, has been widely cited as manipulated to some degree by the contributing banks. To the extent that manipulation may have occurred in the EURIBOR survey, it is unlikely that the effect would be systematically related to the measures used in this paper, none of which settle to EURIBOR. And, if there were a systematic relationship, it is not clear in which direction this might shift the relative breakdown of liquidity versus credit.

$$y_{cmt} = r_{mt} + \beta_{1cm}\kappa_{mt} + \beta_{2m}d_{cmt} + \varepsilon_{cmt} \tag{1}$$

where y_{cmt} is the sovereign bond yield for country c at maturity point m at time t, r_{mt} is the riskfree rate, κ_{mt} represents a common liquidity factor and d_{cmt} is the sovereign default risk premium for country c. Specific measures of the liquidity and credit factors will be proposed in the next section. The riskfree rate, r_{mt}, is common across all euro-area countries and so it varies only over time and by maturity. In contrast, d_{cmt} is a distinct measure of fiscal risk that differs for each country according to its own national fiscal policy. The representation of a single riskfree rate and idiosyncratic default is consistent with the euro-area's framework as a single currency and monetary union but not a fiscal union. It also follows the intuition that the default risk of each country's debt increases as that country's federal budget deteriorates. Additionally, the model allows for countries to load on a common liquidity variable, which is reflected in the absence of a c subscript on the liquidity factor. A common representation of liquidity allows for divergent responses by the various country bond markets to an aggregate liquidity shock. For instance, a flight-to-liquidity may support the prices of sovereign bonds that already enjoy a relatively high level of liquidity at a time when market participants also shun less-liquid markets, thus increasing the liquidity discount in less-liquid bond yields.

To allow for the measurement of each country's relative sovereign yield premium within the model, without taking a stance on the level of the unobserved riskfree rate, we can consider a yield *spread* for each country-maturity pair as the difference between each country's sovereign yield and the euro-area weighted average yield.[3] The weights are defined as $w_{cm} = \dfrac{Q_{cm}}{\sum_{c'=1}^{11} Q_{c'm}}$, where Q_{cm} is the quantity

of debt outstanding for each country, c, at each maturity point m and c' is a counter variable indexing each of the countries for the purpose of computing the euro-area weighted average.[4] From Equation (1) we can deduce that:

$$y_{cmt} - \Sigma_{c'=1}^{11} w_{c'm} y_{c'mt} = (\beta_{1cm} - \Sigma_{c'=1}^{11} w_{c'm} \beta_{1c'm}) \kappa_{mt} + \beta_{2m}(d_{cmt} - \Sigma_{c'=1}^{11} w_{c'm} d_{c'mt}) + \varepsilon_{cmt} - \Sigma_{c'=1}^{11} w_{c'm} \varepsilon_{c'mt} \qquad (2)$$

Hence,

$$\tilde{y}_{cmt} = \tilde{\beta}_{1cm} \kappa_{mt} + \beta_{2m} \tilde{d}_{cmt} + \tilde{\varepsilon}_{cmt} \qquad (3)$$

where $\tilde{y}_{cmt}$ is the sovereign yield spread for country c, at the m-year maturity point, on day t, minus the euro-area weighted-average yield.[5]

1.2   Isolating the Risk Component in Interbank Interest Rates

For the euro-area interbank market, there is a single interest rate across countries. Thus, the interbank counterpart to Equation (1) describes interest rates as a function of the riskfree rate, expected default and market liquidity, without the country subscript, c, which gives:

$$y_{mt} = r_{mt} + \beta_{1m} \kappa_{mt} + \beta_{2m} d_{mt} + \varepsilon_{mt} \qquad (4)$$

where y_{mt} is the unsecured interbank rate at maturity point m and time t, r_{mt} is the riskfree rate, and κ_{mt} and d_{mt} denote liquidity and credit factors, respectively.

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[4] The maturity buckets comprise the total amount of debt outstanding for securities in the following duration ranges: 1-year bucket = 0.5 to 1.5, 2-year bucket = 1.5 to 2.5, 3-year = 2.5 to 3.5, 4-year bucket = 3.5 to 4.5, 5-year bucket = 4.5 to 6.5, 7-year bucket = 6.5 to 8.5, and 10-year bucket = 8.5 to 10.5. The quantities are averaged over all days in the sample period. The seven maturities are chosen in order to match the particular maturities of the credit default swaps introduced later in this section. The weights do not vary over the sample, because there is little change in relative debt quantities outstanding during this short period.

[5] The pattern in sovereign yield spread widening, shown in Figure 1 Panel B, suggests that the weights provide a reasonable anchor to the spreads; the spreads of small countries would likely be the widest if the weights of large countries had a disproportionate influence on the spreads. For instance, the yield spreads of Finland and Austria are very close to the 11-country average over the sample, even though these countries jointly have a weight of less than 5 percent at any maturity point.

In the context of the interbank model, there is no cross-country variation in the interbank interest rate and the interbank measures. Therefore, the unobservable riskfree interest rate cannot be eliminated by considering a cross-section of country interest rates relative to the euro-area average, as done with the sovereign bond market. Instead, in order to identify the risk component in interbank rates, I use the euro overnight-index swap (OIS) rate to proxy for the riskfree rate. An OIS contract has a payoff determined by the future path of overnight interest rates plus a pure term premium. The interbank maturities considered are less than or equal to one year, and default and liquidity premia in OIS rates are negligible (Brunnermeier (2009) and Packer and Baba (2009)), minimizing a possible risk premium effect.[6] Thus, the difference in the EURIBOR rate from the same-maturity OIS rate at a given point in time, $y_{mt} - r_{mt}$, isolates the risk component in interbank rates, represented as $\tilde{y}_{mt}$ in the model:

$$\tilde{y}_{mt} = \beta_{1m}\kappa_{mt} + \beta_{2m}d_{mt} + \varepsilon_{mt} \tag{5}$$

2.   Data

The sample period for this paper is January 1, 2007 through September 30, 2009, which captures the nascent financial crisis in the summer of 2007, the height of asset price volatility following Lehman Brothers' bankruptcy, and the broad reversal in asset prices in the spring and summer of 2009. This section describes the data and construction of the interest rate spreads studied in this paper and the liquidity and credit measures used to identify these effects in rates.

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[6] The default premia are negligible because the OIS rate reflects a sequence of refreshed overnight bank credits, no matter how long the term of the swap. The liquidity component of OIS rates should be negligible for a number of reasons. First, market liquidity premia in the cash bond market will drive LIBOR rates higher via the repo market, because unsecured funding is a close substitute for repo funding. Meanwhile, OIS is not a proxy for repo funding. Also, an OIS is a derivative in zero net supply. As such, it is unclear whether a liquidity premium would be demanded by the payer of the fixed rate or the receiver of the fixed rate. Empirically, the depth of the OIS market far exceeds that of the interbank cash market.

2.1   *Sovereign Bond Yield Spreads*

The sovereign bond data sample includes the government debt securities for 11 euro-area member countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, and Spain. To compare the yields of these countries' sovereign bonds at specific maturity points, *m,* I first estimate a smoothed zero-coupon sovereign yield curve, for each country, *c*, and for each day, *t*. I apply the six-parameter model of Svensson (1994) to the prices of all nominal, coupon, euro-denominated, sovereign debt securities for the 11 countries in the sample, using bond prices from Bloomberg.[7] Seven specific sovereign bond maturity points are considered: 1, 2, 3, 4, 5, 7, and 10 years.

Panels A and B of Figure 1 compare the movements in sovereign bond yields and yield spreads, respectively, for each of the 11 countries in the sample. Although the sovereign bond yields mostly decline over the sample, the sovereign yield *spreads* widen dramatically for several countries. Figure 1 shows yields at the 5-year maturity, but the other maturities show a similar pattern in spread widening. For instance, the bond market summary statistics in Panel A of Table 1 shows that the sample-average sovereign yield spreads range from -23 to 55 basis points at the 5-year maturity, as compared to -15 to 43 basis points at the 2-year maturity and -27 to 50 basis points at the 10-year maturity.

2.2   *Interbank Interest Rate Spreads*

In the money market, I consider the 1-, 3-, 6-, and 12-month maturity points for the EURIBOR-OIS interest rate spread. EURIBOR and OIS rates are obtained from Bloomberg. Panel A of Figure 2 illustrates the decline in the levels of euro interbank interest rates, an even more dramatic movement than the same-period decline in sovereign bond yields. Volatility in the riskfree rate amid the ECB's

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[7] See Gürkaynak, Sack, and Wright (2006) for a discussion of the methodology: http://www.federalreserve.gov/pubs/feds/2006/200628/200628abs.html.

crisis-driven monetary policy easing in 2008 and 2009 underscores the importance of estimating risk components in interest rates with spreads, rather than levels. As the financial crisis began, the spread between EURIBOR and OIS rates rose sharply, first in August 2007, and then most dramatically after Lehman's Brothers' bankruptcy in the fall of 2008, as illustrated in Panel B of Figure 2. The interbank summary statistics reported in Panel A of Table 2 show that the standard deviation in EURIBOR-OIS spreads monotonically increases in maturity, from 30 to 54 basis points. These spikes in short-term spreads received considerable attention in the press and from policymakers. Many private lending rates are tied to term interbank rates, and so widening spreads mean less accommodative financial conditions.[8]

2.3   The K-spread Measure of Market Liquidity

Market liquidity is the premium demanded for buying or selling a large quantity of an asset, such as a sovereign bond, with immediacy.[9] Measuring this empirically is challenging. To identify the liquidity component of the sovereign bond and interbank spreads introduced in the previous subsection, I form a new measure of market liquidity that is constructed entirely from observed bond prices. Thus, the measure reflects all information impounded in yields, including forward-looking information about expected liquidity conditions, which is a potentially large dimension of liquidity not captured by market microstructure or transaction-based liquidity measures. Credit and asset characteristics are entirely controlled for by the nature of the measure's construction, which is described in the next paragraph. As such, identification is not limited to any single model of liquidity frictions (e.g. asymmetric information).

To form the new liquidity measure, I compare the yields of German government bonds with

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[8] Swap rates, forward rate agreements, interest rate futures contracts, and many mortgage rates in the euro area reference EURIBOR.

[9] An important but conceptually distinct type of liquidity is *funding* liquidity, an institution's precautionary demand for term funding so as to have liquid assets on its balance sheet. In the interbank market, precautionary demand for funding is closely tied to market participant's creditworthiness. Credit and *funding* liquidity are thus particularly hard to disentangle and I do not attempt to do so; in this paper, credit incorporates both default risk and associated funding liquidity.

German agency bonds, at specific maturities. German government bonds are highly liquid benchmark euro-area securities, backed by the full faith and credit of the German federal government. Their less-liquid counterparts are bonds issued by the German federal government-owned development bank, KfW, which was founded in 1948 to facilitate post-war reconstruction. A key feature of the KfW agency bonds, which safeguards the new liquidity measure against any credit effects, is that the German federal government has an *explicit* iron-clad guarantee – written into the German constitution – for all of KfW's current and future obligations, equally and without any difference in priority relative to federal government bond issues. Thus, default risk is identical for the two categories of bonds, and so market liquidity is the only substantive difference reflected in their yield spread. KfW and federal government bonds also have identical tax treatment (Germany does not have a class of tax-exempt bonds as in the U.S.), and both classes of bonds have an identical zero risk weight for determining Basel II capital ratios.

To capture the liquidity effect that is most appropriate for the interest rate spreads considered, I form the liquidity measure at the same maturities as the sovereign bond yield spreads: 1-, 2-, 3-, 4-, 5-, 7- and 10-year maturities. To match the sovereign bond yield spread maturities precisely, I first estimate a smoothed zero-coupon yield curve for the KfW bonds, on each day, using the same methodology as described for the sovereign yield curves in subsection 2.1, with daily bond price data from Bloomberg. I then take the yield spread between the KfW bond and the corresponding German federal government bond at each of the seven maturity points considered separately. The *m*-year K-spread is defined as:

$$\kappa_{mt} = KfW_{mt} - Y_{Germany,mt} \tag{6}$$

where KfW_{mt} and $Y_{Germany,mt}$ denote the *m*-year zero-coupon yields for the KfW agency and German government bonds, respectively, from the smoothed yield curves.

I treat the K-spread as a directly observable liquidity measure, denoted κ_{mt}, in Equations (1) - (5). My identifying assumption is that German sovereign and KfW yields have identical credit but that

they load differently on the common liquidity factor. Hence, the spread between KfW and German

sovereign yields allows for recovery of that liquidity factor. Time series variation in euro-area interest

rates that comes from market liquidity will load on the K-spread, but variation due to default will not.

Panel A of Figure 3 shows the time series of the K-spread for the 1- and 5-year maturities over

the sample. The spread is always positive, reflecting the relative ease with which the federal government

debt is traded as compared to the agency debt. The liquidity measure rises most substantially in the

second half of the sample period, reaching a local peak of 50 basis points around the collapse of Bear

Stearns in March 2008, and a global peak of 90 basis points in the months following Lehman Brothers'

bankruptcy in the fall of 2008.

There are some institutional differences between KfW and German federal government bonds

that could contribute to their liquidity differential. Just as with the bonds of two different euro-area

countries, the KfW and German federal government bonds are not fungible, even in the absence of any

difference in characteristics or risks. For instance, there is an active futures market for German 2-, 5- and

10-year federal government bonds, but the comparable-maturity KfW securities cannot be delivered into

these futures contracts.[10] Federal government bond issuance is also larger and trading volume is higher

than for KfW securities.[11] Moreover, euro repo funding rates are consistently slightly higher for KfW

collateral than for German federal government collateral, reflecting the relative attractiveness of the

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[10] The existence of futures markets enhances the liquidity of Treasury securities in the U.S. (Fleming (1997), allowing an investor to hedge a position in the underlying security. For comparison, no euro-area sovereign bond markets outside of Germany have futures contracts associated with them. French, Italian and Spanish futures contracts were initiated in the past, but ceased trading due to lack of investor interest.

