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Second year MSc Student

Islam Utyagulov

Scientific Advisor: Carsten Sprenger

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Content

Abstract

We find that liquidity risk is priced in yield spreads in Russian corporate bond market. We use panel data techniques on dataset which covers more than 250 corporate bonds during 2004-2014, spanning both investment grade and speculative ones. We examine influence of embedded options on yield spreads and in particularly liquidity risk. Our findings indicate that yield spreads of bonds with both put and call options is on average higher by 150 basis points that yield spread of regular bonds. We also find that embedded put options in corporate bonds do not serve as insurance and there is no evidence that it can reduce liquidity risk due to the presence of both put and call features in Russian corporate bonds. And finally we obtain results that liquidity component was priced more heavily during crisis periods than afterwards.

Introduction

Many research papers, dedicated to examining what risk factors affect corporate bond yield spreads came to the conclusion that credit risk determinants cannot fully capture the yield spread variation. Longstaff et al. (2005, [12]) suggested that possible solution to this problem is to add illiquidity risk factors to the structural models. The rationale behind this proposition is following: illiquid markets lead to the fact that investors cannot continuously hedge their risk, hence they require additional risk premium by lowering prices.

Chen et al. (2007, [3]), Dick-Nielsen et al. (2012, [5]) and other research papers proposed different illiquidity measures, which coupled with credit risk determinants and macro-variables can more comprehensively capture the yield spread variation.

In our paper we want to investigate what risk factors are priced in Russian corporate bonds using panel data techniques, because most of the papers written on similar topics confirm the importance of liquidity risk in pricing securities (see e.g. Bao, Pan & Wang (2011, [2]); Chen et al. (2007, [3]); Dick-Nielsen, Feldhutter & Lando (2012, [5])), however there is more recent research done by Grass & Ward (2012, [10]), which is in direct contrast with papers mentioned just before. Our findings confirm that liquidity risk matters in corporate bonds pricing in Russia. Results stay robust after controlling for various risk factors including credit risk determinants, aggregated macro variables and proxies of systematic risk in the economy.

Interesting characteristic of most corporate bonds issued by Russian companies is that bonds contains both put and call options. Put option gives its holder the right to sell the bonds back to the issuer at predetermined price (usually price is close to par) and dates in the future before the maturity. Since the holder of the issue has the right to sell before the maturity, these options provide insurance against risk factors discussed above. However call feature of Russian corporate bonds consists in the right of issuer to change the coupon rate at the date close to the put exercise date at his discretion. We find an evidence that bonds containing both put and call options are not simply the regular bonds with maturity date equal to the first put exercise date. Results of regression analysis indicates that such bonds trade on average with additional risk premium of 150 basis points compared to the yield spreads of regular bonds with no options.

Despite the fact that a lot of research effort was dedicated in studying callable and convertible corporate bond issues, only in few papers authors examined puttable bonds. For example, Ericsson et al. (2011, [7]) discovered in what ways embedded put option influence various risk factors. That is why it is interesting to see whether embedded put options have influence on liquidity risk. We find no evidence that such embedded options in Russian corporate bonds can provide an insurance against various risk factors. Besides following the methodology proposed in Ericsson et al. (2011, [7]) we find that correlations of risk factors with yield spread of bond with options is more pronounced than for regular bond's yield spread. However this particular analysis was done using only 26 matched pairs of bonds, hence results may be not so strong.

Also in our work we investigate one additional issue of whether liquidity was priced more heavily during recent financial crisis than afterwards. We follow the methodology proposed in Dick-Nielsen (2012, [5]) and find evidence that liquidity component has bigger impact on yield spreads during financial crisis than afterwards. In addition we run separate regressions for investment grade and speculative bonds and observe that influence of illiquidity component in speculative bonds is almost three times bigger than in investment grade bonds!

This paper contributes to the debate of bond market liquidity and corporate bond yield spreads. Our findings that liquidity risk matters for pricing corporate bonds in Russia are consistent with recent research papers. Second, we examine the influence of embedded options on yield spreads and find that yields of bond with options are on average higher by 150 basis points than yields of regular bonds. Finally, we confirm the hypothesis that liquidity was priced more heavily during the recent financial crisis and show that influence of liquidity is increasing drastically when credit rating deteriorates. Research is particularly urgent because most of Russian corporate bonds contain embedded options.

Research paper is structured as follows. Firstly we give an overview of Russian corporate bond market, its major indicators and past dynamics. We will compare it with corporate bond markets of other emerging countries, such as Brazil, China, India and others.

In the second part of study we describe more thoroughly various risk factors influencing corporate bond yields and measures suggested by previous empirical works. Also we provide our initial hypotheses about interrelationships of risk proxies with credit spreads proceeding from theoretical underpinnings.

Third part of our paper dedicated to data description. We provide overall statistics about our data sample and some particular characteristics. Also in this part we provide detailed description of how data were processed and every dependent and independent variables were computed and monthly observations of them were obtained.

In the Section 4 we provide results of the regression analysis, which indicates significant correlations between corporate bond yield spreads and various risk proxies. Here we will discuss influence of liquidity risk on credit spreads in Russia.

In the Section 5 we apply regressions to analyze the effect of embedded put options on various risk proxies and compare our results with initial hypotheses. We will try to answer the major question: how put options in corporate bonds influence on liquidity risk.

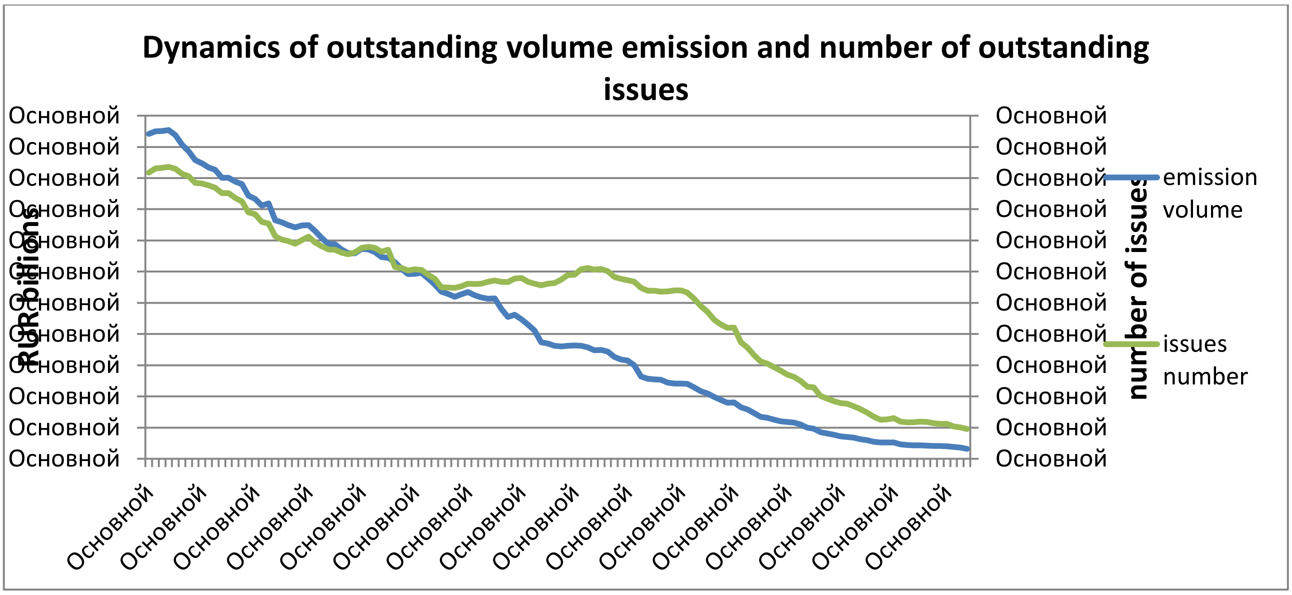
In the sixth part of our study due to availability of daily trading data from 2004 up to present time we will compare effect of liquidity proxies on credit spreads during the financial crisis and afterwards. Our initial hypothesis is that credit spread contribution from illiquidity increases considerably with the onset of financial crisis.

Finally we will conclude and present all main findings.

Section 1: Russian Corporate Bond Market Overview.

Corporate Bond Market in Russia is dynamic and fast growing market. For example in January of 2004 number of issuers and issues in corporate bonds were only 161 and 195 correspondingly. So roughly speaking there is one issue matching with one issuer. Nowadays number of issuers doubled (353 issuer) and number of issues is 5 times bigger than in 2004 (1017 issues), so on average one issuer has 3 issues outstanding. Maybe these figures doesn't tell you much and one would say that it is not a big change for 10 years, but probably outstanding emission volumes will make another impression. For the same period emission volumes in rouble-denominated corporate bonds have raised 32 times, from 161 RUR billions in January of 2004 up to 5210 RUR billions at the end of April 2014.

Figure 1: Dynamics of outstanding volume emission and number of outstanding issues in Russia



Source: Cbonds Database

Ideally to compare the rate of development of Russian corporate bond market with markets of other emerging countries (Brazil, China, India, UAE and etc.) we would like to see the growth rates and absolute values of corporate bond markets of emerging countries, but we will look at the growth rates and values of Corporate Eurobond volume emissions. There are two reasons for that:

1. We do not possess such data for emerging countries corporate bond markets.
2. Every number will be in currency of that country and we will have to convert all these figures using correct exchange rates and this will lead to potential errors in our estimates.

