Commonality in Credit Spread Changes: Dealer Inventory and Intermediary Distress

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Puzzling bond-price variation

U.S. corporate bond price changes are only partially explained by structural factors (Collin-Dufresne, Goldstein, and Martin, 2001) (CGM)

- Regress credit spread changes on, e.g., leverage, interest rate, etc.
- $R^2 \approx 30\%$

But residual variation strongly **co-moves with a latent factor**

- Factor measured as PC1 of group-averaged (e.g., by ratings) residuals
- PC1 $R^2 \approx 80\%$ for these residuals

What is this latent factor?

- This paper takes the perspective of **Intermediary Asset Pricing**
- Highlight two forces capturing **supply** and **demand**
- Sudden desire to sell bonds (supply) and willingness to provide liquidity (demand)

Our paper: explain common variation with 2 factors

1. Intermediary **Distress**
    - Combines balance sheet measure of He, Kelly, and Manela (2017) (HKM) with "noise" variable of Hu, Pan, and Wang (2013) (HPW)
    - HKM: market leverage of primary dealers
    - HPW: pricing errors of Treasuries w.r.t some no-arbitrage yield curve models
2. Dealer **Inventory**
    - Dealer trades of bonds in TRACE, corrected for maturity and issuance

Related to literature on OTC illiquidity and its effect on bond prices:

Bao, O'Hara, and Zhou (2018); Schultz (2017); Di Maggio, Kermani, and Song (2017); Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018); Bao, Pan, and Wang (2011); Dick-Nielsen, Feldhütter, and Lando (2012); Dick-Nielsen and Rossi (2018); Friewald and Nagler (2019); He and Milbradt (2014); Cui, Chen, He, and Milbradt (2017).

Related to broader intermediary asset pricing literature:

Adrian, Etula, and Muir (2014); He, Kelly, and Manela (2017).

Main findings

1. **Explanatory power:** Distress and Inventory factors explain substantial fraction of common residual variation.
    - Explains about 51% of PC1; $R^2 = 43\%$ (versus PC1 $R^2 = 80\%$)
    - Distress accounts for 2/3 of explanatory power; Inventory for 1/3

2. **Pattern:** yield spreads load positively on Distress and Inventory, with higher sensitivities for lower-rated bonds.
    - 4-70bp spread increase for 1SD Distress shock
    - 3-40bp spread increase for 1SD Inventory shock

3. **Interpretation:** intermediary model with cross-sectional market segmentation (Vayanos and Vila, 2021).
    - Rationalize findings above.
    - Develop new tests.

Further tests supporting the model

Prediction 1. No pattern when sorting bonds by any characteristic unrelated to risk.

- Indeed, nothing on maturity or **trading volume** sorts
- Our results are not driven by micro-structure based liquidity factors

Prediction 2. Assets more segmented from corporate bonds are less sensitive to **Inventory**. All assets are sensitive to **Distress**.

- CDS sensitive to Inventory; IG/HY bonds sensitive to others' Inventory
- MBS, CMBS, ABS, options insensitive to Inventory

Prediction 3. Inventory increases partly due to liquidity shocks.

- Downgrade-induced selling by insurance companies, mutual funds, pension funds increases dealer Inventory
- "fallen angels" selloffs (IG $\searrow$ HY): IV for Inventory (supply shocks)

Part I

Main Empirical Results

Bond Data

Bond Datasets.

- *Enhanced TRACE*: CUSIP-level trades, importantly with (uncapped) principal amount and dealer indicators, from 2005q1-2015q2
- *Mergent FISD*: bond characteristics
- *CRSP*: equity prices
- *Compustat*: accounting data

Our bond sample.

- Keep publicly-traded, non-financial, non-utility firms' bonds with dollar denominations, no embedded options, constant coupon rates, senior unsecured, credit rated, $\geq$ \$10*m* issuance.
- Drop trades with P1 flag, or time-to-maturity $<$ 1*yr*.

Credit spreads

$cs_{i,t} :=$ credit spread for bond i in quarter t.

