Empirical analysis of liquidity risk premium based on bond age

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Abstract: - By using panel data of corporate bond in Shenzhen Exchange and Shanghai Exchange we research on liquidity risk premium in corporate bond spread. We choose squared price return, issued amount, volume, trading turnover and bond age as corporate bond liquidity proxies to analyze liquidity risk. Squared price return is significant in the regression, and the squared price return could indicate to what extent the bond is underpriced. Meanwhile, corporate bond trading volumes increase, but liquidity risk premium decreases, so the corporate bond spread decreases. Also, the large issued amount means high liquidity. We find that the threshold of 12 months is the best in corporate bond market in Exchange in China, and the liquidity risk premium which presented by age is a very important part in corporate bond spread. The results above are consistent with our hypotheses. But in the regression, the variable of corporate bond trades is positively correlated with corporate bond spread, and it's different from the null hypothesis. We infer that there're several reasons, maybe too much missing data in the sample or the samples are in an economic crisis period. Overall, squared price return, issued amount, volume and trading turnover are proxies of liquidity risk, however they are less important than bond age.

Key-Words: - yield volatility, turnover, maturity, liquidity risk, issued amount, age

1 Introduction

Bond markets of Shenzhen Exchange and Shanghai Exchange in China are immature compared with bond markets in America and Europe. In China corporate bonds are less liquid than bonds in America, so there are large liquidity risk premium in corporate bond spread. We use several liquidity risk proxies to study the influence of liquidity risk of corporate bond on corporate bond spread.

There are many literatures on liquidity risk, mainly on the aspects below. Perraudin(2003) classifies bond liquidity risk proxies[1], mainly including quote frequency, bond age and issued amount, and he finds liquidity risk is an important part of corporate bond spread and liquidity risk premiums in bonds with high credit ratings is larger than these in low credit rating bond. Acharya(2005) uses simple equilibrium model to solve liquidity risk[2].

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In the asset pricing model, bond expected returns rely on liquidity in the future and covariance between returns and market liquidity. Also, the consistent negative shock on bond liquidity will lead to low returns in the current period. The empirical analysis proves and indicates the methods are important in economics. Houweling(2005) studies liquidity risk by using liquidity proxies[3], mainly including: issued amount, listed, on-the-run, bond age, missing prices, yield volatility, number of contributors and yield dispersion. He applies four variables model to control interest risk, maturity and credit ratings. The results reject null hypothesis which indicates corporate bond price doesn't contain liquidity risk premium, and eight variables are significant, and only one is insignificant.

Ericsson(2006) gets liquidity and credit risk by using structural bond valuation model[4]. The model indicates in financial crisis repeat bargaining is influenced by debt crisis of market illiquidity. When default probability increases, the illiquidity part in bond spread will increases. He studies short term bonds and finds liquidity spread decreases and the liquidity spread has convex term structure. He finds illiquidity correlates with default positively in yield spread by using 15 years bond prices data, also

the results support declivitous liquidity spread term structure. Chen(2007) finds corporate bond yield spread contains liquidity[5]. He chooses 4000 corporate bonds, including investment grade bonds and speculative grade bonds, and he finds bonds with poor liquidity have higher yield spread, moreover, liquidity increase will lead to yield spread decrease. Although controlling individual bond factors, corporate factors, macro variables, issuers fixed effect and potential endogenous bias, the results are also significant. The results indicate default risk can't explain bond spread completely. Acharya(2010) studies the correlation among corporate bond yield and equity and treasury liquidity from 1973 to 2007[6]. Equity or bond liquidity decreases leads to conflict effect: when speculative grade bond price decreases investment grade bond price increases, and the impact changes dynamically with periods. In economic downturn periods the impact is consistent. By using macroeconomic variables and financial market variables which correlate with adverse economic conditions, the model could forecast the probability in the period. His model could forecast bond returns out of the sample in the period of economic downturn in 2008-2009. After controlling other systemic risk such as term or default, the results are also robust. His study indicates there is liquidity risk which changes with periods in corporate bond returns. Dick-Nielsen(2010) researches on corporate bond liquidity before or after financial crisis by using illiquidity methods[7]. He finds in financial crisis bond illiquidity increases significantly, and bond spread increases slowly and consistently. When the first guarantor of the bond suffers terrible influences in financial crisis, the bond becomes less liquid, and the bonds issued by financial companies stop flowing in financial crisis.

