Mind the Gap: Disentangling Credit and Liquidity in Risk Spreads

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Abstract

Euro-area sovereign bond and interbank interest rate spreads rose by more than an order of magnitude in the 2007-2009 Financial Crisis, sharply increasing financing costs. Such rate volatility could represent concerns over asset liquidity or issuer solvency. To precisely identify the relative contribution of these two effects in interest rate spreads, this paper uses a model-free measure of euro-area bond market liquidity. Liquidity accounts for 36% of the average trough-to-peak sovereign spread widening during the Crisis, after controlling for default risk. Aggregate bond liquidity also explains a substantial portion of interbank spreads, even after controlling for interbank credit and liquidity.

JEL Classification: E44, G01, G12, G15
Keywords: market liquidity, interbank credit, money markets, interest rates, financial crisis.

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Abstract

Euro-area sovereign bond and interbank interest rate spreads rose by more than an order of magnitude in the 2007-2009 Financial Crisis, sharply increasing financing costs. Such rate volatility could represent concerns over asset liquidity or issuer solvency. To precisely identify the relative contribution of these two effects in interest rate spreads, this paper uses a model-free measure of euro-area bond market liquidity. Liquidity accounts for 36% of the average trough-to-peak sovereign spread widening during the Crisis, after controlling for default risk. Aggregate bond liquidity also explains a substantial portion of interbank spreads, even after controlling for interbank credit and liquidity.

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The 2007-2009 Global Financial Crisis was marked by extraordinary interest rate spread widening and heightened volatility in asset prices, contributing to a broad tightening of financial conditions. One example is the increase in euro-area government bond spreads, which spiked by more than an order of magnitude to levels not seen since the introduction of the common currency in 1999. In the money market, spreads between unsecured interbank borrowing rates (EURIBOR) and overnight-indexed swap (OIS) rates of comparable maturities also rose by more than an order of magnitude, reaching their widest levels since the inception of the OIS market. Despite the enormity of these interest rate movements, there has been a lack of consensus on the dominant driver. One hurdle to identification is the difficulty in precisely capturing the risk components in prices. This paper documents a model-free measure of euro-area market liquidity, constructed directly from asset prices, that is used to parse these historic movements in euro-area sovereign bond and interbank interest rate spreads. The results show that aggregate market liquidity contributed at least as much to the movements in these spreads as the pricing of default risk in the Crisis period. An equal-weighted average across all countries and maturities attributes 36% of the trough-to-peak sovereign bond spread widening to deteriorating liquidity and 35% to heightened default risk. Likewise, aggregate bond market liquidity explains a substantial portion of interbank interest rate spreads over and above the effects of interbank credit and liquidity.

Beyond the expected path of future short-horizon interest rates, it is difficult to empirically determine what drives sovereign bond yields or interbank rates, especially at times of market stress. Two possible influences that are explored in this paper are credit, reflecting compensation for heightened default risk (Afonso, Kovner and Schoar (2011), Filipović and Trolle (2013), Taylor and Williams (2009), Beber, Brandt and Kavajecz (2009), and McAndrews, Sarkar and Wang (2008)), and market liquidity, reflecting trading conditions in asset markets (Michaud and

Upper (2008), Acharya and Skeie (2011)). The Global Financial Crisis is an ideal period to study the liquidity and credit components of sovereign and interbank spreads because they were so variable both over time and in the cross section. In contrast, before 2007, these spreads were roughly constant near zero, making identification almost impossible.

Understanding the default and liquidity components in interest rates is important for portfolio allocation and policy decisions. Investors with the longest horizons should prefer to hold higher yielding assets if the elevated yields represent compensation for deteriorating market conditions, but not necessarily if they represent a greater risk of loss due to default. Amihud and Mendelson (1986) and Longstaff (2009) both propose models with different types of investors, in which the longer-horizon investors receive a premium for holding less liquid assets. From the perspective of policymakers, efforts to improve market functioning could help to dampen the effects of poor asset market liquidity on yields, mitigating the knock-on effects of higher financing costs. For example, an exchange of more-liquid for less-liquid bonds (such as in the Federal Reserve's securities lending facility) could reduce liquidity premia. On the other hand, if higher yields are largely attributable to a credit shock, then this argues for addressing solvency.

This paper first documents the tremendous deterioration in euro-area market liquidity during the Financial Crisis, using the yield differential between two duration-matched bonds with an identical credit guarantee to construct a measure of euro-area market liquidity. This yield spread identifies any deviation in an asset's price from its hold-to-maturity value, fully capturing market liquidity effects impounded in prices. Specifically, the yield of a German federal government bond is compared to that of its less-liquid agency counterpart, KfW (Kreditanstalt für Wiederaufbau). The German federal government bond systematically commands a premium across maturity points over the sample period. I refer to this yield differential as the K-spread. While this paper is the first to construct the K-spread, comparing two types of government-guaranteed securities goes back to Longstaff (2004), who explained the yield differential between Refcorp (Resolution Funding Corporation) and U.S. Treasury bonds as a measure of Treasury market liquidity. In this paper, the K-spread is used to identify the contribution of aggregate market liquidity to the unprecedented widening of various interest rate spreads across euro-area countries in the Global Financial Crisis.

Prior to the Financial Crisis, the K-spread typically remained below 10 basis points. During the Crisis, the spread became unusually wide and volatile. At the 2-year maturity, it spiked as high as 99 basis points in November 2008. Even amid the euro-area's recent currency crisis, the spread has remained below its Financial Crisis peak. The K-spread is a model-free identification of euro-area market liquidity – it does not rely on single interpretation of liquidity frictions. It is also tradable in that an investor can form a portfolio comprised of a long KfW bond position and a corresponding short German federal bond position. This position earns the "liquidity spread" and hedges against credit fluctuations.

This paper uses the K-spread and other measures to parse euro-area sovereign bond and interbank interest rate spreads into liquidity and credit components over the Global Financial Crisis. Researchers have proposed theoretical models in which liquidity can have an important effect on bond yields, especially during a crisis (Acharya and Skeie (2011), Favero, Pagano and von Thadden (2010) and Manganelli and Wolswijk (2009)). Separately, there is evidence of a common factor driving liquidity premia across markets ((Chordia, Sarkar and Subrahmanyam (2005) and Brunnermeier and Pedersen (2009)). In the decomposition of euro-area sovereign yields spreads, the single K-spread's identification of liquidity relies on commonality across the different member countries' sovereign bond markets. The results show a strong and significant influence of aggregate market liquidity on sovereign spreads over the crisis period that is robust to controlling for country-specific default risk. The common liquidity component in spreads also explains more variation than is explained by several extant country-specific liquidity measures jointly. The finding that liquidity is an important driver of bond spreads during the Financial Crisis is familiar in the corporate bond literature (e.g. Chen, Lesmond and Wei (2007), Bongaerts, de Jong and Driessen (2013)). This paper highlights the importance of a single liquidity factor for sovereign bond and interbank spreads during the Financial Crisis.

Brunnermeier and Pedersen (2009) and Bolton, Santos and Scheinkman (2011), model the relationship between aggregate market liquidity and idiosyncratic funding liquidity to explain market features seen in the early stages of the Financial Crisis. To consider a possible link between aggregate bond market liquidity and money markets, I use the K-spread to decompose unsecured interbank rates, assuming proportionality in bond and funding market liquidity. In order to measure credit and liquidity specific to the interbank market, I obtain a novel dataset of high-frequency interbank transactions. I find that the K-spread, constructed in the sovereign bond market, explains a substantial share of interbank spreads beyond what is captured by the interbank measures of credit and liquidity. Both sovereign and interbank spreads are affected by a common liquidity factor. One possible explanation is the close link between the liquidity of sovereign bonds used as collateral in funding markets and the funding rates themselves.[1]

The plan for the remainder of the paper is as follows. Section 1 introduces the data including the liquidity measure's construction. Section 2 parses the euro-area sovereign bond yield spreads into liquidity and credit components. Section 3 identifies these two effects in interbank interest rate spreads. Section 4 concludes with the paper's contributions and implications.

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[1] Sovereign bonds are often used as collateral in euro repo transactions (e.g. the central bank's liquidity operations). Market liquidity premia in the cash bond market will drive EURIBOR rates higher via their collateral value in the repo market; unsecured funding is a close substitute for repo funding.

1. 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 euro-area sovereign debt and EURIBOR-OIS spreads, and discusses the construction of the various measures of liquidity and credit used in this paper.

1.1 Sovereign Bond Yield Spreads

Starting with the sovereign bond market, the data sample includes 77 country-maturity pairs: the government debt securities for 11 euro-area member countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, and Spain) at seven specific maturity points (1, 2, 3, 4, 5, 7, and 10 years). To precisely compare these yields, I estimate a smoothed zero-coupon yield curve, for each maturity m, each country c, and each day t, by applying the six-parameter model of Svensson (1994) to the prices of all euro-denominated nominal coupon sovereign debt securities. Bond prices are obtained from Bloomberg.[2]

The European Central Bank (ECB) is responsible for setting a single monetary policy for the euro-area member countries, giving euro-area interest rates a common term structure. Correlations of euro-area sovereign bond yield *levels* rose around the time of the 1999 monetary union -- see Ehrmann, Fratzscher, Gürkaynak and Swanson (2011) -- largely reflecting the common component in rates influenced by the state of euro-area monetary policy. To difference out this common term structure, I take German bonds as a benchmark.[3] Then, I consider the *spread*

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

[3] Germany is the largest economy in the euro area, and is one of the three largest euro-area government debt markets in par value outstanding, along with France and Italy. However, Germany has maintained a lower debt-to-GDP ratio

of other countries' sovereign bond yields relative to those of Germany.[4]

Figure 1 illustrates the movements in sovereign bond yields levels (Panel A) and yield spreads (Panel B), respectively, for the countries in the sample. The levels of yields mostly decline over the sample period, but the yield spreads widen dramatically across countries. Higher sovereign spreads increase the issuer's cost of rolling over existing debt, even in the absence of net new debt issuance. Figure 1 shows the largest spread widening in basis points is for Greece, peaking at 321 basis points, and Ireland, reaching 279 basis points, at the 5-year maturity. Although not as evident in the figure, the 5-year spreads of France, the Netherlands, Austria and Finland widened by more than two orders of magnitude over this period. Other maturities show similar spread movements. Table 1 gives the sample period summary statistics for each country's sovereign yield spread at the 2-, 5-, and 10-year maturities. These extreme yield spread movements in the Crisis sparked substantial debate; were investors demanding compensation for heightened default likelihood or for difficulty in executing market transactions?

1.2 Interbank Interest Rate Spreads

In the money market, I consider euro interbank borrowing rates (EURIBOR). EURIBOR is the reference rate at which large euro-area banks borrow some notional amount of euro currency, uncollateralized, for a specified term.[5] EURIBOR contains a common risk-free term structure and risk components. To remove the common component, I consider the spreads of EURIBOR relative

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than France and Italy since the 1999 monetary union. Additionally, at the time of the Financial Crisis, Germany's sovereign bond market was the only euro-area bond market with a complementary futures market.

