Aggregate Risk in the Term Structure of Corporate Credit

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August 22nd, 2022

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Motivation

- **Well-known fact:** credit conditions on the US corporate bond market deteriorate sharply during large crises (e.g. the Global Financial Crisis (2008-09), the Euro Area Sovereign Debt Crisis (2011-12), and the COVID Crisis (2020)).

- **Less well-known fact:** credit conditions in short-term credit markets deteriorate *more* than credit conditions in long-term credit markets, leading to a **flattening of the term structure of credit spreads**

- As corporate bonds are an important source of financing for US firms, this is important for understanding the fall in investment during such crises.

- Understanding the impact of the term structure of credit spreads on firm policies is highly policy relevant, as it sheds light on the effects of recent and novel Fed policies, e.g. the SMCCF.

This Paper

- We use micro data from the US, non-financial corporate credit default swap (CDS) market to rigorously document the flattening of the term structure of credit spreads during crises **at the firm level**.
  - It is more pronounced for riskier firms.
  - It is not driven by liquidity.
  - It is driven by expected default losses, not risk premiums.

- We investigate the importance of the flattening of the term structure for firm investment and financing decisions in a dynamic model with **heterogeneous firms** and aggregate uncertainty.

- Key model ingredients:
  - Firms make endogenous investment, leverage and debt maturity, dividend and default decisions $\Rightarrow$ rich cross-section of firms.
  - Multiple, defaultable debt contracts and risk-averse investors $\Rightarrow$ endogenous term structure of credit spreads with time-varying risk premiums.

Main Results

- The calibrated model can reproduce the flattening of the term structure of CDS spreads. The mechanism is as follows:
  - During good times, short-term debt is **information-insensitive** for most firms.
  - During bad times, short-term debt becomes information-sensitive, especially for risky firms.
  - As **short-run default risk** dominates **long-run default risk** during recessions, the term structure flattens out.

- The flattening of the term structure of credit spreads has important implications for investment:
  - During good times, firms use short-term debt to smooth out negative **liquidity shocks**.
  - During bad times, firms are priced out of short term debt and instead reduce their assets to smooth out negative liquidity shocks.
  - This leads to a **disinvestment-default-spiral**.

Literature

Empirical Papers on Debt Maturity and Credit Spread Risks
Gilchrist and Zakrajsek (2012), Faust, Gilchrist, Wright and Zakrajsek (2013), Xu (2017), Han, Subrahmanyam, and Zhou (2017), Augustin (2018), Mian and Santos (2018), Parise (2018), Chen (2021), Haddad, Moreira, and Muir (2021)

Structural Models of Credit Spreads
Leland (1994), Leland and Toft (1996), Chen (2010), Bhamra, Kuehn, and Strebulaev (2010), He and Xiong (2012), Gourio (2013), Kuehn and Schmid (2014)

Models of Debt Maturity
Diamond (1991), Greenwood, Hanson and Stein (2010), He and Milbradt (2016), Crouzet (2017), Jungherr and Schott (2020, 2021), Chen (2021), Hu, Varas, and Ying (2021)

Our contribution:

