How Inventory Holding Costs Affect Dealer Behavior in the US Corporate Bond Market

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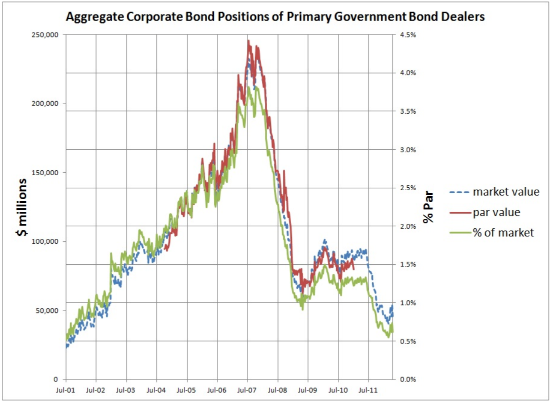
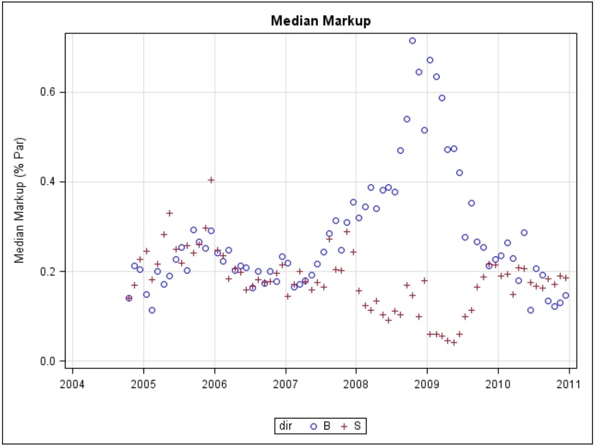
Corporate Bond Holdings of Primary Gov't Bond Dealers



- Dealers reduced inventory in crisis: no "leaning against the wind".
- October 2007: Citi, Merrill Lynch, and UBS reported significant asset write-downs.
- March 2009: TARP ▸ Other assets ▸ Dealer names ▸ Index

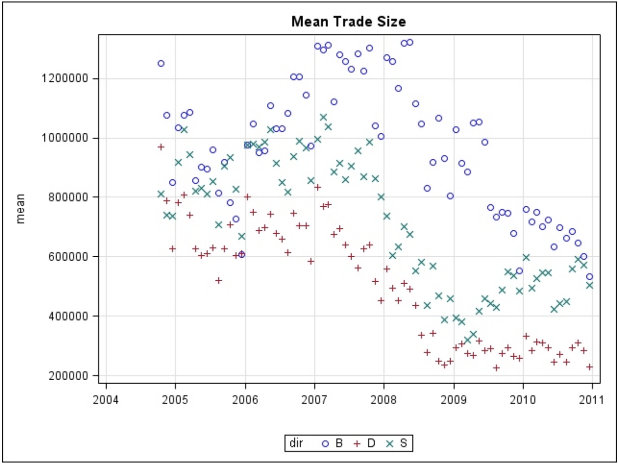
In Crisis, Dealers Priced Bonds to Sell



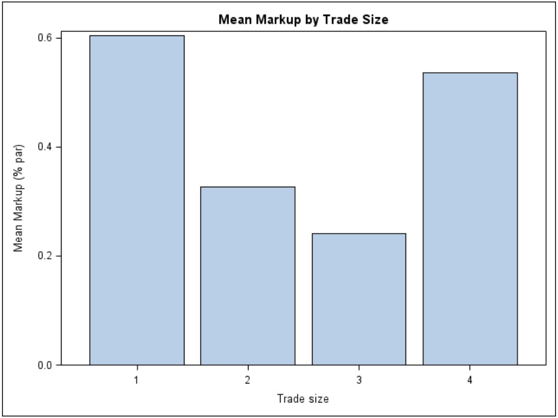
- Dealers have time-varying aversion to holding inventory.

View from the Street

Trade Sizes Have Fallen



Customers and Dealers Bargain over Prices



1. "retail": < 100,000; 2. "odd lot": [100,000, 1 million); 3. "institutional": [1 million, 10 million]; 4. "mega": >10 million] $ par. Most people don't have data on category 4.

Finer detail

Theoretical Results for Over-The-Counter Markets

1. I solve a dynamic equilibrium model of trading in a hybrid market (customer-dealer & inter-dealer), where dealers are averse to holding inventory.
    - Nash bargaining between dealers and customers over price & quantity.
    - Competitive inter-dealer market. ▸ Price dispersion ▸ Inter-dealer concentration
    - Liquidity ("markup") is diff: customer-dealer and inter-dealer prices.
2. Structural equilibrium relationship for liquidity:
    - Related to dealers' inventory holding costs, trade size, and customer bargaining power
3. Structural equilibrium relationship for dealers' inventory holdings:
    - Not optimal to minimize inventory holding costs by holding zero inventory.
    - But scale position down by expected holding costs.
    - Long or short position? Trade off current price with discounted expected future prices.

Empirical Results for US Corporate Bond Market

When dealers' inventory holding costs are high relative to customers':

1. Dealers' flight to quality:
   - Sell more high yield bonds
   - Buy more investment grade bonds
2. Liquidity is worse for customers.
   - Especially for high yield bonds & customers with lower bargaining power.
   - Conditioning on bargaining power, more pronounced for larger trades.
3. For high yield bonds, dealers more likely to act just as broker between customer and another dealer (greater incentive to risk-share).