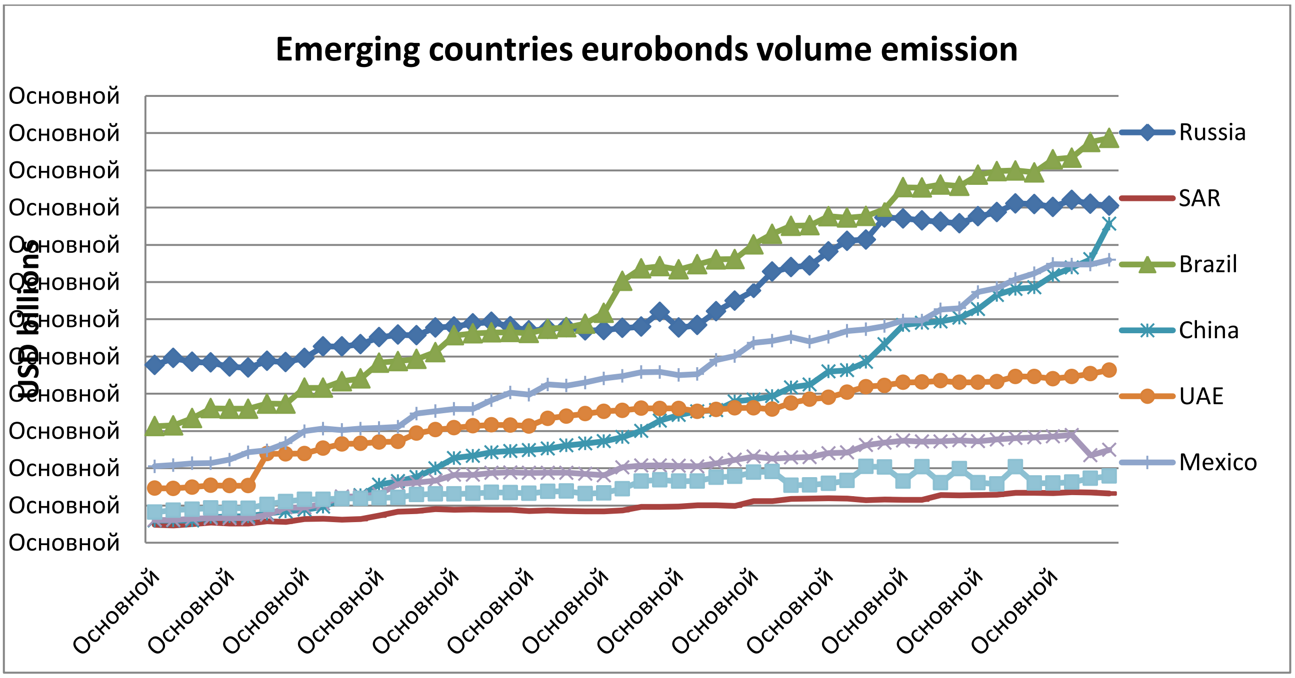
Table 1: Summary statistics of average growth rate in volume emissions of corporate Eurobond markets in Emerging countries

Average growth rate in volume emissions of Corporate Eurobond Markets						
Russia	SAR	Brazil	China	UAE	Mexico	India
16.3%	**27.1%**	**34.1%**	**87.4%**	**31.2%**	**36.1%**	**39.2%**

Despite the fact that Russian Eurobond market demonstrates high values while comparing with other countries, growth rate is the smallest one. For example China is rising with growth rate equal 87.4% which is almost **5 times** higher than Russian's growth rate! However this growth rate can be explained at least by two factors:

1) Size of Chinese economy (here we refer to GDP indicator) is 4 times bigger[1] than Russian one, so the demand of capital from the companies should be several times higher.
2) At the start of 2010 emission volume of Eurobonds in China was only 12 USD billions, while in Russia analogous indicator was at the level of 95 USD billions. That is why Chinese growth rate is such high and also Chinese market for Eurobonds is relatively young comparing to Russian, which had analogous indicator of 12 USD billions in early 2004.

Figure 2: Emerging countries corporate Eurobond markets volume emissions



[1] Tradingeconomics.com

Besides dynamic growth of bond market and increase in issues outstanding, there are another interesting facts about Russian corporate bond market. For example, most of rouble-denominated corporate bonds have embedded put options. Essentially put option in the corporate bond is the right of the bondholder to sell issue to the issuer at fixed price and prescribed date. Availability of embedded put option and seniority of the bond is not the same things, because seniority represents priority of claims in the case of default, but does not provide with an option to sell the bond at fixed price (usually at par) at predetermined set of dates. But another striking feature of this type of bonds is that usually at the put exercise dates, issuer has a right to change coupon rate at his discretion. Typical structure of this kind of bond will be the following:

- before the first put exercise date, coupon rate is fixed and known to all market participants
- around put exercise date issuer announces new coupon rate which will be valid until next put exercise date or the maturity of issue
- in most issues coupon rate changes to a lower level

These two features (presence of put options and variability of coupon rates) could be found in most of the corporate bond issues.

Section 2: Literature Review. Hypotheses

Many research papers were dedicated to studying how different risk factors influence corporate bond yields. For example, in the paper done by Collin-Dufresne, Goldstein & Martin (2001, [4]), authors find that variables used in theory to explain credit spread changes have limited explanatory power and they suggest that there is single common factor (corporate bond specific supply/demand shocks), which drives corporate bond market. Huang & Huang (2003, [11]) showed that credit risk does not explain much of the variation in corporate yield spreads. The degree of explanation rises as credit rating deteriorates: high fraction of yield spreads for junk bonds is explained by credit risk factors. Duffee (1998, [6]) in his paper presented results about relation between corporate bond yield spreads and Treasury yields. He confirmed negative relationship: yield spreads on both callable and noncallable corporate issues fall when yield on Treasury securities rises. In papers written by Chen, Lesmond & Wei (2007, [3]) and Friewald et al. (2012 [9]), authors demonstrated important role of illiquidity in pricing of corporate bonds and emphasized its influence during recent financial crisis. Making this short overview of research papers we could derive three main risk factors out there**: credit**, i**nterest rate** and **liquidity** risks.

In our paper we examine relationships between different risk proxies and corporate bond yield spreads and in particularly the influence of embedded put option on risk determinants. Firstly we give a couple of definitions. Yield spread is the difference between the yields of corporate bonds and government bonds of the same maturity. Put option in corporate bond is the right of the owner of the bond to sell it back to the issuer at predetermined price and date. So the put option can be considered as an insurance against different risks. Typical example when such option brings the value to the bond holder is when interest rates rise in the economy (insures against interest rate risk). It becomes profitable to exercise put option and invest proceeds to different securities providing higher yield. Analogously put option can be beneficial in cases of illiquid markets or issuer's credit rating deterioration.

Let's now discuss more thoroughly various determinants of credit spreads discovered in previous research papers and particularly those which were used in our work. As it was mentioned credit/default risk is one of the major risk factors influencing corporate yield spreads. One of the first papers of the role of default risk was done by Merton in (1974, [13]). Merton's structural model outlined several determinants of default risk, such as leverage and equity return volatility of the firm. Collin-Dufresne et al. (2001, [4]) in his paper used this measures as control variables for credit risk. Rationale behind these determinants is following: a firm with higher leverage potentially has higher probability of default, because in such firm there is not enough equity to cover liabilities in a case of unfavorable environment. The same story is with equity return volatility, so both leverage and volatility are positively correlated with yield spreads.

In our paper we use another credit risk proxy which was proposed in empirical papers, namely firm's numerical credit rating denoted by $\mathbf{rating_t}$. Credit rating is mix of quantitative and qualitative evaluation of the credit worthiness of an issuer based both on public and non-public information available to analysts of particular rating agency. The lower the credit rating the weaker debtor's ability to pay back the debt and higher the corresponding probability of default. There is one-to-one matching of letter ratings to their numerical counterparts (for example, **AAA** – **1**, **AA+** – **2**). We expect the sign of rating proxy to be positive, because higher values of numerical ratings correspond to weaker debtors, hence probability of credit event is higher and consequently yield spread should be higher ceteris paribus. But if the put options really serve as insurance, then the effect should be less pronounced for puttable bonds.

Structural models and empirical papers provide evidence that default-free interest rates negatively influence corporate bond spreads. For example, Duffee (1998, [6]) in his paper confirmed negative relationship: yield spreads on both callable and noncallable corporate issues fall when yield on Treasury securities rises. To explain negative relationship following intuition can be applied: high default-free interest rate should lead to high growth rate of firm assets, which reduces the likelihood of default. As default-free interest rate we use the yield of five-year Russian government bond denoted by $\mathbf{rf_t}$. When we think about the effect of default-free interest rate in puttable corporate bond, we will observe two offsetting effects. Since puttable bond can be considered as regular bond plus a put option, let's consider the effects separately. When interest rate environment changes, for example interest rates rise, then the value of regular bond will decrease, because we receive the same cash flows (our data sample contains only fixed rate bullet Rouble-denominated bonds), but discount factors will decrease, making present value of the bond lower. On the other hand, value of put option will increase, since exercising of the option in current interest rate environment becomes optimal. Overall we expect the sign of interest rate to be negative, but cannot definitely predict how put option affects overall relationship.

Several research papers demonstrated influence of non-default risk components as well as systematic risk premia, which can be captured by aggregated macro-variables. For example Longstaff et al. (2005, [12]) find that non-default component is strongly related to measures of bond-specific illiquidity as well as to macroeconomic measures of bond-market liquidity, while

Elton et al. (2001, [8]) find that substantial portion of the premium in corporate rates over treasuries can be explained by state taxes and they also find that factors explaining risk premiums for common stocks might be helpful in explaining yield spread. Since our data sample contains Russian corporate bonds, we will use Russian analogues of market variables, which were proposed in previous research papers:

1. MICEX return denoted by $\mathbf{mmvb_t}$. MICEX index is capitalization-weighted index of 50 biggest and most liquid preferred and common shares. Index computation happens in real-time in Russian Roubles. Collins-Dufresne et al. (2001, [4]) used such return to proxy for the overall state of the economy. We expect that the relationship between MICEX return and yield spreads will be negative: higher returns indicate good state of economy, which in turn lead to lower spreads.
2. Collin-Dufresne et al. (2001, [4]) proposed using volatility index as measure which captures market uncertainty risk. RTSVX denoted by $\mathbf{rtsvx_t}$ is Russian aggregated indicator that tracks the performance of the futures and options market. We expect a positive correlation between $\mathbf{rtsvx_t}$ and bond spreads. Option values should also be positively correlated with volatility measure, because the larger the market risk is the higher the value of the put option should be.
3. Elton et al. (2001, [8]) and Wang et al. (2011, [18]) provided evidence in their papers that systematic risk should be priced in corporate bond yield spreads. We introduce credit default spreads on Russia government bonds as another market variable, which should capture systematic risk in the economy. We expect $\mathbf{cds_t}$ be positively correlated with yield spreads and also with put option values.