Steps:

- Take the last trade in quarter t, calculate yield-to-maturity, and subtract the same-maturity Treasury yield that day
- Drop observations where the time between these trades is < 45 days or > 120 days
- Remove upper/lower 1% tails of credit spread levels
- Compute credit spread changes $\Delta cs_{i,t} := cs_{i,t} - cs_{i,t-1}$ and scale to represent 90-day changes
- Drop bonds without 16 consecutive quarterly observations of $\Delta cs_{i,t}$

Summary stats

All Bonds					
Number of bonds	2,584				
Number of firms	653				
Number of bond-quarters	55,398				
	mean	std	p25	p50	p75
Yield spread	2.51	2.69	0.95	1.60	3.12
Coupon	6.32	1.59	5.38	6.30	7.25
Time-to-Maturity	9.78	8.07	4.19	6.80	11.84
Age	5.12	4.32	2.14	3.86	6.67
Issuance	550.50	471.97	250.00	400.00	650.00
Rating	9.25	3.43	7.00	9.00	11.00

Collin-Dufresne, Goldstein, and Martin (2001) analysis

$cs_{i,t}$:= credit spread for bond i in quarter t.

$$\Delta cs_{i,t} = \alpha_i + \beta_{1,i} \times \Delta Lev_t^i + \beta_{2,i} \times \Delta VIX_t + \beta_{3,i} \times \Delta Jump_t + \beta_{4,i} \times \Delta r_t^{10y} + \beta_{5,i} \times (\Delta r_t^{10y})^2 + \beta_{6,i} \times \Delta slope_t + \beta_{7,i} \times ret_t^{SP} + \varepsilon_{i,t}$$

7 structural variables based on Merton (1974):

- firm leverage $Lev_{i,t} := \text{book debt}_{i,t}/\text{market equity}_{i,t}$
- VIX_t (CBOE)
- S&P 500 option jump factor $Jump_t$ (OptionMetrics)
- 10-year Treasury rate r_t^{10y}
- squared rate $\left(r_t^{10y}\right)^2$
- yield curve slope $slope_t := r_t^{10y} - r_t^{2y}$
- S&P 500 return ret_t^{SP}

Common residual variation – goodness of fit

Groups				PC	
Maturity	Rating	R^2_{adj}	$\varepsilon_i^{var} / \sum_{i=1}^{15} \varepsilon_i^{var}$	PC1	PC2
Medium	AA	0.296	0.58%	0.057	-0.042
Medium	A	0.331	1.01%	0.096	-0.017
Medium	BBB	0.444	2.09%	0.148	-0.034
Medium	BB	0.607	6.10%	0.235	0.191
Medium	B	0.617	15.93%	0.419	-0.005
Pct Explained (incl Short and Long)				0.801	0.068

Common residual variation – goodness of fit

A little higher than CGM for BB, B

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Similar to CGM

Intermediary factors

Inventory:

$\Delta Inventory_t := log(Inventory_t) - log(Inventory_{t-1})$

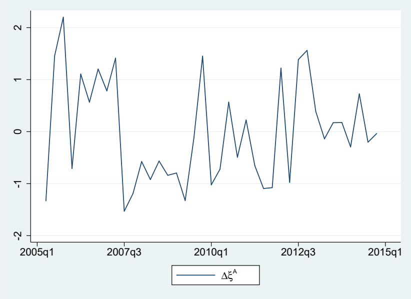
- $Inventory_t$ is the par value of cumulative order flows + adjustments for bonds maturing and primary offerings
- Lack of info on initial inventory level. We set $Inventory_{2002q3} = 0$ and use the sample after 2005q1 only

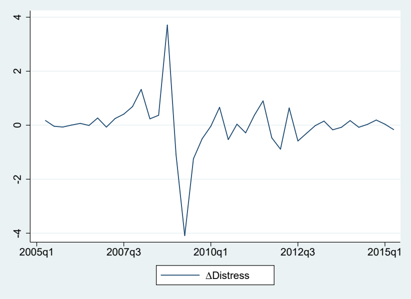
Distress:

$\Delta Distress_t := PC1\{\Delta \text{NLev}_t^{\text{HKM}}, \Delta Noise_t\}$

- $\Delta \text{NLev}_t^{\text{HKM}} := (\text{Lev}_t^{\text{HKM}})^2 - (\text{Lev}_{t-1}^{\text{HKM}})^2$, where Lev^{HKM} is the leverage of primary dealers
- $Noise_t$ (HPW) is the root mean squared difference between market yields and model yields from Svensson (1994)

Factor time-series summary





	$\Delta Inventory^A$	$\Delta Distress$	$\Delta Noise$	$\Delta \text{NLev}^{\text{HKM}}$	ΔVIX	ΔILiq
$\Delta Inventory^A$	1.000					
$\Delta Distress$	-0.028	1.000				
$\Delta Noise$	-0.058	0.840***	1.000			
$\Delta \text{NLev}^{\text{HKM}}$	0.011	0.840***	0.411**	1.000		
ΔVIX	0.044	0.466***	0.235	0.548***	1.000	
ΔILiq	0.306*	0.224	0.192	0.185	0.381**	1.000

ΔILiq: Dick-Nielsen, Feldhütter, and Lando (2012) [94% corr with Bao, Pan, and Wang (2011)]

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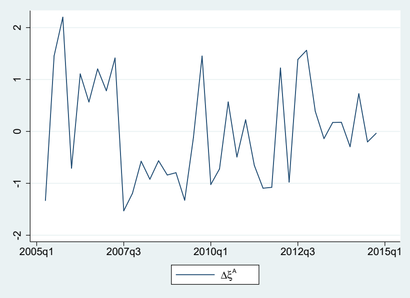

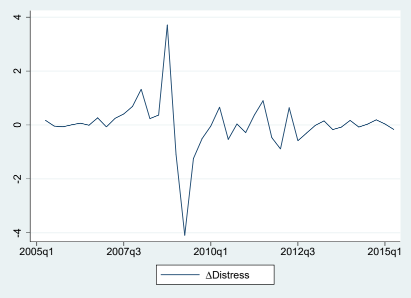

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Two factor structure

ΔILiq: Dick-Nielsen, Feldhütter, and Lando (2012) [94% corr with Bao, Pan, and Wang (2011)]

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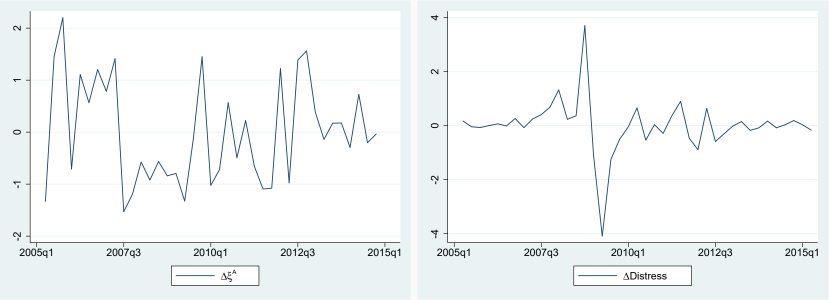

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Low corr with extant liquidity measures

Two intermediary factors explain common variation

Maturity	Rating	$\Delta Inventory$	$\Delta Distress$	R^2_{adj}	% Explained
Medium	AA	0.033	0.050***	0.169	0.531
		(1.612)	(3.691)		
Medium	A	0.072**	0.093***	0.355	
		(2.491)	(2.703)		
Medium	BBB	0.105***	0.145***	0.408	
		(2.860)	(2.965)		
Medium	BB	0.199***	0.261***	0.465	
		(2.866)	(5.105)		
Medium	B	0.338***	0.498***	0.594	
		(5.149)	(4.203)		
Total					0.426

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Explain almost half

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Monotonic pattern

Part II

Model

Model setup

Risky assets:

- Cash flows, net of interest, $\delta \sim \text{Normal}(\bar{\delta}, \Sigma)$
- Partition into N classes $\mathcal{A}_1, \ldots, \mathcal{A}_N$ (e.g., bonds, equities, etc.)
- All assets in zero net supply

Hedger n: (agglomeration of institutional investors in asset class n)

$$\max_{\theta_{H,n}} \mathbb{E}[W_{H,n}] - \frac{\rho_n}{2}\text{Var}[W_{H,n}] \quad \text{where} \quad W_{H,n} := h_n'\delta + \theta_{H,n} \cdot (\delta - p)$$

subject to $\theta_{H,n,a} = 0$ for all $a \notin \mathcal{A}_n$ (“habitat” for hedger n is $\mathcal{A}_n$).