[4] The yield spread could alternatively be constructed relative to the euro-area average yield, giving very similar results.

[5] EURIBOR is a survey rate of unsecured interbank euro borrowing rates compiled by the European Money Markets Institution for eight maturities, from overnight to 1-year. LIBOR, also a survey of interbank borrowing, has been widely cited as manipulated to some degree by the contributing banks. It is unlikely that any potential manipulation of EURIBOR would be systematically related to the measures used in this paper. Further there is no clear direction in which it would potentially shift the relative breakdown of liquidity versus credit.

to the euro overnight-index swap (OIS) rate, which I take as a proxy for the risk-free rate. An OIS is a money market derivative, with a payoff determined by the future path of overnight interest rates plus a pure term premium. There is no payment required at inception of the contract. For any maturity of OIS contract, the fixed rate reflects a sequence of refreshed overnight bank credits. For these and other reasons,[6] default and liquidity premia in OIS rates are negligible (Brunnermeier (2009) and Packer and Baba (2009)), allowing for the EURIBOR-OIS spread to be interpreted as interbank risk premia.

I consider the 1-, 3-, 6-, and 12-month maturity EURIBOR-OIS interest rate spreads, which are the EURIBOR maturities commonly referenced in financial contracts. Panel A of Figure 2 shows the *level* of EURIBOR rates. The roughly 450 basis point drop in short-term rates over the sample is largely driven by the ECB's crisis-driven monetary policy easing, and thus a lower risk-free rate. The ECB cut its policy repo rate from 4.25% to 1% over 2008 and 2009, aiming to ease financial conditions in the Crisis. However, Panel B shows a sharp rise in the *spread* between EURIBOR and OIS rates, first in August 2007, and then most dramatically following Lehman's Brothers' bankruptcy in September 2008. The rise in short-term spreads received considerable attention in the press and from policymakers as it worked directly counter to the effect of a lower ECB policy rate. Wider spreads mean less accommodative financial conditions *ceteris paribus*, since many private lending rates are tied to term interbank rates; swap rates, forward rates, interest rate futures, and many mortgage rates in the euro area reference EURIBOR.

[6] Default risk in OIS is negligible since the notional principal is not exchanged, mitigating counterparty risk, and the fixed reference rate is for overnight credit. The liquidity component of OIS rates should be negligible for a number of reasons. First, an interest rate swap does not require upfront 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.

1.3 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.[7] Measuring this empirically is challenging. To identify the liquidity component of euro-area interest rate spreads, I construct a measure of market liquidity that compares the yields of German government bonds with German agency bonds, at specific maturities. German government bonds are highly liquid 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 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 the federal government bond issues. Credit and asset characteristics are entirely controlled for in the measure's construction.

To precisely compare the two classes of German yields, 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 1.1. I then take the zero-coupon yield spread between the KfW bond and the corresponding German federal government bond at each of the seven maturity points considered. The *m*-year K-spread is defined as:

$$\kappa_{mt} = KfW_{mt} - Y_{Germany,mt} \tag{1}$$

[7] 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.

where KfW_{mt} and $Y_{Germany,mt}$ denote the *m*-year zero-coupon yields for the KfW agency and German government bonds, respectively. Since default risk is identical for the two categories of bonds, 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. The K-spread is treated as a directly observable liquidity measure. Its identifying assumption is that German sovereign and KfW yields have identical credit but that they load differently on the common liquidity factor. Time series variation in interest rates that comes from market liquidity will load on the K-spread, but variation due to default will not. Hence, the yield spread between these bonds allows for recovery of that liquidity factor.

Panel A of Figure 3 plots the K-spread for the 1- and 5-year maturities. The spread remains positive over the sample, reflecting the relative ease with which the federal government debt is traded as compared to the agency debt. The liquidity yield differential rises most substantially in the second half of the sample, reaching a local peak of 47 basis points around the collapse of Bear Stearns in March 2008, at the 5-year maturity, and a global peak of 90 basis points later that year following Lehman Brothers' bankruptcy. Since the K-spread is constructed from observed bond prices, identification is not limited to any single model of liquidity frictions (e.g. asymmetric information). The K-spread's evolution reflects all information impounded in bond yields, including forward-looking information about future liquidity conditions, which is a potentially large dimension of liquidity not captured by market microstructure or transaction-based liquidity measures that are typically used to measure euro-area market liquidity.

There are some institutional differences between KfW and German federal government bonds that could contribute to their liquidity differential. Although they share the same creditworthiness, KfW and German federal government bonds are not fungible, even in the absence of any difference in characteristics. 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.[8] Federal government bond issuance is also larger and trading volume is higher than for KfW securities.[9] Moreover, euro repo funding rates are consistently slightly higher for KfW collateral than for German federal government collateral, reflecting the relative attractiveness of the federal government securities as collateral in funding markets.[10] 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)).

1.4 Market Microstructure Liquidity Measures

In order to compare the proposed K-spread liquidity measure with traditional liquidity measures, and to allow for market-specific liquidity effects, I obtain detailed data on interbank borrowing and sovereign bond transactions. With these data, I construct a set of five microstructure liquidity measures, separately for the sovereign bond market and the interbank market. The measures are: trade size, trading volume, bid-ask spread, order flow, and the bid-ask spread scaled by trading volume (Bollen and Whaley (1998) liquidity index), each of which is expressed as a daily average value.

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[8] 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.

[9] In 2008, gross annual issuance was €216 billion in federal government debt versus €74 billion for KfW, and the size of government debt was about 8 times that of KfW agency debt. Issue sizes outstanding at the time were around €20 billion for benchmark federal debt issues versus €5 billion for benchmark KfW issues. Nonetheless, KfW is the 4th largest euro-area debt issuer by volume, after the sovereigns of Germany, France and Italy. 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), on the MTS platform, over the sample period.

[10] KfW bonds may not be used as collateral in federal government repo agreements and vice versa. 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).

The sovereign bond transactions come from MTS, a large electronic European bond trading platform.[11] To allow for the independent variation of each country's liquidity at various horizons, I construct a separate microstructure measure for each of the 77 country-maturity pairs. Table 1 reports the country-level summary statistics. The measures are expressed relative to their maturity-matched German counterparts, in parallel with the construction of the yield spreads. For instance, the positive sign on Italian bond trading volume at each maturity point means that a greater quantity of Italian debt is traded each day as compared to German debt, on average over the sample. At the 2-year maturity, the daily average transaction volume in Italian bonds (€330 million in excess of German bonds) is higher than that of any other country's bonds in the sample. However, the average Italian trade sizes are the smallest of any country; the relatively high Italian trading volume is achieved through a high frequency of small trades.

Interbank borrowing transactions, data which are notoriously opaque and difficult to access, are sourced directly from e-MID, a large electronic euro-area interbank trading platform.[12] Euro interbank borrowing is concentrated at the very shortest maturities; most transactions are overnight, and more than 90% are for a horizon of less than one month.[13] Because of sparse observations at longer horizons, the microstructure measures are formed with overnight transactions. Table 2 summarizes statistics for the interbank measures. The average interbank bid-ask spread is only 4.5 basis points, shown in Panel B. On average over the sample, daily transaction volume is €11.3 billion with a trade size of €33.4 million.

[11] 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% of electronic inter-dealer transactions (Euroweek special report, May 2007).
[12] e-MID is an acronym for Elettronica Mercato Interbancario dei Depositi (Electronic Interbank Deposit Market). Transactions on this platform comprise roughly 20% of all unsecured euro-denominated interbank transactions over the sample period. 98% of the unsecured interbank e-MID sample is comprised of overnight transactions.
[13] 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.

1.5 Credit Risk Measures

To identify the credit component in interest rates, I collect credit default swap (CDS) premia for each country in the sovereign bond market sample, and for each EURIBOR survey-member bank.[14] I treat these as directly observable credit metrics. The sovereign bond credit measure is defined as the deviation of each country's CDS spread from the benchmark German CDS spread, on each day, for each maturity point, denoted d_{cmt}. Measuring interbank credit risk with bank CDS faces the challenge that the EURIBOR-OIS spreads reflect short-horizon risk, while CDS contracts are concentrated at the 5-year maturity. Very short- (or long-) maturity CDS contracts are less likely to be precise measures of default risk, (Pan and Singleton (2008)). To approach the horizon of the interbank spreads, I use the 1-year CDS premia. Then, I average the CDS premia over the member banks on each day, as in the calculation of EURIBOR.[15] All CDS data are obtained from Markit.

Because of the default-horizon mismatch of CDS, I form a new short-horizon measure of interbank credit risk that uses the daily tiering of bank credit that is priced into their borrowing rates, as an alternative to bank CDS premia. The measure is formed by taking the daily difference in the actual borrowing rates of banks with differing creditworthiness. It is constructed with all of the overnight transactions that occurred on the e-MID trading platform (described earlier in this section). The use of this measure assumes that the dispersion and level of credit risk are proportional. This proportionality has been employed by several researchers to explain events in

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[14] 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.

[15] EURIBOR is a trimmed arithmetic average of interbank survey rates collected from a particular set of banks. 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.

the Financial Crisis. For example, Heider, Hoerova, and Holthausen (2015) model this relationship specifically in interbank markets. Gorton and Ordoñoz (2014) use variation in the cross section of stock returns as a proxy for the level of perceived collateral value. Appendix I describes the proposed bank-tiering measure in detail. Figure 4 illustrates a large spike in both interbank credit measures over the sample. The specific risk captured appears to differ; the bank-tiering measure reaches its highest level in the fall of 2008 (Panel A), while the bank CDS premium peaks in early 2009 (Panel B).

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

Now to empirically investigate whether—and to what extent—credit and liquidity potentially drove the unprecedented variation in euro-area sovereign yield spreads during the Global Financial Crisis. The aim in this estimation is to quantify the relative contribution of these variables to spread widening over the Crisis, and to document differences by country. With this in mind, I estimate the following equation at the daily frequency:

$$y_{cmt} = \alpha_{cm} + \beta_{cm}\kappa_{mt} + \chi_{cm}d_{cmt} + \varepsilon_{cmt} \tag{2}$$

where y_{cmt} is the sovereign yield spread for country c relative to the German benchmark, at the m-year maturity point on day t, κ_{mt} is the KfW spread at the same maturity point, and d_{cmt} is the deviation of the CDS spread from its benchmark German counterpart for that country and that maturity point. Equation (2) is then estimated as a seemingly unrelated regression (SUR) over all country-maturity pairs. To gauge the relative responses, the coefficient estimates on credit χ_{cm} and liquidity β_{cm} are allowed to vary by country and maturity.

