Decomposing and Pricing Corporate Bond Yields

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Abstract: The main results of this paper are summarized as follows. First, we propose a new extended Fama-French model based on yield curve information. To the best of our knowledge, this is the first paper that proposes the corporate bond pricing model that considers simultaneously interest rate, credit, and illiquidity factors together with three main characteristics of yield curve (level, steepness and concavity) by extending Fama-French 2 factor model. Second, we show the importance of "net credit risk factor" in the determination of yield spreads of corporate bonds and the under-estimation problem of illiquidity premium (over-estimation of credit premium) that has been overlooked by current literature. Third, we find that each factor of bond yields responds differently according to the source of financial shocks by examining the impact (performance decomposition) of each factor on bond yield spreads. Fourth, we find that new extracted variables are important risk factors in explaining yield spreads of corporate bonds. Fifth, we find that there exists a non-linear relation between bond yields and betas. Sixth, we find that the relationship between credit and illiquidity is different depending on the economic situations and it is essential and crucial to measure and manage risk separately by the risk factors that we discover in the paper. Lastly, we find that liquidity black holes arise in the beginning of the financial crisis when uncertainty prevails and show that financial markets became unstable suddenly since self-stabilizing mechanism of bond markets did not work appropriately due to the liquidity preference of investors in the global financial crisis.

***Keywords*:** Analytic decomposition method, Net credit, Liquidity risk, Yield curve information, Flight-to-liquidity, Flight-to-quality

***JEL Classification*:** G12, G14

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1 Introduction

Liquidity in financial markets has attracted a great attention after Fisher (1959) found that corporate bond yields reflect not only default risk but also liquidity premium and Amihud and Mendelson (1986) incorporated liquidity effect in asset pricing. Since the global financial crisis started in 2007, recognizing the importance of liquidity risk management for well-functioning financial markets, Basel Committee on Banking Supervision announced new basic principles strengthening liquidity risk management for banks in 2008. International Accounting Standards Board (IASB) also announced a revised public draft for Phase II of IFRS4 that requires insurance companies to use discount rates that reflect liquidity risk in measuring fair values of insurance liabilities (IASB, 2013). Consequently, liquidity has become a more important subject for policy establishments that stabilize financial systems, risk management, asset allocation and profit management, and policy makers, financial institutions such as banks and insurance companies, and related institutions become more interested in finding the ways of managing liquidity risk more effectively while complying with the related regulations.

The word of liquidity has many dimensions and meanings[1] but we use liquidity as indicating market liquidity in the paper. Prior studies on liquidity have focused mainly on equity markets (Amihud et al., 2006) and there have been a few studies on liquidity related with bond markets. Amato and Remolona (2003) initiated a study on bond liquidity to explain credit spread puzzle most of which can be explained by incorporating illiquidity premium additionally into bond pricing model, which have been shown by subsequent research (Driessen, 2005; Longstaff et al., 2005; Chen et al., 2007; De Jong and Driessen, 2012, etc.)

The objectives of this study are as follows. First, we attempt to extract factors that determine excess bond returns defined as corporate bond returns minus risk-free rates by decomposing corporate bond yields in an analytic way (we will call it analytic decomposition method). Second, we examine whether extracted factors may explain corporate bond spreads better than Fama-French two factor models (1993) and also investigate meanings and characteristics of the information that each extracted factor possesses. Third, we examine whether illiquidity factor may be a risk price for determining corporate bond spreads. Lastly, we use our model to analyze roles and contributions of each extracted

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1 According to Foucault et al. (2013), liquidity has three dimensions. First, it means market liquidity which indicates the ability to trade a security quickly at a price close to its consensus value. Second, liquidity also indicates having enough cash or the ability to obtain credit at acceptable terms to meet obligations without incurring large losses, which is called funding liquidity. Third, In practice, liquidity is often identified with money itself, whether defined as the cash held by households and firms and bank reserves("monetary base"), or as broader monetary aggregates that also include bank deposits of various types (M1, M2, M3), which is monetary liquidity.

factor under different economic circumstances. More specifically, we examine how the risk factors such as credit and illiquidity affect corporate bond spreads differently, depending on whether during financial crisis period or after financial crisis. We consider two financial crises of global financial crisis and European national debt crisis occurring in late 2000s.

Our paper contributes to the current literature of corporate bond pricing. To the best of our knowledge, this is the first attempt to apply an analytic factor decomposition method to corporate bond pricing. We extend Fama-French two factors model by extracting an illiquidity factor implied in corporate bond yields and reflecting yield curve information, which makes it possible for us to take the determinants of corporate bond yields into account consistently and systematically.

Many research on the US and European bond markets have used bid-ask spread or trading volume data for liquidity measures (Roll, 1984; Amihud, 2002; Pastor and Stambaugh, 2003; Bekaert et al., 2007). In this paper, as a market liquidity measure for corporate bond pricing, we use KfW (Kreditanstalt fur Wiederaufbau) spread which is a difference in yields between German government bonds and KfW agency bonds, because two maturity-matched bonds share an identical credit guarantee from the German government but differ in liquidity. Schwarz (2015) argues that KfW spread is entirely free from credit influences and that it captures all effects of market liquidity, including the forward-looking concept of liquidity risk. Schuster and Uhrig-Homburg (2015) also argues that the measure includes risk premium and expectations of market in addition to the severeness of frictions.

The remainder of this paper is structured as follows. Section 2 briefly reviews the relevant literature. Section 3 describes the main characteristics of our data and derives extended Fama-French model based on yield curve information. Section 4 and 5 report time series regression and cross-sectional regression, respectively. Section 6 analyzes the relation between credit and illiquidity. Section 7 summarizes our main findings and concludes the paper.

2 Related Literature

2.1 Fama-French Models alike

We call the multi-factor models that have attempted to explain corporate bond spreads after Fama and French (1993) found that term spread and credit spread together explain over 90% of corporate bond spreads as Fama-French models alike. Among them, Gebhardt et al. (2005) introduce bond characteristic variables such as remaining maturity and credit ratings in addition to the two factors that Fama and French consider, and Houweling et al. (2005) analyze the liquidity of bond markets using Gebhardt et al.’s model. Lin et al. (2011) add a liquidity factor to the Fama-French five factors(equity premium, size, book-to-market ratio, term spread and credit spread) and find that liquidity risk is an important determinant of corporate bond spreads and flight-to-quality phenomena occur during the recession of business cycle. Acharya et al. (2013) analyze the effect of liquidity shocks on asset prices using a regime switching model and find that the effect is conditional in that it is stronger during recessions.

2.2 Illiquidity Premium of Corporate Bonds

Prior studies regarding the estimation of illiquidity premium of corporate bonds are classified into three approaches; market microstructure approach, structural model approach and no arbitrage approach. According to market microstructure approach, information risk arising from asymmetric information, time change and liquidity discrepancy among firms affect long-term equilibrium prices. The central issue in the empirical studies of market microstructure is how to specify a right liquidity measure (Roll, 1984; Amihud, 2002; Pastor and Stambaugh, 2003; Bekaert et al., 2007). Dick-Nielsen et al. (2009), Lin et al. (2011) and De Jong and Driessen (2012) are the examples of this approach. Structural model approach estimates illiquidity premium by subtracting bond yields estimated from the structural models like Merton model from bond yields observed in the markets (Webber, 2007). According to no arbitrage approach, illiquidity premium is regarded as the difference in bond yields of the identical bonds in terms of quality of credit, maturity, tax, and collateral. Examples of illiquidity premium of this approach are spreads between T-Notes and T-bills, spreads between off-the-run and on-the-run, CDS negative spreads, covered bond spreads, and spreads between government bonds and government-guaranteed agency bonds.

Longstaff (2004) provides a test of the effect of liquidity on bond yields by using the spreads in yields between U. S. Treasury bonds and bonds issued by the Resolution Funding Corporation (Refcorp), a government agency and finds that the average yield premium on Refcorp bonds ranges from 10 to 16 basis points being statistically significant and the illiquidity premium reacts to varying market conditions (flight-to-liquidity). Schwarz (2015) proposes new market liquidity measure of KfW spreads and new interbank credit measure of Bank Tiering spreads and finds that her measures can explain changes in interbank and sovereign bond spreads very well and illiquidity drives spread changes 1.5 to 3 times more than credit. She also argues that KfW spread measure captures all effects of market liquidity because it reflects both current and future transaction costs expected by investors whereas traditional measures of market liquidity, such as bid-ask spreads, reflect only current transaction costs. Schuster and Uhrig-Homburg (2015) estimate term structure of illiquidity premium using a two-regime Markov switching AR model and find that the illiquidity premium calculated from KfW spreads is related to intermediaries' capital and foreign flows only in the stress regime and is a priced risk factor. Monfort (2014) analyzes the joint dynamics of credit and liquidity that constitutes bond yield spreads though modelling a regime-switching affine term structure model and finds that KfW spreads can explain the liquidity of bond markets.

3 Data and Methodology

3.1 Data

European corporate bond indices used in our paper are 23 rating and maturity class broad Markit iBoxx EUR Corporate bond indices.[2] Eight of the indices are composite indices for 3 different credit ratings (Corporates AA, A, BBB) and 5 different maturities (Corporates 1-3, 3-5, 5-7, 7-10, 10+).

Following the bond liquidity literature, we use a bond's yield to maturity rather than the bond's realized return as proxy for its expected return because yields are forward-looking, while realized returns are backward-looking (Longstaff, 2005; Houweling et al., 2005; Chen et al., 2007; Ilmanen, 2011). Bond index returns are the weighted average of individual bond returns generated by Markit Group Limited. Our sample covers the period from January 2003 to August 2015. The reason that we cover the period for the sample is that Markit iBoxx EUR Corporate indices were launched on 18 April 2001 and its rating and maturity indices are available since 2002.

We use the zero coupon rates of Bunds and KfW with the same modified durations[3] as those of corporate bond indices. We use duration-matching returns rather than maturity-matching returns because differences in returns can occur when the coupons of maturity-matching Bunds and KfWs are not the same. We apply the Svensson method to estimate zero yield curves for Bunds and KfWs, which have been adopted by the central banks of the U. S. and many European countries including Germany. To improve the flexibility of the curves and the fit, Svensson (1994) extended Nelson and Siegel's function by adding a further term that allows for a second hump.

We collect issue and price information of corporate bonds from Bloomberg to estimate zero yield curves and maintain the consistency of data by abiding by the same bond selection rules as those of Markit iBoxx EUR Corporates indices. For the durations of corporate bond indices, we use the data generated by Markit Group Limited.

Table 1 provides descriptive statistics for the sample bond indices. The duration of corporate composite bond indices is 4.39 years and the durations of rating indices are in the range of 4.14～4.53 years, indicating the differences in duration due to the rating classes are not big. The mean yield spread of corporate composite bond indices is 2.34% and the mean yield spreads of rating and

[2] Refer to Markit (2015) for bond selection rules and index calculations of Markit iBoxx EUR Corporate indices.
[3] We will call modified duration simply as duration in the paper.

maturity class corporate bond indices increase consistently as the duration gets longer or the credit rating goes lower.