Bongaerts(2011) uses equilibrium asset pricing model to analyze bond spread, also he puts corporate liquidity risk[8], derivatives and short positions which is used for hedging non transaction risk. He demonstrates that if short position owners hold more assets, illiquid asset will have lower prospective earnings, and lower levels of risk aversion. Pricing on liquidity risk of derivative is different from pricing on liquidity risk of positive net asset, and the former relies on investors' acceptance of non-trading risk. He uses the model in credit default swap market, and he finds credit protection seller will earn expected liquidity premium. Liquidity risk is very important but it has little impact on economy. Lin(2011) studies liquidity risk pricing by using corporate bond cross-section data from January 1994 to March 2009[9]. Bonds which have high sensitivity on liquidity earn more than 4% yearly average returns than bonds which have low sensitivity on liquidity. Bond expected returns have positive relation with liquidity β, even for the models with different default, term β, liquidity and other bond characteristic, or for various different measures the results are still robust. The results indicate liquidity risk is an important determinant factor for prospective bond returns. Recent global financial crisis indicates inner liquidity risk is important for corporate credit risk, but few person studies its impact on corporate bond yield spread. By using pane data from 1993 to 2008, Chen(2011) finds after controlling bond yield determinant variables[10], traditional methods used for measuring company repaying ability, cash flow volatility, credit grade and state variables, liquidity risk in company has important influence on bond yield spread. The results indicate inner liquidity risk should be included in bond yield spread model. Friewald(2012) studies whether liquidity is important price factor in American corporate bond market. Especially, he analyzes whether liquidity is more significant in financial crisis. He chooses 20000 bonds from October 2004 to December 2008[11]. He finds liquidity factor accounts for 14% in corporate bond spread. He considers in financial crisis liquidity is more important for speculative bonds. Chen(2009) predicts Taiwan 10-year government bond yield[12]. Neri(2012) shows how L-FABS can be applied in a partial knowledge learning scenario or a full knowledge learning scenario to approximate financial time series[13]. Neri(2012) makes Quantitative Estimation of Market Sentiment: A Discussion of Two Alternatives[14]. Wang(2013) finds idiosyncratic volatility has an impact on corporate bond spreads: Empirical evidence from Chinese bond markets[15].

In China, literatures are mainly about review or qualitative analysis, few quantified analysis. Ren (2006) sets a defaultable bond pricing model based on liquidity risk, and he separates default risk and liquidity risk from credit spread, and then he gets the liquidity risk adjusted credit default swap pricing[16]. He estimates the default intensity parameters with liquidity risk and without liquidity risk, and then calculates the swap price. He (2012) analyzes the impact of liquidity risk on corporate bond spread in subprime crisis by using data from April 2007 to September 2009[17]. He uses illiquidity methods, and the results are significant and robust. Also, some scholars research on liquidity risk by reviewing or qualitative analyzing.

Foreign scholars mainly apply equilibrium model and structural model to study liquidity risk, because

they can't measure liquidity risk directly, and many scholars choose various liquidity risk proxies to measure liquidity risk. The literatures indicate liquidity risk premium is very important in corporate bond spread. In China, scholars study liquidity risk from bond pricing and illiquidity. We choose five liquidity risk proxies and analyze the impact of liquidity risk on corporate bond spread by empirical method.

2 Data and variables description

2.1 Data description

AS Shanghai Stock Exchange has bond transaction data since 2007, and Shenzhen Stock Exchange has bond transaction data since 2008. In order to get continuous data, we get rid of the bonds which don't match with treasuries, also we get rid of bonds which have less than 1 year to maturity, because bonds which are less than one year to maturity are very sensitive to interest, so in the end we select nearly 50 corporate bonds weekly transaction data from December 2011 to December 2012. We get the data from Wind database, and the bonds have simple interest, fixed rate. According to Duffee(1998)[18], we divide the bonds into three categories, including short term bonds with 2 to 7 years maturity; median bonds with 7 to 10 years maturity; long term bonds with maturity more than 10 years. In the paper, most of the bonds are short term and median term bonds, also some are long term bonds. And the bonds can be divided into AAA, AA+ and AA three ratings. The sample contains Manufacturing industry, Power industry, Building industry, Mining and Quarrying industry, Transportation industry, Real Estate and Service industry bonds. The sample covers almost all the industries.

2.2 Variables description

(1) Corporate bond spread series: we choose corporate bonds and treasury bonds with similar maturity, and bond spreads are estimated by the difference of the two bond returns. We choose the difference of returns between treasury bonds and corporate bonds with similar value date and delivery date. Here spread denotes corporate bond spreads.

(2) Yield volatility series: It measures yield uncertainty. Most of foreign scholars use squared price return or the average of absolute price return to calculate yield volatility. We choose squared price return to calculate yield volatility. Here pricey2 denotes yield volatility.

(3) Issued amount series: according to foreign study we choose the variable. We take one hundred million yuan as unit. Here amount denotes issued amount.

