Common Factors in the Pricing of European Corporate High Yield Bonds

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Abstract

We examine the impact of common factors in the pricing of European corporate high yield bonds across ratings, maturities and industries. We create a composite illiquidity measure from activity-based and price-based illiquidity proxies from 1,112 sample bonds. We analyse the illiquidity component of bond excess returns over the period 2000 to 2016. Our results identify illiquidity as an important factor, and suggest that high yield bonds exhibit higher illiquidity than their investment grade counterparts. Illiquidity increases after the onset of the distress period while the term factor seems to deteriorate. We also report higher illiquidity of financial firms compared to non-financial ones.

1. Introduction

Stricter regulations imposed on European banks made bank loans more difficult to obtain. The European corporate bond market has gradually become an alternative to traditional bank loans (Aussenegg et al., 2015). During the period from January 2012 to the first quarter of 2016, the amount of bank loans have decreased by €471 billion. During the same period, European non-financial companies had issued corporate bonds with a net value of €344 billion (BlackRock, 2016). Therefore, corporate bonds have played a pivotal role in European corporate debt financing.

Previous research have investigated the association between illiquidity and bond returns focusing on the U.S. corporate bond market (Chen et al., 2007; Bao et al., 2011; Lin et al., 2011; Dick-Nielsen et al., 2012; Friewald et al., 2012; Acharya et al., 2013; Bongaerts et al., 2017). Evidence from the European markets primarily focus on investment grade bonds (Houweling et al., 2005; Aussenegg et al., 2015, 2017). High yield bonds are essential for balancing asset portfolios, due to their unique characteristics and illiquidity risk across different economic conditions, yet they received no attention in the literature. The objective of this paper is to examine the impact of illiquidity risk on European high yield bond returns. The paper also contributes to the literature by examining the effect of illiquidity on bond excess returns across ratings, maturities, and industries.

2. Literature and working hypotheses

Chen et al. (2007) and Bao et al. (2011) show that illiquidity plays a vital role in determining U.S. corporate yield spreads, and document that bonds with a higher degree of illiquidity are accompanied by higher yield spreads. Houweling et al. (2005) use nine bond liquidity measures, derived from bond characteristics and trading activities, to determine the presence of liquidity premium in European corporate investment grade bonds in the period 1st January 1999 to 31st May 2001. Finding around 13 to 23 basis points from the liquidity premia. Furthermore, Aussenegg et al. (2015) conclude that illiquidity risk is an important determinant of European corporate investment grade bond returns. Normally, high yield bonds are traded less frequently compared to their investment grade counterparts. We therefore anticipate that illiquidity risk will play an important role in the pricing of European high yield bonds. Thus,

Hypothesis 1: *Illiquidity risk is priced in the European corporate high yield bond market.*

Expected corporate bond returns tend to be affected by economic conditions. For example, returns tend to be higher during recessions and lower during economic booms (Fama and French, 1989). Furthermore, Longstaff (2004) and Beber et al. (2009) find that investors tend to prefer liquid assets during periods of economic and financial crisis. Dick-Nielsen et al. (2012) and Friewald et al. (2012) report different OLS coefficients for high yield bonds' illiquidity before and during the recent financial crisis. Acharya et al. (2013) adopt the Markov regime switching model to demonstrate that there is a significant difference in illiquidity between high yield and investment grade bonds under two different regimes. Bond prices are not significantly influenced by illiquidity in "normal" periods. However, prices of high yield bonds tend to fall significantly in "stress" periods. The authors explain this results with the phenomenon of "flight to liquidity" and "flight to quality". Aussenegg et al. (2017) demonstrate that illiquidity risk has a time-varying influence on European corporate investment grade bond returns, using a threshold model. Owing to a greater quality of investment grade bonds, they tend to be more popular than high yield bonds during crisis periods, and it is therefore expected that prices of European high yield bonds will decrease substantially in times of financial stress. Thus,

Hypothesis 2: *Illiquidity effect on European high yield bond returns is time-varying.*

3. Data and sample selection

The primary data source used in this paper is Bloomberg Terminal Database. The sample is limited to active and matured corporate bonds which are denominated in Euro currency and were issued between 1st January 2000 and 31st December 2016. We consider only fixed coupon bonds and bullet type of maturity. Bonds with options (e.g. callable, puttable, convertible, and sinking funds) are excluded due to their complexities (Lin et al., 2011; Aussenegg et al., 2015). Our sample bonds are rated as high yield grades by at least one of the following agencies: Standard & Poor's (S&P), Moody's, Fitch, (see Appendix A, Table A.1, Panel A).[1] Furthermore, bonds with a term to maturity less than one year are excluded due to their low liquidity and potentially high pricing errors (Lin et al., 2011; Aussenegg et al., 2015). Bonds without annual or semi-annual frequency of coupon payments, as well as these with no daily clean prices available are excluded from our sample. All ratings remain unchanged during the sample period. In line with Dick-Nielsen et al. (2012), we start with S&P rating, if this rating is not available, Moody's or Fitch ratings are applied. If there are still some missing bond ratings, the issuer's ratings are used. Bonds are excluded from the sample, in cases where ratings are not identified either from bond's ratings or issuer's ratings. If bond or issuer ratings belong to an investment grade level by any of the credit rating agencies, then these bonds are also eliminated from the sample due to mismatch ratings. Furthermore, we use price filters to remove bond outliers or potential errors from the sample. Filters include prices below €1 or over €500, bid prices or ask prices being negative, or ask prices being higher than bid prices. If there are over 50% of observations having month-end missing or stale prices, or having month-end bid prices higher than ask prices, these bonds are also removed from the sample. The above sample selection criteria resulted in a sample of 1,112

[1] In cases where bond ratings are not available, we use issuers ratings of the same agencies.

high yield bonds (see Appendex A, Table A.1, Panel B).[2]

Insert Table A.1 about here

4. Methodology

4.1. *Excess bond returns*

We calculate monthly excess returns based on the formula that is used in Gebhardt et al. (2005); Lin et al. (2011); Acharya et al. (2013); Jostova et al. (2013); Aussenegg et al. (2015)

$$EBR_{i,t} = \frac{(P_{i,t} + AI_{i,t} + C_{i,t}) - (P_{i,t-1} + AI_{i,t-1})}{P_{i,t-1} + AI_{i,t-1}} - Eur_{i,t-1} \qquad (1)$$

Where $EBR_{i,t}$ is the monthly excess return for bond i as of time t, $P_{i,t}$ is quoted month-end price of bond i in month t, $AI_{i,t}$ is month-end accrued interest in month t, $C_{i,t}$ is annual or semi-annual coupon payment incurred for bond i during month t (if any). $Eur_{i,t-1}$ is the one month Euribor rate at month t-1. Euribor rate is based at a continuously compounded rate. According to Biais (2006), quoted prices are reasonably close to transaction prices. We therefore use quoted month-end prices from Bloomberg. One month Euribor rates are downloaded from Bloomberg.

4.2. *TERM factor*

TERM factor is used to measure the spread of the expected interest rates. The higher the TERM factor coefficient, the higher the excess returns. TERM factor is defined as the difference between the yield of long-term government bonds, and the yield of one previous Treasury bill rate in the context of U.S. (Fama and French, 1993; Gebhardt et al., 2005; Lin et al., 2011; Acharya et al., 2013). In addition, TERM factor is defined as the monthly log return on the iBoxx German government bond index, minus the one month Euribor rate from the previous month. We use the difference between the German government bond index (with maturity of 7 years) and the one month Euribor rate in the previous month to proxy for the TERM factor. Yield of German government bonds are downloaded from DataStream Database.

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[2]Additional price filters are tried. For example, the nine-trading-day median centred at the trading day is used to replace the clean price (Dick-Nielsen, 2009). If the number of daily median used to replace accounts for over 10% of the observations, these bonds are deleted from the sample (Friewald et al., 2012). However, there are only few observations that would be identified by the nine-trading day median value. Hence, the median filter is not appropriate for high yield bonds and not applied in our study.

4.3. *DEF factor*

DEF factor is used to measure the riskiness of the bond above the risk-free rate. Fama and French (1993) use the difference between the returns of long-term corporate bonds and the returns of long-term government bonds to measure the DEF factor. Gebhardt et al. (2005) and Lin et al. (2011) use the difference between the long-term investment grade bond returns and the long-term government bond returns to proxy for the DEF factor. Acharya et al. (2013) use the difference between monthly returns on corporate bond portfolio and average returns on government bonds. Aussenegg et al. (2015) use the difference between corporate composite index and matched Euro zone Sovereign bond index to measure the DEF factor. Additionally, Aussenegg et al. (2017) use the difference between corporate composite index and the matched German government bond index to capture the DEF factor. Thus, we use the difference between iBoxx Euro overall index (with the maturity of 7-10 years) and the German government bond index with the maturity of 7 years as a proxy for DEF factor. Yield of iBoxx Euro overall index (with maturity of 7-10 years) are downloaded from DataStream Database.[3]

4.4. *Illiquidity measures*

Illiquidity is unobserved and, as such, different illiquidity proxies are used in the related literature. A single measure is not enough to capture all the dimensions of market illiquidity. We use several measures in order to capture the illiquidity of the European high yield bond market. Furthermore, a composite illiquidity measure is created from activity-based and price-based illiquidity proxies, as bond-related measure (e.g. age) fails to capture the aggregate level of the illiquidity effect, and behaves oddly compared to other illiquidity measures.

