Not risk free: The relative pricing of euro area inflation-indexed and nominal bonds

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Keywords: Inflation-linked bond, breakeven rate, credit risk, liquidity risk, selective default

JEL: C51, F15, G01, G12, H63

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Understanding the relative pricing of inflation-linked and nominal sovereign debt is important. First, these securities directly determine the breakeven inflation rate, the yield difference between nominal and inflation-linked bonds, henceforth ILBs, which is a market-based proxy for inflation expectations. However, if different levels of risk premia drove these bond prices, the breakeven rate would be distorted. Consistent with this idea, Pflueger and Viceira (2016) and Driessen, Nijman and Simon (2014) show that the liquidity premium differs among indexed and nominal bonds. Second, these securities play an important role in the portfolio choice of a wide range of investors. For instance, pension funds and insurers are seeking inflation-linked products, thus indexed-bonds too, to incorporate into their portfolios. Moreover, the adequate understanding of the risk profile of sovereign bonds is crucial not only from the risk management perspective of investors, but also from a monetary policy point of view. By identifying the risk premia in the yields of these securities, institutions can better manage their portfolios and comply with prudential regulation, whereas governments can issue bonds that are correctly priced.

The key result of this paper is the empirical evidence of selective default risk premium in inflation-linked sovereign bond yields of Germany, France and Italy. I define selective default as an event in which a sovereign issuer chooses not to meet obligations on a class of bonds, while servicing its other debt. I identify this effect from the difference of breakeven rates from pairs of countries. Differencing eliminates common components, such as the effect of inflation expectations, monetary policy or interest rate risk. What the differencing does not take out is the exposure to risks that do not affect nominal and inflation-linked bonds equally within a country. I show that there are two systematic risk factors that drive a wedge between inflation expectations and the breakeven rate: these are liquidity and sovereign credit risks. This implies that yields of ILBs and nominal bonds carry different levels of liquidity and sovereign risk premia. The latter suggests that even without explicit seniority between the two types of bonds, the market perceives that an issuer is more likely to selectively default on its more risky, inflation-linked debt in periods of financial distress.

The idea of comparing yields of securities with similar exposures to certain risks is not new in the literature. Longstaff (2004) compares yields of US Treasuries to those of bonds issued by the Refcorp (Resolution Funding Corporation), whereas Schwarz (2015) examines yield differences of German federal government bonds and bonds issued by KFW, a government owned development bank. The key feature of theses agency bonds is that they have explicit government guarantees, and consequently the same credit risk as government bonds. However, the liquidity of government bonds is substantially higher and thus the yield difference measures general market liquidity conditions. What I do in this paper is similar but goes the other way around: while controlling for liquidity on both the nominal and inflation-linked bond markets the same way, I show that the remaining yield difference is attributed to sovereign risk. This idea is also consistent with the alternative interpretation of the Refcorp and KfW spreads - some say that these yield differentials, rather than capturing liquidity, can also be interpreted as breakup or selective default risk measures.

The secondary contribution of this paper is to provide partial explanation for the ILB-nominal puzzle documented by Fleckenstein, Lustig and Longstaff (2014). They claim that there exists a persistent mispricing between nominal bonds and ILBs of the US and other G7 countries on a significant scale. In a frictionless world, one can replicate a nominal bond with a portfolio of an ILB and inflation swaps. They find that the replicating portfolio has a lower price than the nominal bonds, suggesting that ILBs are underpriced. For the US market, Driessen et al. (2014) show that a large part of this price discrepancy is attributable to liquidity risk. However, there are other factors that could drive the mispricing, namely the impact of the deflation option[1] embedded in ILBs, liquidity and counterparty risk premia in the inflation swap quotes, or even different levels of selective default risk premia in nominal and real bonds.

The fore mentioned identification strategy can also be derived from the ILB-nominal puzzle, substituting the breakeven rates by the mispricing between nominal bonds and their replicating portfolios. Instead of examining these two prices in one country, I take this price difference and compare across countries. A unique feature of this cross-country sample is that in these three euro area countries both inflation swaps and inflation-indexed bonds are linked to the same price index[2] and the same deflation protection applies to all bonds. Therefore, as a result of the differencing, the swap component and the price effect of the deflation option mutually cancel out, reducing the new strategy to four bonds or a spread on two breakeven rates. The differencing sheds light to the drivers of the ILB-nominal puzzle: inflation swap quotes or the value of the deflation option cannot account for the overall magnitude of the puzzle. Second, I estimate the difference in liquidity and credit premia in ILB and nominal bonds and find that although the mean effect of liquidity is small, these two effects can explain the persistent nature of the puzzle. And lastly, I find that investors perceived ILBs to have higher sovereign risk exposure than nominal bonds during the financial and euro crises, further increasing the yield difference between the two securities.

Unlike most papers in the literature, I do not restrict my attention to examining the nominal sovereign spread. My primary aim is to understand what drives the wedge between breakeven rates and inflation expectations, in other words the relative pricing of indexed and nominal sovereign bonds. Other papers looking at the relative pricing of nominal and indexed sovereign bonds are Campbell, Shiller and Viceira (2009), Christensen and Gillan (2011), Pflueger and Viceira (2011, 2016), Fleckenstein et al. (2014), Fleckenstein (2013) and Driessen et al (2014). Fleckenstein (2013) specifically focuses on the relative pricing of nominal and indexed bonds in G7 countries, whereas Driessen et al (2014) show that most of the price difference between nominal and indexed US Treasuries is due to liquidity risk premium in prices.

By exploring the liquidity features of indexed and nominal sovereign bonds, I contribute to the long-standing literature on the effect of liquidity on asset prices (Amihud and Mendelson, 1986; Amihud, 2002; Bekaert, Harvey and Lundblad, 2007 among many others). More specifically, I provide new evidence of liquidity risk being priced in major Eurozone sovereign bond markets. Other studies often examine liquidity in the context of spillover effects between European nominal sovereign bond and CDS markets (Calice, Chen and Williams, 2011) or focus on specific markets to show how liquidity improved upon EBC interventions (Pelizzon et al., 2014). Moreover, Darbha and Dufour (2013) show that even after controlling for interest rate and credit risks similarly to Fama and French (1993), liquidity is an important determinant of sovereign yields both in the cross-section and during the financial crisis.

Naturally, this paper also links to the strand of literature on European nominal sovereign market. Ejsing and Lemke (2009) investigate the dynamics of credit risk premium in bank and sovereign CDSs during the financial crisis, especially focusing on the effect of government rescue packages. Moreover, papers

[1] The deflation floor provides protection for investors when negative inflation occurs. In the absence of the par floor, negative inflation would erode the value of the principal. In all European inflation-linked bonds, the principal value is protected against deflation, but not the intermediate coupon payments.

[2] HICP stands for Harmonized Index of Consumer Prices. This index is the weighted average of inflation of Eurozone countries and is published by the European Central Bank on a monthly basis.

also examine the information content of sovereign CDS contracts and bonds (for instance Fontana and Scheicher, 2010) or look at the basis, the yield difference between these two assets (Arce, Mayordomo and Peña, 2011; Palladini and Portes, 2011). In this paper there is novel evidence on the price of credit risk on both nominal and inflation linked sovereign bonds. Further, I also provide evidence on a subtler aspect of credit risk, namely selective default risk in the bonds under examination.

My analysis is closest related to recent work on Euro area government bonds research that considers both liquidity and credit risks. Beber, Brandt and Kavajecz (2009) disentangle the effects of liquidity and credit quality in 10 Eurozone countries to identify flight to quality and liquidity episodes. They show that liquidity is a non-trivial determinant of yields with an increasing prominence when flights occur, whereas credit quality affects valuation. On the other hand, by means of market related measures, Schwarz (2015) separates the components of yields due to liquidity and credit risk. She estimates a model of liquidity risk and finds that liquidity is priced in the cross-section of (nominal) sovereign debt. Ejsing, Grothe and Grothe (2012) quantify liquidity and credit risk premia in German and French government bond yields based on a state-space model with two latent factors. Bai, Julliard and Yuan (2012) examine what caused the sovereign debt crisis – illiquidity of markets or deteriorating credit conditions – and find spillover, but not feedback effect between aggregate level credit and liquidity risk in a country. And finally, Darbha and Dufour (2014) study the term structure of default and illiquidity in a sample of nominal Euro area government bonds, whereas Monfort and Renne (2014) present an arbitrage-free model of euro-area bond spreads, whose dynamics are driven by liquidity and credit risk. They find a non-diversifiable euro-area credit component in these yields.

My work differs from the above papers in two main aspects. First, I examine a cross-country sample that goes beyond the nominal segment of bond markets and allows me to look at the relative pricing of nominal and inflation-indexed bonds in the Eurozone – allowing me to set up clean, more stringent tests: the asset pricing tests I run are particularly strong, in the sense that I control for many confounding factors by the differencing. Therefore, in the subsequent step I am less likely to capture the effect of factors other than differential liquidity or credit risk. Second, the unique identification strategy based on differencing also allows me to address the empirical challenge of disentangling alternative explanations of the ILB-nominal puzzle.

The remainder of the paper is organized as follows. Section 1 discusses the European bond markets and the methodology, whereas Section 2 explains the data and the estimation strategy. In Section 3 I present the empirical findings alongside with a discussion, and finally; Section 4 discusses possible extensions and concludes.

1 Are liquidity and credit risks priced in European nominal and inflation-indexed bonds?

In this section I shortly present the three major European sovereign bond markets: France, Germany and Italy. I specifically focus on market conventions, microstructure similarities and the inflation-linked bond segment. After showing why this is an ideal setting to study the relative pricing of real and nominal bonds, I discuss the identification strategy that helps to disentangle price effects of liquidity and credit risks in the corresponding bond yields. I present a multifactor asset pricing model with illiquidity and credit risk factors, inspired by Pastor and Stambaugh (2003), Acharya and Pedersen (2005), and Fama and French (1993). Then I show how to generalize this relationship to breakeven rates, and Appendix A shows how this relates to the trading rule of Fleckenstein et al. (2014). The economic interpretation of the generalized model is the cornerstone of this paper: both liquidity and (sovereign) credit[3] risk premia can differ among nominal and inflation-linked bonds of the same issuer.

1.1 European bond markets

France, Germany and Italy are the three largest sovereign debt issuers of the Eurozone. These countries are part of a monetary union, consequently investors investing across these countries do not face exchange rate risk and have access to a wider range of bonds. However, the common monetary policy is not the only thing these markets share: the institutional features, market conventions, even the market (micro)structure of these products are similar across these three countries.

Although in the past issuance via syndication was a common practice, nowadays both nominal and inflation-linked bonds are issued via auctions of the corresponding Treasury agencies.[4] These auctions, identical to those in the US, are open to primary dealers, institutional investors who buy these assets. These institutions, typically either directly or through subsidiaries, participate in markets of all three countries. After the issuance and often multiple re-openings, these bonds are traded on the OTC secondary market, which in Europe consists of a handful of trading platforms. Most of the platforms trade all securities, however, there is some degree of specialization among them.

Nevertheless, it is not only the way these securities are traded that is similar in this cross-country sample. These products also have the same market conventions. This is especially interesting for inflation linked bonds in this study. The inflation-linked bond markets of these three countries are among the largest inflation-linked market segments of the world (Fleckenstein, 2014), their total value ($450 million) is half of the corresponding US segment. An interesting feature of the ILBs in my sample is that they are linked to one price index, to the Harmonized Index of Consumer Prices, henceforth HICP. This index is the weighted average of inflation of Eurozone countries and is published by the European Central Bank on a monthly basis. Moreover, the same deflation option applies to them: the principal payment of these bonds is protected when deflation occurs.

These countries started to issue ILBs in the past two decades. First, France issued inflation-linked bonds in 1998, a year after the US, but those were indexed to the French Consumer Price Index. Later, in 2001 they added HICP-linked bonds to their range of products. These bonds were especially popular among institutional investors across the Eurozone, as they were the first to compensate for Eurozone inflation with moderate sovereign risk at that time. Since 2003, the Ministry of Economy and Finance in Italy has also been issuing HICP indexed bonds. Today, they have the largest outstanding inflation-linked debt in the Eurozone. And at last, the German Finanzagentur has also issued its first ILB in 2006, and Germany was the first to issue an ILB after the financial crisis in 2008.

In conclusion, these three countries constitute a unique cross-section to study the relative pricing of real and nominal bonds. The fore mentioned features are the same across all bonds in the sample, therefore it is unlikely that any convenience yield would arise due to differences in trading or market

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[3] Finding differing credit risk premium in nominal and inflation-indexed yields of the same issuer would comply with the notion of partial or selective default, a possibility allowed by numerous macroeconomic models, like in Barro (2006) or Bolton-Jeanne (2009).

4 In Germany this is the Finanzagentur GMbH, whereas in Italy and France these institutions are the Treasury Department of the Ministry of Finance (Dipartimento del Tresoro) and the Agence France Tresor, respectively.

conventions. Moreover, despite sharing the same currency and monetary policy, these countries still have different fiscal behavior[5], which results in diverse risk exposures of these debt securities.

1.2 Identification of liquidity and credit risk effects

The simplest way to quantify liquidity and credit effects in bond yields is to look at the individual asset markets in each country and estimate models with the corresponding risk factors separately. This can be applied to both indexed and nominal bonds. Practically this means that I would estimate a separate model for each bond segment: altogether six models in this cross-country sample. The clear advantage of this method is the direct comparability to results from the US Treasury market, as in Pflueger and Viceira (2013) or in Driessen et al. (2014). However, the major shortcoming is that not only one has to impose a lot of structure and assumptions on the estimation, but also that I cannot efficiently measure the relative riskiness of real and nominal bonds by only comparing risk exposures and price of a certain risk among different segments. Moreover, estimation might be infeasible due to insufficient data in segments with short time series and small cross-sections, such as the German ILB segment.

The methodological innovation in this paper is to propose a method, in which I directly estimate relative risk exposures and prices of differential risk exposures. For that I show how a price of a single asset can be modelled as a combination of market, liquidity and sovereign credit risk exposures. The next section explains how this pricing relationship applies to breakeven rates, whereas Appendix A links it to the trading rule in Fleckenstein et al (2014). An implicit assumption of the analysis is that Eurozone bond markets are integrated, which in light of the monetary union, common currency and other features of these markets is fairly reasonable. However, assuming integration not only has interesting economic implications but also a crucial role in the aggregation: it helps to restrict the number of parameters in the estimation and allows for the identification of the model in the cross-section of breakeven rates. Therefore, I define the market return as the equally weighted[6] average return of all bonds: inflation-linked and nominal bonds.

To discover the effect of liquidity, I first assume that credit risk is negligibly small in the bond markets under examination. The literature on the effect of liquidity on asset prices points out that liquidity is a multifaceted concept; both the level of asset and market liquidity (Amihud and Mendelson, 1986, Amihud, 2002, and Bekaert et al., 2007) and liquidity risk (Pastor and Stambaugh, 2003, Acharya and Pedersen, 2005, Schwarz, 2015, and Driessen et al., 2014) are likely to be priced. Moreover, Driessen et al. (2014) show that the importance of the level and risk aspects of liquidity differ across TIPS, nominal Treasury and inflation swap markets in the US. Therefore, I include both features in my analysis: the level of liquidity of an asset is proxied by bond characteristics, such as age or size of an issue, whereas liquidity risk is captured by a liquidity factor.[7] The following relationship describes expected returns in each market segment of the three countries:

$$\mathrm{R_{i,t} - R_{f,t} = \alpha_i + \beta_{MKT,i}\left(R_{MKT,t} - R_{f,t}\right) + \beta_{LIQ,i}\eta_t + \varepsilon_{i,t}} \quad , \tag{1}$$

$$E\left(R_{i,t} - R_{f,t}\right) = \kappa E\left(Liq_{i,t}\right) + \lambda_{MKT}\beta_{MKT,i} + \lambda_{LIQ}\beta_{LIQ,i}. \tag{2}$$

[5] I would like to thank Carolin Pflueger for pointing out this feature of the above markets.

[6] Equal weighting over-represents the smaller ILB segment, potentially exposing the market factor to liquidity and credit risks, which would weaken my results. As a robustness check, I will introduce a value-weighted market factor.

[7] Detailed description of these measures can be found in the section explaining the data and measures applied.

In the above equations $\beta_{MKT,i}$ and $\beta_{LIQ,i}$ are exposures to market and liquidity risk factors respectively, and η_t is the liquidity risk factor. $E(Liq_{i,t})$ captures the level of liquidity, proxied by asset characteristics, whereas λ_{MKT} and λ_{LIQ} are the market and liquidity risk premia.