(4) Bond age series: Bond age means the period from issue date to recent trading date, we take one year as unit. According to foreign study, they choose any time between 4 months to 24 months as thresholds. Here we choose 4 months, 8 months, 12 months, 16 months, 20 months and 24 months as thresholds, and we divide the sample into 12 groups, every two as one pair. For example, take 4 months as threshold, bonds which have age less than 4 months are young ones, others older than 4 months are old ones. We choose weekly average returns of old bonds to minus weekly average returns of young bonds, and get the series age4. In the same way, we get age8 series, age12 series, age16 series, age20 series and age24 series.

(5) Trading volume series: according to foreign literatures, we take bond weekly trading volume, and then divide by 1000000, and we get the trading volume series. Here volume denotes trading volume.

(6) Weekly turnover series: according to foreign literatures, we take weekly turn over series, and then divide by 1000000, and we get weekly turnover series. Here turnover denotes weekly turnover.

(7) Maturity series: according to foreign literatures, we take maturity as controlling variable, and take one year as unit. Here maturity denotes bond maturity.

3 Basic hypotheses

Hypothesis1: Corporate bond spread correlates with yield volatility.

Yield volatility could measure yield uncertainty. Higher yield volatility will lead to higher information uncertainty, and this will cause higher inventory cost for traders. According to Houweling(2005), the higher yield volatility will cause higher bid-ask spread, and lower liquidity, then the higher corporate bond spread. We take yield volatility as liquidity proxy variable to study its impact on corporate bond spread.

Hypothesis2: corporate bond spread has negative relation with issued amount.

Larger issued amount will cause higher bond liquidity, and lower corporate bond liquidity premium. If one corporate issues large amount bonds, more investors will hold the bond, and trading probability will increase. On the other hand, more investors will search information about the company, then information uncertainty will decrease, and this is good for trading in time. So we choose

issued amount as liquidity proxy variable to study its influence on corporate bond spread.

Hypothesis 3: corporate bond spread has positive correlation with bond age.

The new issued bonds have higher liquidity than older bonds, because when a new bond issues, investors will come to buy, and trade. But as time flies, especially for bonds older than two years, according to foreign literatures, investors will buy and hold the bonds till maturity, and they don't trade anymore. We choose bond age as liquidity proxy variable, and take 4 months, 8 months, 12 months, 16 months, 20 months and 24 months respectively as threshold, and we get six independent variables.

Hypothesis 4: Corporate bond spread has negative relation with bond volume.

Larger bond volume means the bond has higher liquidity, and lower liquidity risk premium, so the corporate bond spread will be smaller. Volume correlates with corporate bond spread negatively. We choose bond volume as liquidity proxy variable to analyze its impact on corporate bond spread.

Hypothesis 5: Corporate bond spread has negative relation with turnover.

Turnover is another proxy variable of corporate bond liquidity. Generally speaking, larger turnover means higher liquidity, and lower liquidity risk premium, and lower corporate bond spread. Turnover affects corporate bond spread by liquidity risk.

Hypothesis 6: Maturity has negative relation with corporate bond spread.

Maturity means the remaining time-to-maturity of a bond, measured in years. We choose it as a controlling variable in the model to better explain the liquidity risk in corporate bond spread.

4 Empirical analysis

4.1 Descriptive statistics

Table1 indicates descriptive statistics of corporate bond spread, pricey2, amount, age4, age8, age12, age16, age20, age24, volume, turnover and maturity. From the table, we can see that the mean value of corporate bond spread is 2.538, maximum value is 7.276, minimum value is -7.04; Mean value of pricey2 is 0.650, maximum value is 98.998, minimum value is 0.00; The mean value of amount is 14.976, maximum value is 79.00, minimum value is 3.00; Mean value of Age4 is -0.526, maximum value is -0.181, minimum value is -1.15; Mean value of age8 is -0.756, maximum value is -0.369, minimum value is -1.45; Mean value of age12 is -0.619, maximum value is 0.037, minimum value is -1.55; Mean value of age16 is -1.275, maximum value is -0.679, minimum value is -2.48; Mean value of age20 is -1.074, maximum value is -0.409, minimum value is -2.45; Mean value of age24 is -0.900, maximum value is -0.428, minimum value is -1.79; Mean value of volume is 1.248, maximum value is 56.04, minimum value is 0.00; Mean value of turnover is 12.399, maximum value is 566.6, minimum value is 0.00; Mean value of maturity is 4.753, maximum value is 7.627, minimum value is 1.65. According to the JB value of every series we can see all the series reject null hypothesis, namely all the series are sharp peak and heavy tail, and don't obey normal distribution.