Why Liquidity in the Corporate Bond Market is Important

1. Large market: \$8.5 trillion (June 2012)
2. Feedback effect from liquidity in secondary market to the primary market
   - He and Milbradt (2012): amount of financing that can be raised
   - Dick-Nielsen, Feldhutter, Lando (2012): bonds have illiquidity discount
   - Worse liquidity in secondary market $\Rightarrow$ higher cost of capital $\Rightarrow$ under-investment in positive NPV projects $\Rightarrow$ cost to the real economy.
3. Why is this important going forward?
   - Volcker Rule increases cost of holding inventory:
     - Restrictions on proprietary trading by commercial banks. Monitoring:
       (a) inventory turnover: positions too large or held too long = speculation
       (b) ratio of trades initiated by customers / bank
     - Limits banks' ability to make a market in corporate bonds
   - Changing landscape: MarketAxess (Hendershott and Madhavan, 2012), Blackrock.

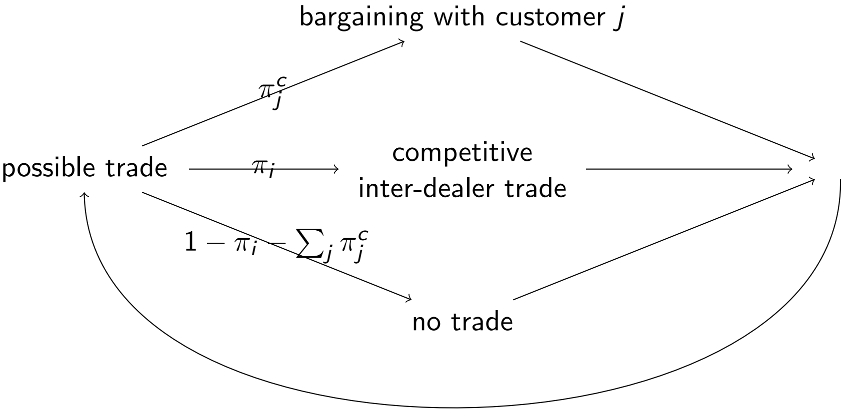
Need a New Model for the US Corporate Bond Market

1. Existing OTC literature doesn't explain why dealers reduced their inventory in the crisis.
   - Duffie, Garleanu, Pedersen (2005, 2007): dealers risk neutral.
   - Weill (2007) and Lagos, Rocheteau, Weill (2011): dealers risk neutral and "lean against the wind", because crisis modeled as customer crisis.
   - Lagos and Afonso (2012): dealers' risk averse, but aversion not time-varying.
2. Existing exchange-trading literature doesn't explain why larger trades are generally associated with better prices.
   - Limit order markets: larger orders associated with worse liquidity as they walk up/down the limit order book, if insufficient depth at best bid/ask.

Key Features of my Model

1. Dealers' time-varying aversion to holding inventory
   - Stylized fact #1: Dealers reduced inventory of corporate bonds in crises.
   - Stylized fact #2: Liquidity correlated with inventory holding costs.
   - Stylized fact #3: Trade size has decreased since onset of financial crisis.
   - Key feature 1: **Dealers are averse to holding costly inventory**.
   - Key feature 2: **Aversion and holding costs vary with the state**.
2. Customer-dealer bargaining
   - Stylized fact #4: Larger trades are generally associated with better liquidity, except for very large trades.
   - Key feature 3: **Dealers and customers bargain over price**.
     Smaller trades more likely done by smaller customers with less bargaining power: worse prices than larger trades.

Dealers' Possible Trades Between Issuance and Maturity



- Probabilities exogenous

Dealers

- Continuum, mass 1.
- Infinitely-lived.
- "Effectively" risk averse as in Etula (2009): risk neutral in cash-flows, but pay holding cost $f(s_t).(a_t^d)^2$ per period on their risky asset position a_t^d. Related to Value-at-Risk.
- Value function at time t, $V_t^d(\$_t^d, \{a_t^{d,k}\}_k, s_t)$:

$$= \max_{\{q_\tau^i, p_\tau^c, q_\tau^c, q_\tau^{issuer}\}_{\tau=t}^{\infty}} E_t^d \left[\sum_{u=0}^{\infty} \delta^u \left(\underbrace{\$_{t+u}^d \left(1 - R^{-1}\right)}_{\text{receive interest}} - \underbrace{p_{t+u} q_{t+u}}_{\text{trade}} - \underbrace{f(s_{t+u}).(a_{t+u}^d)^2}_{\text{holding cost}} \right) \right]$$

where dealer arrives at time t with a_t^d units of risky asset, and $\$_t^d$ in cash which includes interest accrued for the period $(t-1, t]$, which is paid at t.

Budget constraints

Customers

- Continuum.
- Risk neutral over wealth (cash + risky asset holdings).
- Live for one period: trade with dealer at birth, consume wealth at death.
- Type j defined by (bargaining power relative to dealer, expected asset valuation at death, interest rate) $= (\eta_j, V^{c_j}(s_t), R^{c_j}(s_t))$

$$\text{Customer's gain from trade} = \delta^c R_t^c q_t^c \left(p_t^c - \tilde{V}_t^c \right)$$

where $\tilde{V}_t^c \equiv V_t^c / R_t^c$.

- Gain doesn't depend on a_t^c or $\$_t^c$ because risk-neutral.

