Liquidity Supply and Demand in the Corporate Bond Market

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*HKUST*

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The views expressed here are those of the authors and need not represent the views of the Federal Reserve Board or its staff.
Motivation

- Estimated transaction costs for corporate bonds have declined since the financial crisis.
Improved Liquidity?

- Popular press says the opposite:
  - Big Bond Investors Say Liquidity Has Declined in Past Year (WSJ, May 31, 2016)
  - Liquidity Specter Haunts Corporate-Bond Markets (WSJ, Jan 11, 2015)
    - "Corporate-Debt Issuance Is at Records, but Trading Problems Remain a Worry for Investors"
  - Bond liquidity risks top fund managers’ agenda (FT, May 15, 2015)
    - Industry body to contact investors, warning of the risks
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- Backgrounds
  1. Banking regulations: Supplemental leverage ratio, CCAR, the Volker rule
  2. Changing investor base: Rise of Corporate bond ETFs, mutual funds
  3. Increasing new issuances
Challenge

- Changing transaction costs can be due to:
  1. More supply of liquidity
  2. Less demand of liquidity

- By looking at the transaction costs, we cannot tell 1 or 2.

- We have to look at *price* and *quantity* to tell the different drivers of liquidity.

- Other questions which cannot be answered without a unifying framework of liquidity supply and demand.
  1. Why is liquidity priced in asset prices?
  2. Do liquidity supply and demand shocks carry different price of risk?
What We Do

- Build a simple model of segmented markets following Gromb and Vayanos (2002)
What We Do

- Build a simple model of segmented markets following Gromb and Vayanos (2002)
- Define the price and quantity of liquidity
  - Price: Noise in the corporate bond yield curve
  - Quantity: Aggregate dealers’ gross positions on corporate bonds
- Structural VAR with sign restrictions
- Run a VAR with price and quantity
- Supply shocks: move price and quantity in the opposite direction
- Demand shocks: move price and quantity in the same direction
- Bayesian estimates in which we jointly estimate reduced-form and structural VARs
- Use estimated VAR to study the impact of banking regulations and the source of liquidity premiums.
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- Use estimated VAR to study the impact of banking regulations and the source of liquidity premiums.
Literature

- Liquidity measures for corporate bonds

- Effect of recent banking regulations on dealer balance sheet

- Supply and demand analysis

- Theory of segmented markets
Theory of Segmented Markets

- Time periods, 1, 2, and 3
- Two investors, A and B
- Two securities, A and B: Claim on an uncertain cash flow $\nu$ in time 3
  - $E[\nu] = \mu$
  - $\text{Var}[\nu] = \sigma$
- $i$-investors can trade only $i$-bond and cash: $i \in \{A, B\}$
- Each security has net supply $g$
- Gross-interest rate is normalized to one.
- $i$-investor has a preference
  \[ E[w_i] - \frac{1}{2\gamma} \text{Var}[w_i] \]
- Hedging motive: endowment at time 3 given by $e_A = -e_B$ and $\text{Cov}(\nu, e_A) = u > 0$. 
Theory of Segmented Markets

- Dealers can trade both securities
- Cash flow $\nu$ is revealed in time 2.
- With probability $\lambda$, forced to liquidate positions at $p_i,2 = \nu + \varepsilon_i$
- Preference: $E[w_D] - \frac{1}{2\gamma_D} \text{Var}[w_D]$
- Time 1 risk premia
  \[ \varphi_i = \mu - p_{i,1} \]
- Define
  \[ g^* = \left(1 + \frac{2\gamma\sigma}{\gamma_D\sigma + \gamma\lambda\sigma\varepsilon}\right) \frac{u}{\sigma} > 0 \]
- Assume $|g| < g^* \Rightarrow$ In equilibrium, the dealer has positions $x_A > 0$ and $x_B < 0$
Equilibrium

- Dealers’ payoffs have a variance-covariance matrix by
  \[ \Omega = \begin{bmatrix} \sigma + \lambda \sigma \epsilon & \sigma \\ \sigma & \sigma + \lambda \sigma \epsilon \end{bmatrix} \]

- Dealers’ positions are given by \( x = \gamma_D \Omega^{-1} \varphi \).