We include several bond-specific measures as proxies for liquidity and tax effects:

1. Effective time to maturity of the issue, which we denote as $\mathbf{etm_t}$. If the bond contains a put option, then we will be using as the maturity date the earlier date of the closest put exercise date or the maturity date, if exercise date has been elapsed. If the bond does not contain an option we use issue’s maturity date to calculate time to maturity. Structural model of Merton (1974, [13]) predicts different impact of bond maturity depending on the degree of distress risk, so the overall effect is ambiguous.
2. We think of bond age as a proxy for illiquidity and denote it by $\mathbf{age_t}$. Some similarity can be found when comparing with on- and off-the-run Treasury bonds. The older the bond the less liquid it would be, hence the yield spread should be higher. So we expect positive correlation between bond age and bond spreads. Coming back to puttable

bonds, if put option mitigates various risks, we expect also positive correlation with puttable bond spreads, but less pronounced.

3. Next bond-specific feature we use in our analysis is coupon rate, denoted by $\mathbf{coupons_t}$. We think of coupon rate as a proxy for tax, duration or investor preference effects. In literature coupon rates has been associated to proxy for tax effects in corporate bond markets, because corporate bonds are more taxed than municipal or government bonds at the investor level. Then higher coupon corporate bond should have higher yield spread and we would expect positive correlation with yield spread both for regular and puttable bonds. For values of put option we could observe more direct link: higher coupon rate will lead to increase of the bond price ceteris paribus, which will make exercise of put option not profitable (for example, exercise price is 100, but currently bond is trading at 101) and hence decrease the value of the put option.

In papers written by Chen, Lesmond & Wei (2007, [3]), Dick-Nielsen et al. (2012, [5]) and Friewald et al. (2012 [9]), authors demonstrated important role of illiquidity in pricing of corporate bonds and emphasized that influence of liquidity factors during recent financial crisis was much higher than before the crisis. Now let's describe liquidity proxies which we use in our analysis. Since data available for us contains only daily observations, some liquidity measures proposed by recent research works are impossible to calculate.

1. Proportional bid-ask spread denoted by $\mathbf{b\_a_t}$ is illiquidity measure, which was exploited in recent paper done by Chen et al. (2007, [3]), where authors find that liquidity is priced in corporate yield spreads. Proportional bid-ask spread equals the ask minus the bid divided by the average bid and ask price. Since we have only daily data and do not observe trade by trade during the day, we estimate proportional bid-ask spread using closing prices. We expect proportional spread to be positively correlated with both regular and puttable bond spreads and option values. Rationale is following: if put option diminishes various risks, then we expect positive but less pronounced correlation between illiquidity measure and yield spread for puttable bond.
2. Zero-trading days, which we denote as $\mathbf{ztd_t}$ is illiquidity measure, which will be used in regression analysis. This measure was proposed in the paper written by Chen et al. (2007, [3]) and actively used in another papers, for example in Dick-Nielsen et al. work (2012, [5]). It is average number of days in a month where no bond trading happened at all. The closer the measure to one the less liquid bond is. We expect zero-trading days measure to be positively correlated with both regular and puttable bond spreads and

option values. Intuition is following: if put option serves as insurance, then we expect positive but less pronounced correlation between illiquidity measure and yield spread for puttable bond.

3. Turnover is the monthly turnover in percent of total amount outstanding for particular bond denoted by $\mathbf{turnover_t}$**.** Turnover is one of the famous liquidity measures, which could be encountered in numerous numbers of papers. Recent research papers (Dick-Nielsen (2012, [5]), Bao et al. (2011, [2])) in which authors investigate influence of liquidity in corporate bond pricing very often resort to turnover measure. We expect negative correlation between turnover measure and bond yield spreads and option values. The situation is directly opposite to the cases of zero-trading days and proportional bid-ask spreads, because turnover measures liquidity and the bigger the turnover the more liquid issue is.
4. We also introduce another measure of liquidity – scaled trading volume, denoted by $\boldsymbol{log\_trading_t}$. We use logarithmic transformation of absolute values of trading volume for a better fit. We expect the sign of trading volume be negative in a regression analysis with bond yield spreads as dependent variable, since the more active trading happens in particular bond one can much easier get fair price for its security and this leads to lower liquidity premia in spreads.
5. Bao et al. (2011, [2]) suggest to use emission volume as another proxy of liquidity. Bao et al. apply logarithmic transformation to absolute value, so do we. Rationale behind this measure, denoted by $\boldsymbol{log\_emission_t}$, is following: The bigger the issue the more attention it receives from investors, hence the issue will be more liquid, comparing to smaller issues. We expect that emission volume and yield spreads will be negatively correlated.
6. And finally we introduce another measure of illiquidity proposed in the paper of Feldhutter (2008, [15]), namely, imputed roundtrip costs and denoted by $\mathbf{irc_t}$ and actively used by other researchers, for example in the recent paper written by Dick-Nielsen et al. (2012, [5]). The idea behind this proxy is that sometimes we could observe a couple of trades (two or three trades) in corporate bond in short period of time after a longer period with no trade and this is likely to be explained by the fact that dealer matches a buyer and a seller and collects the bid-ask spread as a fee. Originally this measure by its nature is close to bid-ask spreads, however it requires intraday data to be estimated and exploited as illiquidity proxy. We on the other hand obtain only daily data and estimate approximate values of imputed roundtrip costs measure. Details

of what filters we apply to calculate this measure could be found in data processing section, but we want emphasize that this is an additional measure of liquidity which we will use, but we will be careful in its interpretation due to the fact of imprecise computation. We expect imputed roundtrip costs measure to be positively correlated with both regular and puttable bond spreads and option values, because the bigger value of the measure leads to higher risks which in turn should result in higher compensation to investors or higher yield spreads. If put option mitigates risk, then we expect positive but less pronounced correlation between illiquidity measure and yield spread for puttable bond.

And finally we discuss another measure of bond volatility denoted by $\mathbf{vol_t}$ which will be serving a role of another credit risk control. This measure was introduced in the most recent paper written by Grass and Ward (2012, [10]). It should be emphasized that results obtained by Grass and Ward directly contradict recent studies by Bao et al. (2011, [2]), Friewald et al. (2012, [9]) and Dick-Nielsen (2012, [5]). In these paper authors were examining the relation between proxies for liquidity and corporate bond yield spreads and concluding that liquidity is important pricing factor, while Grass and Ward found evidence that role of liquidity in corporate bond markets has been substantially overstated.

Authors confirm previously obtained correlation between bond spreads and various liquidity measures, but argue that it is due to the fact these measures are implicitly based on measures of bond volatility and hence at least partially capture credit risk. Using structural model of Merton (1974, [13]) Grass and Ward derive the relationship between bond volatility and credit spreads and document that bond volatility measure has more explanatory power than all proposed liquidity measures grouped together after controlling for bond volatility. We use this measure as an additional control variable in order to exclude various influences created by credit risk. Theoretical underpinnings why this measure serves as a proxy for credit risk could be found in the paper. We will present shortly the derivation of the link between bond volatility and credit spreads derived in the paper of Grass and Ward (2012, [10]).

In line with Merton (1974, [13]) model following formula describes relationship between equity σ_E and asset volatility σ_V as

$$\sigma_V = \frac{E}{V * N(d_1)} * \sigma_E{}^2$$

[2] $\frac{V}{E}$ represent leverage and $N(d_1)$ - sensitivity of option values to changes in values of underlying

There is an analogous relation between debt volatility and asset volatility. Later this formula will be used to illustrate the link between bond volatility and bond yield spreads.

$$\sigma_V = \frac{D}{V * N(-d_1)} * \sigma_D$$

F is the face value of debt, T – time to maturity and y – yield to maturity, D – zero-coupon bond value.

$$D = F * e^{-y*T}$$

Correspondingly bond yield spread equals to

$$s = -\frac{\ln\left(\frac{D}{F}\right)}{T} - r$$

Here r refers to risk-free rate. Merton's structural model (1974, [13]) considers debt is a combination of risk-free bond with face value F and a short put option on firm assets, then another way of expressing of zero-coupon bond value is

$$D = F * e^{-r*T} - P$$

$$P = F * e^{-r*T} * N(-d_2) - V * N(-d_1)$$

where P – value of put option on firm assets with

$$d_1 = \frac{\ln\left(\frac{V}{F}\right) + (r + 0.5 * \sigma_V^2) * T}{\sigma_V * \sqrt{T}}$$

and

$$d_2 = d_1 - \sigma_V * \sqrt{T}$$

Grouping all formulas together, Grass and Ward obtained relationship below and using simulations plotted the dependence of credit spreads and bond volatility, which turn out to be monotonically increasing and convex plot.

$$s = -\frac{1}{T} * \ln\left(e^{-r*T} * N(d_2) + \frac{V}{F} * N(-d_1)\right) - r$$

We expect bond volatility measure to be positively correlated with both regular and puttable bond spreads and option values, because the bigger value of the measure leads to higher risks which in turn should result in higher compensation to investors or higher yield spreads. If put option serves as insurance, then we expect positive but less pronounced correlation between bond volatility measure and yield spread for puttable bond.

Below we provide a table, which summarizes our expectations about signs of correlations of proxy variables with spreads of regular and puttable bonds and also with put option values.