Intermediaries: (e.g., primary dealers)

$$\max_{\theta_I} \mathbb{E}[W_I] - \frac{\gamma(w)}{2}\text{Var}[W_I] \quad \text{where} \quad W_I := w + \theta_I \cdot (\delta - p)$$

Shocks and CGM residuals

- **Supply shocks:** hedger risk aversion $(\rho_n)_{n=1}^N$ affects the amount of assets that dealers must intermediate
- **Demand shocks:** intermediary wealth w affects their risk aversion thus willingness to intermediate
- Define "return" of asset a as $\delta_a + \mathrm{d}p_a$, where $\mathrm{d}p_a$ are price changes due to the supply and demand shocks
- Construct "market portfolio:"
  - cash flow is the aggregate endowment $(\sum_{n=1} h_n)'\delta$
  - price is the computed using $(\sum_{n=1} h_n)'p$
  - return is thus $x'\delta + \mathrm{d}(x'p)$, where $x := (\sum_{n=1} h_n)/(\sum_{m=1} h_m'\mathbf{1})$ are the market weights
- To compare to our results (after taking out CGM factors), compute market beta and extract residuals for each asset a:

$$\epsilon_a := \mathrm{d}p_a - \beta_{a,\mathrm{mkt}}\mathrm{d}(x'p)$$

Two benchmarks

No segmentation: if $N = 1$, then ϵ_a is independent of $\mathrm{d}w$ and $\mathrm{d}\rho$.

No heterogeneity: without the intermediaries, cannot even define dealer bond inventory so the model cannot produce the “two-factor structure” of CGM residuals

Simplifying assumptions

Both assumptions below just for simpler algebra.

Assumption 1: (fundamentals are less correlated "between" asset classes than "within")

$$\text{Cov}[\delta_a, \delta_{a'}] > 0 \quad \text{for} \quad a, a' \in \mathcal{A}_{\text{bonds}}$$
$$\text{Cov}[\delta_a, \delta_{a'}] \approx 0 \quad \text{for} \quad a \in \mathcal{A}_n, a' \in \mathcal{A}_{n'}, n' \neq n.$$

Assumption 2: (supply shocks are "rebalancing" shocks)

$$\text{market capital gain} \quad \mathrm{d}(x'p) \quad \text{is independent of} \quad (\mathrm{d}\rho_n)_{n=1}^{N}$$

Bond pricing and PC1

Under Assumption 1, we have the following equilibrium pricing formula

$$p_a \approx \bar{\delta}_a - \Gamma_{n(a)}(\Sigma h)_a, \quad \text{where} \quad \Gamma_n := (\rho_n^{-1} + \gamma^{-1})^{-1}.$$

- Single-factor Γ_n determines non-fundamental variation for assets in class n (like PC1)
- But Γ_n is driven by shocks to ρ_n and γ
- Formula is robust to "partial segmentation" where hedgers portfolios can overlap, as long as we reinterpret ρ_n as a sum of risk aversions for hedgers participating in asset class n (see paper)

Inventory and Distress factors:

$$\xi := \log(\sum_a \theta_{I,a} \mathbf{1}_{a\in\mathcal{A}_{\text{bonds}}}) \quad \text{and} \quad \lambda := \log(\sum_a \theta_{I,a}/w)$$

Bond regressions in the model produce the following:

(*explanatory power*) $\epsilon_a \approx \beta_{a,\xi}\mathrm{d}\xi + \beta_{a,\lambda}\mathrm{d}\lambda, \quad a \in \mathcal{A}_{\text{bonds}}$