[Table 1 here]

3.2 Methodology

3.2.1 Analytic Factor Decomposition Method

Yield curve relationships are generally analyzed from three perspectives- bond yields, forward rates and expected returns and each perspective contains the information on short term rates plus risk premiums (Cochrane and Piazzesi, 2009). We analyze yield curve relationships based on Fama-French 2 factor model from the perspective of bond yields. As you can see in equation (1), corporate bond yields are composed of short term rates[4] and risk premiums, and risk premiums are also decomposed into yield spread of long term corporate bonds (*DEF)*, term spread of risk-free rates (*TERM*) and yield spread between individual corporate bonds and long term corporate bonds.[5] From equation (1), we know that $-(Y_{i,l} - Y_i)$ term (the difference in yields of individual corporate bonds and long term corporate bonds) appears, which was not mentioned in Fama-French 2 factor model.

$$Y_i = Y_{f,s} + (Y_{i,l} - Y_{f,l}) + (Y_{f,l} - Y_{f,s}) - (Y_{i,l} - Y_i), \quad (1)$$

where Y_i is corporate bond i's yield, $Y_{f,s}$ is short term risk-free rate, $Y_{f,l}$ is long term risk-free rate, and $Y_{i,l}$ is long term corporate bond yield.

Using Figure 1, we can explain the meaning of the term $-(Y_{i,l} - Y_i)$. If we denote Y_i^{LI} the yield with the same maturity as that of corporate bond i, a linear interpolation of long term and short term corporate bond yields, then $-(Y_{i,l} - Y_i)$ can be expressed as the difference between Y_i-Y_i^{LI} and $Y_{i,l} - Y_i^{LI}$.

[Figure 1 here.]

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4 The bill rate is meant to proxy for the general level of expected returns on bonds, so that TERM proxies for the deviation of long-term bond returns from expected returns due to shifts in interest rates (Fama and French, 1993, p.7). The level of interest rate can be measured by any maturity yield on the yield curve and the information contained in yield is identical regardless of its maturity (Duffie, 1998, p.2228).

5 Arbitrage opportunity cannot arise only if long term rates are the average of risk-adjusted short term rates.

As you can see in equation (2), applying the property of similar right triangles[6] to the term $-(Y_{i,l} - Y_i)$, it turns out that it contains the information on the steepness factor and the concavity factor.

$$
\begin{aligned}
Y_i &= Y_{f,s} + (Y_{i,l} - Y_{f,l}) + (Y_{f,l} - Y_{f,s}) - \{(Y_{i,l} - Y_i^{LI}) - (Y_i - Y_i^{LI})\} \\
&= Y_{f,s} + (Y_{i,l} - Y_{f,l}) + (Y_{f,l} - Y_{f,s}) \\
&\quad - \left[\begin{array}{l} \frac{D_{i,l} - D_i}{D_{i,l} - D_{i,s}} \{(Y_{f,l} - Y_{f,s}) + (Y_{i,l} - Y_{f,l}) - (Y_{i,s} - Y_{f,s})\} \\ -(Y_{f,i} - Y_{f,i}^{LI}) - \{(Y_i - Y_{f,i}) - (Y_i^{LI} - Y_{f,i}^{LI})\} \end{array} \right] \\
&= Y_{f,s} + (Y_{i,l} - Y_{f,l}) \\
&\quad + \left(1 - \frac{D_{i,l} - D_i}{D_{i,l} - D_{i,s}}\right)(Y_{f,l} - Y_{f,s}) - \frac{D_{i,l} - D_i}{D_{i,l} - D_{i,s}} \{(Y_{i,l} - Y_{f,l}) - (Y_{i,s} - Y_{f,s})\} \\
&\quad + (Y_{f,i} - Y_{f,i}^{LI}) + \{(Y_i - Y_{f,i}) - (Y_i^{LI} - Y_{f,i}^{LI})\},
\end{aligned} \tag{2}
$$

where Y_i, $Y_{f,s}$ $Y_{f,l}$, $Y_{i,l}$ and Y^{LI} are the same as were defined in the above, *D* is bond duration, and $Y_{f,i}$ are zero coupon rates of German government bonds with the same duration as that of corporate bond *i*.

Equation (2) tells us that corporate bond yields can be decomposed into 4 factors; short term risk-free rate factor plus 3 factors of the term structure of yield spreads such as level factor, steepness factor, and concavity factor. Although our result looks similar to Litterman and Scheinkman (1991)'s which shows that three factors-level, steepness and concavity determine bond yields by principal component analysis, we claim that our approach is different from them because we decompose corporate bond yield spreads into short term risk-free rates and each yield curve factor much more clearly and intuitively. We also claim that our model not only can explain corporate yield spreads better than the existing models but also reduce measurement errors because our model incorporates "missing factor" of corporate bond yields that have not been considered in Fama-French 2 factor models alike and because it reflects the characteristics of bond yield curves in more systematic ways.

Since government bonds are more liquid than corporate bonds, yield spreads between them with the same maturities generally include liquidity factor as well as credit factor. Thus, we argue that *DEF* factor of Fama-French 2 factor model can be regarded as "gross credit factor" which includes not only credit factor but also liquidity factor and that we should consider "net credit factor" which is calculated by subtracting liquidity factor from *DEF* factor to measure credit risk premium more accurately and specify more exact relations between credit risk and liquidity risk. In the similar vein,

6 It is known that ancient Greek philosopher Thales was able to measure the height of King Khufu's pyramid that is known to be the tallest in Egypt using the property of similar right triangle.

Longstaff et al. (2005, p 2223) claim that the Refcorp curve may provide a more accurate measure of the riskless curve than the Treasury curve since Refcorp bonds have the same default risk as Treasury bonds, but not the same liquidity of Treasury bonds.

If we decompose yield spreads between corporate bonds and government bonds using KfW bonds, as in equation (3), corporate bond yields are determined by the three term structure factors (level, steepness, and concavity) of risk-free rate, net credit and illiquidity. KfW spread can be regarded as common factor of illiquidity since it is illiquidity factor for Bund (Monfort, 2014; Schwarz, 2015; Schuster and Uhrig-Homburg, 2015). Advantages of decomposing yield spreads based on KfW bonds are two-fold. First, we can reflect net credit factor and illiquidity factor systematically according to the term structure theory of interest rates. Second, it is more convenient to estimate illiquidity term structure of bonds when we use KfW spreads as illiquidity measure. While existing literature treat either only the sources of risk (interest rate, credit, and illiquidity) or one or partial aspect of term structure of interest rates, this paper provides the model that enables us to perform a comprehensive analysis by decomposing yield spreads into each term structure factor of interest rate, net credit and illiquidity.

$$\begin{aligned} Y_i = Y_{f,s} &+ \left[\left(Y_{i,l} - Y_{KfW,l}\right) + \left(Y_{KfW,l} - Y_{f,l}\right)\right] \\ &+ \begin{bmatrix} \left(1 - \frac{D_{i,l} - D_i}{D_{i,l} - D_{i,s}}\right)\left(Y_{f,l} - Y_{f,s}\right) \\ - \frac{D_{i,l} - D_i}{D_{i,l} - D_{i,s}}\left\{\left(Y_{i,l} - Y_{KfW,l}\right) - \left(Y_{i,s} - Y_{KfW,s}\right)\right\} \\ - \frac{D_{i,l} - D_i}{D_{i,l} - D_{i,s}}\left\{\left(Y_{KfW,l} - Y_{f,l}\right) - \left(Y_{KfW,s} - Y_{f,s}\right)\right\} \end{bmatrix} \\ &+ \begin{bmatrix} \left(Y_{f,i} - Y_{f,i}^{LI}\right) \\ + \left\{\left(Y_i - Y_{KfW,i}\right) - \left(Y_i^{LI} - Y_{KfW,i}^{LI}\right)\right\} \\ + \left\{\left(Y_{KfW,i} - Y_{f,i}\right) - \left(Y_{KfW,i}^{LI} - Y_{f,i}^{LI}\right)\right\} \end{bmatrix}, \end{aligned} \tag{3}$$

where all variables are the same as defined in equations (1) and (2).

3.2.2 Extended Fama and French Model

We show that in equation (3), corporate bond yield spreads which are the difference between corporate bond yields and short term risk-free rates can be decomposed by the three term structure factors (level, steepness, and concavity) of interest rate, credit and illiquidity. We apply the following Model 3 ("Extended Fama-French Model") to European corporate bond markets to investigate whether each factor may be a determinant and/or priced risk factor of corporate yield spreads. In addition, we examine the impact of gross credit and net credit on illiquidity premium using "Extended

Fama-French Model". The expected signs of the coefficients of regressions estimated by "Extended Fama-French Model" are negative for β_{p,crd_s} and $\beta_{p,illiq\_s}$ and positive for all the others. Furthermore, we compare Fama-French 2 factor model (Model 1) with Model 2 that has an additional term of $-(Y_{i,l} - Y_i)$.

Model 1: $Y_{p,t} - Y_{f,s,t} = \alpha_p + \beta_{p,ir\_s} TERM_t + \beta_{p,crd\_l} DEF_{l,t} + \varepsilon_{p,t}$

Model 2: $Y_{p,t} - Y_{f,s,t} = \alpha_p + \beta_{p,ir\_s} TERM_t + \beta_{p,crd\_l} DEF_{l,t} + \beta_{p,neo} NEO_t + \varepsilon_{p,t}$

Model 3:
$$
\begin{aligned}
Y_{p,t} - Y_{f,s,t} &= \alpha_p + \beta_{p,ir\_s}(1 - DUR_{l,t}) TERM_t + \beta_{p,ir\_c} IR\_C_t \\
&+ \beta_{p,crd\_l} CRD\_L_t + \beta_{p,crd\_s}(DUR_{l,t} \cdot CREDIT\_S_t) + \beta_{p,crd\_c} CRD\_C_t \\
&+ \beta_{p,illiq\_l} ILLIQ\_L_t + \beta_{p,illiq\_s}(DUR_{l,t} \cdot ILLIQUIDITY\_S_t) + \beta_{p,illiq\_c} ILLIQ\_C_t + \varepsilon_{p,t} \\
&= \alpha_p + \beta_{p,ir\_s} IR\_S_t + \beta_{p,ir\_c} IR\_C_t \\
&+ \beta_{p,crd\_l} CRD\_L_t + \beta_{p,crd\_s} CRD\_S_t + \beta_{p,crd\_c} CRD\_C_t \\
&+ \beta_{p,illiq\_l} ILLIQ\_L_t + \beta_{p,illiq\_s} ILLIQ\_S_t + \beta_{p,illiq\_c} ILLIQ\_C_t + \varepsilon_{p,t} ,
\end{aligned}
$$

where Y_p: yield to maturity of corporate bond portfolio p,

$Y_{f,s}$: zero coupon rate of German government bonds (Bunds) with the same duration as that of short term corporate bond portfolio,

$TERM$: term spread measured by the difference in zero coupon rates between short term and long term German government bonds with the same duration as that of short term and long term corporate bond portfolio,

DEF: credit spread measured by the difference in yields between long term corporate bond portfolio and long term German government bonds with the same duration as that of long term corporate bond portfolio,

NEO: the difference in yields between long term corporate bond portfolio and corporate composite,

IR_C: concavity factor for risk-free rates measured by the difference between Bunds yields calculated by linear interpolation and Bunds yields with the same duration as that of corporate composite,

CRD_L: the difference in yields between long term corporate bond portfolio and KfW bonds with the same duration as that of long term corporate bond portfolio,

$CREDIT\_S$: steepness factor for credit measured by the difference between long term credit spreads and short term credit spreads,

CRD_C: concavity factor for credit spreads measured by the difference between credit spreads calculated by linear interpolation and credit spreads corresponding to the duration of corporate composite,

$ILLIQ\_L$: the difference in zero coupon rates between Bunds and KfW bonds with the same duration as that of long term corporate bond portfolio,

$ILLIQUIDITY\_S$: steepness factor for illiquidity measured by the difference between long term illiquidity spreads and short term illiquidity spreads,

$ILLIQ\_C$: concavity factor for illiquidity spreads measured by the difference between illiquidity spreads calculated by linear interpolation and illiquidity spreads corresponding to the duration of corporate composite, and

DUR_l: scaling factor calculated by $(D_{p,l} - D_p)/(D_{p,l} - D_{p,s})$.

