Liquidity Risk of Corporate Bond Returns
(Preliminary and Incomplete)

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(joint with Yakov Amihud and Sreedhar Bharath)

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Outline

- Explaining corporate bond returns
- Liquidity risk
  - Framework
  - Data
  - Regime switch in liquidity betas
  - Nature of regimes
- Interpretation of results
- Relationship to results for stocks
- Conclusions

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Explaining bond returns/spreads

- **Changes in the spread** are not explained well
  - By changes in factors affecting credit risk
    - Collin-Dufresne, Goldstein and Martin (2001)
    - $R^2$ of 30% to 40% only, higher for lower-rated bonds
    - Unexplained portion appears to have a common factor

- **Hedge ratios** from credit risk models are close to the empirically computed hedge ratios
  - Schaefer and Strebulaev (2006)
  - Unexplained portion thus most likely unrelated to credit risk

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Possible explanations

- **Liquidity and liquidity risk**
  - A burgeoning area of research but many open questions

- **Time-varying risk-premium**
  - A less commonly adopted approach but potentially important

- **This paper:**
  - Liquidity risk
  - Time-varying liquidity risk
  - Interpretation: Time-varying (liquidity) risk premium
Liquidity risk

• Framework based on

• Controls for interest rate and default risk
  ✓ Fama and French (1993), Schaefer and Strebulaev (2006)

\[
R_{j,t} = \alpha_j + \beta_{j,T} \times \text{Term} + \beta_{j,D} \times \text{Def}
+ (\beta_{j,I} \times \text{Illiqinnov} + \beta_{j,BI} \times \text{Bondilliqinnov} + \epsilon_{j,t})
\]

• **Regime-switching analysis of betas**
  ✓ Hamilton (1994)
Corporate bond returns

- **Lehman Brothers Fixed Income Database**  
- **NAIC**: 1994 - 2005
- High intersection in the overlapping period
- Elimination criteria:
  - Matrix prices
  - Special features
  - Not in Lehman Brothers bond indices
- **Term**: Long-term govt minus one-year govt
- **Def**: Value-wtd market of all corp bonds > 10yrs
  - Also use firm-level equity returns (Schaefer, Strebulaev (2006))
IG and Junk bond returns

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Measurement of liquidity risk

• **Equity-market liquidity fluctuations**
  - Illiqinnov: AR(2) innovations in equally-weighted, monthly (average of daily) price-impact measure ILLIQ of Amihud (2002)
    - Acharya and Pedersen (2005), de Jong, Driessen (2005)

• **Treasury-market liquidity fluctuations**
  - Bondilliqinnov: First difference in the monthly quoted % bid-ask on off-the-run treasuries, equally-weighted across maturities

• **Corporate bond-market factor**
  - Downing, Underwood and Xing (2005), Chacko (2005)
  - Limited data prevents significant time-series analysis

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Illiqinnov and Bondilliqinnov

High volatility

Illiquidity Innovations

High volatility

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**Correlation amongst risk factors**

<table>
<thead>
<tr>
<th></th>
<th>TERM</th>
<th>DEFAULT</th>
<th>ILLIQINNOV</th>
<th>BONDILLIQINNOV</th>
</tr>
</thead>
<tbody>
<tr>
<td>TERM</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEF</td>
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<td>1</td>
<td>-0.0705</td>
<td></td>
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<tr>
<td>ILLIQINNOV</td>
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<td>-0.0705</td>
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<tr>
<td>BONDILLIQINNOV</td>
<td>-0.0916</td>
<td>-0.1273</td>
<td>0.1117</td>
<td>1</td>
</tr>
</tbody>
</table>

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Unconditional liquidity risk