[11] In 2008, gross annual issuance was €216 billion in federal government debt versus €74 billion for KfW, and the size of federal government debt was about 8 times that of KfW debt (similar in magnitude to other years). Issue sizes outstanding at the time were typically around €20 billion for benchmark federal debt issues versus €5 billion for benchmark KfW issues. The MTS bond trading platform shows that trading volume for the federal government debt is roughly 10 times higher than that of the agency market (a daily average of €443 million versus €42 million, respectively, over the sample period). KfW is the 4th largest euro-area debt issuer by volume, after the sovereigns of Germany, France and Italy.

federal government securities as collateral in funding markets.[12] The financing rate differential could be both a cause and a consequence of their greater liquidity (Brunnermeier and Pedersen (2009) and Gorton and Metrick (2012)). The K-spread is similar in spirit to the measure proposed by Longstaff (2004), who shows that the yield spread between Refcorp (Resolution Funding Corporation) and U.S. Treasury bonds can identify liquidity premia in U.S. Treasury markets. The euro-denominated K-spread allows for cross-country analysis within the euro-area and also the identification of future expected liquidity risk through the joint time series and cross-sectional variation in euro-area bond yields.

2.4   *Market Microstructure Liquidity Measures*

For comparison with more traditional approaches to measuring liquidity, I consider several market microstructure-based measures of liquidity: average trade size, total trading volume, the average bid-ask spread, order flow, and the bid-ask spread scaled by trading volume (Bollen and Whaley (1998) liquidity index). I form each measure separately for the sovereign bond market and again for the interbank money market.

In the sovereign bond market, to isolate each country's distinct liquidity contribution, I construct each of the five microstructure liquidity measures, for each country, at the maturity points corresponding to the sovereign bond yield spreads to be parsed (1-, 2-, 3-, 4-, 5-, 7- and 10-years). Let X_{cmt} be a vector of the five microstructure liquidity measures for country, c, at maturity m, on day t, and let $\Sigma_{c'=1}^{11} w_{c'm} X_{c'mt}$ be the sovereign debt-weighted euro-area average of these liquidity measures at maturity m, where $w_{c'm}$ is the set of weights used in Equation (2), and c' is a counter variable indexing each of the countries.

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[12] KfW bonds may not be used as collateral in federal government repo agreements and vice versa, just as the delivery specification in the futures markets. However, both securities are actively used for funding purposes; they each have centrally-cleared general collateral repo markets, and the settlement convention is the same: three days following trade execution (t+3).

Next, to isolate each country's distinct liquidity contribution, I define $\tilde{X}_{cmt}$, the microstructure liquidity measure for each of the 77 country-maturity pairs, as:

$$\tilde{X}_{cmt} = X_{cmt} - \Sigma_{c'=1}^{11} w_{c'm} X_{c'mt} \qquad (7)$$

These measures are formed with transaction data from MTS, a large electronic European bond trading platform, aggregated to a daily frequency.[13] Country-specific liquidity measures have the empirical advantage of relating distinctly to each country's sovereign bond yield spreads.in the decomposition.

For the interbank market, I construct a parallel set of each of the five microstructure liquidity measures, at each of the four EURIBOR-OIS maturity points (1-, 3-, 6-, and 12-months). These measures are formed with unsecured interbank borrowing transaction data from e-MID, a large electronic euro-area interbank trading platform.[14] The interbank microstructure liquidity measures, denoted X_{mt}, are already euro-area aggregates, coming from the single interbank market. The measures are all formed with overnight transaction data, which comprise 98 percent of the unsecured interbank e-MID sample.

The country-level summary statistics for each of the individual sovereign bond microstructure liquidity measures, as defined in Equation (7) are shown in Table 1. In Panel A, the sample-average country bid-ask spreads are within a tight range of one another. At the 2-year maturity, all of the country bid-ask spreads are within one basis point of the euro-area average. Germany is the only country with a bid-ask spread greater than 3 basis points from the euro-area average; at the 10-year maturity the German sovereign bid-ask is 8 basis points below the average. Panel B of Table 1 shows that there is little correlation between the K-spread and the idiosyncratic country component of the microstructure

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[13] MTS is an acronym for Mercato dei Titoli di Stato (Market for Sovereign Bonds). MTS is the largest inter-dealer European sovereign bond market platform, comprising an estimated 80 percent of electronic inter-dealer transactions (Euroweek special report, May 2007).

[14] e-MID is an acronym for Elettronica Mercato Interbancario dei Depositi (Electronic Interbank Deposit Market). Transactions on this platform comprise roughly 20 percent of all unsecured euro-denominated interbank transactions over the sample period.

liquidity variables. However, Panel C shows that the average of each microstructure liquidity indicator (X_{cmt} in Equation (7)), across countries is indeed correlated with the K-spread, the factor representation of liquidity.

Panel B of Table 2 shows summary statistics and correlations among the interbank microstructure liquidity measures. The sample-average unsecured interbank bid-ask spread is 5 basis points, and the daily average transaction volume captured by the e-MID platform is €11 billion, over the sample. The correlation among the K-spread and the microstructure liquidity variables is comparable to the correlation among the K-spread and the averages of the sovereign microstructure liquidity variables. This makes sense since the interbank measures are not idiosyncratic deviations from average as in the sovereign case. However, the interbank bid-ask spread and the Bollen-Whaley Index (the bid-ask relative to trading volume) show a low correlation with the K-spread. This may be explained in that the interbank bid-ask spread is less a measure of market liquidity than of credit risk of the market participants. In the sovereign bond market, the bid-ask spread represents the risk of a market maker in sovereign debt, whereas in the interbank market, the bid-ask spread represents the risk of the counterparty to an interbank loan.

2.5   CDS Risk Measures

To identify the credit factor in yields, I collect the sovereign credit default swap (CDS) premium separately for each of the 11 sovereign issuers in the sample separately, at the seven bond maturities considered. I treat the CDS spread as a directly observable credit measure, denoted d_{cmt}, in Equation (1). I then subtract the sovereign debt-weighted euro-area average CDS premium from each sovereign CDS premium, notated as $d_{cmt} - \Sigma_{c'=1}^{11} w_{c'm} d_{c'mt}$ in Equation (2), giving $\tilde{d}_{cmt}$ in Equation (3), shown in Panel B of Figure 3.

For the interbank market, in order to precisely estimate the amount of default risk impounded in the EURIBOR-OIS spread, I tailor the CDS credit risk measure to the specific banks that contribute to the EURIBOR survey. EURIBOR is a trimmed arithmetic average of survey data on interbank rates collected from a particular set of participant banks. So, I take a simple average of the EURIBOR survey-banks' CDS premia on each day, denoted, $d_{mt}^{BankCDS}$.[15] Measuring interbank credit risk with bank CDS premia faces the challenge that EURIBOR-OIS spreads reflect risks for one year or less (the maturities analyzed in Section 4 are 1, 3, 6, and 12 months), but little CDS origination occurs at maturities shorter than one year. To approach the short maturity of the interbank spreads considered, I use the 1-year maturity of bank CDS premia for the decomposition at each of the 1-, 3-, 6- and 12-month maturities. All sovereign and bank CDS data are obtained from Markit.

2.6   A Bank-Tiering Measure of Credit Risk

Euro interbank transactions are concentrated at the very shortest maturities; more than 90 percent of unsecured interbank borrowing is for a horizon of less than one month.[16] As noted in the previous subsection, bank CDS premia are unfortunately difficult to obtain at maturities shorter than one year; the highest concentration of CDS issuance is at the 5-year maturity. CDS contracts with very short (or very long) maturities are less likely to be precise measures of default risk, as per Pan and Singleton (2008). Consequently, I propose a new short-horizon measure of interbank credit risk that is motivated by this default-horizon mismatch as the baseline interbank credit factor representation, d_{mt}, in Equation (5).

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[15] The 22 EURIBOR survey banks are: Banco Bilbao Vizcaya Argentaria (BBVA), Banco Santander SA, Barclays, Bank of Tokyo Mitsubishi, BNP Paribas, Caiza General de Depositos, Citibank, Credit Agricole, Credit Suisse First Boston (CSFB), Danske Bank, Deutsche Bank, DZ Bank, HSBC, ING, Intesa San Paolo, JP Morgan Chase, Mizuho, Monte dei Paschi di Siena, Lloyds, National Bank of Greece, Natixis, Nordea, Pohjola, Rabobank, Royal Bank of Scotland, Societe Generale, and Unicredit. I do not trim the bank CDS premia before averaging them, because it is not clear that the same banks would be trimmed from the EURIBOR survey as those trimmed according to the distribution of bank CDS premia.

[16] The ECB's annual euro money market reports give detailed statistics on borrowing and lending each year. The maturity distribution has consistently shown that the largest share of transactions occurs at the overnight maturity.

To form the measure, I obtain overnight interbank transaction data obtained directly from e-MID (introduced in subsection 2.4).

Risk premia in unsecured interbank interest rates are unobservable, which is the empirical challenge faced in forming a default measure. But, the *difference* in rates paid by different borrowers at the same point in time reflects the difference in risk premia between these borrowers. Several researchers have related the dispersion and level of credit risk to explain events in the financial crisis. Heider, Hoerova, and Holthausen (2015) model this relationship in interbank markets. Gorton and Ordoñoz (2014) use the variation in the cross-section of stock returns as a proxy for the level of perceived collateral value.

The new bank-tiering credit measure takes the difference between two contemporaneous unsecured borrowing rates: the daily-average rate paid by banks in the highest quintile of credit and the daily-average rate paid by banks in the lowest quintile of credit. Considering only the spread between these two borrowing rates removes the *common* risks and market conditions that are faced by all borrowers. The bank-tiering credit measure, d_t , is then only driven by the relative credit premia of the two bank types, defined as follows:

$$d_t = \overline{r}_{t,High} - \overline{r}_{t,Low} \tag{8}$$

where $\overline{r}_{t,High}$ and $\overline{r}_{t,Low}$ denote the average unsecured interbank borrowing rates paid by the banks in the highest and lowest risk quintiles, respectively, on day t. The estimation of the measure's risk quintiles is detailed in Appendix 1.

The new bank-tiering credit measure is plotted in Figure 4, Panel A, which shows the credit measure peaking at 63 basis points in October 2008. In normal times, the difference in average rates paid by the best- versus worst-credit banks is only a few basis points. Summary statistics in Table 2, Panel B, show that the bank-tiering credit measure has a positive correlation (0.59) with the 1-year bank CDS premia,

as would be expected for two measures of interbank default risk.

3.   Credit versus Liquidity in Euro-Area Sovereign Bond Spreads

I begin my empirical analysis of interest rate spreads in the euro-area sovereign bond market, to determine whether – and to what extent – credit and liquidity potentially drive variation in country yield spreads (country yields relative to the euro-area average yield) over the sample, following the analytical structure introduced in Section 1. The crisis period shows a spike in bond yield volatility over this period for the individual countries. There is also a sharp cross-sectional divergence in country yields relative to one another, breaking out of a tight range that had been maintained among sovereign yields since the introduction of the single currency. Panel A of Figure 1 shows that Greece and Ireland have the highest levels of sovereign yields over the sample. At the 5-year maturity, the sample-average yield spreads for these two countries are 55 and 36 basis points, respectively, as shown in Panel A of Table 1, and the standard deviation in both spreads exceeds 50 basis points. At the other end of the spectrum, Germany shows the lowest sample-average sovereign yield level, across all maturities, suggesting that its sovereign debt may have benefitted from a relative flight-to-liquidity or a flight-to-safety in the crisis.

3.1   The Independent Component of Credit versus Liquidity in Yield Spreads

In order to precisely investigate the drivers of sovereign yield spreads, I match each sovereign yield spread with the K-spread of the same maturity, such that the 2-year Italian yield spread is decomposed with the 2-year K-spread, and so on. Correspondingly, I match the sovereign CDS spreads to the sovereign yield spreads, at each of the seven maturity points considered, for each of the 11 countries in the sample. I fit the model as specified in Equation (3) in a seemingly unrelated regression (SUR) to account for contemporaneous cross-equation error correlation, which could give more efficient estimates than with independent time series regressions. I estimate the model for all of the countries and

each maturity point. The coefficient $\tilde{\beta}_{1cm}$ represents the intertemporal sensitivity of sovereign yield spreads to a common euro-area market liquidity factor, as measured by the K-spread directly, for each country-maturity pair. The coefficient β_{2m} measures the common loading across different country default premia, measured by country CDS spreads, at each maturity point. An increase in the K-spread or the sovereign CDS spread means a deterioration in liquidity and credit, respectively.

Table 3 reports the results of the sovereign bond yield spread estimation at the 2-, 5-, and 10-year maturities in Panels A, B and C, respectively.[17] The univariate regression results, in the first four columns of each panel, show that market liquidity and credit are independently significantly related to sovereign yield spreads. In the univariate regressions of sovereign bond yield spreads onto the K-spread alone, the highly significant estimate on the K-spread across countries supports the idea that there is commonality in the market liquidity effect that the measure identifies, rather than only a German-specific influence. Indeed, a test of the hypothesis that $\tilde{\beta}_{1cm} = 0$ for all countries jointly is strongly rejected. Further, if the K-spread were a poor measure of liquidity outside of Germany, then this would bias the coefficient on the K-spread in the univariate case toward zero for the non-German estimates.[18]

The joint regression of sovereign yield spreads on credit and liquidity together gives additional evidence that these two variables are independently important. Columns 5 and 6 in Table 3 show that credit and liquidity together explain over 80 percent of variation in most sovereign bond yield spreads, substantially more than is explained by either credit or liquidity alone. For liquidity alone, the average univariate R-squared values range from 61 to 68 percent, depending on the maturity, and the univariate

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[17] Results across the other eight maturities are similar, and detailed in a web appendix (http://finance.wharton.upenn.edu/~kschwarz/Mind%20the%20Gap%20Web%20Appendix.pdf.