Relaxing the above assumption on credit risk allows me testing for its effect in bond returns. Most studies that examine credit risk look at the differences across countries.[8] Despite that these differences are pronounced and highly economically significant,[9] looking at within country dissimilarities can be equally interesting: it might happen that a country defaults on certain types of bonds, but not or to a different extent on others. A fairly recent historical example[10] described by Duffie, Pedersen and Singleton (2003), is Russia defaulting on its ruble-denominated internal debt in 1998m whereas not on its eurobonds, shows that the occurrence of such event might not be unlikely. Moreover, eurobonds are similar to inflation-linked debt in nature, as the exchange rate and inflation risks both introduce uncertainty concerning the future payments that the issuer has to deliver. Inspired by this anecdotal evidence, I scrutinize selective default after having controlled for liquidity. To investigate the mutual effect of liquidity and credit risks, I look at the following equation, where all risk factors measure Eurozone-wide risks:

$$E(R_{i,t} - R_{f,t}) = E(Liq_{i,t}) + \lambda_{MKT}\beta_{MKT,i} + \lambda_{LIQ}\beta_{LIQ,i} + \lambda_{Credit}\beta_{Credit,i}. \quad (3)$$

To directly test the proposition of selective default, one has to compare the prices of credit risk in the nominal and inflation-indexed bond markets. If these two prices were not equal, that would provide evidence that nominal and indexed bonds are exposed to credit risk to a different extent. The next section presents a more direct approach, with which selective default risk can be directly measured.

1.3 The spread on breakeven strategy

In order to directly measure risk exposures, I propose to estimate risk premia based on pairs of breakeven rates. Breakeven rate or breakeven inflation is the yield difference between a nominal and real yields of bonds with similar maturities and credit quality. This yield spread is often though of as a proxy for inflation expectations (e.g. Ciccarelli and Garcia, 2009), however it contains convexity and compounding effects (Kerkhof, 2005), inflation risk premia (Gurkaynak, Sack and Wright, 2008 and Grishchenko and Huang, 2012) and other risk premia, such as compensation for liquidity risk (D'Amico et al., 2008 and Pflueger and Viceira, 2015). Looking at the breakeven rate in one country is informative, nevertheless, taking the difference between pairs of breakeven rates across countries allows me directly identify relative risk premia in the underlying bonds.

Differencing breakeven rates eliminates common components, such as 1) the compounding and convexity effects that arise due to inflation; 2) the effect of inflation expectations and inflation risk premia; 3) any other factors that are the same across the three Eurozone countries, such as the effect of monetary policy or market or interest rate risk. The residual that the differencing does not take out is the exposure to risks that do not affect nominal and inflation-linked bonds equally within and across

[8] The literature on credit risk is vast; however, some papers focus on this feature of sovereign issues. See for instance Arce et al. (2011), Beber et al. (2008) or Ejsing et al. (2012).

[9] Especially around major credit events such as the Euro crisis.

[10] More recent examples are Argentina defaulting on its dollar denominated debt from the IMF in 2002, or the default of Ecuador in 2008.

countries. While testing relative risk exposures, I also examine the assumption underlying the literature that studies relative liquidity of inflation-linked and nominal bonds that these bonds have identical sovereign credit risk exposures. Furthermore, this differencing based strategy not only allows me to study liquidity and credit risk premia in sovereign bond prices alongside with excluding the above alternative explanations, but it also proposes a more stringent test of the relative pricing of inflation indexed and nominal bonds.

Most studies that analyze the breakeven rate rely on the difference between two smooth zero coupon curves. As opposed to this, I choose to focus on pairs of bonds with the smallest possible maturity mismatch between potential pairs across countries. I do this because on the one hand this allows me to use observable yields, therefore incorporate market information; on the other hand, I have to impose less assumption on the data as I am not fitting yield curves. Additionally, fitting the real curve would not be feasible at the country level due to insufficient number of cross-sectional data points. Also, pairs of breakeven rates are practically bond portfolios with long and short positions. Consequently, I can show that the asset level models from the previous section can be aggregated to the portfolio level and as a result similar pricing relationships arise. Moreover, Appendix A shows, that one would get to the same conclusions by using the trading rule of Fleckenstein et al. (2014)[11] as the starting point of the analysis.

To determine the effect of liquidity, I first assume that credit risk is the same both within and across the three countries in the sample. Therefore, after excluding a battery of common components by the differencing, what I am left with is most likely attributable to liquidity differences – both within and across countries. Imposing that credit risk is identical across all bonds in the portfolio facilitates testing the relative liquidity exposures across countries; alongside with the Eurozone level integrated liquidity risk factor. For the sake of notational simplicity, I show how to quantify these effects from a matched German and Italian bond pair:

$$R_t^G - R_t^{IT} = \left(R_{nom,t}^G - R_{rep,t}^G\right) - \left(R_{nom,t}^{IT} - R_{rep,t}^{IT}\right) \approx \left(y_{nom,t}^G - y_{ILB,t}^G\right) - \left(y_{nom,t}^{IT} - y_{ILB,t}^{IT}\right), \qquad (4)$$

where $R_t^{country}$ stands for the return on the country-level breakeven or bond portfolio. This return, can be proxied by the yield difference of nominal and inflation-linked bonds, following Campello et al. (2008), who treat yield-to-maturity of a bond as a forward-looking expected return proxy. Next step is to apply Equation 2 to all bonds in the strategy:

$$\begin{aligned} R_t^G - R_t^{IT} = {} & \kappa_i^{G,nom} Liq_{i,t}^{G,nom} + \beta_{MKT,i}^{G,nom} \lambda_{MKT,t}^{G,nom} + \beta_{LIQ,i}^{G,nom} \lambda_{LIQ,t}^{G,nom} \\ & - \kappa_i^{G,ILB} Liq_{i,t}^{G,ILB} + \beta_{MKT,i}^{G,\mathrm{ILB}} \lambda_{MKT,t}^{G,ILB} + \beta_{LIQ,i}^{G,ILB} \lambda_{LIQ,t}^{G,ILB} \\ & - \kappa_i^{IT,nom} Liq_{i,t}^{IT,nom} + \beta_{MKT,i}^{IT,nom} \lambda_{MKT,t}^{IT,nom} + \beta_{LIQ,i}^{IT,nom} \lambda_{LIQ,t}^{IT,nom} \\ & + \kappa_i^{IT,ILB} Liq_{i,t}^{IT,ILB} + \beta_{MKT,i}^{IT,ILB} \lambda_{MKT,t}^{IT,ILB} + \beta_{LIQ,i}^{IT,ILB} \lambda_{LIQ,t}^{IT,ILB}. \end{aligned} \qquad (5)$$

Note that the above betas are coming from the asset level relationship; and has to be estimated at the asset level. To get these betas I regress excess individual bond returns on the market and liquidity risk factor η_t. The next step is to impose that the above yields can be described as a combination of factor exposures and their respective premia. This is similar to the second stage of the Fama-MacBeth approach. In what follows, I apply these assumptions together with the following: I conjecture that the

[11]Appendix A discusses the trading rule of Fleckenstein et al (2014) in detail.

level of liquidity has the same coefficients across all assets in the strategy. Consequently, the equation is simplified:

$$
\begin{aligned}
R_t^G - R_t^{IT} \;=\; & \kappa_i\big(Liq_{i,t}^{G,nom} - Liq_{i,t}^{G,ILB} - Liq_{i,t}^{IT,nom} + Liq_{i,t}^{IT,ILB}\big) \\
& + \big(\beta_{MKT,i}^{G,nom}\lambda_{MKT,t}^{G,nom} - \beta_{MKT,i}^{G,\mathrm{ILB}}\lambda_{MKT,t}^{G,ILB} - \beta_{MKT,i}^{\mathrm{IT},nom}\lambda_{MKT,t}^{IT,nom} + \beta_{MKT,i}^{IT,ILB}\lambda_{MKT,t}^{IT,ILB}\big) \\
& + \big(\beta_{LIQ,i}^{G,nom}\lambda_{LIQ,t}^{G,nom} - \beta_{LIQ,i}^{G,ILB}\lambda_{LIQ,t}^{G,ILB} - \beta_{LIQ,i}^{IT,nom}\lambda_{LIQ,t}^{IT,nom} + \beta_{LIQ,i}^{IT,ILB}\lambda_{LIQ,t}^{IT,ILB}\big). \qquad (6)
\end{aligned}
$$

Nevertheless, if I wanted to quantify the respective risk premia from Equation 6, I would have to estimate nine risk premium estimates. Given the limited number of maturity-matched basis pairs in the cross-section at any point in time, I need to restrict the number of parameters in order to be able to empirically identify the regressions. Therefore, I focus my attention to cases where both the market and liquidity risks are integrated across at the Eurozone level. I do this by restricting the market and liquidity risk premia to be equal across the four market segments in the two countries. Economically this means that liquidity and credit risk exposures are consistently priced in the cross-section of countries in the sample. Ultimately I get the following relationship:

$$
\begin{aligned}
R_t^G - R_t^{IT} \;=\; & \kappa_i\big(Liq_{i,t}^{G,nom} - Liq_{i,t}^{G,ILB} - Liq_{i,t}^{IT,nom} + Liq_{i,t}^{IT,ILB}\big) \\
& + \lambda_{MKT,t}\big(\beta_{MKT,i}^{G,nom} - \beta_{MKT,i}^{G,\mathrm{ILB}} + \beta_{MKT,i}^{IT,nom} - \beta_{MKT,i}^{IT,ILB}\big) \\
& + \lambda_{LIQ,t}\big(\beta_{LIQ,i}^{G,nom} - \beta_{LIQ,i}^{G,ILB} + \beta_{LIQ,i}^{IT,nom} - \beta_{LIQ,i}^{IT,ILB}\big). \qquad (7)
\end{aligned}
$$

And finally, by relabeling the portfolio of betas and liquidity characteristics as net effects, the sum of the asset level effects, I get a relationship that is almost identical to Acharya and Pedersen (2005)'s Liquidity CAPM[12]:

$$
R_t^G - R_t^{IT} = \kappa_i\big(Liq_{i,t}^{net}\big) + \lambda_{MKT,t}\big(\beta_{MKT,i}^{net}\big) + \lambda_{LIQ,t}\big(\beta_{LIQ,i}^{net}\big). \qquad (8)
$$

A natural extension of this model is to relax the assumption on credit risk being negligibly small; and allow it to differ across countries. Nevertheless, this only allows me to identify credit premium either in case the loadings of such premium differ across nominal and indexed bonds or if the price of credit risk differs between ILBs and nominal bonds. This latter possibility implies the risk of selective sovereign default. One can imagine scenarios, for instance a high inflationary environment, in which paying back inflation-linked debt becomes a burden for an issuer, who then decides to default on such bonds, while fulfilling payments, likely by printing more money, on her nominal debt. Yet, similarly to liquidity risk, I can also examine the effect of Eurozone-wide credit shocks. To test for selective default in the representative German and Italian bond pairs, the following relationship arises from Equation 5:

$$
\begin{aligned}
R_t^G - R_t^{IT} = & \;\kappa_i^{G,nom} Liq_{i,t}^{G,nom} + \beta_{MKT,i}^{G,nom}\lambda_{MKT,t}^{G,nom} + \beta_{LIQ,i}^{G,nom}\lambda_{LIQ,t}^{G,nom} + \beta_{CR,i}^{G,nom}\lambda_{CR,t}^{G,nom} \\
& - \kappa_i^{G,ILB} Liq_{i,t}^{G,ILB} + \beta_{MKT,i}^{G,\mathrm{ILB}}\lambda_{MKT,t}^{G,ILB} + \beta_{LIQ,i}^{G,ILB}\lambda_{LIQ,t}^{G,ILB} + \beta_{CR,i}^{G,ILB}\lambda_{CR,t}^{G,ILB} \\
& - \kappa_i^{IT,nom} Liq_{i,t}^{IT,nom} + \beta_{MKT,i}^{IT,nom}\lambda_{MKT,t}^{IT,nom} + \beta_{LIQ,i}^{IT,nom}\lambda_{LIQ,t}^{IT,nom} + \beta_{CR,i}^{IT,nom}\lambda_{CR,t}^{IT,nom} \\
& + \kappa_i^{IT,ILB} Liq_{i,t}^{IT,ILB} + \beta_{MKT,i}^{IT,ILB}\lambda_{MKT,t}^{IT,ILB} + \beta_{LIQ,i}^{IT,ILB}\lambda_{LIQ,t}^{IT,ILB} + \beta_{CR,i}^{IT,ILB}\lambda_{CR,t}^{IT,ILB}. \qquad (9)
\end{aligned}
$$

[12] In their paper net beta refers to the sum of market and the three distinctive liquidity betas that they estimate. Otherwise they also estimate a multifactor model with systematic and liquidity risks.

This, after imposing similar assumptions to level of liquidity and integrated risk premia, Equation 9 becomes a multifactor model inspired by Fama and French (1993) and Acharya and Pedersen (2005):

$$R_t^G - R_t^{IT} = \kappa_i\left(Liq_{i,t}^{net}\right) + \lambda_{MKT,t}\left(\beta_{MKT,i}^{net}\right) + \lambda_{LIQ,t}\left(\beta_{LIQ,i}^{net}\right) + \lambda_{CR,t}\left(\beta_{CR,i}^{net}\right). \tag{10}$$

The next section presents the estimation and gives a detailed explanation on how these equations are applied to the data.

2 Estimation strategy

This section presents the data and describes their various sources. It is followed by the presentation of the main variables: the different liquidity and credit risk measures, the risk factors and the way I proxy expected returns. Finally, I give a detailed description of the estimation of both the market segment-level and breakeven-based strategies.

2.1 The data

The data are coming from different sources. The daily mid-quotes of nominal and inflation-linked bond prices are from Bloomberg, alongside with information on individual bond issues, such as issue and redemption dates, amount issued and coupon rates. The sample contains all available HICP-linked[13] inflation indexed issues from the three countries: I have 5 German, 9 French and 13 Italian ILBs. There is also a wide range of nominal issues, approximately 50-60 bonds from each country.[14] The maturity dates of these bonds typically range between 2005 and 2055 and daily closing prices are adjusted by accrued interest following the market convention. I collect data for the period between July 2004 and February 2014.

To capture the price effect of liquidity and credit risks, I complement the above data with sovereign CDS prices for the credit risk factor, next to additional controls, such as the VIX and its European equivalents, and the EURIBOR and EONIA indexes from Bloomberg. In order to define my liquidity measures, I obtain the 10-year KfW agency bond yields and that of the 10-year constant maturity German nominal bond index from Datastream. To construct the benchmark liquidity proxy, I get data on monthly aggregate primary dealer transaction volumes directly from the German Finanzagentur and the Italian Dipartimento del Tresoro. These figures are based on reports submitted by primary dealers on all transactions with other such institutions or third parties. Then these numbers are aggregated across counterparties and over the month and are available for the nominal and indexed segments separately.

In the Eurozone German bonds are argued to be the safest, therefore I use the 6-month constant maturity German sovereign yield as the risk free rate in my sample. Unfortunately, there are no bills issued with maturities shorter than 6 months, thus by imposing the assumption of bills having a flat term structure, I use it as the proxy for the 1-month rate, which equals the implicit holding period of the regressions.

[13] My analysis focuses on HICP-linked assets: in the euro-area both inflation swaps and many inflation-indexed bonds are linked to this harmonized price index. This is important, as both Italy and France issue index linkers that are indexed to local inflation indices. However, having the same price index is crucial for the identification strategy.

[14] While the previous section provides a short outlook of these markets, detailed description of them can be found in Fleckenstein (2013).

2.2 Main variables

2.2.1. Asset, market and expected returns

To calculate bond return, I take the ratio of consecutive prices, which are corrected for coupon payments. Market wide returns are based on the implicit assumption of Eurozone integration, and are defined as the equally weighted average across all bonds in the three countries. Standard asset pricing tests are usually performed on realized excess returns. As opposed to this, I quantify the effect of liquidity from bond yields[15]. I do so because yields are more persistent, whereas the sample period is too short to estimate the price of risk exposures from biased realized return estimates. Under a set of assumptions, bond yields qualify to be forward looking expected return proxies. First, I propose that markets are frictionless and that the term structure of expected returns is flat. For nominal bonds this relationship holds under the condition that yields follow a random walk process. As for ILBs, I also propose that inflation is constant in expectation and it is independently and identically distributed with yields. Absent liquidity and credit effects, I can show that the swap rate equals the breakeven rate. That case it can be proxied by the difference of nominal and real yields, therefore with the difference between two random walk processes that also follows similar dynamics.

2.2.2. Liquidity and credit measures

To explore the effect of liquidity, I include both asset and market level liquidity measures in the analysis. As in Fleckenstein et al. (2014) and Driessen et al. (2014), I face the problem that the directly observable bid-ask spreads do not seem to be reliable over my sample period. Moreover, due to data availability, I cannot construct the same set of measures for the seven markets in my sample.[16] Therefore I proxy bond liquidity by using issue characteristics, such as age or amount issued, following Houweling et al. (2003). The reasoning behind a bond's age capturing liquidity is simple: the more time passes since issuance, the more likely that a bond gets locked-up in buy-and-hold investors' portfolios. This decreases its liquidity, which suggests a positive relationship between illiquidity and age, whereas issued amount is negatively related to the latter: larger issues tend to be more liquid. I define age as the years passed since issuance, whereas I use the natural logarithm of the amounts issued.

