Liquidity (Risk) Premia in Corporate Bond Markets

Dion Bongaert(RSM) Joost Driessen(UvT)
Frank de Jong(UvT)

January 18th 2010

Agenda

Corporate bond markets

- Credit spread puzzle
  - Credit spreads much higher than justified by historical default losses
  - For example, long-term AA bonds:
    - Historical default loss generates credit spread of 3 basis points
    - Average credit spread of 67 basis points in our sample
- Related question: are stock and corporate bond markets integrated?

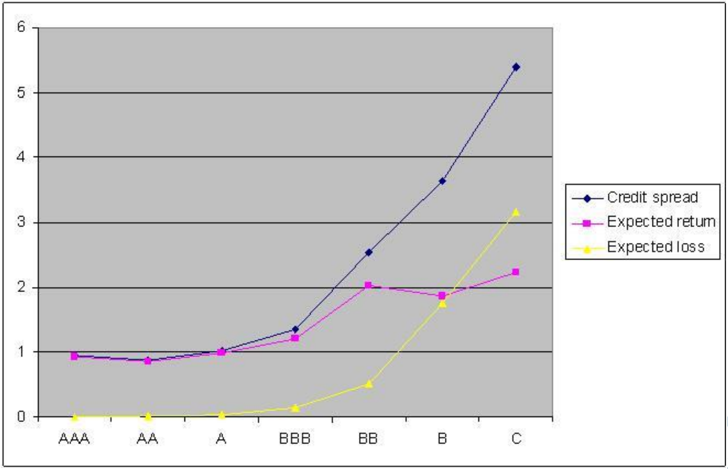
Historical Default Rates (S&P, 1985-2007)

Rating	5 years	10 years	15 years
AAA	0.28%	0.67%	0.79%
AA	0.18%	0.72%	1.14%
A	0.60%	1.73%	2.61%
BBB	1.95%	4.44%	6.50%
BB	8.38%	14.62%	17.28%
B	23.84%	30.43%	35.04%
CCC/C	44.50%	49.76%	52.50%

Source: S&P

Note: recovery for unsecured bonds on average over 40%

Credit spreads and expected returns



Credit spread puzzle

- Recent attempts to explain this puzzle: mixed success
  - Taxes (Elton, Gruber, Agrawal & Mann, JF 2001)
  - Debated (Amato & Remolona, 2004)
  - No tax effect in Europe, but still similar puzzle
- Exposure to priced market risk factors
  - Equity risk premium (Elton, Gruber, Agrawal & Mann, JF 2001)
  - Jump risk premium (Collin-Dufresne, Goldstein & Helwege, 2005, and Driessen, RFS 2005)

Contribution of this paper

- Can differences in transaction costs or liquidity risk explain the credit spread puzzle?
- Related to two earlier papers
  - De Jong and Driessen (2007): Corporate bond indexes
  - Bongaerts, de Jong, Driessen (JF fc): CDS market
- Papers fit in asset pricing and liquidity literature
  - Liquidity as priced characteristic (expected liquidity)
  - Liquidity as a systematic risk factor (liquidity risk)

Liquidity and asset pricing

- Recent literature in asset pricing stresses the role of liquidity for asset prices
- Amihud-Mendelson (JFE 86): high transaction costs must be compensated by higher expected returns
  - Empirically supported, both from equity and treasury bond markets
- Recent developments to treat liquidity also as a priced risk factor

Liquidity risk

- Hasbrouck-Seppi (JFE 01) and Chordia et al. (RFS 03) document commonality in liquidity for stocks
- Acharya and Pedersen (JFE 05) and Pastor and Stambaugh (JPE 03):
- Multifactor pricing model with exposure to liquidity risk
  - Acharya and Pedersen: expected liquidity premium of 3.5% and a liquidity risk premium of 1.1%
  - Pastor and Stambaugh: 7.5% liquidity risk premium

Liquidity premia in corporate bond returns

- Cross-sectional effects of liquidity proxies on spreads:
  - Houweling, Mentink, Vorst (2005); Chacko et al. (2005); Chen, Lesmond and Wei (2005)
  - Corporate bonds: good testing ground for pricing models, as expected returns are easy to measure by spreads
    - corrected for default losses
  - Recent independent work on liquidity risk by Downing, Underwood and Xing (2006) and Mahanti, Nashikkar and Subrahmanyham (2008)
    - using individual bond data (TRACE)

Model

- Multifactor model with liquidity effects and risk premiums

$$E(r_i) = \beta'_{F,i}\lambda_F + \zeta E(c_i) \tag{1}$$

$$r_{i,t} = \alpha_i + \beta'_{F,i}F_t + \epsilon_{i,t} \tag{2}$$

- Risk factors: loading of returns on common shocks
  - Include equity market return and unexpected changes in aggregate corporate bond liquidity (liquidity risk)
- Expected liquidity (Amihud-Mendelson, 1986)
  - Proxied by average transaction costs over the sample