(*sign of sensitivities*) $\beta_{a,\xi} < 0$ and $\beta_{a,\lambda} < 0$ if

(*i*) bonds more sensitive to w than non-bond assets

(*ii*) ξ and λ are proxies for shocks $\mathrm{d}\rho_{\text{bonds}}$ and $\mathrm{d}w$, respectively

(*monotonic sensitivities*) $\beta_{i,\xi}/\beta_{j,\xi} \approx \beta_{i,\lambda}/\beta_{j,\lambda} \approx \underbrace{\text{Cov}[\delta_i, x'\delta]/\text{Cov}[\delta_j, x'\delta]}_{\text{ratio of fundamental riskiness}}$

Empirically-measured sensitivities: $\hat{\beta}^{\text{B}}_{\xi}/\hat{\beta}^{\text{AA}}_{\xi} \approx 10 - 19$ and $\hat{\beta}^{\text{B}}_{\lambda}/\hat{\beta}^{\text{AA}}_{\lambda} \approx 8 - 18$

Summary of model

Consistent both with (1) single latent factor and (2) two structural factors.

Interpret two factors as proxies for “bond supply shocks” and “intermediary demand shocks”

Pattern of loadings on factors resembles risk patterns

Part III

Further tests

Prediction 1

Risk-based pattern: Sensitivities related to a bond's aggregate riskiness

- Similar loading pattern sorting bonds by regression betas on S&P 500.
- Similar loading pattern sorting bonds by regression betas on VIX.

Placebo test: No loading pattern if sorting bonds by any characteristic unrelated to aggregate risk

- No pattern in loadings sorted by maturity.
- No pattern in loadings sorted by trading volume.

Placebo test: sorting on trading volume

Groups		Regressions of Residuals		
Rating	TrdVolume ($ mil)	Δ*Inventory*	Δ*Distress*	R^2_{adj}
AA	2.462	-0.008	0.032	0.062
		(-0.311)	(1.299)	
AA	17.779	0.022	0.051***	0.219
		(1.195)	(3.603)	
AA	136.25	0.040***	0.041**	0.206
		(2.735)	(1.942)	
B	2.360	0.339***	0.381***	0.354
		(3.118)	(3.621)	
B	17.342	0.328***	0.455***	0.493
		(4.111)	(2.804)	
B	89.654	0.401***	0.537***	0.528
		(3.833)	(3.084)	

Prediction 2

Spillovers and Segmentation: Assets in the same class as corporate bonds will be sensitive to bond inventory; other assets less so. All assets will be sensitive to Distress.

- HY bonds sensitive to IG inventory, and vice versa.
- CDS sensitive to bond inventory.
- MBS, CMBS, ABS, S&P options sensitive to distress but not bond inventory.

Spillovers: HY and IG Inventory

Maturity	Rating	$\Delta Inventory^{HY}$	$\Delta Distress$	R^2_{adj}	$\Delta Inventory^{IG}$	$\Delta Distress$	R^2_{adj}
Medium	AA	0.032	0.051***	0.177	0.008	0.048**	0.128
		(1.577)	(3.144)		(0.631)	(2.368)	
Medium	A	0.055**	0.087*	0.288	0.016	0.082	0.209
		(2.395)	(1.815)		(0.687)	(1.539)	
Medium	BBB	0.087**	0.145**	0.349	0.023	0.137*	0.259
		(2.485)	(2.129)		(0.714)	(1.834)	
Medium	BB	0.150**	0.261***	0.371	0.068*	0.251***	0.295
		(2.001)	(3.708)		(1.759)	(3.845)	
Medium	B	0.251**	0.520***	0.494	0.175***	0.511***	0.446
		(2.310)	(3.038)		(2.726)	(2.976)	
FVE				0.364			0.340

Spillovers: CDS

Groups		Regression of Residuals			
Maturity	Rating	$\Delta Inventory^A$	$\Delta Distress$	R^2_{adj}	FVE
5y	AA	0.023***	0.026***	0.215	0.304
		(3.091)	(2.751)		
5y	A	0.053***	0.045***	0.487	
		(3.646)	(6.916)		
5y	BBB	0.078***	0.069***	0.468	
		(3.619)	(3.734)		
5y	BB	0.055	0.114***	0.176	
		(1.376)	(3.939)		
5y	B	0.308***	0.422**	0.313	
		(3.085)	(2.128)		
Total FVE					0.312