The results of equation (2) are shown in Table 3 at the 2-, 5-, and 10-year maturities.[16] The coefficient estimates on the K-spread are significant and positive for each country, at each maturity point, when considered alone (Panel A) and when controlling for credit (Panel C) with CDS spreads. The pricing of market liquidity conditions is pervasive in yields; a wider K-spread is associated with a higher bond discount for each country-maturity pair. CDS spreads differ by country, allowing the effect of each sovereign issuer's fiscal position on yields to vary independently. Theoretical CDS-bond arbitrage arguments (Duffie, 1999) imply that CDS spreads and bond yield spreads should be identical, giving a coefficient of one on CDS for each country-maturity pair. However, as argued by Longstaff, Pan, Pedersen and Singleton (2011) and others, this theoretical relationship fails to hold in practice because of frictions including transactions costs, tax effects and the delivery option in fulfillment of the CDS contract in the event of default. Ammer and Cai (2011) argue that the cheapest-to-deliver option makes yield spreads move less than one-for-one with CDS spreads. The coefficients on CDS spreads when estimated alone (Panel B) and when controlling for liquidity (Panel C), are highly significant and positive, but generally less than 1. As a robustness check, equation (2) is run imposing a coefficient of 1 on the CDS spread, and the results are shown in the internet appendix.

The significance of the estimates from a regression of sovereign yield spreads onto the K-spread and CDS spreads jointly shows that these two measures have distinct and separate influences on sovereign spreads. However, this does not necessarily mean that each variable has an economically meaningful incremental contribution to spreads, after controlling for the other variable. One way to assess the additional contribution of each variable in explaining the movement in sovereign yield spreads, is to compare the adjusted R-squared values in the joint

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

estimation (Panel C) with those in the univariate estimations (Panels A and B) that are nested versions of equation (2). Credit and liquidity jointly explain 87% of the variation in sovereign spreads, as measured by the R-squared value, averaged over countries and maturities in Panel C. This compares to the average R-squared values of 62% and 66%, from univariate estimation of the effects of liquidity alone (Panel A) and credit alone (Panel B).

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

Each sovereign spread in the sample reached its widest point (shown in Figure 1) within the six months following Lehman's September 2008 failure. What drove the sudden increase in the discount demanded by investors to hold these bonds at this time? To understand the relative importance of liquidity versus credit to this episode, I match the trough-to-peak yield spread change for each country-maturity pair, to the corresponding change in credit and liquidity measures over the same dates. For example, the Italian 5-year bond yield spread widened from a sample-period low of 3 basis points on June 6, 2007 to a high of 141 basis point on January 23, 2009. Over this period, the 5-year K-spread widened by 68 basis points, and the 5-year Italian CDS spread widened by 118 basis points. Next, I calibrate the movements in the credit and liquidity measures to the jointly estimated coefficients in Panel C of Table 3 to calculate the independent contribution of each measure. The K-spread explains 57 basis points (68×0.84) of the 138 basis point Italian sovereign spread widening, controlling for credit, and the CDS spread explains 43 basis points (118×0.36), controlling for liquidity; a 0.41 and 0.31 share contribution to the 5-year Italian yield spread widening for liquidity and credit, respectively.

Each symbol in Figure 5 represents the share of trough-to-peak sovereign yield spread widening explained by credit (x axis) versus liquidity (y axis), averaged over maturities for each country. The spread widening of countries in the upper left quadrant of the figure (e.g. France and

Finland) are primarily explained by an illiquidity discount, while default risk explains relatively more of the additional yield demanded to hold debt of the countries shown in the lower right quadrant (e.g. Greece and Ireland). The contribution of credit to the spreads of France and Finland is small enough that they would have remained within historic ranges had market liquidity been unaffected. Several countries are near the center of the figure, showing a sizeable influence for both liquidity and default risk. An equal weighted average across all countries and maturities shows a comparable role for credit and liquidity overall, with the K-spread explaining 36% of the peak-to-trough spread widening and CDS explaining 35%. Weighting the shares by the sample-average size of debt outstanding for each country and maturity tilts the importance toward liquidity, showing 45% yield spread widening attributable to the K-spread and 26% attributable to credit.

Finally, to compare sensitivity across countries to credit and liquidity shocks of a similar magnitude, I consider the change in the sovereign yield spread associated with a one standard deviation shock to each measure. The effects are calibrated using the jointly estimated coefficients in Panel C of Table 3 and the bond summary statistics in Table 1. Again using the Italian spread for illustration, a one standard deviation (24.77 basis point) widening of the 5-year K-spread, is associated with a 21 basis point widening (24.77×0.84) of the 5-year Italian bond spread.

Figure 6 summarizes each country's average response across maturities, in basis points, to a one standard deviation widening in CDS spreads (x axis) and a one standard deviation widening in the K-spread (y axis). The average liquidity shock effect ranges from 9 to 20 basis points across countries. For a country with a relatively small sovereign spread to start, this magnitude of shock could more than double the size of its spread. The effect of a one standard deviation movement in the CDS spread ranges from having close to no effect for the countries situated along the y axis

(France and Finland), to nearly 60 basis points of widening for Greece and Ireland. It makes sense that countries closer to the default boundary would be more sensitive to further credit shocks. The Greek debt crisis had not yet taken hold during the sample period, though Greece's fiscal position was already the weakest as measured by debt/GDP in the euro area, and the Irish government moved closer to the default boundary upon guaranteeing the debt of its private banks in 2008 to prevent their collapse.

2.2 Controlling for Country-Specific Liquidity

To compare the K-spread with traditional liquidity measures, and to addresses the potential concern that a measure with German origins may not fully capture other countries' liquidity effects, equation (2) is now expanded to include the five country-specific market microstructure measures as defined in subsection 1.4:

$$y_{cmt} = \alpha_{cm} + \beta_{cm}\kappa_{mt} + \chi_{cm}d_{cmt} + \Xi'_{cm}X_{cmt} + \varepsilon_{cmt} \qquad (3)$$

where X_{cmt} is the vector of the five country-specific liquidity characteristics, relative to those of Germany. The coefficient Ξ_{cm} measures yield spread sensitivity to the additional liquidity measures at each maturity point. For two of the microstructure measures, the bid-ask spread and the Bollen-Whaley index, a higher value indicates deteriorating liquidity, and so a positive coefficient estimate is consistent with an illiquidity discount in yields. For the remaining three measures (volume, trade size and order flow), a higher value denotes improving liquidity.

Panel D of Table 3 shows the expanded regression results. No single microstructure measure is significant across countries, and the estimates $\hat{\Xi}_{cm}$ are unstable in sign. However, the CDS and the K-spread estimates remain highly significant and close to their values in the bivariate case (Panel C). A comparison of the R-squared values for the different specifications shows little incremental benefit to adding the microstructure measures; averaged across countries and maturities, the adjusted R-squared is 87% when sovereign CDS and the K-spread are the only as explanatory variables, compared to 88% with the full specification.

The relatively small role for microstructure measures of liquidity is consistent with Beber, Brandt and Kavajecz (2009), who found that credit (also measured with sovereign CDS spreads) was far more important than microstructure liquidity variables for euro-area sovereign yields over 2003 and 2004. Despite the empirical advantage of the microstructure measures in relating distinctly to each country's sovereign bond yield spreads, the K-spread remains paramount in explaining the liquidity component in sovereign spreads. The nature of the liquidity effect captured by the K-spread could represent liquidity problems that are not well measured by microstructure measures such as the pricing of liquidity risk—a premium demanded by investors for holding securities that might become less liquid in a high marginal-utility state of the world (Acharya and Pedersen (2005), Dow (2004), Musto, Nini, and Schwarz (2018)).

A natural concern in the estimation of equations (2) and (3) is that the variables are highly persistent, and so spurious regression problems may arise. This motivates running the regression in first differences. As a robustness check, I estimated equations (2) and (3) in weekly changes (not daily changes, because of concerns of slight non-synchronicity). The results are reported in the internet appendix. While the t-statistics are smaller, the overall conclusions are robust.

3. The Role of Aggregate Bond Market Liquidity in Euro-Area Interbank Spreads

The models of Brunnermeier and Pedersen (2009) and Bolton, Santos and Scheinkman (2011) describe a close relationship between bond and funding markets. This section empirically assesses the effect of aggregate bond liquidity in the funding market by using the K-spread to parse interbank rates.

3.1 *Aggregate Bond Market Liquidity and Bank-Tiering Credit in Interbank Interest Rates*

To examine euro-area money market spreads, I conduct a time-series regression of interbank spreads onto liquidity and credit measures. The specification is:

$$y_{mt} = \beta_m \kappa_t + \chi_m d_t + \delta_m d_t^{cds} + \Xi_m' X_t + \varepsilon_{mt} \tag{4}$$

where y_{mt} denotes the EURIBOR minus OIS spread at maturity *m* on day *t*, κ_t is the K-Spread measure of euro-area sovereign bond market liquidity[17], d_t is the bank-tiering measure of credit risk, d_t^{cds} is the average EURIBOR bank CDS premium and X_t is a vector containing the interbank market microstructure liquidity measures. Separate time series regressions are run for the 1-, 3-, 6- and 12-month EURIBOR-OIS maturities.[18]

Table 4 shows the estimation results for equation (4) at each of the four maturity points, in Panels A through D. Univariate regression estimates, reported in the first three columns of each panel, show that the K-spread, the bank-tiering credit measure, and the bank CDS premia, are each independently significant at the 1% level. The estimates are all positive, consistent with the intuition that a deterioration in either credit or aggregate market liquidity conditions would lead banks to charge one another a higher borrowing premium.

The fourth column of each panel in Table 4 shows the joint effect of credit and liquidity, estimated with a regression of EURIBOR-OIS spreads onto both the K-spread and the bank-tiering credit measure. In comparison to the univariate case, the K-spread coefficient estimates $\hat{\beta}_m$ are nearly unchanged in size, but the bank-tiering credit estimates $\hat{\chi}_m$ fall to less than one quarter of

[17] Results are reported when using the 1-year maturity K-spread measure for the analysis of interbank spreads, but the estimation is not sensitive to the choice of maturity.
[18] The explanatory variables are the same at all four maturities; so estimating the equation at the four maturities jointly by SUR gives numerically identical results.

their size in univariate regressions. Now, I assess the EURIBOR-OIS spread sensitivity to a one standard deviation shock in credit and liquidity, using the summary statistics in Panel B of Table 2 and the joint estimates in column 4 of each panel for calibration. A 9 basis point increase in bank tiering implies a 2 to 4 basis point EURIBOR-OIS spread increase, depending on the maturity. A one standard deviation increase in the K-spread (24 basis points) is associated with a 23 basis point increase in the 1-month EURIBOR-OIS spread, and a 50 basis point increase in the 12-month spread. For comparison, a typical ECB monetary policy tightening of 25 basis points is expected to produce roughly the same magnitude increase in other short-horizon interest rates. Considering that trillions of euros worth of contracts are linked to prevailing EURIBOR, worsening bond liquidity implies a potentially substantial tightening of financial conditions.