- Investors’ positions are given by
  \[ y = \frac{1}{\sigma} \left( \gamma \varphi - u \begin{bmatrix} 1 \\ -1 \end{bmatrix} \right). \]

- Market clearing: \( x + y = g \)
Equilibrium

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- Market clearing: \( x + y = g \)

- Price dispersion is
  \[ \frac{|p_{B,1} - p_{A,1}|}{2} = \frac{1}{\gamma_D \frac{1}{\lambda} \frac{\sigma}{\sigma} + \gamma} u \]

- Dealer gross position is
  \[ \frac{|x_A| + |x_B|}{2} = \frac{1}{\sigma + \frac{\gamma}{\gamma_D} \lambda \sigma} u \]
Proposition

1. An increase in dealer risk tolerance $\gamma_D$ leads to lower price dispersion and higher dealer gross positions.

$$\frac{d \left[ |p_{B,1} - p_{A,1}| \right]}{d \gamma_D} < 0,$$

$$\frac{d \left[ |x_A| + |x_B| \right]}{d \gamma_D} > 0.$$

$\Rightarrow$ A Supply Shock.
Proposition

1. An increase in dealer risk tolerance $\gamma_D$ leads to lower price dispersion and higher dealer gross positions.

\[
\frac{d \left[ |p_{B,1} - p_{A,1}| \right]}{d \gamma_D} < 0, \\
\frac{d \left[ |x_A| + |x_B| \right]}{d \gamma_D} > 0.
\]

$\Rightarrow$ A Supply Shock.

2. An increase in investor risk tolerance $\gamma_i$ (or a decrease in investor trading needs $u$) leads to lower price dispersion and lower gross positions.

\[
\frac{d \left[ |p_{B,1} - p_{A,1}| \right]}{d \gamma_i} < 0, \\
\frac{d \left[ |x_A| + |x_B| \right]}{d \gamma_i} < 0.
\]

$\Rightarrow$ A Demand Shock.
Liquidity Quantity

- Primary dealers’ aggregate gross positions on corporate bonds.
Liquidity Quantity

- Primary dealers’ aggregate gross positions on corporate bonds.
- Regulatory TRACE from 2005 to 2016: Trade with a dealer identity
  - Cumulate trades for each CUSIP for each dealer: LIFO method.
  - Weekly inventory data
    - Remove trades with volume greater than 1/3 of amount outstanding
    - Remove trades that are not closed within four weeks
- Aggregate across dealers $d$
- Aggregate across CUSIP $k$ and across issuer $j$

$$q_t = \log \sum_j \sum_k \sum_d |Q_{d,j,k,t}|$$
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    \[ q_t = \log \sum_j \sum_k \sum_d |Q_{d,j,k,t}| \]
- Senior, unsecured US dollar-denominated bonds with no optionalities other than make-whole calls.
- 18,986 bonds issued by 4,466 issuers from April 2005 to December 2016
### Liquidity Quantity

The LIFO method.

<table>
<thead>
<tr>
<th>ID</th>
<th>Week</th>
<th>Volume</th>
<th>Amount Outstanding</th>
<th>End-of-Week Inventory</th>
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<td>-300</td>
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<td>4</td>
<td>4</td>
<td>-500</td>
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<td>5</td>
<td>100</td>
<td>0 0 0 0 100</td>
<td>100</td>
</tr>
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</table>
Liquidity Quantity

Liquidity Quantity Measure

(Correlation with FR-2004 since April 2013 = 0.58)
Liquidity Price

- Segmented markets across maturity: Preferred Habitat.

Noise (Hu, Pan and Wang (2013)) for Corporate Bonds

Merrill Lynch U.S. Corporate Master Database.

Same filters as quantity, plus additional requirement that an issuer has more than 7 bonds (NS) or 15 bonds (NSS) outstanding.

