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 **demand** and **supply**

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 53% of PC1; $R^2 = 48\%$ (versus PC1 $R^2 = 82\%$)
    - 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.
    - 5-60bp spread increase for 1SD Distress shock
    - 3-30bp spread increase for 1SD Inventory shock

3. **Interpretation:** intermediary model with margin/capital constraints (Brunnermeier and Pedersen, 2008; Garleanu and Pedersen, 2011).
    - Rationalize findings above.
    - Develop new tests.

Part I

Main Empirical Results

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

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

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

7 structural variables based on Merton (1974):

- firm leverage $Lev_{i,t} :=$ book debt$_{i,t}$/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%	0.055	-0.073
Medium	A	0.331	1.01%	0.089	-0.026
Medium	BBB	0.444	2.09%	0.143	-0.038
Medium	BB	0.607	6.10%	0.237	0.101
Medium	B	0.617	15.93%	0.431	0.061
$\sum_{i=1}^{15} \varepsilon_i^{var}$			112.96		
Pct Explained				0.817	0.056

Common residual variation – goodness of fit

A little higher than CGM for BB, B

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Similar to CGM

Intermediary factors

Inventory:

$\Delta Inventory^A_t := log(Inventory^A_t) - log(Inventory^A_{t-1})$

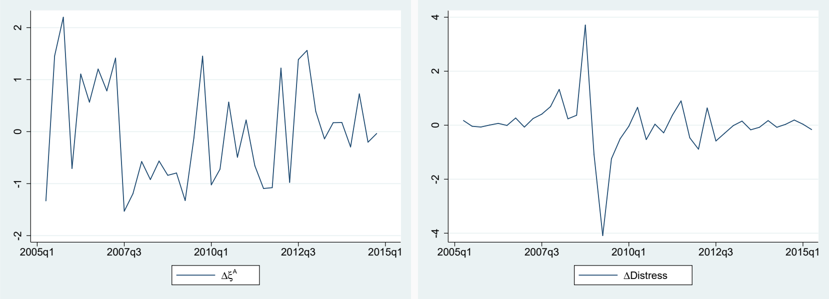
- $Inventory^A_t$ is the par value of cumulative order flows + adjustments for bonds maturing and primary offerings
- Lack of info on initial inventory level. We set $Inventory^A_{2002q3} = 0$ and use the sample after 2005q1 only

Distress:

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

- $\Delta \text{NLev}^{\text{HKM}}_t := (\text{Lev}^{\text{HKM}}_t - \text{Lev}^{\text{HKM}}_{t-1}) \times \text{Lev}^{\text{HKM}}_{t-1}$, 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					
$\Delta Distress$	-0.116	1.000				
$\Delta Noise$	-0.094	0.833***	1.000			
$\Delta \text{NLev}^{\text{HKM}}$	-0.099	0.833***	0.388**	1.000		
ΔVIX	-0.094	0.357***	0.167	0.427***	1.000	
ΔILiq	-0.106	0.228	0.192	0.188	0.381**	1.000

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

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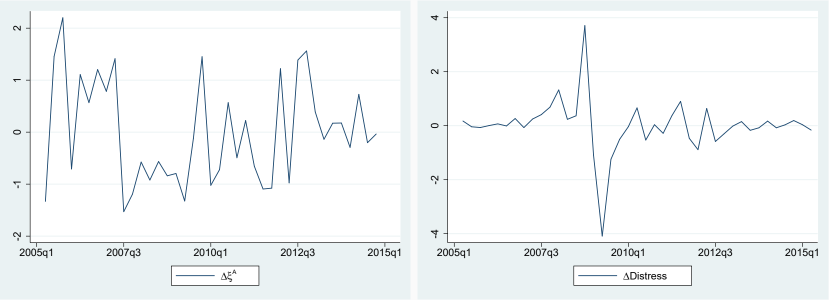

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Two factor structure

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

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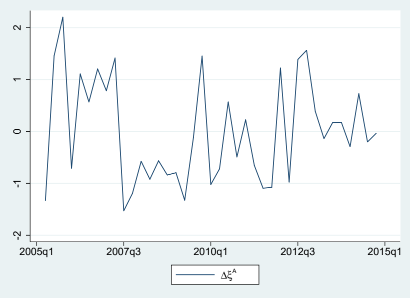

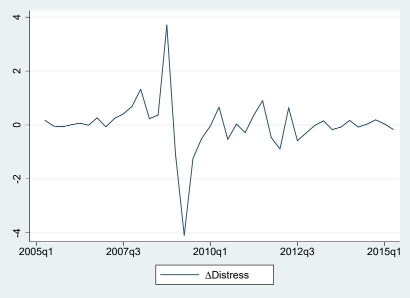

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Low corr with extant liquidity measures