3.2 Controlling for Bank CDS and Interbank Market Liquidity Effects

To address the potential contribution of idiosyncratic interbank liquidity or default risk in bank CDS spreads to EURIBOR-OIS spreads, I now estimate equation (4), including these additional variables as controls. The fifth column of Table 4 reveals that the bank CDS estimates $\hat{\delta}_m$ are unstable in sign and insignificant at 6- and 12-month maturities. Bank CDS premia explain little in interbank spreads beyond what is already captured jointly by the bank-tiering and K-spread measures. The sixth column of Table 4 gives estimates with the full set of controls, now adding the five interbank microstructure liquidity measures, X_t. The bid-ask spread and the Bollen-Whaley index are significant at all maturities, but they give little incremental benefit in explaining EURIBOR-OIS spreads, beyond the liquidity effect from the K-spread. The adjusted R-squared values, when including the full set of controls (column 6), are very close those from the regressions without the five interbank liquidity measures (column 5). The final column of Table 4 shows the expanded specification without the K-spread measure of aggregate liquidity. Accounting for aggregate bond market liquidity improves the explanation of EURIBOR-OIS spreads, beyond the effect of all of the interbank measures, by 22%, as measured by comparing the average of R-squared values over maturities (columns 6 and 7).

The estimation results in Table 4 suggest that steps to improve aggregate market liquidity could narrow interbank spreads substantially, independent of any credit effect. In the fall of 2008, EURIBOR-OIS spreads rose from less than 10 basis points to 150 and 240 basis points at the 1- and 12-month maturities, respectively. An extreme hypothetical counterfactual scenario in which all assets are made equally liquid, would result in a K-spread equal to zero (below even the small positive spread prior to the crisis). Judging from the bivariate regression results in the fourth column of Table 4, such a market environment 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. As in the sovereign bond spread analysis, equation (4) is also run in first differences for robustness. The interpretation of the results, reported in the internet appendix, is unchanged.

4. 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 potential

[19] The sample average EURIBOR-OIS spread is 30.4 and 75.1 basis points at the 1- and 12-month maturities, respectively (Table 2, Panel A), and the K-spread is 26.3 basis points on average over the sample (Table 2, Panel B). At the 1-month maturity, a 0 basis point K-spread implies a 25.2 (=0.96×26.3) basis point decline in the 1-month EURIBOR-OIS spread, and 55.0 (=2.09×26.3) basis points at the 12-month maturity. Subtracting these from the sample-average EURIBOR-OIS spreads gives 1- and 12-month EURIBOR-OIS spreads of 5 (=30.4-25.2) and 20 (=75.1-55.0) basis points, respectively.

drivers behind these movements: (1) a higher likelihood of default, and (2) market liquidity effects, separate from default risk. Policy prescriptions for addressing these risk conditions differ. If the chief component is default, then only actions to improve the solvency of the issuer are likely to be successful. On the other hand, if wider spreads represent a discount for poor liquidity, then measures to improve market functioning are the most appropriate, and could help prevent adverse repercussions due to a sustained period of higher financing costs. From a practitioner standpoint, a relative price premium attributable to a disruption to market liquidity may represent an attractive opportunity for a long-horizon investor to exploit, whereas deteriorating credit risk would not.

This paper first documents the large and persistent liquidity differential between yields on two duration-matched bonds that share an identical credit guarantee from the German federal government. I interpret this yield spread as a model-free measure of euro-area market liquidity, conceptually similar to the Refcorp spread proposed by Longstaff (2004). Formed directly from asset prices, this liquidity yield differential, the K-spread liquidity measure, recovers all information in bond yields that is not related to default risk.

The K-spread and other measures are then used to estimate the effect of credit and market liquidity risks in explaining the extreme euro-area sovereign bond and EURIBOR-OIS spread movements during the 2007-2009 Financial Crisis. I find that aggregate market liquidity played a substantial role in sovereign bond yield spread widening in the Crisis. A decline in liquidity, as measured by the K-spread, accounted for 36% of the trough-to-peak spread widening in sovereign bond spreads over the Crisis (averaged over countries and maturities in the sample), an effect comparable to that of default risk. The common component of liquidity in sovereign bond spreads is substantially larger than the influence of country-specific microstructure bond liquidity measures. This suggests that the K-spread captures a liquidity dimension not priced into instantaneous microstructure liquidity measures.

Additionally, the K-spread measure of aggregate bond market liquidity shows an important role in explaining interbank interest rates spreads, beyond the effects of credit and liquidity measures constructed from interbank transactions. This gives empirical evidence of the large and significant influence of aggregate bond market liquidity on interbank rates. It also underscores the potential for spillover effects stemming from market liquidity disruptions. A common liquidity factor is consistent with the idea that the ease with which securities are traded is related to their value as collateral in funding transactions. The large role for liquidity supports existing findings from the corporate bond literature (Chen, Lesmond and Wei (2007), Bongaerts, de Jong and Driessen (2013)), but applies here to the sovereign bond and interbank markets during the Global Financial Crisis.

The results in this paper have implications for policymakers and for the portfolio choices of investors. For practitioners, a long/short position mimicking the K-spread can hedge against credit fluctuations. The measure itself can gauge real-time pricing of market liquidity risk, helping to inform investment decisions. For policymakers, the results imply that measures to improve market functioning, or even an action that addresses risk perceptions alone, could be effective in bringing down risk spreads. Importantly, 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 I

Bank Credit Tiering Measure Estimation

Default risk premia in unsecured interbank interest rates are unobservable, But, the *difference* in interbank borrowing rates at the same point in time controls for the common component and isolates the difference in risk premia between these borrowers.[20] 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 the two rates removes the common risks and market conditions that are faced by all market participants on the e-MID platform. The bank-tiering credit measure, d_t, driven by the *relative* credit premia of the two bank types, is defined as follows:

$$d_t = \overline{r}_{t,High} - \overline{r}_{t,Low} \tag{5}$$

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*.

To motivate this approach, 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 of b_j be θ. Then the average credit premium on any day is r_t and the dispersion across banks on any day is θr_t. The average credit premium on day *t* is thus

[20] In the unsecured interbank market, the lender is fully exposed to the credit risk of the borrower, and this is the only credit risk that the lender faces. The interbank rate thus prices the likelihood of repayment by the borrower.

proportional to the dispersion in rates.[21] In this model, 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 model of Merton (1974) 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 (Longstaff, Pan, Pedersen and Singleton (2011)).

To operationalize this bank-tiering measure, I use the 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.[22] There are 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.[23] A bank will initiate a market order to lend only if the posted

[21] 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 $r_{high}b_{worst} - r_{high}b_{best} = 5$.

[22] 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 EURIBOR and LIBOR may be affected by manipulation. A comparison of LIBOR and other measures of bank borrowing costs is reported in Kuo, Skeie and Vickery (2012).

[23] In contrast, the MTS bond trading platform follows conventional price-time priority; trades are matched automatically based on the most attractive quote submitted, with priority given to the earliest submission. The

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.[24]

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: [25]

$$r_{h,i,j,t} = \alpha + \Sigma_{h=1}^{m-1}\beta_{1,h}T_h + \Sigma_{j=1}^{n-1}\beta_{2,j}B_j + \Sigma_{t=1}^{T-1}\beta_{3,t}D_t + \varepsilon_{i,h,j,t} \tag{6}$$

where $r_{h,i,j,t}$ denotes the unsecured interbank rate paid by borrower *j* in its i^{th} transaction on day *t* in hour *h*. T_h denotes the time-of-day indicator variable for each hour, *h*, B_j denotes the indicator variable for bank borrower *j,* and D_t denotes the indicator variable for day *t*. The day and time indicators control for effects common to all rates, including interbank market-wide liquidity shocks.[26] The bank dummy coefficient, $\beta_{2,j}$, estimates the average credit quality of each bank.[27] Considering only the borrowing side of the quote avoids any contribution of noise

counterparty's identity is revealed only after the trade is agreed to, which eliminates counterparty risk effects from bond trades on the MTS platform.

[24] 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 counterparty 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; 81% of interbank lending volume in the sample is 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."

[25] 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.

[26] Controlling for the day effect in equation (6) 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 (6). However, this approach confounds the credit component with repo market seasonality.

[27] 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

to the measure from the bid-ask bounce. I re-estimate the banks' creditworthiness each day, using the past 30 days of transactions, updating each banks' relative ranking based on its most recent borrowing rates.

2. Next, I sort borrowers into credit quintiles according to their $\beta_{2,j}$ credit coefficient estimates; the top quintile represents banks that paid the highest average rates, and are thus perceived as the worst credits.[28] Each quintile contains the same number of banks. For an apples-to-apples comparison, I use only maturity-matched trades.[29] To mitigate any survivorship bias, I only use rates of banks transacting in both the first and last quarters of the sample, reducing the bank sample to 135.

3. In the third and final step, I define the bank-tiering credit measure. Let $\overline{r}_{t,High}$ and $\overline{r}_{t,Low}$ denote the average rates paid by the banks in the highest and lowest risk quintiles, respectively, on day *t* (averaged across all hours on each day). The bank-tiering credit measure is then simply $\overline{r}_{t,High} - \overline{r}_{t,Low}$ as in equation (5).

Figure 4, Panel A plots the new bank-tiering credit measure, showing that it peaks at 63 basis points in October 2008. This compares a less-than 5 basis point difference in average rates paid by the best- versus worst-credit banks in normal times.

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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.

[28] 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. Low credit banks should prefer to borrow via limit order so that their identity is factored into the counterparty's lending 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% in the best credit quintile, compared to 57% 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.

[29] In the sample, 91% 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.