Fit Nelson-Siegel-Svennson curve given by

\[ f(n) = \beta_0 + \beta_1 \exp\left(-\frac{n}{\tau_1}\right) + \beta_2 \left(\frac{n}{\tau_1}\right) \exp\left(-\frac{n}{\tau_1}\right) + \beta_3 \left(\frac{n}{\tau_2}\right) \exp\left(-\frac{n}{\tau_2}\right) \]

Liquidity price measure is given by

\[ p_{t} = \frac{1}{J} \sum_{j} \sqrt{\frac{1}{K} \sum_{k} \epsilon_{k}, j, t} \]

where \( \epsilon_{k}, j, t \) is the difference in yield between bond \( k \) and the curve.

3,040 bonds issued by 169 issuers.
Liquidity Price

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- Liquidity price measure is given by
  \[ p_t = \frac{1}{j} \sum_j \sqrt{\frac{1}{K_j} \sum_k \epsilon_{k,j,t}^2} \]
  where \( \epsilon_{k,j,t} \) is the difference in yield between bond \( k \) and the curve.
- 3,040 bonds issued by 169 issuers.
Figure: Yield to Maturity on Dec 23, 2016
Noise

**Figure:** Yield to Maturity on Oct 24, 2008

- **COMCAST CORP NEW**
- **UNITEDHEALTH GRP INC**
- **SIMON PPTY GROUP LP**
### Selection Bias

Comparison between Bonds in the Price Sample and Others

#### Panel A: Correlation Between Matched and Unmatched Bonds

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<thead>
<tr>
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<th>IRC</th>
<th>Amihud</th>
<th>Vol</th>
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<td>All</td>
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<td>0.94</td>
<td></td>
<td>0.89</td>
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<tr>
<td>IG</td>
<td>0.95</td>
<td>0.94</td>
<td></td>
<td>0.85</td>
</tr>
<tr>
<td>HY</td>
<td>0.72</td>
<td>0.78</td>
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<td>0.73</td>
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#### Panel B: Average values and number of observations

<table>
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<th>Amihud</th>
<th>Vol</th>
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<td>1,495,208</td>
<td>1.89</td>
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<td>7420</td>
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<td>IG</td>
<td>Matched</td>
<td>351,562</td>
<td>0.52</td>
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<td>925,402</td>
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<td>0.57</td>
<td>7867</td>
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<tr>
<td>HY</td>
<td>Matched</td>
<td>24,609</td>
<td>0.82</td>
<td>0.64</td>
<td>8014</td>
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<td>569,806</td>
<td>3.79</td>
<td>0.68</td>
<td>6695</td>
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## TRACE versus Merrill Lynch Data

### Average yield to maturity

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<td>AAA</td>
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<td>4.03</td>
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<tr>
<td>AA</td>
<td>2.99</td>
<td>3.86</td>
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<tr>
<td>A</td>
<td>2.88</td>
<td>3.76</td>
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<tr>
<td>BBB</td>
<td>3.34</td>
<td>4.28</td>
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<tr>
<td>HY</td>
<td>11.18</td>
<td>9.57</td>
</tr>
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</table>

Note: Average yield to maturity of bonds that show up both in TRACE and Merrill Lynch. 229,228 bond-month observations.
TRACE versus Merrill Lynch Data

End of year only

<table>
<thead>
<tr>
<th></th>
<th>AAA</th>
<th>AA</th>
<th>A</th>
<th>BBB</th>
<th>HY</th>
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<td>4yr</td>
<td>3.24</td>
<td>3.03</td>
<td>2.85</td>
<td>4.00</td>
<td>16.34</td>
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<tr>
<td>4-7yr</td>
<td>4.24</td>
<td>3.82</td>
<td>3.83</td>
<td>4.50</td>
<td>11.81</td>
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<td>7-12yr</td>
<td>4.54</td>
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<td>4.70</td>
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<tr>
<td>12yr-</td>
<td>4.83</td>
<td>5.08</td>
<td>5.39</td>
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<td>2.91</td>
<td>2.74</td>
<td>3.86</td>
<td>16.05</td>
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<td>4-7yr</td>
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<td>7-12yr</td>
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<td>12yr-</td>
<td>4.78</td>
<td>5.04</td>
<td>5.33</td>
<td>6.11</td>
<td>12.46</td>
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Note: Average yield to maturity of bonds that show up both in TRACE and Merrill Lynch. 7,468 bond-month observations.
## Summary Statistics