Table 2: Initial hypotheses about signs of risk proxies

Variables	***Regular bond spread***	***Puttable bond spread***	***Put option value***
Macro variables			
MICEX return	<<0	<0	<0
5-year risk-free rate	<<0	<0	<>0
RTSVX index	>>0	>0	>0
CDS	>>0	>0	>0
Credit risk proxies			
Numerical credit rating	>>0	>0	>0
bond volatility	>>0	>0	>0
Liquidity proxies			
proportional bid-ask spread	>>0	>0	>0
zero-trading days	>>0	>0	>0
turnover	<<0	<0	<0
imputed roundtrip costs	>>0	>0	>0
logarithm of trading volume	<<0	<0	<0
logarithm of emission volume	<<0	<0	<0
Bond-specific measures			
bond maturity	<>0	<>0	<>0
bond age	>>0	>0	>0
coupon rate	>>0	>0	<0

Section 3: Data description and processing

Bond transaction data being used in this work are taken from Cbonds Database. This data includes details of daily transactions (closing bid/ask, open, minimum, maximum and weighted average prices, number of trades, roubles turnover, yield and duration measures, accrued coupon interest and spread above government bonds). Bond- and issuer- specific information like (credit ratings, maturity and put/call option exercise dates, coupon rates and volume of bond emission) and data on credit default spreads of Russia was also downloaded from Cbonds database. Daily data of the term structure of interest rates was sourced from Russian Central Bank website. Returns of MICEX index and volatility index of Russian stock market (RTSVX index) were obtained from MICEX website.

In this work we use data only on three types of bonds which are the following: 1) bonds trading at this time 2) redeemed bonds and 3) early redeemed bonds. We do not include defaulted bonds because we cannot obtain credit ratings for these issues from sources available to us and credit ratings will be one of the major credit risk proxies used in regression analysis. Further we clean our data to increase its validity and use following filters:

1. Data contains only corporate bond issues, municipal and government ones were not included. We are not considering these types of bonds, because most of these issues do not have embedded options (most issues are bullet or with sinking fund provision) and also both municipal and government bonds are much safer (higher credit ratings) and this will lead to less pronounced effect of various risk proxies on yield spreads and potential bias in coefficient estimates. We suggest analyzing these types of bonds separately.
2. Issuers without credit ratings are eliminated. We are considering numerical credit ratings as one of major credit risk proxy that is why we want our data sample to be constituted by bonds with credit ratings. We do not think that limiting our sample data to bonds with credit ratings only will introduce bias in estimation. Usually bonds without credit ratings are small issues issued by a regional small size firms with lack of trading.
3. Sample of data contains only with fixed coupon RUR denominated bullet bonds
4. We do not include callable, convertible bond issues or bonds with sinking funds provision to our sample.

5. All variables used in the analysis are 99% winsorized: corporate bond yield spread values smaller than 0.5% quantile and bigger than 99.5% quantile are removed from data sample.

In total, our sample contains 258 issues with almost 97 issuers from different sectors of Russian economy. Data includes observations starting from March 2004 up to May 2014. At the appendix one could find a table 3 with number of bonds and issuers at the beginning and remaining number of bonds and issuers after each step using the filters mentioned above.

Here we provide a table with descriptive statistics of data sample (monthly observations), which is used in regression analysis. As one can observe emission volumes of bonds considered vary from 0.2 to 20 RUR billions with an average at 5.5 RUR billions. Numerical ratings of issues range between Baa1 and C with a majority between Ba1 and Ba3. Average transaction size is about 15.3 millions of roubles with maximum transaction size almost two billions. Coupon rates lie between 0.1% and 20% with an average coupon rate – 9%. Mean time to maturity and bond age are almost the same 1.84 and 1.80 years respectively. 5-year risk-free rate varies between 5.9% and 11.1%. Also here one can find summary statistics of liquidity measures, market variables and average and total number of trades.

Table 4: Descriptive statistics of the data sample.

Variable	Obs	Mean	Std. Dev.	Min	Max
spread (in bps)	6765	368.4	713.8	-767.5	13234.5
irc	6765	0.03	0.07	0.00	1.00
turnover	6765	0.23	0.44	0.00	6.24
ztd	6765	0.39	0.27	0.00	1.00
coupons (in %)	6765	9.15	2.29	0.10	20.00
etm (in years)	6765	1.84	1.87	0.02	31.59
age (in years)	6765	1.80	1.27	0.00	6.69
numerical rating	6765	11.76	2.92	8.00	21.00
5 year risk-free rate (in bps)	6765	718.8	128.8	586.9	1112.9
bond volatility (in bps)	6765	832.5	1102.6	0.0	10712.0
average turnover	6765	0.02	0.04	0.00	0.82
proportional bid-ask spread	6765	0.02	0.12	0.00	2.00
mmvb (in bps)	6765	25.6	806.1	-3877.5	1771.8
rtsvx (in bps)	6765	3939.6	2321.0	2080.9	16803.5
cds (in bps)	6765	184.1	153.8	39.8	761.5
total # of trades	6765	83.8	131.7	2.0	2150.0
average # of trades	6765	5.3	6.2	1.0	102.4

emission volume (in RUR billions)	6765	5.5	3.7	0.2	20.0
trading volume (in RUR billions)	6765	1.4	3.2	0.0	42.6
log_emission	6765	22.1	0.9	19.1	23.7
log_trading	6765	19.3	2.3	6.5	24.5
transaction size (in RUR millions)	6765	15.3	46.6	0.0	1860.0

The only dependent variable used in this work is spread, which is the difference of corporate bond yield and government bond yield of the same maturity. Independent variables include different proxies of liquidity risk, credit risk, interest rate risk, bond volatility and variables reflecting overall market condition, such as MICEX return, volatility index, credit default spreads. Main instrument of studying relationship between spreads and independent variables is panel data regression analysis. Below I will discuss the methodology which I have used to estimate both yields and independent variables from the daily data obtained and build a panel with monthly observations, which will be used in regression analysis. In the appendix we provide a table 13 with exact definitions of all variables.

Corporate bond yield:

Data contains daily observations, which consist of various prices, number of trades and rouble turnovers. To use price data provided from Cbonds database in a most efficient way, we excluded only those days with no pricing data at all. Here to calculate yield, we refer to promised yield and use “street convention”. Below I will provide the formula for the “clean” price and using it one can exploit numerical methods to find approximate value of yield. Now I will explain each component used in the formula.

$$\boldsymbol{P} = \left[\frac{\boldsymbol{redemption\ value}}{\left(\boldsymbol{1} + \frac{\boldsymbol{yield}}{\boldsymbol{frequency}}\right)^{(\boldsymbol{N-1+w})}}\right] + \sum_{\boldsymbol{k=1}}^{\boldsymbol{N}} \frac{\boldsymbol{100} * \frac{\boldsymbol{coupon\ rate}}{\boldsymbol{frequency}}}{\left(\boldsymbol{1} + \frac{\boldsymbol{yield}}{\boldsymbol{frequency}}\right)^{(\boldsymbol{k-1+w})}} - \boldsymbol{100} * \frac{\boldsymbol{coupon\ rate}}{\boldsymbol{frequency}} * (\boldsymbol{1} - \boldsymbol{w})$$

- **P** – clean/quoted price
- **yield** – corporate bond yield
- **frequency** is number of times coupon is paid during the year
- **w** is the ratio of days between settlement day and next coupon payment date and days in corresponding coupon period
- **N** is the number of coupon payments between settlement date and maturity date

One can use this formula with all entries except for the yield (here we refer to yield to maturity) and find the yield with numerical methods.

On days at which no trading happened we used midpoint of closing bid and ask prices as the price at which potential trade could happen. However on days at which there was trading we exploited volume weighted average price. Coupon rates and its frequency were also available from the data provided by Cbonds. We do not calculate yields based only on days at which trading happened, because in this case we are losing significant amount of our dataset (daily closing bid and ask prices) and we are potentially exposed to bias in yield estimation. This bias can be caused by the fact that we are omitting all non-trading days and our estimate will be biased downwards, since computation is based only on "liquid" days.

Government bond yield:

To describe zero-coupon bond yield curve for Russian government bonds, which is also being called G-curve, Nelson-Siegel parametric model with adjusting terms[3] (for continuously compounding interest rate) is used by Russian Central Bank and other market participants. Ancestor of this model was described in the paper of Nelson et al. (1987, [20]) and contained only 3 parameters, but since that time many variations of initial Nelson-Siegel model appeared and one of them used by Russian Central Bank. This model fully described by 7 parameters, which are recomputed after every trade every day with government bonds which satisfy two conditions:

1. Bond issue is a member of the set of government bonds, which are used for estimating Nelson-Siegel model with adjusting terms
2. Maturity of the bond issue is more than 30 calendar days.

Below we provide the Nelson-Siegel model with adjusting terms

$$R(t) = \beta_0 + (\beta_1 + \beta_2) * \frac{\tau}{t} * \left[1 - e^{\left(-\frac{t}{\tau}\right)}\right] - \beta_2 * e^{\left(-\frac{t}{\tau}\right)} + g_1 * e^{\left(-\frac{t^2}{2}\right)} + g_2 * e^{\frac{-(t-1)^2}{2}} + g_3 * e^{\frac{-(t-2)^2}{2}}$$

- β_0 is interpreted as long-run levels of interest rates
- β_1 is the short-term component
- β_2 is the medium-term component
- τ is decay factor, allows for better fitting the curve

[3] More details about constructing term structure could be found on Russian Central Bank website: http://www.cbr.ru/gcurve/MetMat.asp

- g_i *and* $i = 1,2,3$ is adjusting terms. They are used for more precise estimation of initial part of the curve

As we mentioned above values of all 7 parameters are recomputed after every trade using numerical methods. Russian Central Bank provides averaged estimates of these 7 parameters for every day, so one can construct term structure of interest rates for every day using these parameters. So given time to maturity of the corporate bond, one can find the exact value of government bond yield of the same maturity.

Spreads:

After calculating yields for every issue and every day in which trades happened and estimating daily yields of government bonds with same maturity, we computed the value of yield spreads, which are the difference between corporate bond yields and government bond yields. Then monthly values of yield spreads were calculated using simple averaging of daily observations.