4.4.1. *Fraction of zero returns (FZR)*

FZR is an activity-based illiquidity measure. Bonds with higher FZR values are more likely to be traded less frequently, and therefore, they are more illiquid compared to their counterparts. We first calculate the fraction of zero returns for each individual bond i in month t, using the formula of Aussenegg et al. (2017).

$$FZR_{i,t} = \frac{NZR_{i,t}}{NTD_{i,t}} \tag{2}$$

Where $FZR_{i,t}$ is the proportion of the number of observations with zero returns in the available trading days for bond i in month t. $NZR_{i,t}$ is the number of zero return days in

[3] Possible implication of using iBoxx Euro overall index construction of DEF does not include high yield bonds. This may introduce a slightly downward bias.

month t for bond i, and $NTD_{i,t}$ is used to count the available trading days in month t for bond i.

Clean prices are used to calculate daily returns. Letting $r_{i,\tau}$ being the return on trading day τ for bond i, and $P_{i,\tau}$ being the clean price of bond i on trading day τ, then,

$$r_{i,\tau} = \frac{p_{i.\tau} \quad - p_{i,\tau}}{p_{i,\tau}} \tag{3}$$

Secondly, we calculate the FZR for each grouping (i.e. rating, maturity, industry, by aggregating individually):

$$FZR_{k,t} = \sum_{i=1}^{n} (FZR_{i,t} \frac{MV_{i,t}}{\sum_{i=1}^{n} MV_{i,t}}) \tag{4}$$

Where $FZR_{k,t}$ is the fraction of zero returns for each index k in month t weighted by market value, n is used to denote the number of bonds included in the group during month t, and $MV_{i,t}$ denotes the market value at the end of the month t.[4]

4.4.2. *Roll measure*

We follow the same version of Roll (1984) illiquidity measure as in Aussenegg et al. (2017) for each individual bond i in month t.

$$Roll_{i,t}^{KL} \;=\; 2 \cdot \sqrt{|cov\,(r_{i,\tau}, r_{i,\tau-1})|} \tag{5}$$

where $cov\,(r_{i,\tau}, r_{i,\tau-1})$ is the first order autocovariance of the two consecutive daily returns in month t. $Roll_{i,t}^{KL}$ denotes the Kim and Lee (2014) approach of the Roll measure. Higher bid ask spreads give rise to higher Roll values. Therefore, bonds with higher Roll values are inclined to be illiquid.

4.4.3. *Bid ask spreads*

We also use bid ask spreads as price-based illiquidity proxies. Higher spreads reflect that bonds are less popular and thus more illiquid. We calculate bid ask spreads as in (European-Commission, 2017, p. 173).

$$Bid\ ask\ spread_{i,t} = \frac{\sum_t \frac{ask_{i,\tau} \;-\; bid_{i,\tau}}{mid_{i,\tau}}}{number\ of\ daily\ observations\ in\ month} \times\ 100 \tag{6}$$

Where $ask_{i,\tau}$, $bid_{i,\tau}$, $mid_{i,\tau}$ are daily ask price, bid price, and mid price for bond i. Bloomberg database define the $mid_{i,\tau}$ as the average of the $ask_{i,\tau}$ and $bid_{i,\tau}$. $Bid\ ask\ spread_{i,t}$ is the average of the monthly spread for bond i in month t in percentage.

[4]Bloomberg provides the history data of the amount outstanding that starts from January 2003

Bid and ask prices are downloaded from Bloomberg Terminal Database by using Bloomberg Generic Prices (BGN) and Bloomberg Valuation Service (BVAL) pricing sources. If the price is not available from BGN pricing source, we use the BVAL pricing source to acquire more available prices. Spreads are usually not available for all bonds in the sample. Chen et al. (2007) also report similar issues when dealing with spreads, particularly for bonds with low trading frequency or for those approaching maturity.

4.4.4. *Age*

The age of a bond defined as the number of months between the issue date and quote date, is normally used as an illiquidity proxy for a bond. When a bond becomes older, it is traded less frequently, and it seems to be less liquid. Once older bonds are traded infrequently, they are most probably put in buy-and-hold portfolios. The prominent liquidity premium occurs when the age of the bond is between 4 to 24 months, and they arbitrarily choose 12 months as the measure of the bond age threshold (Houweling et al., 2005).

4.4.5. *Composite illiquidity measure*

Given that FZR, Roll, and bid ask spreads have different scales, we initially normalise them to a common scale as in Dick-Nielsen et al. (2012).

$$\widetilde{L}_{it}^{j} = \left(L_{it}^{j} - \mu^{j}\right) / \sigma^{j} \tag{7}$$

Where L_{it}^{j} is the measure of j for bond i at month t, j is an index for bid ask spreads, Roll, and FZR measure. μ^{j} and σ^{j} are the mean and standard deviation of the L^{j}, respectively. Then we conduct a principal component analysis in order to extract the main factors of the illiquidity measures. Then we conduct LAMBDA as the sum of the normalised illiquidity proxies multiplied by their respective first principal component eigenvectors. The higher the LAMBDA, the more illiquid the bonds.

4.5. *Illiquidity augmented Fama and French factor model*

We start with OLS illiquidity augmented Fama and French factor model (Fama and French, 1993), as in Aussenegg et al. (2017):

$$\Delta Bond\ Index_{k,t} = a + \beta_{k,T} \cdot TERM_t + \beta_{k,D} \cdot DEF_t + \beta_{k,L} \cdot LAMBDA_t + \varepsilon_{k,t} \tag{8}$$

Where ΔBond $Index_{k,t}$ represents the monthly excess return for bond index k as of time t. $TERM_t$ defines the difference between the yield of German government bond index with a maturity of 7 years at month t and the one month Euribor rate at month t-1. DEF_t is the difference between the yield of monthly iBoxx European overall bond index with a maturity of 7 to 10 years, and the yield of German government bond index with a maturity of 7 years at month t. The composite illiquidity measure is the sum of the normalised bid ask spreads multiplied by its first principal component eigenvector, the normalised Roll multiplied by its first principal component eigenvector, and the normalised FZR multiplied by its first principal component eigenvector.

5. Results

5.1. *Excess bond returns*

The sample descriptive statistics by bond composite, ratings, maturities, and industries is presented in Table A.2.[5] The sample comprises of 1,112 European high yield bonds for the period 1st January 2000 to 31st December 2016. Bonds with BB ratings contribute the largest number of constituents (958 bonds) to the sample. Bonds with B ratings exhibit the highest modified duration among rating classes (3.99). Bonds with a longer term to maturity tend to exhibit a higher modified duration and excess returns. Credit quality is correlated with yield to maturity and excess returns, except in the case of the Rating CCC and below group. As expected, the financial sector is dominated by bonds issued by banks. Excess returns from the Non-financial sector are higher than those from the Financial sector, in line with the results for the investment grade bond market reported in Aussenegg et al. (2017). The Consumer Discretionary industry provides the highest excess return among the industries. Government-related bonds are represented by 141 bonds, and their bonds are issued by winding up agencies, government agencies, and government development banks. The Material and Utility industries have 66 and 38 bonds in the sample, respectively, a relatively higher number of bonds compared to their counterparts, apart from the Government industry, this might be due to their capital intensive features, as they require a larger amount of capital to maintain the operation of business. Overall, there is a decisive violation of normality in the distribution of excess bond returns across the ratings, maturities, and industries.

Insert Table A.2 about here

5.2. *Illiquidity proxies*

Table A.3 presents the descriptive statistics for our five illiquidity measures categorised by ratings, maturities, and industries based on market value weighted. The FZR descriptive statistics are shown in (Table A.3, Panel A). The mean of the FZR is 9.065 in high yield

[5] There are only 4 bonds in the Rating CC and below group, so we combine Rating CCC with Rating CC and below.

bond composite index, this is much higher than in the investment grade bond composite (1.114%), which is presented in Aussenegg et al. (2017), suggesting that the overall illiquidity in the high yield bond market is relatively high. The median of FZR measure of the bond composite is 0%, this is in line with Dick-Nielsen et al. (2012), they report a 0% for the median number of zero-trading days based on firm level data between January 2005 and June 2009. Furthermore, the maximum value of the FZR per month for the high yield bonds composite is 100%.[6] These results suggest that some sample bonds are traded infrequently, and some bonds are traded on a daily basis. The mean of the FZR increases with decreased credit rating. For example, the mean of the FZR for Rating CCC and below is almost twice as high compared to Rating BB. The maturity 1-3 years index shows the highest mean FZR among the maturity indices (20.804%), Financial high yield bond issuers have higher FZR measures compared to the non-financial index. Aussenegg et al. (2017) also find similar results in their sample of the investment grade bonds.