4 Time Series Regressions

Table 2 provides descriptive statistics and correlations for explanatory variables. The averages of explanatory variables of the extended Fama-French Model (Model 3) are 0.39% for IR_S, 0.08% for IR_C, 1.41% for CRD_L, 0.09% for CRD_S, 0.31% for CRD_C, 0.27% for $ILLIQ\_L$, 0.04% for $ILLIQ\_S$, and 0.01% for $ILLIQ\_C$, respectively. We see that the variable credit level CRD_L has the highest mean value but the concavity variable for illiquidity $ILLIQ\_C$ has the lowest mean value. The averages of explanatory variables of Model 2 are 1.30% for $TERM$, 1.68% for DEF and 0.64% for NEO, respectively. The average values of IR_S and CRD_L which correspond to $TERM$ and DEF for Fama-French 2 factor Model are relatively lower than those of $TERM$ and DEF, respectively, as can be expected from equation (3). Since both the correlations of $TERM$ and IR_S and the correlations of DEF and CRD_L show 0.99 in Table 2, we know that the steepness factor of interest rate and the level factor of credit reflect the same information as contained in the two factors of Fama and French (1993).

We showed in equation (3) that we can decompose traditional credit factor into net credit factor and illiquidity factor using KfW bonds. However, since the correlation between CRD_L and $ILLIQ\_L$ is 0.82 in Table 2, CRD_L and $ILLIQ\_L$ will affect each other.[7] Consequently, we extract "orthogonal credit level" which is not affected by illiquidity level factor common to bond markets as in equation (4) (Cieslak and Povala, 2015).

[7] We test the multicollinearities among variables using variance inflation factor and find that $ILLIQ\_L$ can be expressed as a linear combination of other variables. We also find that only level factor shows a significant coefficient when we run a time series regression between credit and illiquidity factors. We do not report the results of multicollinearity test and this regression due to space limitations.

$$OrthoCreditLevel_t = DEF_t - \hat{a} - \hat{b} \cdot ILLIQ\_L_t \tag{4}$$

[Table 2 here.]

Table 3 provides the results for times series regression of 23 rating and maturity indices. Panel A shows that the two explanatory variables of Fama and French model (1993) are statistically significant at 1% level and adjusted R square is at least 86%. Panel B shows that not only the new variable *NEO* which was not considered in Fama-French 2 factor model is statistically significant at 1% level for all portfolio except BBB 10Y+ but also adjusted R square is at least 96%, indicating the suitability of Model 2 enhances a great deal compared to that of Fama-French 2 factor model. Furthermore, it shows that the estimated value of alpha which is not explained by the model gets smaller in model 2 than model 1. Hence, we argue that the new variable *NEO* that is added by the analytic factor decomposition method is a meaningful factor in explaining bond yield spreads. For the extended Fama-French model (Model 3) that has all the factors of yield curve regarding interest rate, net credit and illiquidity, we report two results in Panels C and D. Panel C shows the results for Model 3-1 when non-orthogonal credit level is used as net credit factor, whereas Panel D shows the results for Model 3-2 when orthogonal credit level is used as net credit factor. Both Panels show that all the 8 explanatory variables have significant coefficients and adjusted R square is more than 97%. The coefficients of the steepness factors of net credit and illiquidity show negative signs as expected. Comparing Panel C with Panel D, we see that all variables have the same coefficients except for illiquidity level factor, $ILLIQ\_L$ and constants. Interestingly, not only the size of β_{illiq_l} becomes greater but also the tendency of increase of β_{illiq_l} gets more significant as credit rating downgrades and remaining maturity increases in Model 3-2 than in Model 3-1. This result implies that if we do not take credit factor into account appropriately (not net credit factor but gross credit factor), liquidity risk is underestimated and credit risk is overestimated at the same time.

[Table 3 here.]

5 Cross Sectional Regressions

To test if the factors of the extended Fama-French model are important risk factors in determining bond yield spreads in cross sections, we run Fama-MacBeth regressions.8 We estimate betas using 5

[8] Petersen (2009) suggests that when the residuals are correlated across firms and across time, OLS standard errors can be biased and the Fama-MacBeth procedure to estimate standard errors is appropriate.

year rolling window data. We use Markit iBoxx EUR Corporates Indices as rating and maturity class corporate bond portfolio. For the dependent variable, we use yield spreads of rating and maturity class corporate bond portfolio which are calculated by subtracting short term risk-free rates from yields to maturity of each portfolio at the end of each month. For short term risk-free rates, we use zero coupon rates of Bunds with the same duration as that of short term (1~3 years) corporate bond portfolio. In equilibrium, bond realized returns are related to factor loadings in cross sections and generally have linear relations with betas. In our paper, to examine if yield spreads have linear relations with betas as realized returns, we use the following regression models that include squared betas (5) ~ (7).

$$\text{Model 1:} \quad Y_{p,t} - Y_{f,s,t} = \gamma_0 + \gamma_1 \beta_{p,ir_s} + \gamma_3 \beta_{p,crd_l} + \gamma_9 \beta_{p,ir_s}^2 + \gamma_{11} \beta_{p,crd\_l}^2 + u_p \tag{5}$$

$$\begin{aligned} \text{Model 2:} \quad Y_{p,t} - Y_{f,s,t} &= \gamma_0 + \gamma_1 \beta_{p,ir\_s} + \gamma_3 \beta_{p,crd\_l} + \gamma_{17} \beta_{p,neo} \\ &\quad + \gamma_9 \beta_{p,ir\_s}^2 + \gamma_{11} \beta_{p,crd\_l}^2 + \gamma_{18} \beta_{p,neo}^2 + u_p \end{aligned} \tag{6}$$

$$\begin{aligned} \text{Model 3:} \quad Y_{p,t} - Y_{f,s,t} &= \gamma_0 + \gamma_1 \beta_{p,ir\_s} + \gamma_2 \beta_{p,ir\_c} + \gamma_3 \beta_{p,crd\_l} + \gamma_4 \beta_{p,crd\_s} + \gamma_5 \beta_{p,crd\_c} \\ &\quad + \gamma_6 \beta_{p,illiq\_l} + \gamma_7 \beta_{p,illiq\_s} + \gamma_8 \beta_{p,illiq\_c} \\ &\quad + \gamma_9 \beta_{p,ir\_s}^2 + \gamma_{10} \beta_{p,ir\_c}^2 + \gamma_{11} \beta_{p,crd\_l}^2 + \gamma_{12} \beta_{p,crd\_s}^2 + \gamma_{13} \beta_{p,crd\_c}^2 \\ &\quad + \gamma_{14} \beta_{p,illiq\_l}^2 + \gamma_{15} \beta_{p,illiq\_s}^2 + \gamma_{16} \beta_{p,illiq\_c}^2 + u_p \end{aligned} \tag{7}$$

If a bond has a relatively greater systematic risk, it should have a higher yield spread and if a beta of some factor that determines yield spread is an important risk factor, it should have a statistically significant positive coefficient.

Table 4 provides cross-sectional regression results of Fama-MacBeth for 23 rating and maturity class corporate bond portfolio. We find that there exists a non-linearity between yield spreads and betas since the coefficients of squared betas are all statistically significant in Fama-French 2 factor model (Model 1) and Model 2 which includes the *NEO* factor. Specifically, since not only the coefficients of β_{neo} and β_{neo}^2 are statistically significant at 1% level but also R-square of Model 2 (92%) increases 19% point compared to Model 1 (73%), the factors derived from analytic decomposition method have high possibilities that they will be crucial risk factors in determining yield spreads. In Model 3, we find that portfolio yield spreads show significant relationships with betas in cross-sections except the concavity factors of interest rate and illiquidity (IR_C, $ILLIQ\_C$) and that there exists a non-linearity between yield spreads and betas overall. In Model 3-1 and Model 3-2, it is interesting to note the relation between the betas of illiquidity level and yield spreads. As the betas of illiquidity increase, yield spreads also increase for both models but with opposite growth rates (coefficients for $\beta^2_{illiq\_l}$>0 for Model 3-1 but coefficients for $\beta^2_{illiq\_l}$<0 for Model 3-2).

[Table 4 here.]

Table 5 provides risk prices of bond risk factors. Risk prices are calculated by partial differentiation (e.g., $\frac{\partial YS_{p,t}}{\partial \beta_p} = \widehat{\gamma_1} + 2\widehat{\gamma_2}\beta_p$), with consideration of non-linear relationship between yield spreads and betas (e.g., $YS_{p,t} = \widehat{\gamma_1}\beta_p + \widehat{\gamma_2}\beta_p^2$). β_p's calculated as the averages of rolling betas of each factor.

Since all risk prices of risk factors in Model 3 as well as Model 1 and Model 2 show positive values, we know that there are trade-offs between betas and yield spreads. In Model 3-2, when one unit of each risk factor changes, yield spreads are affected by the following order and magnitude; interest rate factor (59.0%), illiquidity factor (26.9%) and credit factor (14.1%). The risk price of illiquidity factor is almost 1.8 times higher than that of credit factor. With respect to the risk factors of yield curve, yield spreads are affected by the following order and magnitude; concavity (44.8%), level (43.9%) and steepness (11.3%). Interestingly, the risk prices of steepness of credit and illiquidity show negative values, implying the corporate bonds with higher betas for CRD_S and $ILLIQ\_S$ can reduce yield spreads. Also, the risk factors that contribute to enlarging yield spreads are related to steepness of interest rate, concavity of credit and level of illiquidity. From the results, we know that for effective bond portfolio management and risk management, we need to measure and manage risk by each risk factor.

[Table 5 here.]