I also construct market wide liquidity measures that serve as a basis for the factor construction. One such proxy is the ILLIQ measure of Amihud (2002). I define the measure as the ratio of monthly absolute bond market returns over monthly aggregate trading volume, where the volume is aggregated across all dealers and all securities within their segment and is observable at the monthly frequency. The second measure that I incorporate in the analysis is the KfW spread, which like Schuster and Uhrig-Homburg (2013) and Schwarz (2015), I define as the yield difference between a German agency bond issued by the Kreditanstalt fur Wiederaufbau and the maturity-matched nominal government bond. In constructing this liquidity spread, I follow Longstaff (2004) who quantifies liquidity premium as the yield difference between two securities that have the same credit risk but differ in their respective liquidities. Nevertheless, another potential interpretation of this measure is that it captures breakup risk or selective default risk. If this was the case, then using this spread as a liquidity measure could

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[15] By doing so I follow Campello et al. (2008), Bongaerts et al (2012), Pflueger and Viceira (2013) and Driessen et al. (2014).

[16] Bid and ask prices in many cases are indicative quotes with very little time variation. Besides, I could have used the Roll measure in all markets, but sovereign bond returns tend to be positively autocorrelated for longer period of time, which results in an uninformative measure.

capture part of the credit risk premium in prices, which would result in an underestimated credit premium.[17]

To capture a country's credit risk, I collect quotes on CDS spreads. I use the changes in levels of the spread to construct the credit risk factor. Appendix B provides graphs of the time-series of the different ILLIQ measures, the KfW spread, swap market measures and the three CDS spreads. Next to the previous liquidity and credit proxies, I construct additional controls that are included in some of the robustness checks, such as yield volatility or a control for the slope of term structure of bonds. Yield volatility is defined as the difference between the standard deviations of individual issues and the cross-sectional average standard deviation of quoted yields, where the average is taken over the different maturities for a given month. This definition is the same across both swaps and bonds. For bonds I also include time-to-maturity, which is defined as the remaining years until maturity of a given issue. This variable controls for a maturity structure and incorporates the slope effect of the term structure of bonds.

2.2.3. Liquidity and credit risk factors

In order to examine Eurozone integrated effects of liquidity and credit risks, I construct factors that incorporate the country-level measures, and take out their variation by using principal component analysis. The Eurozone-wide liquidity measure consists of the four ILLIQ measures from Italian and German markets and the KfW spread. All the above measures are formulated so that the factor loadings ensure they all capture illiquidity. Similarly, to get an integrated credit risk measure, I take the first principal component of the individual measures from the three countries. In both cases the first principal components capture the most part of the variation, and serve as input for the factor construction. I define the risk factors as the unexpected or surprise component of these persistent measures:

$$Factor_t = M_t - E(M_{t-1}),$$
$$\text{where } M_t = [\eta_t, \theta_t]. \tag{11}$$

The above residual defines the risk factor: the difference between M and its expectation in the preceding period. To compute these innovations, I impose a first order autoregressive structure on the different principal components capturing both liquidity and the credit measures in the sample.

2.3 Estimation method

In this section I explain how liquidity and credit risks affect asset returns: how Equations 3 and 10 are applied to the data. For this, I first estimate bond level betas to measure risk exposures, then in the second step I aggregate these betas to measure the price of relative risk.

2.3.1. Bond betas

To estimate the relative risk exposures from the breakeven rates, I turn to the standard two-step procedure based on Fama and MacBeth (1973). Unlike in most asset pricing tests, I do not sort my assets into portfolios, as I am interested in their individual characteristics and this way I can also take advantage of their larger cross-sectional variation. However, this comes at the cost of having less

[17] I am planning to take the KfW spread out of the liquidity measure and substitute it with a French ILLIQ measure and a Eurozone-wide noise measure, following Hu-Pan, and Wang (2013).

precise beta estimates. Thus in the first stage I estimate the betas from bond level time-series regressions where I regress bond excess returns on the liquidity and credit risk factors, η_t and θ_t, respectively:

$$\mathrm{R}_{\mathrm{i},\mathrm{t}} - \mathrm{R}_{\mathrm{f,t}} = \alpha_i + \beta_{MKT,i}\left(R_{MKT,t} - \mathrm{R}_{\mathrm{f,t}}\right) + \beta_{LIQ,i}\eta_t + \beta_{Credit,i}\theta_t + \varepsilon_{i,t}, \quad (12)$$

for t = 1, 2 ... T for each i, market and country in the sample.

Equation 11 showed that the risk factors are residuals from autoregressive regressions. I estimate betas and risk loadings for each nominal and inflation-linked bond in my sample. I restrict my attention to integrated risk premia, where the market, liquidity and credit betas capture a common, Eurozone-wide risk exposure to the underlying factors. Given the liquidity and credit measures, I am able to measure an asset's covariation with the integrated market liquidity and credit risk. The former captures the same facet of liquidity risk as Pastor and Stambaugh (2003), whereas the credit beta proxies the exposure to the average sovereign credit risk in the Eurozone. These covariances suggest that market liquidity and credit risks affect required returns positively, such that the more illiquid or credit risky a bond is, the higher returns investors expect, which decreases the asset's price.

2.3.2.Breakeven betas and the price of differential risk exposures

Given the limited number of available breakeven pairs, identification and estimation of the betas and risk factors is nontrivial. If I wanted to conduct the usual Fama-MacBeth procedure, in the first stage I would need to regress the spread on breakeven rates on country-level market and illiquidity and credit risk factors from Germany and Italy, η_t^G, η_t^{IT}, θ_t^G and θ_t^{IT}, respectively to get beta estimates. However, there is no need to do this, as in the previous step I have already estimated the respective risk exposures based on Equation 12. Moreover, I am only interested in loadings on Eurozone risks – the ones that are common and likely to play an important role in both countries in the strategy. Therefore, I calculate the net betas from the bond level regressions the following way:

$$\hat{\beta}_{G-IT,MKT,i}^{net} = \hat{\beta}_{EU-MKT,i}^{G,nom} - \hat{\beta}_{EU-MKT,i}^{G,\mathrm{ILB}} + \hat{\beta}_{EU-MKT,i}^{IT,nom} - \hat{\beta}_{EU-MKT,i}^{IT,ILB},$$

$$\hat{\beta}_{G-IT,LIQ,i}^{net} = \hat{\beta}_{EU-LIQ,i}^{G,nom} - \hat{\beta}_{EU-LIQ,i}^{G,\mathrm{ILB}} + \hat{\beta}_{EU-LIQ,i}^{IT,nom} - \hat{\beta}_{EU-LIQ,i}^{IT,ILB},$$

$$\hat{\beta}_{G-IT,CR,i}^{net} = \hat{\beta}_{EU-CR,i}^{G,nom} - \hat{\beta}_{EU-CR,i}^{G,\mathrm{ILB}} + \hat{\beta}_{EU-CR,i}^{IT,nom} - \hat{\beta}_{EU-CR,i}^{IT,ILB}. \quad (13)$$

The net betas are portfolios of the respective risk exposures of the two nominal and indexed bonds that comprise the two basis series. In this portfolio, the sign of each bond is according to that of the position in the breakeven rate. I also control for asset level liquidity, as shown in Equation 10, which is constructed as a portfolio of asset level liquidity measures:

$$\mathrm{Liq}_i^{net} = Liq_i^{G,nom} - Liq_i^{G,\mathrm{ILB}} + Liq_i^{IT,nom} - Liq_i^{IT,ILB}. \quad (14)$$

This transformation is applied to the asset characteristics for which I have data on all four bonds in the strategy, such as amount issued, age or time-to-maturity. Then to run repeated OLS regressions, I substitute expected returns by their forward-looking[18] empirical counterpart, by the breakeven rates, and estimate the following regressions:

$$b_t^G - b_t^{IT} = \gamma_t^{net} + \kappa_t^{net} Liq_{i,t}^{net} + \lambda_{MKT,t}\left(\hat{\beta}_{MKTi}^{net}\right) + \lambda_{LIQ,t}\left(\hat{\beta}_{LIQ,i}^{net}\right) + \lambda_{CR,t}\left(\hat{\beta}_{CR,i}^{G,net}\right) + \varepsilon_{i,t}^{net} \tag{15}$$

for $i = 1,2 \ldots N$ for each t and basis pair in the sample.

Where $b_{country,t}$ is the yield difference between the respective ILB and nominal issues, thus the breakeven rate. Estimates from these repeated regressions are averages across time and errors include both a 12-month Newey-West correction and account for the averaging of the coefficients. Moreover, the resulting premium estimates are directly interpretable: they show how large a part of the yield difference is accounted for by the reward for all four bonds in the strategy being exposed to liquidity and credit risks. This is a direct measure of partial or selective default risk premium.

3 Empirical results

This section presents the results of this study. First, I show the descriptive statistics of the main variables, then proceed with reporting the estimated betas and the net or portfolio betas. I also discuss the time-series properties of the factors. Then I proceed, with the analyses of the relative pricing of nominal and indexed bonds. These are based on the direct approach following Equation 15. At last, as part of the battery of robustness checks, I contrast these results to the case when instead of using breakeven rates, I pool all bond markets together to alleviate estimation caveats. And finally, a discussion concludes this section.

3.1 Descriptive statistics, betas and factors

Table I contains descriptive statistics of the main variables, whereas Table II provides an overview of the beta estimates for both the benchmark and segmented market cases. In Table I, Panels A to C compare the different features of nominal and inflation-linked bond. The main variables are in line with expectations: in ILB markets the yields are lower and, on average, less volatile than nominal ones, where the German average yield is the lowest. German ILBs are the youngest as these bonds are only issued since 2006, whereas nominal bonds are older in all three markets. In Germany the average size of nominal issues is almost 30% larger than ILBs, whereas in Italy and France this difference is even larger, 50% and 100%, respectively. I also present the ILLIQ measure that shows the absolute euro change in price triggered by trading 1 million EUR. This price impact is the highest in the German ILB and the lowest in the German nominal segments. This observation verifies that German nominal bonds are highly liquid, especially in times of flight to liquidity. Inflation swaps have an average yield of 2.19% whereas the difference between average indexed and nominal yields is 67 basis points in Germany, and 164 and 83 basis points in France and Italy, respectively.

Figure 1 depicts the time evolution of both the country and Eurozone level illiquidity and credit factors. All series have their peaks at the financial and the euro crises, which is in line with anecdotal and previous empirical evidence. The country level liquidity factors differ slightly: in Germany it is constructed by taking the first principal component of the KfW spread, and the ILLIQ and zero return

[18] Appendix A explains why this substitution is conceptually feasible. Besides, substituting realized returns with their less noisy yield counterparts is common in the fixed income literature, see e.g. Campello et al. (2008), Bongaerts et al. (2011), Pflueger and Viceira (2014), Driessen et al. (2014).

measures from both the nominal and indexed segments. All of these measures have a positive loading in the first component, except for zero returns in the ILB market. However, this is not surprising in light of the segment being relatively young and there are a high number of zero return days in the months succeeding its introduction, but not later. For Italy, the principal component is based on the different ILLIQ and zero return measures, where the constituent measures show the same relation: all measures constituting the German and Italian factors are positively correlated to one another. Individual measures are depicted in Appendix B. The three illiquidity factors from the bond markets follow similar dynamics and hence their correlations are sizeable: it is 0.41 between the German and Italian liquidity factor. The credit factors are based on the unexpected changes in the sovereign CDS series. These series tend to closely follow each other, as can be seen in Figure B-4 and exhibit correlations above 90%. After taking the residuals from the respective autoregressive processes, the countrywide credit factors remain highly correlated: all coefficients are above 0.7.

Table II presents the distribution of beta coefficients across the six bond market segments and the net betas from Equation 13. The betas are estimated from asset-level time-series regressions of excess returns on the market, illiquidity and credit factors; under the assumption of either integrated or segment-level market factors.[19] Under these assumptions the market factor is the Eurozone or asset segment-wide equally weighted average return, respectively. In both cases I expect liquidity and credit betas to be negative on average, whereas the segmented market betas being close to one. On the one hand, this is not what I find in the data in all cases. Market betas in all segments are different from one and often negative. This is due to the non-homogeneous and imbalanced nature of the market factor, whose composition changes whenever a new issue enters or an old one reaching maturity leaves the sample. On the other hand, there is a pattern in nominal integrated market betas that is consistent with flight-to-quality: Italian nominal yields increase whenever European systematic risk rises, French bonds show only a slight effect, whereas the negative beta of the German nominal sector suggests that investor find safe haven in these assets. The other irregularity of the betas is that not all liquidity and credit betas are negative on average. In German and Italian markets this seems less of a problem, unlike in France, where I cannot construct a segment-specific French illiquidity factor to measure the respective beta. Instead I substitute the missing information with the integrated, Eurozone-level liquidity factor.

3.2 Net betas

Net betas can be found in Panel D of Table II, as well as they are depicted in Figure 2. Net betas are a portfolio of nominal and ILB betas that constitute the spread on breakeven strategy. There are twenty such strategy pairs in the sample that have at least 12 monthly observations. Panel D shows that the average net beta is negative in all three cases, in addition, Figure 2 is also in line with this observation. Economically speaking, if the liquidity and credit risk exposure were the same among nominal and inflation-linked bonds, net betas would line up at the zero. Therefore, finding values other than zero suggests that exposures differ among the two bonds, moreover, this difference is also not consistent or the same across the two countries. Moreover, the sign of these betas also suggest which of the underlying four bonds drives the result, this can be derived from the sizes and signs of the individual bond betas.

[19] I also looked at median betas, as well as weighted average betas, where I used the number of available observations as weights. This latter method would tilt the average towards more precise estimates, the ones that are based on more monthly observations. However, the resulting betas are not significantly different from the ones that are presented in the table: they are similar in magnitude and have identical signs.

Liquidity net betas can be found in a narrow range around zero, while credit net betas in the mid-panel are more dispersed and larger – often even by two orders of magnitude. The negative liquidity betas suggest that ILBs are less liquid than nominal bonds, a finding in line with previous literature. However, one of the most surprising finding of this paper is that I find that credit risk exposures of bond within a country, issued by the same issuer, are also large enough to survive the double differencing. The sign of the credit betas also provides suggestive evidence of which bond is driving this relationship: ILBs are more exposed to sovereign risk, whereas there is also a natural ordering across the countries in terms of their riskiness: Germany is the safest from a sovereign perspective, Italy is the least creditworthy, whereas there is mixed evidence for France. Finally, the market net betas in the lower panel are the largest in size and dispersion, despite that one would expect such exposures to be zero. These loadings are a clear proof that the breakeven spread is exposed to integrated non-diversifiable Eurozone risk, similarly to the finding of Monfort and Renne (2014). This is due to the integrated market factor capturing some aspects of liquidity and credit risks in the euro area, which are apparently relevant in the pricing of the markets under scrutiny.

The beta estimates reflect how difficult it is to disentangle the effect of liquidity and credit risk, two concepts that are highly correlated and intertwined, especially in distressed periods. There have been many papers trying to separate them, and my approach is the best attempt to explore such a highly relevant question in this recently available cross-section of indexed and nominal euro area sovereign bond data. Besides, I am aware that the betas presented might be estimated with considerable errors due to the short and imbalanced sample in addition to estimating them from individual assets. These econometric issues might be carried over to the second stage regressions, as discussed in Kleibergen (2009) and Kleibergen and Zhan (2013). To overcome this potential shortcoming in my analysis, the section on conclusion and extensions offers a solution.

3.3 The relative pricing of indexed and nominal bonds

There is evidence from the US Treasury markets that both the level (Krishnamurthy, 2002, Goyenko et al. 2011, Fleckenstein et al., 2014 and Pflueger and Viceira, 2013) and risk (Driessen et al. (2014)) aspects of liquidity are priced, whereas empirical findings from the Eurozone are restricted to nominal bonds (Darbha and Dufour (2013), Pelizzon et al. (2014) and Schwarz (2015)). As opposed to this, to my best knowledge this is the first study to present empirical evidence for selective default risk premium in the relative pricing of nominal and inflation-linked bonds. Next to this, the main contribution of the paper is coming from the identification strategy that helps better understanding the relative pricing of inflation-linked and nominal bonds and to set up clean asset pricing tests in a difference-in-differences setting, ensuring that the analysis is the least contaminated by confounding effects. This strategy quantifies liquidity and credit effects directly from the spread on breakeven rates, as described in the methodology part, and does so by eliminating the commonalities, such as inflation and interest rate risks or the effect of monetary policy.