Customer-Dealer Price

- Nash bargaining between customers and dealers over price and quantity.
  Dealer gain from trade
- Price is average of valuations, weighted by bargaining power:
  $$p_t^c = \eta V_t^d + (1-\eta) V_t^c$$
  where V_t^d characterized as price such that dealer's gain from trade is zero.
- $$p_t^c = \tilde{V}_t^c + \eta \delta q_t^c \sum_{u=0}^{T-t-1} \tilde{\pi}^u E_t[f_{t+u+1}]$$
  where $\tilde{\pi} = \delta \left(1 - \pi_i - \sum_j \pi_j^c (1-\eta_j)\right)$
- If customer's bargaining power $\eta = 0$, price $= \tilde{V}_t^c$, dealer gets all gain from trade.
- Higher customer bargaining power $\Rightarrow$ better price for customer: higher if customer selling ($q_t^c > 0$), and lower if customer buying ($q_t^c < 0$).

Dealers' Post-Trade Inventory

$$a^d_{t+1} = \frac{\delta E^d_t\left[\sum_{u=0}^{T-t-2}\tilde{\pi}^u\left(\pi_i p^i_{t+u+1} + \sum_j \pi^c_j(1-\eta_j)V^{c_j}_{t+u+1}\right) + \tilde{\pi}^{T-t-1}V^{\text{issuer}}_T\right] - V_t}{2\delta\sum_{u=0}^{T-t-1}\tilde{\pi}^u E^d_t\left[f_{t+u+1}\right]}$$

where $V_t = \tilde{V}^c_t$ for a customer-dealer trade and $V_t = p^i_t$ for an inter-dealer trade.

- Post-trade inventory does not depend on pre-trade inventory.
- Stylized fact #1: **Dealers' inventory scaled down by expected holding costs.**
- Stylized fact #3: **Higher holding cost** $\Rightarrow$ smaller inventory and reluctance to change position $\Rightarrow$ **smaller trades**.
- Sign and magnitude: trade-off valuation of the current customer (or inter-dealer price) vs expected future valuations and inter-dealer prices.
- All dealers hold same inventory after inter-dealer trading, since they are identical.

Dealer Mark-up

- Decompose bid-ask spread into 2 pieces:

$$\text{mark-up}_t \equiv \begin{cases} p_t^i - p_t^{c,bid} & \text{if dealer buys from a customer at time } t \\ p_t^{c,ask} - p_t^i & \text{if dealer sells to a customer at time } t \end{cases}$$

- Mark-to-market profit of dealers.
- Theoretical counterpart to empirical measure of Feldhutter (2010) and Zitzewitz (2010), who compute it only for "paired" trades, when there is an inter-dealer and customer-dealer trade within a few minutes.
- I focus on unpaired trades, where inventory risk should matter.
- I can compare actual customer-dealer prices to hypothetical inter-dealer prices had there been inter-dealer trade at that time.

Dealer Mark-up

- Markup when dealer is buying from a customer:

$$p_t^i - p_t^{c,bid} = \delta\left(2(a_t^{d,c} - \bar{a}_t^{d,i}) + (2-\eta)|q_t^c|\right)\sum_{u=0}^{T-t-1}\tilde{\pi}^u E_t[f_{t+u+1}]$$

- Markup when dealer is selling to customer:

$$p_t^{c,ask} - p_t^i = \delta\left(2(\bar{a}_t^{d,i} - a_t^{d,c}) + (2-\eta)|q_t^c|\right)\sum_{u=0}^{T-t-1}\tilde{\pi}^u E_t[f_{t+u+1}]$$

- $a_t^{d,c}$ = inventory of dealer trading with customer, $\bar{a}_t^{d,i}$ = mean inventory of inter-dealer trade
- Stylized fact #2: **If $a_t^{d,c} > \bar{a}_t^{d,i}$, i.e. dealer's inventory is above the mean, then markup is higher when dealer is buying than selling. More pronounced when expected holding costs are higher.**

Map to regression specification

Data & Proxies

- Enhanced TRACE data-set:
  - Trade size not censored (18 month lag)
  - Longer time series for counterparty type and trade direction
  - October 2004 - December 2010
  - 6,954,148 unpaired customer-dealer trades; 10,580 bonds; 1,045 issuers
    Data cleaning
  - Total markup $2.2 billion / year.
  - Total volume 67% higher than censored data.
- Proxy bargaining power by trade size group (larger trades more likely done by larger customers, with more bargaining power): split into 11 groups.
- Estimate trade intensity, bond-by-bond (run-by-run):
  $\pi_t = \frac{1}{E_t[wait]}$, where $\log(wait) \sim hour + month$. Intraday volume

Proxying the Dealers' Inventory Holding Cost

Dealers' inventory holding cost is a product of aggregate and bond-specific components.