The Roll descriptive statistics are presented in (Table A.3, Panel B). A lower credit quality and longer term to maturity are likely to be accompanied with a higher Roll value. Financial bond issuers show higher Roll measures compared to their non-financial counterparts. Aussenegg et al. (2017) find similar results in their investment grade bonds. As expected, high yield bonds appear to have higher Roll measures than the investment grade bonds. For example, the mean of the high yield bond composite is 0.262% compared to 0.194% in Aussenegg et al. (2017).

The bid ask spread descriptive statistics are presented in (Table A.3, Panel C). Higher credit ratings are more likely to have lower spreads. Bid ask spreads increase with the term to maturity. An exception is maturity 3-5 years with the lowest bid-ask spreads. Financial index has a higher bid ask spread than the non-financial index.

The age descriptive statistics are presented in (Table A.3, Panel D) The average age of bonds in the sample is less than 3 years. Rating B has the highest age among rating groups (3.090 years), this is in line with the sample descriptive statistics results.[7]

Table A.3, Panel E presents the composite illiquidity measure (LAMBDA) descriptive statistics. The LAMBDA is the sum of the normalised bid ask spreads multiplied by its first principal component eigenvector (0.615), the normalised Roll multiplied by its first principal component eigenvector (0.760), and the normalised FZR multiplied by its first principal component eigenvector (-0.208). Each group is constructed on market value weighted. The median of the LAMBDA increases with decreased credit ratings. For example, the median for Rating CCC and below (-0.057) is higher than the Rating BB (-0.176). The longer the term to maturity, the higher the median value of the LAMBDA.

[6] Acharya et al. (2013) report that the maximum of quarterly bond zero-trading days is 96.8% in their sample of investment and high yield bonds.

[7] Rating B has the highest term to maturity in rating groups (the average of the term to maturity in the Rating B group is 9.92 years, Rating BB is 7.6 years, and Rating CCC and below is 6.81 years).

Overall, European high yield bonds are less liquid than their investment counterparts. Bonds with lower credit ratings exhibit higher illiquidity for all measures. Bonds issued by financial issuers appear less liquid than those issued by non-financial issuers for all measures. The effect of term to maturity on the FZR is different compared to other measures: the longer the term to maturity, the lower the FZR measure; the longer the term to maturity, the higher the Roll value, bid ask spreads and age value.

Insert Table A.3 about here

We also plot the fluctuation of the FZR, Roll, bid ask spreads, and age proxies over time. If appropriate, the illiquidity proxies should all depict well documented extremes during the recent financial crisis. Figure A.1a presents the fluctuation of Roll, bid ask spreads and FZR measures during the sample period. Roll and bid ask spread measures tend to have a similar trend over time, as they both are price-based illiquidity measures. The FZR measure seems to have a lagged effect compared to the Roll measure over time, which might explain the negative correlation between Roll and FZR measures. Leman Brothers announced its bankruptcy officially on 15 September 2008, Roll and bid ask spread respond to the market promptly and reach a new peak, followed by the FZR measure, none of them exhibit persistently. Then in June 2009, Roll and FZR measures tend to be back to the similar levels as the pre-financial crisis, in line with findings in Dick-Nielsen et al. (2012). Since January 2014, there is an increase in the number of zero returns per month. (European-Commission, 2017, p. 60) presents the trend of the bid ask spreads of European high yield bonds is similar to our time series of bid ask spreads. As they do not filter their prices, their graph appears to have higher extreme values.

Insert Figure A.1a about here

Figure A.1b presents the pattern of age measure between 2000 and 2016 and shows a monotonic increase in number of years after May 2011. Age seems to be at odds with other proxies. There are two potential reasons that cause an increase in number of years for the aggregate level of the age. One is illiquidity: older bonds are inclined to be traded less frequently. The second is associated with the year of issuing bond and its term to maturity. For example, some companies prefer to issue bonds with a longer term to maturity to lock into the low interest rate. Therefore, age is not appropriate to the aggregate level of illiquidity measure, and will not be used in further analysis.

Insert Figure A.1b about here

5.3. *Common factors*

Figure A.2 presents the trend of the excess bond returns, composite illiquidity measure (LAMBDA), TERM, DEF factors from January 2000 to December 2016. After 2008, the volatility of the excess bond returns and a few peaks of the LAMBDA, might be due to the recent financial crisis and European sovereign debt crisis. According to Bisschop et al. (2016), Federal Chairman Ben Bernanke gave a speech to the U.S. congress, and stated that the Federal planned to reduce the monthly asset purchases of the QE program. Although the statement was the implication of potential changes in the future policy, the market response was prompt, and the yield of European corporate bonds increased. Taper Tantrum was named after the announcement and started on 22nd May 2013. Our graph of the monthly excess bond returns capture this Taper Tantrum effect by displaying a peak in May 2013. In January 2015, the European central bank announced and began to expand asset purchases, bond yields dropped significantly and the euro area experienced a phenomenon of market stress in April 2015, in mid-April, it is rumoured that the European central bank planned to stop purchasing bonds, and the yields of bonds increase swiftly (Bisschop et al., 2016). Our graph of the monthly excess bond returns also reflects these troughs and peaks in 2015. The pattern of the TERM captures the fluctuation of the expected interest rates. After September 2008, the expected interest rates present an overall decreasing trend. The peak of the DEF factor also captures the effect of the recent financial crisis and European sovereign debt crisis on the bond market. Generally, the trends of these risk factors are consistent with Aussenegg et al. (2017).

Insert Figure A.2 about here

Table A.5 presents the pairwise correlation between LAMBDA, TERM and DEF risk factors.[8] According to Acharya et al. (2013), the correlation between DEF and innovation in the bond index is -0.057, they use on-the-run government bonds with a short maturity sample to calculate bid ask spreads. Their illiquidity measure comprises a lower default risk compared to our sample. The correlation between DEF and stock market illiquidity risk is -0.153. They conclude that illiquidity measures both for bond and stock have a clean explanation for illiquidity risks. The correlation among the LAMBDA, TERM, and DEF measures are not strong. The correlation between LAMBDA and TERM shows -0.02, and the correlation between LAMBDA and DEF is 0.13 in our sample, which is weaker than

[8] We also run the pairwise correlation between FZR, Roll, bid ask spreads, and age measures, (see Table A.4) and find that they are generally less correlated to each other at an individual bond level. Roll and Bid ask spreads appear to have a relatively higher correlation than others. The correlation between bid ask spreads and Roll is 0.15. Dick-Nielsen et al. (2012) also find the general illiquidity measures tend to have a weak correlation between each other

0.153 from Acharya et al. (2013). These indicate that the LAMBDA is a clean proxy for illiquidity risk.

Insert Table A.5 about here

5.4. *Illiquidity augmented model*

Table A.6 shows the cross-sectional regression results. Coefficients for LAMBDA are predominantly positive and statistically significant. Additionally, the overall absolute value of the LAMBDA coefficient is higher than the TERM and DEF factors, which demonstrates that illiquidity plays an important role in pricing of high yield bonds. Coefficients for TERM are predominantly negative and statistically significant. DEF is consistently not statistically significant. High yield bonds are already risky, so DEF factor does not play an important role in explaining variability of excess returns. Generally low adjusted R^2 and high intercept suggest that there might be other factors which are important to price high yield bonds.

Insert Table A.6 about here

5.5. *Results before and after financial crisis*

Aussenegg et al. (2015) and Dick-Nielsen et al. (2012) separate their samples into the periods of before and after the financial crisis, and investigate the effects of risk factors into two regimes. We follow their approach and separate our sample into two sub-periods of before and after the financial crisis. The first sub-period of before the financial crisis spans from January 2000 to May 2007, and the second sub-period of after the financial crisis starts from June 2007 to December 2016.

Table A.7 presents the cross-sectional results of the illiquidity augmented Fama French factor model in two subperiods. For regression coefficients of TERM factor, 9 out of 23 are statistically significant before the financial crisis, while 15 out of 24 regression coefficients are statistically significant after the financial crisis. As an increase in term to maturity, the coefficients for TERM factor decrease after the financial crisis. This is the opposite of the results from Aussenegg et al. (2015), they find that the coefficients for TERM factor in their liquidity augmented Fama French factor model, appear to increase with increased term to maturity.