Data

- TRACE data October 2004 - December 2007
- All trades in US corporate bonds
    - Time, transaction price and volume
    - Over 30 million trades
- Aggregate these data in portfolios based on
    - Rating (AAA to C)
    - Activity (number of trades per bond, low or high)

Estimation

- Preliminary steps
  - Construct transaction costs and returns from TRACE data
  - Construct expected excess returns by correcting credit spreads for expected default and recovery rates
- First step regressions
  - Estimate exposures of bond returns to risk factors as in 2
- Second step
  - Regress expected returns on expected costs and betas as in 1

RSM Erasmus University
40 YEARS OF LOOKING FORWARD
1970-2010

Estimating transaction costs

- Data only contain transaction prices
  - No direct observations of bid-ask spreads
- We use Hasbroucks (2006) method to estimate costs based on transaction prices only
  - Refinement of Rolls (1977) estimator
  - Based on Bayesian Gibbs sampling
  - Hasbrouck shows that for U.S. stocks, the Gibbs estimates are strongly correlated with observed bid-ask spreads

The Roll model for bond returns

Roll (1977) proposes a simple model for transaction prices

$$p_{it} = m_{it} + c_{it} q_{it}$$

The usual procedure is to estimate this model in first difference form

$$p_{it} - p_{i,t-1} = \Delta m_{it} + c_{it} q_{it} - c_{i,t-1} q_{i,t-1}$$

- $\Delta m_{it} \sim N(0, \sigma_m^2)$ is the innovation in the *efficient price*
- q_{it} is an IID trade indicator that can take values $+1$ and -1 with equal probability.
- c_{it} are the effective bid-ask half-spreads
  - restrictions will be imposed on c_{it}

Irregularly spaced observations

- Prices of bonds are sampled every hour, but not every bond trades each hour: use a repeat sales approach (see, for example, Case and Shiller (1987))
- t_{ik} denotes the time of the k'th trade in bond i
- Taking differences w.r.t. the previous trade of bond i, the reduced form of the model is

$$p_{i,t_{ik}} - p_{i,t_{i,k-1}} = \sum_{s=t_{i,k-1}+1}^{t_{ik}} \Delta m_{is} + c_{i,t_{ik}} q_{i,t_{ik}} - c_{i,t_{i,k-1}} q_{i,t_{i,k-1}}$$

Portfolio restrictions

- Change in the efficient price is sum of portfolio return and idiosyncratic component

$$\Delta m_{it} = r_t + u_{it}$$

with $r_t \sim N(0, \sigma_r^2)$ and $u_{it} \sim N(0, \sigma_u^2)$

- Transaction costs are the same for all bonds in the same portfolio

$$c_{it} = c_t$$

- Complete model for all data in the same portfolio

$$p_{i,t_{ik}} - p_{i,t_{i,k-1}} = \sum_{s=t_{i,k-1}+1}^{t_{ik}} r_s + c_{t_{ik}} q_{i,t_{ik}} - c_{t_{i,k-1}} q_{i,t_{i,k-1}} + e_{it}$$

where $e_{it} = \sum^{t_{ik}} \ldots u_i$

Duration extension

- Loading on the common return factor is dependent on the bond duration

$$\Delta m_{it} = z_{it} r_t + u_{it}$$

with

$$z_{i,t_{ik}} = z_{ik} = 1 + \gamma(Duration_{ik} - \overline{Duration})$$

$\overline{Duration}$ is the average duration of all bonds

- Complete model for all data in the same portfolio

$$p_{i,t_{ik}} - p_{i,t_{i,k-1}} = \sum_{s=t_{i,k-1}+1}^{t_{ik}} z_i r_s + c_{t_{ik}} q_{i,t_{ik}} - c_{t_{i,k-1}} q_{i,t_{i,k-1}} + e_{it}$$

where $e_{it} = \sum_{s=t_{i,k-1}+1}^{t_{ik}} u_{is}$

Estimation

- Estimation of the coefficients is by means of the Gibbs sampling method developed by Hasbrouck (2006), adapted for the repeat sales model
- In the Gibbs sampler, the parameters c and σ_u^2 and the latent series q and r are simulated step-by-step from their Bayesian posterior distributions
  - $q|c, r, \sigma_u^2 \sim$ binomial
  - $c|q, r, \sigma_u^2$ regression
  - $r|c, q, \sigma_u^2$ repeat sales regression
  - $\sigma_u^2|c, q, r \sim$ Inverse Gamma
- Simulating u is not necessary as it follows immediately from the observed values of p and the simulated values of q, c and r