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<td>0.18</td>
<td>0.98</td>
<td>0.67</td>
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<tr>
<td>p</td>
<td>21.45</td>
<td>12.24</td>
<td>0.97</td>
<td>0.68</td>
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<table>
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<td>0.57</td>
<td>0.61</td>
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<td>Amihud</td>
<td>0.93</td>
<td>-0.62</td>
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<tr>
<td>IRC</td>
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<td>-0.66</td>
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Structural VAR

- The reduced form VAR is
  \[ Y_t = b + B_1 Y_{t-1} + \ldots + B_L Y_{t-L} + \xi_t \]
  where \( Y_t = (p_t \quad q_t)' \) and \( E[\xi\xi'] = \Sigma \).

- \( L = 6 \) based on AIC

- Structural shocks \( \nu \) is obtained from the rotation \( \nu = A^{-1}\xi \)
Structural VAR

- The reduced form VAR is
  \[ Y_t = b + B_1 Y_{t-1} + \ldots + B_L Y_{t-L} + \xi_t \]
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- \( L = 6 \) based on AIC

- Structural shocks \( \nu \) is obtained from the rotation \( \nu = A^{-1}\xi \)

- Identify \( A \) with a sign restriction:
  \[
  \begin{pmatrix}
  \xi^p_t \\
  \xi^q_t \\
  \xi^s_t \\
  \xi^d_t
  \end{pmatrix} = \begin{pmatrix}
  - & + \\
  + & + \\
  \boxed{A}
  \end{pmatrix}
  \begin{pmatrix}
  \nu^s_t \\
  \nu^d_t
  \end{pmatrix}
  \]

- Bayesian estimation
Use weak Normal-Wishart prior for $B$ and $\Sigma$.

1. Draw $B_i$ and $\Sigma_i$ from the posterior distribution.
Sign Restriction

- Use weak Normal-Wishart prior for $B$ and $\Sigma$.

1. Draw $B_i$ and $\Sigma_i$ from the posterior distribution.
2. Given $B_i$ and $\Sigma_i$, do the following:
   1. Draw entries for 2-by-2 matrix $W$ from a standard normal distribution
   2. Apply the QR decomposition to obtain orthogonal matrix $Z_W$
   3. Obtain lower triangular matrix $C$ from the Cholesky decomposition of $\Sigma_i$
   4. Check if candidate matrix $A_m = CZ_W$ satisfies the sign restriction
   5. Retain $A_m$ if it does, discard if not.
   6. Repeat steps 2.1 to 2.5 100 times

3. Repeat steps 1 and 2 100 times to obtain the posterior distribution of structural parameters and shocks.
Sign Restriction

- Use weak Normal-Wishart prior for $B$ and $\Sigma$.

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Liquidity Supply and Demand Shocks

Pointwise mean of the cumulative sum of structural shocks, 
\[ \sum_{j=0}^{t} v_j \]

Pre Crisis Crisis Post Crisis Dodd Frank Volcker

<table>
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</tbody>
</table>

- Bear Hedge Fund Problem
- Bear Sterns Sold
- Lehman Bankruptcy
- First Greek Bailout
- Greek PM Resigns
- Taper Tantrum
- Third Ave Redemption

Supply
Demand
Liquidity Supply and Demand Shocks: IG

Pointwise mean of the cumulative sum of structural shocks, 
\[ \sum_{j=0}^{t} v_j \]
Liquidity Supply and Demand Shocks: HY

Pointwise mean of the cumulative sum of structural shocks, 
\[ \sum_{j=0}^{t} v_j \]
Forecast Error Variance Decomposition

Fraction of variance of $\xi_t$ explained by a supply shock.
Attributing Supply Shocks

To understand the drivers of supply shocks, regress shocks to known instruments.