Before describing liquidity measures that we use in our work more thoroughly, we will give an explanation why these measures were chosen. Since there is natural restriction of available data and we do not have intraday data about trades happened during the day, estimation of more precise liquidity measures (Amihud measure (Amihud (2002, [19]), Roll measure (Roll (1984, [16]), Dick-Nielsen-Lando measure (Dick-Nielsen et al. (2012, [5])) becomes impossible in our research[4].

Proportional bid-ask spread measure:

Proportional bid-ask measure is used in this work as proxy of illiquidity. Using closing bids and closing asks, we calculated this measure for every day in which trading happened and then aggregated daily observations of it monthly values by simple averaging. The bigger the value the less liquid is trading.

$$\boldsymbol{Bid_{ask} = 2 * (Closing\ ask - Closing\ bid)/(Closing\ ask + Closing\ bid)}$$

Zero-trading days:

Zero-trading days is another measure of illiquidity, which was used in the paper of Chen, Lesmond, and Wei (2007, [3]). For every day in which trading happened in particular bond in particular month, we put **0** in zero-trading day dummy variable and for every day in which there were no trading activity we put **1**. Then using daily values we arrive to monthly ones by taking

[4] However we estimate one illiquidity measure (imputed roundtrip cost) using daily data, but we will interpret results obtained with caution.

the average. The closer the value to 1 in a particular month, the less trading of this issue during that month was happening,

$$\boldsymbol{zero-trading\ days} = \frac{\sum_{k=1}^{N} \boldsymbol{dummy_k}}{\boldsymbol{N}}$$

where N is total number of trading days in a particular month.

Turnover:

Turnover measure used in this work is another proxy of liquidity. To calculate daily relative measures we divide the rouble trading volume by bond volume emission. Using daily values we compute monthly ones by adding daily values constituting a particular month. The bigger the value, the more liquid is the issue.

$$\boldsymbol{turnover} = \sum_{k=1}^{N} \boldsymbol{daily\ turnover_k}$$

where N is total number of trading days in a particular month.

Trading volume:

Daily trading volumes for each bond are available from the Cbonds Database. To calculate monthly values we add all daily values constituting a particular month. The larger the trading volume, the more liquid issue should be.

$$\boldsymbol{Trading\ volume} = \sum_{k=1}^{N} \boldsymbol{daily\ trading\ volume_k}$$

For a better fit inside the model we apply logarithmic transformation, since absolute values of are tremendous. We add one inside the brackets to deal with months with no trading at all.

$$\boldsymbol{log\_trading} = \boldsymbol{ln}(\boldsymbol{1} + \boldsymbol{Trading\ volume})$$

Emission volume:

For a particular bond for every month value of emission volume is the same. Emission volume is a liquidity proxy, which captures investor’s attention to the issue. The bigger the issue the more liquid particular bond should be. Here again we use logarithmic transformation to adjust large absolute values of volume emission to the nature of panel data.

$$\boldsymbol{log\_emission} = \textbf{ln}(\boldsymbol{Emisssion\ volume})$$

Imputed roundtrip costs:

Feldhutter (2011, [15]) proposed an alternative measure of transaction costs (another illiquidity measure) based on so called imputed roundtrip trades. Rationale behind this measure is following: one can observe couple of trades in a corporate bond (two or three) happening within a short period of time after some period with no trading at all and it probably occurs because dealer tries to match buyer and seller and after matching she collects bid-ask spread as a fee. If two or three trades with the same trade size happens on the same day and there were no trades of this size at this day Feldhutter defines these trades as part of imputed roundtrip trades and introduce imputed roundtrip costs measure, which is equal

$$IRC = \frac{P_{max} - P_{min}}{P_{max}}$$

where P_{max} **and** P_{min} are the largest and the smallest price in imputed roundtrip trades.

So far as, we do not have intraday data about trades and we only have data about overall trading activity during the day, we estimate approximate daily value of IRC, using following filter: if amount of trades is larger or equal two, then using formula above we calculate it, otherwise on days in which no trading happened or there was only 1 deal, we do not calculate IRC. Since we cannot distinguish between trades during the day we take P_{max} **and** P_{min} maximum and minimum bond price during the day correspondingly. This approximate measure is highly correlated with bid-ask spread measure, so we will be using it later in regression analysis, but we will interpret it with alertness. After estimation of daily values, by simple averaging we compute monthly values of imputed roundtrip costs for issues.

Rating:

As we stated all issuers in our sample has at least one credit rating from one of the major international rating agencies (Moody's, Standard&Poor's, and Fitch). In case of if there is no rating from international agency we use ratings given by Russian agencies. We intended to use credit rating as a proxy for credit risk of the issuer. However there is one shortcoming of this proxy: snapshot of credit ratings were taken in 2012 and changes of ratings are not captured by this proxy. But since we do not include defaulted bonds and our data sample contains only "nice" bonds (after filtering out) we think of this rating transition as minor issue. Nevertheless we include another proxy to capture credit risk, which we discuss later, to make sure that we control for credit risk.

There is one-to-one correspondence of character ratings to numerical ones. Numerical rating increases as an issuer's credit quality deteriorates. For example, AAA rating corresponds to 1, AA+ to 2 and so on. One can find full correspondence between letter ratings and numerical ratings in the table 5, provided in appendix. More details about rating correspondence of international and Russian rating agencies could be found on the Ministry of Finance website.[5]

Bond-specific measures:

For every bond and every month we calculate monthly values of coupons, effective time to maturity and bond age by simple averaging daily observations. In the case of bonds with coupon rate that does not change through bond's life, monthly coupon rate observations will be the same. For those bonds, where coupon rate is changing, we also calculate the monthly observation of the coupon rate and these bonds will not display the same value of coupon rate during bond's life.

Besides coupon rate we also exploit effective time to maturity variable in our analysis. If the bond contains a put option, then we will be using as the maturity date the earlier date of the closest put exercise date or the maturity date, if exercise date has been elapsed. If the bond does not contain an option we use issue's maturity date to calculate time to maturity. After computing for every day time to maturity we find the monthly value for it, by taking simple average.

And finally we calculate bond age by taking the difference between settlement date (date of trading) and date at which interest on the bond started accruing. We use the same procedure to estimate monthly values of this measure as we did with time to maturity.

5-year "risk free" rate:

We have discussed already how we calculated government bond yields with the same maturity as corporate bonds exploiting Nelson-Siegel model with adjusting terms. Actually we are using this model again to find 5-year "risk free" rates, which will be a proxy variable for interest rate risk. The rationale behind this proxy is following: if the interest rate environment changes and interest rates rise in the economy, then it becomes optimal for the holders of puttable bonds to sell the issue back to the issuer, receive proceeds and invest in other issues granting higher coupon rates, which reflect changed interest rates. On the other hand if the interest rates decline then the investors will face reinvestment risk, because they receive coupon payments and invest these coupons in securities with lower yield. That is why we use 5-year "risk-free" rate as proxy variable for interest rate risk.

[5] http://www.minfin.ru/ru/regulation/akkrreitagenstv/akkr_expert/

We are plugging in time to maturity $\boldsymbol{t = 5}$ to the formula describing the Nelson-Siegel model and obtain estimates of these rates for every trading day. Then using daily observations of this rate we could estimate monthly values by simply averaging days constituting particular month.

Bond volatility:

Grass and Ward (2012, [10]) in their paper suggested a simple measure of bond volatility, which is nicely capturing variations in credit spreads and has more explanatory power than all proposed liquidity measures grouped together. We use this measure as an additional control variable in order to exclude various influences created by credit risk. Theoretical underpinnings why this measure serves as a proxy for credit risk could be found in the paper. We follow the methodology of Grass and Ward in estimating bond volatility[6]. Here we will shortly describe the main steps of estimating bond volatility. Using daily data, we compute bond returns and then estimate standard deviation of all bond returns in a month period. The drawback of this measure is that trades are not observed at the same frequency for all bonds and to account for this fact Grass and Ward suggest using square root of time rule. In order to compute comparable annualized values of standard deviations using daily return data, one has to multiply original standard deviation by the square root of 252 (based on the assumption of 252 trading days in a year).

Credit Default Spreads:

Longstaff et al. (2005, [12]), Elton et al. (2001, [8]) and a few other research papers highlight the role of non-default risk components as well as systematic risk premia in corporate bond spreads, which could be captured by macro variables. In the paper we use several such variables, which are: MICEX return, RTSVX and CDS. We will discuss first two variables in more detail a little bit later and for now we will concentrate on CDS. Credit default spreads serve as a proxy for credit (default) risk in overall Russian economy. Daily data on CDS was obtained from Cbonds database and to get monthly values of credit default spreads we take an average of corresponding daily data.

Returns on MICEX index:

Collin-Dufresne et al. (2001, [4]) used in their paper the S&P 500 return to proxy for overall state of the economy. MICEX index is capitalization-weighted index of 50 biggest and most liquid preferred and common shares. Index computation happens in real-time in Russian

[6] "Do Corporate Bond Spreads Really Contain Illiquidity Premia?", paper by Grass and Ward (2012), page 23.

Roubles. Using daily data on MICEX index, which was obtained from MICEX's website[7] we estimated monthly averages of the index. Then using monthly averages we calculated monthly returns on index.

RTSVX index:

Collin-Dufresne et al. (2001, [4]) proposed using volatility index as measure which captures market uncertainty risk. RTSVX is an aggregated indicator that tracks the performance of the futures and options market. The index is calculated on the basis of volatility levels of the nearby and next series of options on RTS index futures using Black-Scholes option pricing formula with futures as the underlying asset. More details about exact procedure of computing the index values could be found on official website of Moscow exchange.[8] To obtain monthly averages we simply take an average of daily values of volatility index.

[7] www.micex.com/marketdata/indices/today

[8] www.moex.com/a605

Section 4: Is liquidity a pricing factor in Russian corporate bond market?