[18] In a multivariate regression, if the liquidity measure is the only regressor that is measured with error, then the coefficient estimate on the liquidity measure would still be biased towards zero. If the mis-measurement stems from something else as well, then the biases for the individual coefficients cannot necessarily be signed, although the coefficient estimate vector must lie in an ellipsoid through the true value and the origin (Wansbeek and Meijer, 2000).

credit R-square values range from 21 to 40 percent, across maturities. Both variables remain highly significant in the joint specification, evidencing the distinct contribution of each variable to sovereign bond yield spreads. However, the balance between market liquidity and credit differs substantially by country. At the 10-year maturity, the German sovereign yield spread narrows 78 basis points, on average, for every 100 basis point widening in the same-maturity K-spread. Meanwhile, the Greek 10-year sovereign bond yield spread shows the sharpest widening when market liquidity deteriorates, rising by 152 basis points with a 100 basis point increase in the K-spread.

3.2   *The Relative Role of the K-spread versus Sovereign CDS Spreads*

To compare each country's relative sensitivity to liquidity versus credit, I consider the change in sovereign bond yield spreads associated with a one standard deviation shock to the respective measure, using the credit and liquidity coefficients estimated jointly in Columns 5 and 6 of Table 3. The bond summary statistics in Table 1 are referenced for calibration; a one standard deviation deterioration in market liquidity corresponds to an 18 to 25 basis point increase in the K-spread, depending on the maturity, as shown in Panel C. Meanwhile, a country's creditworthiness is determined by its independent fiscal position. So, intertemporal shocks to sovereign default risk are measured according to the variation in each country's respective CDS spread, as shown in Panel A of Table 1. Figure 5 plots each country's sovereign bond yield spread response in basis points, averaged over maturities for that country, to a one standard deviation deterioration in credit (x axis) versus liquidity (y axis).

The average basis-point sensitivity to shocks, shown in Figure 5, is clearly largest for Greek and Irish sovereign bonds, the two countries showing the largest absolute response to both types of shocks. Irish sovereign bond spreads widen 20 basis points on average with a one standard deviation worsening fiscal position and they widen 15 basis points with a one standard deviation deterioration in market liquidity. Greek bond yield spreads widen 13 and 29 basis points with comparable worsening in credit

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and liquidity conditions, respectively.

German sovereign bonds, on the other hand, show the greatest relative benefit from an overall worsening in euro-area market liquidity. The within-country difference in the relative role of liquidity versus credit notably shows a net *decline* in German yield spreads amid comparable negative credit and liquidity shocks. In the case of a concurrent one standard deviation negative shock to credit and liquidity, German yield spreads decline by 7 basis points on net; a 5 basis point widening is due to credit, but this is more than offset by a 12 narrowing associated with liquidity, on average. Four other countries in the sample (Austria, Finland, France and the Netherlands) show narrower spreads amid worsening liquidity alone. Although, the average yield spreads of these countries are higher on net, amid a comparable shock to credit, with the exception of the Netherlands (which narrows by one basis point). That worsening aggregate liquidity is associated with such a large relative decline in German yields supports the idea of liquidity concentration (into the most liquid market) at times of overall liquidity deterioration. This result is consistent with the anecdotal reputation of the German sovereign bond market as a euro-area liquidity haven, akin to the liquidity concentration in on-the-run U.S. Treasury securities.

Greek yields are more than twice as sensitive to liquidity versus credit, whereas credit dominates for Irish yields. The liquidity risk estimation in Section 5 will help to shed light on the nature of the liquidity effect – does it represent the manifestation of poor liquidity or the risk of worsening liquidity? The outsized role for credit in Irish sovereign yields may not be surprising since the Irish government guaranteed the debt of its private banks to prevent their collapse in 2008, explicitly adding to the government's default risk during the crisis. Intuitively, it makes sense that a country close to the default boundary would show a relatively large response to credit shocks. During the sample, the Greek debt crisis had not yet taken hold, but Greece's fiscal position was already among the weakest in the euro area. Even prior to 2007, Standard & Poors assigned a lower credit rating to Greek sovereign debt than

that of any other country in the sample.

3.3   Controlling for Country-Specific Liquidity Measures

To compare the K-spread with more traditional liquidity measures, and to address the potential concern that a measure with origins in the German bond market may not fully capture liquidity effects in other countries, I include five microstructure liquidity measures that are constructed separately from each country's sovereign bond market (described in Section 2). As before, I relate sovereign yield spreads to the K-spread and sovereign CDS spreads, except that now Equation (3) is expanded to contain $\tilde{X}_{cmt}$, the five additional microstructure liquidity measures for each country-maturity pair, as follows:

$$\tilde{y}_{cmt} = \tilde{\beta}_{1cm}\kappa_{mt} + \beta_{2m}\tilde{d}_{cmt} + \beta'_{3m}\tilde{X}_{cmt} + \tilde{\varepsilon}_{cmt} \tag{9}$$

The coefficient β_{3m} measures the sensitivity to sovereign microstructure liquidity measures, defined in section 2.4. For two out of the five market microstructure measures, a higher value is interpreted as deteriorating liquidity; the bid-ask spread and the Bollen-Whaley index, and for the remaining three measures a higher value denotes improving liquidity; volume, trade size and order flow.

The two right-most columns of Table 3 show the expanded regression results. A joint hypothesis test for all five market microstructure liquidity measures of the null, $\beta_{3m}=0$, is rejected. However, no single microstructure liquidity measure is significant across all maturities, and the estimates are unstable in sign. Further, the coefficient estimates on both the country CDS and K-spread in the expanded specification remain remarkably close to those in the bivariate case, underscoring the importance of these two variables in explaining the range of sovereign spreads in the sample.

Economically, the magnitude of the yield spread effect associated with any of the market microstructure estimates is a small fraction of that associated with a comparable change in the K-spread

or credit; a one standard deviation shock to market liquidity is associated with an average basis point yield spread change between 0.004 to 0.5 for the microstructure measures. This compares to an average yield spread change between 2 to 29 basis points associated with the K-spread for the same magnitude liquidity shock. The relatively small role for the microstructure measures as compared to credit is consistent with the results of Beber, Brandt and Kavajecz (2009), who analyzed an earlier sample period and found that credit was far more important in a regression of euro-area yield spreads onto sovereign CDS spreads (as a proxy for credit) and microstructure liquidity measures over 2003 and 2004. The minor incremental benefit to adding the controls in the regression specification is also seen by comparing the average R-squared value, across countries and maturities, in the specification that includes all of the controls, 85 percent, as compared to the average R-squared value with only sovereign CDS and the K-spread as explanatory variables, 83 percent. The incremental role for country-specific liquidity is at most very small, once common liquidity is controlled for with the K-spread. The results suggest that the common component of sovereign bond market liquidity dominates any country-specific effect over the sample, which will be further explored in Section 5.

4.   Credit versus Liquidity in Euro-Area Interbank Spreads

Now, turning to euro-area money markets, I use the same empirical strategy to parse EURIBOR-OIS spreads as in the sovereign bond estimation, which is presented in Equation (5). The difference is that there is only a single interest rate to parse at each maturity point since the representative interbank rate does not vary by country, as discussed in Section 1, and the transmission of liquidity effects from bond markets to funding markets is key to the K-spread's importance in interbank risk spreads.

Specifically, I conduct time-series regressions as follows:

$$\tilde{y}_{mt} = \beta_{1m}\kappa_t + \beta_{2m}d_t + \beta_{3m}d_t^{cds} + \beta_{4m}'X_t + \varepsilon_{mt} \tag{10}$$

where $\tilde{y}_{mt}$ denotes the EURIBOR minus OIS spread at maturity m on day t, κ_t is the 1-year K-Spread measure of euro-area market liquidity, d_t is the new measure of overnight interbank credit risk (described in subsection 2.6), d_t^{cds} is the average CDS premium of the EURIBOR survey banks at the 1-year maturity and X_t is a vector containing the additional overnight interbank microstructure liquidity measures constructed from e-MID transactions data. Separate regressions are run for the 1-, 3-, 6- and 12-month EURIBOR-OIS maturities, the most commonly referenced interbank rate horizons.

4.1   The Relative Role of Credit and Liquidity in Interbank Interest Rates

Table 4 shows the estimation results for Equation (10), at each of the four maturity points in Panels A through D. The first 3 columns of each panel show estimates from univariate regressions of EURIBOR-OIS spreads onto the K-spread, the bank-tiering credit measure and the bank CDS premia, with no additional controls. For each variable on its own, the coefficient estimate is significant at the 1 percent level, indicating that credit and liquidity individually play a significant role in explaining EURIBOR-OIS spreads, as was found for sovereign bond yield spreads in Section 3. The estimates are all positive, consistent with the intuition that a deterioration in either credit or liquidity conditions would lead banks to charge one another a higher borrowing premium. On average; the univariate adjusted R-Squared values for regressions on the K-spread range from 76% to 88%, depending on the maturity, as compared to 50 to 53 percent for the univariate regressions onto the overnight interbank credit tiering measure alone, and 16% to 41% for the univariate regressions on the 1-year bank CDS measure alone.

The fourth column of each panel in Table 4 shows the joint effect of credit and liquidity, which is estimated with a regression of EURIBOR-OIS spreads onto both the K-spread and the bank-tiering

credit measure, at each maturity. Comparing the bivariate results to the univariate case, the coefficient estimates on the K-spread are nearly unchanged in size, but the bank-tiering credit estimates fall to less than one quarter of their univariate size. Using the bivariate estimates, I compare the EURIBOR-OIS spread response to a comparable shock in credit and liquidity by considering the effect of a one standard deviation shock to each measure; 26 basis points for the K-spread and 8 basis points for the bank-tiering credit measure (Panel B of Table 2). A one standard deviation shock to the K-spread is associated with a 23 to 49 basis point increase in the EURIBOR-OIS interest rate spread, and the magnitude of the estimate increases in maturity. Meanwhile, a comparable shock to the bank-tiering credit measure implies a much-smaller 2 to 4 basis point EURIBOR-OIS spread increase, depending on the maturity.

To evaluate the possibility that the bank CDS premia could explain additional variation in interbank spreads, I include both of the credit variables as regressors along with the K-spread (fifth column of Table 4). I find that the bank CDS estimates are insignificant at the 6- and 12-month maturities and unstable in sign, even though the maturity of the bank CDS measure matches the 12-month EURIBOR-OIS horizon precisely. Bank CDS premia add little information beyond that already captured with the bank-tiering credit measure.

4.2   Controlling for Interbank Liquidity Measures

The K-spread liquidity measure is formed in the sovereign bond market, and so a potential concern is that it may not fully capture market liquidity in interbank spreads. To address this, I now include five interbank market microstructure liquidity measures, formed with overnight interbank transaction data, as controls. In contrast to the sovereign bond estimation, the interbank controls do not differ from the K-spread in the dimension of common versus idiosyncratic risk. Nonetheless, as in the sovereign bond estimation, the interbank transaction-based measures do not capture the effect of liquidity risk as the asset price-based K-spread measure does.

Table 4 shows that the alternative liquidity measures contribute little, if at all, to the explanation of EURIBOR-OIS spreads, beyond what is already captured by the K-spread and credit; the adjusted R-squared values range from 86% to 92% (column 6) when including all of the additional interbank liquidity controls, which is very close to the range of 86% to 89% in R-squared (column 5) without the microstructure controls. The final column in each Panel of Table 4 shows the result from the expanded specification that includes all variables except the K-spread. A comparison of the first with the final column of Table 4 shows that the other seven credit and liquidity measures together explain less of the variation in EURIBOR-OIS than the K-spread alone, at each maturity.

The models of Brunnermeier and Pedersen (2009) and Bolton, Santos and Scheinkman (2011) describe a close relationship between bond and funding markets that shows how sovereign bond yields could be informative for money market rates. The results in this paper give direct empirical evidence of this relationship, specifically in the context of market liquidity. Such an important role for the K-spread suggests that this measure captures a liquidity channel that is missed by the other liquidity measures considered. In the interbank market, the missed channel could include the transmission of liquidity from the bond market to the money market, or the risk of worsening liquidity in the future. The pricing of liquidity risk in sovereign bond yields will be directly tested for in the next section.

The estimation results in Table 4 suggest that steps to improve market liquidity alone could narrow interbank spreads substantially, independent of any credit effect. Consider an extreme hypothetical counterfactual scenario in which all assets are made equally liquid. The K-spread would then be zero (below even the small positive spread prior to the crisis). Judging from the bivariate regression results in fourth column of each panel in Table 4, this would narrow the sample-average EURIBOR-OIS spread to 5 basis points at the 1-month maturity and 20 basis points at the 12-month maturity, closely approximating the narrowness of pre-crisis interbank spreads (illustrated in Figure 2,

Panel B).[19] The other regression specifications give similar implications. The importance of liquidity in interbank spreads is consistent with the results of Gefang, Koop and Potter (2011) who find that a liquidity factor helps explain much of the variation in a panel dataset of LIBOR-OIS spreads.

A near absence of credit risk at the very shortest interbank horizons may seem surprising at first, but it could partly stem from a belief that government intervention would prevent near-term bank defaults, especially for the large banks that comprise the EURIBOR survey. Beginning in August 2007, U.S. and European central banks took many operational measures to target general funding pressures.[20] Though such measures may mitigate default risk in the short run, they could exacerbate long-run risk if the extraordinary measures taken by the authorities are not sustainable.

5.   Pricing Liquidity Risk

Liquidity risk is a forward-looking manifestation of market liquidity, defined as the covariance of sovereign bond returns with changes in market liquidity. To the extent that the liquidity risk channel matters, the effect of overall market liquidity in interest rates is understated by liquidity measures that only reflect instantaneous risk pricing. For example, the liquidity risk channel is missed by market transaction characteristics, such as bid-ask spreads and trading volume. However, a liquidity measure constructed directly from bond yield spreads includes all of the information embedded in asset prices. Sections 3 and 4 of this paper give evidence that microstructure variables show a lesser role for liquidity in sovereign and interbank risk spreads, respectively, than the K-spread. This leaves scope for liquidity

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[19] The sample-average EURIBOR-OIS spread is 30 and 75 basis points at the 1- and 12-month maturities, respectively (Table 2, Panel A), and the K-spread is 26.4 basis points on average over the sample (Table 2, Panel B). At the 1-month maturity, a K-spread equal to 0 implies a decline in the 1-month EURIBOR-OIS spread to 0.94×26.4=25 basis points, and 2.08×26.4=55 basis points at the 12-month maturity. Subtracting these from the sample-average OIS spreads give 1- and 12-month EURIBOR-OIS spreads of 30-25=5 and 75-55=20 basis points, respectively.