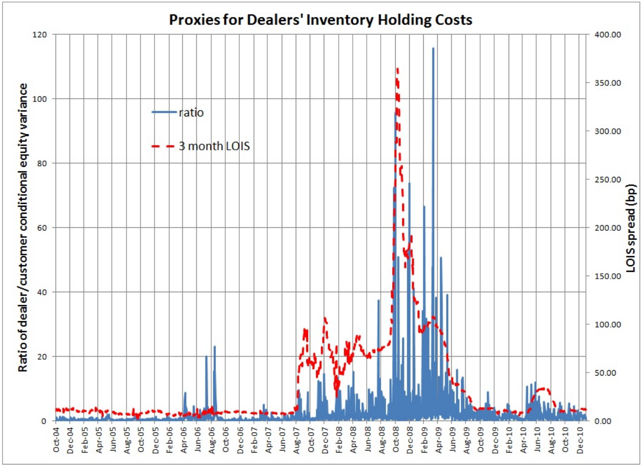
- Aggregate component:
  1. LIBOR-OIS spread
  2. dealers' risk appetite relative to customers:

$$\frac{\text{conditional variance of dealers' daily equity returns}}{\text{conditional variance of insurance sector's daily equity returns}} = \frac{\sigma_d^2}{\sigma_c^2}$$

  - When dealers were selling, insurance sector was buying. Insurance trades
  - Estimate variances using GARCH(1,1).

- Bond-specific component:
  1. S&P credit rating: investment grade vs high yield
  2. $Var_t[p_{t+1}]$
     - Assume holding cost $= f(s_t).(a_t^d)^2 = Var_t[wealth_{t+1}]$
     - $a_t^d =$ units of the risky asset $\Rightarrow f(s_t) = Var_t[p_{t+1}]$.

Dealers' Effective Risk Appetite (Relative to Customers)



Dealers' Flight to Quality

The higher the dealers' cost of holding inventory (relative to customers'):

1. For unpaired customer-dealer trades:
   - the more high yield bonds dealers sell to customers;
   - the more investment grade bonds dealers buy from customers.

2. For paired customer-dealer trades:
   - trade direction not affected, neither for high yield nor investment grade bonds.

Dealers' Flight to Quality

Dependent variable: Signed Trade Size

	Unpaired Trades	**Paired**	All Trades	Unpaired Trades
Investment Grade	-4,593.6**	-964.4	-2,419.5**	-4,899.5**
	(-2.23)	(-0.70)	(-2.10)	(-2.35)
High Yield	-12,631.2***	7,342.0**	-3,147.9	-13,057.5***
	(-3.95)	(2.23)	(-1.48)	(-3.98)
$\frac{\sigma_d^2}{\sigma_c^2}$	**-840.9*** **	**205.8**	-360.1	-868.3***
	(-2.81)	**(0.32)**	(-1.10)	(-2.84)
$\frac{\sigma_d^2}{\sigma_c^2} \times$ Investment Grade	**1,055.8*** **	**-578.5**	180.3	1,164.9***
	(2.88)	**(-0.88)**	(0.52)	(3.06)
π_t				175,399.6*
				(1.77)
$\pi_t \times \frac{\sigma_d^2}{\sigma_c^2}$				20,943.1
				(1.05)
$\pi_t \times$ Investment Grade				-40,099.6
				(-0.32)
$\pi_t \times \frac{\sigma_d^2}{\sigma_c^2} \times$ Investment Grade				-46,588.6*
				(-1.88)
N	6,954,148	8,850,406	15,804,554	6,953,766

LOIS

Interpolating Inter-dealer Price at Customer Trade Times

1. Regression, using approximation from model:

$$p_t^i = c + \phi p_{t-1}^i + \beta a_t^D f_t + \beta_i(index_t - index_{t-1}) + \varepsilon_t$$

- $index_t$ = volume-weighted daily price index: helps mitigate the staleness in the last inter-dealer price.
- Since I don't know the level of aggregate dealer inventory, I estimate:

$$p_t^i = c + \beta a_0^D f_t + \phi p_{t-1}^i + \beta(a_t^D - a_0^D) f_t + \beta_i(index_t - index_{t-1}) + \varepsilon_t$$

2. Kalman filter:

$$\begin{bmatrix} p_t^{c,obs} \\ p_t^{i,obs} \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \bar{p}_t^i + \begin{bmatrix} \varepsilon_t^c \\ \varepsilon_t^i \end{bmatrix}$$

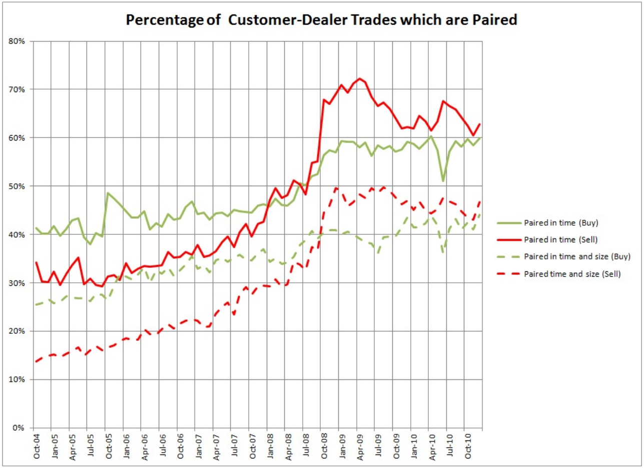
$$\bar{p}_{t+1}^i = \bar{p}_t^i + \varepsilon_{t+1}^m$$

Liquidity Worse When Inventory Holding Costs Higher

Dependent variable: Dealer's markup (difference between customer-dealer price and estimated inter-dealer price)