We raise issue about pricing of risk factors, namely liquidity risk, because most of the papers written on similar topics confirm the importance of liquidity risk in pricing securities (see e.g. Bao, Pan & Wang (2011, [2]); Chen et al. (2007, [3]); Dick-Nielsen, Feldhutter & Lando (2012, [5])). But more recent research done by Grass & Ward (2012, [10]) is in direct contrast with papers mentioned just before. Authors argue that liquidity risk has almost no effect on pricing and as a matter of fact all liquidity proxies are capturing credit risk.

That is why we want to investigate what risk factors are priced and now we discuss our empirical methodology that we partially borrowed from the paper of Ericsson et al. (2011, [7]). Our methodology differs from the latter research that we use more direct measures of liquidity risk and introduce new variables in our research, namely: bond volatility and credit default spreads.

For regression methodology, we fit a panel data regression with random effects with an AR(1) error structure in line with Ericsson et al. (2011, [7]). We rely on methodology developed by Baltagi and Wu (1999, [1]) to adjust for the unbalanced nature of the data panel. To confirm applicability of this methodology we run panel data tests (Hausman test, Breusch-Pagan LM test and F-test) and also Wooldridge first-order panel data autocorrelation test and find that model with random effects and AR(1) error structure is the best fitting one.

Since question we raise is whether liquidity matters in corporate bond pricing in Russia, we run following regressions to capture influence of liquidity risk on bond yield spreads controlling other risk factors with variables discussed before:

$$\mathbf{Yield\_spread_{it}} = c_0 + c_1 * \mathbf{Liquidity\_proxy_{it}} + c_2 * coupons_{it} + c_3 * etm_{it} + c_4 * age_{it} + c_5 * rating_{it} + c_6 * r^f_{it} + c_7 * mmvb_{it} + c_8 * rtsvx_{it} + c_9 * cds_{it} + c_{10} * vol_{it} + \varepsilon_{it}$$

Below in the table 6, we provide regression results. Among the variables bond-specific variables (coupon rate, time to maturity and bond age), numerical credit rating, credit default spreads, Russian volatility index, return on MICEX index, yield of 5-year government bonds, bond volatility and liquidity proxies. As one can observe in all six regressions credit rating is positive and significant at 0.1% level highlighting the fact that credit risk is priced. Among the market variables MICEX return is positively correlated and significant at 1% level. The result is not expected one, however in a paper done by Campbell and Taskler (2003, [17]) authors found that bond yield spreads increased despite the fact that stock market performed well and explained this effect by idiosyncratic volatility unpriced in stock returns, but captured by bond spreads.

Bond spreads are positively and significantly correlated with Russian volatility index and credit default spreads as expected at 0.1% level, consistent with Longstaff et al. (2005, [12]). Risk-free interest rate negatively correlated with yield spreads and significant, which is consistent with Duffee (1998, [6]).

Coefficient of coupon rate is positive and significant, which is in line with our initial hypothesis. We think that coupon rates can serve as a proxy for tax effects and since, corporate bonds are taxed in Russia more than government and municipal bonds, investors require higher yield. Bond-specific measures such as time to maturity and bond age are insignificant.

Bond volatility measure proposed in Grass and Ward paper is also positive and significant at 0.1% level. Coefficient is in line with our initial hypothesis.

Liquidity measures are all significant at least at 1% significance level, except for logarithm of emission volume, which is significant only at 10% and every proxy except for turnover is in line with theoretical underpinnings and our initial hypotheses! Sign of turnover is quite puzzling, though Bao et al. (2011, [2]) in their paper obtained the same result for turnover measure. Dick-Nielsen et al. (2012, [5]) in their research found that turnover measure becomes positive for speculative bonds, while being negative for investment grade bonds. To check whether our findings is in line with results of Dick-Nielsen et al. (2012, [5]) we run separate regressions with turnover measure for both types of bonds and below in table 7 we provide results. Results are indicating that for investment grade bonds turnover measure is still positive, but its significance reduced to 5% level. Potential explanation to such phenomenon might be that due to overall illiquidity of bonds market, high turnover leads to higher volatility of prices, which in turn represents market risk and not captured by other independent variables. Hence investors require higher compensation.

Overall regression results indicate that liquidity risk matters for pricing of corporate bonds in Russia!

Table 6: Corporate bond yield spreads and various risk proxies in Russia.

Spread	proportional bid-ask spread	zero-trading days measure	Turnover	logarithm of emission	logarithm of trading
Liquidity measure	1066.08*** (69.57)	121.24** (40.25)	124.99*** (27.52)	-44.07 (27.64)	-9.61*** (2.56)
coupon rate	73.10*** (7.08)	86.11*** (7.74)	83.88*** (7.84)	83.13*** (7.84)	85.20*** (7.67)
time to maturity	-16.93 (8.97)	-16.27 (10.13)	-21.13* (10.31)	-17.68 (10.20)	-17.26 (10.02)
bond age	9.53 (12.23)	8.44 (13.45)	20.91 (13.61)	11.87 (13.45)	8.57 (13.32)
numerical rating	51.50*** (6.38)	47.06*** (7.16)	47.98*** (7.35)	39.79*** (8.74)	45.77*** (7.11)
5-year risk free rate	-0.64*** (0.15)	-0.34* (0.16)	-0.28 (0.16)	-0.29 (0.17)	-0.36* (0.16)
MICEX return	0.03** (0.01)	0.04** (0.01)	0.03** (0.01)	0.03** (0.01)	0.03** (0.01)
RTSVX index	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)	0.03*** (0.01)
CDS	1.40*** (0.14)	1.41*** (0.16)	1.39*** (0.16)	1.43*** (0.16)	1.42*** (0.16)
bond volatility	0.04*** (0.01)	0.05*** (0.01)	0.05*** (0.01)	0.05*** (0.01)	0.05*** (0.01)
_cons	-852.19*** (132.53)	-1162.60*** (146.68)	-1188.63*** (148.77)	-63.74 (682.69)	-894.01*** (157.83)
r2_o	**29.0%**	**22.0%**	**22.0%**	**22.0%**	**23.0%**
r2_b	58.0%	50.0%	47.0%	50.0%	50.0%
r2_w	20.0%	15.0%	15.0%	15.0%	15.0%

Here * refers to 5% significance level, ** to 1% and *** to 0.1% significance levels correspondingly.

Table 7: Influence of creditworthiness of issuer on interrelationship between corporate bond yield spreads and turnover measure in Russia.

	Investment grade	**Speculative bonds**
turnover	52.03* (26.30)	151.56*** (42.14)
coupon rate	38.66*** (7.35)	102.10*** (11.36)
time to maturity	-17.32* (8.00)	-32.66 (17.62)
bond age	-30.37** (10.33)	63.55** (23.29)
numerical rating	26.27 (21.47)	39.72* (16.22)
5-year risk free rate	0.25 (0.13)	-0.65* (0.28)
MICEX return	0.04*** (0.01)	0.04* (0.02)
RTSVX index	0.02 (0.01)	0.05*** (0.01)
CDS	0.27 (0.15)	2.14*** (0.26)
bond volatility	0.03* (0.01)	0.06*** (0.01)
_cons	-599.47** (228.42)	-1257.57*** (297.91)
r2_o	**8.00%**	**25.00%**
r2_b	12.00%	48.00%
r2_w	8.00%	21.00%

Here * refers to 5% significance level, ** to 1% and *** to 0.1% significance levels correspondingly.

Section 5: Influence of embedded options on risk proxies

Here we apply regressions to analyze the influence of embedded options on liquidity risk proxies. Our initial hypothesis was that embedded put options should reduce various risks, including liquidity risk, as put option can be considered as insurance.

We introduce dummy variable $\boldsymbol{opt_t}$ which equals one if bond contains a put option and zero if bond is without put option. We also create six different interaction variables according to number of liquidity proxies, which are calculated in following way:

$$\boldsymbol{Interaction\ term_t = opt_t * liquidity\ measure_t}$$

If embedded option really serves as insurance, then we expect negative correlation of option dummy with yield spread and also negative coefficient for illiquidity measures. Our regression methodology is following:

$$\mathbf{Yield\_spread_{it}} = c_0 + c_1*\mathbf{Liquidity\_proxy_{it}} + c_2*coupons_{it} + c_3*etm_{it} + c_4*age_{it} + c_5*rating_{it} + c_6*r^f_{it} + c_7*mmvb_{it} + c_8*rtsvx_{it} + c_9*cds_{it} + c_{10}*vol_{it}\ c_{11}*\mathbf{opt_{it}} + c_{12}*\mathbf{interaction\_term_{it}} + \varepsilon_{it}$$

However our findings from regression analysis in table 8 and are in direct contradiction with our initial beliefs. Almost all liquidity proxies become insignificant and even some of the coefficients before liquidity measures change sign to the opposite ones. Option dummy is positive and significant in most of the cases and interaction terms are also mostly positive and significant!

We suggest following explanation to this phenomenon. Most of Russian corporate bonds puttable, but usually these bonds also have a callable feature. Issuer have the right to change the coupon rate by his discretion and such coupon rate changes usually happen near put exercise dates. In most cases coupon rate decreases. This is so called bonds with “oferta”. Below we give an example of such a bond.

Typical example of bond containing both put and call features would be a bond with coupon rate, which is fixed and known to market participants. However this coupon rate is valid before the first put exercise date. At put exercise date issuer assigns new coupon rate, which will be valid till the next put exercise date or maturity of the bond.