\[ v_t = b_1 \varepsilon_t^{VIX} + b_2 |FLOW_t| + b_3 \Delta ISSUE_t + b_4 HYSHARE_t \\
+ b_5 \varepsilon_t^{CAP} + b_6 \varepsilon_t^{TED} + b_7 R_{t-1} + u_t. \]

- \( \varepsilon_t^{VIX} \): Innovation to VIX
- \( FLOW_t \): Mutual fund flow to US domestic IG mutual funds
- \( ISSUE_t \): Total face values of new issues
- \( HYSHARE_t \): Share of HY bonds among new issues
- \( \varepsilon_t^{CAP} \): Innovation to bank holding company capital (He, Kelly and Manela (2017))
- \( \varepsilon_t^{TED} \): Innovation to TED spread
- \( R_{t-1} \): Lagged return on the corporate bond index
## Attributing Supply Shocks

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<tr>
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<th>IGFLOW</th>
<th>dISSUE</th>
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<th>CAP</th>
<th>TED</th>
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## Attributing Demand Shocks

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Cross-Section of Corporate Bond Returns

- Liquidity risk is priced in cross-section of stocks and corporate bonds.
Cross-Section of Corporate Bond Returns

- Liquidity risk is priced in cross-section of stocks and corporate bonds.
- Existing liquidity measures reflect i) information asymmetry, ii) dealers' willingness to supply liquidity, and iii) investors' demand for liquidity.
- Our measures are not affected by i), and we can disentangle ii) and iii).

\[
R_k^t = b_0 + \beta_k^{s,v} s_v^t + \beta_k^{d,v} d_v^t + \epsilon_k^t.
\]

We sort bonds based on their liquidity supply and demand betas into 5 portfolios.

We report value-weighted average returns and factor alphas by running regressions,

\[
R_p^t - R_f^t = \alpha_p + \sum_{j=1}^{J} \beta_p^{f_j} f_j^t + \eta_p^t,
\]

where \(f_j^t\) is the \(j\)th pricing factor.
Cross-Section of Corporate Bond Returns

- Liquidity risk is priced in cross-section of stocks and corporate bonds.
- Existing liquidity measures reflect i) information asymmetry, ii) dealers’ willingness to supply liquidity, and iii) investors’ demand for liquidity.
- Our measures are not affected by i), and we can disentangle ii) and iii).
- Specifically, run time-series regression of returns on bond $k$ over the 3-year rolling window,

$$ R_{k,t} = b_0 + \beta_{k,s} v_s^t + \beta_{k,d} v_d^t + \varepsilon_{k,t}. $$

- We sort bonds based on their liquidity supply and demand betas into 5 portfolios.
- We report value-weighted average returns and factor alphas by running regressions,

$$ R_{p,t} - R_{f,t} = \alpha_p + \sum_{j=1}^{J} \beta_{p,j} f_{j,t} + \eta_{p,t}. $$
## Corporate Bond Returns Sorted on $\beta_{k,s}$

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<tr>
<th></th>
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<th>4</th>
<th>High</th>
<th>H-L</th>
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<td><strong>Average Excess Returns</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$E \left[ R_{p,t}^e \right]$</td>
<td>0.24</td>
<td>0.30</td>
<td>0.40</td>
<td>0.56</td>
<td>0.82</td>
<td>0.58</td>
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<td>$tE \left[ R_{p,t}^e \right]$</td>
<td>(1.54)</td>
<td>(2.69)</td>
<td>(3.25)</td>
<td>(3.39)</td>
<td>(2.64)</td>
<td>(2.64)</td>
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</table>

**Fama-French 5 Factor Model + TERM + DEF**

|                |     |    |    |    |      |     |
| $\alpha_p$    | -0.08 | 0.09 | 0.18 | 0.30 | 0.49 | 0.57 |
| $t(\alpha_p)$ | (-0.69) | (1.18) | (1.97) | (2.07) | (2.10) | (3.23) |

**Bai, Bali and Wen 4 Factor Model**

|                |     |    |    |    |      |     |
| $\alpha_p$    | -0.23 | -0.06 | 0.00 | 0.03 | 0.22 | 0.45 |
| $t(\alpha_p)$ | (-3.21) | (-1.98) | (0.03) | (0.59) | (2.50) | (3.30) |