	Trade size bin	1	3	5	7	9	11
	Min. trade size	0	100,000	550,000	1,000,000	5,000,000	9,000,000
	Max. trade size	50,000	325,000	775,000	3,000,000	7,000,000	
	Intercept	1.189***	0.736***	0.350***	0.340***	0.095***	0.248***
		(19.850)	(27.080)	(9.900)	(49.820)	(3.110)	(38.660)
	$\lvert q_t^c \rvert$	-42.162***	-14.795***	-0.291	-0.303***	0.271***	-0.004
		(-2.880)	(-17.310)	(-0.560)	(-9.350)	(4.830)	(-1.280)
	$\lvert q_t^c \rvert \times \pi_t$	-6878.270***	-50.409	8.035	-3.937	4.771	1.631***
		(-5.430)	(-0.930)	(0.380)	(-0.790)	(1.560)	(2.580)
IG:	$\lvert q_t^c \rvert \times \frac{\sigma_d^2}{\sigma_c^2}$	-0.717	0.279***	0.093***	0.027***	0.010***	0.002***
		(-0.810)	(7.590)	(6.690)	(10.070)	(7.660)	(2.990)
HY:	$\lvert q_t^c \rvert \times \frac{\sigma_d^2}{\sigma_c^2}$	0.608	0.338***	0.111***	0.028**	0.012***	0.003***
		(0.310)	(5.780)	(5.900)	(9.690)	(6.470)	(4.220)
IG:	$\lvert q_t^c \rvert \times \frac{\sigma_d^2}{\sigma_c^2} \times \pi_t$	-169.773**	-14.960***	-4.186	-0.597	0.141	0.039
		(-2.190)	(-3.220)	(-1.200)	(-1.200)	(0.340)	(0.290)
HY:	$\lvert q_t^c \rvert \times \frac{\sigma_d^2}{\sigma_c^2} \times \pi_t$	453.006**	18.386	-15.441	-5.193***	-3.745***	-0.640
		(2.260)	(0.800)	(-1.220)	(-3.080)	(-2.980)	(-1.290)
	N	3,507,047	807,544	121,233	787,335	280,675	204,910

% of Customer Trades Paired With Inter-dealer Trades



% of Customer Trades Paired With Inter-dealer Trades

Some customer-dealer trades occur very close in time to an inter-dealer trade ("paired"), often for the same quantity.

- The smaller the quantity, the easier to pair.
- The higher the dealers' cost of holding inventory (relative to customers'), the greater the incentive for dealers to risk-share, by pairing customer-dealer trades with inter-dealer ones, so:
  - The higher the proportion of customer-dealer trades are paired. *(Dealers more likely to only do trade if they can immediately lay it off.)*
  - This is much less pronounced for investment grade bonds. *(Less inventory risk.)*
  - This is more pronounced when a dealer is selling, than buying. *(When the cost is high, it is easier to find a dealer wanting to sell.)*

% of Customer Trades Paired With Inter-dealer Trades

Logit regression. Dependent variable: $1_{\text{paired trade}}$

	Dealer Buys	Dealer Sells	All
Intercept	3.0484***	2.9373***	3.0033***
	(0.00450)	(0.00414)	(0.00304)
log(trade_size)	-0.2727***	-0.2511***	-0.2619***
	(0.000412)	(0.0000385)	(0.000281)
$\frac{\sigma_d^2}{\sigma_c^2}$	0.0360***	0.0729***	0.0524***
	(0.00148)	(0.00174)	(0.00114)
$\frac{\sigma_d^2}{\sigma_c^2} \times$ Investment Grade	-0.0299***	-0.0753***	-0.0467***
	(0.00161)	(0.00180)	(0.0012)
log(trade_size) $\times \frac{\sigma_d^2}{\sigma_c^2}$	-0.00380***	-0.00794***	-0.00572***
	(0.000135)	(0.000161)	(0.000105)
log(trade_size) $\times \frac{\sigma_d^2}{\sigma_c^2} \times$ Investment Grade	0.00417***	0.00978***	0.00663***
	(0.000145)	(0.000167)	(0.00011)

Future OTC Work

Test hypotheses on:

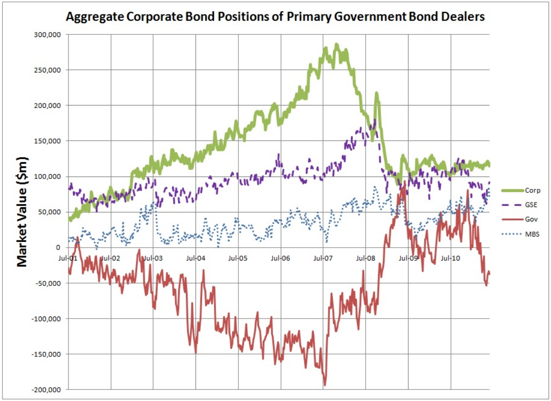
- liquidity
- changes in inventory holdings
- pairing

in:

- US corporate bond market, using individual dealer data.
- Other OTC markets: ABS, MBS, CMO, TBA, swaps, and municipal bond markets.

Thank you!

Inventory of Primary Government Bond Dealers



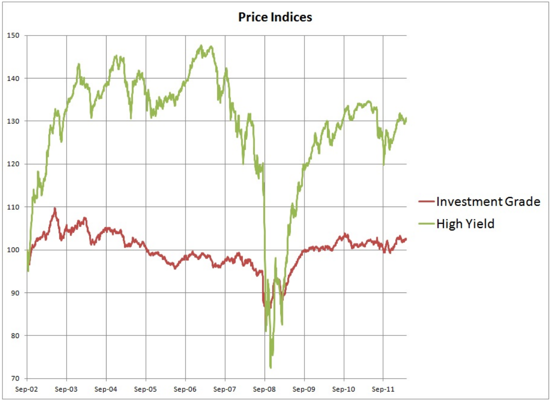
Return

Who are the Dealers?