The DEF factors are predominantly positive and 13 out of 23 regression coefficients are statistically significant before the financial crisis, while 7 out of 24 regression coefficients lack statistical significance after the financial crisis. High yield bonds are already risky, especially in times of financial crisis, these bonds tend to be much riskier. Further, due to the effect of flight to liquidity during financial crisis, DEF factor has a vague explanation of the variability of excess high yield bond returns.

In 11 out of 23 regression coefficients for LAMBDA are statistically significant before the financial crisis, and 19 out of 24 regression coefficients for LAMBDA are statistically significant after the financial crisis. Only the coefficients for LAMBDA in Communications (32 bonds), Energy (25 bonds), Health Care (12 bonds), Materials (66 bonds), Technology (6 bonds) industries are not statistically significant after the financial crisis, which might be due to the small number of bonds in these industry groupings. The regression coefficient for LAMBDA in the total sample before the financial crisis is negative, while it is in reverse after the financial crisis. The financial crisis exacerbates the total risk of the high yield bonds, and as expected, investors need additional returns to compensate the extra risks that they are undertaking. For instance, bonds with lower ratings appear to have a higher illiquidity premium, and investors require higher returns from them. As expected, Rating B and Rating CCC and below tend to have higher coefficients of LAMBDA than Rating BB with statistical significance, this is in line with findings from Dick-Nielsen et al. (2012). According to Helwege and Turner (1999), high yield bond issuers are less likely to default and tend to distribute bonds with longer maturity. Particularly after the financial crisis, investors might be more sensitive to risk, therefore investors are more likely to require lower excess returns for long-term high yield bonds than short-term high yield bonds. For instance, bonds with term to maturity over 7 years, the coefficient for LAMBDA drops significantly after the financial crisis. Moreover, the coefficient for LAMBDA in Maturity 10+ years tenure is lower than the Maturity 7-10 years index with statistical significance after the financial crisis.

Insert Table A.7 about here

6. Conclusion and future work

The paper investigates the role of common factors in pricing of European corporate high yield bonds distributed by ratings, maturities, and industries. We create a composite illiquidity measure which is derived from the Roll, bid ask spreads, and FZR based on principal component analysis. As expected, we find that European high yield bonds are more illiquid than their investment counterparts. In addition, there is a negative relation between bond ratings and their illiquidity, and bonds issued by financial firms tend to be more illiquid than those issued by non-financial firms.

We initially run the cross-sectional regression for the whole sample period, the results demonstrate illiquidity is an important factor in high yield bond pricing. The result is in line with our hypothesis 1. DEF factor is consistently not statistically significant. Furthermore, we separate our sample into two sub-periods of before and after the financial crisis and find that illiquidity factor tends to be more prominent and significant in explanation of the variability of high yield bond returns after the financial crisis. The result is in line with our hypothesis 2.

Since we observe significant time variations in coefficients before and after the financial crisis, we intend to use a Markov regime switching model to further examine our hypotheses.

Appendix A: Data

Table A.1

Sample criteria and selection

This table describes the sample criteria and selection process. Panel A presents 2,460 high yield bonds that are downloaded from Bloomberg Terminal Database based on the criterion below. Panel B presents selection requirements and price filters that are used to remove potential pricing errors and outliers. Hence, there are 1,112 high yield bonds left in the sample.

	Panel A. Sample criteria	
	Criteria	Number of bonds
	Active and matured corporate bonds	
And	Euro Currency	
And	Fixed coupon type	
And	Bullet maturity type	
And	Issue between 1^{st} January 2000 and 31^{st} December 2016	
And	S&P Rating (BB+, BB, BB-, B+, B, B-, CCC+, CCC, CCC-, CC, C, D)	
Or	S&P Issuer Rating (BB+, BB, BB-, B+, B, B-, CCC+, CCC, CCC-, CC, C, D)	
Or	Fitch Rating (BB+, BB, BB-, B+, B, B-, CCC+, CCC, CCC-, CC, C, DDD, DD, RD)	
Or	Fitch Issuer Rating (BB+, BB, BB-, B+, B, B-, CCC+, CCC, CCC-, CC, C, DDD, DD, RD)	
Or	Moody's Rating (Ba1, Ba2, Ba3, B1, B2, B3, Caa1, Caa2, Caa3, Ca, C)	
Or	Moody's Issuer Rating (Ba1, Ba2, Ba3, B1, B2, B3, Caa1, Caa2, Caa3, Ca, C)	2460
	Panel B. Sample selection	
	Selection process	Number of bonds
	Number of bonds downloaded from Bloomberg Terminal Database	2,460
Less	Bonds without coupon frequency 1 and 2	202
Less	Bonds with term to maturity less than 1 year	265
Less	Bonds with unavailable daily clean prices	294
Less	Bonds without ratings assigned	115
Less	Bonds with investment grade ratings due to mismatch rating	209
Less	Daily clean, bid, ask price with value below 1 or over 500	3
Less	Over 50% of observations with month-end missing clean, bid or ask prices for each bond	206
Less	Over 50% of observations with month-end stale clean, bid or ask prices for each bond	51
Less	Over 50% of observations that have higher month-end bid than ask price for each bond	2
Less	Bonds were issued in December 2016 (one month price is not available to calculate monthly return)	1
Total		1112

Table A.2

Sample descriptive statistics

This table provides descriptive statistics on market value, yield to maturity, term to maturity, modified duration and monthly excess returns for high yield bonds, which are distributed by bond composite, ratings (Rating BB, Rating B, Rating CCC and below), maturities (Maturity 1-3 years, Maturity 3-5 years, Maturity 5-7 years, Maturity 7-10 years, and Maturity 10+ years) and industries (the Financial sector which includes Banks, Consumer Finance and Others, and the Non-financial sector which includes Communications, Consumer Discretionary, Consumer Staples, Energy, Government, Health Care, Industrials, Materials, Technology, and Utilities). The sample comprises of 1,112 high yield bonds for the period between 1st January 2000 and 31st December 2016, and were downloaded from Bloomberg Terminal Database. The market value per bond, yield to maturity, term to maturity, modified duration and monthly excess returns for each group are averages (means) during the sample period. Market value per bond is calculated by using quoted month-end clean price multiplied by its relevant amount outstanding in month t. Market value per index is computed by using market value per bond multiplied by the number of the composites. Term to maturity (years) is calculated using the actual number of calendar days from issue date to bond final maturity date, which is divided by 365.25 days. Monthly excess returns are the difference between bond returns in month t and the one month Euribor rate in month t-1. Euribor rate is based at a continuously compounded rate. The numbers in the bracket show the value in median. Excess kurtosis is the difference between the value of kurtosis and 3. Skewness and kurtosis normality test is used. ** represents at 1% significance level.