Two intermediary factors explain common variation

Maturity	Rating	$\Delta Inventory^A$	$\Delta Distress$	R^2_{adj}	$\varepsilon_i^{var} / \sum_{i=1}^{15} \varepsilon_i^{var}$	FVE
Medium	AA	0.011	0.048***	0.140	0.58%	0.550
		(0.591)	(3.956)			
Medium	A	0.048**	0.093***	0.342	1.01%	
		(2.132)	(3.661)			
Medium	BBB	0.075**	0.146***	0.410	2.09%	
		(2.543)	(4.030)			
Medium	BB	0.129***	0.251***	0.414	6.10%	
		(3.050)	(5.934)			
Medium	B	0.278***	0.499***	0.647	15.93%	
		(5.455)	(6.477)			
$\sum_{i=1}^{15} \varepsilon_i^{var}$					112.96	
Total						0.482

	PC1	PC2
Pct Explained	0.817	0.056
Corr($\Delta Inventory^A$, PC)	0.286	-0.253
Corr($\Delta Distress$, PC)	0.625	0.321

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Total					Explain about half	0.482

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Monotonic pattern

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1/3 versus 2/3 explanatory power

Robustness checks and other results

- Sorts based on time-to-maturity and firm leverage
- Monthly rather than quarterly
- Separate $\Delta \mathit{Distress}$ into $\Delta \text{NLev}^{\text{HKM}}$ and $\Delta \mathit{Noise}$
- Dollar value $\Delta \mathit{Inventory}$ rather than par value
- Match intermediary factors to trading days used to compute $\Delta cs_{i,t}$
- Control for other factors
    - $\Delta \text{NLev}^{\text{AEM}}$ in Adrian, Etula, and Muir (2014) and $\Delta \mathit{TED}$
    - Pástor and Stambaugh (2003) stock liquidity factor
    - ΔILiq in Dick-Nielsen, Feldhütter, and Lando (2012)
- Exclude 2008 financial crisis
- Only measure inventory of large dealers

Part II

Model

Model setup

Risky assets: (including corporate bonds)

- Cash flows, net of interest, $\delta \sim \text{Normal}(\bar{\delta}, \Sigma)$
- Market clearing: $\theta_H + \theta_I = 0$, where θ_i indicates agent i's demand

Hedgers: (agglomeration of institutional investors)

$$\max_{\theta_H} \mathbb{E}\left[h'\delta + \theta_H \cdot (\delta - p)\right] - \frac{\alpha}{2}\text{Var}\Big[\underbrace{h'\delta}_{\text{random endowment}} + \theta_H \cdot (\delta - p)\Big]$$

where $h = s\bar{h}_{\text{bond}} + \bar{h}_{\text{other}}$ for $\bar{h}_{\text{bond}} \cdot \bar{h}_{\text{other}} = 0$

Intermediaries: (e.g., primary dealers)

$$\max_{\theta_I} \mathbb{E}\left[\theta_I \cdot (\delta - p)\right] \quad \text{s.t.} \quad \underbrace{\theta_I \cdot m \leq w}_{\text{margin-like constraint}}$$

See Brunnermeier and Pedersen (2008) and Garleanu and Pedersen (2011) for other types of margin constraints (e.g., large absolute $|\theta_I|$ penalized).

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Bond "supply shock"

where $h = s\bar{h}_{\text{bond}} + \bar{h}_{\text{other}}$ for $\bar{h}_{\text{bond}} \cdot \bar{h}_{\text{other}} = 0$

Intermediaries: (e.g., primary dealers)

Asset "demand shock"

$$\max_{\theta_I} \mathbb{E}\left[\theta_I \cdot (\delta - p)\right] \quad \text{s.t.} \quad \underbrace{\theta_I \cdot m \leq w}_{\text{margin-like constraint}}$$

See Brunnermeier and Pedersen (2008) and Garleanu and Pedersen (2011) for other types of margin constraints (e.g., large absolute $|\theta_I|$ penalized).

Pricing and shocks

Single-factor model: (like PC1)

$$p = \bar{\delta} - \mu m, \quad \text{where} \quad \mu := \text{multiplier on margin constraint}$$

As μ is unobservable, examine **two underlying shocks**: $\mu = \alpha \frac{(m'h-w)^+}{m'\Sigma^{-1}m}$

$$\begin{aligned} s = & \text{ bond "supply shock" to intermediaries} \\ w = & \text{ asset "demand shock" for intermediaries} \end{aligned}$$

Prices move in proportion with margins (with binding constraints):

$$\begin{aligned} (\text{"Supply Shock"}) \quad & \frac{\partial p}{\partial s} = -\Big(\frac{m'\bar{h}_{\text{bond}}}{m'\Sigma^{-1}m}\Big)\alpha m \\ (\text{"Demand Shock"}) \quad & \frac{\partial p}{\partial w} = \Big(\frac{1}{m'\Sigma^{-1}m}\Big)\alpha m. \end{aligned}$$