Primary Government bond dealers	**Major MarketAxess Dealers**
BNP Paribas Securities Corp.	BNP Paribas Securities Corp.
Barclays Capital Inc.	Barclays Capital Inc.
Cantor Fitzgerald & Co.	
	CIBC World Markets
Citigroup Global Markets Inc.	Citigroup Global Markets Inc.
Credit Suisse Securities (USA) LLC	Credit Suisse Securities (USA) LLC
Daiwa Capital Markets America Inc.	
Deutsche Bank Securities Inc.	Deutsche Bank Securities Inc.
	FTN Financial
Goldman, Sachs & Co.	Goldman, Sachs & Co.
HSBC Securities (USA) Inc.	HSBC Securities (USA) Inc.
Jefferies & Company, Inc.	Jefferies & Company, Inc.
J.P. Morgan Securities LLC	J.P. Morgan Securities LLC
Merrill Lynch, Pierce, Fenner & Smith Incorporated	BofA Merrill Lynch
Mizuho Securities USA Inc.	
Morgan Stanley & Co. Incorporated	Morgan Stanley & Co. Incorporated
Nomura Securities International, Inc.	
RBC Capital Markets, LLC	RBC Capital Markets, LLC
RBS Securities Inc.	RBS Securities Inc.
UBS Securities LLC.	UBS Securities LLC.
	Wells Fargo Securities
	Wall St Access

Return

Corporate Bond Price Indices



◂ Return

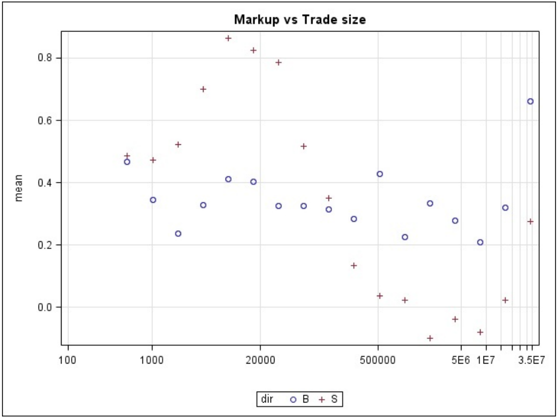
View from The Street

The **reduced holdings** may expose investors to wider price swings if sentiment turns negative, according to State Street Corp.'s William Cunningham in Boston.

"**Liquidity is very scarce when you need it**," said Cunningham, head of credit strategies and fixed-income research at the investment unit of State Street, which oversees almost $2 trillion. "While the markets are operating, the **depth of bids and the depth of liquidity is so shallow** that you cannot rely on this if conditions get worse."

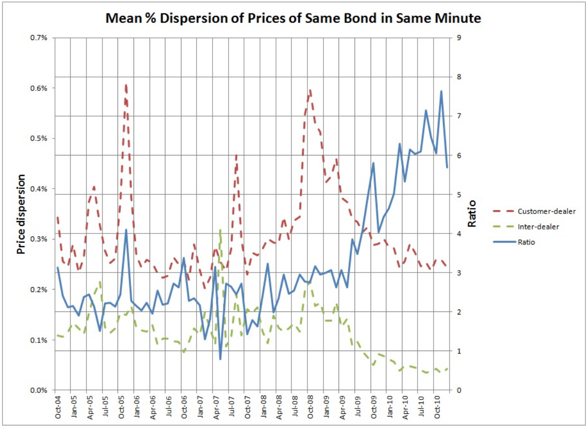
Bloomberg.com (July 15, 2010) Return

Markup, by Trade Size



Return

Competitiveness: Inter-dealer vs Customer-dealer Markets



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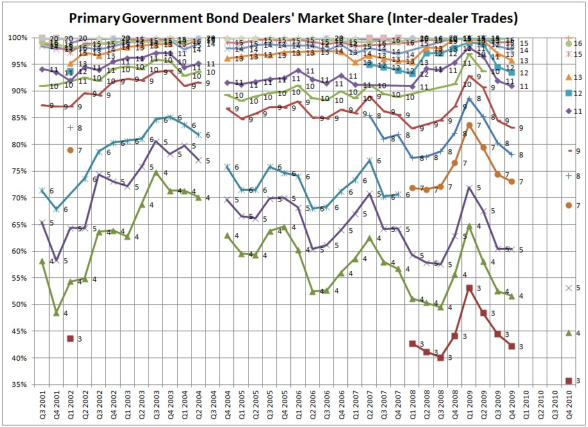
Concentration of Inter-dealer Market



Return

Dealers' Budget Constraints

1. no trade at τ:

$$\begin{aligned} \$^d_{\tau+1} &= R\left(\$^d_\tau - \underbrace{\$^d_\tau(1-R^{-1})}_{\text{interest}} - \underbrace{f_\tau.(a^d_\tau)^2}_{\text{holding cost}}\right) \\ a^d_{\tau+1} &= a^d_\tau \end{aligned}$$

2. trade at τ:

$$\begin{aligned} \$^d_{\tau+1} &= R\left(\$^d_\tau - \underbrace{\$^d_\tau(1-R^{-1})}_{\text{interest}} - \underbrace{p_\tau q_\tau}_{\text{trade}} - \underbrace{f_\tau.(a^d_\tau)^2}_{\text{holding cost}}\right) \\ a^d_{\tau+1} &= a^d_\tau + q_\tau \end{aligned}$$