Other classes: Inventory irrelevant, but Distress matters

A: Agency MBS				
	FN30y	FN15y	FG30y	FG15y
Δ*Inventory*	0.027	0.008	0.029*	-0.006
	(1.554)	(0.466)	(1.925)	(-0.399)
Δ*Distress*	0.049***	0.054***	0.058***	0.046***
	(2.840)	(3.282)	(3.666)	(2.756)
R^2_{adj}	0.138	0.197	0.153	0.127
B: CMBS				
	Duper	AM	AJ	
Δ*Inventory*	0.040	-0.185	-0.278	
	(0.411)	(-1.177)	(-1.436)	
Δ*Distress*	0.270***	0.877***	0.915***	
	(3.225)	(3.128)	(3.464)	
R^2_{adj}	0.178	0.346	0.321	
C: ABS				
	Credit Card	Auto AAA	Auto A	Auto BBB
Δ*Inventory*	-0.020	-0.002	-0.004	-0.067
	(-0.797)	(-0.085)	(-0.050)	(-0.709)
Δ*Distress*	0.185***	0.046	1.210***	1.216**
	(3.194)	(0.857)	(2.657)	(2.349)
R^2_{adj}	0.248	0.009	0.436	0.378

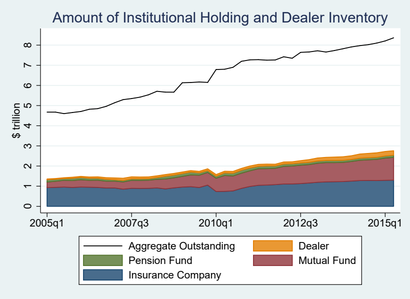
Prediction 3

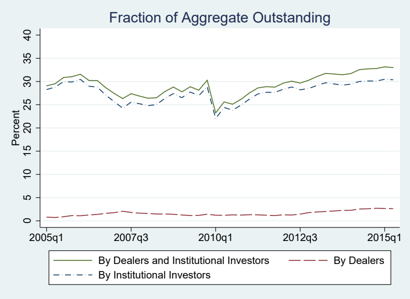
Supply shocks: Inventory increases partly due to institutional investors' liquidity shocks.

- Use Lipper eMAXX data to see holdings of insurers, mutual funds, pension funds.
- After bond downgrades, dealers' inventory increases and insurers' holdings decrease, especially for "fallen angels."
- Use fallen angels as an IV for Δ*Inventory* to purge inventory of demand effects.

“Fallen angels” as supply shocks

Lipper eMAXX data: corporate bond holdings by insurance companies, mutual funds, and pension funds (≈ 30% of the market)





Supply shock: bond downgrades forcing some institutions to sell (e.g., Ambrose, Cai, and Helwege (2008) and Ellul, Jotikasthira, and Lundblad (2011))

- **Downgrade (IG):** IG rated before and after
- **Fallen Angels:** IG rated before and HY after

Measuring supply shocks during downgrades

	Downgrade (IG)		Fallen Angels		No Rating Change	
	Amount	% Holding	Amount	% Holding	Amount	% Holding
			A: Insurance Companies			
$\Delta Holding_t$	-0.916	-1.249	-1.353	-1.904	-0.390	-0.448
$\Delta Holding_{t+1}$	-1.008	-1.374	-1.274	-1.793	-0.404	-0.464
$Holding_{t-1}$	73.359		71.075		87.087	
			B: Mutual Funds			
$\Delta Holding_t$	0.376	0.489	0.116	0.153	-0.423	-0.649
$\Delta Holding_{t+1}$	-0.161	-0.209	-0.237	-0.312	-0.390	-0.599
$Holding_{t-1}$	76.882		75.998		65.153	
			C: Pension Funds			
$\Delta Holding_t$	0.285	1.453	0.204	1.126	-0.321	-2.682
$\Delta Holding_{t+1}$	-0.246	-1.254	-0.474	-2.617	-0.309	-2.581
$Holding_{t-1}$	19.621		18.110		11.971	
			D: Dealers			
$\Delta Inventory_t$	0.343	17.599	1.311	76.756	0.254	21.381
$\Delta Inventory_{t+1}$	0.022	1.129	-0.275	-16.101	0.028	2.357
$Inventory_{t-1}$	1.949		1.708		1.188	