Table 6 provides risk premium of each risk factor and its contribution to total risk premium when the extended Fama-French 8 factor model is applied. Risk premium is calculated by multiplying the average betas of 23 rating and maturity class corporate bond portfolio with the risk prices estimated by Fama-MacBeth regressions (7).[9] The betas of each corporate bond portfolio are estimated using the data of whole sample from January 2003 to August 2015. We find the followings. First, risk premium (size/proportion) of European corporate bond is estimated in the following order; level premium (1.71/52.4%), steepness premium (1.05/32.4%) and concavity premium (0.50/15.2%) when

[9] This is the same as we multiply market risk premium (risk price of market portfolio) with individual security's beta when we calculate risk premium of that security.

Model 3-2 is applied. This result corresponds to that of Litterman and Scheinkman (1991)'s principal component analysis. Second, total risk premium (size/proportion) is decomposed by each risk factor in the following order; illiquidity premium (1.44/44.3%), credit premium (1.23/37.6%) and interest rate premium (0.59/18/1%) when Model 3-2 is applied. The contribution of credit premium to the total risk premium does not exceed 52% even for Model 3-1 (Elton et al., 2001; De Jong and Driessen, 2012; Huang and Huang, 2012). Third, Model 3-1 that uses the non-orthogonal net credit factor shows higher contribution of credit premium (2.02%) than illiquidity premium (1.12%), differently from Model 3-2 that uses the orthogonal net credit factor. Also, total risk premium given by Model 3-1 (3.85%) is bigger than that given by Model 3-2 (3.26%). Thus, we find that not only credit premium but also total risk premium get overestimated due to the correlation between the level factors of credit and illiquidity when the orthogonality of net credit factor is not taken into consideration.

[Table 6 here.]

6 Liquidity Black Holes and Liquidity Preference

While we have been undergoing two disastrous financial crises in the first decade of the twenty-first century, yield spreads of bond markets have skyrocketed and financial markets have shown very shaky appearances. While prior literature has examined the relation between credit and illiquidity mainly during the period of global financial crisis, our paper investigates the relation between them both during the global financial crisis which is characterized as private sector crisis and during the European national debt crisis which is characterized as public sector crisis.

6.1 Liquidity Black Holes

Panel (A) of [figure 2] depicts the yield spreads that are differences between yields to maturity of Markit iBoxx EUR Corporates indices and zero coupon rates of German government bonds, Bunds during January 2003 and August 2015. On June 7, 2007, Bear Stearns announced it temporarily would stop buying back high-grade structured credit enhanced leveraged fund, which ignited the global financial crisis and on September 15, 2008, Lehman Brothers went bankrupt, which made yield spreads of corporate bond markets soar up. When Euro member countries and IMF reached an agreement on the emergency rescue plan for the relief of Greece of €110 billion on May 2, 2010, the crisis of the private sector migrated to the public sector and on October 18, 2012, through European summit meeting, European national debt crisis has stepped into a stable phase. The sample period is divided into 4 periods; before the global financial crisis (2003.1～2007.5), during the global financial crisis (2007.6～2010.4), during the European national debt crisis (2010.5～2012.9), and after the European national debt crisis (2012.10～2015.8).

(B) and (C) of [Figure 2] depict time trends of interest rate premium, credit premium and illiquidity premium, and level premium, steepness premium and concavity premium, respectively. Each risk premium is calculated monthly by multiplying the average betas of 23 rating and maturity class corporate bond portfolio with the risk prices estimated by Fama-MacBeth cross-section regressions. The risk prices used here are estimated using Model 3-2 where orthogonal credit factor is used. The average betas of portfolio are calculated by averaging the estimated betas using at least 60 months data from the starting point of January 2003 so that risk premium is generated from January 2008. From (B), we see that credit and interest rate premium rose during the global financial crisis but decreased gradually during the European national debt crisis. However, illiquidity premium, differently from credit and interest rate premium, showed not only a time-varying but also opposite trend, compared to credit premium. From (C), we see that only level and steepness premium among yield curve factors rose during the global financial crisis but showed a stable appearance after that. Interestingly, interest rate premium and steepness premium, differently from other risk premiums, rose during the global financial crisis and have maintained their high levels after the European national debt crisis.

[Figure 2 here.]

Table 7 provides the results of the time-series regressions on the relation between illiquidity premium and credit premium. The regression model we use is $ILLIQ_t = \alpha + \beta \cdot CRD_t + \varepsilon_t$, where $ILLIQ$ is illiquidity premium and CRD is credit premium. The sample period is from January 2003 to August 2015. We find the followings. First, we find the same significantly negative relation between illiquidity premium and credit premium in European corporate bond markets at 1% level during the sample period as in Beber et al. (2009) which examined the relation in European government bond markets from April 2003 to December 2009. Second, we find that the relation between illiquidity premium and credit premium during the global financial crisis was significantly positive at 5% level, which is substantiated by the simultaneous rises of both premiums during the second half period of 2008 when Lehman Brothers went bankrupt as can be seen in [Figure 2]. Although in normal market situations demand for an asset arises when its price falls according to the endogenous feedback mechanism, in severe financial crises liquidity black holes can arise where the price of an asset continues to fall when it begins to fall because there are only sellers in the markets due to loss limits for example (Morris and Shin, 2004). Ericsson and Renault (2006) also report a positive relationship between illiquidity factor and credit factor in the U. S. corporate bond markets from 1986 to 2001. Third, we find that the negative relationship between credit premium and illiquidity premium gets stronger recently with adjusted R square of 0.98.

In summary, we find that the relation between illiquidity and credit is different depending on the economic situations, and there occur liquidity black holes that cause the dissipation of asset prices since self-stabilizing market mechanism gets weaker or does not work appropriately in the beginning of financial crisis when uncertainty is profound.

[Table 7 here.]

6.2 Liquidity Preference

During the financial crisis investors prefer safe assets (flight-to-quality) and/or prefer liquidity (flight-to-liquidity). However, it is not easy to tell the role and contribution of one factor from that of the other since credit and liquidity move with a close relationship. In this section, to test the adequacy of our research model, we analyze the role of credit and illiquidity and the cause of sudden increase of bond yield spreads discovered during the two financial crises both from the perspective of total risk premium of corporate bonds and form the perspective of difference in risk premium between high quality bonds and low quality bonds. We apply Model 3-2 which includes 8 factors that are extracted from the analytic bond decomposition method and uses the orthogonal net credit factor.

Table 8 provides risk premium for each factor and its contribution to total risk premium in three different economic situations. Each risk premium is the arithmetic average of risk premiums calculated monthly. A common feature that is found in all three periods is that the contribution of each factor to bond yield spreads is in descending order of credit, illiquidity and interest rate premium. Compared to the after-period of European national debt crisis (3.18), total risk premium increases for both crisis periods (3.35 in the global financial crisis and 3.38 in the European national debt crisis) but the main risk factor that causes the increase of risk premium is different between the two crises. Whereas during the global financial crisis the illiquidity level premium makes the biggest contribution to total risk premium (42.2%) which corresponds to the flight-to-liquidity phenomenon, during the European national debt crisis the credit level premium makes the biggest contribution to total risk premium (28.7%) which corresponds to the flight-to-quality phenomenon. This implies that measuring and managing risk by each risk factor is essential not only for the appropriate portfolio management, risk management and economic policy establishment but also for the effective crisis management.

[Table 8 here.]

During the financial crisis there is a tendency that maturities of all money market instruments shortened and the decrease in duration of capital markets makes economic environments easily broken even by small impact (Gorton et al., 2015). Table 9 shows the changes of the term structure of risk premium and the differences in risk premium between high quality bonds and low quality bonds depending on the economic situations. Specifically, we estimate the differences in risk premium between AA rating portfolio and BBB rating portfolio according to the economic situations and remaining maturities. Remaining maturities are classified to short term (1～3 years), medium term (5～7 years) and long term (7～10 years). The differences in risk premium between AA rating portfolio and BBB portfolio are calculated by averaging arithmetically the differences in risk premium of portfolio estimated monthly. The differences in risk premium of two portfolios are calculated monthly by multiplying the differences of factor betas of AA and BBB rating portfolios across each maturity estimated by time-series regressions with the risk prices of each factor estimated by Fama-MacBeth cross-section regressions. The monthly betas of rating and maturity class corporate bond portfolio are estimated using the data from January 2003 until the previous month when the betas are estimated. The estimation period of betas is at least 5 years.

From table 9, we find that the differences in risk premium between AA and BBB portfolio are greater in the financial crises than in post European national debt crisis (the only exception is for short term maturity portfolio in the global financial crisis). As far as the term structure of risk premiums (short term/medium term/long term) according to the different economic situations is concerned, both periods of the global financial crisis (1.19/1.62/1.91%) and the European national debt crisis (1.37/1.86/2.02%) have steeper term structure than post-European debt crisis (1.28/1.36/0.73%). Specifically, the global financial crisis shows the steepest term structure and the lowest difference in short term risk premium, implying the most significant the flight-from-maturity phenomenon, compared to the other periods. Interestingly, we find that the contribution of illiquidity premium for short term maturity is greatest (62.2%) for the global financial crisis. The results suggest that during the global financial crisis differently from the European national debt crisis, financial markets became unstable rapidly due to liquidity black holes and liquidity preference.

[Table 9 here.]

7 Conclusions

The right recognition and effective management of liquidity is important and imminent. The main results of this paper are summarized as follows. First, we propose a new extended Fama-French model based on yield curve information. To the best of our knowledge, this is the first paper that proposes the corporate bond pricing model that considers simultaneously interest rate, credit, and illiquidity factors together with three main characteristics of yield curve (level, steepness and concavity) by extending Fama-French 2 factor model. Second, we show the importance of “net credit risk factor” in the determination of yield spreads of corporate bonds and the under-estimation problem of illiquidity premium (over-estimation of credit premium) that has been overlooked by current literature. Third, we find that each factor of bond yields responds differently according to the source of financial shocks by examining the impact (performance decomposition) of each factor on bond yield spreads. Fourth, we find that yield curve information that new extracted variables contain plays an important role in explaining yield spreads of individual bonds. Fifth, we find that there exists a non-linear relation between bond yields and betas. Sixth, we find that the relationship between credit and illiquidity is different depending on the economic situations and it is essential and crucial to measure and manage risk separately by the risk factors that we discover in the paper. Lastly, we find that liquidity black holes arise in the beginning of the financial crisis when uncertainty prevails and show that financial markets became unstable suddenly since self-stabilizing mechanism of bond markets did not work appropriately due to the liquidity preference of investors in the global financial crisis.

The results of this paper can be used for policy makers when they establish financial policies according to liquidity and credit situations of the bond markets and for financial institutions and investors as useful information for effective risk management and right bond pricing.

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Figure 1 Decomposing $\boldsymbol{Y_{i,l} - Y_i}$

This figure shows the meaning of the term $-(\boldsymbol{Y_{i,l} - Y_i})$. Y_i is corporate bond i's yield, $Y_{i,l}$ is long term corporate bond yield, $Y_{i,s}$ is short term corporate bond yield, and Y_i^{LI} is the yield with the same maturity as that of corporate bond i, a linear interpolation of long term and short term corporate bond yields.