3. maturity and reissuance at time τ:

$$\begin{aligned} \$^d_{\tau+1} &= R\left(\$^d_\tau - \underbrace{\$^d_\tau(1-R^{-1})}_{\text{interest}} + \underbrace{a^d_\tau V_\tau}_{\text{maturity}} - \underbrace{p^{\text{issuer}}_\tau q^{\text{issuer}}_\tau}_{\text{re-issuance}} - \underbrace{f_\tau.(a^d_\tau)^2}_{\text{holding cost}}\right) \\ a^d_{\tau+1} &= q_\tau \end{aligned}$$

Return

Dealer's Gain from Trade with a Customer at time t

$$
(1+\delta R\gamma^{\$})\Bigg(\underbrace{-p_t^c q_t^c}_{\text{buy } q_t^c \text{ units from time-}t\text{ customer}} \underbrace{-\delta\overbrace{\left(2a_t^d+q_t^c\right)q_t^c}^{(a^d+q^c)^2-(a^d)^2}\sum_{s=0}^{T-t-1}\left(\delta(1-\pi^i-\pi^c)\right)^s E_t[f_{t+s+1}]}_{\text{discounted holding costs on } (a^d+q^c) \text{ units instead of } a^d\text{, until next expected trade}}
$$

$$
\underbrace{+\delta\sum_{s=0}^{T-t-2}\left(\delta(1-\pi^i-\pi^c)\right)^s\times\Bigg(\pi^i E_t[p_{t+s+1}^i]\left(\cancel{-q_{t+s+1}^i}-(-(\cancel{q_{t+s+1}^i}+q_t^c))\right) + \sum_j \pi_j^c E_t\Bigg[\underbrace{-q_{t+s+1}^{cj}\cdot p_{t+s+1}^{cj}\left(a_t^d+q_t^c,q_{t+s+1}^{cj}\right)}_{\text{trade at } t \text{ and } t+s+1}-\underbrace{\left(-\left(q_t^c+q_{t+s+1}^{cj}\right)\cdot p_{t+s+1}^c\left(a_t^d,q_t^c+q_{t+s+1}^{cj}\right)\right)}_{\text{trade at } t+s+1 \text{ only}}\Bigg]\Bigg)}_{\text{buy } q_{t+s+1} \text{ units from time-}(t+s+1)\text{ counterparty, instead of } q_{t+s+1}+q_t^c\text{. The counterparty is a dealer with probability } \pi^i\text{, and customer } j \text{ with probability } \pi_j^c}
$$

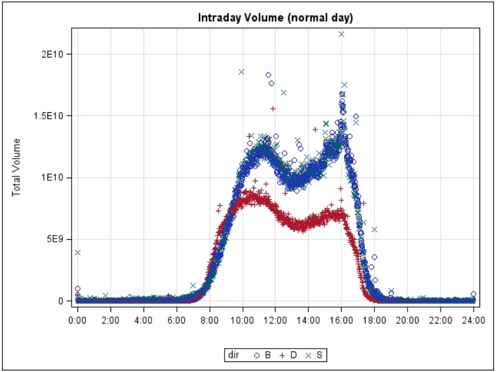
$$
+\underbrace{\left(\delta(1-\pi^i-\pi^c)\right)^{T-t-1}\delta\left(\cancel{-a_t^d}-(-(\cancel{a_t^d}+q_t^c))\right)E_t\left[V_T^{\text{issuer}}\right]}_{\text{cash in } a_t^d \text{ units instead of } (a_t^d+q_t^c) \text{ from maturity at time } T\text{, if dealer doesn't meet a counterparty in the previous } T-t-1 \text{ rounds of trading}}\Bigg)
$$

Cleaning the Data

- Remove canceled/corrected trades as in Dick-Nielsen (2009)
- Only bonds with $>$ 50 inter-dealer trades (biases against finding inventory holding cost effect, since excludes least liquid bonds)
- Winsorize markup at 1% level
- Add in missing commissions, median by trade size group

Return

Trading Volume: Intra-day



Return

Inventory Holding Costs, Not Asymmetric Information

Asymmetric information in corporate bond market less plausible than in e.g. equity markets:

- Unclear that customer has more information than dealer.
- If customer has better information, would exploit in more information-sensitive, more liquid security?

Control for information asymmetry at issuer level:

- Companies have multiple bond issues.
- Use within-issuer variation.
- Aggregate holding cost, bargaining power, trade size effects: robust to inclusion of issuer fixed effects. Issuer FEs
- Lose IG vs HY differential. Not enough variation within issuer.

Inventory Holding Costs, Not Asymmetric Information

Within issue:

- Larger customer trades could be more informed, explaining worse prices.
- But if buys/sells equally informed, no buy/sell asymmetry in liquidity.
- If customer sales more likely for liquidity needs (uninformed) than customer buys, markup when dealer buys would be lower than when dealer sells. Opposite to plot.