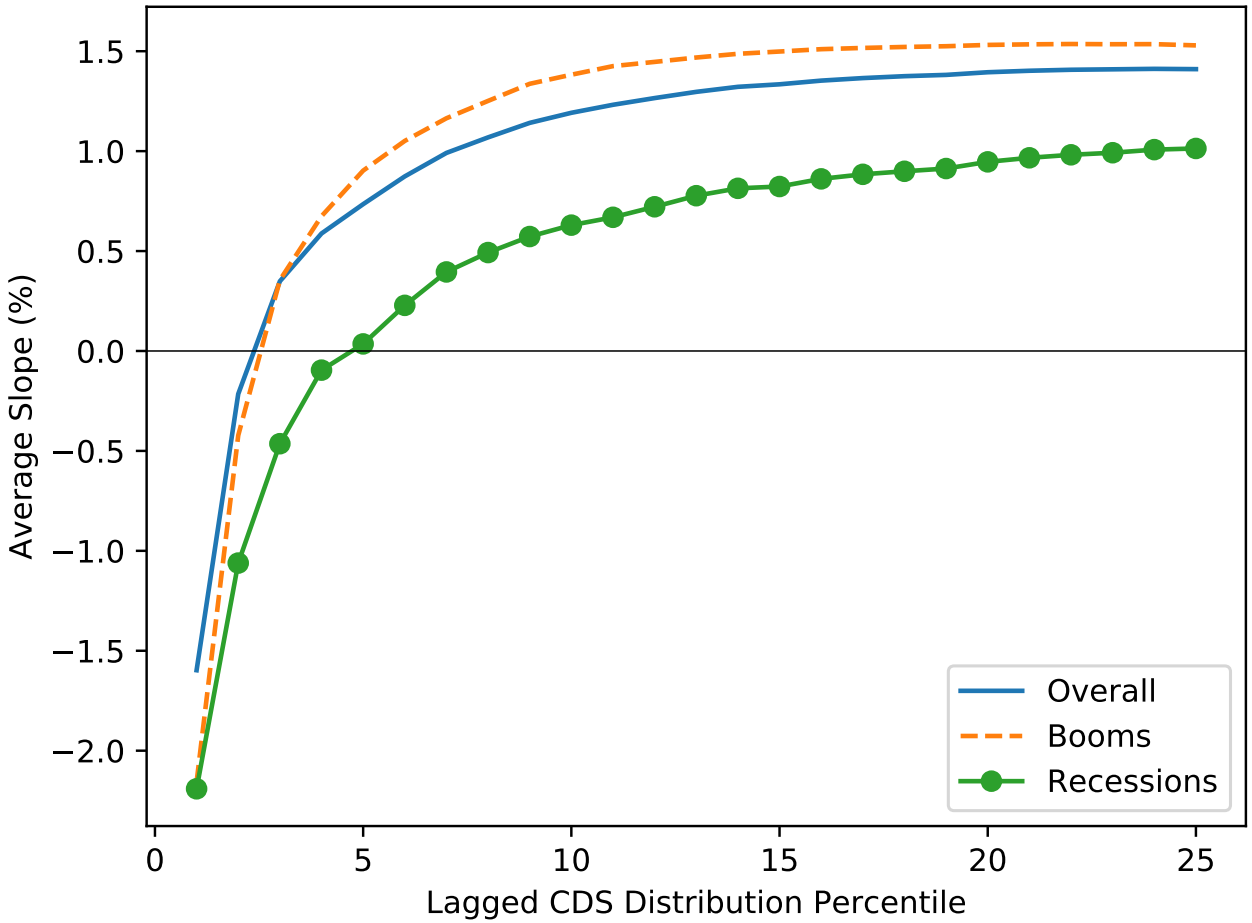
1. We document novel facts about the cyclicality of the term structure of credit spreads.
2. We study the implications of this cyclicality on firm investment and financing decisions in a structural model.

Outline

Data & Sample Selection

- Daily CDS quotes (bid-ask averages) from Markit:
  - U.S., non-financial firms
  - Aggregated to monthly frequency, between January 2001 – January 2021
  - As in Augustin (2018), three maturities of interest (1Y, 5Y, 10Y)
  - We require that all maturities are reported for each firm, such that our results are not driven by selection
- Why credit default swaps, as opposed to corporate bonds?
  - Directly tied to default events of a reference entity and reflective of a risk spread
  - Contract terms are relatively standardized allowing for more direct comparison across maturities (Han et al. (2017))
  - Less susceptible to pricing frictions, related to illiquidity and imperfect information (Bai and Collin-Dufresne (2019))
  - Real-time pricing of information (Lee, Naranjo, and Velioglu (2018))
- CDS data is merged with Compustat and Moody's EDF data, which will factor into our analysis
- Roughly 500 firms per month in the CDS-only sample and $\sim$ 250 in the merged samples

The slope of the term structure of CDS spreads flattens out during recessions - especially for risky firms



▸ Default Probabilities

Firm-level Evidence on the Flattening of the Term Structure

- To establish cyclicality at the firm level, we regress CDS spreads s_{it}^m onto a measure of the business cycle M_t (baseline: industrial production):

$$s_{it}^m = \beta_{i,m} + \beta_M M_t + \sum_{\mathcal{M} \in \{5Y, 10Y\}} \beta_{\mathcal{M}} \left(M_t \times \mathbb{1}_{\{m=\mathcal{M}\}} \right) + \beta_X' X_{i,t-1} + \varepsilon_{it}^m$$

- β_M measures the semi-elasticity of the 1 year spread s_{it}^{1Y} with respect to the business cycle indicator M_t.
- $\beta_{\mathcal{M}}$ measures the difference in the semi-elasticity of the 5 year and 10 year spreads relative to the 1 year spread.
- $X_{i,t-1}$ is a set of firm-level controls variables that control for time-variation in idiosyncratic risk

The Term Structure Flattens Out During Recessions

	(1)	(2)	(3)
$\Delta IndPro$	-0.459***	-0.434***	-0.289***
	(-12.815)	(-12.996)	(-8.032)
$\Delta IndPro \times \mathbb{1}_{\{5Y\}}$	0.050***	0.059***	0.049***
	(6.716)	(7.979)	(5.569)
$\Delta IndPro \times \mathbb{1}_{\{10Y\}}$	0.117***	0.126***	0.106***
	(10.056)	(10.825)	(7.490)
Fixed Effects	Sector × Mat	Firm × Mat	
Compustat Controls	N	N	Y
Obs	352,944	352,863	185,271
R^2	0.047	0.511	0.595

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In the paper, we establish that this pattern

- is driven by expected default losses, not risk premiums.
- is not driven by liquidity.