[20] These measures include massive overnight funds injections, loosening the terms of standard funds injections (such as accepting a broader range of collateral), relaxing the terms of emergency lending facilities (such as widening the base of eligible counterparties), and introducing new dollar swap, term funds lending, and securities lending facilities. See Brunnermeier (2009) for a detailed account of liquidity and credit events over this period.

risk to account for the relatively larger liquidity effect given by the K-spread, which I now investigate.

The rich cross-section of bond returns across countries and maturities in the euro-area is an ideal setting in which to directly test the pricing of liquidity risk.[21] I employ a two-step Fama MacBeth procedure to estimate sovereign bond liquidity risk premia. In the first step of the estimation, I assess the factor sensitivity of each country's sovereign bond market to changes in the K-spread by running a different time series regression for each country-maturity combination.[22] The estimated regression is:

$$\tilde{y}_{cmt} - \tilde{y}_{cmt-1} = \alpha_{cm} + \beta_{cm}^{Liq}(\kappa_{mt} - \kappa_{mt-1}) + \varepsilon_{cmt} \tag{11}$$

where $\tilde{y}_{cmt} - \tilde{y}_{cmt-1}$ denotes the change in the country yield spread, relative to the corresponding 11-country average, from holding the zero-coupon bond of that country c and maturity m from day t-1 to day t, and $\kappa_{mt} - \kappa_{mt-1}$ denotes the corresponding change in the K-spread. I estimate β_{cm}^{Liq} for each of the 77 country-maturity pairs, which identifies each country-maturity pair's sensitivity in sovereign bond returns to changes in aggregate market liquidity. An asset with a very positive β_{cm}^{Liq} has relatively low returns (rising yield spreads) if aggregate liquidity deteriorates, whereas an asset with a negative β_{cm}^{Liq} is a good hedge because it has high returns when liquidity worsens. The largest absolute β_{cm}^{Liq} estimates are -0.31 for Germany and 0.38 for Greece, both at the 5-year maturity, and the β_{cm}^{Liq} standard deviation is 0.17. Cross-sectional variation in the liquidity betas helps to precisely identify liquidity risk premia in the second-stage regression.

To learn whether the relative ranking of liquidity risk betas is systematically related to future expected returns, I proceed to the second step of the Fama MacBeth procedure. To control for credit and liquidity characteristics that could affect the yield spread separately from liquidity risk, I include the

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[21] The EURIBOR-OIS spread does not have the same cross-country variation needed for liquidity risk identification.
[22] The excess return is approximately the negative change in yield, multiplied by the duration.

sovereign CDS spreads and microstructure liquidity measures, as considered in the sovereign yield spread decomposition in Section 3. I run the following cross-sectional regression:

$$\tilde{y}_{cm} = \gamma_0 + \gamma_1 \beta_{cm}^{Liq} + \gamma_2' X_{cm} + \varepsilon_{cm} \tag{12}$$

where $\tilde{y}_{cm}$ is the sample-average sovereign yield spread for country, c, at maturity, m, β_{cm}^{Liq} is the coefficient estimate on the K-spread in the time series regressions in Equation (11), and X_{cm} represents the controls (CDS spreads and liquidity characteristics).[23] In this regression, γ_1 gives the market pricing of liquidity risk and γ_2 gives the direct effects of CDS spreads and liquidity characteristics on yield spreads. Thus, if X_{cm} is a liquidity measure, then the coefficients γ_1 and γ_2 can be thought of as liquidity being a factor and a characteristic, respectively, in the terminology of Daniel and Titman (1997).

The results in Table 5 show that liquidity *risk* is priced in sovereign bond markets, with or without including the control variables. The coefficient estimate, γ_1, is highly significant and positive, in all specifications, reflecting a premium demanded by investors for the *risk* that bonds will become less liquid in the future. An investor demands a higher yield on bonds that are risky in the sense of the bonds offering lower returns if aggregate liquidity is poor. Figure 7 plots the average basis point effect of liquidity risk on country sovereign bond yields, by maturity, using the second stage regression estimates that include all controls (column 3 of Table 5). Perhaps unsurprisingly, liquidity risk tends to play the smallest role in the shortest-maturity bonds, but the effect of liquidity risks peaks around the 5-year maturity for most of the countries in the sample.

On average across the maturities shown in Figure 7, liquidity risk accounts for a 12 basis point discount on German sovereign bond yields, which is remarkably close in magnitude to the 14 basis point

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[23] The strategy is similar in spirit to Calomiris, Love, and Peria (2012), who consider a cross-sectional regression of firms' average stock returns onto their time-series betas with respect to crisis shocks.

premium on Greek sovereign bond yields, relative to the euro-area average. On the other hand, the estimates suggest that Irish sovereign bond yields are far less affected by liquidity risk than Greek bond yields, perhaps explained as a largely temporary liquidity-disruption associated with the Irish banking crisis. Meanwhile, Italian sovereign bond yields show nearly as large of a liquidity risk premium in basis points as Greek yields. Though Italian sovereign bond yield spreads were narrower and less volatile than those of Ireland, over the sample, a relatively high risk of worsening Italian market liquidity is priced.

The coefficient estimate on sovereign CDS spreads, γ_2, shown in the second and third columns of Table 5, is also highly significant and positive, which is consistent with the important role shown for credit in the sovereign yield spread estimation in Section 3. Liquidity characteristics, as represented by the microstructure liquidity variables, have little role in explaining sovereign yield spreads if we include the K-spread liquidity risk beta coefficient as a factor. The regression including all controls increases the adjusted R-Squared value by only 0.02 when compared to a regression with only β^{liq} and CDS.

The results in this section evidence that there is indeed a systematic relationship among the sensitivities of different country sovereign bond markets in the euro area to a common liquidity factor. The nature of the relationship benefits the German sovereign bond market relative to other country bond markets when liquidity worsens in aggregate. In the crisis sample period, a measure of liquidity risk pricing helps to better understand the relative yield movements among the different euro-area country bond markets, beyond what is explained by instantaneous liquidity effects.

6. Conclusion

Beginning in August 2007, interest rate spreads across markets widened dramatically, threatening the stability of the financial system and the broader economy. There are two primary factors behind these movements: (1) a higher likelihood of default, and (2) market liquidity effects, separate from default

risk. Policy prescriptions for addressing risk conditions differ, depending on the primary driver of interest rate spread widening. If the chief component is default risk, then only actions to improve the solvency of the issuer are likely to be successful. On the other hand, if the main risk driver is market liquidity, then measures to improve market functioning are the most appropriate. From a practitioner standpoint, a disruption to market liquidity may represent an attractive opportunity for a long-horizon investor to exploit, whereas deteriorating credit risk would not.

The first contribution of this paper is to construct a new market liquidity factor from asset prices that does not rely on any particular model of market liquidity, and that fully captures market liquidity effects. The yields on German KfW-agency bonds and federal government bonds have identical credit risk, but they load differently on a common liquidity factor. So the yield spread between these two bonds at a particular maturity is a measure of market liquidity that captures all forward-looking information impounded in bond yields.

Second, I use the new liquidity factor, which I refer to as the K-spread, to estimate the precise contribution of credit and market liquidity risks, independent from one another, in explaining euro-area sovereign bond and EURIBOR-OIS spreads during the 2007-2009 financial crisis. Credit and market liquidity each have important effects in explaining these spreads. However, the effect of liquidity in interbank spreads overwhelms that of credit. The K-spread captures two dimensions of liquidity that are not contained in interbank transaction-based measures of liquidity; the transmission of bond market liquidity to interbank funding markets, and the forward-looking liquidity risk channel. These effects can help to explain the magnitude of the liquidity effect found interbank risk spreads.

A liquidity measure that is formed from forward-looking bond yields incorporates the premia associated with the risk of future market liquidity: the compensation that investors demand for the possibility that liquidity will worsen in the future at a time when they might most want to transact.

Transaction-based measures of current liquidity will tend to understate the contribution of liquidity to interest rates since they do not capture this liquidity channel. This underestimation is most critical at times of market stress when risk premia play an important role. Using dispersion in return sensitivities over time, countries and maturities, I find large and highly significant liquidity factor risk premia in bonds over the crisis sample period.

This paper provides new empirical evidence for the general equilibrium relationship between asset markets and money markets, in that a market liquidity measure constructed entirely in the bond market shows a large and significant role in explaining money market rates. The results have implications for policymakers and for the portfolio choices of investors. For practitioners, the liquidity measure itself is a yield spread that can be captured in a long-short position to hedge against any fluctuations other than liquidity. The measure can also gauge real-time pricing of market liquidity risk. For policymakers, the results imply that measures to improve market functioning, even an action that addresses risk perceptions alone, could be effective in bringing down risk spreads. Such measures can help to avoid the risk of an adverse feedback loop between the liquidity of asset markets and the liquidity of funding markets, and in turn the state of the economy.

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Appendix 1: Bank Credit Estimation

Suppose that the *spread* between the interest rate that bank j has to pay on day t and the hypothetical risk-free interest rate is multiplicative of the form $b_j r_t$ where b_j is a bank fixed effect and r_t is a time fixed effect. Normalize the average b_j to one and let the cross-sectional dispersion (standard deviation) of b_j be θ. Then the average credit premium on any day is r_t and the dispersion of rates across banks on any day is θr_t. The average credit premium on day t is thus proportional to the dispersion in rates. [24]

In the case of interbank credit premia, as the default risk of low credit institutions worsens, that of high credit institutions worsens proportionately more, and so an increase in the average rate difference between these two tiers of borrowers reflects an increase in the overall level of credit. The intuition is consistent with that of structural credit models. For instance, the Merton (1974) model predicts that the credit premium is approximately proportional to rate volatility. It is also consistent with the idea that credit is largely driven by a systemic factor, as per Longstaff, Pan, Pedersen and Singleton (2011).

To convert the bank-tiering intuition into empirical data, I obtain a unique database of signed interbank transactions from e-MID, an electronic interbank trading platform. These data show the negotiated rate and bank identities of the borrower and lender for each individual trade that takes place over the sample, plus the time stamp, maturity, volume, and the initiating side of each trade.[25] There are

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[24] A simple example illustrates the model's multiplicative assumption. Suppose $r_t = 1$ on a day with low credit and $r_t = 5$ on a day with high credit, and suppose $b_j = 0.5$ for the best credit bank and $b_j = 1.5$ for the worst credit bank. Then credit tiering on a good credit day would be $r_{low} b_{worst} - r_{low} b_{best} = 1$ and credit tiering on a bad credit day would be $r_{high} b_{worst} - r_{high} b_{best} = 5$.

[25] One distinct advantage of the new credit measure is that it is constructed from rates on actual unsecured interbank transactions and thus reflects true borrowing costs, whereas survey-derived rates such as LIBOR may be affected by

two key features of the e-MID platform that are important to the interpretation of the transaction rates. First, the lender in a trade is fully exposed to the default risk of a borrower in these trades that are facilitated but not backed by e-MID. This contrasts with trades in centrally cleared markets, such as futures, where the clearinghouse effectively becomes the counterparty to each trade. Second, e-MID transactions are identity-transparent; a participant can view all limit orders posted by platform participants, alongside of their respective bank identities, and can choose to take the other side of any order that is posted.[26] A bank will initiate a market order to lend only if the posted borrowing rate sufficiently compensates the lender for the risk of the trade. It follows that the credit-relevant information on e-MID comes from the rates on limit orders to borrow (or equivalently market orders to lend), where trades are agreed to with the foreknowledge of the borrower's identity.[27]

I use the rate and borrower identity information in e-MID limit order data to form a bank-tiering measure of credit, in the following 3 steps.

1. First, to estimate banks' credit quality, I run the following pooled regression: [28]

$$r_{hijt} = \alpha + \Sigma_{h=1}^{m-1}\beta_{1h}T_h + \Sigma_{j=1}^{n-1}\beta_{2j}B_j + \Sigma_{t=1}^{T-1}\beta_{3t}D_t + \varepsilon_{ihjt} \tag{11}$$

where $r_{h,i,j,t}$ denotes the unsecured interbank rate paid by borrower j in its ith transaction on day t in

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manipulation. A comparison of LIBOR and other measures of bank borrowing costs is reported in Kuo, Skeie and Vickery (2012).

[26] In contrast, the MTS bond trading platform follows conventional price-time priority; trades are matched automatically based on the most attractive bid or offer submitted, with priority given to the earliest submission. The identity of its counterparty is revealed only after the trade takes place, which incidentally eliminates any effect of counterparty risk from bond trades on the MTS platform.

[27] The intuition behind an identity-transparent platform for interbank markets is that the interbank loan is effectively the equivalent to the traded asset in an asset market. Just as a bond market participant would find it difficult to price a bond without knowing the identity of the bond issuer, an interbank market participant would be reluctant to lend unsecured funds to a mystery borrower. The relationship between a counterparty's default risk and the credit of an interbank trade is precisely what drives the transparent information structure of the e-MID platform. The importance of the borrower's identity is evident in that 81 percent of interbank lending volume in the sample occurs via market order. Following the crisis, e-MID introduced a parallel platform where identities were not revealed, but there was very little market interest to transact "confidentially."