Inventory measurement and bond regressions

Inventory and Distress factors:

$$\xi := \log(\theta_I \cdot \mathbf{1}_{\text{bond}}) \quad \text{and} \quad \lambda := w^{-1}$$

Bond regressions with only (s, w) shocks (and binding constraints):

$$\mathrm{d}p = \beta_\xi \mathrm{d}\xi + \beta_\lambda \mathrm{d}\lambda$$
$$\text{where} \quad \beta_\xi^{(i)} / \beta_\xi^{(j)} = \beta_\lambda^{(i)} / \beta_\lambda^{(j)} = m_i / m_j$$

Empirically-measured sensitivities:

$$\hat{\beta}_\xi^{\text{B}} / \hat{\beta}_\xi^{\text{AA}} \approx 10 - 25 \quad \text{and} \quad \hat{\beta}_\lambda^{\text{B}} / \hat{\beta}_\lambda^{\text{AA}} \approx 7 - 15$$
$$\text{not far from} \quad m_{\text{B}} / m_{\text{AA}} = 150\% / 20\% = 7.5 \quad \text{(Basel II)}$$

Part III

Additional Tests

Prediction 1

Placebo test: No patterns if sorting bonds by any characteristic unrelated to margin/capital requirements

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

Prediction 2

Spillovers and Segmentation: Assets (not) traded by corporate bond desks are (not) sensitive to Inventory, in proportion to their margin requirements. All assets are sensitive to Distress.

- Extend model by allowing asset-class-specific constraints:

$$\sum_{a \in \mathcal{A}_1} \theta_{I,a} m_a \leq w_1 \quad \text{and} \quad \sum_{a \in \mathcal{A}_2} \theta_{I,a} m_a \leq w_2 \quad \text{where} \quad w_1 + w_2 = w$$

- 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.

Prediction 3

Supply shocks: Inventory increases partly due to institutional investors' liquidity shocks (like shocks to hedgers' h, thus s).

- 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".
    - **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						
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Insurance Co's sell most

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Only dealers intermediate “Fallen Angels”

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$\Delta Holding_{t+1}$	-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	

Large position change in percentage

IV: SECOND STAGE

Groups		$IVs: \Delta Holding_t^{FA}$ + Insurance $Loss_t$	
Maturity	Rating	$\Delta Inventory_t^A$	$\Delta Distress_t$
Medium	AA	0.305***	-0.058
		(3.093)	(-0.812)
Medium	A	0.266***	0.069
		(2.595)	(0.970)
Medium	BBB	0.237**	0.234***
		(2.421)	(3.760)
Medium	BB	0.657***	0.286**
		(2.712)	(2.192)
Medium	B	0.702***	0.753***
		(3.313)	(6.715)
MP Test		8.343	
Critical Value		[8.044]	

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2SLS coefficients 2-3X larger

(consistent with identifying supply shock)

Prediction 4

Regulation as demand shock: Regulatory tightening raises credit spreads, while simultaneously forcing dealers to reduce inventory and leverage

$\Rightarrow$ sign reversal

- Extend model by adding intermediary holding cost

$$\chi \sum_{a=1}^{A} \theta_{I,a}$$

  Regulatory tightening conceptualized as $\chi \uparrow$

- In 4 quarters around Dodd-Frank (2010q1–2010q4) and Volcker Rule (2013q4–2014q3), spreads mildly positively related to Inventory and Distress

Regulatory tightening: Dodd-Frank and Volcker Rule

$$D_{RegShock,t} = \mathbf{1}\{t \in \text{2010q1–2010q4 or } t \in \text{2013q4–2014q3}\}$$

	AA	A	BBB	BB	B
			B: Medium		
$\Delta Inventory^A$	0.023	0.049**	0.070***	0.163***	0.243***
	(1.295)	(2.303)	(2.620)	(2.682)	(5.071)
$\Delta Inventory^A \times D_{RegShock}$	-0.050	0.073	0.090	-0.429***	-0.189*
	(-0.905)	(1.298)	(0.911)	(-4.550)	(-1.786)
$D_{RegShock}$	0.039	0.015	0.047	-0.012	-0.011
	(0.829)	(0.301)	(0.576)	(-0.187)	(-0.101)
$\Delta Distress$	0.057***	0.102***	0.159***	0.267***	0.532***
	(6.327)	(3.945)	(4.213)	(5.884)	(5.638)
$\Delta Distress \times D_{RegShock}$	-0.428***	-0.278***	-0.406**	-0.835***	-1.696***
	(-5.873)	(-3.052)	(-2.480)	(-5.767)	(-6.246)
R^2_{adj}	0.337	0.471	0.517	0.483	0.697

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Consistent with negative demand 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