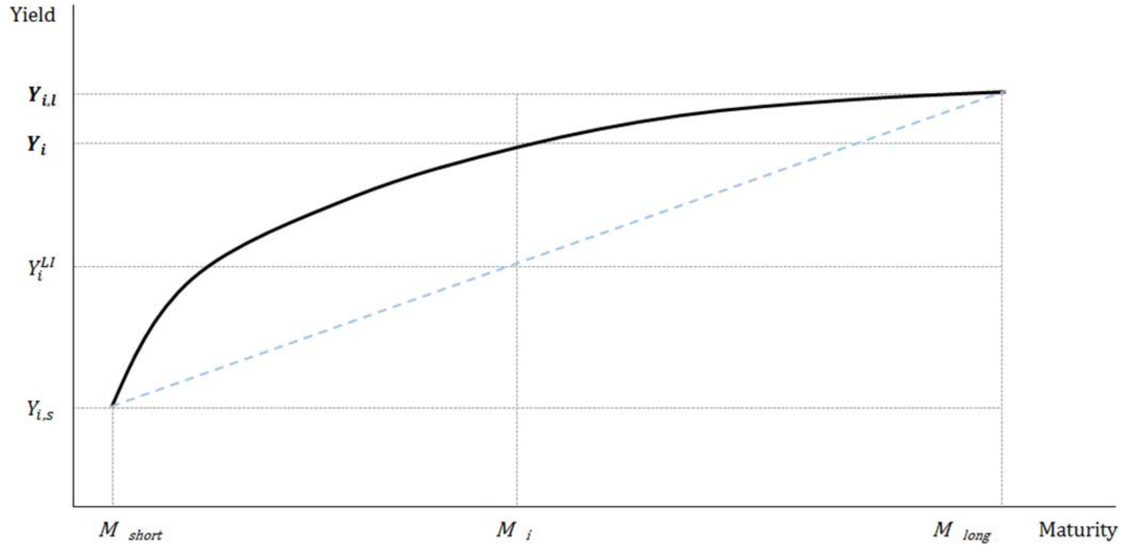
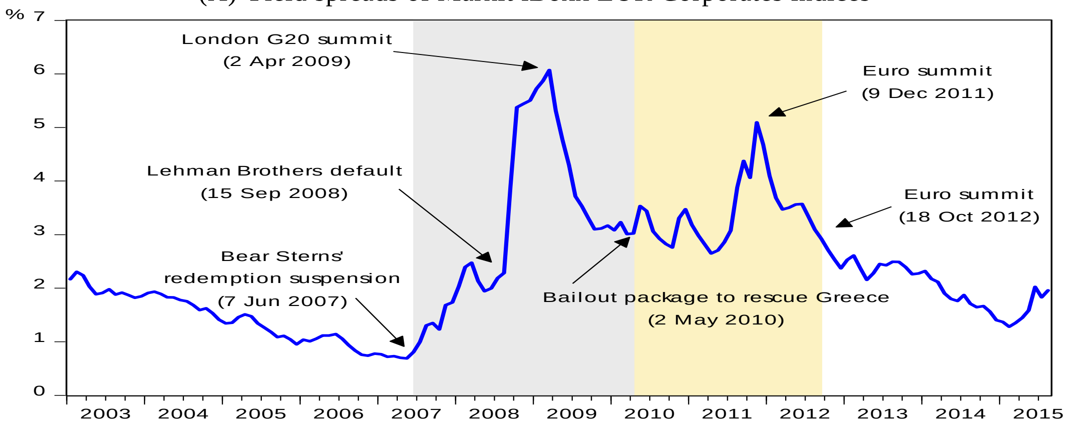


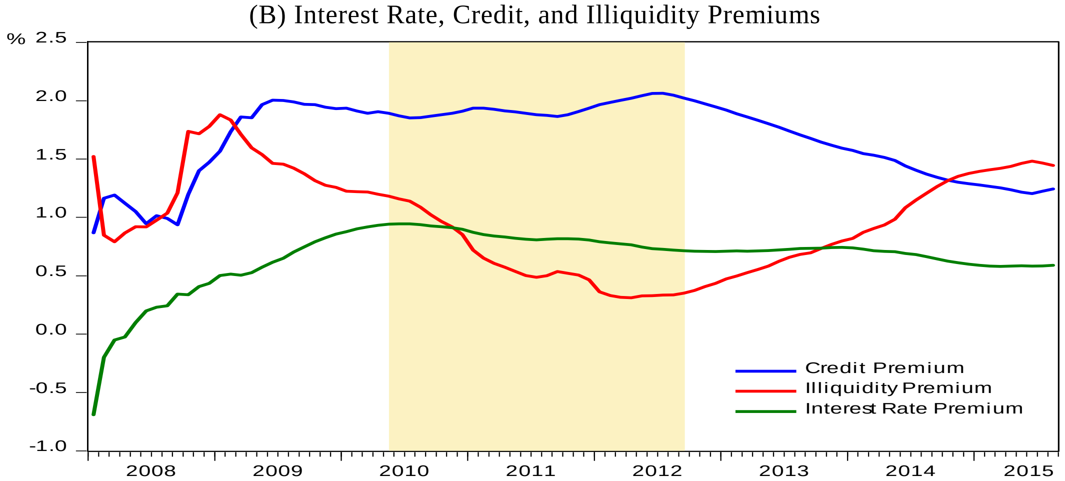
Figure 2 Yield spread and risk premiums

Panel (A) of Figure 2 depicts the yield spreads that are differences between yields to maturity of Markit iBoxx EUR Corporates indices and zero coupon rates of German government bonds, Bunds during January 2003 and August 2015. The sample period is divided into 4 periods; before the global financial crisis (2003.1 ~ 2007.5), during the global financial crisis (2007.6 ~ 2010.4), during the European national debt crisis (2010.5 ~ 2012.9), and after the European national debt crisis (2012.10 ~ 2015.8). (B) and (C) of Figure 2 depict time trends of interest rate premium, credit premium and illiquidity premium, and level premium, steepness premium and concavity premium, respectively. The average betas of portfolio are calculated by averaging the estimated betas using at least 60 months data from the starting point of January 2003 so that risk premium is generated from January 2008.

(A) Yield spreads of Markit iBoxx EUR Corporates indices



(B) Interest Rate, Credit, and Illiquidity Premiums



(c) Level, Steepness, and Concavity premiums

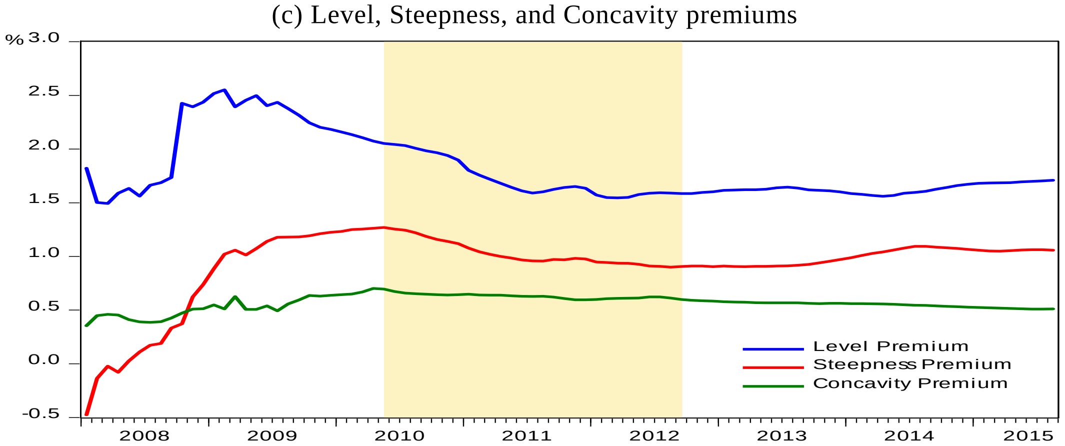


Table 1 Descriptive statistics of corporate bond indices

This table indicates descriptive statistics for the sample bond indices. The sample period is from January 2003 to August 2015. European corporate bond indices used in our paper are 23 rating and maturity class broad Markit iBoxx EUR Corporate bond indices. Eight of the indices are composite indices for 3 different credit ratings (Corporates AA, A, BBB) and 5 different maturities (Corporates 1-3, 3-5, 5-7, 7-10, 10+).

	Duration	Yield spreads (%)						
Index	(years)	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
Corp. Composite	4.39	2.34	2.03	6.07	0.69	1.19	1.05	3.86
Corp. 1-3Y	1.81	1.47	1.13	5.46	0.31	1.15	1.46	4.77
Corp. 3-5Y	3.48	1.89	1.61	5.61	0.46	1.18	1.13	3.88
Corp. 5-7Y	5.00	2.33	2.01	6.52	0.61	1.35	1.13	3.99
Corp. 7-10Y	6.67	2.72	2.42	6.81	0.80	1.35	0.91	3.55
Corp. 10Y+	10.09	2.99	2.98	5.49	0.98	1.09	0.13	2.32
Corp. AA	4.53	1.85	1.69	4.44	0.45	0.92	0.79	3.24
Corp. A	4.50	2.29	1.96	6.59	0.72	1.27	1.46	5.25
Corp. BBB	4.19	2.88	2.41	7.23	0.85	1.52	1.06	3.56
Corp. AA 1-3Y	1.83	0.94	0.65	3.62	0.18	0.80	1.54	4.93
Corp. AA 3-5Y	3.52	1.38	1.08	4.11	0.30	0.92	1.19	3.89
Corp. AA 5-7Y	5.09	1.76	1.54	4.49	0.40	0.97	0.86	3.32
Corp. AA 7-10Y	6.77	2.16	1.97	5.27	0.46	1.11	0.60	2.82
Corp. AA 10Y+	11.03	2.63	2.71	4.89	0.71	1.05	0.05	2.25
Corp. A 1-3Y	1.81	1.41	0.88	6.13	0.30	1.30	1.85	6.12
Corp. A 3-5Y	3.48	1.79	1.39	6.45	0.46	1.26	1.63	5.68
Corp. A 5-7Y	5.01	2.22	1.84	7.01	0.57	1.38	1.46	5.19
Corp. A 7-10Y	6.68	2.72	2.36	7.41	0.84	1.49	1.29	4.70
Corp. A 10Y+	9.86	2.85	2.70	5.49	0.98	1.08	0.33	2.40
Corp. BBB 1-3Y	1.80	1.99	1.46	7.14	0.41	1.54	1.36	4.48
Corp. BBB 3-5Y	3.43	2.43	2.04	6.52	0.58	1.50	1.02	3.37
Corp. BBB 5-7Y	4.91	2.89	2.30	7.73	0.74	1.70	1.03	3.41
Corp. BBB 7-10Y	6.50	3.32	2.84	8.23	0.99	1.68	0.95	3.38
Corp. BBB 10Y+	9.78	3.68	3.68	7.02	1.25	1.34	0.39	2.69

Table 2 Summary statistics of explanatory variables

This table indicates descriptive statistics and correlations for explanatory variables. IR is interest rate, CRD is credit, $ILLIQ$ is illiquidity, $\_L$ is level, $\_S$ is steepness, and $\_C$ is concavity, respectively. $TERM$ and DEF are Fama and French (1993) two factors. NEO is the difference between the corporate bond composite index and long-term corporate bond index bond index.