Ideally, one would construct the the breakeven rate relying on the difference between two smooth zero coupon curves. As opposed to this, I choose to focus on pairs of bonds with the smallest possible maturity mismatch between potential pairs across countries. I construct the matched pairs by minimizing the mismatch of the two bond maturities, as well as I try to match similar tenors to one another. Consequently, I have breakeven rates on 5 or 10 year or mixed maturities. Due to this heterogeneity in tenors, and the various contaminating effects that are eliminated by the differencing, studying these yield spreads are less informative then doing so based on their differences. Therefore, I focus the analysis on the spread on such breakeven series. To construct the spread, I use the pool of 27 maturity matched bond pairs. The resulting series are depicted in Figure 3, where the different panels correspond to different country pairs. There are twenty pairs of pairs with at least 12 months of data available in the sample: 6 of these are taken between Germany and Italy, 5 pairs are formulated across German and French bond pairs and 9 pairs are among Italian and French breakeven rates. The descriptive statistics of these series are in Panel A of Table V.

Panel A of Table V shows that the average breakeven spread is between -36 and 23 basis points across all the pairs. The lowest value the spread takes is -272 basis points, for Italian-French matched basis pair, whereas its peak is 401 basis points for a pair from Germany and Italy. The latter series are the most volatile. The Eurozone average spread is -18.3 basis points and ranges between -76 and 90 basis points over time. In the next step of the analysis liquidity and credit effects are identified from the cross-section of these series. The economic interpretation of the German-Italian example based on the average series is that if an investor were engaged in German and Italian ILB and nominal positions according to Equation 5, her average return would amount to 23 yield basis points. However, the panel also shows that holding the underlying positions results in volatile returns with large swings ranging between a loss of 66 basis points or gains in the order of 4% per annum. This suggests that even without taking transaction costs into account, there are potential sizeable losses arising if the strategy cannot be held until maturity. This is even more prominent in German-French and Italian-French bond pairs.

However, discovering the limits to the tradability and risk-return characteristics of the breakeven spread is not the main focus of the paper. Instead, Tables III and IV contain the results estimated from monthly repeated cross-sectional regressions of the spread on breakeven series on the illiquidity and credit factors, alongside with composite asset level liquidity proxies, based on Equation 13 and 15. Net betas are portfolios of betas estimated from the first stage of market segment level Fama-MacBeth regressions, as loadings on the Eurozone market, illiquidity and credit factors. The results correspond to the period between July 2004 and February 2014.

Table III focuses on the effect of liquidity differences between nominal and inflation-linked sovereign bonds. Different exposures to the integrated Eurozone-wide illiquidity risk factor would result in significant estimates in the current analysis: and the first column proves this proposition. I find that illiquidity is priced with a highly significant discount. This effect, evaluated at the mean net liquidity beta, explains 3.48 basis points of the spread of breakeven rates. This illiquidity effect is robust to the inclusion of bond group-level liquidity measures, such as size or age of a portfolio or the duration factor captured by time-to-maturity. However, column 5 warns that the presence of the net market beta erodes the effect of illiquidity. This implies that (1) the spread on breakeven is exposed to systematic risk; (2) the European interest rate or integrated market factor is likely to be capturing some aspects of liquidity and credit risk. This is additional proof of how important these risks are in the pricing of sovereign bonds. Nevertheless, this finding shows that liquidity differences between nominal bonds and ILBs is probably more a within than an across-country effect.

Table IV extends the prior analysis by incorporating credit risk. By doing so I rely on the exploratory evidence from net betas, namely that credit risk differs among nominal and sovereign bonds, and these regressions aim to put a price tag on this differential risk exposure. The most striking and key finding of the paper is that indeed, differential credit risk is priced in the cross-section of Eurozone breakeven pairs. This implies that investors probably perceive ILBs more risky from a sovereign risk perspective and see governments to be more likely to default on their inflation-indexed obligations than on nominal debt. This observation is in accordance with selective default events that occurred in Russia in 1998 with its ruble-debt, or with Argentina between 2003 and 2005 that defaulted on eurobonds. Moreover, to my knowledge this finding makes my paper the first to provide empirical evidence on such phenomenon.

Finding significant credit effects can partly be explained by the existence of a non-diversifiable euro-area credit risk as in Monfort and Renne (2014), and the constituent assets' exposure to such a factor. However, identifying any credit effects that does not cancel out within a certain country suggests that this is selective default risk. Moreover, this finding is robust: the extent to which credit exposure dominates illiquidity is surprising – once included in the regressions together, liquidity's effect is wiped out and even its size and sign is not consistent across specifications. Moreover, including credit risk almost doubles R-squared compared to when only illiquidity is considered. Credit risk carries a large discount, its market price is -126 basis points; and accounts for a sizeable yield difference of 41.6 basis points evaluated at the mean net credit beta. This effect is persistent and robust to the inclusion of liquidity level proxies, among which the relative age of bonds also matters; and to incorporating systematic risk, the market factor.

As unusual as pricing differential risk exposures might seem, the idea of comparing yields of securities with similar exposures to certain risks is not new in the literature. Longstaff (2004) compares yields of US Treasuries to those of bonds issued by the Refcorp (Resolution Funding Corporation), whereas Schwarz (2015) examines yield differences of German federal government bonds and bonds issued by KFW, a government owned development bank. The key feature of theses agency bonds is that they have explicit government guarantees, and consequently the same credit risk as government bonds. However, the liquidity of government bonds is substantially higher and thus the yield difference measures general market liquidity conditions. What I do in this paper is similar but goes the other way around: while controlling for liquidity on both the nominal and inflation-linked bond markets the same way, I show that the remaining yield difference is attributed to sovereign risk. This idea is also consistent with the alternative interpretation of the Refcorp and KfW spreads - some say that these yield differentials, rather than capturing liquidity, can also be interpreted as breakup or selective default risk measures.

Figure 4 depicts the percentage yield risk premium due to relative illiquidity and credit risk in all available breakeven spreads. It is calculated as the product of the cross-sectionally estimated risk premia and the respective net betas. The upper panel shows the illiquidity premium estimated in Table III in the respective pairs, whereas the lower graph depicts both liquidity and credit premia based on Table IV. There are two noteworthy observations: 1) illiquidity is not robust to the inclusion of credit risk, as both the magnitudes and signs are changing; 2) the magnitude of the yield difference that is explained by credit risk is tenfold compared to that of illiquidity, and in certain cases it is up to 1.5%.

The final step of examining the breakeven spreads is to evaluate the effect of risk adjustments. This shows how would the series change if I took out the estimated liquidity and credit premia, as in Table V and Figure 5. Table V presents descriptive statistics of the average unadjusted series, in Panel A; and the liquidity, and liquidity and credit risk-adjusted series in Panel B and C, respectively. The idea underlying the adjustment is based on Equation 5, where I proxy the spread-on-basis strategy by the portfolio of constituent bonds. To calculate the adjustment for each bond 'pair of pair', I sum up the asset level risk premia and deduct this sum from the spread. I apply this raw correction term to all bond pairs in the sample and recalculate the average of the adjusted spread series. Panel B presents the specification when I only consider and adjust for illiquidity risk. In all three country pairs I find that by taking out the estimated risk premia, the spread shrinks considerably. This is in line with my expectations. The average European spread almost diminishes: it increases from -18.3 to 1.3 basis points. The new average is not only a magnitude smaller, but also has the opposite sign. Panel C shows the case when the adjustment is based on the sum of liquidity and credit effects. As opposed to liquidity, taking both liquidity and credit risks out deepens the spread. The Eurozone average drops to -94.5 basis points. Also the extreme values show that the series are shifted downwards, further from their equilibrium level of zero.[20]

Figure 5 gives a visual representation of the moments in the table. The top panel shows the breakeven pairs matched between German and Italian bonds; the middle panel refers to those from Germany and France; whereas the bottom panel depicts French-Italian pairs. In all three panels the solid line refers to the average series, the dashed one to liquidity, whereas the dotted line to the composite adjustment. The average series presented are also imbalanced: their composition over which they are defined varies over time.

The upper panel shows that the German and Italian spreads have their peaks at times most likely coinciding with ECB intervention. Applying liquidity adjustment to this series does not have a large effect. In general, the figure suggests that the corresponding liquidity corrections are not too large and probably average out. On the other hand, applying credit adjustment shifts the average further from zero: it deepens the yield difference if the respective bonds in the strategy. This is not surprising, as these pairs contain the smallest and the largest credit risk estimates and by definition of the portfolio formation, the sum of these effects is expected to be negative. The middle section demonstrates the average of the five Germany and France-based series, for which liquidity shifts the average upwards, closer to zero. This helps to explain the price difference by illiquidity differences, but taking credit risk into account moves the opposite direction. This result is in line with the selective default story, where investors perceive ILBs more risky than their nominal counterparts. And finally, the lower panel shows how the changing composition of the average series influences the results: in the first period where the two adjustments exhibit different dynamics, one matched bond pair is available. Once other pairs enter the sample, the effect of credit risk goes to the same direction as that of the liquidity correction: taking them out of the spread deepens the spread by pushing it further away from zero.

3.4 Robustness tests and discussion

This section presents some robustness tests. In unreported robustness tests include models with different illiquidity and credit measures and additional controls. The effects of liquidity are stronger when a funding liquidity proxy, the OIS spread, is included, whereas defining the credit factor based on changes not levels of the CDS spread virtually produces the same results. Age and time-to-maturity are also considered as proxies for asset level liquidity, though results are mixed. Nevertheless, this section focuses on a way of partly overcoming the statistical difficulties of the small number of breakeven spreads by pooling all bond data together. This method does not allow me to directly look at the pricing of differential credit risk, but helps me to convince the reader that these risks are important on the

[20] Note that this adjustment does not allow me to incorporate time variation in risk premia; therefore, I can only induce parallel shift in the series. Incorporating time variation would require splitting the sample or using rolling window estimation that are not feasible due to the empirical issues explained before.

pricing of bonds in the sample. And finally, this sections concludes with some discussion regarding selective default and its alternative interpretations.

3.4.1.Pooled regressions

Disentangling liquidity and credit risks is a difficult task. Moreover, the sample of this study is relatively short and highly imbalanced: despite that it spans ten years, there is barely any asset would span the whole period. This is due to new bonds being issued and old ones reaching maturity on a regular cycle. The resulting instability in composition mostly affects the market factor, but is likely to also increase the standard errors of other beta estimates. In addition, some markets are rather young and only a few assets are traded, which makes it even more difficult to identify cross-sectional effects. One way to alleviate the problem of small samples, although this does not allow for direct comparison, is to pool all bonds together for the analysis. This helps to establish the relationship between bond yields and liquidity and credit risks, and hopefully also to convince the reader of the relevance of the differential pricing.

To alleviate the problem, I run regressions that are pooled across all bond market segments and estimate euro area wide risk premia; results are presented in Tables VI and VII. Table VI focuses on the effect of illiquidity. The euro area market risk is priced and its size is rather stable across the different specifications. The second column shows that adding illiquidity to systematic risk increases the R-squared substantially and results in a positive price for illiquidity. From this premium, multiplied by the average negative illiquidity beta, follows a negative average effect, whereas considering the central mass of the beta distribution shows that illiquidity has a positive and economically significant impact in the order of 20 yield basis points. The significant price effect of illiquidity is robust to the inclusion of size and time-to-maturity of a bond issues, but is dominated by the effect of age. Age has the right sign and shows that if a bond gets a year older, its yield goes up by approximately 2.6 basis points. This translates into an increase in expected return as older and off-the-run issues are likely to be locked in buy-and-hold investors' portfolios.

Table VII presents similar analysis with incorporating sovereign credit risk. The Eurozone interest rate or market factor is positive and significant across all specifications. Including credit risk in the analysis strengthens the effect of illiquidity risk: they are priced and highly significant together; moreover, their effects are robust to the inclusion of any asset level liquidity proxy. Adding these two factors increases the R-squared considerably. The average betas of both credit and illiquidity are negative; therefore, the market wide illiquidity premium translates into a negative average effect. Despite this unexpected effect, similarly to the previous table, I find positive impact on yields, which is in line with economic theory. For credit risk, I find a market wide discount that is stable in size and across specifications. Eurozone-wide credit risk has positive average effect on yields, yet its impact is negative. These inconsistent signs among average and interquartile effects show that the betas are asymmetrically distributed. And finally, age still has a significant effect in the order of 2 basis points.

These pooled regressions help to alleviate the burden of estimating market level models from short and highly imbalanced subsamples. However, the spread on breakeven identification is an alternative and robust way of pooling the constituent markets, which has the merit of serving as a cleaner test of risk premia due to the confounding effects being filtered out of the analysis.

3.4.2.Discussion

The section on the relative pricing of sovereign bonds presents empirical evidence on selective default risk premium. I define selective default as an event, in which a sovereign issuer chooses not to meet obligations on a class of bonds, while servicing her other debt. Sovereign defaults are rare events in the post-WW II era; moreover, there has not been a precedent for a sovereign issuer specifically defaulting on her inflation-linked debt. This is partly due to the novelty of inflation-linked products. However, the sample period of this study suggests that this effect is identified from the increased sovereign risk of the euro area countries during the financial and subsequent euro crises. Consistent with this idea, although the likelihood of such an event is small, my analysis shows that investors attached positive probability to Eurozone issuers to decide to strategically default on their indexed debt.

What are the scenarios under which partial default could happen in the euro area? There are two possible channels or mechanisms. On the one hand, this event could be triggered through the channel of inflation. These countries do not have full control over their monetary policy, as they are part of the euro zone, however, the decision to default on their debt is the issuer's discretion. Consequently, the default on ILBs is most likely to happen if the harmonized inflation gets substantially higher than that of the issuer country, for which it becomes a burden to pay back the HICP-indexed debt. On the other hand, an alternative scenario is when a highly indebted country has to exit the euro zone, and once it gained back its control over its monetary policy, it can decide to print more money to fulfill its nominal obligations. This would increase inflation and likely result in the depreciation of the local currency. Then the inflation channel only plays a role if ILBs are linked to local inflation, as the country after the exit cannot affect the average HICP. Besides, the exit raises the issue of a potential currency mismatch: the originally euro or local currency denominated debt might be honored in a (likely depreciated) foreign currency. This is the second, redenomination risk channel, similar to what Krishnamurthy et al. (2014) or De Santis (2015) describes. Under this scenario, (part of) the selective default premium might arise as a compensation for this source of risk, which is present, as the indexed debt should be honored in euros. However, due to the exchange rate, meeting the euro-denominated debt becomes very expensive, and in response the issuer is likely to decide to strategically default on these bonds.

Lastly, I would like to add a note on the relative importance of credit and liquidity in the relative pricing of indexed and nominal sovereign debt. The many attempts in the literature show that disentangling liquidity and credit risk in sovereign bond yields is a non-trivial task. In the specific case of my analysis, there is a possibility that the credit factor is picking up some aspect of liquidity or flight-to-safety. Then my method would overestimate the effect of credit risk at the cost of liquidity. Overcoming this issue is not straightforward, and it remains to be solved as an extension of this current draft. However, as the analysis points out, the differential liquidity and credit channels are equally important to understand the relative pricing of indexed and nominal bonds.

4 Conclusion and extensions

This paper presents unique empirical evidence of selective default risk premium in inflation-linked sovereign bond (ILB) yields of Germany, France and Italy. Selective default is an event in which a sovereign issuer chooses not to meet obligations on a class of bonds, while servicing her other debt. I identify this effect from the difference of breakeven rates from country pairs. Differencing controls for common components, such as the effect of inflation expectations, monetary policy or interest rate risk. I find that the remaining part in breakeven rates is explained by two systematic risk factors, liquidity and sovereign credit risks - both within and across countries. I link these findings to the ILB-nominal puzzle, which shows that ILBs are underpriced relative to nominal bonds of the same issuer. I show that this underpricing is in part due to relative risk premia differences between nominal and inflation-linked debt: ILBs are less liquid, moreover investors perceive them to have higher credit risk during the financial and euro crises. This implies an implicit seniority and a subsequent convenience yield in nominal bonds.

Nonetheless, the method presented above has its limitations. First, the description of the results already pointed out specific features of the sample that make statistical inference more challenging. My strategy to overcome this burden is to improve the estimation of the betas, either in a statistical or in an economic sense. The first could be performed by using a statistical method that allows me to benefit from the use of data at different frequencies as in Ghysels, Sinko and Valkanov (2007). By applying mixed data sampling or the MIDAS method, I could estimate and profit from having daily observations on market returns and credit risk, whereas I could simultaneously use these estimates with betas from the monthly illiquidity regressions. An alternative improvement is to impose structure on the beta estimation in an economic sense: make betas dependent on the asset characteristics, such as maturity or to construct another, higher frequency liquidity measure. Apart from the estimation, a natural extension would be to treat the identification as a trading strategy and to further explore the (limits to) its tradability and the risk-return characteristics.

Another related question to be answered is whether liquidity (and credit) proxies are affected and how the relative pricing of bonds changes in reaction to quantitative easing of the ECB. One could even go one step further to see how the spread of breakeven rates changes due to such unconventional monetary actions, and whether these markets price such events symmetrically in the nominal and inflation-indexed market segments. Studies to date, like Krishnamurthy and Vissing-Jorgensen (2011) and Krishnamurthy et al (2014), focus on the effects on different market segments separately, whereas one could look at the relative, potential lead-lag effects across indexed and nominal bonds.