<table>
<thead>
<tr>
<th>Rating</th>
<th>$\alpha$</th>
<th>$\beta_t$</th>
<th>$\beta_d$</th>
<th>$\beta_i$</th>
<th>$\beta_{bi}$</th>
<th>Adj-Rsq</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>56.34</td>
<td>47.48</td>
<td>21.96</td>
<td>-31.80</td>
<td>-596.97</td>
<td>0.60</td>
</tr>
<tr>
<td>AA</td>
<td>58.80</td>
<td>56.52</td>
<td>45.04</td>
<td>-49.30</td>
<td>-1371.50</td>
<td>0.76</td>
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<tr>
<td>A</td>
<td>93.10</td>
<td>58.82</td>
<td>56.37</td>
<td>-74.67</td>
<td>-448.04</td>
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<tr>
<td>BBB</td>
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<td>60.16</td>
<td>84.23</td>
<td>-46.07</td>
<td>-305.24</td>
<td>0.38</td>
</tr>
<tr>
<td>BB</td>
<td>96.92</td>
<td>46.66</td>
<td>41.62</td>
<td>-184.17</td>
<td>-2166.04</td>
<td>0.16</td>
</tr>
<tr>
<td>B</td>
<td>96.55</td>
<td>42.17</td>
<td>66.59</td>
<td>-155.02</td>
<td>-2555.24</td>
<td>0.22</td>
</tr>
<tr>
<td>CCC &amp; below</td>
<td>145.32</td>
<td>21.04</td>
<td>48.41</td>
<td>-337.70</td>
<td>-5802.63</td>
<td>0.09</td>
</tr>
<tr>
<td>Unrated</td>
<td>76.37</td>
<td>36.91</td>
<td>27.37</td>
<td>-149.36</td>
<td>-1652.47</td>
<td>0.12</td>
</tr>
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</table>
Economic magnitude small

- **IG and Junk differences significant, except for Def**

<table>
<thead>
<tr>
<th>Rating</th>
<th>( \sigma_t )</th>
<th>( \sigma_d )</th>
<th>( \sigma_i )</th>
<th>( \sigma_{bi} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>82%</td>
<td>23%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>AA</td>
<td>91%</td>
<td>43%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>A</td>
<td>56%</td>
<td>32%</td>
<td>6%</td>
<td>2%</td>
</tr>
<tr>
<td>BBB</td>
<td>60%</td>
<td>50%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>BB</td>
<td>41%</td>
<td>22%</td>
<td>13%</td>
<td>7%</td>
</tr>
<tr>
<td>B</td>
<td>41%</td>
<td>38%</td>
<td>12%</td>
<td>9%</td>
</tr>
<tr>
<td>CCC and Below</td>
<td>15%</td>
<td>20%</td>
<td>18%</td>
<td>15%</td>
</tr>
<tr>
<td>Unrated</td>
<td>36%</td>
<td>16%</td>
<td>11%</td>
<td>6%</td>
</tr>
</tbody>
</table>

- **IG**: Effect of liquidity risk of the order of 10 bps in returns
- **Junk**: 30 bps in returns (smaller than de Jong, Driessen)

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Time-varying betas

- **Estimate a Markov regime-switching model**
  - Regime-shift absent in IG, but strong in Junk betas

Regime 1:
\[ R_{Junk, t} = \alpha_{Junk}^1 + \beta_{Junk, T}^1 \text{Term}_t + \beta_{Junk, D}^1 \text{Def}_t + \beta_{Junk, I}^1 \text{IlliqInnov}_t + \beta_{Junk, BI}^1 \text{BondilliqInnov}_t + \epsilon_{Junk, t}^1 \]

Regime 2:
\[ R_{Junk, t} = \alpha_{Junk}^2 + \beta_{Junk, T}^2 \text{Term}_t + \beta_{Junk, D}^2 \text{Def}_t + \beta_{Junk, I}^2 \text{IlliqInnov}_t + \beta_{Junk, BI}^2 \text{BondilliqInnov}_t + \epsilon_{Junk, t}^2 \]

Markov switching probability for state transition:

\[ P(s_t = 1 \mid s_{t-1} = 1) = p \]
\[ P(s_t = 2 \mid s_{t-1} = 2) = q \]
Liquidity beta changes substantially