Dependent variable: average daily sell markup - average daily buy markup	
Intercept	0.01821***
	(3.74)
$\frac{\sigma_d^2}{\sigma_c^2}$	0.00678***
	(9.74)
N	1,574

Robustness: Asymmetric Information

Dependent variable: Dealer's markup (difference between customer-dealer price and estimated inter-dealer price)

	Trade size bin	1	3	5	7	9	11
	Min. trade size	0	100,000	550,000	1,000,000	5,000,000	9,000,000
	Max. trade size	50,000	325,000	775,000	3,000,000	7,000,000	
	$\lvert q_t^c \rvert$	-38.615***	-14.230***	-0.402	-0.303***	0.167***	-0.004***
		(-49.36)	(-72.64)	(-0.84)	(-12.66)	(3.66)	(-3.61)
	$\lvert q_t^c \rvert \times \pi_t$	-4,849.200***	-1.892	45.722**	9.195***	9.928***	2.414***
		(-72.76)	(-0.09)	(2.28)	(2.72)	(5.11)	(5.33)
IG:	$\lvert q_t^c \rvert \times \frac{\sigma_d^2}{\sigma_c^2}$	0.665***	0.367***	0.097***	0.033***	0.012***	0.002***
		(-8.14)	(26.5)	(9.60)	(20.66)	(12.99)	(8.24)
HY:	$\lvert q_t^c \rvert \times \frac{\sigma_d^2}{\sigma_c^2}$	-0.120	0.182***	0.099***	0.023***	0.009***	0.003***
		(-0.69)	(7.43)	(6.55)	(12.92)	(7.21)	(5.11)
IG:	$\lvert q_t^c \rvert \times \frac{\sigma_d^2}{\sigma_c^2} \times \pi_t$	-226.910***	-17.770***	-3.508	-0.816***	0.001	0.044
		(-18.66)	(-6.16)	(-1.37)	(-2.99)	(0.001)	(0.59)
HY:	$\lvert q_t^c \rvert \times \frac{\sigma_d^2}{\sigma_c^2} \times \pi_t$	557.032***	-20.139*	-29.567***	-5.435***	-3.821***	-0.427
		(26.28)	(-1.69)	(-2.81)	(-4.25)	(-3.94)	(-1.07)
	Issuer fixed effects	Y	Y	Y	Y	Y	Y
	N	3,507,047	807,544	121,233	787,335	280,675	204,910

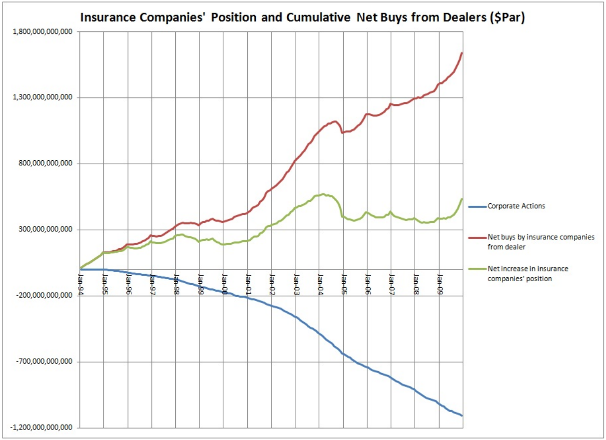
Return

Dealers' Flight to Quality

	Dependent variable: Signed Trade Size			
	Unpaired Trades		**Paired Trades**	
IG	-4,593.6**	-4,221.7	-964.4	8,606.7**
	(-2.23)	(-1.17)	(-0.70)	(2.37)
HY	-12,631.2***	1,379.3	7,342.0**	-9,967.4***
	(-3.95)	(0.35)	(2.23)	(-2.64)
$\frac{\sigma_d^2}{\sigma_c^2}$	**-840.9*** **		**205.8**	
	(-2.81)		**(0.32)**	
$\frac{\sigma_d^2}{\sigma_c^2} \times$IG	**1,055.8*** **		**-578.5**	
	(2.88)		**(-0.88)**	
LOIS		**-32,727.0*** **		**-2,685.7**
		(-6.61)		**(-0.23)**
LOIS $\times$ IG		**29,691.2*** **		**107.9**
		(4.13)		**(0.01)**
N	6,954,148		8,850,406	

Return

Insurance Companies' Position



Return

Mapping Markup: Theory → Empirics

I make the following simplifying assumptions, in order to test markup expression empirically:

1. $\delta \approx 1$ but still $\delta < 1$;
2. $T \gg t$, i.e. many possible trade times until bond matures, and time to maturity approximately same for all trades;
3. Expected holding cost linear in current holding cost: $E_t[f_{t+u+1}] \approx \beta_u + \beta_{f,u} f_t$ for all u, with $\beta_u, \beta_{f,u} > 0$.
4. $\left(1 - \pi_i - \sum_j \pi_j^c (1 - \eta_j)\right)^u \approx c_u + \beta_{i,u}\pi_i + \sum_j \beta_{c_j,u}\pi_j^c$ for all u, where $\beta_{i,u}, \beta_{c_j,u} < 0$ for all u and j.

Then the regression specification for the markup becomes:

$$\begin{aligned} markup_{t,r}^{\eta} &\equiv (\hat{p}_t^i - p_t^c) \times 1_t^{buy/sell} \\ &\approx |q_t^c| 1_t^{\eta} \left(\beta_\eta + \beta_{\eta,f} f_t - \beta_{\eta,\pi}\pi_t - \beta_{\eta,f,\pi}\pi_t f_t\right) + \varepsilon_t^{\eta} \end{aligned}$$

where β's positive & proportional to $2 - \eta$; η = customer bargaining power.

Return