Sample bonds	Number of bonds	Market value per index (billion €)		Market value per bond (million €)		Yield to maturity (% p.a.)		Term to maturity (years)		Modified duration (years)		Monthly excess return (p.m)						
												Mean (%)	Median (%)	Std.Dev. (%)	Min (%)	Max (%)	Excess Kurtosis	Skewness
Total sample	1112	38364.00	(11231.20)	34500.0	(10100.0)	4.31	(3.49)	7.26	(6.00)	3.09	(2.43)	0.51	0.33	4.59	-81.39	163.90	199.53**	4.11**
Rating BB	958	34200.60	(9359.66)	35700.0	(9770.0)	4.01	(3.31)	7.23	(5.50)	3.09	(2.43)	0.51	0.33	4.39	-81.39	163.90	238.59**	4.3**
Rating B	45	1854.00	(1597.50)	41200.0	(35500.0)	7.52	(5.60)	9.55	(10.00)	3.99	(3.91)	0.85	0.52	6.97	-52.24	125.43	56.34**	2.67**
Rating CCC and below	109	1842.10	(547.18)	16900.0	(5020.0)	5.32	(4.27)	6.14	(5.00)	2.54	(1.82)	0.33	0.32	4.60	-67.58	103.58	127.49**	3.98**
Maturity 1-3 years	263	1383.38	(149.91)	5260.0	(570.0)	3.09	(2.74)	2.09	(2.00)	0.95	(0.92)	0.43	0.29	1.22	-11.89	18.49	28.78**	0.74**
Maturity 3-5 years	276	5658.00	(695.52)	20500.0	(2520.0)	3.23	(2.68)	3.36	(3.00)	1.48	(1.44)	0.37	0.25	2.28	-43.57	103.58	640.68**	13.29**
Maturity 5-7 years	235	10645.50	(4535.50)	45300.0	(19300.0)	3.78	(3.16)	5.23	(5.00)	2.36	(2.43)	0.45	0.30	3.00	-67.58	79.53	171**	2.39**
Maturity 7-10 years	138	7093.20	(7189.80)	51400.0	(52100.0)	4.32	(3.33)	7.29	(7.00)	3.71	(3.95)	0.51	0.39	3.99	-72.05	77.83	79.97**	1.61**
Maturity 10+ years	200	7400.00	(4880.00)	37000.0	(24400.0)	5.84	(4.83)	13.01	(10.00)	5.84	(5.58)	0.67	0.46	6.95	-81.39	163.90	104.4**	3.09**
Financials	704	18163.20	(3139.84)	25800.0	(4460.0)	4.31	(3.47)	5.69	(5.00)	2.22	(1.67)	0.45	0.32	3.68	-67.58	103.58	105.22**	2.95**
Banks	656	14825.60	(2086.08)	22600.0	(3180.0)	4.02	(3.31)	5.60	(4.50)	2.18	(1.64)	0.46	0.32	3.43	-67.58	103.58	107.3**	2.44**
Consumer Finance	36	2365.20	(1620.00)	65700.0	(45000.0)	7.98	(5.59)	6.53	(5.00)	2.23	(1.84)	0.40	0.19	5.99	-43.57	78.91	62.05**	4**
Others	12	637.20	(417.60)	53100.0	(34800.0)	6.19	(4.30)	7.33	(7.00)	3.99	(3.88)	0.51	0.31	4.41	-36.34	37.34	33.03**	-0.11
Non-financials	408	17911.20	(17136.00)	43900.0	(42000.0)	4.30	(3.51)	9.00	(7.10)	3.98	(3.55)	0.57	0.35	5.40	-81.39	163.90	191.17**	4.22**
Communications	32	2646.40	(2451.20)	82700.0	(76600.0)	3.81	(3.70)	12.76	(7.00)	5.24	(4.02)	0.50	0.30	2.40	-14.43	15.72	5.85**	0.03**
Consumer Discretionary	37	2508.60	(2023.90)	67800.0	(54700.0)	5.25	(4.40)	8.97	(7.00)	3.86	(3.49)	0.73	0.47	5.09	-52.24	125.43	184.33**	6.01**
Consumer Staples	30	2055.00	(1932.00)	68500.0	(64400.0)	3.04	(2.94)	9.31	(7.00)	4.40	(3.50)	0.43	0.25	2.53	-15.50	63.49	216.75**	9.02**
Energy	25	1905.00	(1750.00)	76200.0	(70000.0)	5.52	(4.33)	8.79	(10.10)	4.51	(4.54)	0.57	0.59	4.21	-29.10	34.33	12.39**	-0.38**
Government-related	141	892.53	(116.89)	6330.0	(829.0)	4.86	(3.36)	8.81	(8.00)	3.35	(2.68)	0.63	0.32	7.82	-81.39	163.90	109.43**	3.31**
Health Care	12	552.00	(600.00)	46000.0	(50000.0)	1.81	(1.72)	7.23	(7.00)	5.14	(5.08)	0.68	0.68	1.36	-5.03	5.23	2.26**	-0.09
Industrials	21	1394.40	(1293.60)	66400.0	(61600.0)	4.02	(3.99)	10.84	(10.00)	5.49	(5.30)	0.54	0.51	3.30	-21.95	19.35	8.82**	-0.53**
Materials	66	3702.60	(3418.80)	56100.0	(51800.0)	3.62	(3.22)	7.25	(7.00)	3.94	(3.97)	0.59	0.42	3.16	-29.06	44.44	33.89**	1.44**
Technology	6	399.60	(325.80)	66600.0	(54300.0)	5.03	(4.59)	7.37	(5.10)	3.12	(2.96)	0.57	0.37	3.63	-16.95	23.43	14.09**	0.4**
Utilities	38	2200.20	(1976.00)	57900.0	(52000.0)	3.67	(3.54)	8.71	(7.30)	3.64	(3.47)	0.35	0.28	2.13	-19.06	18.88	15.25**	0.09*

Table A.3

Illiquidity measures

This table presents descriptive statistics for FZR (Panel A), Roll (Panel B), Bid ask spread (Panel C), age (Panel D), and LAMBDA (Panel E) during period January 2000 to December 2016. FZR is the proportion of trading days with zero returns for each month. Daily bond clean price data is used to compute FZR and Roll, daily bid price and ask price are used to estimate the spread, this data is provided by Bloomberg Terminal database. Age of the bonds is defined as the difference between their issue date and quote date. The LAMBDA measure is the sum of the normalised bid ask spreads multiplied by its first principal component eigenvector (0.6158), the normalised Roll multiplied by its first principal component eigenvector (0.7599), and the normalised FZR multiplied by its first principal component eigenvector (-0.2081). The illiquidity measures for each index are estimated based on the month-end market value weighted.

Panel A: FZR measure (%)

Sample bonds	**Number of bonds**	**Mean**	**Median**	**Std.Dev**	**Min**	**Max**
Total sample	1112	9.065	0.000	19.619	0.000	100.000
Rating BB	958	8.273	0.000	18.355	0.000	100.000
Rating B	45	15.345	4.348	26.482	0.000	100.000
Rating CCC and below	109	16.145	4.348	28.135	0.000	100.000
Maturity 1-3 years	263	20.804	4.348	32.022	0.000	100.000
Maturity 3-5 years	276	10.911	0.000	23.935	0.000	100.000
Maturity 5-7 years	235	7.979	0.000	17.953	0.000	100.000
Maturity 7-10 years	138	9.916	0.000	19.233	0.000	100.000
Maturity 10+ years	200	8.265	0.000	18.619	0.000	100.000
Financials	704	10.384	0.000	21.783	0.000	100.000
Banks	656	11.227	0.000	22.878	0.000	100.000
Consumer Finance	36	5.071	0.000	13.989	0.000	100.000
Others	12	13.957	4.762	20.764	0.000	100.000
Non-financials	408	8.216	0.000	18.041	0.000	100.000
Communications	32	7.769	0.000	17.630	0.000	95.238
Consumer Discretionary	37	8.030	0.000	15.995	0.000	100.000
Consumer Staples	30	6.093	0.000	15.980	0.000	100.000
Energy	25	6.973	0.000	14.840	0.000	100.000
Government-related	141	15.646	0.000	31.354	0.000	100.000
Health Care	12	26.369	23.810	24.884	0.000	90.476
Industrials	21	7.182	0.000	15.536	0.000	100.000
Materials	66	7.884	0.000	16.793	0.000	100.000
Technology	6	2.871	0.000	8.234	0.000	77.273
Utilities	38	7.962	0.000	17.946	0.000	100.000

Panel B: Roll measure (%)

Sample bonds	Number of bonds	Mean	Median	Std.Dev	Min	Max
Total sample	1112	0.262	0.134	0.493	0.000	25.386
Rating BB	958	0.245	0.131	0.407	0.000	25.386
Rating B	45	0.400	0.176	0.915	0.000	19.094
Rating CCC and below	109	0.404	0.135	0.957	0.000	15.587
Maturity 1-3 years	263	0.130	0.051	0.359	0.000	5.529
Maturity 3-5 years	276	0.150	0.063	0.450	0.000	15.587
Maturity 5-7 years	235	0.219	0.111	0.432	0.000	19.094
Maturity 7-10 years	138	0.270	0.138	0.552	0.000	17.713
Maturity 10+ years	200	0.338	0.200	0.509	0.000	25.386
Financials	704	0.296	0.135	0.635	0.000	20.127
Banks	656	0.280	0.133	0.540	0.000	20.127
Consumer Finance	36	0.374	0.124	1.026	0.000	17.713
Others	12	0.298	0.188	0.347	0.000	4.522
Non-financials	408	0.240	0.133	0.373	0.000	25.386
Communications	32	0.254	0.169	0.291	0.000	4.270
Consumer Discretionary	37	0.270	0.146	0.448	0.000	19.094
Consumer Staples	30	0.174	0.096	0.262	0.000	6.679
Energy	25	0.353	0.185	0.481	0.000	5.849
Government-related	141	0.238	0.084	0.607	0.000	25.386
Health Care	12	0.079	0.057	0.068	0.002	0.503
Industrials	21	0.301	0.183	0.420	0.000	5.611
Materials	66	0.221	0.117	0.333	0.000	5.076
Technology	6	0.194	0.102	0.281	0.002	2.371
Utilities	38	0.193	0.120	0.249	0.000	3.709

Panel C: Bid ask spreads (%)