Table 1 Panel data descriptive statistics

	mean	std	min	max	JB
Spread	2.538	1.224	-7.04	7.276	7465.6***
Pricey2	0.650	4.926	0.00	98.998	6703991***
Amount	14.976	13.75	3.00	79.00	9394.8***
Age4	-0.526	0.164	-1.15	-0.181	1379.9***
Age8	-0.756	0.229	-1.45	-0.369	353.97***
Age12	-0.619	0.319	-1.55	0.037	350.07***
Age16	-1.275	0.398	-2.48	-0.679	692.44***
Age20	-1.074	0.454	-2.45	-0.409	783.54***
Age24	-0.900	0.296	-1.79	-0.428	385.23***
Volume	1.248	3.047	0.00	56.04	487663***
Turnover	12.399	30.58	0.00	566.6	509354***
maturity	4.753	1.400	1.65	7.627	125.25***

*** denotes statistical variables are significant at 1% confidence level.

4.2 Series correlation test and stationary test

4.2.1 Correlation coefficient matrix

From table2 we can see spread correlates strongly with amount, age4, age8, age12, age16, age20, and maturity, and the coefficients are: -0.419, 0.263, 0.290, 0.302, 0.277, 0.281 and 0.218. Amount correlates with volume, turnover and maturity positively, and the coefficients are: 0.174, 0.167 and 0.174. Maturity correlates with age4, age8, age12, age16 and age20, and the coefficients are: 0.155, 0.169, 0.173, 0.169 and 0.169. Volume has strong relation with turnover, and the coefficient is 0.968.

Table 2 correlation coefficient matrix

	spread	Pricey2	amount	Age4	Age8	Age12
Spread	1.000					
Pricey2	-0.081	1.000				
Amount	-0.419	0.039	1.000			
Age4	0.263	-0.019	0.000	1.000		
Age8	0.290	-0.005	0.000	0.909	1.000	
Age12	0.302	-0.013	0.000	0.899	0.985	1.000
Age16	0.277	-0.012	0.000	0.892	0.973	0.975
Age20	0.281	-0.014	0.000	0.890	0.970	0.973
Age24	0.012	-0.008	0.000	0.540	0.546	0.514
Volume	0.007	0.010	0.174	0.061	0.053	0.048
Turnover	0.016	0.004	0.167	0.061	0.054	0.050
maturity	0.218	0.042	0.174	0.155	0.169	0.173

	Age16	Age20	Age24	volume	turnover	maturity
Age16	1.000					
Age20	0.998	1.000				
Age24	0.621	0.616	1.000			
Volume	0.045	0.046	0.023	1.00		
Trades	0.048	0.049	0.025	0.97	1.000	
maturity	0.169	0.169	0.026	-0.01	-0.03	1.00

4.2.2 Stationary test

From table3 we can see that by using LLC, IPS, ADF and PP test, the spread series, pricey2 series, age24 series, volume series and turnover series are stationary significant at 1% confidence level. Age8 series is significant at 1% confidence level in LLC and PP test, but not significant in IPS and ADF test. Age16 series is significant at 1% confidence level in LLC and IPS test, but not significant in ADF and PP test. Age20 and maturity series are significant at 1% confidence level only in LLC test, but not significant in IPS, ADF and PP test. However, age4 and age12 accept null hypothesis, and that means they aren't stationary.

Table 3 unit root test

	spread	Pricey2	Age4	Age8	Age12
LLC	-7***	-44***	15.2	-5.9***	3.601
IPS	-5***	-37***	10.6	1.53	5.027
ADF	225***	1210***	8.43	54.4	27.64
PP	301***	1322***	41.9	220***	75.46

	Age16	Age20	Age24	volume	turnover	maturity
LLC	-8***	-4***	-20***	-31***	-32***	-10***
IPS	-3***	-1	-24***	-30***	-31***	3
ADF	111	84	753***	1043***	1081***	39
PP	66	37	776***	1179***	1190***	40

*** denotes statistical variables are significant on the 1% confidence level.

4.3 Model selecting

4.3.1 Fixed effects test within the groups

From table 4 we can see, F(10,2690)= 153.42, F is significant on 1% confidence level, namely the variables in the model are significant. F(53,2690) =123.11, means the fixed effect model is significant on 1% confidence level, so the fixed effect model is significant.

Table 4 fixed effect test results within groups

variables	Coef.	Std.	t	prob
Pricey2	-0.02***	0.0024	-9.18	0.000
Age4	-0.16	0.1769	-0.91	0.365
Age8	0.367	0.3264	1.12	0.261
Age12	1.275***	0.2646	4.82	0.000
Age16	-2.95***	0.5277	-5.60	0.000
Age20	1.606***	0.4259	3.77	0.000
Age24	0.015	0.1088	0.14	0.892
Volume	-0.003	0.0161	-0.17	0.868
Turnover	0.0003	0.0016	0.17	0.865
maturity	1.391***	0.1340	10.37	0.000
cons	-5.10***	0.7355	-6.94	0.000
F(10,2690)		153.42***		
F(53,2690)		123.11***		

*** denotes statistical variables are significant on the 1% confidence level.

4.3.2 Random effect test

From table 5 we can see, LR 2(10) = 1166.06, LR is significant on 1% confidence level, namely the variables in the model are significant. chibar2 (01) = 3023.51, means the random effect model is significant on 1% confidence level, so the random effect model is significant.