**He, Kelly and Manela 2 Factor Model**

|                |     |    |    |    |      |     |
| $\alpha_p$    | 0.09 | 0.20 | 0.30 | 0.42 | 0.53 | 0.44 |
| $t(\alpha_p)$ | (0.54) | (1.55) | (2.04) | (2.34) | (1.96) | (2.37) |
**Corporate Bond Returns Sorted on $\beta_{k,s}$**

Average characteristics of bonds:

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<tr>
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<th>High</th>
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<td>Maturity (years)</td>
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<tr>
<td>Size (mil. USD)</td>
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<td>852.1</td>
<td>871.8</td>
<td>808.5</td>
<td>768.4</td>
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<td>IRC (%)</td>
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<td>0.51</td>
<td>0.60</td>
<td>0.87</td>
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Fraction of Credit Ratings

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<th>A</th>
<th>Baa</th>
<th>HY</th>
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<td>11%</td>
<td>6%</td>
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<tr>
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<td>38%</td>
<td>42%</td>
<td>38%</td>
<td>30%</td>
</tr>
<tr>
<td>Baa</td>
<td>31%</td>
<td>34%</td>
<td>37%</td>
<td>40%</td>
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<tr>
<td>HY</td>
<td>20%</td>
<td>13%</td>
<td>13%</td>
<td>22%</td>
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Corporate Bond Returns Sorted on $\beta_{k,d}$

<table>
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<th>3</th>
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<th>High</th>
<th>H-L</th>
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</thead>
<tbody>
<tr>
<td>Average Excess Returns</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>$E \left[ R^e_{p,t} \right]$</td>
<td>0.85</td>
<td>0.57</td>
<td>0.37</td>
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<tr>
<td>$tE \left[ R^e_{p,t} \right]$</td>
<td>(3.65)</td>
<td>(4.01)</td>
<td>(3.22)</td>
<td>(2.24)</td>
<td>(1.67)</td>
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<td>Fama-French 5 Factor Model + TERM + DEF</td>
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<td>(2.34)</td>
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<td>(1.70)</td>
<td>(0.60)</td>
<td>(0.15)</td>
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<td>Bai, Bali and Wen 4 Factor Model</td>
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<tr>
<td>$\alpha_p$</td>
<td>0.66</td>
<td>0.46</td>
<td>0.27</td>
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<td>(3.02)</td>
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## Corporate Bond Returns Sorted on $\beta_{k,d}$

### Average characteristics of bonds:

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<td>Size (mil. USD)</td>
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<td>Roll (%)</td>
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<td>IRC (%)</td>
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<td>0.49</td>
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### Fraction of Credit Ratings

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<tr>
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Fama-MacBeth Regression of Monthly Bond Returns

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### Fama-MacBeth Regression of Monthly Bond Returns

**Panel C: With Amihud (2002) Measure**

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<th>A</th>
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<td>(-2.29)</td>
<td></td>
<td>(-0.65)</td>
<td>(3.65)</td>
<td>(1.90)</td>
<td>(2.22)</td>
<td>(-2.99)</td>
<td>(-2.45)</td>
<td>(0.45)</td>
<td></td>
</tr>
</tbody>
</table>
Predicting Bond Index Returns

We examine whether the dealer’s capital commitment predicts bond index returns, depending on the major driver of the capital commitment.

\[
R_{t+h} = b_0 + b_1 q_t + cX_t + \nu_{t+h},
\]
\[
R_{t+h} = b_0 + b_1 D_t q_t + b_2 (1 - D_t) q_t + cX_t + \nu_{t+h}
\]

where

\[
D_t = \begin{cases} 
1 & \text{if } |\sum_{m=1}^{13} v_{t-13+m}^d| > |\sum_{m=1}^{13} v_{t-13+m}^s|, \\
0 & \text{otherwise.}
\end{cases}
\]

Idea: The capital commitment predicts returns when it is driven by supply shocks, not demand shocks.
## Predicting Bond Index Returns