Table 8: Influence of embedded options in Russian corporate bonds on liquidity risk through interaction terms

Spread	b_a	irc	turnover	ztd	log_emission	log_trading
Liquidity proxy	**9.39** (307.89)	**-834.14*** (401.08)	**69.14** (48.97)	**-108.557** (65.95)	**4.205** (45.23)	**7.774** (5.97)
coupon rate	70.03*** (6.98)	67.59*** (6.67)	80.99*** (7.72)	82.893*** (7.58)	79.426*** (7.68)	82.090*** (7.50)
time to maturity	-10.88 (8.89)	-12.27 (8.51)	-12.95 (10.26)	-10.519 (9.95)	-10.248 (10.01)	-11.061 (9.82)
bond age	10.78 (12.02)	11.72 (11.65)	22.12 (13.43)	13.134 (13.18)	14.477 (13.20)	12.881 (13.04)
numerical rating	48.75*** (6.25)	45.98*** (5.99)	43.64*** (7.18)	43.755*** (6.94)	33.520*** (8.42)	42.010*** (6.86)
5 year risk-free rate	-0.61*** (0.15)	-0.72*** (0.14)	-0.27 (0.16)	-0.304 (0.16)	-0.257 (0.17)	-0.32 (0.16)
MICEX return	0.03** (0.01)	0.03*** (0.01)	0.04** (0.01)	0.035** (0.01)	0.034** (0.01)	0.034** (0.01)
RTSVX index	0.03*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.034*** (0.01)	0.032*** (0.01)	0.033*** (0.01)
CDS	1.41*** (0.14)	1.37*** (0.13)	1.37*** (0.16)	1.392*** (0.16)	1.422*** (0.16)	1.403*** (0.16)
bond volatility	0.05*** (0.01)	0.04*** (0.01)	0.05*** (0.01)	0.050*** (0.01)	0.050*** (0.01)	0.052*** (0.01)
Option	**113.90***** (33.44)	**74.63*** (32.84)	**162.88***** (40.38)	**34.685** (50.48)	**1765.813** (1 076.72)	**562.262***** (129.45)
liquidity interaction term	**1104.01***** (315.46)	**2350.75***** (418.19)	**69.94** (58.40)	**330.472***** (81.68)	**-71.086** (48.47)	**-20.495**** (6.54)
_cons	-890.94*** (130.79)	-751.42*** (125.58)	-1221.37*** (147.13)	-1152.045*** (144.47)	-1177.224 (1 045.21)	-1301.620*** (191.44)
r2_o	**30.0%**	**31.0%**	**22.0%**	**23.5%**	**22.9%**	**24.0%**
r2_b	60.0%	58.0%	50.0%	53.1%	53.8%	54.1%
r2_w	21.0%	22.0%	15.0%	15.4%	14.8%	15.7%

Significance levels stated in the table 8 correspond: * refers to 5% significance level, ** to 1% and *** to 0.1% significance levels correspondingly.

The reasons why such bonds are highly popular in Russia could be following:

1. High transaction costs of issuing bonds
2. Such bond structure provides an issuer flexibility to adjust coupon rates to market conditions

As one can probably observe from the table 9, option dummy in all regressions is positive and demonstrates highly significance in most of the regressions. This result implies that bonds with options embedded are bonds with higher yield spreads! In other words investors require higher yield from bonds containing both put and call features than from simple bonds with no options.

To confirm this hypothesis we will provide in the table below, results from regression analysis that option dummy is positive and highly significant! In regression we will control for various risk proxies, while including option dummy, which will equal 1 in the case if bonds have options embedded and 0 otherwise.

Table 9: Influence of option presence in corporate bonds on yield spreads

	b_a	irc	turnover	ztd
Liquidity proxy	1056.96*** (69.50)	1303.76*** (122.69)	117.45*** (27.34)	102.711* (40.22)
coupon rate	70.90*** (7.00)	68.88*** (6.73)	81.07*** (7.71)	82.967*** (7.63)
time to maturity	-11.08 (8.92)	-14.34 (8.56)	-14.07 (10.19)	-9.636 (10.02)
bond age	10.79 (12.08)	11.14 (11.78)	22.16 (13.39)	11.146 (13.25)
numerical rating	48.36*** (6.27)	44.42*** (6.02)	43.46*** (7.16)	42.878*** (6.99)
5 year risk-free rate	-0.63*** (0.15)	-0.75*** (0.14)	-0.27 (0.16)	-0.328* (0.16)
MICEX return	0.03** (0.01)	0.03*** (0.01)	0.04** (0.01)	0.036** (0.01)
RTSVX index	0.03*** (0.01)	0.04*** (0.01)	0.04*** (0.01)	0.034*** (0.01)
CDS	1.39*** (0.14)	1.33*** (0.14)	1.37*** (0.16)	1.394*** (0.16)

bond volatility	0.04*** (0.01)	0.03*** (0.01)	0.05*** (0.01)	0.050*** (0.01)
option dummy	**130.54*** (33.15)	**124.20*** (31.79)	**177.00*** (38.51)	**171.651*** (37.78)
_cons	-889.39*** (131.28)	-753.24*** (126.74)	-1231.41*** (146.59)	-1202.307*** (144.76)
r2_o	**30.00%**	**30.00%**	**23.00%**	**22.90%**
r2_b	**60.00%**	**58.00%**	**51.00%**	**53.00%**
r2_w	20.00%	20.00%	15.00%	14.90%

Here * refers to 5% significance level, ** to 1% and *** to 0.1% significance levels correspondingly.

All regressions demonstrate highly significant and positive coefficient of option dummy in the regression analysis with yield spreads as dependent variable. Magnitude of coefficient in all regressions of the same order: on average yield spread of bond with “oferta” is higher than analogous spread of ordinary bond on 150 bps, which is very interesting results and unexpected result!

For example in the recent paper of Militskova (2013, [14]) author argues that presence of embedded options in corporate bonds does not affect yield spreads, since effect of put and call options cancel out each other and yield spread of such bond corresponds to the yield of ordinary bonds with date of maturity equal to first put exercise date.

Possible explanation of such result might be the following: investors have negative association with bonds with embedded options, because corporate practice shows that coupon rates are falling after put exercise date in the most cases. Investor’s expectation of the fact that coupon rates will fall will lead to the following:

- If investors do not sell their issues at the put date and expect coupon rates to fall, then yield of such bond should be higher.
- If investors sell their issues at the put date they will face reinvestment problem of proceeds, obtained from selling the issue, since initial investment horizon matches the maturity date of the bond!

In section 2, while discussing how various risk factors should affect ordinary corporate bonds and bonds with put option, we also touched the problem why put option can be considered as an insurance and further we provide analysis of how risk factors affect value of option, measured as the difference of yield spreads between ordinary bond and bond with put options.

Data selection criteria and quantitative methodology that we use we borrowed from the paper of Ericsson et al. (2011, [7]), who studied the same problem on corporate bonds market in US. Dataset, which we used to analyze the problem, consisted of pairs of bonds, issued by the same company, where one bond is an ordinary and other bond contains put option. Another restriction imposed on matched pairs is that, both bonds should be issued with the difference of 10 days. As we already discussed that in Russia many issuers like to issue bonds with both call and put features embedded, we could not manage to find bonds which contained only put option without coupon rate changing feature. After finding not many bonds using research paper criteria, we added bonds, which possess following characteristic: the difference between maturity date of bond A company Co. and first put option exercise date of bond B of the same issuing company is 10 days. To clarify the last statement we will give an example of such pair:

1. Ordinary bond A of Comp Co. issued at 15 April of 2004 and maturing on 15 April of 2010
2. Bond B of Comp Co. issued at 15 September of 2007 and has first put option exercise date on 15 April of 2010

Overall our dataset on which we run regressions contain two types of matching and contains only **26** bonds:

1. Matching proposed in the paper of Ericsson et al. (2011, [7]), where two bonds issued around the same time and one is ordinary and another is with embedded options
2. Matching using the criteria discussed above

Value of embedded option is calculated as the difference between monthly observations of the yield spread of bonds with option and the yield spread of regular bonds. Regression methodology is in line with paper of Ericsson et al. (2011, [7]).

$$\mathbf{Regular\_spread_{it}} = c_0 + c_1*log\_emission_{it} + c_2*coupons_{it} + c_3*etm_{it} + c_4*age_{it} + c_5*rating_{it} + c_6*r^f_{it} + c_7*mmvb_{it} + c_8*rtsvx_{it} + c_9*cds_{it} + \varepsilon_{it}$$

$$\mathbf{Puttable\_spread_{it}} = c_0 + c_1*log\_emission_{it} + c_2*coupons_{it} + c_3*etm_{it} + c_4*age_{it} + c_5*rating_{it} + c_6*r^f_{it} + c_7*mmvb_{it} + c_8*rtsvx_{it} + c_9*cds_{it} + \varepsilon_{it}$$

Here we regress option value on market- and firm-level explanatory variables as well to control different contractual features between regular bonds and bonds with embedded options, we include their

- maturity difference $\mathbf{etm\_diff_t} = \mathbf{etm_t^{option}} - \mathbf{etm_t^{regular}}$
- age difference $\mathbf{age\_diff_t} = \mathbf{age_t^{option}} - \mathbf{age_t^{regular}}$
- coupon rate difference $\mathbf{coupon\_diff_t} = \mathbf{coupon_t^{option}} - \mathbf{coupon_t^{regular}}$
- emission volume difference $\mathbf{log\_emission\_diff_t} = \mathbf{log\_emission_t^{option}} - \mathbf{log\_emission_t^{regular}}$

regression analysis.

$$\mathbf{Option\_value_{it}} = c_0 + c_1{*}log\_emission\_diff_{it} + c_2{*}coupons\_diff_{it} + c_3{*}etm\_diff_{it} + c_4{*}age\_diff_{it} + c_5{*}rating_{it} + c_6{*}r^f_{it} + c_7{*}mmvb_{it} + c_8{*}rtsvx_{it} + c_9{*}cds_{it} + \varepsilon_{it}$$

Below in the table 10, we provide results obtained from these three regressions:

Table 10: **Risk factors influence on spreads of regular bond and bond with embedded options and option value, measured in terms of difference of yield spreads.**

	options value	**regular bond**	**bond with options**
coupon rate	52.35*** (6.47)	42.87*** (12.82)	45.59*** (11.22)
time to maturity	-8.62 (25.06)	-31.31 (20.18)	-65.06 (36.54)
bond age	-24.18 (47.64)	-31 (22.88)	-49.64 (36.43)
numerical rating	15.26 (25.92)	-20.81 (14.16)	45.38* (22.08)
5 year risk-free rate	-0.52* (0.22)	-0.15 (0.22)	-0.73* (0.32)
MICEX return	-0.02 (0.02)	0.05 (0.03)	0.01 (0.02)
RTSVX index	0.01 (0.02)	-0.01 (0.02)	0.02 (0.01)
CDS	1.01*** (0.26)	1.85*** (0.26)	2.67*** (0.29)
log of emission volume	131.16 (157.46)	-257.24*** (56.38)	-52.76 (98.76)
_cons	-130.22 (316.37)	5831.02*** (1 368.10)	678.63 (2 328.55)
r2_o	**38%**	**46%**	**57%**
r2_b	**73%**	**84%**	**77%**
r2_w	14%	25%	38%

Here * refers to 5% significance level, ** to 1% and *** to 0.1% significance levels correspondingly.