Table 5 LM random effect test results

variables	Coef.	Std.	Z	prob
Pricey2	-0.022***	0.0024	-9.15	0.000
Age4	0.011	0.1769	0.06	0.952
Age8	0.272	0.3273	0.83	0.406
Age12	0.984***	0.2643	3.72	0.000
Age16	-2.416***	0.5274	-4.58	0.000
Age20	1.878***	0.4266	4.40	0.000
Age24	-0.456***	0.1017	-4.49	0.000
Volume	-0.001	0.0162	-0.07	0.945
Turnover	0.0002	0.0016	0.13	0.897
Maturity	0.6959***	0.1211	5.75	0.000
Cons	-1.412**	0.6894	-2.05	0.041
LRchi2(10)		1166.06***		
chibar2(01)		3023.51***		

*** denotes statistical variables are significant on the 1% confidence level. **denotes statistical variables are significant on the 5% confidence level.

Table 6 Breusch and Pagan LM test

	var	sd = sqrt(Var)
spread	1.499038	1.224352
e	0.3783601	0.6151098
u	0.9357731	0.9673536
chibar2(01)	32837.68***	

*** denotes statistical variables are significant on the 1% confidence level.

spread[id,t] = Xb + u[id] + e[id,t] (1)

According to table 6, we test the random effect model, chibar2(01)= 32837.68, and it's significant on 1% confidence level. The result indicates the random effect model is significant.

4.3.3 Hausman test

According to table7, chi2 (3) = (b-B)'[(V_b-V_B)^(-1)](b-B)=0.91, prob=0.8234, so accept null hypothesis, so the individual effect is not correlated with independent variables. The random effect

model is better for us, so we choose the random effect model.

Table 7 hausman test

	fe	re	Difference	S.E.
Pricey2	-0.0238	-0.02379	-0.00005	0.000095
Volume	0.0029	0.0022	0.0007	0.00086
turnover	0.0008	0.0008	-0.00006	0.00008
chi2(3)	0.91	prob	0.8234	

4.4 Regression analysis

4.4.1 Regression model with yield volatility, issued amount, trading volume and turnover factors

After choosing random effect model, we build the model as below:

$$spread_{it} = C + \alpha_i^* + \beta_{1t} pricey2_{it} + \beta_{2t} amount_i + \beta_{3t} volume_{it} + \beta_{4t} turnover_{it} + \beta_{5t} maturity_{it} + e_{it} \quad (2)$$

We do regression by using EVIEWS, and get the results below:

Table 8 random effect test results

variables	Coef.	Std.	t	prob
C	-2.232***	0.2195	-10.1677	0.0000
Pricey2	-0.023***	0.0025	-9.3591	0.0000
Amount	-0.058***	0.0073	-7.9141	0.0000
Volume	-0.002	0.0163	-0.0936	0.9255
Overturn	0.0005	0.0016	0.3372	0.7360
maturity	1.1888***	0.0360	33.043	0.0000
R^2	0.2900	S.E.	0.6497	
F	224.45***	DW	0.4933	

*** denotes statistical variables are significant on the 1% confidence level.

From table8 we can see, F=224.45, and it's significant at 1% confidence level, so the model is significant. The constant is significant at 1% confidence level. Pricey2 is significant at 1% confidence level, and it's correlated with spread negatively, so accept null hypothesis. When yield volatility changes for 1 unit, then corporate bond spread changes 0.023 in the opposite direction. Yield volatility could be used to measure return uncertainty. In market microstructure model, higher information uncertainty will lead to higher inventory cost for traders. Yield volatility in future is an important source of uncertainty. So higher yield uncertainty will cause higher bid-ask spread, and lower liquidity, and then will lead to higher corporate bond spread. In foreign literatures, Shulman et al.(1993) finds price volatility represent uncertainty, and it correlates with corporate bond spread positively[19]. Hong, Warga(2000) uses squared price returns to measure uncertainty, and he make bid-ask spread as dependent variable, and he finds they have positive relation and the result is significant, and it also indicates it's correlated with corporate bond spread positively[20]. Alexander et al. (2000) uses the average of absolute price returns to represent yield volatility[21], and he finds it correlates with trading volume positively, and the result indicates yield volatility has negative relation with corporate bond spread. And our result is the same with Alexander's.