[28] Estimation is necessary because each bank in the sample has a unique but generic identifier that does not reveal the bank's actual identity. *A priori*, I cannot tell which banks are good/bad credits from their e-MID identifiers alone.

hour h. β_{1h} denotes the time-of-day indicator variable for each hour, h, β_{2j} denotes the indicator variable for bank borrower j, and β_{3t} denotes the indicator variable for day t. The day and time indicators control for any effect that is common to all rates, including interbank market-wide liquidity shocks.[29] The bank dummy coefficient, β_{2j}, then estimates the average credit quality of each institution.[30] Considering only one side of the quote (the borrowing rate) avoids any bid-ask bounce effect, which would otherwise add noise to the measure. I re-estimate the banks' creditworthiness each day, using the past 30 days of transactions, updating the relative ranking of banks based on each banks' most recent borrowing rates.

2. In the second step, I sort borrowers into credit quintiles according to their β_{2j} credit coefficient estimates; the top quintile represents the banks that on average paid the highest rates and are thus perceived as the worst credits.[31] Each quintile contains the same number of banks. For an apples-to-apples comparison across quintiles, I use only maturity-matched trades, those agreed to for maturity the next business day.[32] Further, to mitigate any effects of survivorship bias, I only use the rates of banks that transacted in both the first and the last quarters of the sample, which reduces the sample

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[29] Controlling for the day effect in Equation (11) is important as the overall level of rates changed over the sample. The ECB raised its policy rate by 25 basis points on March 14, 2007 and again on June 13, 2007. Another way to isolate the credit component of interbank rates is to subtract the daily GC repo rate from the left-hand side of Equation (11). However, this approach confounds the credit component with repo market seasonality.

[30] There is no way to insure against the default of interbank deposits. In principal, a CDS contract could be entered into each day with the counterparty's debt as the reference obligation, but transactions costs would be prohibitive. In practice, these loans are not resold. Novation requests, or third party risk assumption for a transaction, occurred during the crisis. But, this was motivated by risk reduction of outstanding obligations, not to insure new transactions.

[31] To check whether I have captured the difference between rates paid by high credit and low credit institutions, I consider the propensity to borrow via limit order versus market order for different credit quintiles. Especially low credit banks should want to borrow via limit order, so that their identity is factored into the counterparty's decision to lend at a particular rate; the lending bank will know that the borrower is low risk and will thus agree to a relatively low rate. It turns out that borrowing via market order as a fraction of total borrowing is 92 percent in the best credit quintile, compared to 57 percent in the lowest credit quintile. In fact, the propensity to borrow via limit order is monotonically increasing in credit quintile, supporting the idea that the grouping of banks by quintile has indeed separated the good credit banks from the bad credit banks.

[32] In the sample, 91 percent of transaction volume is agreed to for maturity on the following business day. This is comparable to the interbank market as a whole, in which the vast majority of transactions are overnight, to help banks meet day-to-day fluctuations in their funding needs.

from 150 banks to 135 banks.

3. In the third and final step, I define the bank-tiering credit measure. Let $\bar{r}_{tj,High}$ and $\bar{r}_{tj,Low}$ denote the average rates paid by the banks in the highest and lowest risk quintiles, respectively, on day t at time h. The bank-tiering credit measure is:

$$credit_t = \frac{\sum_{h=1}^{m}\left(\bar{r}_{tj,High} - \bar{r}_{th,Low}\right)}{m} \tag{12}$$

where m is the number of hours in the day.

Table 1. Sovereign Bond Market

Panel A: Sovereign Yield Spreads, Sovereign CDS Spreads, and Microstructure Liquidity Measures (Deviations from 11-Country € Average)

	Sovereign Yield Spread$_c$ (bps)		Sovereign CDS$_c$ (bps)		Bid-Ask$_C$ (bps)		Volume$_C$ (€bn)		Trade Size$_C$ (€mn)		Order Flow$_C$ (€bn)		BW Index$_C$ (ratio)	
	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev	Mean	St Dev
2-Year Maturity														
Austria	1.83	7.09	10.63	23.19	0.29	0.91	-0.11	0.09	1.39	1.91	-0.01	0.26	0.05	0.21
Belgium	4.49	5.26	-2.33	4.95	0.75	0.75	-0.09	0.09	1.02	2.13	-0.08	0.39	0.01	0.30
Germany	-14.97	16.52	-12.85	15.34	-0.19	0.36	-0.07	0.08	-0.01	1.88	0.02	0.18	0.08	0.26
Spain	5.07	6.76	5.96	6.69	0.62	0.64	-0.10	0.08	1.07	2.52	0.00	0.26	0.05	0.22
Finland	-7.42	7.62	-11.98	14.37	-0.28	1.02	-0.12	0.09	-0.60	2.76	0.00	0.21	0.18	0.31
France	-7.50	9.34	-11.63	13.60	0.39	0.52	-0.08	0.08	0.62	2.13	-0.04	0.21	0.03	0.21
Greece	42.60	47.52	32.90	40.47	0.29	0.93	-0.11	0.08	-0.69	2.37	0.02	0.22	0.11	0.28
Ireland	17.14	33.27	44.74	65.60	-0.75	1.09	-0.12	0.09	1.40	2.06	0.14	0.20	-0.09	0.21
Italy	14.54	16.37	15.35	18.15	-0.55	0.37	0.26	0.20	-2.02	1.30	0.02	0.24	-0.13	0.15
Netherlands	-9.75	10.48	-4.77	4.63	0.01	0.62	-0.09	0.14	2.39	4.74	0.03	0.63	-0.03	0.20
Portugal	14.00	13.73	4.39	5.57	-0.34	1.21	-0.07	0.09	1.24	1.81	0.02	0.44	-0.11	0.21
5-Year Maturity														
Austria	1.25	7.48	10.00	26.10	0.47	2.20	-0.05	0.07	0.90	2.33	-0.03	0.25	0.09	0.74
Belgium	7.33	7.99	-2.31	4.86	1.38	1.38	-0.01	0.08	0.55	1.96	-0.05	0.28	0.05	0.72
Germany	-23.37	22.26	-17.68	17.07	-2.18	1.70	-0.04	0.06	-0.55	1.81	0.00	0.17	0.07	0.64
Spain	4.33	7.16	10.17	8.26	1.26	2.40	-0.03	0.07	1.16	2.44	0.02	0.24	0.09	0.96
Finland	-3.34	4.24	-16.35	15.65	-0.15	2.08	-0.03	0.07	1.65	1.80	-0.12	0.36	-0.12	0.56
France	-8.52	9.74	-14.88	14.77	1.26	1.20	-0.04	0.06	-0.20	1.90	-0.01	0.16	0.15	0.60
Greece	54.94	59.45	41.69	43.41	0.41	1.84	-0.04	0.06	-0.42	2.01	0.00	0.16	0.20	0.68
Ireland	35.76	54.79	44.41	63.10	-0.44	1.78	-0.05	0.06	0.73	2.47	-0.01	0.27	-0.24	0.56
Italy	15.66	13.41	21.09	18.96	-0.74	1.25	0.16	0.19	-1.60	1.14	0.03	0.31	-0.27	0.46
Netherlands	-4.29	3.76	-9.20	6.46	-0.64	1.97	-0.03	0.12	2.35	2.64	0.04	0.51	-0.17	0.52
Portugal	16.09	15.69	7.32	6.73	0.52	2.14	-0.01	0.09	1.12	2.03	0.01	0.36	-0.14	0.47
10-Year Maturity														
Austria	-2.36	6.47	5.55	23.04	-0.16	3.79	-0.03	0.06	1.18	2.35	-0.02	0.22	-0.38	1.46
Belgium	-0.29	4.48	-5.13	6.45	1.30	3.97	-0.03	0.06	2.15	2.13	0.04	0.23	-0.27	1.37
Germany	-26.76	22.33	-21.73	19.15	-7.93	4.72	-0.02	0.06	1.21	2.15	-0.06	0.25	-0.99	1.34
Spain	1.44	6.56	9.07	7.79	0.79	4.50	-0.03	0.06	2.26	2.18	-0.03	0.20	-0.16	1.70
Finland	-13.19	7.27	-19.40	16.57	-2.89	4.91	-0.01	0.08	2.74	1.68	-0.19	0.47	-0.89	1.30
France	-13.43	12.75	-18.29	16.30	2.70	3.18	-0.03	0.06	-0.59	1.68	0.02	0.14	0.59	1.46
Greece	50.20	46.18	40.85	37.37	2.61	4.67	-0.02	0.06	-0.06	2.58	0.02	0.17	0.42	1.52
Ireland	34.64	55.50	39.14	56.05	-0.19	3.03	-0.03	0.06	0.97	2.68	-0.01	0.18	-0.08	1.57
Italy	20.93	13.44	21.37	15.44	-0.28	3.00	0.08	0.15	-1.96	1.04	0.02	0.19	0.02	1.40
Netherlands	-11.74	8.91	-12.79	8.06	3.40	6.50	-0.02	0.15	0.91	2.80	0.06	0.72	0.38	2.15
Portugal	11.27	10.14	6.13	8.95	-0.27	5.24	0.01	0.09	0.23	2.08	-0.04	0.44	-0.30	1.77

Panel B: Credit and Liquidity Correlation, by Maturity

	K-Spread (bps)	Sovereign CDS (bps)	Bid-Ask (bps)	Volume (€bn)	Trade Size (€mn)	Order Flow (€bn)	BW Index (ratio)
2-Year Maturity							
K-Spread	1.00						
Sovereign CDS	0.19	1.00					
Bid-Ask	-0.12	-0.12	1.00				
Volume	0.17	0.07	-0.17	1.00			
Trade Size	0.00	-0.05	0.02	-0.08	1.00		
Order Flow	0.04	0.06	-0.11	0.14	0.13	1.00	
BW Index	-0.12	-0.19	0.30	-0.24	-0.30	-0.01	1.00
5-Year Maturity							
K-Spread	1.00						
Sovereign CDS	0.21	1.00					
Bid-Ask	0.03	-0.07	1.00				
Volume	0.04	0.04	-0.10	1.00			
Trade Size	-0.05	-0.22	0.03	0.02	1.00		
Order Flow	0.03	0.03	0.00	0.16	0.09	1.00	
BW Index	-0.03	-0.07	0.26	-0.21	-0.37	-0.01	1.00
10-Year Maturity							
K-Spread	1.00						
Sovereign CDS	0.15	1.00					
Bid-Ask	0.11	0.20	1.00				
Volume	0.05	0.02	-0.12	1.00			
Trade Size	-0.07	-0.21	-0.20	0.07	1.00		
Order Flow	0.05	0.02	0.12	0.21	0.00	1.00	
BW Index	-0.05	0.09	0.41	-0.14	-0.37	0.08	1.00

Panel C: K-Spread Statistics and Correlation with Euro-Area Average Microstructure Measures

	K-Spread		Bid-Ask$_\epsilon$	Volume$_\epsilon$	Trade Size$_\epsilon$	Order Flow$_\epsilon$	BW Index$_\epsilon$
	(bps)	(bps)	(bps)	(€bn)	(€mn)	(€bn)	(ratio)
	Mean	St Dev	Correlation with K-Spread				
2-Year Maturity	30.70	25.23	0.70	-0.55	0.01	0.01	0.49
5-Year Maturity	35.72	24.87	0.83	-0.36	-0.17	0.03	0.60
10-Year Maturity	27.60	18.30	0.82	-0.33	-0.52	0.03	0.58

Table 1. This table reports summary statistics for euro-area sovereign bonds, at the 2-, 5-, and 10-year maturities. Panel A reports the mean and standard deviation for sovereign zero-coupon yield spreads, CDS spreads and microstructure liquidity measures for each of the 11 countries separately. Each of the measures is expressed as the country indicator's deviation from the sovereign debt-weighted euro-area average indicator. Panel B reports correlations among the K-spread liquidity measure and the other sovereign bond market measures that are reported in Panel A. The CDS spreads and microstructure liquidity measures are de-meaned, but the K-spread is not, as it does not vary by country. The correlations are run separately for each maturity, using all country data. Panel C reports the K-spread mean and standard deviation, and the K-spread's correlation with the euro-area average of each of the microstructure liquidity indicators. All statistics in Panels A, B and C are formed from data at the daily frequency. The sample period is from January 1, 2007 to September 30, 2009.

Table 2. Interbank Money Market

Panel A: Interest Rates and Spreads by Maturity

	EURIBOR (pct pts)		OIS (pct pts)		EURIBOR - OIS (bps)	
	Mean	St Dev	Mean	St Dev	Mean	St Dev
1-Month Maturity	3.33	1.47	3.02	1.45	30.41	29.54
3-Month Maturity	3.63	1.45	3.02	1.48	60.04	42.33
6-Month Maturity	3.73	1.40	3.04	1.51	69.05	48.19
12-Month Maturity	3.84	1.37	3.09	1.48	75.06	53.88

Panel B: Credit and Liquidity Indicators

	K-Spread (bps)	Bank-Tiering (bps)	Bank CDS (bps)	Bid-Ask (bps)	Volume (€bn)	Trade Size (€mn)	Order Flow (€bn)	BW Index (ratio)
Mean	26.40	8.27	59.26	4.52	11.29	33.35	-7.40	1.01
Std. Dev.	23.57	9.03	56.79	6.28	6.15	14.12	4.66	1.91
Correlation								
K-Spread	1.00							
Bank-Tiering	0.74	1.00						
Bank CDS	0.69	0.59	1.00					
Bid-Ask	0.19	0.39	0.58	1.00				
Volume	-0.56	0.22	-0.69	-0.61	1.00			
Trade Size	-0.52	0.37	0.54	0.51	0.15	1.00		
Order Flow	0.42	-0.48	-0.60	-0.55	-0.58	-0.12	1.00	
BW Index	0.06	-0.44	0.41	0.92	-0.90	-0.51	0.50	1.00

Table 2. This table reports summary statistics for euro-area interbank money markets. Panel A reports the mean and standard deviation of the EURIBOR and OIS rates and spreads at 1-, 3-, 6-, and 12-month maturities. Panel B reports the mean and standard deviation for the one-year maturity K-spread liquidity measure, the overnight bank-tiering credit measure, the overnight interbank market microstructure liquidity measures and the one-year euro-area average bank CDS premia. Correlations among these indicators are also reported. The K-spread is constructed as the one-year KfW yield minus the one-year German federal government yield. The bank-tiering credit measure is formed as the difference in average unsecured interbank borrowing rates paid by the banks in the highest and lowest risk quintiles (estimated in Appendix 1) on each day, using data on overnight interbank borrowing transactions from a large electronic trading platform, e-MID. The market microstructure liquidity measures are also formed with the overnight interbank data. The bank CDS measure is the simple average of the EURIBOR panel banks' one-year CDS premia on each day. All statistics in Panels A and B are formed from data at the daily frequency. The sample period is from January 1, 2007 to September 30, 2009.