▸ Other Measures ▸ Recession States

The Flattening of the Term Structure is More Pronounced for Riskier Firms

We sort firms by lagged CDS spreads and run the regression for each subsample.

	(1) Risk Grp 1	(2) Risk Grp 3	(3) Risk Grp 5
$\Delta IndPro$	-0.019***	-0.077***	-1.215***
	(-8.575)	(-8.519)	(-7.568)
$\Delta IndPro \times \mathbb{1}_{\{5Y\}}$	-0.004***	-0.013**	0.269***
	(-2.719)	(-2.294)	(6.460)
$\Delta IndPro \times \mathbb{1}_{\{10Y\}}$	-0.001	0.003	0.477***
	(-0.613)	(0.417)	(7.267)
Fixed Effects		Firm × Mat	
Compustat Controls	Y	Y	Y
Obs	38,208	37,011	35,505
R^2	0.679	0.631	0.560

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In the paper, we establish that this pattern is also driven by expected default losses, not risk premiums.

▶ Other Measures ▶ Recession States

Outline

Firm Problem

The firm maximizes the market value of equity, which depends on the states $\mathcal{S} = (n, b_L, Z)$:

$$v(\mathcal{S}) = \max_{k', b'_L, b'_S, e} \left\{ (1 + \phi 1_{e \leq 0}) e + \mathbb{E} \left[M\left(Z, Z'\right) \times \underbrace{\max\left\{0, v(\mathcal{S}')\right\}}_{\text{Default decision}} \right] \right\},$$

subject to the budget constraint, where endogenous bond prices depend on choices $\mathcal{S}^* = (k', b'_S, b'_L, Z)$,

$$k' - (1-\delta)k = \underbrace{n - (1-\delta)k}_{\text{Internal equity financing}} - \underbrace{e}_{\text{External equity financing}} + \underbrace{\left[Q_S(\mathcal{S}^*) - \xi_S 1_{b'_S > 0}\right] b'_S}_{\text{ST debt financing}} + \underbrace{\left[Q_L(\mathcal{S}^*) - \xi_L 1_{b'_L > (1-\mu) b_L}\right] \left[b'_L - (1-\mu) b_L\right]}_{\text{LT debt financing}}$$

the definition of net worth,

$$n = (1-\tau) \underbrace{\left[Z k^{\alpha} - c(b_S + b_L) - \delta(1+\varepsilon)k - \psi\right]}_{\text{Taxable income}} + (1+\varepsilon)k - b_S - \mu b_L$$

and a leverage constraint,

$$\kappa k' \leq \mathbb{E}\left[M\left(Z, Z'\right) \times \max\left\{0, v(n', b'_L, Z')\right\}\right].$$