Amount is significant at 1% confidence level, and the coefficient is -0.058, so accept null hypothesis. Bond issued amount has negative relation with corporate bond spread, when issued amount changes for one unit, corporate bond spread changes 0.058 in the opposite direction. Scholars often apply issued amount to represent bond liquidity, and most investment banks use it as liquidity criterion in building their bond indices. Issued amount is first used by Fisher(1959)[22], and he proves bonds with large issued amount trade frequently, so issued amount is usually taken as liquidity proxy. Some scholars propose that issued amount has positive relation with liquidity. Smidt(1971) and German(1976)[23,24] come up with the viewpoint in market microstructure model, they consider when traders have inventory, the trading prices will rise, if the bond information is hard to get and the expected holding time is long, then the traders will face very high inventory cost. Crabbe and Turner(1995) prove that large issued amount of a bond will lead to low information obtaining cost[25], because more investors buy the bond and analyze its characteristics. In the same way, bonds with small issued amount will cause high information cost, for the reason that fewer investors hold the bond, and investors don't know well about the bond. Also, Sarig ,Warga(1989) and Amihud, Mendelson(1991) [26,27]consider bonds with small issued amount will be bought and held, and they have little volume and have low liquidity. Our results are the same as theirs, and they are consistent with our hypothesis.

F=224.45, and it's significant at 1% confidence level, so the model is significant. We add maturity as controlling variable, but the results are robust. Moreover, from the coefficients of trading volume and trading turnover, they aren't significant, combined with the correlation test before, they have strong relation, so we get rid trading volume, and then do regression.

Table9 regression without volume

variable	Coef.	Std.	t	prob
C	-2.246***	0.2204	-10.193	0.0000
Pricey2	-0.023***	0.0025	-9.364	0.0000

Amount	-0.058***	0.0074	-7.868	0.0000
Turnover	0.0004	0.0004	0.8916	0.3727
Maturity	1.192***	0.0360	33.085	0.0000
R^2	0.2905	S.E.	0.6492	
F	281.44***	DW	0.4936	

*** denotes statistical variables are significant at 1% confidence level.

From table9 we can see trading turnover isn't significant even if we get rid of trading volume variable. We try to get rid of maturity variable, and get the results in table10.

Table10 regression with maturity variable

variable	Coef.	Std.	t	prob
C	3.099***	0.159	19.49	0.0000
Pricey2	-0.024***	0.003	-7.90	0.0000
Amount	-0.037***	0.008	-4.78	0.0000
Turnover	0.001**	0.0005	2.06	0.0399
R^2	0.0313	S.E.	0.7611	
F	29.573***	DW	0.1718	

*** denotes statistical variables are significant on the 1% confidence level.

According to table10 we can see turnover is significant at 5% confidence level, so trading turnover has positive relation with corporate bond spread, and the coefficient is 0.001. When trading turnover changes for 1 unit, corporate bond spread changes 0.001 unit in the same direction, the result is different with null hypothesis. We assume that they have negative relation, because the higher trading turnover means higher liquidity, and that will lead to lower corporate bond spread. We analyze the reason of positive relation between trading turnover and corporate bond spread. The result comes in financial crisis, and we'll set financial crisis period and prospect periods in the future, and compare the results in future research.

We get the regression equation below:

$$spread_{it} = 3.099 + \alpha_i^* - 0.024pricey2_{it} -$$

$$-0.037amount_i + 0.001turnover_{it} + e_{it} \quad (3)$$

Table10 indicates random effect intercepts, and we add random effect intercept in the equation and get the regression equation of CD corporate.

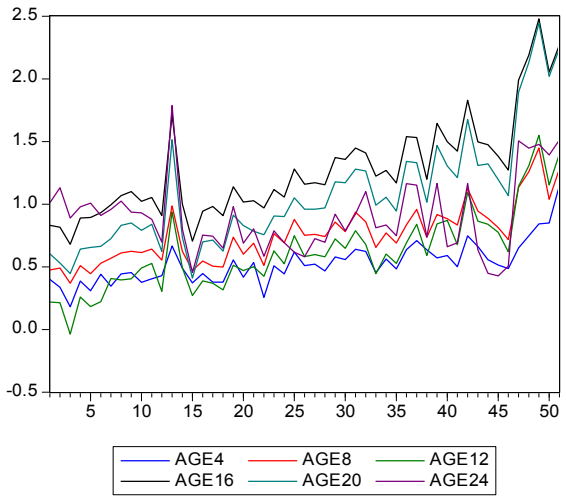
$$spread_{1t} = 2.586 - 0.024pricey2_t -$$