Sample bonds	Number of bonds	Mean	Median	Std.Dev	Min	Max
Total sample	1112	0.653	0.419	1.683	-47.067	88.191
Rating BB	958	0.614	0.401	1.724	-47.067	88.191
Rating B	45	0.828	0.652	1.208	-36.024	8.949
Rating CCC and below	109	1.226	0.870	1.250	0.000	8.749
Maturity 1-3 years	263	0.547	0.313	0.596	0.000	4.006
Maturity 3-5 years	276	0.490	0.294	0.572	-0.795	8.709
Maturity 5-7 years	235	0.504	0.349	0.525	-3.560	7.619
Maturity 7-10 years	138	0.589	0.412	0.990	-36.024	43.707
Maturity 10+ years	200	0.887	0.552	2.685	-47.067	88.191
Financials	704	0.792	0.486	1.957	-47.067	88.191
Banks	656	0.892	0.583	2.064	-47.067	88.191
Consumer Finance	36	0.284	0.184	0.971	-36.024	8.949
Others	12	0.790	0.462	2.307	-3.374	43.707
Non-financials	408	0.564	0.396	1.475	-11.994	54.112
Communications	32	0.464	0.332	0.402	0.000	3.877
Consumer Discretionary	37	0.461	0.347	0.428	-0.361	7.377
Consumer Staples	30	0.385	0.286	0.355	-0.364	3.426
Energy	25	1.062	0.566	4.378	-7.396	54.112
Government-related	141	0.705	0.300	1.746	-11.994	27.250
Health Care	12	0.503	0.488	0.152	0.180	1.052
Industrials	21	0.714	0.610	0.755	-6.446	8.218
Materials	66	0.536	0.439	0.466	-7.223	15.193
Technology	6	0.503	0.405	0.329	-0.137	2.093
Utilities	38	0.494	0.340	0.546	-0.182	9.661

Panel D: Age measure (years)

Sample bonds	Number of bonds	Mean	Median	Std.Dev	Min	Max
Total sample	1112	0.653	0.419	1.683	-47.067	88.191
Rating BB	958	2.975	2.434	2.367	0.000	13.933
Rating B	45	3.090	2.656	2.292	0.000	13.112
Rating CCC and below	109	2.781	2.442	1.956	0.000	9.971
Maturity 1-3 years	263	1.067	1.049	0.601	0.000	2.845
Maturity 3-5 years	276	1.596	1.533	0.977	0.000	4.923
Maturity 5-7 years	235	2.300	2.185	1.409	0.000	6.834
Maturity 7-10 years	138	2.718	2.401	1.899	0.000	8.068
Maturity 10+ years	200	4.298	3.849	2.945	0.000	13.933
Financials	704	2.557	2.125	1.942	0.000	13.407
Banks	656	2.514	2.018	1.994	0.000	13.407
Consumer Finance	36	2.800	2.691	1.644	0.000	13.112
Others	12	2.473	1.936	1.872	0.003	7.053
Non-financials	408	3.244	2.686	2.538	0.000	13.933
Communications	32	3.911	2.946	3.290	0.000	13.933
Consumer Discretionary	37	3.220	2.702	2.509	0.000	13.281
Consumer Staples	30	3.176	2.875	2.096	0.005	9.925
Energy	25	3.156	2.527	2.534	0.003	10.067
Government-related	141	3.399	2.875	2.425	0.019	11.055
Health Care	12	1.866	1.799	1.168	0.003	4.758
Industrials	21	3.534	3.014	2.675	0.011	13.051
Materials	66	2.587	2.201	1.971	0.000	9.977
Technology	6	3.344	3.066	2.122	0.063	9.979
Utilities	38	3.484	3.012	2.513	0.003	11.504

Panel E: Composite (LAMBDA)

Sample bonds	Number of bonds	Mean	Median	Std.Dev	Min	Max
Total sample	1112	-0.021	-0.167	0.810	-17.540	30.692
Rating BB	958	-0.045	-0.176	0.767	-17.540	30.692
Rating B	45	0.132	-0.075	1.000	-10.422	19.473
Rating CCC and below	109	0.265	-0.057	1.218	-1.087	17.109
Maturity 1-3 years	263	-0.264	-0.326	0.486	-1.107	6.297
Maturity 3-5 years	276	-0.198	-0.289	0.568	-1.107	17.109
Maturity 5-7 years	235	-0.106	-0.222	0.523	-1.096	19.473
Maturity 7-10 years	138	-0.041	-0.168	0.689	-10.422	16.696
Maturity 10+ years	200	0.137	-0.061	1.098	-17.540	30.692
Financials	704	0.051	-0.143	0.975	-17.540	30.692
Banks	656	0.065	-0.120	0.968	-17.540	30.692
Consumer Finance	36	-0.016	-0.249	1.026	-10.422	16.696
Others	12	0.030	-0.105	0.891	-2.285	16.130
Non-financials	408	-0.068	-0.178	0.681	-3.645	26.431
Communications	32	-0.086	-0.147	0.404	-1.021	3.923
Consumer Discretionary	37	-0.074	-0.183	0.512	-1.050	19.473
Consumer Staples	30	-0.180	-0.248	0.351	-1.024	5.667
Energy	25	0.221	-0.076	1.634	-2.716	18.897
Government-related	141	-0.070	-0.277	0.933	-3.645	26.431
Health Care	12	-0.366	-0.323	0.206	-0.848	0.282
Industrials	21	0.051	-0.065	0.530	-2.285	5.101
Materials	66	-0.093	-0.188	0.422	-3.629	4.500
Technology	6	-0.097	-0.184	0.345	-0.770	2.374
Utilities	38	-0.136	-0.202	0.393	-1.038	4.563

Table A.4

Illiquidity measures correlation matrix

The table presents the correlation between the FZR, Roll, bid ask spreads, and Age. 1,112 bonds are included in the sample from January 2000 to December 2016. *** stands for 0.1% significance level.

	FZR	Roll	Bid ask spreads	Age
FZR	1.0000			
Roll	-0.1266***	1.0000		
Bid ask spreads	0.0952***	0.1532***	1.0000	
Age	0.0811***	0.0618***	0.0809***	1.0000

Table A.5

Factors correlation matrix

The table presents the pairwise correlation of LAMBDA, TERM and DEF factors. The LAMBDA is the composite illiquidity measure derived from PCA analysis. 1,112 bonds are included in the sample from January 2000 to December 2016. *** stands for 0.1% significance level.

	LAMBDA	TERM	DEF
Lambda	1		
TERM	-0.02***	1	
DEF	0.13***	-0.14***	1

Table A.6

Results of the Illiquidity augmented Fama and French factor model

$$\Delta Bond\ Index_{k,t} = a\ +\ \beta_{k,T}\ \cdot\ TERM_t + \beta_{k,D}\ \cdot\ \ DEF_t + \beta_{k,L}\ \cdot\ LAMBDA_t +\ \varepsilon_{k,t}$$

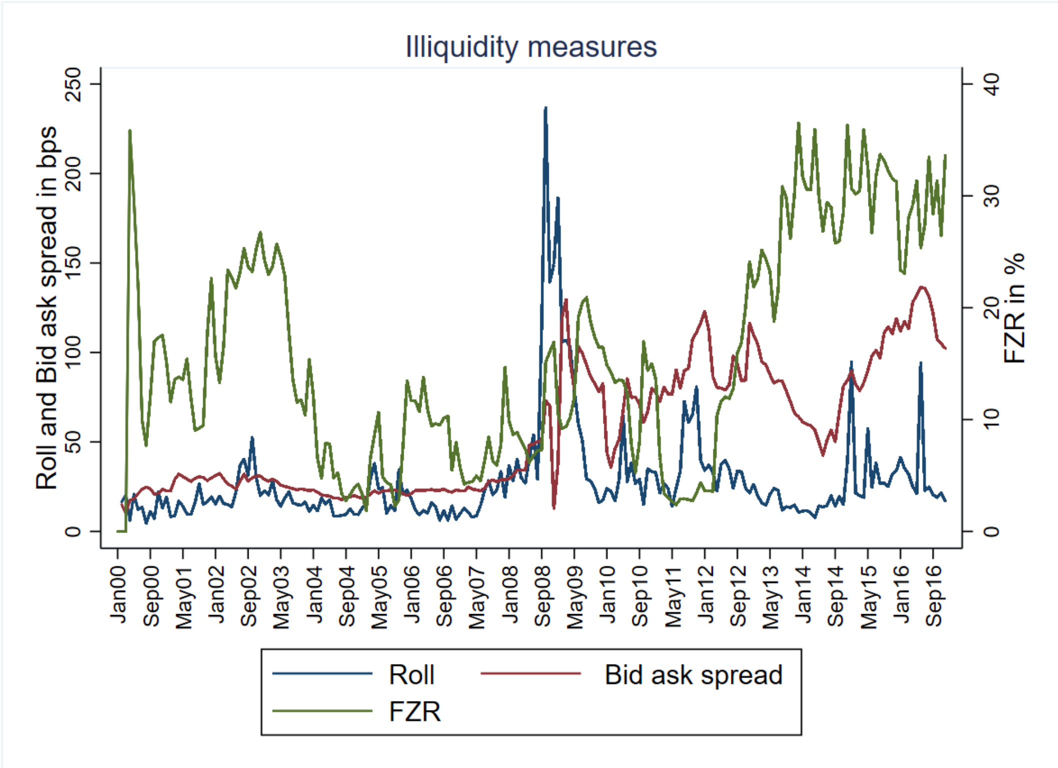
The table exhibits the results of the above model: Where ΔBond $Index_{k,t}$ represents the monthly excess return for bond index k as of time t. $TERM_t$ defines the difference between the yield of German government bond index with maturity of 7 years at month t and the one month Euribor rate at month t-1. DEF_t is the difference between the yield of monthly iboxx European overall bond index with a maturity of 7 to 10 years and the German government bond index with maturity of 7 years at month t. The $LAMBDA_t$ is the composite illiquidity measure. 1,112 bonds are included in the sample from January 2000 to December 2016. Value in bracket is the p-value. *** denotes $p<0.01$, ** denotes $p<0.05$, and * denotes $p<0.1$.