Table 1. Sovereign Bond Market Summary Statistics

Panel A: Yield Spreads, CDS Spreads, and Microstructure Liquidity Measures (Deviations from Germany)

	Sovereign Yield Spread (basis points)		Sovereign CDS (basis points)		Bid-Ask (basis points)		Daily Volume (€ billion)		Trade Size (€ million)		Order Flow (€ billion)		BW Index (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	16.71	18.77	23.61	36.75	0.48	1.01	-0.04	0.09	1.37	2.87	-0.02	0.31	-0.03	0.39
Belgium	19.31	20.95	10.57	14.28	0.94	0.90	-0.02	0.09	1.19	2.95	-0.09	0.43	-0.07	0.46
Spain	19.90	22.60	18.74	19.40	0.80	0.84	-0.03	0.09	0.99	3.42	-0.01	0.33	-0.05	0.39
Finland	7.47	10.38	1.17	4.28	-0.09	1.12	-0.05	0.09	-0.35	3.39	-0.03	0.27	0.10	0.45
France	7.40	8.36	1.31	4.49	0.58	0.74	-0.01	0.09	0.62	3.41	-0.06	0.30	-0.05	0.40
Greece	57.14	62.96	45.46	55.28	0.46	1.08	-0.04	0.09	-0.64	3.08	0.01	0.28	0.03	0.41
Ireland	31.90	47.71	57.55	79.60	-0.56	1.22	-0.05	0.09	1.38	2.84	0.12	0.25	-0.17	0.39
Italy	29.30	32.42	27.98	33.13	-0.37	0.54	0.33	0.26	-2.01	2.61	0.00	0.35	-0.22	0.36
Netherlands	5.15	9.83	8.48	13.89	0.20	0.63	-0.02	0.15	2.41	5.56	0.02	0.71	-0.11	0.38
Portugal	28.77	29.88	17.16	17.15	-0.15	1.41	-0.01	0.11	1.23	2.61	0.00	0.49	-0.19	0.38
5-Year Maturity														
Austria	24.51	27.35	27.58	40.99	2.42	3.47	-0.01	0.05	1.54	3.00	-0.04	0.29	-0.09	0.86
Belgium	30.53	29.73	15.30	16.21	3.55	2.53	0.03	0.09	1.13	2.86	-0.05	0.33	-0.03	1.07
Spain	27.55	28.20	27.76	23.03	3.44	3.56	0.01	0.08	1.67	3.43	0.01	0.31	0.03	1.37
Finland	19.90	20.55	1.29	3.38	2.02	3.14	0.01	0.07	1.98	2.90	-0.06	0.35	-0.11	1.04
France	14.79	13.38	2.78	3.19	3.44	2.19	0.00	0.06	0.39	3.09	-0.01	0.25	0.09	1.03
Greece	77.91	80.94	59.03	60.05	2.60	3.04	0.00	0.06	0.18	2.75	0.00	0.19	0.13	0.96
Ireland	59.05	74.09	62.00	78.79	1.74	3.14	-0.01	0.05	1.33	3.10	-0.01	0.30	-0.33	0.84
Italy	38.80	34.14	38.55	35.53	1.44	2.16	0.20	0.24	-1.00	2.24	0.02	0.41	-0.34	0.83
Netherlands	18.98	21.05	8.40	13.54	1.53	2.22	0.01	0.12	2.95	3.46	0.05	0.56	-0.25	0.79
Portugal	39.28	37.55	24.91	18.98	2.71	3.39	0.03	0.11	1.73	2.78	0.01	0.41	-0.21	0.87
10-Year Maturity														
Austria	24.32	26.01	27.18	39.67	7.61	6.04	-0.02	0.05	0.08	3.06	-0.02	0.33	0.73	1.69
Belgium	26.39	23.31	16.53	16.12	9.25	6.21	-0.02	0.05	0.74	2.70	0.02	0.33	0.85	1.72
Spain	28.13	27.47	30.71	22.05	8.60	5.60	-0.02	0.05	1.05	3.28	-0.04	0.34	0.92	1.99
Finland	13.51	15.61	2.30	4.01	5.06	6.25	0.00	0.07	1.59	2.69	-0.20	0.52	0.18	1.48
France	13.29	10.05	3.42	3.89	10.67	6.67	-0.02	0.05	-1.78	3.21	0.01	0.31	1.69	2.49
Greece	76.67	67.98	62.24	55.84	10.54	7.95	-0.01	0.06	-1.25	2.99	0.01	0.30	1.51	2.02
Ireland	61.37	75.98	60.78	73.48	7.74	6.31	-0.02	0.05	-0.21	3.32	-0.02	0.29	1.01	1.85
Italy	47.51	35.06	42.88	33.88	7.64	6.25	0.09	0.21	-3.15	2.45	0.02	0.36	1.09	2.11
Netherlands	14.97	14.01	8.87	13.59	11.35	8.55	-0.01	0.15	-0.44	4.01	0.06	0.82	1.64	2.67
Portugal	37.95	31.24	27.77	17.89	7.73	8.34	0.02	0.09	-0.95	2.50	-0.04	0.50	0.75	2.07

Table 1 Continued

Panel B: K-Spread Statistics and Correlation with German Microstructure Liquidity Measures

	K-Spread (basis points)	(basis points)	Bid-Ask (basis points)	Daily Volume (€ billion)	Trade Size (€ million)	Order Flow (€ billion)	BW Index (ratio)
	Mean	St Dev	German Liquidity Measure Correlation				
2-Year Maturity	30.53	25.13	0.73	-0.29	-0.09	0.04	0.36
5-Year Maturity	35.56	24.77	0.88	-0.25	-0.11	-0.08	0.64
10-Year Maturity	27.49	18.22	0.58	-0.12	-0.38	0.21	0.29

Panel C: Liquidity and Credit Correlation

	K-Spread (basis points)	Sovereign CDS (basis points)	Bid-Ask (basis points)	Daily Volume (€ billion)	Trade Size (€ million)	Order Flow (€ billion)	BW Index (ratio)
	2-Year Maturity						
K-Spread	1.00						
Sovereign CDS	0.52	1.00					
Bid-Ask	-0.27	-0.21	1.00				
Daily Volume	0.01	0.05	-0.18	1.00			
Trade Size	0.06	0.02	-0.01	0.00	1.00		
Order Flow	0.02	0.05	-0.09	0.11	0.11	1.00	
BW Index	-0.22	-0.24	0.28	-0.22	-0.35	0.00	1.00
	5-Year Maturity						
K-Spread	1.00						
Sovereign CDS	0.58	1.00					
Bid-Ask	-0.09	-0.17	1.00				
Daily Volume	-0.05	0.00	-0.16	1.00			
Trade Size	-0.01	-0.16	-0.07	0.07	1.00		
Order Flow	0.08	0.07	0.01	0.11	0.07	1.00	
BW Index	-0.31	-0.23	0.43	-0.21	-0.42	-0.01	1.00
	10-Year Maturity						
K-Spread	1.00						
Sovereign CDS	0.61	1.00					
Bid-Ask	0.25	0.12	1.00				
Daily Volume	-0.10	-0.02	-0.24	1.00			
Trade Size	0.07	-0.08	-0.01	0.05	1.00		
Order Flow	-0.08	-0.03	-0.01	0.28	-0.06	1.00	
BW Index	0.11	0.06	0.52	-0.24	-0.27	-0.01	1.00

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 bond yield spreads, CDS spreads and microstructure liquidity measures for 10 euro-area countries. Each measure is expressed as the country indicator's deviation from the German indicator. Panel B reports the K-spread mean, standard deviation and correlation with the microstructure liquidity indicators for Germany. Panel C reports correlations among the K-spread liquidity measure and the other sovereign bond market liquidity indicators that are reported in Panel A. The correlations are run separately for each maturity, using all country data. The K-spread is formed as the KfW agency bond yield minus the German federal government bond yield. The CDS spread is each country's sovereign debt premia minus German sovereign debt premia. The market microstructure liquidity measures are formed using sovereign bond transaction data from the MTS trading platform, as the country measure minus the German measure. All statistics 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 Summary Statistics

Panel A: Interest Rates and Spreads

	EURIBOR (percentage points)		OIS (percentage points)		EURIBOR - OIS (basis points)	
	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: Liquidity and Credit Measures

	K-Spread (basis points)	Bank-Tiering (basis points)	Bank CDS (basis points)	Bid-Ask (basis points)	Daily Volume (€ billion)	Trade Size (€ million)	Order Flow (€ billion)	BW Index (ratio)
Mean	26.25	8.27	59.26	4.52	11.29	33.35	-7.40	1.01
Standard Deviation	23.52	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				
Daily Volume	-0.56	0.22	-0.69	-0.61	1.00			
Trade Size	-0.51	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, the OIS rate and the EURIBOR-OIS spread 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 average one-year euro-area bank CDS premia. Correlations among these indicators are also reported. The K-spread is formed as the KfW agency bond yield minus the German federal government bond yield, at the one-year maturity. The bank-tiering credit measure is formed as the average unsecured interbank borrowing rate paid by the highest risk quintile of banks minus that of the lowest risk quintile (estimated in Appendix 1) on each day, using data on overnight interbank borrowing transactions from the e-MID electronic interbank trading platform. The market microstructure liquidity measures are also formed as daily averages, using the overnight interbank data. The bank CDS measure is the simple average of the EURIBOR panel banks' one-year CDS premia on each day. The sample period is from January 1, 2007 to September 30, 2009.

Table 3. Credit versus Liquidity in the Sovereign Bond Market

Dependent Variable: Bond Yield $Spread_{cmt}$

Panel A: Regressions onto $K\text{-}Spread_{mt}$

	Austria	Belgium	Finland	France	Greece	Ireland	Italy	Netherlands	Portugal	Spain
2-Year Maturity										
	0.61***	0.80***	0.36***	0.30***	1.96***	1.57***	1.19***	0.32***	1.10***	0.84***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.23)	(0.05)	(0.02)	(0.01)	(0.05)	(0.02)
R^2 - Adjusted (%)	0.66	0.91	0.73	0.82	0.09	0.52	0.79	0.43	0.37	0.61
5-Year Maturity										
	0.99***	1.14***	0.77***	0.51***	2.45***	2.24***	1.30***	0.75***	1.29***	1.01***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.19)	(0.08)	(0.02)	(0.01)	(0.05)	(0.03)
R^2 - Adjusted (%)	0.81	0.91	0.86	0.88	0.18	0.51	0.87	0.80	0.42	0.64
10-Year Maturity										
	1.30***	1.18***	0.80***	0.50***	3.10***	3.33***	1.79***	0.71***	1.48***	1.32***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.19)	(0.11)	(0.03)	(0.01)	(0.06)	(0.04)
R^2 - Adjusted (%)	0.82	0.84	0.87	0.77	0.25	0.54	0.83	0.84	0.43	0.59

Panel B: Regressions onto CDS $Spread_{cmt}$

	Austria	Belgium	Finland	France	Greece	Ireland	Italy	Netherlands	Portugal	Spain
2-Year Maturity										
	0.42***	0.78***	0.17***	0.30***	1.04***	0.47***	0.73***	0.28***	0.67***	0.61***
	(0.01)	(0.02)	(0.04)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
R^2 - Adjusted (%)	0.85	0.60	0.06	0.19	0.98	0.68	0.86	0.31	0.75	0.69
5-Year Maturity										
	0.53***	1.31***	1.58***	0.26***	1.08***	0.84***	0.64***	1.23***	0.86***	0.67***
	(0.01)	(0.02)	(0.07)	(0.04)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
R^2 - Adjusted (%)	0.90	0.84	0.17	0.14	0.96	0.93	0.84	0.86	0.75	0.72
10-Year Maturity										
	0.55***	1.01***	0.89***	0.67***	0.95***	0.94***	0.69***	0.72***	0.71***	0.73***
	(0.01)	(0.01)	(0.05)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
R^2 - Adjusted (%)	0.92	0.87	0.15	0.41	0.94	0.92	0.86	0.80	0.72	0.81