$$0.037amount + 0.001turnover_t + e_{1t} \quad (4)$$

Table 11 the α_i^* of the model

CD	ZJ	CK	WY	JC	SD
-0.513	1.424	-0.931	0.858	0.556	-0.185
ZJZ	LY	BB	CG	YG	SG
-0.772	-2.737	-0.175	0.581	1.867	-1.189
NG	YW	SL	KEB	DYG	KM
1.011	-0.069	-0.489	-0.017	-0.381	0.1113
FZ	TW	ZT	HZ	HG	JKY
0.237	-0.508	-0.180	0.116	-0.025	0.093
PLQ	BG	LG	HY	TX	AG
-0.556	-0.119	-0.451	0.416	0.056	0.227
XT	ZH	YT	YD	DY	NB
-1.005	1.055	-0.091	-2.154	0.078	-0.719
JN	RK	LX	LGZ	GM	SGZ
-0.454	0.218	0.126	-0.513	0.939	0.409
WF	XY	JD	DK	ZTZ	ZF
0.490	-0.153	-0.502	0.355	0.035	0.611
HD	KD	AT	BX	XJ	XZ
-0.003	1.246	-0.543	0.296	0.656	1.372

4.4.2 Add bond age factor into the original model



Grap1 line chart of age4, age8, age12, age16, age20 and age24 factor

According to graph1, we make 4 months as threshold to divide young bonds and old bonds, and we get the liquidity risk premium by using the weekly average returns of young bonds to minus the weekly average returns of old bonds. From the graph we can see the liquidity risk premium of age4 is the lowest, and indicates the value of it is the smallest compared with others. The highest one is age16, and the age12 is just following it. We can see the liquidity premium rises suddenly in March 2012, and it becomes common in April 2012, and then it rises slowly, but in the end of 2012, it rises suddenly again.

Table12 the model with bond age factor

variable	Coef.	Std.	t	prob
C	2.841***	0.245	11.609	0.0000
Pricey2	-0.022***	0.002	-8.952	0.0000
Amount	-0.037***	0.008	-4.739	0.0000
Turnover	0.0002	0.0005	0.480	0.6311

Age4	0.182	0.177	1.025	0.3054
Age8	0.176	0.332	0.530	0.5965
Age12	0.693***	0.263	2.630	0.0086
Age16	-1.878***	0.527	-3.561	0.0004
Age20	2.150***	0.431	4.991	0.0000
Age24	-0.928***	0.061	-15.215	0.0000
R^2	0.3366***	S.E.	0.6277	
F	154.68	DW	0.5895	

*** denotes statistical variables are significant at 1% confidence level.

According to table12, the independent variables pricey2 and amount are significant at 1% confidence level, but trading turnover factor isn't significant, we infer that there's multicollinearity in the regression. We will find the reason in future study. Age4 and age8 are not significant. Age12, age16, age20 and age24 are significant at 1% confidence level. According to the null hypothesis, age12 and age20 are the proper variables, and accept the null hypothesis. R^2=0.3366, and it's more than times of R^2 in table10. This indicates bond age factor contains more liquidity risk premium than other factors, such as issued amount, yield volatility and trading turnover. In table12, F=154.68, and it indicates the model is significant at 1% confidence level.

Bond age is the most common proxy variable for bond liquidity. Sarig&Warga(1989) find more bonds are contained in the buy and hold model as the bonds become older. As a bond becomes older, it's traded less, and it will have low liquidity. Moreover, when a bond turns to an illiquid bond, it will be held until maturity. McGinty(2001) and Schultz(2001)[28,29] find the newly issued bond trade more frequent than older bond. Schultz considers the newly issued bonds usually have low prices, and traders will buy and trade and then hold until maturity. Bond practitioners use a threshold to distinguish young bonds and old bonds, and many scholars use the method. Alexander et al. (2000) uses two years as threshold, and Ericsson &Renault (2001) takes three months as threshold, and Elton et al.（2002）uses one year as threshold[30,31]. To determine which one is the most proper, we choose six groups, and we make four months, eight months, twelve months, sixteen months, twenty months and twenty four months as thresholds, and we find the threshold of twelve months is the best one. Also according to graph1, we get the conclusion that the 12 months is the best one in China Exchange corporate bond market, and the liquidity risk premium is significant, and it can be observed best. Our result is the same as Elton et al's. Houweling et al. (2005) finds the best threshold is fourteen months, and it's similar with our result. He assumes that corporate bond spread correlates with bond age positively, and it's the same as ours.