References

Acharya, V. and Pedersen, L. H. (2005): Asset Pricing with Liquidity Risk, *Journal of Financial Economics*, Vol. 77, pp. 375-410

Amihud, Y. (2002): Illiquidity and stock returns: Cross-section and time-series effects, *Journal of Financial Markets*, Vol. 5, pp. 31–56.

Amihud, Y. and Mendelson, H. (1986): Asset pricing and the bid-ask spread, *Journal of Financial Economics*, Vol. 17, pp. 223-249

Ang, A., J. Liu, and Schwarz, K. (2008): Using stocks or portfolios in tests of factor models. *Working Paper*, Columbia University

Arce, O., Mayordomo, S. and Pane, J. I (2011): Do Sovereign CDS and Bond Markets Share the Same Information to Price Credit Risk? An Empirical Application to the European Monetary Union Case, *Working paper*

Bai, J., Julliard, C., and Yuan, K. (2012): Eurozone Sovereign Bond Crisis: Liquidity or Fundamental Contagion, *Working Paper*.

Barro, R. J. (2006): Rare Disasters and Asset Markets In The Twentieth Century, *The Quarter Journal of Economics*, Vol. 121, No. 3, pp. 823-866.

Beber, A., Brandt, M. W., and Kavajecz, K. A. (2009): Flight-to-Quality or Flight-to-Liquidity? Evidence from the Euro-Area Bond Market, *Review of Financial Studies*, Vol. 22 -3

Bekaert, G., C.R. Harvey, and C. Lundblad (2007), Liquidity and Expected Returns: Lessons from emerging Markets, *Review of Financial Studies*, Vol. 20, pp. 1783-1832.

Bolton, P. and Jeanne, O. (2009): Structuring and Restructuring Sovereign Debt: The Role of Seniority, *Review of Economic Studies*, Vol. 76, pp. 879-902

Bühler, W. and Vonhoff, V. (2011): Term Structures of Liquidity Premia in the U.S. Treasury Market, *Working paper* available at SSRN: http://ssrn.com/abstract=1618357

Campbell, J. Y, Shiller, R. J. and Viceira, L. M. (2009): Understanding Inflation-Linked Bond Markets, in David Romer and Justin Wolfers, ed.: Brookings Papers on Economic Activity, Spring 2009 (Brookings Institution Press), pp. 79-120

Christensen, J. H. and Gillan, J. M. (2011): Has the Treasury Benefited from Issuing TIPS?, *FRBSF Economic Letter* 2011-12

Ciccarelli, M. and Garcia, J.M. (2009): What drives euro area breakeven inflation rates?, ECB Working paper series, #996/January 2009

Darbha, M. and Dufour, A. (2013): Microstructure of the Euro-area government bond market. In: Baker, H. K. and Kiymaz, H. (eds.) Market microstructure in emerging and developed markets. Robert W. Kolb series in finance. John Wiley, Hoboken. ISBN 9781118278444

Darbha, M. and Dufour, A. (2014): The Term Structure of Bond Market Illiquidity and Default Risk, *Working paper* available at SSRN: http://ssrn.com/abstract=2470968

Daves, P. R. and Ehrhardt, M. C. (1993): Liquidity, Reconstitution, and Value of U.S: Treasury Strips, *Journal of Finance*, Vol. 48, pp. 315-329

De Pooter, M., Martin, R. F. and Pruitt, S. (2013): The Liquidity Effects of Official Bond Market Intervention, Working paper available at SSRN: http://ssrn.com/abstract=2143326

De Santis, R.A. (2015): A Measure of Redenomination Risk, ECB Working Paper No. 1785

Driessen, J., Nijman, T. E. and Simon, Z. (2014): The missing piece of the puzzle: Liquidity premia in inflation-indexed markets, *Working paper*

Duffie, D., Pedersen, L. H and Singleton, K. J. (2003): Modeling Sovereign Yield Spreads: A Case Study of Russian Debt, *Journal of Finance*, Vol. 58, pp. 119-159

Ejsing, J. and Lemke, W. (2011): The Janus-Headed Salvation: Sovereign and Bank Credit Risk Premia during 2008-2009, *Economics Letters*, Vol. 110(1), pp. 28-31

Ejsing, J., Grothe M. and Grothe, O. (2012): Liquidity and credit risk premia in government bond yields, *EBC working paper* No. 1440

Fama, E. and French, K. (1993): Common risk factors in returns on stacks and bonds, *Journal of Financial Economics*, Vol. 33, pp. 3-56.

Fleckenstein, M. (2013): The Inflation-Indexed Bond Puzzle, *Working paper*

Fleckenstein, M., Longstaff F. A. and Lustig, H. (2014): Why does the Treasury Issue TIPS? The TIPS-Treasury Bond Puzzle, *forthcoming in Journal of Finance*

Fleming, M. and Sporn, J. (2012): An Analysis of OTC Interest Rate Derivatives Transactions: Implications for Public Reporting, Appendix: Trading Activity and Price Transparency in the Inflation Swap Market, Federal Reserve Bank of New York Staff Reports.

Fontaine, J-S. and Garcia, R. (2012): Bond Liquidity Premia, *Review of Financial Studies*, Vol. 25, pp. 1207-1254

Fontana, A. and Scheicher, M. (2010): An Analysis of Euro area sovereign CDS and their relation with government bonds, *ECB working paper* No. 1271

Ghysels, E., Sinko, A. and Valkanov, R. (2007): MIDAS Regressions: Further results and New Directions, *Econometric Reviews*, Vol. 26, pp. 53-90

Goyenko, R., Subrahmanyam, A. and Uhkov, A. (2011): The Term Structure of Bond Market Liquidity and Its Implications for Expected Bond Returns, *Journal of Financial and Quantitative Analysis*, Vol. 46, pp. 111-139

Grishchenko, O.V. and Huang, J. (2013): Inflation Risk Premium: Evidence from the TIPS market, Journal of Fixed Income, Vol. 22, No.4

Gurkaynak, R. S., Sack, B. and Writgh, H.J. (2008): "The TIPS Yield Curve and Inflation Compensation," American Economic Journal: Macroeconomics, 2(1), 70–92.

Houweling, P., Mentink, P. and Ton Vorst (2005): Comparing possible proxies of corporate bond liquidity, *Journal of Banking & Finance*, Vol. 29, pp. 1331-1358.

Jordan, B., Jorgensen, R. and Kuipers, D. (2000): The Relative Pricing of U.S. Treasury STRIPS, *Journal of Financial Economics*, Vol. 56, pp. 89-123

Kerkhof, J. (2005): Inflation Derivatives Explained, Fixed Income Quantitative Research, Lehman Brothers (July), pp. 1-80

Kleibergen, F. (2009): Tests of risk premia in linear factor models, *Journal of Econometrics*, Vol. 149, pp. 149-175

Kleibergen, F. and Zhan, Z. (2013): Unexplained factors and their effects on second pass R-squared's and t-tests, *Working paper*

Krishnamurthy, A. (2002): The Bond/Old Bond Spread, *Journal of Financial Economics*, Vol. 66, pp. 463-506

Krishnamurthy, A., Nagel, S. and Vissing-Jorgensen, A. (2014): ECB Policies involving Government Bond Purchases: Impact and Channels, *Working paper*

Longstaff, F. A. (2004): The Flight to Liquidity Premium in U.S. Treasury Bond Prices, *The Journal of Business*, Vol. 77, pp. 511-526

Monfort, A. and Renne, J-P. (2014): Decomposing euro-area sovereign spreads: credit and liquidity risks, *Review of Financial Studies, forthcoming*

Palladini, G. and Portes, R. (2011): Sovereign CDS and Bond Pricing Dynamics in the Euro-area," *NBER Working Papers* 17586

Pastor, L. and Stambaugh, R. F. (2003): Liquidity Risk and Expected Stock Returns, *Journal of Political Economy*, Vol. 111, pp. 642.685.

Pelizzon, L., Subrahmanyam, M. G, Tomio, D. and Uno, J. (2014): Sovereign Credit Risk, Liquidity, and ECB intervention: Deus ex Machina?, *Working paper*
Pflueger, C. E., and Viceira, L. M. (2015): Return Predictability in the Treasury Market: Real Rates, Inflation, and Liquidity, in Chapter 10 in Pietro Veronesi (ed.) Handbook of Fixed-Income Securities, Wiley, NJ.
Roll R. (1984): A Simple Implicit Measure of the Bid-Ask Spread in an Efficient Market, *Journal of Finance*, Vol. 39, No. 4, pp. 1127-1139
Schuster, P. and Uhrig-Homburg, M. (2013): The Term Structure of Bond Market Liquidity Conditional on the Economic Environment: An Analysis of Government Guaranteed Bonds, *Working paper* available at SSRN: http://ssrn.com/abstract=2033170
Schwarz, K. (2015): Mind the gap: Disentangling Credit and Liquidity Risks in Spreads, *Working paper*

Appendix A

Appendix A shows that the direct identification of differential liquidity and selective default risk can not only be derived by using breakeven rates, but also by means of the swapped ILB-nominal basis based on Fleckenstein et al. (2014) and Fleckenstein (2013). They define the basis or mispricing as the price difference between a nominal sovereign bond and a synthetic bond, which replicates the nominal cash flows. The latter is essentially an inflation swapped-indexed bond, whose cash flows are converted to fix payments exactly matching those of the corresponding nominal bond. Moreover, the maturities of the two 'nominal bonds' are also matched.

To replicate this strategy, an investor buys an ILB issue and shorts a nominal bond at the same time. Additionally, she executes a zero-coupon inflation swap contract with the same maturity and notional amount as the ILB coupon – and repeats this for each coupon and for the principal amount, which results in the execution of an entire swap portfolio. The rationale for swapping the bond is that the sum of the two cash flows is constant if they are linked to the same index and equal to the nominal coupon or principal. The investor also takes a small position in nominal principal STRIPS[22] if there is disparity between the nominal swapped ILB cash flows. Based on this logic, she applies these steps to all coupon payments, which result in the successful conversion of the ILB's variable cash flow stream to the fixed one of the corresponding nominal bond.[23]

In sum, the investor short sells the nominal bond, buys the inflation-linked bond issue and holds portfolios of zero-coupon inflation swap contracts and nominal principal STRIPS. Absent liquidity and credit effects, these three components exactly replicating the fixed periodic coupons and the principal of the nominal bond should have the same price as the nominal bond. Finally, I calculate and compare the price of the replicating portfolio to that of the nominal bond. If in a frictionless world the resulting prices of these to securities differ, an arbitrage opportunity would arise. However, there is empirical evidence that both liquidity and credit risks affect European sovereign yield (Fontana and Scheicher, 2010, Palladini and Portes, 2011, or Pelizzon et al., 2014, Darbha and Dufour, 2014, and Monfort and Renne, 2014). Therefore, this price discrepancy, henceforth called the swapped ILB-nominal basis, captured by this strategy, is most likely to be explained by the differences in liquidity and credit risk premia in the constituent asset prices.

I construct the basis series in the spirit of Fleckenstein et al. (2014).[24] The time series evolution of these series is depicted on Figure A-1, where the upper panel shows the country average s, whereas the lower panel displays the overall average across all 27 pairs of ILBs and nominal

[22] However, I only focus on bonds and swaps, although there is some empirical evidence that STRIPS are exposed to liquidity issues, see for instance Daves and Ehrhardt (1993), Jordan et al. (2000). Nevertheless, Buhler and Vonhoff (2011) show that principal STRIPS, the ones used in the strategy, are less affected. Consequently, I am less concerned that small positions that are further reduced in the spread-on-basis strategy, taken in these assets would carry a sizeable liquidity premium that could distort my results. . Moreover, the potentially negative premium, which is in line with previous findings, would only work against me by widening the basis.

[23] A detailed description of this strategy can be found in the original paper of Fleckenstein et al. (2014).

[24] A detailed technical description of the mechanics of the nominal-ILB mispricing or basis can be found in Fleckenstein (2013), who as part of the G7 countries looks at Italian, French and German sovereign bond markets.

bonds across the three countries. The figure shows that the yield difference between the nominal and synthetic nominal bonds varies substantially over time and across the three countries. Negative values of the basis suggest that the nominal bond has a lower yield, thus higher price, than its replicating portfolio. A notable difference between these series and the one presented in Fleckenstein et al. (2014) is that unlike in the US, European series do switch signs over time. This means that the return varies over time depending on market conditions. In Germany and France, the series have a distinctive and large drop at the Lehman crisis, whereas the Italian series is the most volatile, exhibiting large swings around the financial and euro crises. The series plummet in late-2011 and mid-2012, potentially in reaction to ECB intervention, as discussed by Krishnamurthy et al. (2014) and Pelizzon et al. (2014).

This strategy is an appealing way of looking at the relative pricing of the constituent bonds.[25] Fleckenstein et al. (2014) show that the basis cannot be due to differences in the tax treatment of nominal and indexed Treasuries, trading costs, repo financing, collateral value and pledgeability, eligibility of stripping or differences in their ownership structure. However, one could argue that the illiquidity of inflation swaps and the deflation floor of indexed bonds are accountable for the above price discrepancy. Unfortunately these alternative explanations are not possible to formally eliminate within this setting[26].

An economically relevant side product of developing the spread on breakeven strategy is that I improve upon the strategy of Fleckenstein et al. (2014). I do so by exploiting the benefits of my cross-country sample: inspired by the difference-in-differences approach, I scrutinize the swapped ILB-nominal basis across countries by taking the difference of two such series, each coming from one of the countries in my sample. These series are depicted on Figure 3. For instance, one such strategy I could be looking at the difference between German and Italian bond pairs:

$$b_t^G - b_t^{IT} = (y_{nom}^G - y_{replic}^G) - (y_{nom}^{IT} - y_{replic}^{IT}). \tag{A1}$$

The basis can be seen as the return of the Fleckenstein et al. (2014) strategy and thus defined as a portfolio consisting of a nominal issue, an inflation-indexed bond and inflation swaps. The return on such a portfolio is the sum of the returns on the constituent assets:

$$\begin{aligned} R_t^G - R_t^{IT} &= (R_{nom}^G - R_{replic}^G) - (R_{nom}^{IT} - R_{replic}^{IT}) \\ &= \left[R_{nom}^G - \left(R_{ILB}^G + R_{swap}\right)\right] - \left[R_{nom}^{IT} - \left(R_{ILB}^{IT} + R_{swap}\right)\right]. \end{aligned} \tag{A2}$$

R_{nom}^G denotes the return on a German nominal bond, whereas R_{replic}^G refers to that of the cash flow replicating portfolio that consists of a maturity matched ILB issue and a portfolio of swap components. IT superscripts refer to the same assets from a similar Italian bond pair.

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[25] Similarly to Fleckenstein (2013) who looked at G7 countries, I test whether the ILB-nominal basis exists outside the US Treasury market and whether it widens during the financial and Euro crises in the three major European bond markets.

[26] We know very little about the inflation swap market, where anecdotal evidence by Fleming and Sporn (2012) suggests that illiquidity can be severe; and the deflation option cannot be hedged by inflation options either. The asset that is closest to an inflation option is the inflation spread option that takes the spread between two inflation indices and pays if the spread is positive. However, these assets are rarely traded, thus they are illiquid, and carry a sizeable counterparty risk premium (Kerkhof, 2005). Moreover, the value of the deflation option varies across bond maturities, as in Grishchenko et al. (2013), Christensen et al. (2012)

Although the above strategy focuses on the relative pricing of nominal and inflation-indexed bonds, due to the cash flow matching at all coupon dates, portfolios of inflation swaps and STRIPS are required for the exact cash flow replication. To construct the above strategy, I start with certain assumptions on asset positions within the strategy that will be later relaxed to get to a more general case. I presume first, that:

- Nominal bonds have the same coupon as the swapped indexed coupon. This applies to the principal payments too.
- The swapped indexed coupons are equal across the two countries; thus the swap positions are virtually the same. This happens if the indexed bonds have the same coupon rate and coupon payment structure, for instance annual coupons.
- Nominal and indexed bonds have the same maturity date.

If all three of these conditions applied, the swap portfolios in the German and Italian bases would be the same and no STRIPS positions were required. Then I substitute expected returns by their forward-looking proxy[27], by yield-to-maturity, the following relationship arises:

$$R_t^G - R_t^{IT} = \left[R_{nom}^G - \left(R_{ILB}^G + R_{swap}\right)\right] - \left[R_{nom}^{IT} - \left(R_{ILB}^{IT} + R_{swap}\right)\right]$$
$$= \left(R_{nom}^G - R_{ILB}^G\right) - \left(R_{nom}^{IT} - R_{ILB}^{IT}\right). \quad \text{(A3)}$$

$$E(R_t^G - R_t^{IT}) = E(R_{nom}^G - R_{ILB}^G) - E(R_{nom}^{IT} - R_{ILB}^{IT}) \approx (y_{nom}^G - y_{ILB}^G) - (y_{nom}^{IT} - y_{ILB}^{IT}), \quad \text{(A4)}$$

where R_{swap} is the return on a portfolio of different swap positions within the respective strategy. These positions depend on the coupon difference between the nominal and indexed bond as well as on the indexation or reference inflation of the ILB. Note that if the swap portfolios coincide, which holds by assumption, their respective returns cancel out. This leaves me with returns from the bond positions that, in expectation, can be proxied by the differences in their yields.