Table 3. Credit versus Liquidity in the Bond Market

Dependent Variable: Sovereign Yield Spread$_{cmt}$

Panel A: 2-Year Maturity

	Country	Est. (SE)	Adj. R^2	Est. (SE)	Adj. R^2	Est. (SE)	Adj. R^2	Est. (SE)	Adj. R^2
K-Spread	Austria	0.00 (0.03)	0.00			-0.10*** (0.01)	0.47	-0.09*** (0.01)	0.59
	Belgium	0.18*** (0.01)	0.72			0.18*** (0.00)	0.83	0.18*** (0.00)	0.86
	Finland	-0.26*** (0.01)	0.76			-0.13*** (0.00)	0.89	-0.15*** (0.00)	0.92
	France	-0.32*** (0.02)	0.73			-0.15*** (0.00)	0.96	-0.17*** (0.00)	0.97
	Germany	-0.62*** (0.03)	0.90			-0.40*** (0.00)	0.98	-0.42*** (0.00)	0.98
	Greece	1.60*** (0.13)	0.72			1.12*** (0.01)	0.97	1.16*** (0.01)	0.98
	Ireland	1.00*** (0.10)	0.58			0.28*** (0.02)	0.75	0.32*** (0.02)	0.80
	Italy	0.59*** (0.02)	0.83			0.35*** (0.01)	0.95	0.38*** (0.01)	0.96
	Netherlands	-0.31*** (0.02)	0.57			-0.28*** (0.01)	0.78	-0.28*** (0.01)	0.81
	Portugal	0.50*** (0.03)	0.86			0.44*** (0.00)	0.94	0.44*** (0.00)	0.94
	Spain	0.23*** (0.02)	0.76			0.15*** (0.00)	0.83	0.15*** (0.00)	0.85
Sovereign CDS$_c$	Joint			0.42*** (0.00)	0.30	0.31*** (0.00)		0.27*** (0.00)	
Bid-Ask$_c$	Joint							-0.21*** (0.05)	
Volume$_c$	Joint							-3.96*** (0.37)	
Trade Size$_c$	Joint							-0.02 (0.02)	
Order Flow$_c$	Joint							0.27** (0.13)	
BW Index$_c$	Joint							-0.27 (0.17)	

Hypothesis Tests

	F-Statistic	F-Statistic	F-Statistic
H$_0$: $\tilde{\beta}_{1cm} = 0$	9244.36***	2940.57***	5128.03***
H$_0$: $\beta_{2m} = 0$		4962.43***	2299.94***
H$_0$: $\beta_{3m} = 0$			16.71***

Panel B: 5-Year Maturity

	Country	Est. (SE)	Adj. R^2	Est. (SE)	Adj. R^2	Est. (SE)	Adj. R^2	Est. (SE)	Adj. R^2
K-Spread	Austria	0.14*** (0.03)	0.23			-0.06*** (0.00)	0.81	-0.06*** (0.00)	0.82
	Belgium	0.29*** (0.01)	0.84			0.25*** (0.00)	0.89	0.25*** (0.00)	0.91
	Finland	-0.08*** (0.01)	0.23			0.06*** (0.00)	0.54	0.07*** (0.00)	0.62
	France	-0.34*** (0.02)	0.77			-0.13*** (0.00)	0.93	-0.13*** (0.00)	0.94
	Germany	-0.85*** (0.03)	0.91			-0.55*** (0.00)	0.98	-0.55*** (0.00)	0.99
	Greece	2.11*** (0.13)	0.78			1.32*** (0.02)	0.94	1.32*** (0.02)	0.95
	Ireland	1.49*** (0.19)	0.46			0.71*** (0.02)	0.94	0.69*** (0.02)	0.94
	Italy	0.48*** (0.04)	0.79			0.26*** (0.01)	0.93	0.25*** (0.01)	0.93
	Netherlands	-0.09*** (0.01)	0.33			-0.04*** (0.00)	0.71	-0.03*** (0.00)	0.74
	Portugal	0.56*** (0.03)	0.79			0.44*** (0.01)	0.93	0.44*** (0.01)	0.93
	Spain	0.22*** (0.02)	0.56			0.07*** (0.00)	0.63	0.07*** (0.00)	0.64
Sovereign CDS$_c$	Joint			0.31*** (0.00)	0.40	0.31*** (0.00)		0.32*** (0.00)	
Bid-Ask$_c$	Joint							-0.03 (0.02)	
Volume$_c$	Joint							-3.02*** (0.49)	
Trade Size$_c$	Joint							-0.07*** (0.02)	
Order Flow$_c$	Joint							0.04 (0.13)	
BW Index$_c$	Joint							-0.38*** (0.07)	

Hypothesis Tests

	F-Statistic	F-Statistic	F-Statistic
H$_0$: $\tilde{\beta}_{1cm} = 0$	5660.84***	4969.22***	4550.69***
H$_0$: $\beta_{2m} = 0$		4345.31***	4563.43***
H$_0$: $\beta_{3m} = 0$			10.89***

Panel C: 10-Year Maturity

	Country	Est. (SE)	Adj. R^2	Est. (SE)	Adj. R^2	Est. (SE)	Adj. R^2	Est. (SE)	Adj. R^2
K-Spread	Austria	0.15***	0.19			-0.14***	0.64	-0.12***	0.64
		(0.04)				(0.01)		(0.01)	
	Belgium	0.04	0.02			0.06***	0.37	0.06***	0.43
		(0.03)				(0.00)		(0.00)	
	Finland	-0.35***	0.76			-0.22***	0.93	-0.21***	0.95
		(0.02)				(0.01)		(0.01)	
	France	-0.64***	0.85			-0.33***	0.97	-0.34***	0.97
		(0.03)				(0.00)		(0.01)	
	Germany	-1.16***	0.90			-0.78***	0.98	-0.77***	0.98
		(0.04)				(0.01)		(0.01)	
	Greece	2.35***	0.87			1.52***	0.94	1.53***	0.95
		(0.10)				(0.02)		(0.02)	
	Ireland	2.32***	0.59			1.07***	0.94	1.09***	0.94
		(0.20)				(0.02)		(0.02)	
	Italy	0.67***	0.84			0.51***	0.97	0.51***	0.98
		(0.04)				(0.01)		(0.01)	
	Netherlands	-0.45***	0.84			-0.31***	0.95	-0.32***	0.96
		(0.01)				(0.00)		(0.00)	
	Portugal	0.43***	0.59			0.38***	0.82	0.38***	0.83
		(0.06)				(0.01)		(0.01)	
	Spain	0.23***	0.41			0.03***	0.29	0.05***	0.42
		(0.04)				(0.01)		(0.01)	
Sovereign CDS$_c$	Joint			0.39***	0.21	0.29***		0.28***	
				(0.00)		(0.00)		(0.00)	
Bid-Ask$_c$	Joint							0.04***	
								(0.01)	
Volume$_c$	Joint							0.97*	
								(0.50)	
Trade Size$_c$	Joint							-0.13***	
								(0.02)	
Order Flow$_c$	Joint							-0.19*	
								(0.10)	
BW Index$_c$	Joint							0.19***	
								(0.03)	

Hypothesis Tests

	F-Statistic			F-Statistic	F-Statistic
H$_0$: $\tilde{\beta}_{1,m} = 0$	3183.74***			3362.65***	1946.88***
H$_0$: $\beta_{2,m} = 0$				1808.37***	2274.84***
H$_0$: $\beta_{3m} = 0$					39.85***

Table 3. This table reports the coefficient estimates from the estimation of equation (9)—regressions of yield spreads onto the K-spread liquidity measure alone (columns 1 and 2), yields spreads onto the sovereign CDS spreads alone (columns 3 and 4), and yield spreads onto the K-spread and sovereign CDS spreads jointly (columns 5 and 6). The final two columns augment these regressions with sovereign bond market microstructure liquidity measures. The equation is estimated at the daily frequency over the sample period from January 1, 2007 to September 30, 2009. Newey-West standard errors are in parentheses with the Newey (1994) lag length. One, two and three asterisks denote statistical significance at the 10, 5 and 1, percent levels, respectively.

Table 4. Credit versus Liquidity in the Money Market

Dependent Variable: EURIBOR - OIS Spread$_{m,t}$

Regressions onto K-Spread$_t$, Bank Tiering Credit Measure$_t$, Bank CDS Premia$_t$, and Microstructure Liquidity Measures$_t$

Panel A: 1-Month Maturity

K-Spread	1.08***			0.94***	1.23***	1.29***	
	(0.07)			(0.07)	(0.05)	(0.06)	
Bank-Tiering		2.32***		0.49**	0.74***	0.58***	2.31***
		(0.20)		(0.24)	(0.11)	(0.12)	(0.20)
Bank CDS			0.21***		-0.21***	-0.25***	-0.01
			(0.04)		(0.02)	(0.03)	(0.04)
Bid-Ask						0.94***	-1.46***
						(0.26)	(0.51)
Volume						0.01	-1.93**
						(0.33)	(0.77)
Trade Size						-0.07	-0.18
						(0.14)	(0.22)
Order Flow						-0.17	-1.29***
						(0.16)	(0.41)
BW Index						-1.93**	-1.17
						(0.79)	(1.49)
R^2 - Adjusted (%)	75.81	50.27	16.08	76.81	85.51	85.87	59.93

Panel B: 3-Month Maturity

K-Spread	1.67***			1.61***	1.78***	1.76***	
	(0.07)			(0.08)	(0.08)	(0.09)	
Bank-Tiering		3.30***		0.20	0.34**	0.14	2.51***
		(0.31)		(0.22)	(0.16)	(0.16)	(0.27)
Bank CDS			0.42***		-0.12***	-0.24***	0.09*
			(0.06)		(0.03)	(0.03)	(0.05)
Bid-Ask						1.39***	-1.88***
						(0.35)	(0.69)
Volume						-1.22**	-3.93***
						(0.55)	(1.07)
Trade Size						-0.14	-0.26
						(0.14)	(0.25)
Order Flow						-0.20	-1.83***
						(0.40)	(0.67)
BW Index						-4.18***	-3.07
						(1.11)	(1.98)
R^2 - Adjusted (%)	86.31	49.53	31.07	86.38	87.76	89.55	66.49

Panel C: 6-Month Maturity

K-Spread	1.92***			1.81***	1.84***	1.86***	
	(0.08)			(0.09)	(0.10)	(0.10)	
Bank-Tiering		3.88***		0.41**	0.44**	0.20	2.69***
		(0.36)		(0.20)	(0.20)	(0.19)	(0.30)
Bank CDS			0.54***		-0.03	-0.19***	0.15***
			(0.06)		(0.04)	(0.04)	(0.05)
Bid-Ask						1.20***	-2.23***
						(0.31)	(0.68)
Volume						-2.55***	-5.40***
						(0.58)	(1.03)
Trade Size						0.12	-0.01
						(0.13)	(0.22)
Order Flow						-0.66*	-2.37***
						(0.39)	(0.65)
BW Index						-2.67***	-1.50
						(0.94)	(1.81)
R^2 - Adjusted (%)	88.39	52.89	40.52	88.64	88.67	91.63	71.92

Panel D: 12-Month Maturity

K-Spread	2.14***			2.08***	2.16***	2.13***	
	(0.09)			(0.11)	(0.12)	(0.12)	
Bank-Tiering		4.21***		0.20	0.26	0.06	2.91***
		(0.39)		(0.26)	(0.25)	(0.23)	(0.35)
Bank CDS			0.59***		-0.05	-0.23***	0.17**
			(0.07)		(0.05)	(0.05)	(0.07)
Bid-Ask						1.20***	-2.74***
						(0.45)	(0.86)
Volume						-3.38***	-6.65***
						(0.76)	(1.18)
Trade Size						0.27	0.12
						(0.17)	(0.25)
Order Flow						-1.00**	-2.96***
						(0.44)	(0.72)
BW Index						-3.31***	-1.97
						(1.23)	(2.23)
R^2 - Adjusted (%)	87.62	49.65	38.03	87.65	87.80	90.49	69.71

Table 4. This table reports the results from regressing the EURIBOR-OIS spread at different maturities onto the one-year K-spread liquidity measure alone (column 1), the proposed overnight bank-tiering credit measure alone (column 2), and the one-year bank CDS premia alone (column 3). Each regression is nested in equation (10). Estimates of joint regressions of the EURIBOR-OIS spread onto these three variables jointly are shown in columns 4 and 5. The final two columns augment these regressions with overnight interbank market microstructure liquidity measures. The equation is estimated at the daily frequency, over the sample period from January 1, 2007 to September 30, 2009. Newey-West standard errors are in parentheses with the Newey (1994) lag length. One, two and three asterisks denote statistical significance at the 10, 5 and 1, percent levels, respectively.