Table13 the regression without non-significant variables

variables	Coef.	Std.	t	prob
C	3.821***	0.165	23.11	0.000
Pricey2	-0.023***	0.003	-8.63	0.000
Amount	-0.037***	0.008	-4.60	0.000
Age12	1.155***	0.040	29.11	0.000
R^2	0.2567	S.E.	0.6640	
F	316.56***	DW	0.5746	

*** denotes statistical variables are significant on the 1% confidence level.

From table13 we can see, after getting rid of the non-significant variables, all the variables are significant, and the model is significant. Pricey2 is significant at 1% confidence level, and amount is confidence at 1% confidence level, also age12 is significant at 1% confidence level. The coefficient is 1.155, and it means when age12 changes for one unit, corporate bond spread changes 1.155 in the same direction. F=316.56, so the model is significant at 1% level.

Table14 regression with maturity variable

variables	Coef.	Std.	t	prob
C	-0.351	0.311	-1.128	0.259
Pricey2	-0.023	0.002	-9.237	0.000
Amount	-0.052	0.008	-6.668	0.000
Age12	0.517	0.055	9.342	0.000
maturiy	0.842	0.054	15.60	0.000
R^2	0.3148	S.E.	0.6374	
F	315.69	DW	0.5251	

*** denotes statistical variables are significant at 1% confidence level.

According to table14, after adding maturity factor into the model, pricey2, amount and age12 are still significant at 1% confidence level. Also maturity is significant at 1% confidence level.

Table15 the α_i^* of the model

CD	ZJ	CK	WY	JC	SD
-0.535	0.360	1.261	2.935	0.901	0.169
ZJZ	LY	BB	CG	YG	SG
-0.550	-1.050	-0.279	0.106	1.225	0.237
NG	YW	SL	KEB	DYG	KM
0.503	-1.100	0.061	0.535	0.205	-0.729
FZ	TW	ZT	HZ	HG	JKY
0.728	-1.547	0.411	0.519	2.146	-1.282
PLQ	BG	LG	HY	TX	AG
-0.300	1.956	-1.524	0.646	0.799	-1.164
XT	ZH	YT	YD	DY	NB
-2.435	-0.298	0.015	-0.371	1.792	-1.249
JN	RK	LX	LGZ	GM	SGZ
0.696	0.842	-0.855	-1.568	-0.302	-0.818
WF	XY	JD	DK	ZTZ	ZF

0.927	-1.337	-1.665	2.306	0.035	0.801
HD	KD	AT	BX	XJ	XZ
0.207	-0.132	-0.373	-1.239	-0.831	1.547

And we get the regression equation below:

$$spread_{it} = 3.821 + \alpha_i^* - 0.023 pricey2_{it} - 0.037 amount_i + 1.155 \text{Age12}_{it} + e_{it} \quad (5)$$

Table15 indicates random effect intercepts, after adding random effect into the model, we get the regression equation of CD corporate as below:

$$spread_{it} = 3.286 - 0.023 pricey2_{it} - 0.037 amount_i + 1.155 \text{Age12}_{it} + e_{it} \quad (6)$$

The regression equations of other companies are similar with company CD.

5 Conclusion

In China, Exchange corporate bond market is immature. Because we can't measure liquidity risk directly, we study liquidity proxy variables, such as yield volatility factor, bond issued amount factor, bond trading volume factor, bond trading turnover factor and bond age factor, and try to find the impact of liquidity risk on corporate bond spread. According to foreign study, we take corporate bond squared price return as price return volatility factor, and find that it has negative relation with corporate bond spread. When price return volatility turns higher, the issued amount becomes larger, so the corporate bond spread is lower. Bond issued amount correlates with corporate bond spread negatively, and issued amount usually is used by investment bank to estimate bond liquidity risk. If the corporate issued larger amount bond, it will have smaller liquidity risk, and it will have lower liquidity risk premium, so investors will get lower corporate bond spread. Bond trading volume correlates with corporate bond trading turnover strongly, so we get rid of bond volume factor, and the bond trading turnover is significant, but it positively with the corporate bond spread, and this rejects null hypothesis. The results come up in financial crisis, or too much missing data in the sample. We'll research on it in the future, and we plan to separate the sample into financial crisis period group and prospect period group, and make comparison. Bond age is also a liquidity risk proxy variable. We make 4 months, 8 months, 12 months, 16 months, 20 months and 24 months as threshold respectively, and get 6 groups, then in each group we use the weekly average returns of old bonds to minus the weekly average returns of young bonds, and find bond age has positive relation with corporate bond spread. The result is the same as foreign study, also we find the 12 month threshold is proper for the Exchange corporate bond market in China, and this is similar with foreign literatures. Overall, we find liquidity risk is a very important part in corporate bond spread. In Chinese corporate bond market, bonds have poor liquidity, and liquidity risk is the important factor. Research on liquidity risk is very important, and it could afford theory basis for corporate bond market in China.

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