Panel C: Regressions onto $K\text{-}Spread_{mt}$ and CDS $Spread_{cmt}$

	Austria	Belgium	Finland	France	Greece	Ireland	Italy	Netherlands	Portugal	Spain
2-Year Maturity										
$K\text{-}Spread_{2}$	0.26***	0.69***	0.36***	0.29***	0.37***	0.87***	0.64***	0.30***	0.79***	0.57***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.05)	(0.01)	(0.02)	(0.02)	(0.01)
CDS $Spread_{c2}$	0.33***	0.26***	-0.04	0.16***	1.05***	0.34***	0.50***	0.05**	0.60***	0.49***
	(0.01)	(0.01)	(0.03)	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)
R^2 - Adjusted (%)	0.89	0.93	0.73	0.83	0.98	0.75	0.96	0.45	0.91	0.91
5-Year Maturity										
$K\text{-}Spread_{5}$	0.53***	0.87***	0.75***	0.51***	0.64***	0.30***	0.84***	0.39***	0.87***	0.64***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)	(0.04)	(0.02)	(0.01)	(0.02)	(0.02)
CDS $Spread_{c5}$	0.35***	0.47***	0.20***	-0.05**	1.07***	0.81***	0.36***	0.81***	0.77***	0.52***
	(0.01)	(0.02)	(0.04)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
R^2 - Adjusted (%)	0.96	0.95	0.86	0.88	0.97	0.93	0.96	0.91	0.91	0.89
10-Year Maturity										
$K\text{-}Spread_{10}$	0.56***	0.77***	0.84***	0.44***	0.88***	-0.37***	1.08***	0.52***	1.04***	0.76***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.05)	(0.07)	(0.02)	(0.01)	(0.03)	(0.02)
CDS $Spread_{c10}$	0.39***	0.53***	-0.26***	0.47***	0.92***	1.06***	0.43***	0.29***	0.65***	0.57***
	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
R^2 - Adjusted (%)	0.94	0.93	0.89	0.85	0.95	0.93	0.93	0.88	0.88	0.91

Table 3 Continued

Panel D: Regressions onto K-Spread$_{mt}$, CDS Spread$_{cmt}$ and Microstructure Liquidity Measures$_{cmt}$

	Austria	Belgium	Finland	France	Greece	Ireland	Italy	Netherlands	Portugal	Spain
	2-Year Maturity									
K-Spread$_2$	0.27***	0.69***	0.35***	0.29***	0.36***	0.94***	0.64***	0.30***	0.79***	0.57***
	(0.01)	(0.01)	(0.01)	(0.01)	0.04	(0.06)	(0.01)	(0.02)	(0.02)	(0.01)
CDS Spread$_{c2}$	0.33***	0.24***	-0.02	0.16***	1.04***	0.36***	0.50***	0.05**	0.60***	0.48***
	(0.01)	(0.01)	(0.03)	(0.02)	0.01	(0.01)	(0.01)	(0.03)	(0.01)	(0.01)
Bid-Ask Spread$_{c2}$	0.04	-0.22*	-1.26***	0.07	-1.89***	3.00***	0.55	2.02***	0.21	0.05
	(0.18)	(0.13)	(0.15)	(0.13)	0.70	(0.73)	(0.36)	(0.33)	(0.28)	(0.20)
BW Index$_{c2}$	3.52***	-0.92***	1.07***	0.53**	-5.07**	8.68***	-0.56	2.75***	0.85	0.31
	(0.57)	(0.31)	(0.36)	(0.25)	2.11	(2.56)	(0.67)	(0.75)	(0.97)	(0.52)
Order Flow$_{c2}$	0.65	1.13***	1.06*	0.92***	1.78	-5.00*	-1.30**	-0.33	-0.50	-1.22**
	0.59	0.27	0.54	0.28	2.60	2.81	0.55	0.53	0.66	0.53
Daily Volume$_{c2}$	7.64***	-0.64	-6.15***	0.58	2.28	27.28***	-0.64	-2.33	-1.85	8.74***
	(2.46)	(1.53)	(1.90)	(1.03)	9.96	(10.24)	(0.79)	(2.28)	(3.39)	(2.36)
Trade Size$_{c2}$	0.42***	-0.07	0.22***	-0.02	-0.63**	1.71***	0.15*	0.05	0.35***	0.07
	(0.07)	(0.05)	(0.05)	(0.02)	0.27	(0.30)	(0.09)	(0.05)	(0.12)	(0.06)
R^2 - Adjusted (%)	0.90	0.93	0.75	0.84	0.98	0.77	0.96	0.49	0.91	0.91
	5-Year Maturity									
K-Spread$_5$	0.54***	0.87***	0.73***	0.51***	0.63***	0.42***	0.87***	0.38***	0.86***	0.61***
	(0.01)	(0.01)	(0.01)	(0.01)	0.04	(0.04)	(0.02)	(0.01)	(0.02)	(0.02)
CDS Spread$_{c5}$	0.34***	0.47***	0.20***	-0.02	1.08***	0.78***	0.33***	0.79***	0.80***	0.52***
	(0.01)	(0.02)	(0.04)	(0.02)	0.01	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Bid-Ask Spread$_{c5}$	-0.21***	-0.40***	0.06	0.02	0.13	1.20***	0.58***	0.40***	-0.84***	-0.10
	(0.04)	(0.07)	(0.06)	(0.06)	0.25	(0.17)	(0.09)	(0.09)	(0.12)	(0.07)
BW Index$_{c5}$	0.19	-0.05	-2.24***	0.28**	-0.70	-0.67	-0.27	-0.34	-0.96**	-1.09***
	(0.17)	(0.18)	(0.22)	(0.13)	0.77	(0.68)	(0.27)	(0.29)	(0.44)	(0.22)
Order Flow$_{c5}$	-0.48	0.67*	1.08**	-0.26	-3.26	-2.75	-0.55	-0.65	0.31	-0.99
	0.43	0.40	0.49	0.41	2.92	1.77	0.42	0.41	0.74	0.64
Daily Volume$_{c5}$	5.70**	-0.61	-1.06	-2.01	12.61	11.13	0.03	3.69**	-2.26	-3.52
	(2.70)	(1.46)	(2.72)	(1.98)	11.65	(11.47)	(0.75)	(1.86)	(3.08)	(2.41)
Trade Size$_{c5}$	0.06*	0.04	-0.43***	0.17***	-0.28	0.05	0.13	0.01	0.00	-0.05
	(0.03)	(0.06)	(0.07)	(0.04)	0.24	(0.19)	(0.09)	(0.07)	(0.12)	(0.08)
R^2 - Adjusted (%)	0.96	0.96	0.89	0.88	0.97	0.93	0.96	0.92	0.92	0.90
	10-Year Maturity									
K-Spread$_{10}$	0.62***	0.79***	0.84***	0.44***	0.79***	-0.27***	1.12***	0.54***	1.08***	0.76***
	(0.02)	(0.02)	(0.01)	(0.01)	0.05	(0.07)	(0.02)	(0.01)	(0.03)	(0.02)
CDS Spread$_{c10}$	0.36***	0.50***	-0.17***	0.46***	0.93***	1.03***	0.41***	0.26***	0.68***	0.56***
	(0.01)	(0.02)	(0.03)	(0.02)	0.01	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)
Bid-Ask Spread$_{c10}$	-0.04*	-0.07***	-0.03	-0.06***	0.39***	0.20**	-0.25***	-0.02	-0.16***	-0.08**
	(0.03)	(0.02)	(0.03)	(0.01)	0.10	(0.10)	(0.03)	(0.02)	(0.04)	(0.04)
BW Index$_{c10}$	0.08	0.12*	-0.30***	0.13***	-0.25	-1.04***	0.19**	0.06	0.08	-0.22**
	(0.07)	(0.07)	(0.07)	(0.04)	0.25	(0.25)	(0.08)	(0.04)	(0.11)	(0.09)
Order Flow$_{c10}$	0.25	-0.18	0.61**	0.25	1.03	-0.23	-0.80	-0.13	-0.78	-0.87
	0.40	0.31	0.27	0.27	1.94	1.74	0.51	0.15	0.51	0.58
Daily Volume$_{c10}$	3.48	-1.74	8.71***	0.31	-9.11	-4.71	-1.85**	0.27	10.51***	-1.64
	(3.01)	(2.15)	(2.25)	(1.65)	9.81	(11.18)	(0.86)	(0.90)	(3.34)	(3.99)
Trade Size$_{c10}$	0.14***	0.13***	0.07	0.12***	0.10	0.68***	0.15*	0.01	0.16	-0.03
	(0.04)	(0.05)	(0.05)	(0.03)	0.19	(0.16)	(0.08)	(0.03)	(0.10)	(0.07)
R^2 - Adjusted (%)	0.95	0.94	0.90	0.88	0.95	0.93	0.94	0.88	0.90	0.91

Table 3. This table reports the coefficient estimates, standard errors and adjusted R-squared values from the seemingly unrelated regression estimation of equations (2) and (3), at the 2-, 5-, and 10-year maturities. The dependent regression variable is the sovereign bond yield spread of each country relative to the Germany. Panels A through C report the results of regressions that are all nested in equation (2). Panels A and B report the results of regressions onto the K-spread liquidity measure alone and the CDS spread alone, respectively. Panel C reports the joint estimation of the K-spread and CDS spreads. Panel D reports the results of estimating equation (3), which adds the five sovereign microstructure liquidity measures. All equations are 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. *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 4. Credit versus Liquidity in the Interbank Money Market

Dependent Variable: EURIBOR - OIS Spread$_{mt}$

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

Panel A: 1-Month Maturity

K-Spread	1.08***			0.96***	1.24***	1.30***	
	(0.07)			(0.07)	(0.05)	(0.06)	
Bank-Tiering		2.32***		0.48**	0.72***	0.58***	2.31***
		(0.20)		(0.24)	(0.11)	(0.12)	(0.20)
CDS			0.21***		-0.21***	-0.25***	-0.01
			(0.04)		(0.02)	(0.03)	(0.04)
Bid-Ask						0.93***	-1.46***
						(0.26)	(0.51)
Daily Volume						0.03	-1.93**
						(0.33)	(0.77)
Trade Size						-0.07	-0.18
						(0.14)	(0.22)
Order Flow						-0.15	-1.29***
						(0.16)	(0.41)
BW Index						-1.90**	-1.17
						(0.79)	(1.49)
R^2 - Adjusted (%)	75.74	50.27	16.08	76.85	85.46	85.86	59.93

Panel B: 3-Month Maturity

K-Spread	1.67***			1.61***	1.78***	1.77***	
	(0.07)			(0.08)	(0.08)	(0.09)	
Bank-Tiering		3.30***		0.20	0.34**	0.14	2.51***
		(0.31)		(0.22)	(0.17)	(0.16)	(0.27)
CDS			0.42***		-0.12***	-0.24***	0.09*
			(0.06)		(0.03)	(0.03)	(0.05)
Bid-Ask						1.38***	-1.88***
						(0.36)	(0.69)
Daily Volume						-1.21**	-3.93***
						(0.55)	(1.07)
Trade Size						-0.14	-0.26
						(0.14)	(0.25)
Order Flow						-0.19	-1.83***
						(0.40)	(0.67)
BW Index						-4.17***	-3.07
						(1.11)	(1.98)
R^2 - Adjusted (%)	86.24	49.53	31.07	86.30	87.69	89.49	66.49