<table>
<thead>
<tr>
<th>Junk Grade</th>
<th>Regime 1</th>
<th></th>
<th>Regime 2</th>
<th></th>
<th>Parameters</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff</td>
<td>t-stat</td>
<td>Coeff</td>
<td>t-stat</td>
<td>p</td>
<td>q</td>
</tr>
<tr>
<td>Constant</td>
<td>81.61</td>
<td>9.91</td>
<td>196.22</td>
<td>6.38</td>
<td>0.974</td>
<td></td>
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<tr>
<td>Term</td>
<td>41.11</td>
<td>10.33</td>
<td>40.76</td>
<td>3.01</td>
<td>0.932</td>
<td></td>
</tr>
<tr>
<td>Def</td>
<td>60.09</td>
<td>7.13</td>
<td>58.16</td>
<td>3.89</td>
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<td></td>
</tr>
<tr>
<td>Illiqinnov</td>
<td>-81.05</td>
<td>-1.81</td>
<td>-619.69</td>
<td>-5.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bondilliqinnov</td>
<td>-1355.63</td>
<td>-18.31</td>
<td>-4147.74</td>
<td>-35.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_i$</td>
<td>119.91</td>
<td></td>
<td>320.22</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wald tests for differences in coefficients between Regime 1 and Regime 2

<table>
<thead>
<tr>
<th></th>
<th>Chi-Sq</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term</td>
<td>6.30</td>
<td>0.012</td>
</tr>
<tr>
<td>Def</td>
<td>4.82</td>
<td>0.028</td>
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<tr>
<td>Illiqinnov</td>
<td>28.54</td>
<td>0.000</td>
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<tr>
<td>Bondilliqinnov</td>
<td>458.22</td>
<td>0.000</td>
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<tr>
<td>Log Likelihood</td>
<td>-2412.83</td>
<td></td>
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<tr>
<td>Sample Period</td>
<td>1973:01 - 2005:12</td>
<td></td>
</tr>
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</table>
Regime (weakly) linked to recession
High liquidity risk ("stress") regime

- **Striking characteristics:**
  - IG and Junk bond returns more variable
  - Stock-market illiquidity shocks more skewed
  - Treasury illiquidity more variable
  - Stock and treasury illiquidity more correlated

- **Relationship to macroeconomic factors:**
  - Positively linked to
    - *Recession:* NBER, Stock and Watson, Hamilton
    - *Downturn in stock markets*
    - *MKMV aggregate EDF*

- 57% likelihood of switching out in a year
Economic magnitude *large*

- **Is higher volatility driving higher betas?**
  - Correlations with liquidity factors increase too

- **Effect of liquidity risk magnifies three-four times**
  - Little shift in effect of *Term* and *Def*

<table>
<thead>
<tr>
<th>Regime 1</th>
<th>Coeff</th>
<th>σ</th>
<th>Coeff * σ</th>
<th>Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return</td>
<td>149.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junk * Term</td>
<td>41.11</td>
<td>2.32</td>
<td>64%</td>
<td></td>
</tr>
<tr>
<td>Junk * Default</td>
<td>60.09</td>
<td>1.17</td>
<td>47%</td>
<td></td>
</tr>
<tr>
<td>Junk * Illiqinnov</td>
<td>-81.05</td>
<td>0.1962</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Junk * Bondilliqinnov</td>
<td>-1355.63</td>
<td>0.0074</td>
<td>7%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regime 2</th>
<th>Coeff</th>
<th>σ</th>
<th>Coeff * σ</th>
<th>Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return</td>
<td>214.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junk * Term</td>
<td>40.76</td>
<td>2.42</td>
<td>46%</td>
<td></td>
</tr>
<tr>
<td>Junk * Default</td>
<td>58.16</td>
<td>2.18</td>
<td>59%</td>
<td></td>
</tr>
<tr>
<td>Junk * Illiqinnov</td>
<td>-619.69</td>
<td>0.135</td>
<td>39%</td>
<td></td>
</tr>
<tr>
<td>Junk * Bondilliqinnov</td>
<td>-4147.74</td>
<td>0.01102</td>
<td>21%</td>
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</tr>
</tbody>
</table>

10-16 bps in returns
80-150 bps in returns
Robustness checks

• **Controlling for changes in expected cash flows**
  - Default likelihood: MKMV’s aggregate EDF
  - LGD: Altman et al’s aggregate recovery fn (agg EDF)
  - *Little effect*