Variables	Descriptive statistics of factors					Factor correlations										
	Mean	Median	Maximum	Minimum	Standard Deviation	IR_S	IR_C	CRD_L	CRD_S	CRD_C	ILLIQ_L	ILLIQ_S	ILLIQ_C	TERM	DEF	NEO
IR_S	0.39	0.44	0.69	0.00	0.19	1.00										
IR_C	0.08	0.08	0.44	-0.21	0.13	0.67	1.00									
CRD_L	1.41	1.30	2.87	0.74	0.49	0.25	-0.01	1.00								
CRD_S	0.09	0.26	0.52	-1.50	0.39	-0.49	-0.37	-0.79	1.00							
CRD_C	0.31	0.29	0.79	0.06	0.14	-0.05	-0.39	0.42	-0.12	1.00						
ILLIQ_L	0.27	0.23	0.81	0.02	0.20	0.24	0.00	0.82	-0.79	0.39	1.00					
ILLIQ_S	0.04	0.03	0.26	-0.24	0.08	0.12	-0.06	-0.02	-0.12	-0.24	0.36	1.00				
ILLIQ_C	0.01	0.00	0.20	-0.23	0.08	0.23	0.03	0.45	-0.42	-0.08	0.25	0.08	1.00			
TERM	1.30	1.51	2.42	0.00	0.67	0.99	0.68	0.33	-0.58	-0.04	0.34	0.15	0.28	1.00		
DEF	1.68	1.51	3.58	0.81	0.66	0.26	-0.01	0.99	-0.82	0.43	0.90	0.09	0.41	0.34	1.00	
NEO	0.64	0.71	1.23	-0.71	0.41	0.47	0.24	-0.54	0.43	-0.40	-0.42	0.35	-0.21	0.40	-0.53	1.00

Table 3 Time series regression

This table presents the results of following models:

Model 1: $Y_{p,t} - Y_{f,s,t} = \alpha_p + \beta_{p,ir\_s} TERM_t + \beta_{p,crd\_l} DEF_{l,t} + \varepsilon_{p,t}$

Model 2: $Y_{p,t} - Y_{f,s,t} = \alpha_p + \beta_{p,ir\_s} TERM_t + \beta_{p,crd\_l} DEF_{l,t} + \beta_{p,neo} NEO_t + \varepsilon_{p,t}$

Model 3: $Y_{p,t} - Y_{f,s,t} = \alpha_p + \beta_{p,ir\_s} IR\_S_t + \beta_{p,ir\_c} IR\_C_t + \beta_{p,crd\_l} CRD\_L_t + \beta_{p,crd\_s} CRD\_S_t + \beta_{p,crd\_c} CRD\_C_t$
$+\beta_{p,illiq\_l} ILLIQ\_L_t + \beta_{p,illiq\_s} ILLIQ\_S_t + \beta_{p,illiq\_c} ILLIQ\_C_t + \varepsilon_{p,t}$

where $Y_{p,t}$ is the yield to maturity of corporate bond portfolio *p*, $Y_{f,s}$ is the zero coupon rate of German government bonds (Bunds) with the same duration as that of short term corporate bond portfolio, *TERM* is the term spread measured by the difference in zero coupon rates between short term and long term German government bonds with the same duration as that of short term and long term corporate bond portfolio, *DEF* is credit spread measured by the difference in yields between long term corporate bond portfolio and long term German government bonds with the same duration as that of long term corporate bond portfolio, *NEO* is the difference in yields between long term corporate bond portfolio and corporate composite. *IR_C* is the concavity factor for risk-free rates measured by the difference between Bunds yields calculated by linear interpolation and Bunds yields with the same duration as that of corporate composite, *CRD_L* is the difference in yields between long term corporate bond portfolio and KfW bonds with the same duration as that of long term corporate bond portfolio, *CRD_C* is the concavity factor for credit spreads measured by the difference between credit spreads calculated by linear interpolation and credit spreads corresponding to the duration of corporate composite, *ILLIQ_L* is the difference in zero coupon rates between Bunds and KfW bonds with the same duration as that of long term corporate bond portfolio *ILLIQ_C* is the concavity factor for illiquidity spreads measured by the difference between illiquidity spreads calculated by linear interpolation and illiquidity spreads corresponding to the duration of corporate composite. Panel C shows the results for Model 3-1 when non-orthogonal credit level is used as net credit factor, whereas Panel D shows the results for Model 3-2 when orthogonal credit level is used as net credit factor. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: Model 1

Portfolio	Constant	β_{ir_s}	β_{crd_l}	*Adj. R-square*
AA 1-3Y	-0.9709***	0.0309	1.1159***	0.863
A 1-3Y	-1.7715***	0.2062***	1.7331***	0.856
BBB 1-3Y	-2.0610***	0.4548***	2.0581***	0.938
AA 3-5Y	-0.9592***	0.3050***	1.1568***	0.868
A 3-5Y	-1.3965***	0.3300***	1.6390***	0.872
BBB 3-5Y	-1.6208***	0.5819***	1.9604***	0.965
AA 5-7Y	-0.7671***	0.4931***	1.1229***	0.881
A 5-7Y	-1.3285***	0.4953***	1.7254***	0.873
BBB 5-7Y	-1.6857***	0.8788***	2.0396***	0.938
AA 7-10Y	-0.8264***	0.7510***	1.1920***	0.927
A 7-10Y	-1.1468***	0.6263***	1.8144***	0.883
BBB 7-10Y	-1.2340***	0.8998***	2.0126***	0.953
AA 10Y+	-0.1784***	1.0226***	0.8796***	0.965
A 10Y+	-0.1100***	0.9208***	1.0488***	0.991
BBB 10Y+	0.0153	1.1246***	1.3089***	0.971
AA	-0.6124***	0.5323***	1.0514***	0.916
A	-1.0038***	0.4973***	1.5760***	0.892
BBB	-1.2501***	0.7149***	1.9038***	0.964
1-3Y	-1.5356***	0.2762***	1.5749***	0.941
3-5Y	-1.2627***	0.4407***	1.5357***	0.953
5-7Y	-1.2872***	0.6282***	1.6657***	0.937
7-10Y	-0.9582***	0.7617***	1.5993***	0.950
10Y+	-0.0000	1.0000	1.0000	1.000
			Average	0.926
			Max	1.000
			Min	0.856

Panel B: Model 2

Portfolio	Constant	β_{ir_s}	β_{crd_l}	β_{neo}	*Adj. R-square*
AA 1-3Y	-0.0155	0.4621***	0.6184***	-1.0616***	0.966
A 1-3Y	-0.0632	0.9772***	0.8436***	-1.8980***	0.981
BBB 1-3Y	-1.1342***	0.8730***	1.5755***	-1.0297***	0.964
AA 3-5Y	0.1290**	0.7960***	0.5902***	-1.2090***	0.970
A 3-5Y	0.2178***	1.0585***	0.7983***	-1.7937***	0.991
BBB 3-5Y	-1.0211***	0.8526***	1.6481***	-0.6663***	0.977
AA 5-7Y	0.2739***	0.9629***	0.5808***	-1.1566***	0.965
A 5-7Y	0.4275***	1.2878***	0.8109***	-1.9511***	0.990
BBB 5-7Y	-0.4118***	1.4537***	1.3763***	-1.4154***	0.979
AA 7-10Y	0.0962	1.1674***	0.7116***	-1.0251***	0.977
A 7-10Y	0.6376***	1.4316***	0.8852***	-1.9826***	0.987
BBB 7-10Y	-0.0889	1.4166***	1.4163***	-1.2723***	0.986
AA 10Y+	0.2239***	1.2041***	0.6701***	-0.4469***	0.975
A 10Y+	0.0520	0.9940***	0.9644***	-0.1801***	0.992
BBB 10Y+	0.0088	1.1217***	1.3123***	0.0072	0.971
AA	0.2384***	0.9163***	0.6084***	-0.9453***	0.977
A	0.4853***	1.1693***	0.8006***	-1.6545***	0.992
BBB	-0.3622***	1.1157***	1.4414***	-0.9865***	0.989
1-3Y	-0.6220***	0.6885***	1.0992***	-1.0151***	0.986
3-5Y	-0.3565***	0.8497***	1.0638***	-1.0068***	0.996
5-7Y	-0.0509*	1.1861***	1.0219***	-1.3736***	0.998
7-10Y	0.1388***	1.2568***	1.0281***	-1.2189***	0.997
10Y+	-0.0000	1.0000	1.0000	0.0000	1.000
				Average	0.983
				Max	1.000
				Min	0.964

Panel C: Model 3-1

Portfolio	Constant	β_{ir_s}	β_{ir_c}	β_{crd_l}	β_{crd_s}	β_{crd_c}	β_{illiq_l}	β_{illiq_s}	β_{illiq_c}	*Adj. R-square*
AA 1-3Y	0.0184	-0.7851***	1.0847***	0.4144***	-0.7489***	0.9393***	1.5457***	-2.0954***	1.0463***	0.972
A 1-3Y	0.1884**	-1.1130***	1.4950***	0.9338***	-1.8784***	0.9030***	0.7092***	-2.2861***	1.2694***	0.986
BBB 1-3Y	-0.0808	0.4192***	-0.4249**	1.3214***	-2.0444***	0.0879	0.9078***	-0.1228	-0.2583	0.988
AA 3-5Y	-0.0433	-0.2868***	2.0712***	0.4394***	-0.5906***	1.2185***	1.8387***	-2.1619***	2.2196***	0.985
A 3-5Y	0.1098	-0.8781***	2.2086***	0.9346***	-1.6891***	2.0564***	0.2147	-1.0316***	2.1115***	0.992
BBB 3-5Y	-0.5281***	1.2438***	0.3789	1.3525***	-0.7666***	-0.1891	2.7201***	-1.6975***	0.4392	0.981
AA 5-7Y	-0.0791	0.4950***	2.0433***	0.4044***	-0.5013***	1.7257***	1.8187***	-2.1806***	2.3071***	0.988
A 5-7Y	0.1935***	-0.2088**	2.3197***	0.8456***	-1.4776***	2.0121***	1.1612***	-2.6160***	2.7278***	0.994
BBB 5-7Y	-0.0380	0.8939***	1.9579***	1.3306***	-1.8039***	1.3424***	1.0036***	0.1043	1.1699***	0.986
AA 7-10Y	-0.0987	1.3769***	1.8548***	0.5044***	-0.5531***	1.4242***	1.8944***	-1.6855***	2.2322***	0.987
A 7-10Y	0.1441*	0.0103	2.8507***	1.0529***	-1.5228***	2.7438***	0.6702***	-1.7433***	2.8125***	0.993
BBB 7-10Y	0.2391**	1.4188***	1.3481***	1.3027***	-1.6641***	1.3334***	1.2005***	-0.3649	0.7946***	0.989
AA 10Y+	-0.0425	2.8068***	1.3541***	0.6261***	-0.0244	0.5032***	1.7302***	-1.2105***	1.4142***	0.977
A 10Y+	0.1636***	2.8150***	0.3855***	0.7933***	-0.1585***	-0.0754	1.8442***	-0.6262***	0.5487***	0.992
BBB 10Y+	0.1687	3.6155***	-0.4321*	1.6607***	-0.6069***	-0.7110***	0.1215	0.9287***	-1.0735***	0.979
AA	0.0170	0.9244***	1.4079***	0.5143***	-0.4703***	1.0044***	1.5878***	-1.9921***	1.6236***	0.987
A	0.1908***	0.0562	1.9649***	0.9908***	-1.3564***	1.7803***	0.5188***	-1.6812***	2.0104***	0.993
BBB	0.0095	1.1532***	0.8773***	1.3815***	-1.3772***	0.6715***	1.2015***	-0.2751	0.4208**	0.993
1-3Y	-0.0596***	0.0555***	0.0411**	0.9911***	-1.3896***	0.0131	1.0724***	-1.4141***	0.0535***	1.000
3-5Y	-0.1825***	0.4168***	1.0047***	0.9304***	-1.0087***	0.8620***	1.4149***	-1.2041***	1.1255***	0.998
5-7Y	-0.0630*	0.5841***	1.7102***	0.9930***	-1.2987***	1.5524***	1.0811***	-1.1535***	1.7034***	0.998
7-10Y	0.0303	1.2354***	1.5462***	1.0073***	-1.1662***	1.6641***	1.0093***	-0.9175***	1.5443***	0.998
10Y+	-0.0198	3.2634***	0.1749**	0.9942***	-0.0660**	-0.1258**	1.3209***	-0.0881	0.1712**	0.997
									Average	0.989
									Max	1.000
									Min	0.972