Panel C: 6-Month Maturity

K-Spread	1.92***			1.81***	1.85***	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)
CDS			0.54***		-0.03	-0.19***	0.15***
			(0.06)		(0.04)	(0.04)	(0.05)
Bid-Ask						1.19***	-2.23***
						(0.31)	(0.68)
Daily Volume						-2.53***	-5.40***
						(0.57)	(1.03)
Trade Size						0.11	-0.01
						(0.13)	(0.22)
Order Flow						-0.64*	-2.37***
						(0.39)	(0.65)
BW Index						-2.63***	-1.50
						(0.95)	(1.81)
R^2 - Adjusted (%)	88.33	52.89	40.52	88.58	88.62	91.59	71.92

Panel D: 12-Month Maturity

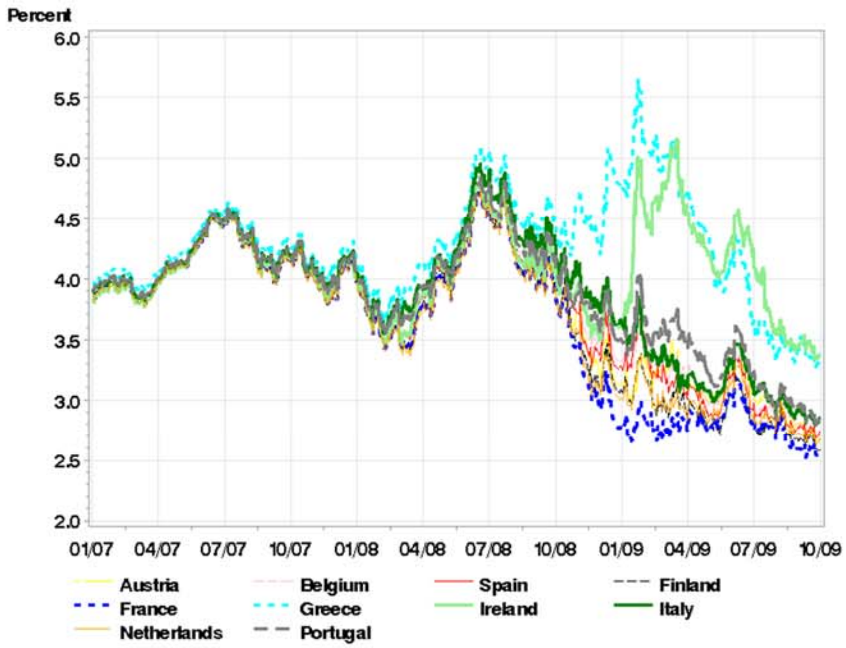
K-Spread	2.14***			2.09***	2.16***	2.13***	
	(0.09)			(0.11)	(0.12)	(0.12)	
Bank-Tiering		4.21***		0.20	0.26	0.05	2.91***
		(0.39)		(0.27)	(0.25)	(0.23)	(0.35)
CDS			0.59***		-0.05	-0.23***	0.17**
			(0.07)		(0.05)	(0.05)	(0.07)
Bid-Ask						1.20***	-2.74***
						(0.46)	(0.86)
Daily Volume						-3.37***	-6.65***
						(0.76)	(1.18)
Trade Size						0.27	0.12
						(0.17)	(0.25)
Order Flow						-0.99**	-2.96***
						(0.44)	(0.72)
BW Index						-3.29***	-1.97
						(1.24)	(2.23)
R^2 - Adjusted (%)	87.54	49.65	38.03	87.58	87.73	90.43	69.71

Table 4. This table reports the results from regressing the EURIBOR-OIS spread at various maturities onto the one-year K-spread liquidity measure, the proposed overnight bank-tiering credit measure, the one-year bank CDS premia, and overnight interbank market microstructure liquidity measures, as in equation (4). Panels A through D show the results for the 1-, 3-, 6- and 12-month maturities, respectively. The first three columns report univariate results for the K-spread, the bank-tiering measure, and the CDS spread alone. Column four in each panel is a regression onto the K-spread and bank-tiering jointly. Column five in each Panel is a joint estimation of the K-spread, bank-tiering and CDS. Column six includes all variables. Column seven is the comprehensive estimation, but without the K-spread. 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. *** indicates significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Figure 1. Euro-Area Government Bond Market

Panel A: Country Yields

5-Year Maturity



Panel B: Country Yields minus German Yield

5-Year Maturity

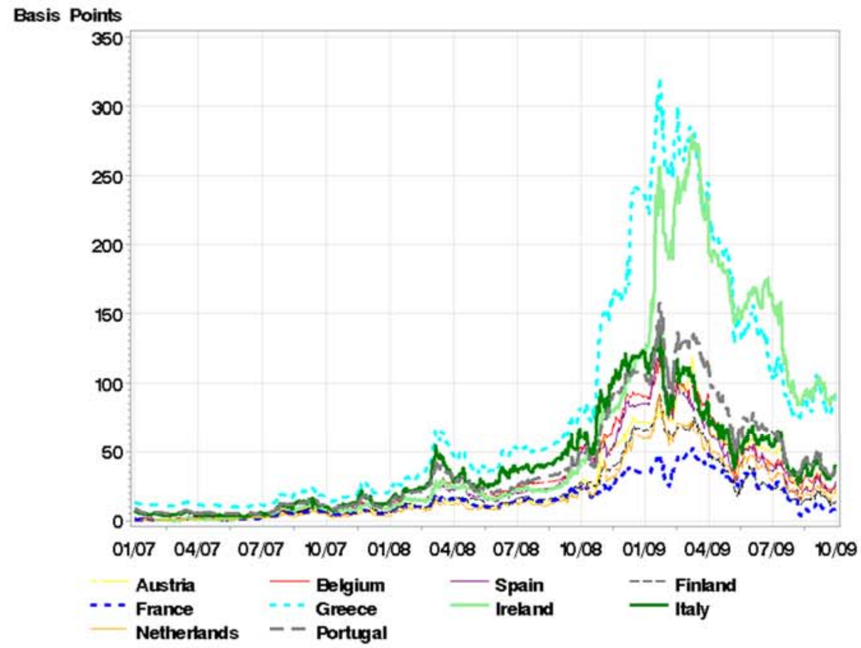
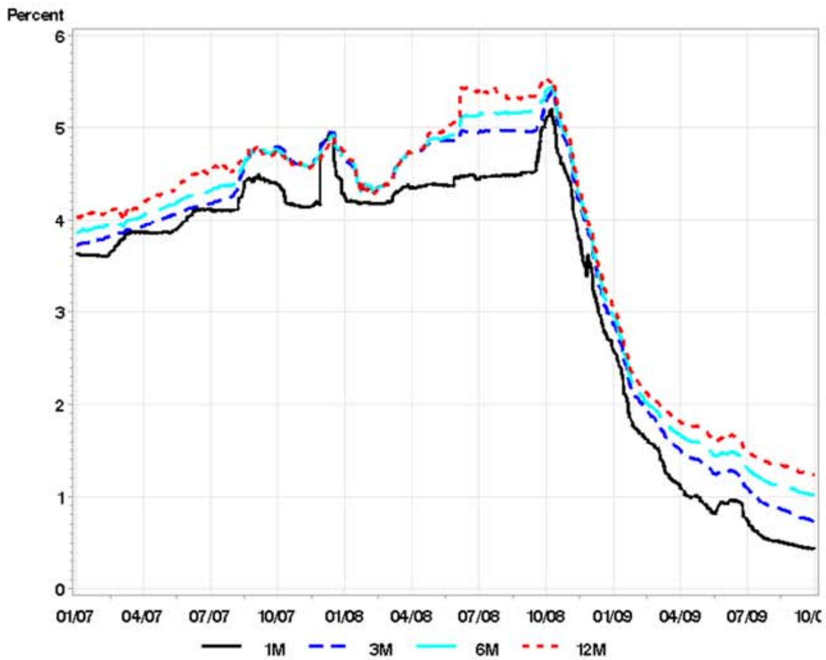


Figure 1. This figure shows sovereign bond yields (Panel A) and yield spreads relative to Germany (Panel B) for each of the euro-area countries in the sample, at the five-year maturity, at a daily frequency. These are based on zero-coupon yields, formed from smoothed curves fitted to all coupon securities, estimated separately for each country, on 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

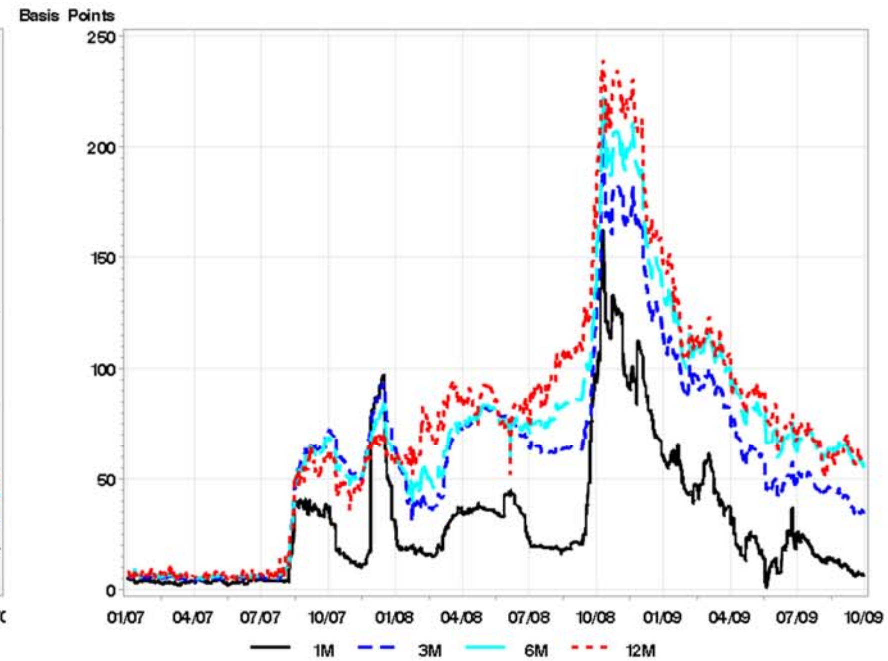
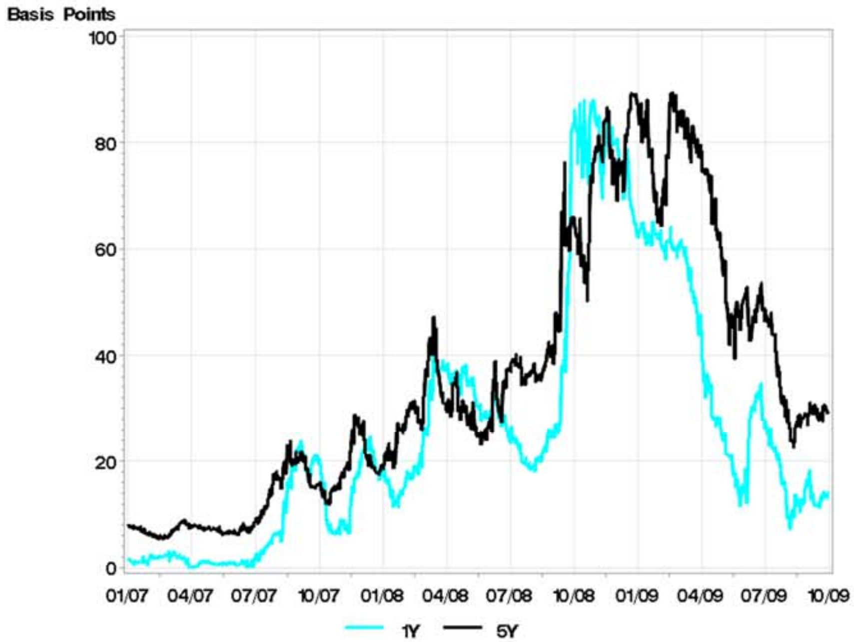