<table>
<thead>
<tr>
<th>Horizon (weeks)</th>
<th>1</th>
<th>4</th>
<th>13</th>
<th>26</th>
<th>52</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Unconditional Forecasting Regressions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$q$</td>
<td>0.18</td>
<td>0.59</td>
<td>-0.52</td>
<td>-2.98</td>
<td>-8.48</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>(0.49)</td>
<td>(0.31)</td>
<td>(-0.11)</td>
<td>(-0.30)</td>
<td>(-0.69)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.04</td>
</tr>
</tbody>
</table>

| **Panel B: Conditional Forecasting Regressions** |     |     |     |     |     |
| $qD$         | 0.44| 2.57| 6.17| 7.29| 5.31|
| $t$-stat      | (0.72)| (0.94)| (1.33)| (1.21)| (0.55)|
| $q(1 - D)$    | -0.04| -1.36| -7.24| -14.18| -23.48|
| $t$-stat      | (-0.11)| (-0.73)| (-2.18)| (-1.50)| (-2.40)|
| $R^2$         | 0.01| 0.07| 0.19| 0.17| 0.18|
Conclusion

- We estimate liquidity supply and demand by jointly analyzing liquidity price and quantity:
  - Price: Noise measure in corporate bond yields
  - Quantity: Dealer gross positions
- No need for ad-hoc instruments
- Our liquidity measures are not affected by i) changing roles of dealers, ii) changing characteristics of realized trades, iii) anything specific to issuers, such as information asymmetry
- Liquidity supply and demand carry different price of risks.
  - In cross section of bonds, supply and demand betas have risk premiums with opposite signs
  - In time-series data, dealer’s capital commitment predicts returns only when it is driven by supply shocks
Liquidity Contagion

- Gromb and Vayanos (2002, 2017): A dealer loses money in one market ⇒ Reduce liquidity supply in the other market (Collateral Constraint)
- Ellul, Jotikasthira and Lundblad (2012): Investment-grade bond and high yield bond markets are segmented
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- Question: Does an increase in noise in one market leads to reduced liquidity supply in the other?
- VAR with a state vector

\[ Y_{t}^{HY\rightarrow IG} = \left( \begin{array}{c} p_{t}^{IG} \\ q_{t}^{IG} \\ p_{t}^{HY} \end{array} \right) \]

- Sign restrictions

\[ \begin{pmatrix} \xi p_{t}, IG \\ \xi q_{t}, IG \\ \xi p_{t}, HY \end{pmatrix} = \begin{pmatrix} - & + & 0 \\ + & + & 0 \\ ? & ? & + \end{pmatrix} \begin{pmatrix} v_{t}^{s} \\ v_{t}^{d} \\ v_{t}^{HY} \end{pmatrix} \]

- \( v_{t}^{HY} \): A shock to the high-yield bond market that is uncorrelated with investment grade market on impact.
Liquidity Contagion

- Conversely, we can also run a VAR with a state vector
  \[
  \gamma_{tIG \rightarrow HY} = (p_t^{HY} \quad q_t^{HY} \quad p_t^{IG})'
  \]

- Sign restrictions
  \[
  \begin{pmatrix}
    \xi_{t}^{p,HY} \\
    \xi_{t}^{q,HY} \\
    \xi_{t}^{p,IG}
  \end{pmatrix} =
  \begin{pmatrix}
    - & + & 0 \\
    + & + & 0 \\
    ? & ? & +
  \end{pmatrix}
  \begin{pmatrix}
    v_{t}^{s} \\
    v_{t}^{d} \\
    v_{t}^{IG}
  \end{pmatrix}
  \]

- \(v_{t}^{IG}\): A shock to the investment grade bond market that is uncorrelated with high-yield market on impact.
Contagion from HY to IG Markets

\[ \sigma \left( \xi_{t}^{p,IG} \right) = 1.7 \text{ bps} \Rightarrow \text{weak contagion.} \]
Contagion from IG to HY Markets

- More visible reaction in noise in the HY market

- IG market is larger than HY market, and thus contagion from IG market is more important.