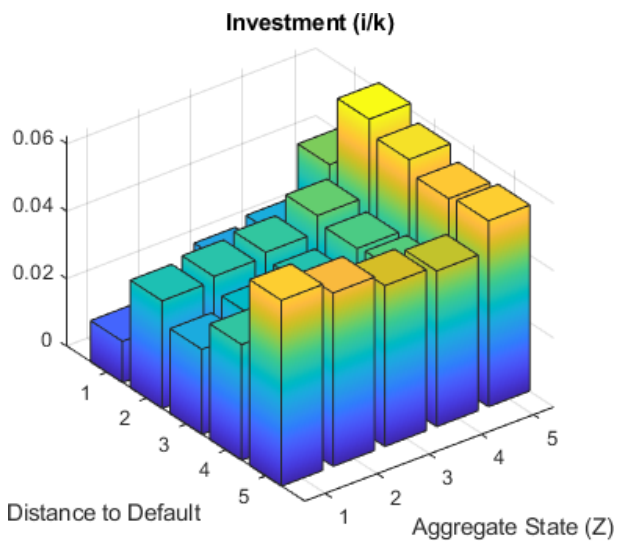
Calibration – Targeted Moments

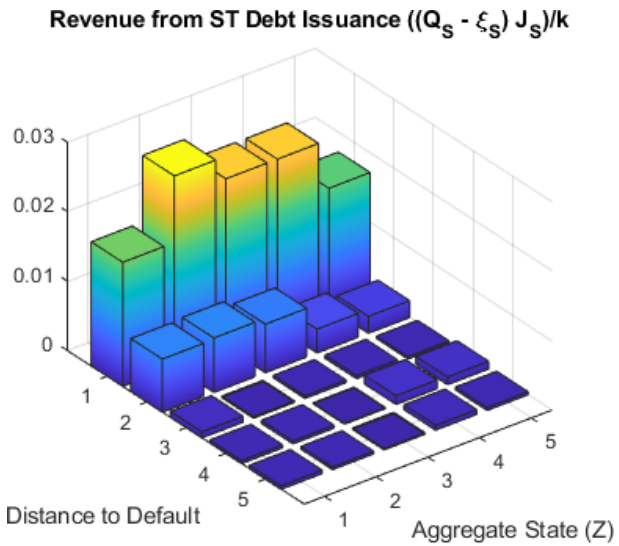
- The model has 16 parameters.
  - 8 of them ($\alpha, \beta, \delta, \tau, \rho^Z, \sigma^Z, \kappa, \chi_Z, \sigma_Z^\varepsilon$) are chosen to match conventional values.
  - The remaining 8 ($\phi, \xi_S, \xi_L, \psi, \bar{\sigma}^\varepsilon, \bar{\chi}, \bar{\gamma}, \gamma_Z$) are chosen to match simulated moments.

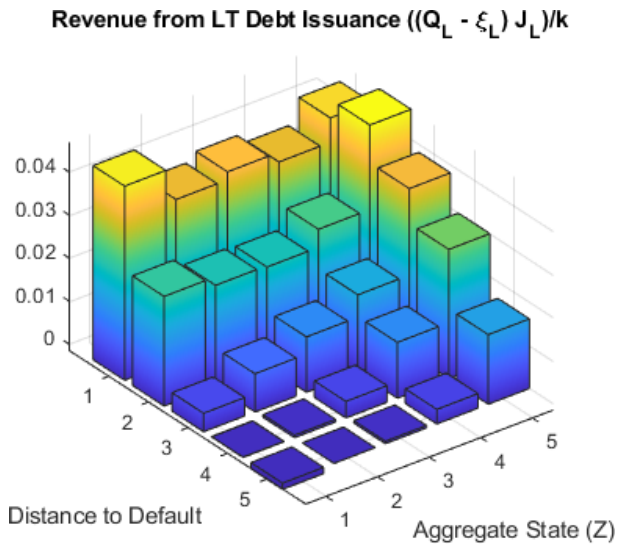
	Value	Role	Target
δ	0.037	depreciation rate	Compustat deprecation rate
α	0.65	returns to scale	Hennessy & Whited (2007)
τ	0.35	corporate tax rate	US corporate tax rate
ρ	0.95	persistence, aggregate shock	Zhang (2005)
σ	0.007	volatility, aggregate shock	Zhang (2005)
β	0.9902	discount rate	4% risk-free rate
χ_1	1.4625	cyclicality, recovery in default	25% decrease in recovery rate in crisis
σ_1^ε	5.25	cyclicality, volatility	25% increase in volatility in crisis

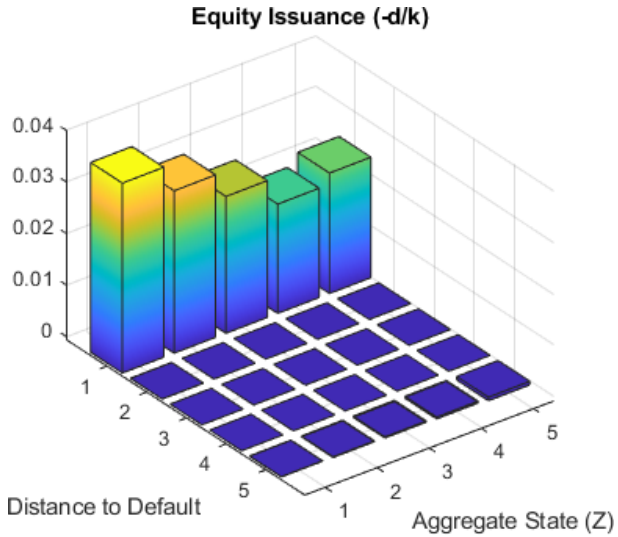
	Value	Role	Target	Data	Model
ϕ	0.18	equity issuance cost	eq issuance, frequency	5.19	6.20
ξ_S	0.0027	ST debt issuance cost	lt debt share, mean	87.18	94.43
ξ_L	0.02	LT debt issuance cost	leverage, mean	32.79	26.61
ψ	36	fixed cost	default rate (1 year)	1.23	0.60
χ_0	0.45	avg. recovery in default	recovery rate, mean	0.41	0.47
σ_0^ε	0.12	volatility, capital quality shock	Volatility, I/K ratio	33.70	39.18
γ_0	20	household sdf	equity risk premium	6.00	2.51