Panel D: Model 3-2

Portfolio	Constant	β_{ir_s}	β_{ir_c}	β_{crd_l}	β_{crd_s}	β_{crd_c}	β_{illiq_l}	β_{illiq_s}	β_{illiq_c}	*Adj. R-square*
AA 1-3Y	0.3791***	-0.7851***	1.0847***	0.4144***	-0.7489***	0.9393***	2.3925***	-2.0954***	1.0463***	0.972
A 1-3Y	1.0012***	-1.1130***	1.4950***	0.9338***	-1.8784***	0.9030***	2.6175***	-2.2861***	1.2694***	0.986
BBB 1-3Y	1.0694***	0.4192***	-0.4249**	1.3214***	-2.0444***	0.0879	3.6082***	-0.1228	-0.2583	0.988
AA 3-5Y	0.3392***	-0.2868***	2.0712***	0.4394***	-0.5906***	1.2185***	2.7366***	-2.1619***	2.2196***	0.985
A 3-5Y	0.9233***	-0.8781***	2.2086***	0.9345***	-1.6891***	2.0564***	2.1246***	-1.0316***	2.1115***	0.992
BBB 3-5Y	0.6493***	1.2438***	0.3789	1.3525***	-0.7666***	-0.1891	5.4841***	-1.6975***	0.4392	0.981
AA 5-7Y	0.2729***	0.4950***	2.0433***	0.4044***	-0.5013***	1.7257***	2.6451***	-2.1806***	2.3071***	0.988
A 5-7Y	0.9296***	-0.2088**	2.3197***	0.8456***	-1.4776***	2.0121***	2.8893***	-2.6160***	2.7278***	0.994
BBB 5-7Y	1.1203***	0.8939***	1.9579***	1.3306***	-1.8039***	1.3424***	3.7229***	0.1043	1.1699***	0.986
AA 7-10Y	0.3404***	1.3769***	1.8548***	0.5044***	-0.5531***	1.4242***	2.9252***	-1.6855***	2.2322***	0.987
A 7-10Y	1.0606***	0.0103	2.8507***	1.0529***	-1.5228***	2.7438***	2.8219***	-1.7433***	2.8125***	0.993
BBB 7-10Y	1.3731***	1.4188***	1.3481***	1.3027***	-1.6641***	1.3334***	3.8628***	-0.3649	0.7946***	0.989
AA 10Y+	0.5025***	2.8068***	1.3541***	0.6261***	-0.0244	0.5032***	3.0097***	-1.2105***	1.4142***	0.977
A 10Y+	0.8541***	2.8150***	0.3855***	0.7933***	-0.1585***	-0.0754	3.4654***	-0.6262***	0.5487***	0.992
BBB 10Y+	1.6144***	3.6155***	-0.4321*	1.6607***	-0.6069***	-0.7110***	3.5154***	0.9287***	-1.0735***	0.979
AA	0.4647***	0.9244***	1.4079***	0.5143***	-0.4703***	1.0044***	2.6389***	-1.9921***	1.6236***	0.987
A	1.0533***	0.0562	1.9649***	0.9908***	-1.3564***	1.7803***	2.5435***	-1.6812***	2.0104***	0.993
BBB	1.2121***	1.1532***	0.8773***	1.3815***	-1.3772***	0.6715***	4.0247***	-0.2751	0.4208**	0.993
1-3Y	0.8031***	0.0555***	0.0411**	0.9911***	-1.3896***	0.0131	3.0978***	-1.4141***	0.0535***	1.000
3-5Y	0.6273***	0.4168***	1.0047***	0.9304***	-1.0087***	0.8620***	3.3162***	-1.2041***	1.1255***	0.998
5-7Y	0.8014***	0.5841***	1.7102***	0.9930***	-1.2987***	1.5524***	3.1105***	-1.1535***	1.7034***	0.998
7-10Y	0.9071***	1.2354***	1.5462***	1.0073***	-1.1662***	1.6641***	3.0678***	-0.9175***	1.5443***	0.998
10Y+	0.8457***	3.2634***	0.1749**	0.9942***	-0.0660**	-0.1258**	3.3527***	-0.0881	0.1712**	0.997
									Average	0.989
									Max	1.000
									Min	0.972

Table 4 Cross-sectional regressions

This table reports results of cross-sectional regression tests of 23 rating and maturity class corporate bond portfolio. Tests are based on Fama-MacBeth regressions in which betas are estimated over rolling past five-year periods for each portfolio. The sample period is from January 2003 to August 2015. The dependent variable is a portfolio's monthly yield spread. β_{ir_s}, β_{ir_c}, β_{crd_l}, β_{crd_s}, β_{crd_c}, β_{illiq_l}, β_{illiq_s}, β_{illiq_c}, and β_{neo} are betas of steepness of interest rate, concavity of interest rate, level of credit, steepness of credit, concavity of credit, level of illiquidity, steepness of illiquidity, concavity of illiquidity, *NEO* factors. To examine if yield spreads have linear relations with betas as realized returns, we use the regression models that include squared betas. The *t*-values are given in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Variables	Model 1	Model 2	Model 3-1	Model 3-2
Constant	-0.1785 (-1.209)	0.6509*** (5.546)	-0.0507 (-0.389)	-0.3568** (-2.099)
β_{ir_s}	2.6220*** (18.469)	2.4730*** (21.724)	0.6024*** (25.749)	0.5567*** (23.271)
β_{ir_c}			0.0897 (1.363)	0.0546 (1.088)
β_{crd_l}	1.1625*** (6.901)	0.4201** (2.267)	1.6167*** (13.015)	0.5743*** (3.074)
β_{crd_s}			-0.6280*** (-9.790)	-0.5297*** (-8.772)
β_{crd_c}			0.3669*** (9.768)	0.4120*** (9.780)
β_{illiq_l}			0.1206 (1.358)	0.5493*** (6.148)
β_{illiq_s}			0.0584 (1.198)	0.0277 (0.615)
β_{illiq_c}			-0.0059 (-0.102)	0.0307 (0.571)
β_{neo}		0.8140*** (10.990)		
$\beta^2_{ir\_s}$	-0.2104** (-2.557)	-0.2124*** (-3.403)	0.0151** (2.189)	0.0256*** (3.933)
$\beta^2_{ir\_c}$			0.0186 (1.315)	-0.0050 (-0.413)
$\beta^2_{crd\_l}$	-0.1818*** (-3.362)	0.1807** (2.568)	-0.4180*** (-11.856)	-0.1941*** (-3.348)
$\beta^2_{crd\_s}$			-0.1108*** (-4.587)	-0.0497** (-2.157)
$\beta^2_{crd\_c}$			0.0054 (0.467)	0.0022 (0.175)
$\beta^2_{illiq\_l}$			0.0679** (2.341)	-0.0360*** (-3.601)
$\beta^2_{illiq\_s}$			0.0598*** (3.131)	0.0338** (2.114)
$\beta^2_{illiq\_c}$			-0.0119 (-0.965)	0.0013 (0.113)
β^2_{neo}		0.1146*** (4.919)		
R-squared	0.729	0.917	0.994	0.994

Table 5 Risk prices

This table reports results of risk prices of cross-sectional regression tests of 23 rating and maturity class corporate bond portfolio. The sample period is from January 2003 to August 2015. Panel A shows the results for Fama and French (1993) model. Panel B shows that not only the new variable NEO which was not considered in Fama-French 2 factor model. Panel C shows the results for Model 3-1 when non-orthogonal credit level is used as net credit factor, whereas Panel D shows the results for Model 3-2 when orthogonal credit level is used as net credit factor. Risk prices are calculated by partial differentiation (e.g., $\partial YS_{p,t}/\partial \beta_p = \widehat{\gamma_1} + 2\widehat{\gamma_2}\beta_p$), with consideration of non-linear relationship between yield spreads and betas (e.g., $YS_{p,t} = \widehat{\gamma_1}\beta_p + \widehat{\gamma_2}\beta_p^2$). β_p's calculated as the averages of rolling betas of each factor. The contribution ratios are given in parentheses. The unit is %.