• **Controlling for changes in (equity-mkt) volatility**
  - *Little effect*

• **Schaefer-Strebulaev (2006) model**
  - Average firm-level equity return as *Def*
  - *Liquidity betas remain strong in stress regime*
  - *Term and Def betas even less significant than before*
## Regime-shift with SS (2006) model

<table>
<thead>
<tr>
<th>Junk Grade</th>
<th>Regime 1</th>
<th>Regime 2</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff</td>
<td>t-stat</td>
<td>Coeff</td>
</tr>
<tr>
<td>Constant</td>
<td>60.72</td>
<td>2.69</td>
<td>55.81</td>
</tr>
<tr>
<td>Term</td>
<td>29.27</td>
<td>10.56</td>
<td>3.67</td>
</tr>
<tr>
<td>Def</td>
<td>92.47</td>
<td>2.09</td>
<td>13.62</td>
</tr>
<tr>
<td>Illiqinnov</td>
<td>-106.68</td>
<td>-0.72</td>
<td>-581.58</td>
</tr>
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<td>Bondilliqinnov</td>
<td>-2168.89</td>
<td>-2.81</td>
<td>-5231.23</td>
</tr>
<tr>
<td>$\sigma_i$</td>
<td>91.19</td>
<td></td>
<td>285.75</td>
</tr>
</tbody>
</table>
Relationship to liquidity risk of stocks

• **Acharya and Pedersen (2005)**
  - Illiquid stocks are also more liquidity risky
  - This paper: Junk bonds are more illiquid and liquidity risky than IG bonds (also de Jong, Driessen 2005)
  - Additional: Liquidity risk is time-varying and economically substantial primarily in stress periods

• **Watanabe and Watanabe (2007)**
  - Stock betas on $ILLIQ$ innovations also show regimes
  - Regimes correspond to high and low $ILLIQ$
  - This paper: Provides a similar result for junk bonds
  - Liquidity risk is priced more in cross-section in stress
Treasury market (il)liquidity

Source: Goyenko (2005)
Stock market effective tick size

High trading cost

Source: Goyenko (2005)

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Interpretation

• Beta = Cash flow beta + Expected return beta
• For corporate bonds, cash flow beta should be small (controlled)

• Higher liquidity beta in stress (high volatility) regime
  -> Higher beta of expected return on liquidity risks,
  But not so for interest rate and default risks

• “Flight to quality/liquidity”
  ✓ Effect of market liquidity on (junk bond) risk premium

• How does this relate to the risk-premium being apparently common across equities and bonds?
  ✓ Chen, Collin-Dufresne, Goldstein (2005): Habit pricing kernel
    • BBB-AAA: credit spread, AAA-Tsy: liquidity spread

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Conclusion

• Much has been accomplished over the past few years
  ✓ Measuring corporate bond market liquidity
  ✓ Quantifying the liquidity risk of corporate bonds
  ✓ Relating liquidity and liquidity risk to spreads

• Our paper:
  ✓ Focused on time-varying liquidity risk of corporate bonds
  ✓ Evidence for time-varying liquidity betas for junk bonds
  ✓ Consistent with “flight to quality/liquidity” in volatile/stress periods
  ✓ Conditional liquidity risk effects large, unconditional effects small

• Much remains to be done…
  ✓ Relating these effects to time-series of spread changes
  ✓ Differentiating fully liquidity risk premium from the usual one
  ✓ Identifying “stress” periods in corporate bond market liquidity

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## Corporate bond liquidity measures

| **One-way or round-trip cost** (bid-ask spread) | Chen, Lesmond and Wei (2005), Goldstein, Hotchkiss and Sirri (2005) |
| **Frequency of zero returns** and its variants | Lesmond, Ogden and Trzcinka (1999), Chen, Lesmond and Wei (2005) |
| **Accessibility**: Turnover of portfolios holding the bond | Chacko (2005), Chacko, Mahanti, Mallik and Subrahmanyam (2005) |