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Table 5. The Pricing of Liquidity Risk in the Cross Section of Sovereign Bond Yield Spreads

	Dependent Variable: Sovereign Yield Spread$_{cm}$		
	Regression onto Credit and Liquidity Indicators		
$\beta^{Liq}_{c,m}$	93.77***	34.34**	49.62***
	(21.55)	(13.70)	(12.19)
Sovereign CDS$_{c,m}$		0.68***	0.62***
		(0.10)	(0.05)
Bid-Ask$_{c,m}$			-0.81
			(1.56)
Volume$_{c,m}$			-17.42
			(12.19)
Trade Size$_{c,m}$			0.74
			(1.16)
Order Flow$_{c,m}$			-50.23**
			(24.31)
BW Index$_{c,m}$			14.46
			(11.82)
R^2 - Adjusted (%)	64.03	86.62	89.11

Table 5. This table reports the results from a cross-sectional regression, as in equation (12), over all country-maturity pairs of average yield spreads onto the liquidity beta estimates (from equation (11)), sovereign CDS spreads, and sovereign market microstructure liquidity measures. Standard errors, clustered by country, are included in parentheses. One, two and three asterisks denote significance at the 10, 5 and 1 percent levels, respectively.

Figure 1. Euro-Area Government Bond Market

Panel A: Country Yields

5-Year Maturity
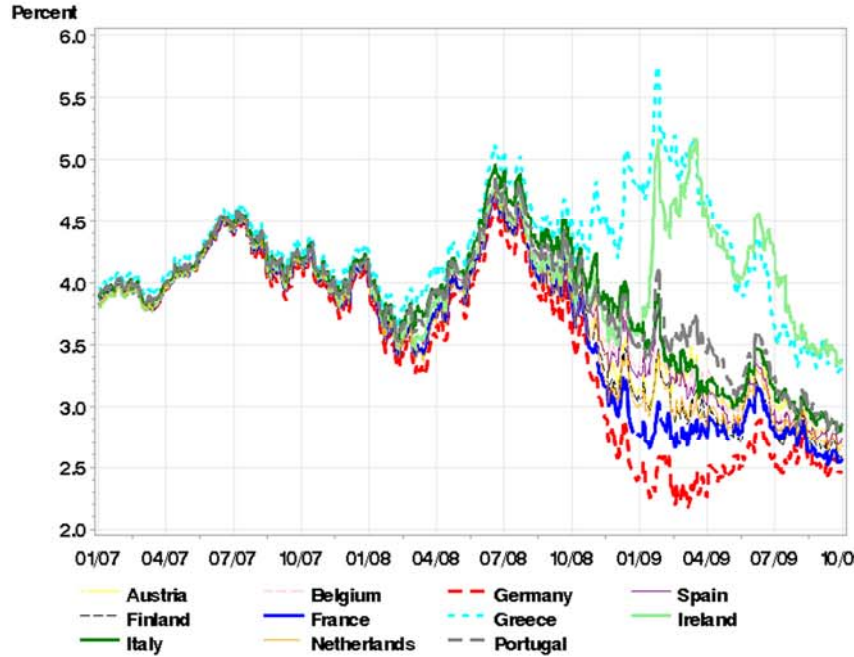
Panel B: Country Yields minus 11-Country Average Yield

5-Year Maturity
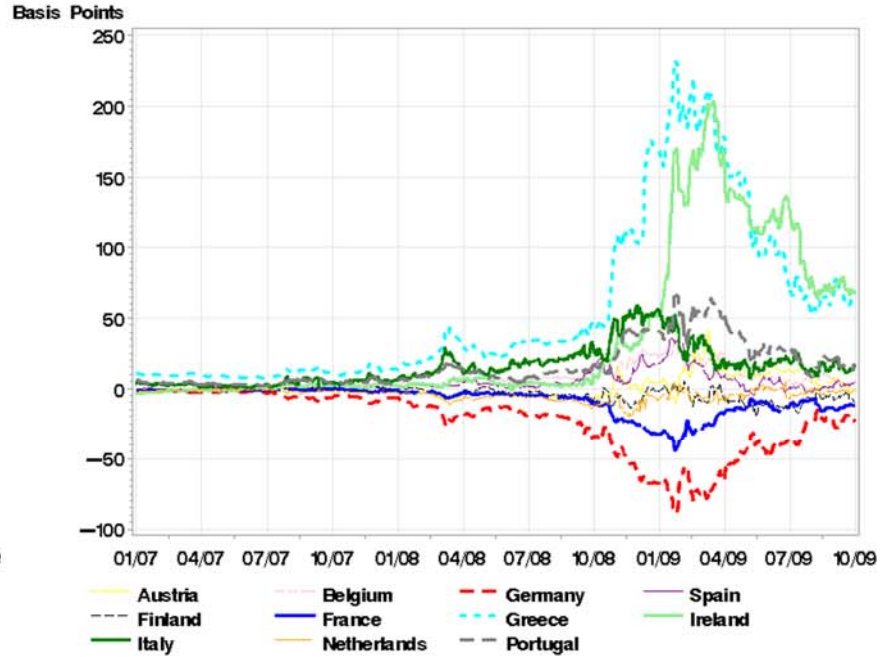
Figure 1. This figure shows government debt yields (Panel A) and spreads (Panel B) for each of the 11 euro-area countries in the sample, at the 5-year maturity, at a daily frequency. The yield spread is defined as $\tilde{y}_{cmt} = y_{cmt} - \Sigma_{c'=1}^{11} w_{c'm} y_{c'mt}$, where $\tilde{y}_{cmt}$ is the sovereign yield spread for country c, at the m-year maturity point, on day t, minus the euro-area weighted-average yield, as in Equations (2) and (3). The weights are defined as $w_{cm} = \dfrac{Q_{cm}}{\sum_{c'=1}^{11} Q_{c'm}}$, where Q_{cm} is the quantity of debt outstanding for each country, c, at each maturity point m and c' is a counter variable indexing each of the countries for the purpose of computing the euro-area weighted average. These are based on zero-coupon yields, formed from smoothed curves fitted to all coupon securities, estimated separately for each country and each day.
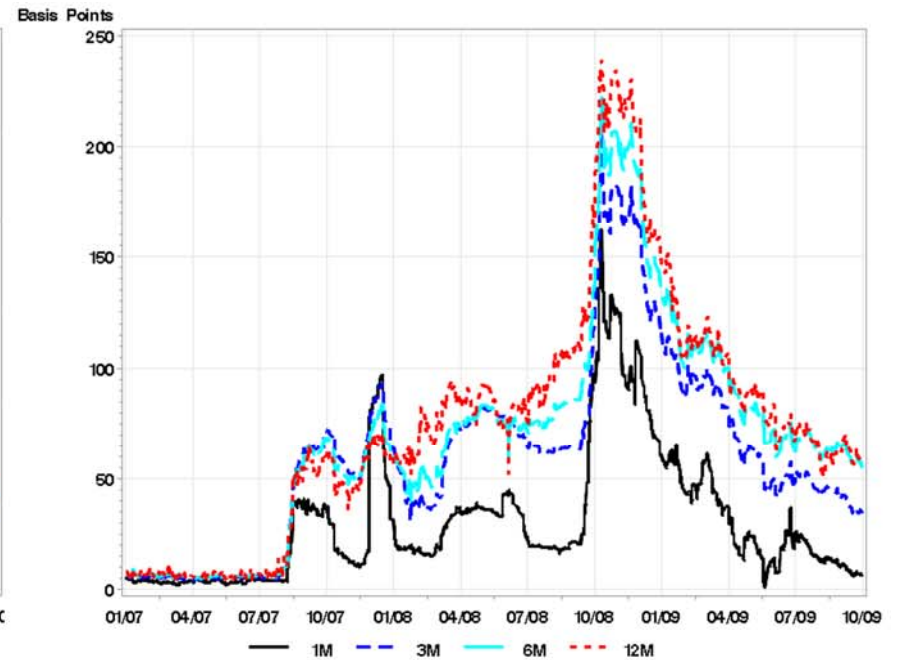
Figure 2. Euro-Area Money Market

Panel A: EURIBOR Rates

1-, 3-, 6-, 12-Month Maturities
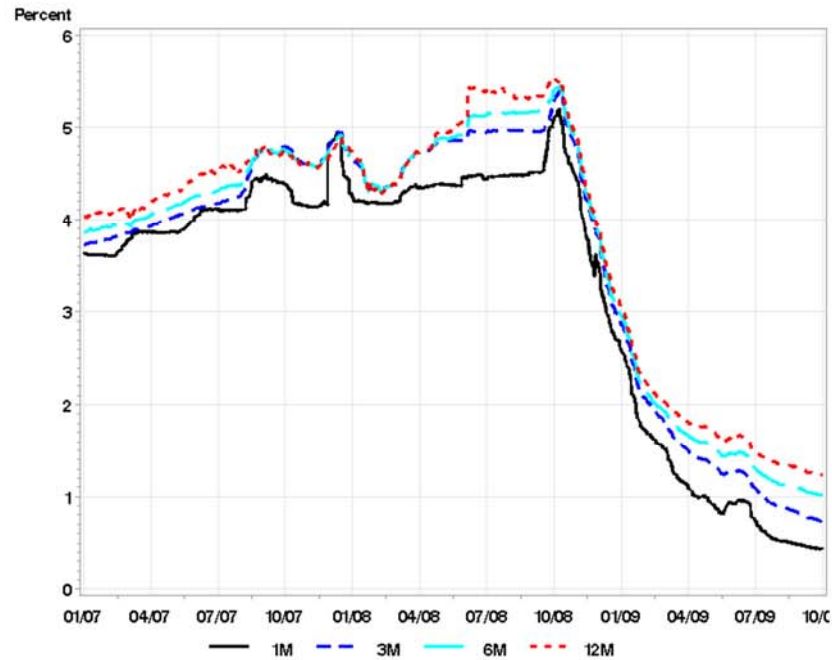
Panel B: EURIBOR minus OIS Interest Rate Spreads

1-, 3-, 6-, 12-Month Maturities

Figure 2. This figure shows interest rate levels (Panel A) and spreads (Panel B) for euro-area interbank money markets for the 1-, 3- , 6- and 12-month maturities, at a daily frequency. Panel A shows the level of EURIBOR rates. Panel B shows the EURIBOR-OIS interest rate spread, defined as the EURIBOR rate minus the comparable-maturity OIS rate.

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Figure 3. K-Liquidity Spread and Country CDS Spreads

Panel A: K-Liquidity Spread (KfW Yield minus German Government Yield)   **Panel B: Country CDS Spread (Country Premia minus 11-Country Average)**

1- and 5-Year Maturities   *5-Year Maturity*
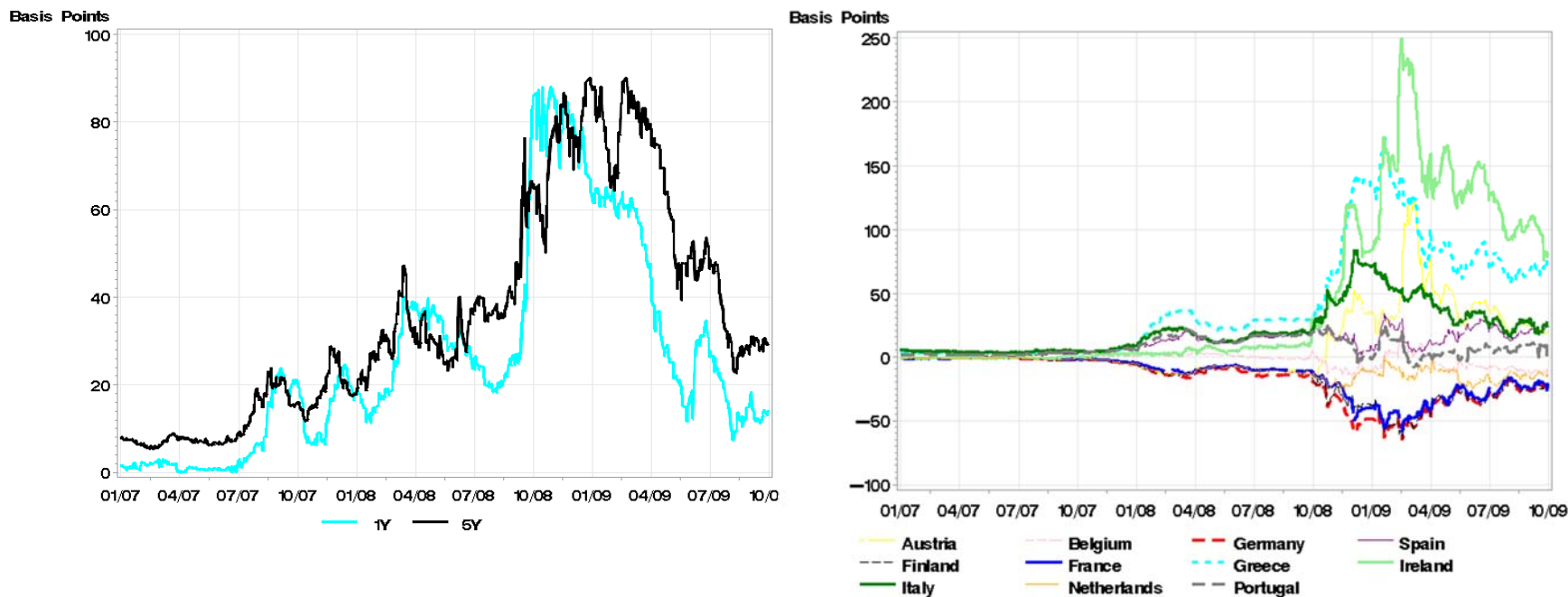
Figure 3. This figure shows a time series of the K-spread liquidity measure and the CDS spread credit measure, at a daily frequency. Panel A shows the K-spread liquidity measure, at the 1- and 5-year maturities. The K-spread is constructed as the KfW yield minus the comparable-maturity German federal government yield (both zero-coupon yields, formed from smoothed curves fitted to all coupon securities, estimated separately for each day). Panel B shows the Credit Default Swap (CDS) spreads for the sovereign debt of each of the 11 euro-area countries in the sample, relative to the 11-country average CDS premium, notated as

$\tilde{d}_{cmt} = d_{cmt} - \Sigma_{c'=1}^{11} w_{c'm} d_{c'mt}$ in Equations (2) and (3). The weights are defined as $w_{cm} = \dfrac{Q_{cm}}{\sum_{c'=1}^{11} Q_{c'm}}$, where Q_{cm} is the quantity of debt outstanding for each country, c,

at each maturity point m and c' is a counter variable indexing each of the countries for the purpose of computing the euro-area weighted average.