Coupon rates as well as CDS spreads are the only significant variables in all three regressions. Coefficient of coupon rate is in line with our initial hypothesis, however effect for puttable bond is a little bit more pronounced. We explain such relation due to the fact that puttable bonds are also callable and investors see such bonds more risky. As we already discovered that yield for bonds with “oferta” is higher than for regular bonds, magnitude of coefficients of coupon rate and CDS spread is in line with our findings. Coefficients of time to maturity and bond age are insignificant and latter are negative. Significance of numerical rating disappears in both regular bond and option value regression. Probable explanation of such behavior could also be attributed to small size of panel data, which is used for this particular analysis. Risk-free rate as well as emission volume has expected signs.

Overall we could observe that bonds with embedded options are more sensitive to risk factors. However explanation of correlation between value option and risk factors are more difficult, since there is no pure puttable bonds in our small sample of 26 bonds and disentangling the effects of put and call features in corporate bonds seems to be unfeasible.

Section 6: Role of liquidity factors during the crisis and afterwards in pricing corporate bonds.

A lot of research effort was dedicated to study the effect of liquidity factors during the crisis and investigate whether liquidity was priced more heavily during the subprime crisis than in other periods. One of the recent paper on this topic was written by Dick-Nielsen et al. (2012, [5]). Authors were exploring spread contribution from illiquidity in different bond classes (investment grade bonds and speculative ones) and found persistent effect for investment grade bonds, while more stronger but short for bonds from speculative classes.

Here we will try to analyze influence of liquidity risk on corporate bond spreads during 2007-2011. We will follow the methodology proposed in Dick-Nielsen paper and we will divide our sample on two periods and two bond classes.

We select time periods consistent with what was done in Dick-Nielsen et al. (2012, [5]) paper:

1. Post-crisis period: April 2007 – June 2009
2. After-crisis period: July 2009 - June 2011

According to classification investment grade bonds can be considered those, which credit rating is equal or higher to BBB according to Standard&Poor's scale. Hence, speculative grade bonds are those, which credit rating is lower than BBB.

For each rating class we run separate regressions using monthly observations, controlling for credit, interest rate and systematic risks.

$$\textbf{Yield\_spread}_{it} = c_0 + c_1{*}Liquidity\_proxy_{it} + c_2{*}coupons_{it} + c_3{*}etm_{it} + c_4{*}age_{it} + c_5{*}rating_{it} + c_6{*}r^f_{it} + c_7{*}mmvb_{it} + c_8{*}rtsvx_{it} + c_9{*}cds_{it} + c_{10}{*}vol_{it} + \varepsilon_{it}$$

Below in the tables 11 and 12, we provide our regression results for two time periods and two classes of bonds. Table 11 and 12 indicates that transaction costs are priced through both proportional bid-ask spreads and imputed roundtrip costs measure. As credit rating of the issue deteriorates liquidity component priced in yield spread increases drastically. Thus during crisis period compensation for illiquidity in speculative bonds are almost 3 times more than in investment grade issues. Analogous ratio can be observed in after-crisis period as well. The significance of results is at 0.1% level! Turning to zero-trading days measure there is no consistent results as with bid-ask proxies. For investment grade bonds compensation measured by zero-trading days is almost the same, while for speculative bonds, coefficient is not significant at all during crisis period. Trading volume proxy during crisis for speculative bonds demonstrates positive sign, indicating that higher trading volume increase spreads, however the coefficient is insignificant. Comparison with results for after-crisis period shows opposite results.

Providing these results, we can conclude that there is some evidence that during financial crisis of 2008, liquidity was priced more heavily in Russian corporate bonds than afterwards, which is consistent with Dick-Nielsen et al. (2012, [5]) paper.

Table 11: Post-crisis (2007:Q2 – 2009:Q2)

	investment grade	**speculative**
proportional bid-ask spread	891.16*** (107.83)	2522.21*** (303.11)
Imputed roundtrip costs	1198.17*** (199.54)	2663.38*** (545.08)
Zero-trading days	229.35* (102.77)	30.72 (133.45)
logarithm of trading volume	-23.46*** (6.01)	4.69 (7.15)

Here * refers to 5% significance level, ** to 1% and *** to 0.1% significance levels correspondingly.

Table 12: After-crisis (2009:Q3 – 2011:Q2)

	investment grade	**speculative**
proportional bid-ask spread	323.36*** (79.37)	1199.20*** (153.19)
Imputed roundtrip costs	531.41*** (151.75)	1383.73*** (303.04)
Zero-trading days	243.28*** (62.92)	708.97*** (162.67)
logarithm of trading volume	-37.66*** (4.57)	-26.87* (12.14)

Here * refers to 5% significance level, ** to 1% and *** to 0.1% significance levels correspondingly.

Conclusions

There are few risk factors which play crucial role in corporate bond pricing and liquidity risk is one of them. Liquidity plays very important role in financial markets and therefore many researchers put their efforts to find and quantify its effect in securities pricing. However there are some papers (Grass and Ward (2012, [10])) in which authors are arguing about the role of liquidity and concluding that liquidity has limited influence on pricing corporate bonds at best!

Therefore in this work we tried to answer few major questions concerning Russian corporate bond market and role of liquidity risk in this market, namely:

a. Is liquidity priced in yields of corporate bonds?
b. Whether embedded put options provide insurance against liquidity risk?
c. Did liquidity influence more heavily yield spreads during the recent financial crisis?

Our results confirm our initial hypothesis that liquidity risk matters in bonds pricing in Russia. We run panel data regressions controlling for credit, interest rate risks and systematic risk in economy. We find evidence that all important control variables mentioned above are priced and coefficients are statistically significant, which is in line with previous researches.

Then we turn to the problem of embedded options in bonds. Most of Russian corporate issues have both put and call features and it turned out that yield of bonds with embedded options is 150 bps higher on average than yield of regular bonds. This result rejects the hypothesis that such bonds can be considered as regular bonds but with maturity date equal to the first put exercise date. We explain such premia caused by investor's expectation of coupon rate decrease, thus requiring higher yield for such a bond.

We also address the question whether embedded put options can be considered as insurance against various risk factors and in particularly against liquidity risk. Our results suggest that there is no evidence that liquidity is affected by the presence of option. This result is explained by the fact that all bonds with embedded put options also contain a call option and we could not find pure puttable bonds, without call feature.

Then using methodology proposed in the paper of Ericsson et al. (2011, [7]) we run regressions with matched pairs of bonds and find that risk proxies have more pronounced influence in bonds with embedded options than in regular bonds. However dataset used in this particular regression analysis contains only 26 matched pairs, so results might be not so strong, although in line with our findings about additional premia for bonds with embedded options.

Finally we examine whether liquidity was priced more heavily during recent financial crisis than in period afterwards. We follow the methodology proposed in Dick-Nielsen et al. (2012, [5]) and find some evidence that during crisis liquidity influence was much bigger than in period afterwards. We also find that liquidity premia rises drastically when credit rating deteriorates. Our findings suggest that liquidity component is almost three times bigger in speculative grade bonds than in investment grade ones both in post-crisis period and afterwards.

Appendix

Table 3: Bond filtering out process

Number of bonds and issuers after each filter we applied		
Filter, #	**Number of Issues**	**Number of Issuers**
1	1964	753
2	795	213
3	428	128
4	346	113
5	**258**	**97**

Table 5: Correspondence of credit rating to numerical rating

Numerical Rating	Standard & Poors	Moody's	Fitch
1	AAA	Aaa	AAA
2	AA+	Aa1	AA+
3	AA	Aa2	AA
4	AA-	Aa3	AA-
5	A+	A1	A+
6	A	A2	A
7	A-	A3	A-
8	BBB+	Baa1	BBB+
9	BBB	Baa2	BBB
10	BBB-	Baa3	BBB-
11	BB+	Ba1	BB+
12	BB	Ba2	BB
13	BB-	Ba3	BB-
14	B+	B1	B+
15	B	B2	B
16	B-	B3	B-
17	CCC+	Caa1	CCC+
18	CCC	Caa2	CCC
19	CCC-	Caa3	CCC-
20	CC	Ca	CC
21	C	C	C

Table 13: Exact definition of the variables used in the analysis

Variable name	Definition
spread	the difference between the yield of corporate bond and yield of government bond with the same maturity
irc	imputed roundtrip costs, measure of illiqudity proposed by Feldhutter (2011, [15])
turnover	is the ratio of monthly trading volume to amount outstanding
coupon rate	average monthly coupon rate
numerical rating	corresponding number in scale matching credit numbers to integers, the bigger the value the worse credibility
5-year risk-free rate	the yield of 5-year government bond
bond volatility	is the measure of credit risk proposed by Grass and Ward (2012, [10])
average turnover	is the ratio of the average daily trading volume to amount outstanding
mmvb	monthly returns on MICEX index
rtsvx	Russian volatility index
CDS	credit default spread on 5-year government bonds
total # of trades	total number of trades during month
average # of trades	average daily number of trades happening
transaction size	is the average size of the transaction during particular month

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Data Sources:

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