Simulating q

Simulation of the trade indicators q

- In Hasbrouck's model, these can take only two values, $+1$ and -1
- The prior is equal probabilities, i.e. $\Pr[q_{i,t_{ik}} = 1] = 1/2$
- After observing p, the posterior odds are

$$\frac{\Pr[q_{i,t_{ik}} = 1]}{\Pr[q_{i,t_{ik}} = -1]} = \frac{f(e_{t_{ik}}|q_{i,t_{ik}} = 1) f(e_{t_{i,k+1}}|q_{i,t_{ik}} = 1)}{f(e_{t_{ik}}|q_{i,t_{ik}} = -1) f(e_{t_{i,k+1}}|q_{i,t_{ik}} = -1)}$$

- We allow for a third value $q = 0$ and calculate two posterior odds ratios, $\Pr[q_{i,t_{ik}} = 1]/\Pr[q_{i,t_{ik}} = 0]$ and $\Pr[q_{i,t_{ik}} = 0]/\Pr[q_{i,t_{ik}} = -1]$

RSM Erasmus University
40 YEARS OF LOOKING FORWARD
1970-2010

Simulating c

- Transaction costs c_t are assumed to be positive, constant within a week
- Estimated sequentially, starting with data from the first week

$$p_{i,t_{ik}} - p_{i,t_{i,k-1}} - \sum_{s=t_{i,k-1}+1}^{t_{ik}} z_i r_s = c_{w_{ik}}(q_{i,t_{ik}} - q_{i,t_{i,k-1}}) + e_{it}$$

- Error term e_{it} is a sum of $t_{ik} - t_{i,k-1}$ components u_{it} and therefore heteroskedastic
- Posterior distribution of c_w is

$$c_w \sim N((X'\Sigma_e^{-1}X)^{-1}X'\Sigma_e^{-1}y,\ (X'\Sigma_e^{-1}X)^{-1})^+$$

RSM Erasmus University
40 YEARS OF LOOKING FORWARD
1970-2010

Simulating c (continued)

- If $t_{i,k-1}$ happens to be in an earlier week

  $$p_{i,t_{ik}} - p_{i,t_{i,k-1}} - \sum_{s=t_{i,k-1}+1}^{t_{ik}} z_i r_s + \tilde{c}_{w_{i,k-1}} q_{i,t_{i,k-1}} = c_{w_{ik}} q_{i,t_{ik}} + e_{it}$$

  where $\tilde{c}_{w_{i,k-1}}$ is the simulated value of the earlier week's transaction cost

- To obtain posterior, estimate $y = Xc_w + e$ with

  $$y_{ik} = p_{i,t_{ik}} - p_{i,t_{i,k-1}} - \sum_{s=t_{i,k-1}+1}^{t_{ik}} z_i r_s + (1 - I_{w_{ik}=w_{i,k-1}}) \widehat{c}_{w_{i,k-1}} q_{i,t_{i,k-1}}$$

  and

  $$x_{ik} = q_{i,t_{ik}} - I_{w_{ik}=w_{i,k-1}} q_{i,t_{i,k-1}}$$

Simulating r

- Simulation of the latent portfolio returns r_t: repeat sales regression

$$y = Xr + e$$

with the matrixes y and X have rows

$$y_{ik} = p_{i,t_{ik}} - p_{i,t_{i,k-1}} - c_{t_{ik}} q_{i,t_{ik}} + c_{t_{i,k-1}} q_{i,t_{i,k-1}}$$

and

$$x_{ik} = \left(0'..z_{ik}\iota'..0'\right)$$

for $k = 1, .., K(i)$ and $i = 1, .., N$ stacked

- Draw r from a normal distribution with mean $\widehat{r}$ and variance Var($\widehat{r}$) $\widehat{r} = (X'X)^{-1}X'y$ and $\text{Var}(\widehat{r}) = \sigma_e^2(X'X)^{-1}$

Simulating σ_u^2

- The error variance is simulated from an inverse-Gamma distribution

$$\sigma_u^2 \sim IG(\alpha_u, \beta_u)$$

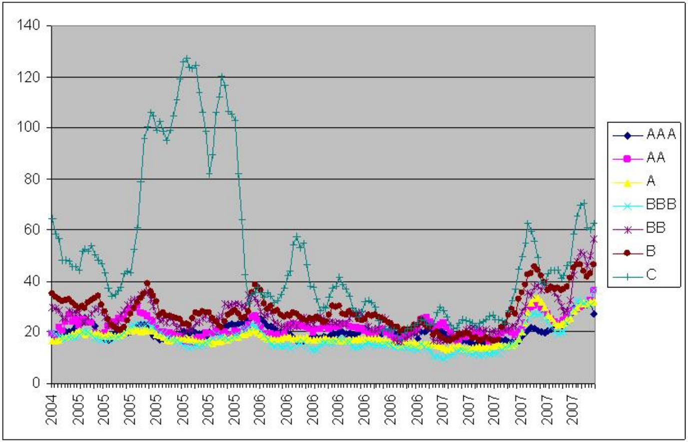
with

$$\alpha_u = \alpha + n/2$$

$$\beta_u = \beta + \frac{1}{2} \sum e_i^2 / (t_{i,k} - t_{i,k-1})$$

where $IG(\alpha, \beta)$ is the prior distribution

Transaction cost estimates for corporate bonds



Constructing expected returns

- Every week, we compute credit spread for each portfolio
- Subtract expected losses due to default
  - Using historical default probabilities and loss rates