Figure 4. Money Market Credit Measures

Panel A: Bank-Tiering Credit Spread

1-Day Maturity
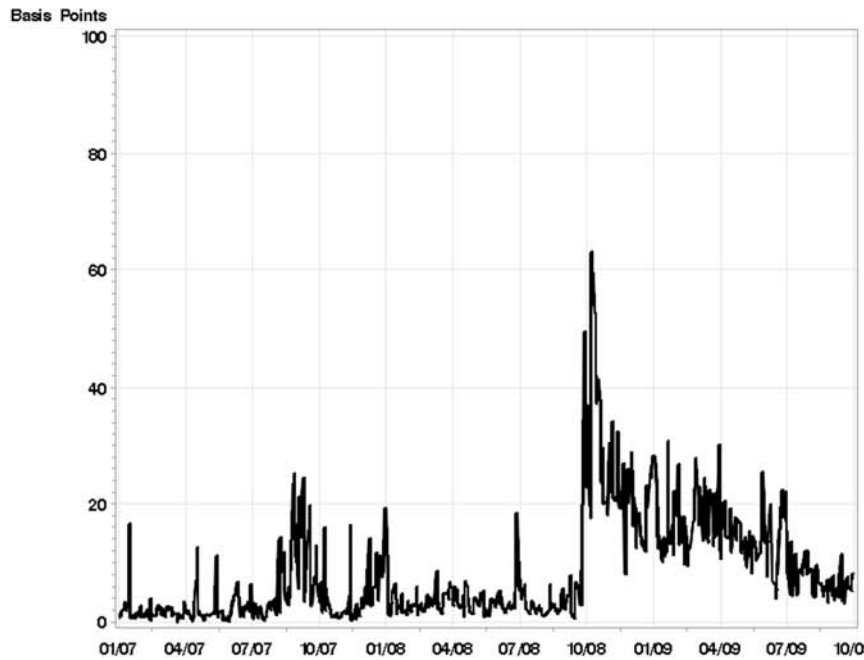
Panel B: Average EURIBOR-Panel Bank CDS Premia

1-Year Maturity

Figure 4. This figure plots the time series of the two credit measures used to decompose interbank money market spreads at a daily frequency. Panel A shows the overnight bank-tiering credit measure, which is formed as the difference in average unsecured interbank borrowing rates paid by the banks in the highest and lowest risk quintiles (estimated in Appendix 1) on each day. Panel B shows the one-year bank CDS measure, which is the simple average of the EURIBOR panel banks' one-year CDS premia on each day.

Figure 5. Basis Point Change in Sovereign Bond Yield Spreads Explained by a One Standard Deviation Shock to Credit and Liquidity

All Countries
(Maturity-Average)
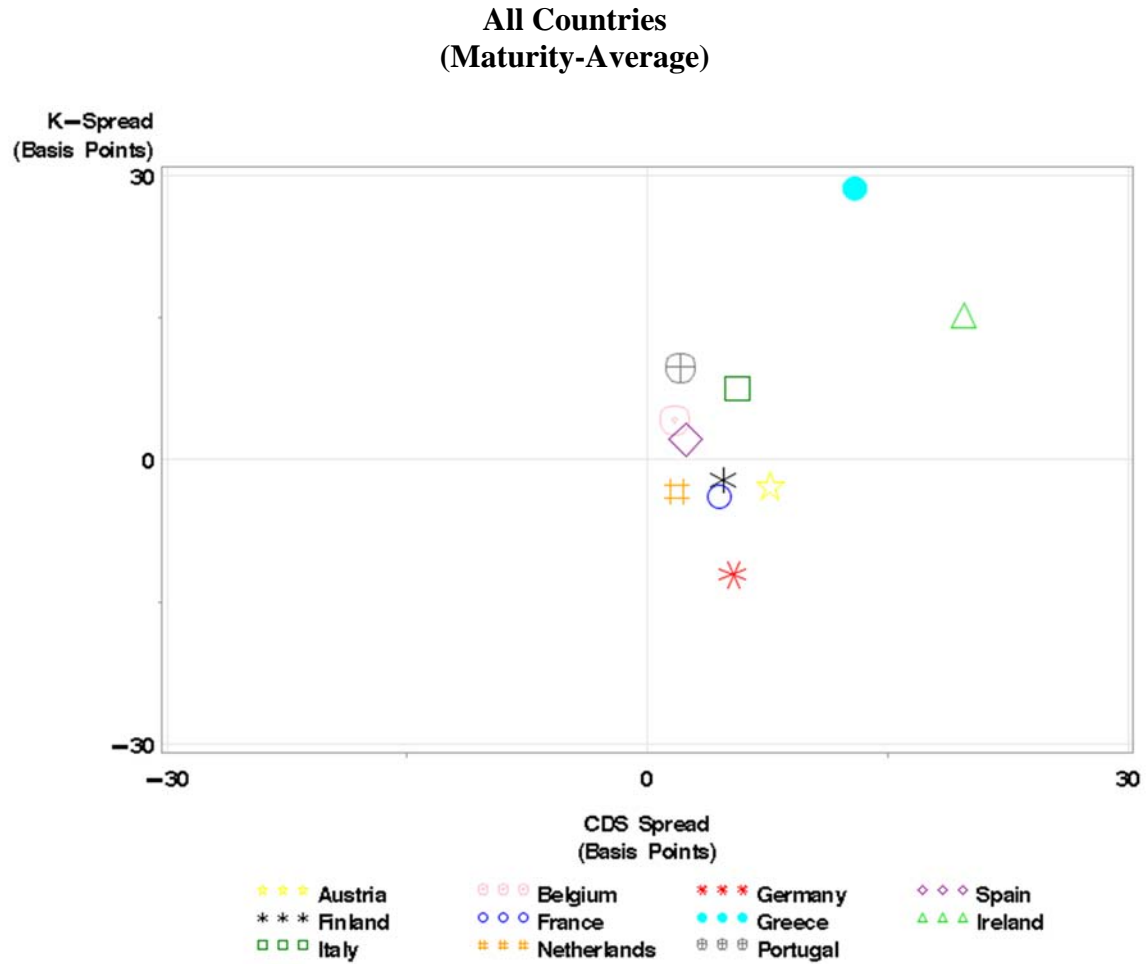
Figure 5. This figure plots the basis point change in country sovereign bond yield spreads (averaged across maturities) associated with a one standard deviation increase in the country CDS spread (x axis) versus a one standard deviation increase in the K-spread (y axis); values are based on coefficient estimates from a regression of sovereign bond yield spreads onto the K-spread and the country sovereign CDS spreads jointly, shown in columns 5 and 6 of Table 3. Standard deviations of country sovereign CDS spreads and the K-spread are shown in Panels A and C of Table 1.

Figure 6. Basis Point Change in EURIBOR-OIS Spreads Explained by a One Standard Deviation Shock to Credit and Liquidity
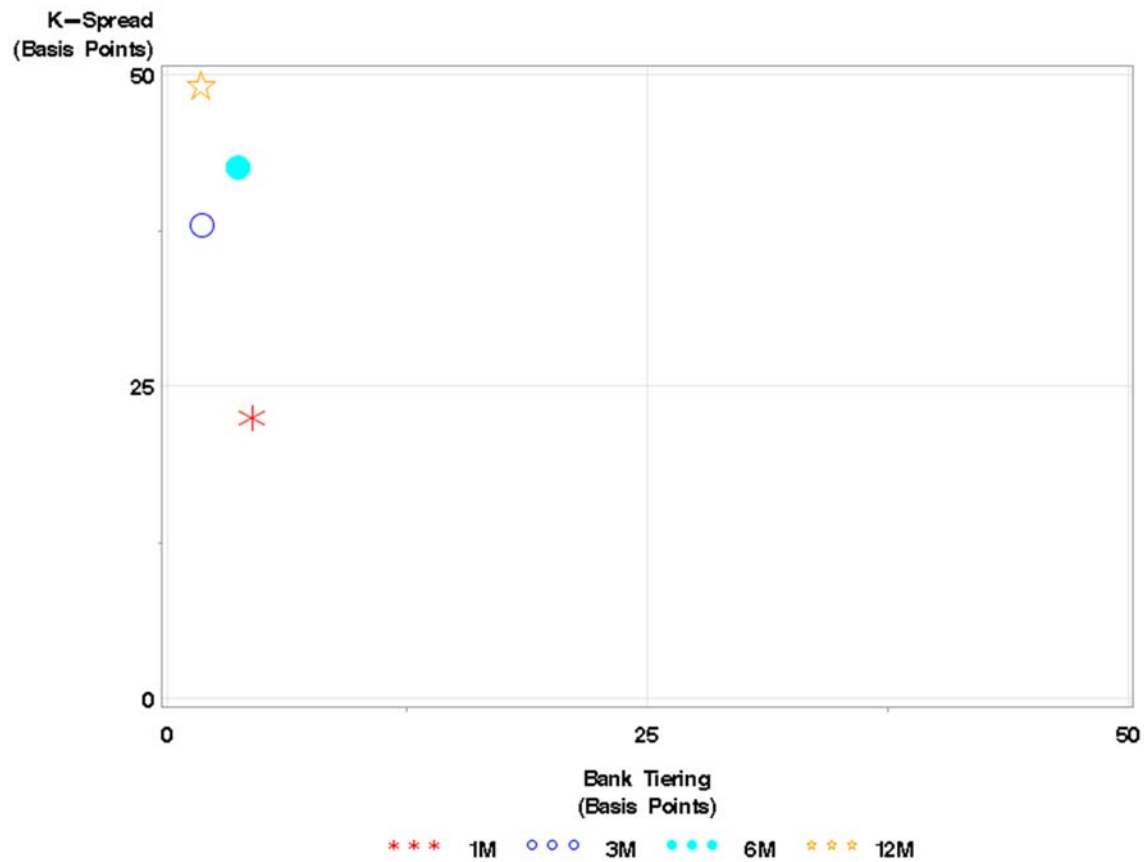
Figure 6. This figure plots the basis point change in EURIBOR-OIS spreads, by maturity, associated with a one standard deviation increase in the country bank-tiering credit measure (x axis) versus a one standard deviation increase in the K-spread (y axis). The plotted values are based on coefficient estimates from a regression of EURIBOR-OIS spreads onto the K-spread and the bank-tiering credit measure jointly, shown in columns 4 in Panels A through D of Table 4. The bank-tiering credit measure and the K-spread standard deviation is shown in Panel B of Table 2.

Figure 7. The Sensitivity of Government Bond Yields to Liquidity Risk
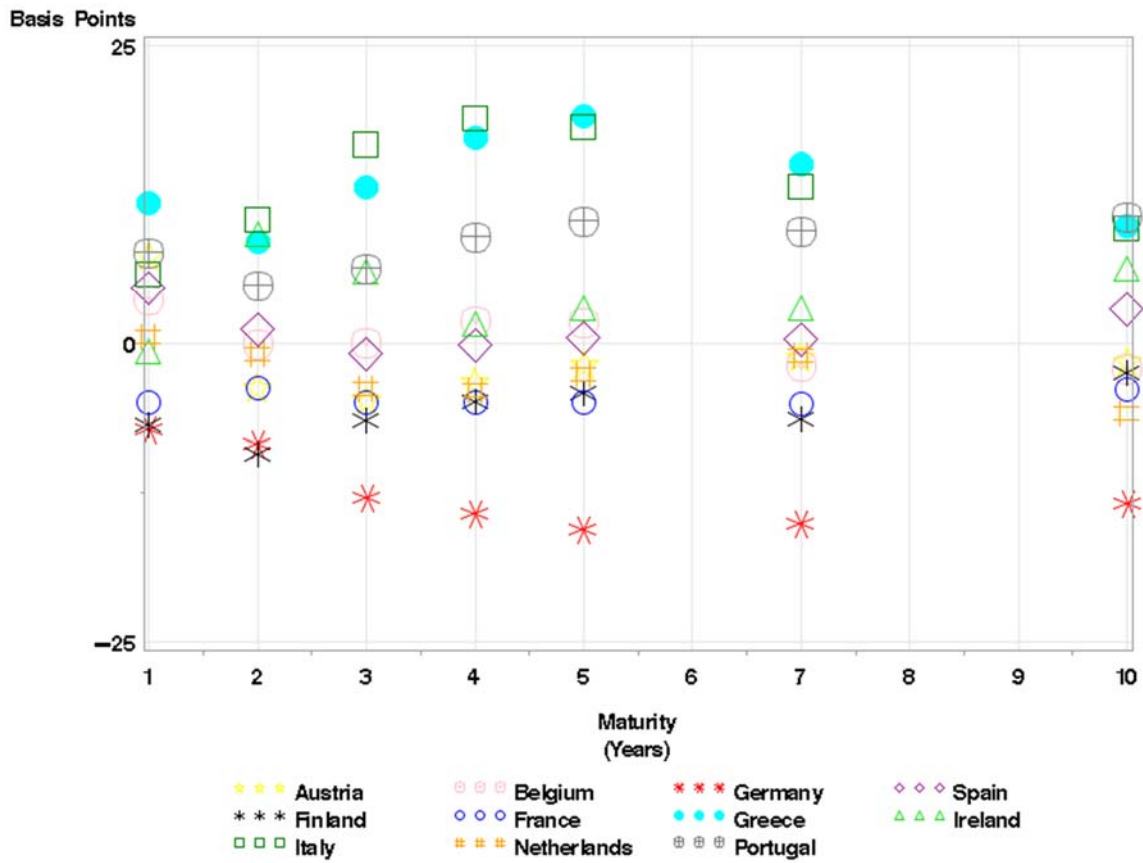
Figure 7. This figure plots $\gamma_1 \beta_{cm}^{Liq}$, the sample-average basis point effect of liquidity risk on sovereign yield spreads, as estimated in Equation (12), including all controls. The values are estimated at each maturity point for each country.