Equation A4 shows that by differencing two basis series we get the difference of two breakeven rates. In particular, this is an improvement of Fleckenstein et al (2014), because differencing successfully eliminates the confounding effects in their strategy. It cancels out any common factors, which offers a clean way of testing the drivers of the relative pricing of indexed and nominal bonds in an international setting. First, the deflation option that applies to all bonds in the sample identically is fully hedged out: bonds in my sample are all indexed to the same inflation index, the HICP index. Furthermore, they also carry the same optionality regarding negative inflation – their principal is protected against deflation but not the individual coupon payments. Consequently, after differencing the floor's effect is fully diminished from this new strategy, so are any common market factors for the same reason. Secondly, because in all three markets the same HICP inflation swaps are traded, the inflation components also cancel out whenever the inflation indexed and nominal coupon rates are the same in both countries. If this does not hold, these positions are still negligibly small and the magnitude depends on the coupon difference of the constituent nominal and inflation bonds across the two countries.

[27] This method is common in the fixed income literature, see e.g. Campello et al. (2008), Bongaerts et al. (2011), Pflueger and Viceira (2014), Driessen et al. (2014).

The two crucial assumptions for the inflation swap positions to cancel out are 1) either the coupons of the nominal or the synthetic bonds coincide – in which case the swap positions cancel out within countries; or 2) we need the swapped ILB coupons to be equal across countries. Note that the first assumption makes sure that no positions in STRIPS are required. However, in reality maturities of bond pairs[28] and index linked coupons are unlikely to match. If I relax the second and third assumptions, I get the following:

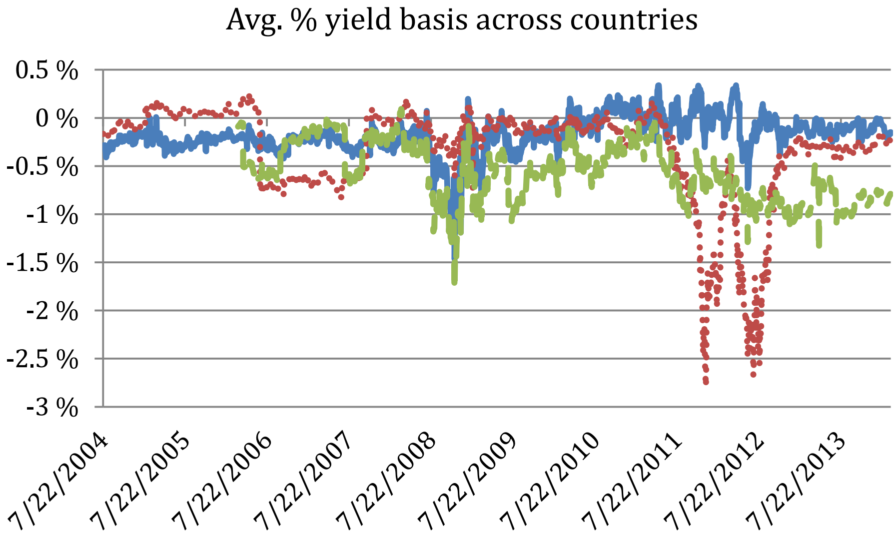
$$
\begin{aligned}
R_t^G - R_t^{IT} &= \left(R_{nom}^G - R_{replic}^G\right) - \left(R_{nom}^{IT} - R_{replic}^{IT}\right) \\
&= \left[R_{nom}^G - \left(R_{ILB}^G + R_{swap}^G\right)\right] - \left[R_{nom}^{IT} - \left(R_{ILB}^{IT} + R_{swap}^{IT}\right)\right] \\
&= R_{nom}^G - R_{nom}^{IT} + R_{ILB}^{IT} - R_{ILB}^G - \left(R_{swap}^G - R_{swap}^{IT}\right). \qquad \text{(A5)}
\end{aligned}
$$

Where the superscript of the swap portfolio return indicates that the underlying swap positions differ depending on which country's mispricing series they are coming from. This difference determines the residual swap position, which depends on the coupon difference between the ILBs, and is likely to be small. Taking the generalization one step further, another departure from the ideal case is when swapped ILB coupons do not match the nominal ones. By relaxing the first assumption we get the closest to reality, where we need to introduce nominal principal STRIPS positions into the portfolio:

$$
\begin{aligned}
R_t^G - R_t^{IT} &= \left(R_{nom}^G - R_{replic}^G\right) - \left(R_{nom}^{IT} - R_{replic}^{IT}\right) \\
&= \left[R_{nom}^G - \left(R_{ILB}^G + R_{swap}^G + R_{STRIPS}^G\right)\right] - \left[R_{nom}^{IT} - \left(R_{ILB}^{IT} + R_{swap}^{IT} + R_{STRIPS}^{IT}\right)\right] \\
&= R_{nom}^G - R_{nom}^{IT} + R_{ILB}^{IT} - R_{ILB}^G - \left(R_{swap}^G - R_{swap}^{IT}\right) - \left(R_{STRIPS}^G - R_{STRIPS}^{IT}\right). \qquad \text{(A6)}
\end{aligned}
$$

The size of the STRIPS position depends on the difference between nominal and swapped index coupons. They are in general small when regular coupon payments occur, however, they might become sizeable for the principal payment. In order to circumvent large STRIPS positions, I looked for the closest possible match in terms of both maturity and tenor when maturity-matching nominal and indexed bonds in the sample. The benefit of matching tenors comes from the fact that bonds issued in similar economic environment (e.g.: low inflation) tend to have fairly similar coupons. This shrinks the position that one has to take as the difference of the nominal coupon and the swapped-ILB coupon.

[28] Besides, I could deal with this issue by pricing bonds as if they had the same maturities, like in Fleckenstein et al. (2014).



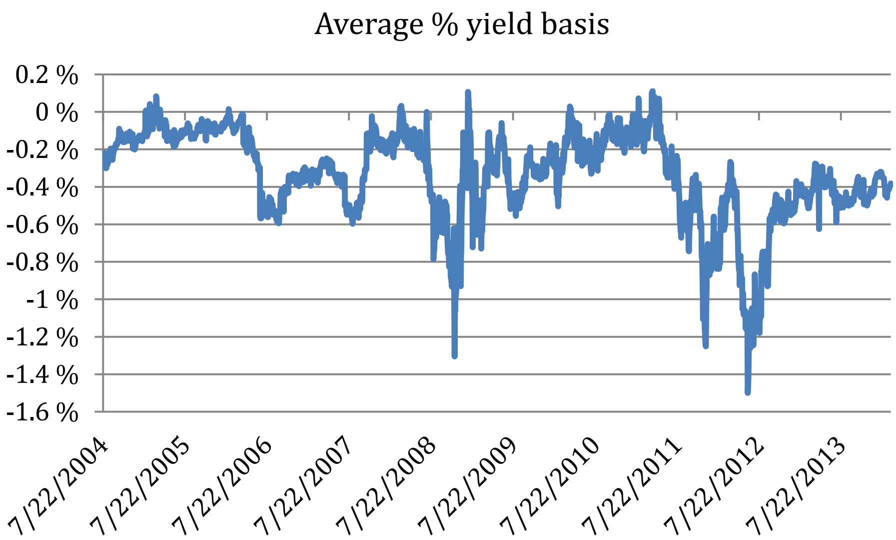
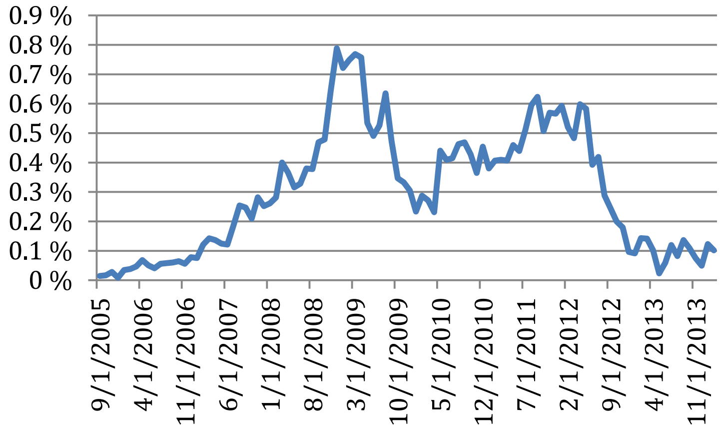


Figure A-1: Aggregate basis series

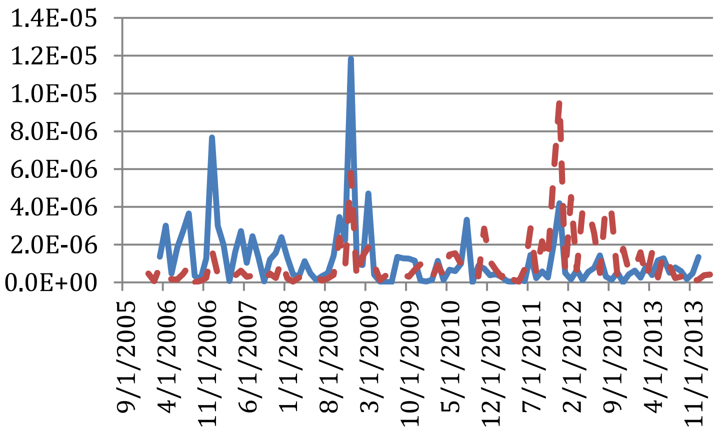
The figure depicts the aggregate basis series defined as the yield difference between a nominal issue and its replicating portfolio following Fleckenstein et al. (2014). The upper panel shows the country-level aggregate series, where Germany is displayed in green jagged, France in solid blue and the Italian series is dotted and red. The aggregation takes places across all maturity-matched bond pairs of a given country. The lower panel shows the average of these three series.

Appendix B

This appendix contains graphs of the different liquidity and credit measures applied in the analysis. Most of these serve as a basis for constructing the principal components that are direct inputs for the risk factors. I also include the graph depicting the time-series dynamics of the sovereign CDS prices.

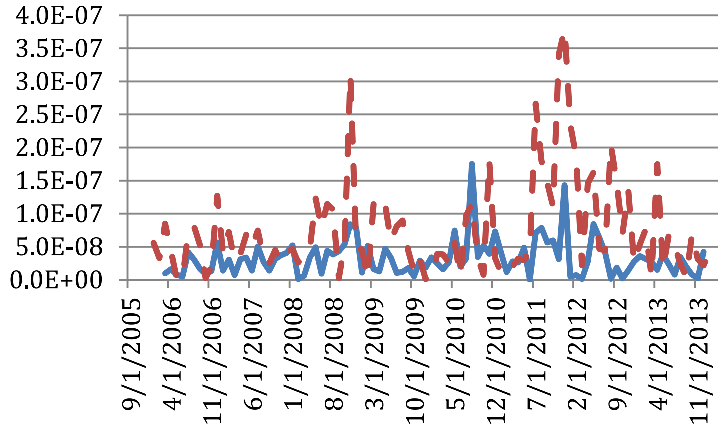


B-1 The KfW spread



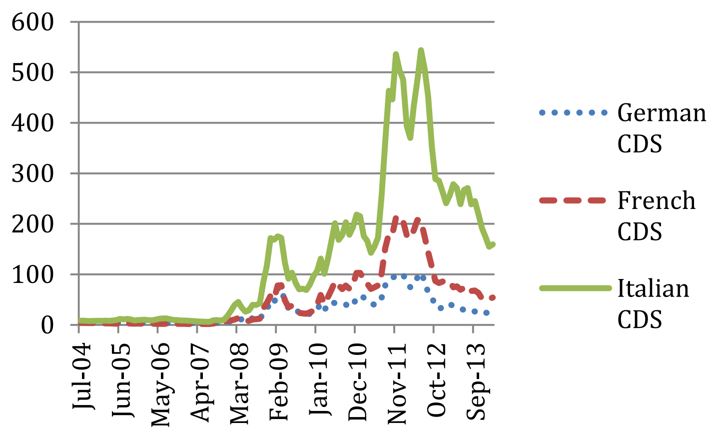
B-2 The ILLIQ measures for the ILB sectors

The figure depicts the time evolution of ILLIQ measures for German (solid line) and Italian (dashed line) ILBs



B-3 The ILLIQ measures for the nominal sectors

The figure depicts the time evolution of ILLIQ measures for German (solid line) and Italian (dashed line) nominal bonds.



B-4 Sovereign CDS spreads

The figure depicts the time evolution of country-level CDS series. The solid line denotes Italy, whereas German and French series are dotted and dashed, respectively.

Table I
Descriptive statistics

The table presents descriptive statistics for variables used in the two-stage estimation. Panel A to C present variables for the analysis of German, French and Italian sovereign bond segments, respectively. All yields are quoted in annualized percentages terms, whereas yield volatility is defined as the difference between the standard deviations of individual issues and the cross-sectional average standard deviation of quoted yields. Age and time-to-maturity are defined relative to the issue and maturity dates and are measured in days; while issued amount captures the size of a given issue in million EUR. Proportion of zero returns is the percentage of days with zero returns over a month. ILLIQ is the monthly ratio of absolute bond market returns over monthly aggregate trading volume, rescaled by 1 million EUR. Yields, volatilities and the zero returns measures are in percentages, age and time-to-maturity are measured in days. The data correspond to the sample period between July 2004 and February 2014.

Panel A: Descriptive statistics of German sovereign bonds

ILBs			Nominal bonds		
	Mean	St. Dev.		Mean	St. Dev.
ILB yield	0.479	0.972	Nominal yield	1.606	1.158
Yield volatility	0.000	0.199	Yield volatility	0.000	0.037
Age	992.5	733.6	Age	2317.0	2351.8
Time-to-maturity	2183.0	1033.1	Time-to-maturity	4219.0	3204.2
Issued amount (million)	€ 13,600	€ 1,498	Issued amount (million)	€ 17,240	€ 4,797
Proportion of zeros	0.407%	1.588%	Proportion of zeros	1.856%	8.331%
ILLIQ	1.176	1.649	ILLIQ	0.033	0.028

Panel B: Descriptive statistics of French sovereign bonds

ILBs			Nominal bonds		
	Mean	St. Dev.		Mean	St. Dev.
ILB yield	1.289	0.946	Nominal yield	2.926	1.272
Yield volatility	0.000	0.123	Yield volatility	0.000	0.039
Age	1694.9	1100.0	Age	2027.3	1788.5
Time-to-maturity	5032.8	3370.9	Time-to-maturity	4483.0	4002.6
Issued amount (million)	€ 11,830	€ 4,532	Issued amount (million)	€ 24,770	€ 7,852
Proportion of zeros	0.240%	1.362%	Proportion of zeros	0.451%	2.037%
ILLIQ	-	-	ILLIQ	-	-

Panel C: Descriptive statistics of Italian ILBs

ILBs			Nominal bonds		
	Mean	St. Dev.		Mean	St. Dev.
ILB yield	3.330	3.124	Nominal yield	4.157	1.270
Yield volatility	0.000	231.155	Yield volatility	0.007	1.576
Age	1137.7	913.1	Age	1899.5	1620.5
Time-to-maturity	3798.0	3100.7	Time-to-maturity	4200.4	2976.3
Issued amount (million)	€ 12,420	€ 3,954	Issued amount (million)	€ 18,900	€ 6,878
Proportion of zeros	0.194%	1.160%	Proportion of zeros	0.576%	4.360%
ILLIQ	1.049	1.475	ILLIQ	0.073	0.073

Table II
Beta estimates

The table presents descriptive statistics for betas estimated from the time-series regression of bond returns on market, illiquidity and credit factors. The table consists of four major segments corresponding to the three countries and the aggregated portfolio betas, henceforth net betas. Panel A contains beta estimates from the ILB and nominal sectors of the German sovereign market, whereas Panel B and C do so for France and Italy, respectively. The forth part, Panel D, presents net betas that serve as a starting point for the breakeven based estimation. I estimated market; illiquidity and credit betas for all available German, French and Italian nominal and inflation-linked bond issues in the sample that spans the period between July 2004 and February 2014.