Measuring supply shocks during downgrades

	Downgrade (IG)		Fallen Angels		No Rating Change	
	Amount	% Holding	Amount	% Holding	Amount	% Holding
A: Insurance Companies						
$\Delta Holding_t$	-0.916	-1.249	-1.353	-1.904	-0.390	-0.448
$\Delta Holding_{t+1}$	-1.008	-1.374	-1.274	-1.793	-0.404	-0.464
$Holding_{t-1}$	73.359		71.075		87.087	
B: Mutual Funds						
$\Delta Holding_t$	0.376	0.489	0.116	0.153	-0.423	-0.649
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Insurance Co's sell most

Measuring supply shocks during downgrades

	Downgrade (IG)		Fallen Angels		No Rating Change	
	Amount	% Holding	Amount	% Holding	Amount	% Holding
A: Insurance Companies						
$\Delta Holding_t$	-0.916	-1.249	-1.353	-1.904	-0.390	-0.448
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Only dealers intermediate “Fallen Angels”

Measuring supply shocks during downgrades

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	Amount	% Holding	Amount	% Holding	Amount	% Holding
A: Insurance Companies						
$\Delta Holding_t$	-0.916	-1.249	-1.353	-1.904	-0.390	-0.448
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$\Delta Inventory_{t+1}$	0.022	1.129	-0.275	-16.101	0.028	2.357
$Inventory_{t-1}$	1.949		1.708		1.188	

Large position change in percentage

IV regressions: first stage

Dependent variable: $\Delta Inventory$	
$\Delta Holding_t^{FA}$	-0.279***
	(-4.532)
$\Delta Distress$	0.443**
	(2.245)
$\Delta Holding_t^{D}$	0.055
	(0.333)
ΔVIX	-0.003
	(-0.175)
$\Delta Jump$	-11.428*
	(-1.653)
Δr^{10y}	0.571**
	(2.117)
$(\Delta r^{10y})^2$	-0.443**
	(-2.000)
$\Delta slope$	-0.293
	(-1.573)
ret_t^{SP}	6.109***
	(4.519)
Intercept	0.027
	(0.167)
R^2_{adj}	0.372

IV regressions: second stage

Maturity	Rating	$\Delta\widehat{Inventory}_t$	$\Delta Distress_t$
Medium	AA	0.269*	-0.008
		(1.759)	(-0.082)
Medium	A	0.244	0.097
		(1.328)	(0.937)
Medium	BBB	0.246**	0.233***
		(2.130)	(2.804)
Medium	BB	0.691**	0.320*
		(2.445)	(1.799)
Medium	B	0.859***	0.709***
		(3.687)	(4.266)
MP Test		12.574	
Critical Value		[12.374]	

IV REGRESSIONS: SECOND STAGE

Maturity	Rating	$\Delta \widehat{Inventory}_t$	$\Delta Distress_t$
Medium	AA	0.269*	-0.008
		(1.759)	(-0.082)
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Medium	B	0.859***	0.709***
		(3.687)	(4.266)
MP Test		12.574	
Critical Value		[12.374]	

2SLS coefficients 2-3X larger

(consistent with identifying supply shock)

Conclusion

- Collin-Dufresne, Goldstein, and Martin (2001): Corporate bond prices co-move a lot, even after controlling obvious structural factors
    - Largely believed to be a mysterious “liquidity factor”
    - Can the research in the past two decades demystify it?
- We find this statistic-based “liquidity factor” is linked to
    - Intermediary Distress: He, Kelly, and Manela (2017) and Hu, Pan, and Wang (2013)
    - Dealer Inventory: a refined measure of inventory change
- “Supply shocks” extracted from other financial institutions’ holdings
- “Demand shocks” from regulatory changes like Volcker rule (in appendix)