$$\tau E(r_t) = ((1 - \pi_D) - \pi_D(1 - L))\,(1 + S_t)^\tau - 1 \qquad (3)$$

- Much more efficient than the traditional averaging of returns
  - See De Jong and Driessen (2007) and Campello et al. (2008)

Risk factors

- Equity market return
  - standard CAPM beta
- Unexpected shocks to aggregate corporate bond liquidity
  - aggregate corporate bond liquidity c proxied by average of rating portfolio transaction costs
  - unexpected shocks: residuals of AR(1) model for c
- Other risk factors: VIX, interest rates, equity market liquidity
  - Points for further research

RSM Erasmus University
40 YEARS OF LOOKING *FORWARD*
1970-2010

Empirical results: first step estimates

- Corporate bond returns have positive exposures to stock market returns
- and negative exposures to unexpected liquidity shocks
- These effects are stronger for lower ratings and for the low activity portfolios

First stage regression results

Portfolio	$E(r)$	$E(c)$	β_{EQ}	β_{cost}
AAA low	1.005	0.206	0.131	-9.37
AAA high	0.859	0.217	0.082	-6.49
AA low	1.033	0.196	0.109	-10.12
AA high	0.712	0.233	0.114	-7.25
A low	1.115	0.217	0.121	-7.74
A high	0.881	0.189	0.134	-8.28
BBB low	1.236	0.199	0.113	-6.30
BBB high	1.184	0.182	0.118	-6.89
BB low	1.968	0.274	0.157	-14.44
BB high	2.157	0.260	0.208	-6.69
B low	1.701	0.262	0.272	-22.44
B high	2.161	0.315	0.389	-21.20
C	2.263	0.506	0.328	-32.56

Note: Expected returns and costs in percent

Empirical results: second step estimates

- Modified Shanken correction for standard errors
  - Takes estimated nature of expected liquidity into account
- Significant and positive expected liquidity premium
  - Robust under various model specifications
- Reasonable estimate of equity premium
  - Around 4% per year
- Effect of liquidity risk is less clear and not robust

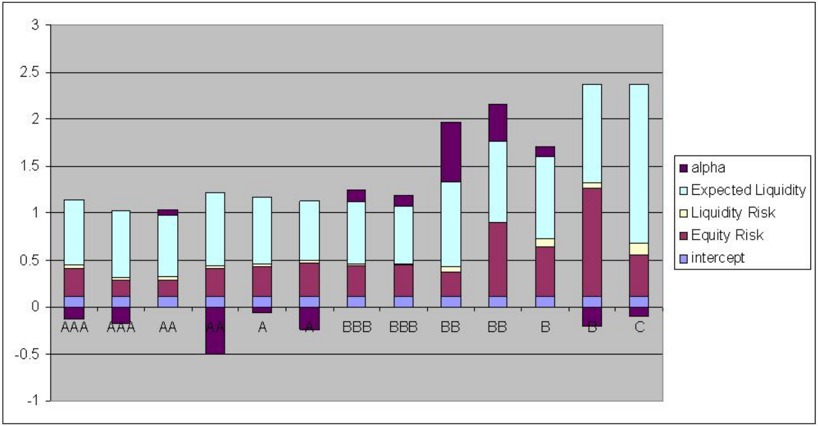
RSM Erasmus University
40 YEARS OF LOOKING *FORWARD*
1970-2010

Second stage regression results

$$E(r_i) = \lambda_0 + \lambda_{EQ}\beta_{i,EQ} + \lambda_{cost}\beta_{i,cost} + \zeta E(c_i) + u_i$$

intercept	λ_{EQ}	λ_{cost}	ζ	R^2
0.56	4.82			0.677
(9.81)	(4.53)			
0.82		-0.048		0.484
(14.51)		(-3.65)		
0.21			4.79	0.538
(0.59)			(2.56)	
0.12	3.83	-0.005	3.33	0.733
(0.46)	(4.42)	(-0.55)	(2.40)	

Model-implied risk premiums and pricing errors



Conclusion

- Corporate bond returns exposed to both equity returns and corporate bond market liquidity
- We explain credit spread puzzle by including liquidity as a characteristic and as a priced risk factor
- Additional liquidity premium goes a long way in explaining credit spread puzzle