Panel A: German beta estimates

ILBs	Mean	St. Dev.	Nominal bonds	Mean	St. Dev.
Integrated market β	-0.2307	0.1939	Integrated market β	-0.2812	0.4833
Integrated illiquidity β	0.0002	0.0007	Integrated illiquidity β	-0.0008	0.0020
Integrated credit β	-0.0009	0.0011	Integrated credit β	0.0002	0.0017
Segmented market β	0.2669	0.3134	Segmented market β	0.2190	0.7175
Segmented illiquidity β	-0.0005	0.0003	Segmented illiquidity β	-0.0011	0.0012
Segmented credit β	-0.0011	0.0007	Segmented credit β	-0.0007	0.0010

Panel B: French beta estimates

ILBs	Mean	St. Dev.	Nominal bonds	Mean	St. Dev.
Integrated market β	0.1716	0.3144	Integrated market β	-0.0007	0.4549
Integrated illiquidity β	0.0021	0.0050	Integrated illiquidity β	0.0013	0.0023
Integrated credit β	0.0007	0.0039	Integrated credit β	0.0033	0.0040
Segmented market β	0.3874	0.3303	Segmented market β	0.1729	0.5330
Segmented illiquidity β	0.0038	0.0031	Segmented illiquidity β	0.0025	0.0025
Segmented credit β	0.0004	0.0021	Segmented credit β	0.0029	0.0025

Panel C: Italian beta estimates

ILBs	Mean	St. Dev.	Nominal bonds	Mean	St. Dev.
Integrated market β	0.1696	0.3648	Integrated market β	0.0788	0.3468
Integrated illiquidity β	-0.0048	0.0045	Integrated illiquidity β	-0.0020	0.0048
Integrated credit β	-0.0102	0.0070	Integrated credit β	-0.0055	0.0036
Segmented market β	0.3711	0.4327	Segmented market β	0.0742	0.1231
Segmented illiquidity β	0.0000	0.0027	Segmented illiquidity β	-0.0013	0.0033
Segmented credit β	-0.0073	0.0080	Segmented credit β	-0.0060	0.0039

Panel D: Net beta estimates

Net betas	Mean	St. Dev.
Net market β	-0.2100	0.4505
Net illiquidity β	-0.0005	0.0060
Net credit β	-0.0033	0.0057

Table III
Spread on breakeven regressions: controlling for liquidity

The table reports results from Equation 8, where the effect of liquidity is directly identified from the difference of cross-country breakeven rates. The dependent variable is the spread on breakeven rates across two countries, whereas the net betas are constructed as a portfolio of individual bond betas from the market-level Fama-MacBeth regressions. Size of issue is measured as the natural logarithm of the amount issued, while age and time-to-maturity are defined relative to the issue and maturity dates, respectively. Displayed coefficients are average figures from the monthly repeated cross-sectional regressions, where errors are adjusted for averaging and include a 12-lag Newey-West correction. The sample period is July 2004 until February 2014. Absolute values of the t-statistics are given in parentheses and *, **, and *** denote significance at the 10%, 5%, and 1% level.

	(1)	(2)	(3)	(4)	(5)
Net illiquidity beta	-69.7724	-70.4573	-73.3500	-77.4821	-44.7348
	(2.05)**	(2.02)**	(2.20)**	(2.32)**	(1.49)
Size of issue		-0.1442			
		(2.56)**			
Age of issue			0.0211		
			(3.51)***		
Time-to-maturity				0.0351	
				(3.58)***	
Net market beta					0.9656
					(3.73)***
Constant	-0.3012	-0.4596	-0.4627	0.1011	-0.1475
	(5.32)***	(5.18)***	(6.19)***	(0.74)	(2.00)**
R^2	0.32	0.57	0.58	0.5	0.47
N	866	866	842	842	866

Table IV

Spread on breakeven regressions: controlling for liquidity and sovereign risk

The table reports results from Equation 10, where liquidity and credit effect are directly identified from the difference of cross-country breakeven rates. The dependent variable is the spread on breakeven rates across two countries, whereas the net betas are constructed as a portfolio of individual bond betas from the market-level Fama-MacBeth regressions. Size of issue is measured as the natural logarithm of the amount issued, while age and time-to-maturity are defined relative to the issue and maturity dates, respectively. Displayed coefficients are average figures from the monthly repeated cross-sectional regressions, where errors are adjusted for averaging and include a 12-lag Newey-West correction. The sample period is July 2004 until February 2014. Absolute values of the t-statistics are given in parentheses and *, **, and *** denote significance at the 10%, 5%, and 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)
Net illiquidity beta	-74.6564	8.0222	36.2303	5.1340	-0.2715	-2.6492
	(2.04)**	(0.36)	(1.52)	(0.31)	(0.01)	(0.1)
Net credit beta		-126.0375	-142.9042	-115.0918	-109.5895	-130.7344
		(5.40)***	(5.02)***	(3.89)***	(7.93)***	(4.52)***
Size of issue			-0.082766			
			(1.4)			
Age of issue				0.0137		
				(2.82)***		
Time-to-maturity					0.0039	
					(0.56)	
Net market beta						-0.5654
						(1.2)
Constant	-0.2922	-0.5114	-0.5753	-0.5759	-0.4790	-0.5339
	(5.72)***	(5.40)***	(8.33)***	(7.10)***	(4.21)***	(4.59)***
R^2	0.31	0.57	0.79	0.79	0.64	0.7
N	866	866	866	842	842	866

Table V
Risk-adjusted breakeven spreads

This table presents descriptive statistics the risk-adjusted spreads on breakeven series presented in Figure 5. I apply two adjustments, as in Equation 2, I first only take out the effect of liquidity, and then following Equation 3, I also exclude credit risk premium. All figures are denominated in percentage yields. Panel A reports the average series across pairs for a given country pairing; whereas Panel B presents liquidity risk adjusted breakeven rates. Panel C also takes out the effect of credit risk. The data correspond to 6 pairs formulated between Germany and Italy, 5 pairs between Germany and France and 9 pairs from Italy and France in the sample period between July 2004 and February 2014.

Panel A: Average breakeven spreads

	Mean	St. Dev.	Min	Max
Germany vs. France	-0.360	0.287	-1.027	0.259
Germany vs. Italy	0.233	1.077	-0.666	4.009
Italy vs. France	-0.290	0.533	-2.727	0.240
Eurozone average	-0.183	0.276	-0.762	0.902

Panel B: Liquidity risk-adjusted breakeven spreads

	Mean	St. Dev.	Min	Max
Germany vs. France	-0.147	0.288	-0.806	0.478
Germany vs. Italy	0.181	1.081	-0.761	3.956
Italy vs. France	-0.028	0.521	-2.417	0.545
Eurozone average	0.013	0.280	-0.522	1.078

Panel C: Liquidity and credit risk adjusted breakeven spreads

	Mean	St. Dev.	Min	Max
Germany vs. France	-1.873	0.264	-2.367	-1.361
Germany vs. Italy	-6.453	1.139	-7.774	-3.475
Italy vs. France	2.788	4.594	-4.993	7.569
Eurozone average	-0.949	2.031	-4.991	1.573

Table VI
Liquidity risk in pooled and integrated markets

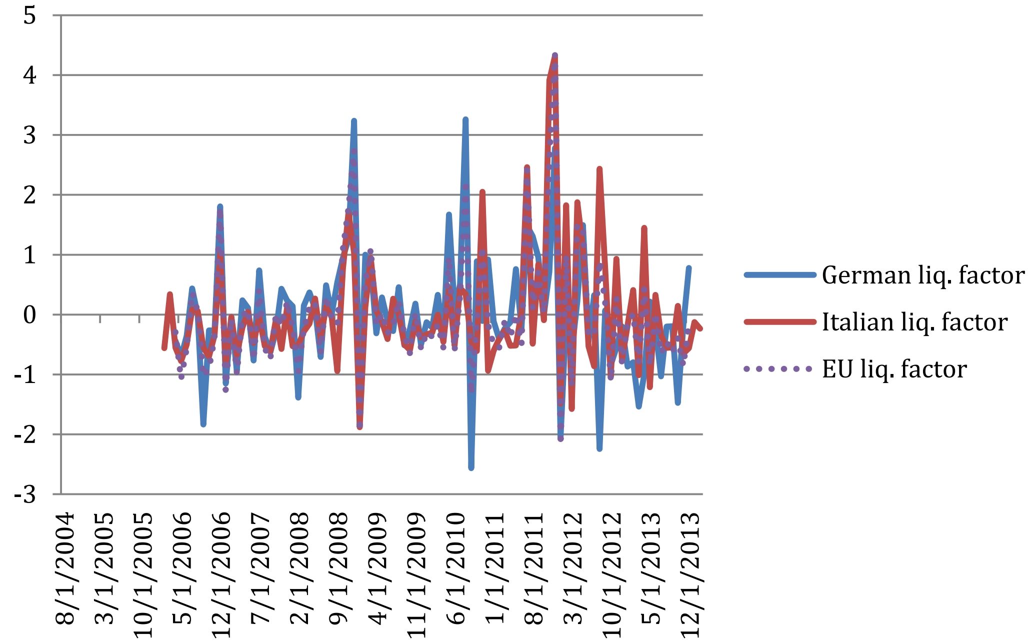
This table reports pooled estimates from the second step of the Fama-MacBeth regressions with Eurozone-level risk factors. Therefore, the market factor is an equally-weighted average of all bonds across the three countries. Unlike in previous tables, this table presents regressions with bonds pooled together to estimate the effects of risk exposures. The dependent variables are the respective bond yields, and betas are estimated in the first step of the procedure as the loading on the common market factor and the illiquidity risk factors. I use the natural logarithm of the original issued amounts to capture the size of an issue. The average effect reported is the product of the estimated risk premium and the mean exposure to the specific risk factor. The calculated economic impact is defined as the interquartile spread – coefficient times the difference between the betas that correspond to the first and third quartile in the cross-section of betas. Displayed coefficients are average figures from the monthly repeated cross-sectional regressions where errors are adjusted for averaging and include a 12-lag Newey-West correction. The sample period is July 2004 until February 2014. Absolute values of the t-statistics are given in parentheses and *, **, and *** denote significance at the 10%, 5%, and 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Integrated mkt. beta	2.1523	2.3344	2.3482	2.4097	2.5539	2.419	2.499
	(7.72)***	(10.21)***	(10.24)***	(10.58)***	(10.67)***	(10.66)***	(9.88)***
Eurozone illiq. beta		83.0767	87.0536	54.9343	57.8322	54.9999	56.419
		(2.00)**	(2.03)**	(1.54)	(1.67)*	(1.46)	(1.55)
Size of issue			-0.0585			0.0254	0.0243
			(2.33)**			(0.66)	(0.64)
Age				0.0261		0.0272	0.0286
				(5.52)***		(5.44)***	(5.73)***
Time-to-maturity					-0.0064		-0.0081
					(0.99)		(1.26)
Constant	3.0461	3.0158	4.3894	2.9254	3.1183	2.3096	2.4084
	(18.02)***	(17.63)***	(6.69)***	(15.85)***	(16.54)***	(2.36)**	(2.64)***
R^2	0.31	0.44	0.45	0.44	0.44	0.44	0.45
N	10,894	10,894	10,894	9,600	9,620	9,600	9,600
Avg. effect of illiq.	-	*-0.0714*	*-0.0748*	*-0.0472*	*-0.0497*	*-0.0473*	*0.0485*
Impact of illiq. risk	-	*0.2590*	*0.2714*	*0.1713*	*0.1803*	*0.1715*	*0.1759*
Avg. effect of mkt. risk	*0.0170*	*0.0184*	*0.0185*	*0.0190*	*0.0202*	*0.0191*	*0.0197*
Impact of mkt. risk	*1.2697*	*1.3771*	*1.3852*	*1.4215*	*1.5066*	*1.4270*	*1.4742*

Table VII
Liquidity and credit risks in pooled and integrated markets

This table reports pooled estimates from the second step of the Fama-MacBeth regressions with Eurozone-level risk factors. Therefore, the market factor is an equally-weighted average of all bonds across the three countries. Unlike in previous tables, this table presents regressions with bonds pooled together to estimate the effects of risk exposures. The dependent variables are the respective bond yields, and betas are estimated in the first step of the procedure as the loading on the common market factor, illiquidity risk and credit risk factors. I use the natural logarithm of the original issued amounts to capture the size of an issue. The average effect reported is the product of the estimated risk premium and the mean exposure to the specific risk factor. The calculated economic impact is defined as the interquartile spread – coefficient times the difference between the betas that correspond to the first and third quartile in the cross-section of betas. Displayed coefficients are average figures from the monthly repeated cross-sectional regressions where errors are adjusted for averaging and include a 12-lag Newey-West correction. The sample period is July 2004 until February 2014. Absolute values of the t-statistics are given in parentheses and *, **, and *** denote significance at the 10%, 5%, and 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Integrated mkt. beta	2.2425	2.2411	1.9554	1.9661	1.9107	2.1056	1.9194	2.0531
	(9.19)***	(9.06)***	(7.49)***	(7.48)***	(6.41)***	(7.61)***	(6.49)***	(6.97)***
Eurozone illiq. beta		105.8911	214.6902	220.2507	198.7834	206.9699	205.5075	218.9859
		(2.01)**	(4.23)***	(4.14)***	(4.10)***	(4.14)***	(3.90)***	(3.83)***
Eurozone credit beta			-106.0974	-106.7479	-122.7884	-125.1224	-124.764	-127.2105
			(4.47)***	(4.43)***	(6.27)***	(6.91)***	(6.29)***	(6.90)***
Size of issue				-0.0359			0.0124	0.0008
				(0.89)			(0.23)	(0.01)
Age					0.0197		0.0188	0.0179
					(3.97)***		(2.98)***	(2.59)**
Time-to-maturity						-0.0069		-0.0095
						(1.63)		(2.28)**
Constant	3.0914	3.0224	2.8477	3.6843	2.7604	2.9486	2.4509	2.8414
	(18.86)***	(18.61)***	(17.34)***	(3.57)***	(15.37)***	(15.54)***	(1.76)*	(1.97)*
R^2	0.29	0.43	0.54	0.55	0.56	0.57	0.57	0.58
N	10,894	10,894	10,894	10,894	9,600	9,620	9,600	9,600
Avg. effect of illiq.	-	*-0.0805*	*-0.1631*	*-0.1674*	*-0.1510*	*-0.1573*	*-0.1562*	*-0.1664*
Impact of illiq. risk	-	*0.2752*	*0.5580*	*0.5724*	*0.5166*	*0.5379*	*0.5341*	*0.5691*
Avg. effect of cr. risk	-	-	*0.1735*	*0.1746*	*0.2008*	*0.2046*	*0.2040*	*0.2080*
Impact of credit risk	-	-	*-0.6738*	*-0.6780*	*-0.7798*	*-0.7947*	*-0.7924*	*-0.8079*
Avg. effect of mkt. risk	*-0.0485*	*-0.0485*	*-0.0423*	*-0.0425*	*-0.0413*	*-0.0455*	*-0.0415*	*-0.0444*
Impact of market risk	*1.2795*	*1.2787*	*1.1157*	*1.1218*	*1.0902*	*1.2014*	*1.0951*	*1.1714*



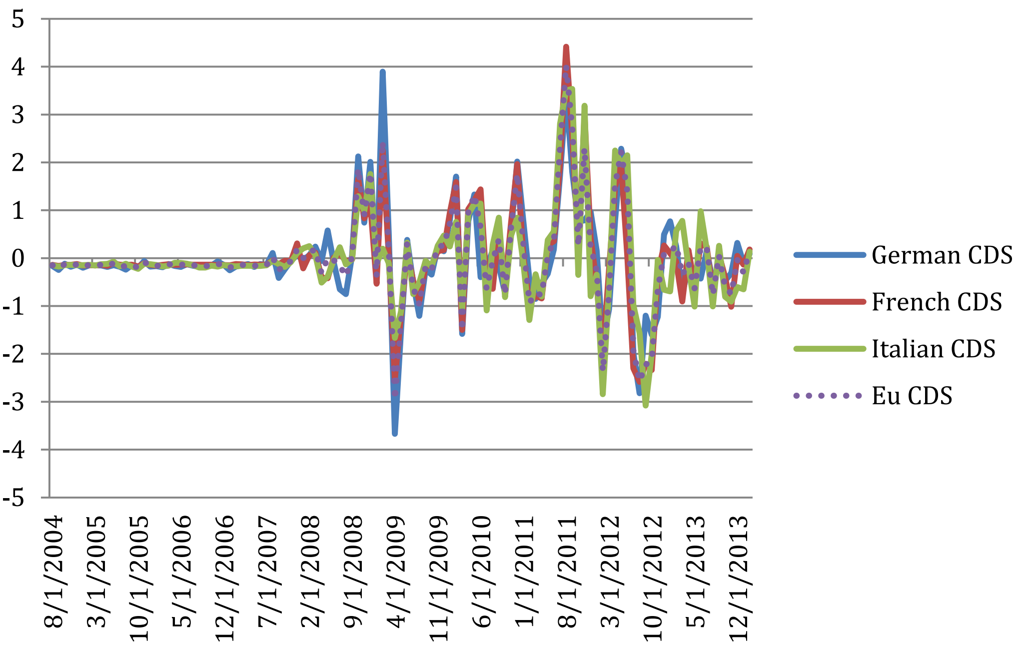


Figure 1: The illiquidity and credit risk factors

The figure depicts the risk factors: the upper panel shows the illiquidity, whereas the lower panel the credit factors, respectively. Country as well as the integrated Eurozone factors are presented. The latter is called the EU factor and is denoted by the dotted line. These factors are calculated as the standardized residuals from autoregressive processes imposed on the underlying liquidity and credit risk measures.