Sample bonds	Constant	TERM	DEF	LAMBDA	$Adj.R^2(\%)$
Total sample	0.738***	-0.148***	-0.039	0.365***	0.871
	(0.000)	(0.000)	(0.281)	(0.000)	
Rating BB	0.617***	-0.111***	0.028	0.087***	0.341
	(0.000)	(0.000)	(0.282)	(0.000)	
Rating B	0.711**	-0.171**	0.212	0.656***	1.850
	(0.013)	(0.025)	(0.254)	(0.000)	
Rating CCC and below	0.098	0.003	0.070	0.553***	1.800
	(0.647)	(0.966)	(0.623)	(0.000)	
Maturity 1-3 years	0.285***	-0.070***	0.124***	-0.230***	1.220
	(0.002)	(0.003)	(0.003)	(0.000)	
Maturity 3-5 years	0.684***	-0.036	-0.059	0.944***	4.470
	(0.000)	(0.116)	(0.170)	(0.000)	
Maturity 5-7 years	0.737***	-0.083***	-0.083	0.496***	0.911
	(0.000)	(0.000)	(0.101)	(0.000)	
Maturity 7-10 years	0.515***	-0.105***	0.120	0.190***	0.355
	(0.000)	(0.001)	(0.116)	(0.001)	
Maturity 10+ years	0.745***	-0.168***	0.057	0.056**	0.455
	(0.000)	(0.000)	(0.286)	(0.044)	
Financials	0.682***	-0.125***	-0.057	0.284***	0.697
	(0.000)	(0.000)	(0.172)	(0.000)	
Banks	0.682***	-0.141***	-0.054	0.127***	0.300
	(0.000)	(0.000)	(0.207)	(0.000)	
Consumer Finance	0.446	-0.074	0.385	1.094***	5.310
	(0.566)	(0.709)	(0.318)	(0.000)	
Others	0.007	-0.015	0.395	-0.532***	1.810
	(0.984)	(0.891)	(0.135)	(0.001)	
Non-financials	0.603***	-0.108***	0.078**	0.086***	0.374
	(0.000)	(0.000)	(0.024)	(0.002)	
Communications	0.708***	-0.144***	0.040	0.182	0.644
	(0.000)	(0.001)	(0.703)	(0.205)	
Consumer Discretionary	0.457**	-0.053	0.354**	-0.189	0.320
	(0.046)	(0.339)	(0.031)	(0.223)	
Consumer Staples	0.514***	-0.017	0.126	1.043***	3.520
	(0.000)	(0.659)	(0.136)	(0.000)	
Energy	0.402	-0.174*	0.265	0.065	0.143
	(0.164)	(0.069)	(0.235)	(0.310)	
Government-related	1.145***	-0.214***	-0.254***	0.629***	3.600
	(0.000)	(0.000)	(0.000)	(0.000)	
Health Care	0.934***	0.160	-0.156	0.278	-0.338
	(0.002)	(0.360)	(0.545)	(0.378)	
Industrials	0.642***	-0.247***	0.183	-0.942***	2.830
	(0.004)	(0.001)	(0.257)	(0.000)	
Materials	0.534***	-0.093**	0.095	-0.097	0.088
	(0.000)	(0.035)	(0.338)	(0.430)	
Technology	1.580***	-0.142	-0.455*	0.962**	0.794
	(0.005)	(0.300)	(0.074)	(0.019)	
Utilities	0.519***	-0.125***	0.080	0.251**	1.340
	(0.000)	(0.000)	(0.327)	(0.033)	

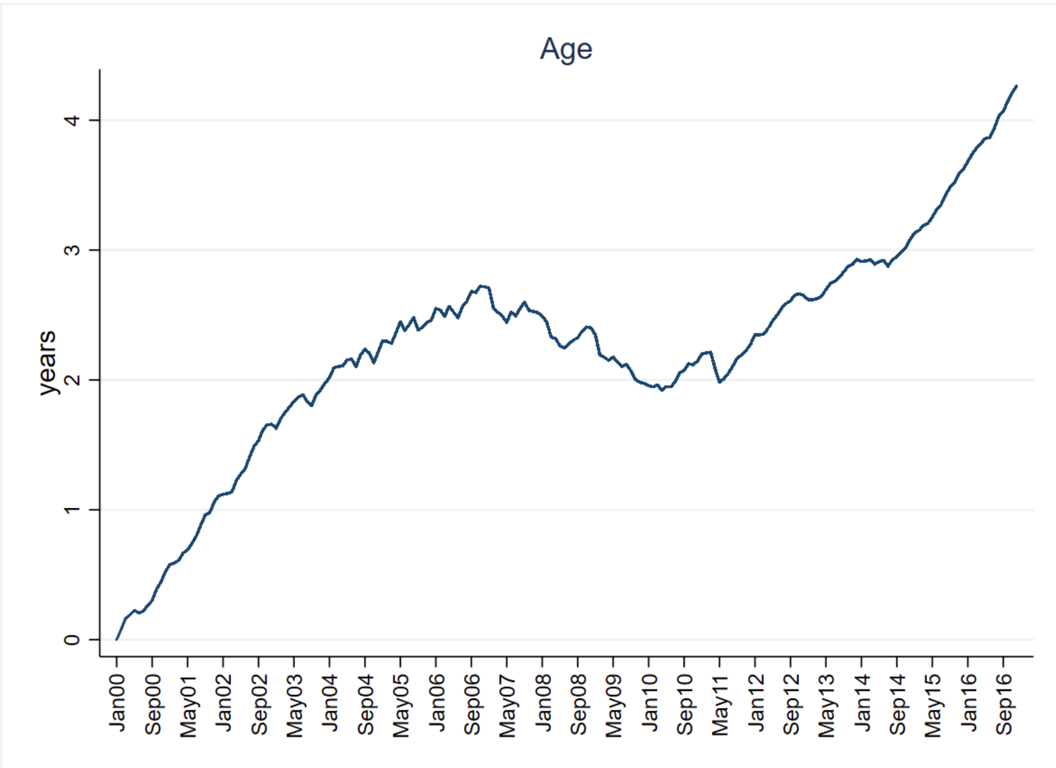
Figure A.1

Time series of Roll, bid ask spread, FZR and age measures

The figure (a) presents the average of monthly illiquidity measures between January 2000 to December 2016. The Roll and bid ask spread measures use the left scale, and the FZR measure use the right scale.The figure (b) presents the average of monthly age measures between January 2000 to December 2016.



(a)



(b)