Panel A: Model 1

	IR	CRD	Total
Level		0.61	0.61
		(21.1)	(21.1)
Steepness	2.29		2.29
	(78.9)		(78.9)
Total	2.29	0.61	2.90
	(78.9)	(21.1)	(100.0)

Panel B: Model 2

	IR	CRD	Mixed	Total
Level		0.80		0.80
		(23.2)		(23.2)
Steepness	2.04			2.04
	(59.7)			(59.7)
Mixed			0.59	0.59
			(17.1)	(17.1)
Total	2.04	0.80	0.59	3.43
	(59.7)	(23.2)	(17.1)	(100.0)

Panel C: Model 3-1

	IR	CRD	ILLIQ	Total
Level		0.76	0.29	1.05
		(45.5)	(17.3)	(62.8)
Steepness	0.63	-0.42	-0.07	0.14
	(38.0)	(-25.1)	(-4.4)	(8.6)
Concavity	0.13	0.38	-0.03	0.48
	(7.9)	(22.7)	(-1.9)	(28.6)
Total	0.76	0.72	0.19	1.67
	(45.9)	(43.1)	(11.0)	(100.0)

Panel D: Model 3-2

	IR	CRD	ILLIQ	Total
Level		0.17	0.31	0.48
		(15.8)	(28.1)	(43.9)
Steepness	0.61	-0.43	-0.05	0.13
	(55.0)	(-39.5)	(-4.2)	(11.3)
Concavity	0.04	0.42	0.03	0.49
	(4.0)	(37.8)	(3.0)	(44.8)
Total	0.65	0.16	0.29	1.10
	(59.0)	(14.1)	(26.9)	(100.0)

Table 6 Risk premium

This table reports risk premium of each risk factor and its contribution to total risk premium when the extended Fama-French 8 factor model is applied. Risk premium is calculated by multiplying the average betas of 23 rating and maturity class corporate bond portfolio with the risk prices estimated by Fama-MacBeth regressions. The betas of each corporate bond portfolio are estimated using the data of whole sample from January 2003 to August 2015. Panel A shows the results for Model 3-1 when non-orthogonal credit level is used as net credit factor, whereas Panel B shows the results for Model 3-2 when orthogonal credit level is used as net credit factor. The contribution ratios are given in parentheses. The unit is %.

Panel A: Model 3-1

	IR	CRD	ILLIQ	Total
Level		1.11	1.10	2.21
		(28.8)	(28.5)	(57.4)
Steepness	0.55	0.50	0.06	1.11
	(14.2)	(13.0)	(1.6)	(28.8)
Concavity	0.16	0.41	-0.04	0.53
	(4.1)	(10.6)	(-1.0)	(13.8)
Total	0.71	2.02	1.12	3.85
	(18.3)	(52.4)	(29.2)	(100)

Panel B: Model 3-2

	IR	CRD	ILLIQ	Total
Level		0.35	1.36	1.71
		(10.6)	(41.8)	(52.4)
Steepness	0.53	0.48	0.04	1.05
	(16.3)	(14.8)	(1.3)	(32.4)
Concavity	0.06	0.40	0.04	0.50
	(1.8)	(12.2)	(1.3)	(15.2)
Total	0.59	1.23	1.44	3.26
	(18.1)	(37.6)	(44.3)	(100)

Table 7 Relation between illiquidity premium and credit premium

This table shows the results of following models: $ILLIQ_t = \alpha + \beta \cdot CRD_t + \varepsilon_t$,

where $ILLIQ$ is illiquidity premium and CRD is credit premium.

This table shows the results of the time-series regressions on the relation between illiquidity premium and credit premium. The sample period is from January 2003 to August 2015. The sample period is divided into 4 periods; before the global financial crisis (2003.1～2007.5), during the global financial crisis (2007.6～2010.4), during the European national debt crisis (2010.5～2012.9), and after the European national debt crisis (2012.10～2015.8). The average betas of portfolio are calculated by averaging the estimated betas using at least 60 months data from the starting point of January 2003 so that risk premium is generated from January 2008. Risk premium is calculated by multiplying the average betas of 23 rating and maturity class corporate bond portfolio with the risk prices estimated by Fama-MacBeth regressions. The extended Fama-French 8 factor model is applied and the orthogonal credit level is used as net credit factor. The *t*-values are given in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Constant	β	N	*Adj. R-Squared*
Global Financial Crisis	0.8705***	0.2954**	28	0.119
	(3.930)	(2.158)		
European National Debt Crisis	6.6105***	-3.0985***	29	0.499
	(5.928)	(-5.377)		
After the European National Debt Crisis	3.2132***	-1.4596***	35	0.980
	(56.934)	(-40.454)		
Full Period	1.9536***	-0.5905***	92	0.195
	(9.305)	(-4.796)		

Table 8 Relation between risk premium and economic situations

This table shows risk premium for each factor and its contribution to total risk premium in three different economic situations. Each risk premium is the arithmetic average of risk premium calculated monthly. The sample period is from January 2003 to August 2015. The sample period is divided into 4 periods; before the global financial crisis (2003.1～2007.5), during the global financial crisis (2007.6～2010.4), during the European national debt crisis (2010.5～2012.9), and after the European national debt crisis (2012.10～2015.8). The average betas of portfolio are calculated by averaging the estimated betas using at least 60 months data from the starting point of January 2003 so that risk premium is generated from January 2008. Risk premium are calculated by multiplying the average betas of 23 rating and maturity class corporate bond portfolio with the risk prices estimated by Fama-MacBeth regressions. The extended Fama-French 8 factor model is applied and the orthogonal credit level is used as net credit factor. The *t*-values are given in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: Global Financial Crisis				
	IR	*CRD*	*ILLIQ*	Total
Level		0.69	1.41	2.11
		(20.7)	(42.2)	(62.8)
Steepness	0.38	0.29	0.05	0.72
	(11.4)	(8.6)	(1.5)	(21.5)
Concavity	0.07	0.58	-0.13	0.52
	(2.2)	(17.3)	(-3.9)	(15.6)
Total	0.46	1.56	1.33	3.35
	(13.6)	(46.6)	(39.7)	(100.0)
Panel B: European National Debt Crisis				
	IR	*CRD*	*ILLIQ*	Total
Level		0.97	0.76	1.72
		(28.7)	(22.3)	(51.0)
Steepness	0.56	0.50	-0.03	1.03
	(16.5)	(14.9)	(-1.0)	(30.4)
Concavity	0.27	0.46	-0.10	0.63
	(8.1)	(13.6)	(-3.1)	(18.6)
Total	0.83	1.93	0.62	3.38
	(24.6)	(57.2)	(18.3)	(100.0)
Panel C: After the European National Debt Crisis				
	IR	*CRD*	*ILLIQ*	Total
Level		0.62	1.01	1.63
		(19.6)	(31.7)	(51.3)
Steepness	0.52	0.48	0.00	1.00
	(16.5)	(15.0)	(-0.1)	(31.4)
Concavity	0.15	0.45	-0.05	0.55
	(4.7)	(14.0)	(-1.4)	(17.3)
Total	0.68	1.54	0.96	3.18
	(21.2)	(48.6)	(30.2)	(100.0)

Table 9 Risk premiums between high quality bonds and low quality bonds

This table shows the changes of the term structure of risk premiums and the differences in risk premiums between high quality bonds and low quality bonds depending on the economic situations. we estimate the differences in risk premiums between AA rating portfolio and BBB rating portfolio according to the economic situations and remaining maturities. Remaining maturities are classified to short term (1~3 years), medium term (5~7 years) and long term (7~10 years). The differences in risk premiums between AA rating portfolio and BBB portfolio are calculated by averaging arithmetically the differences in risk premiums of portfolio estimated monthly. The differences in risk premiums of two portfolios are calculated monthly by multiplying the differences of factor betas of AA and BBB rating portfolios across each maturity estimated by time-series regressions with the risk prices of each factor estimated by Fama-MacBeth cross-section regressions. The extended Fama-French 8 factor model is applied and the orthogonal credit level is used as net credit factor. The monthly betas of rating and maturity class corporate bond portfolio are estimated using the data from January 2003 until the previous month when the betas are estimated.

	Short Term				Middle Term				Long Term			
	IR	CRD	ILLIQ	Total	IR	CRD	ILLIQ	Total	IR	CRD	ILLIQ	Total
Panel A: Global Financial Crisis												
Level		0.33	0.41	0.74		0.25	0.13	0.37		0.21	0.17	0.38
		(27.5)	(34.5)	(61.9)		(15.2)	(7.8)	(23.0)		(11.2)	(8.8)	(20.0)
Steepness	0.40	0.57	-0.08	0.89	0.03	0.56	-0.01	0.58	-0.54	0.55	0.17	0.18
	(33.2)	(48.0)	(-6.8)	(74.5)	(2.0)	(34.5)	(-0.6)	(35.9)	(-28.1)	(28.8)	(8.8)	(9.5)
Concavity	-0.19	-0.66	0.41	-0.43	0.08	0.25	0.34	0.67	0.02	0.87	0.45	1.34
	(-15.8)	(-55.1)	(34.5)	(-36.4)	(5.2)	(15.3)	(20.6)	(41.1)	(1.3)	(45.5)	(23.8)	(70.5)
Total	0.21	0.24	0.74	1.19	0.12	1.05	0.45	1.62	-0.51	1.63	0.79	1.91
	(17.4)	(20.4)	(62.2)	(100.0)	(7.2)	(65.0)	(27.8)	(100.0)	(-26.8)	(85.5)	(41.3)	(100.0)
Panel B: European National Debt Crisis												
Level		0.36	0.02	0.38		0.47	0.10	0.57		0.46	0.30	0.75
		(26.6)	(1.3)	(27.9)		(25.1)	(5.4)	(30.5)		(22.7)	(14.7)	(37.4)
Steepness	0.63	0.74	-0.01	1.36	0.00	0.68	0.09	0.78	-0.49	0.63	0.30	0.44
	(46.0)	(53.8)	(-0.5)	(99.3)	(0.2)	(36.7)	(5.0)	(42.0)	(-24.3)	(31.5)	(14.7)	(21.8)
Concavity	-0.23	-0.16	0.02	-0.37	0.28	0.18	0.05	0.51	0.33	0.36	0.13	0.82
	(-16.9)	(-11.6)	(1.3)	(-27.2)	(15.0)	(9.6)	(2.9)	(27.5)	(16.4)	(17.8)	(6.6)	(40.8)
Total	0.40	0.94	0.03	1.37	0.28	1.33	0.25	1.86	-0.16	1.45	0.73	2.02
	(29.1)	(68.7)	(2.2)	(100.0)	(15.2)	(71.4)	(13.4)	(100.0)	(-7.9)	(71.9)	(36.1)	(100.0)
Panel C: After the European National Debt Crisis												
Level		0.35	0.03	0.38		0.36	0.31	0.67		0.32	-0.01	0.31
		(27.5)	(2.6)	(30.1)		(26.6)	(22.7)	(49.3)		(43.6)	(-1.1)	(42.5)
Steepness	0.87	0.55	-0.02	1.40	0.29	0.55	-0.01	0.83	-0.02	0.48	-0.01	0.46
	(68.3)	(43.4)	(-1.9)	(109.8)	(21.2)	(40.5)	(-1.0)	(60.7)	(-2.2)	(66.1)	(-1.1)	(62.9)
Concavity	-0.23	-0.32	0.03	-0.51	-0.04	-0.16	0.06	-0.14	-0.05	-0.06	0.07	-0.04
	(-17.7)	(-24.8)	(2.6)	(-39.8)	(-2.7)	(-11.8)	(4.6)	(-10.0)	(-6.5)	(-8.7)	(9.9)	(-5.4)
Total	0.65	0.59	0.04	1.28	0.25	0.75	0.36	1.36	-0.06	0.73	0.06	0.73
	(50.6)	(46.2)	(3.3)	(100.0)	(18.4)	(55.3)	(26.3)	(100.0)	(-8.7)	(100.9)	(7.8)	(100.0)