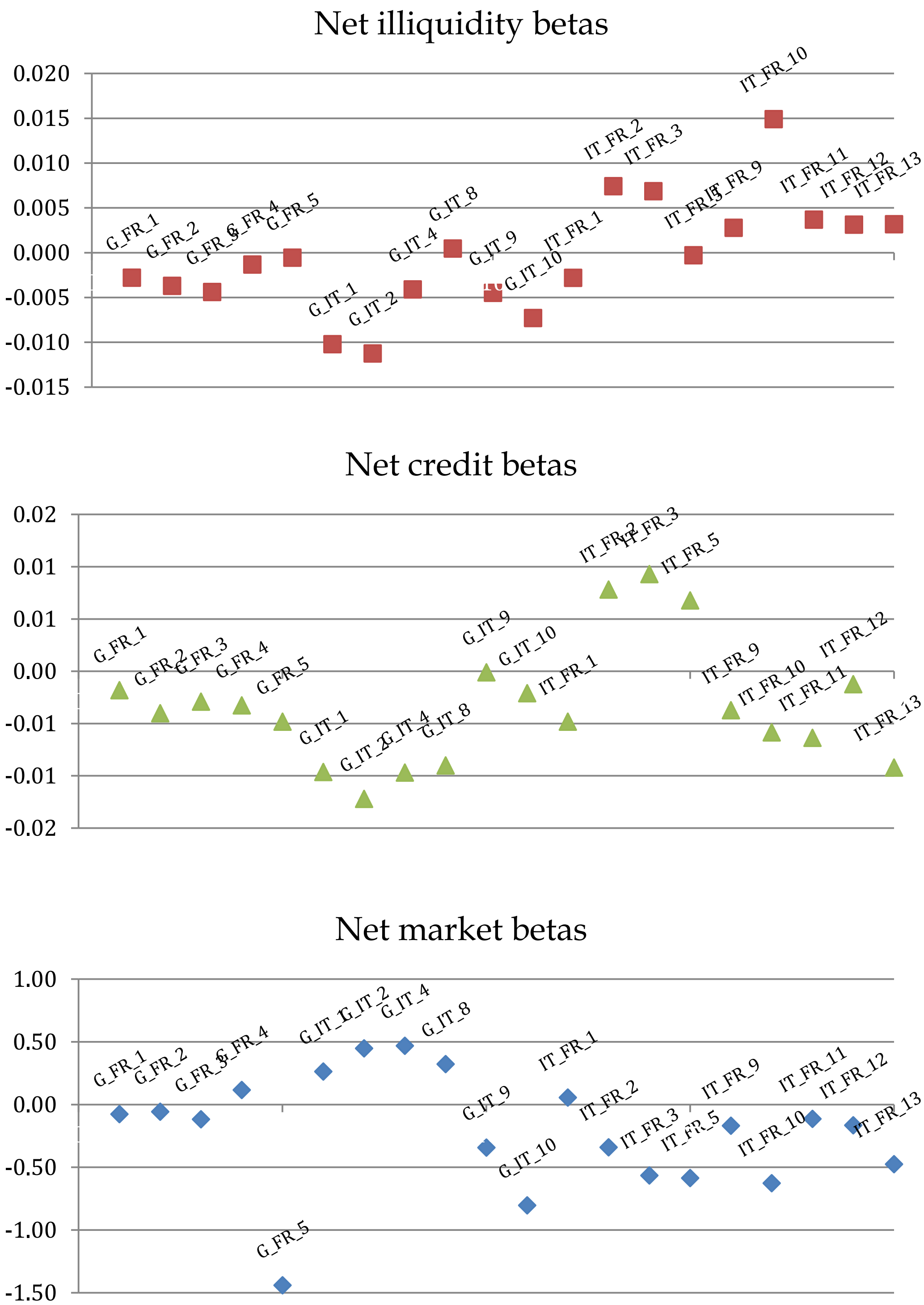


Figure 2: Net betas

The figure depicts the net betas following Equation 15. Net betas are essentially a portfolio of integrated betas of the four bonds constituting the spread-on-basis series. The upper panel shows the net illiquidity, the middle the net credit, whereas the lower panel the net market betas of the 20 spreads available in the sample. Labels indicate the pair of bases to which the individual betas correspond.

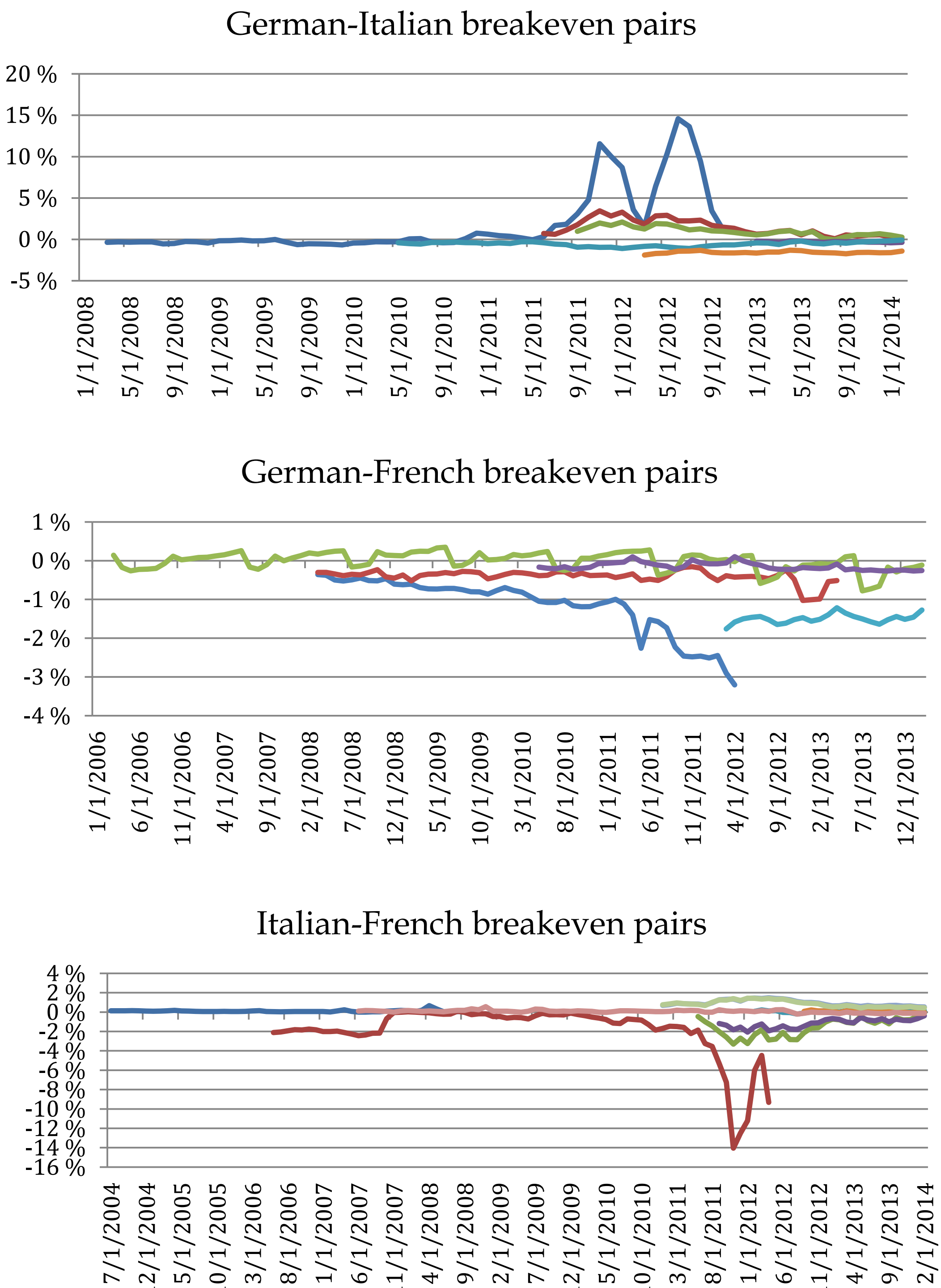
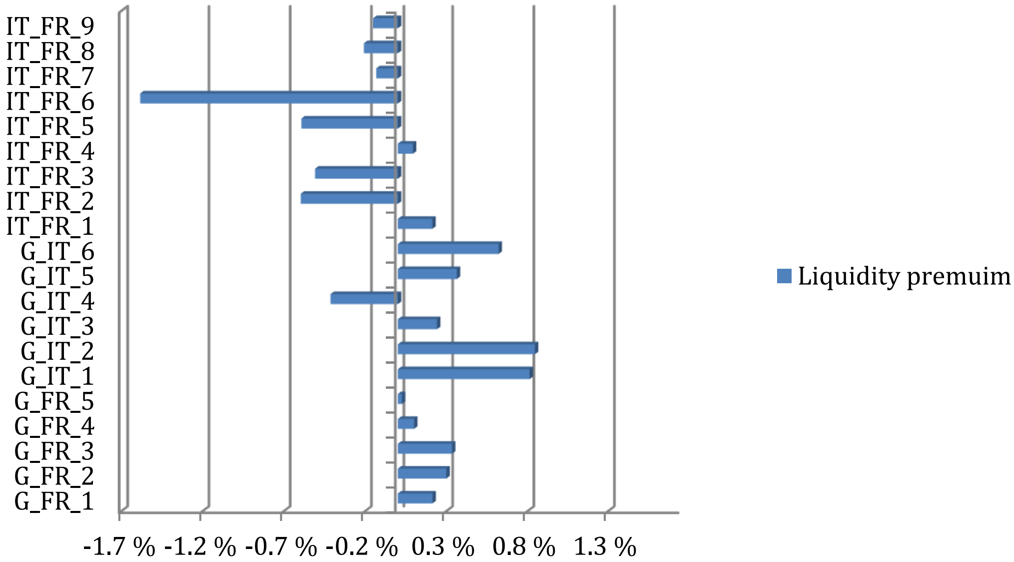


Figure 3: Spread on breakeven series

The figure depicts the percentage difference between two maturity-matched breakeven rates from different countries. In total there are twenty of such pairs: 6 pairs formulated between Germany and Italy (upper panel), 5 pairs between Germany and France (middle panel) and 9 pairs from Italy and France (lower panel).



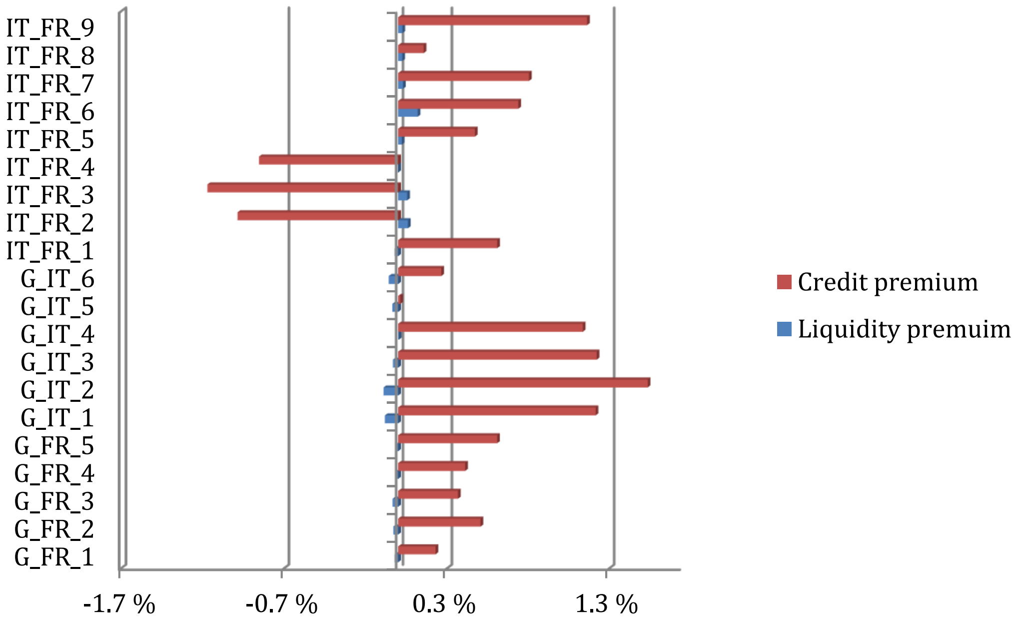


Figure 4: Risk premia identified in the breakeven spreads

The figure depicts the size of percentage yield risk premia identified from spreads of cross-country breakeven pairs. The respective risk premium is the product of a certain pair's net beta and the market price of risk estimated from the cross-section of strategies. The upper panel shows estimates based on the first column of Table III, whereas the lower panel considers estimates from column 2 of Table IV.

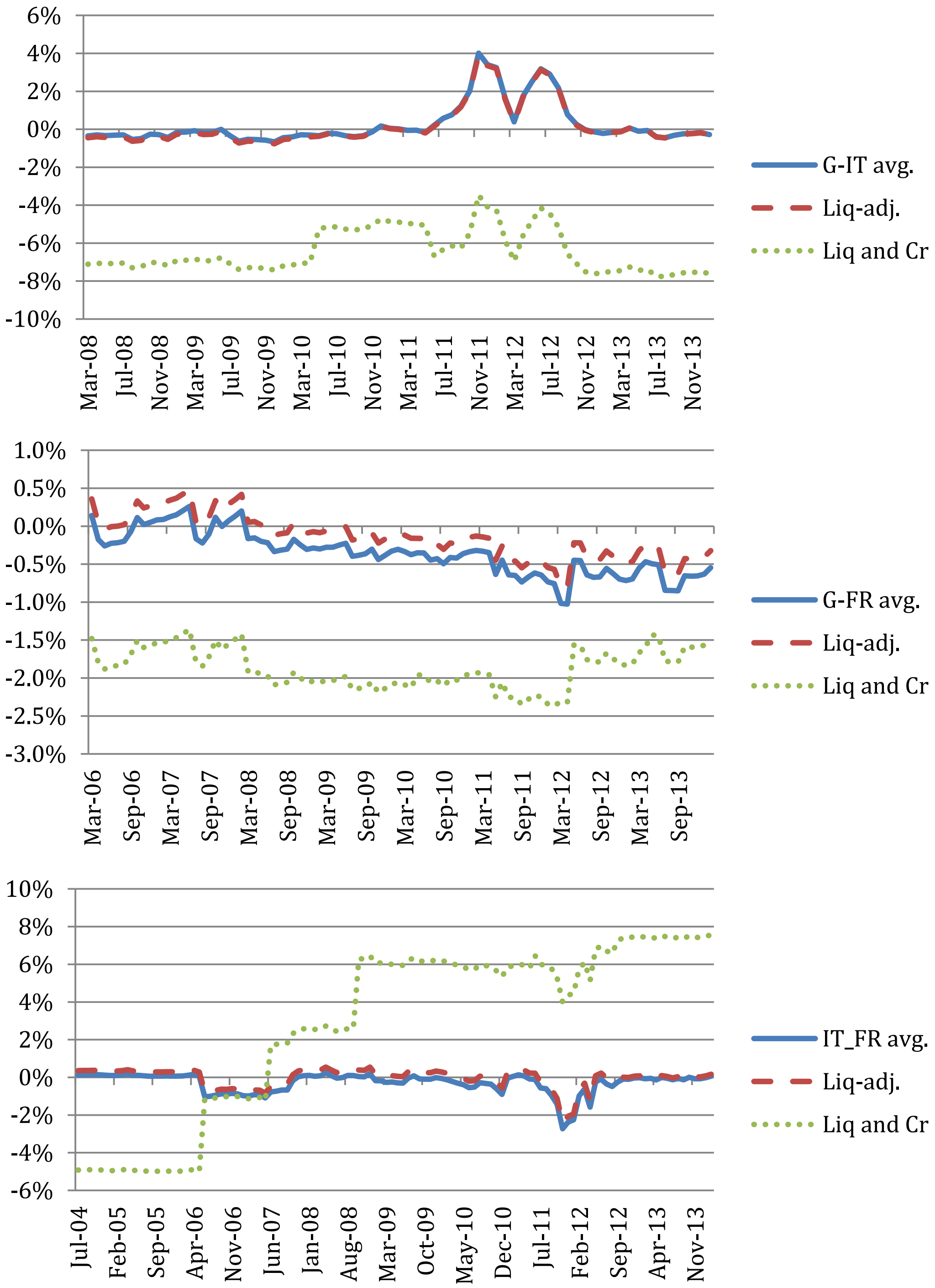


Figure 5: Risk-adjusted breakeven spreads

The figure depicts the risk-adjusted cross-country breakeven spreads: taking the effect of liquidity, or liquidity and credit premia out of the series. Solid lines denote the unadjusted, dashed the liquidity-adjusted, and dotted lines indicate series that are adjusted by the sum of liquidity and credit effects. The upper panel shows pairs from Germany and Italy, whereas the middle and lower panels depict German-French and French-Italian pairs, respectively.