Figure A.2

Excess bond returns and risk factors

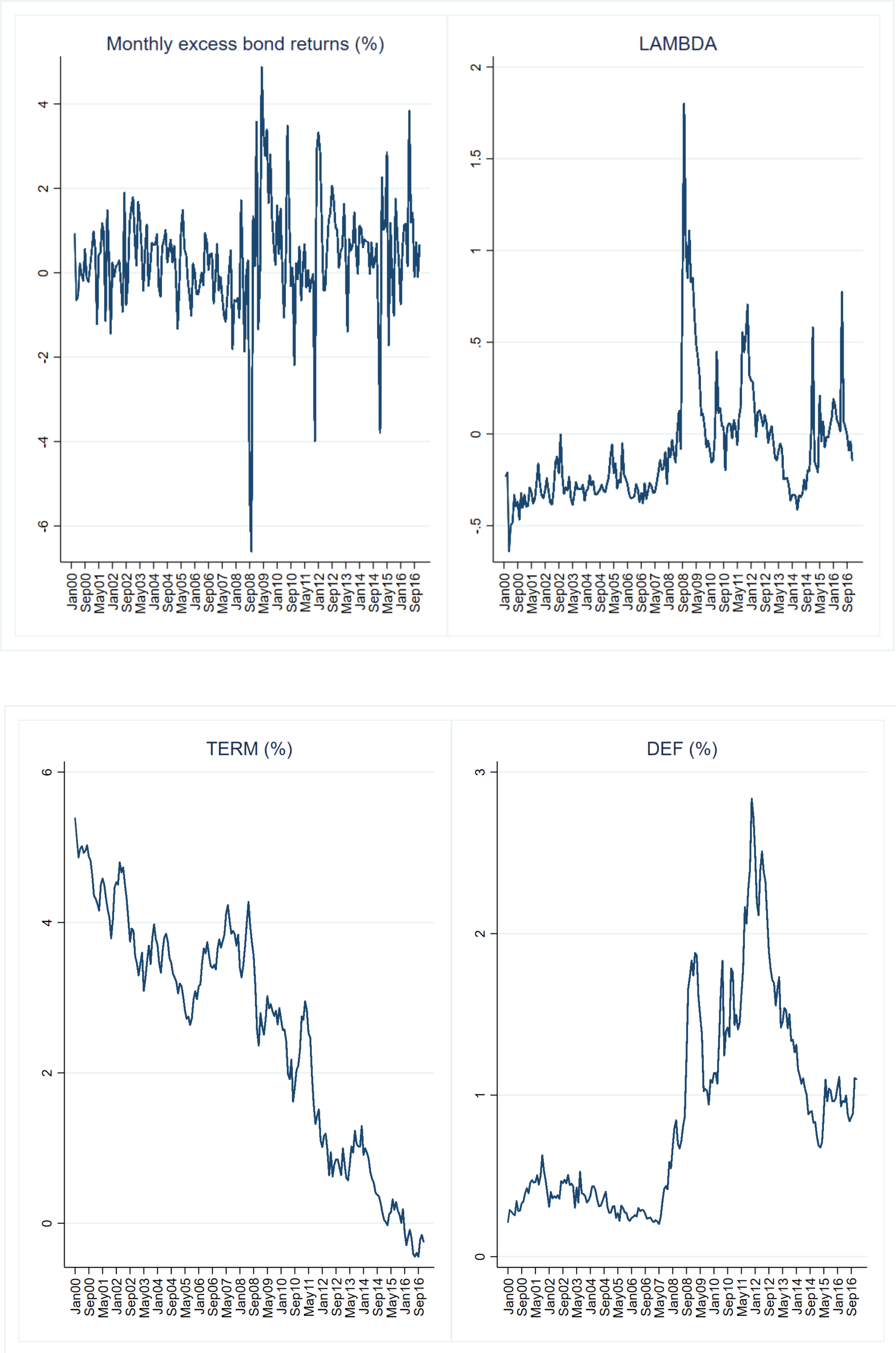


Table A.7

Results before and after the financial crisis

This table displays the illiquidity augmented Fama French factor model regression results in two subperiods. The first subperiod is before the financial crisis, ranging from January 2000 to May 2007, the second sub-period is after the financial crisis, span from June 2007 to December 2016. Value in bracket is the p-value. *** denotes p<0.01, ** denotes p<0.05, and * denotes p<0.1.

	Before crisis					After crisis				
Bond index	Constant	TERM	DEF	LAMBDA	$Adj.R^2$(%)	Constant	TERM	DEF	LAMBDA	$Adj.R^2$(%)
Bond composite	0.522**	-0.346***	2.664***	-0.242***	1.900	0.691***	-0.184***	0.012	0.371***	0.868
	(0.012)	(0.000)	(0.000)	(0.004)		(0.000)	(0.000)	(0.792)	(0.000)	
Rating BB	0.335	-0.245***	2.793***	0.346***	2.120	0.576***	-0.132***	0.068**	0.084***	0.269
	(0.258)	(0.004)	(0.000)	(0.005)		(0.000)	(0.000)	(0.032)	(0.000)	
Rating B	-0.477	0.010	2.606	0.873*	1.580	0.678**	-0.185**	0.245	0.656***	1.680
	(0.758)	(0.981)	(0.215)	(0.052)		(0.033)	(0.036)	(0.267)	(0.000)	
Rating CCC and below	-1.206	0.210	2.846	-0.029	-0.850	-0.035	-0.095	0.215	0.559***	1.880
	(0.519)	(0.682)	(0.217)	(0.950)		(0.880)	(0.321)	(0.207)	(0.000)	
Maturity 1-3 years	-2.217**	0.390	3.011**	-0.805*	6.650	0.296***	-0.095***	0.141***	-0.208***	1.120
	(0.030)	(0.180)	(0.014)	(0.080)		(0.003)	(0.000)	(0.003)	(0.000)	
Maturity 3-5 years	-0.166	-0.033	1.103**	-0.433*	1.410	0.709***	-0.032	-0.075	0.959***	4.580
	(0.650)	(0.775)	(0.047)	(0.062)		(0.000)	(0.261)	(0.166)	(0.000)	
Maturity 5-7 years	-0.836	0.142	2.437***	0.413**	1.740	0.745***	-0.102***	-0.078	0.505***	0.895
	(0.104)	(0.354)	(0.000)	(0.039)		(0.000)	(0.001)	(0.227)	(0.000)	
Maturity 7-10 years	-0.248	0.067	1.487	0.725***	1.030	0.439***	-0.142***	0.196**	0.182***	0.317
	(0.782)	(0.786)	(0.233)	(0.009)		(0.000)	(0.000)	(0.034)	(0.002)	
Maturity 10+ years	1.968***	-0.866***	4.250***	0.027	6.570	0.695***	-0.178***	0.096	0.054*	0.333
	(0.000)	(0.000)	(0.000)	(0.911)		(0.000)	(0.000)	(0.140)	(0.055)	
Financials	-0.562	0.089	1.689**	0.174	0.302	0.662***	-0.147***	-0.029	0.289***	0.677
	(0.312)	(0.583)	(0.022)	(0.376)		(0.000)	(0.000)	(0.566)	(0.000)	
Banks	0.850	-0.491***	2.961***	-0.370	8.670	0.687***	-0.137***	-0.060	0.127***	0.272
	(0.150)	(0.001)	(0.000)	(0.290)		(0.000)	(0.000)	(0.193)	(0.000)	
Consumer Finance	-0.873	0.214	1.382	0.209	0.104	-0.379	-0.253	1.083	1.218***	6.410
	(0.220)	(0.309)	(0.151)	(0.388)		(0.793)	(0.410)	(0.153)	(0.000)	
Others	0.126	-0.090	2.155	0.710	-3.080	-0.005	-0.020	0.407	-0.534***	1.720
	(0.926)	(0.779)	(0.409)	(0.618)		(0.990)	(0.887)	(0.207)	(0.001)	
Non-financials	0.976***	-0.447***	3.288***	0.636***	4.640	0.548***	-0.130***	0.128***	0.077***	0.284
	(0.003)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.003)	(0.008)	
Communications	1.551	-0.775**	4.354**	-0.611	3.250	0.688***	-0.149***	0.055	0.196	0.424
	(0.244)	(0.034)	(0.020)	(0.359)		(0.000)	(0.003)	(0.664)	(0.189)	
Consumer Discretionary	0.789	-0.286	2.597**	0.621*	1.860	0.232	-0.104	0.558**	-0.297*	0.373
	(0.394)	(0.280)	(0.045)	(0.073)		(0.423)	(0.148)	(0.014)	(0.087)	
Consumer Staples	0.548	-0.331**	2.844***	0.229	7.080	0.489***	-0.031	0.153	1.062***	3.430
	(0.332)	(0.035)	(0.000)	(0.496)		(0.004)	(0.526)	(0.155)	(0.000)	
Energy	3.271	-1.000	-1.922	-3.006	-7.920	0.396	-0.176*	0.271	0.065	0.063
	(0.569)	(0.403)	(0.872)	(0.360)		(0.191)	(0.096)	(0.261)	(0.314)	
Government-related	0.505	-0.244	0.556	-0.508*	0.807	1.111***	-0.230***	-0.221**	0.640***	3.590
	(0.384)	(0.143)	(0.473)	(0.057)		(0.000)	(0.000)	(0.010)	(0.000)	
Health Care						0.934***	0.160	-0.156	0.278	-0.338
						(0.002)	(0.360)	(0.545)	(0.378)	
Industrials	4.132*	-1.430**	4.028	2.277	12.200	0.558**	-0.285***	0.263	-0.961***	2.890
	(0.071)	(0.019)	(0.308)	(0.195)		(0.020)	(0.002)	(0.157)	(0.000)	
Materials	1.173	-0.372	1.137	0.257	0.472	0.569***	-0.072	0.058	-0.099	-0.029
	(0.188)	(0.105)	(0.431)	(0.696)		(0.000)	(0.199)	(0.626)	(0.437)	
Technology	1.189	-0.036	1.657	4.052***	50.200	1.359*	-0.134	-0.338	0.317	-0.609
	(0.228)	(0.899)	(0.236)	(0.000)		(0.058)	(0.444)	(0.364)	(0.532)	
Utilities	1.268***	-0.602***	3.005***	-0.059	9.520	0.398**	-0.156***	0.179*	0.227*	1.110
	(0.010)	(0.000)	(0.000)	0.890		(0.017)	(0.000)	(0.095)	(0.077)	

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