Figure 2. This figure shows euro-area interbank money market rate levels (Panel A) and spreads (Panel B) for the one-, three- , six- and 12-month maturities, at a daily frequency. Panel A shows the level of the EURIBOR. Panel B shows the EURIBOR-OIS interest rate spread, defined as the EURIBOR minus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

Figure 3. K-Liquidity Spread and Country CDS Spreads

Panel A: K-Liquidity Spread (KfW Yield minus German Government Yield)

1- and 5-Year Maturities



Panel B: Country CDS Spread (Country Premia minus German Premia)

5-Year Maturity

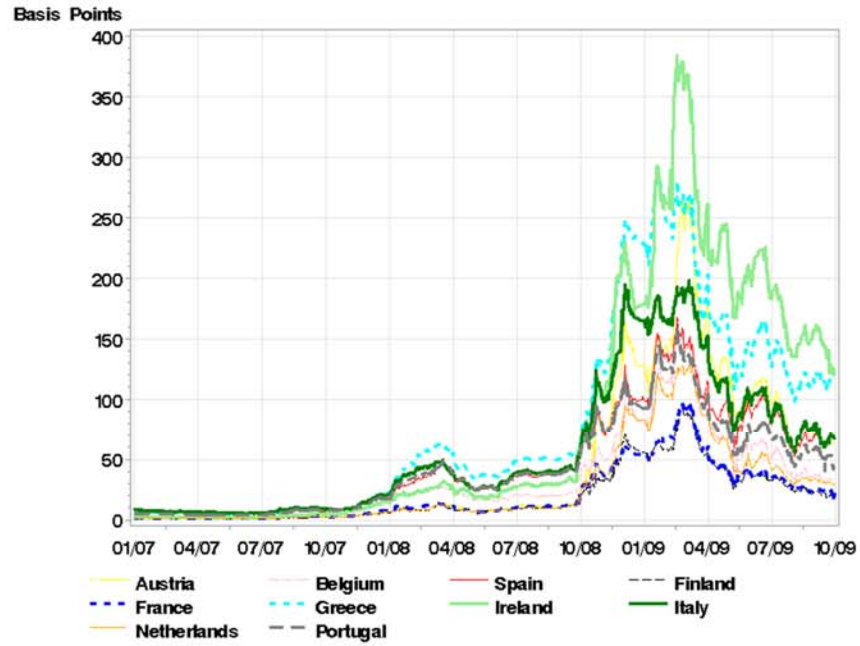
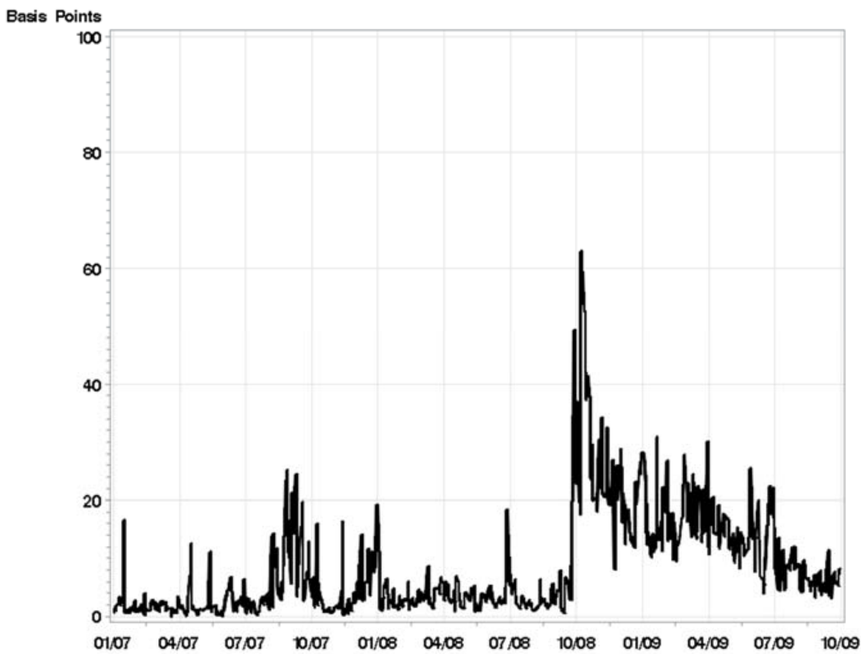


Figure 3. This figure shows a time series of the K-spread liquidity measure (Panel A) and the sovereign CDS spread credit measure (Panel B), at a daily frequency. Panel A shows the K-spread liquidity measure, at the one- and five-year maturities. The K-spread is constructed as the KfW yield minus the 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 at the five-year maturity, for the sovereign debt of each of the euro-area countries in the sample, relative to that of Germany.

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 euro-area interbank credit measures, formed at a daily frequency. Panel A shows the overnight bank-tiering credit measure, which is formed as the difference in the 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 bank CDS measure, which is the simple daily average of the EURIBOR panel banks' one-year CDS premia.

Figure 5. Share of Trough-to-Peak Sovereign Spread Widening Explained by Credit and Liquidity

Figure 5. This figure plots the share of the trough-to-peak sovereign yield spread change over the sample that is attributable to the K-spread (y axis) versus the country CDS spread (x axis), for each country separately, on average over maturities. The plotted values are based on coefficient estimates from a regression of sovereign bond yield spreads onto the K-spread and the country sovereign CDS spreads, shown in Panel C of Table 3. Each country's trough-to-peak is calculated as that country's highest yield spread minus lowest yield spread, over the sample. The same dates are used to compute the change in the K-spread and the sovereign CDS spread, for each country and each maturity.

Figure 6. Basis Point Change in Sovereign Spread Explained by One Standard Deviation Shock to Credit and Liquidity

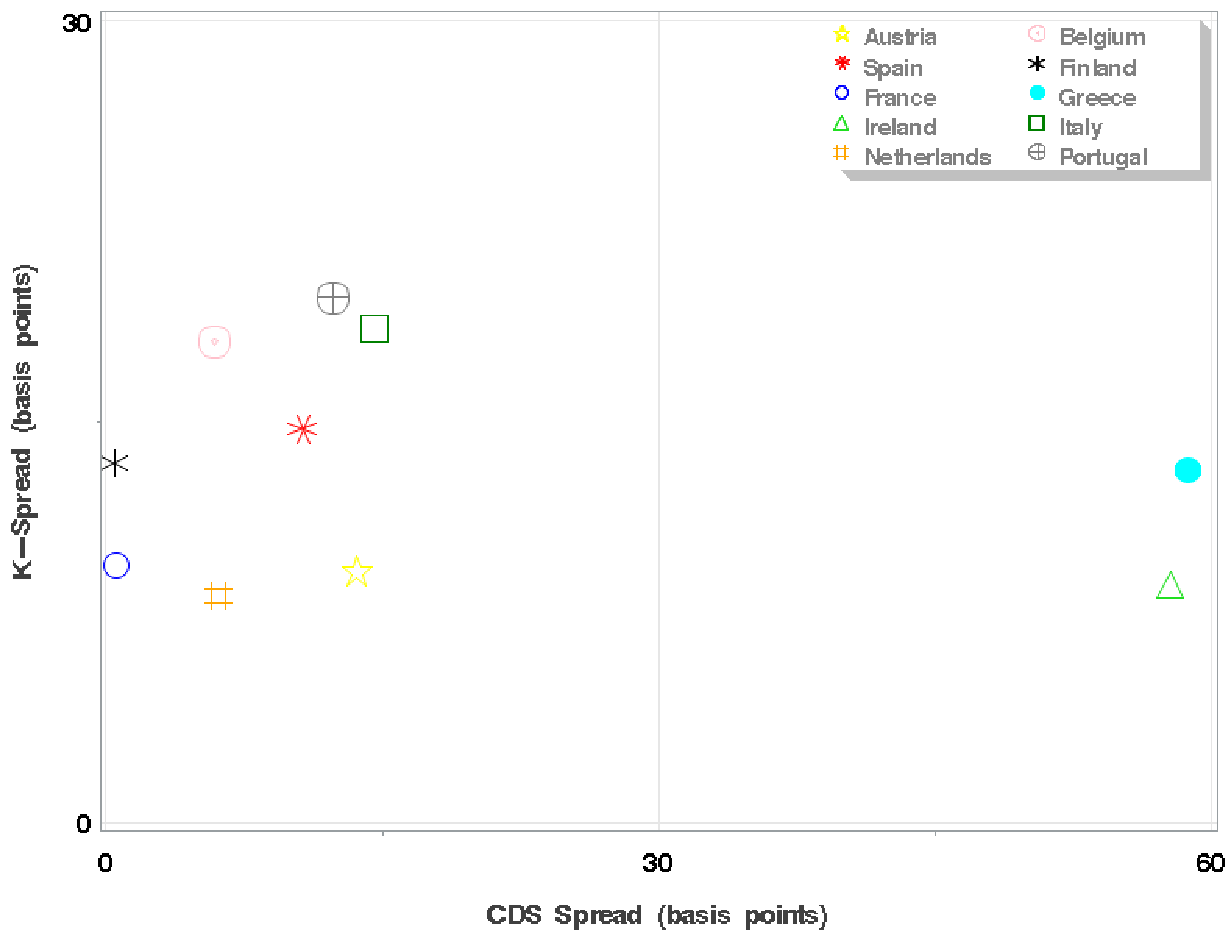


Figure 6. This figure plots the basis point change in country sovereign bond yield spreads (averaged across maturities) associated with a one standard deviation increase in the country CDS spread (x axis) versus a one standard deviation increase in the K-spread (y axis). The plotted values are based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