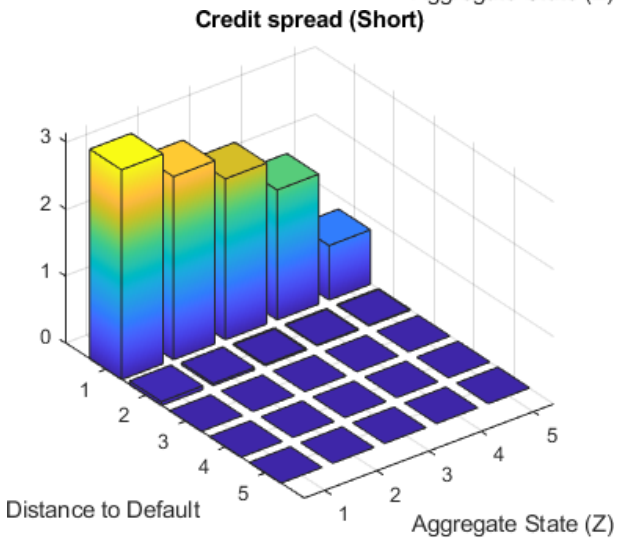
Implications for Firm Policies

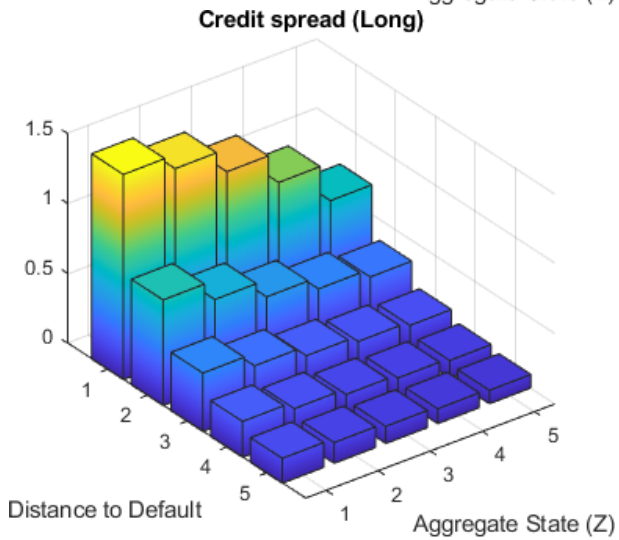






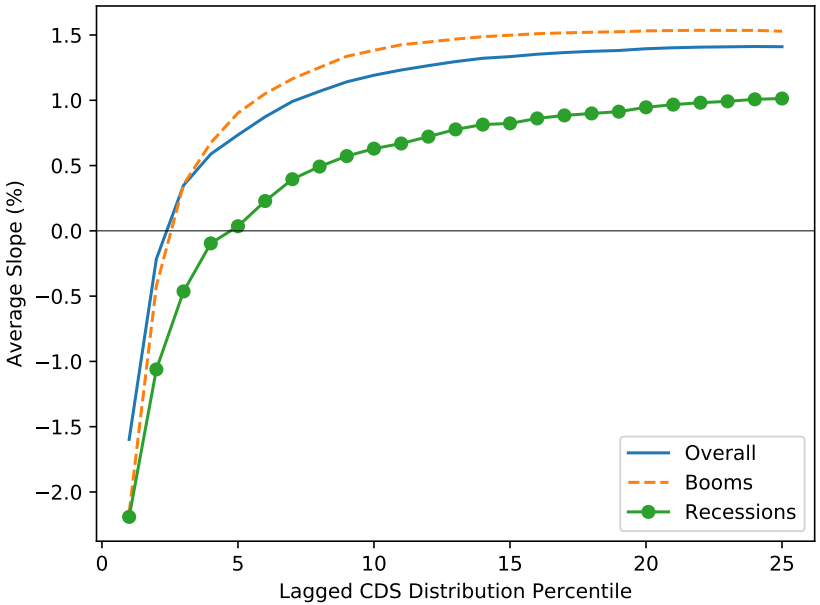


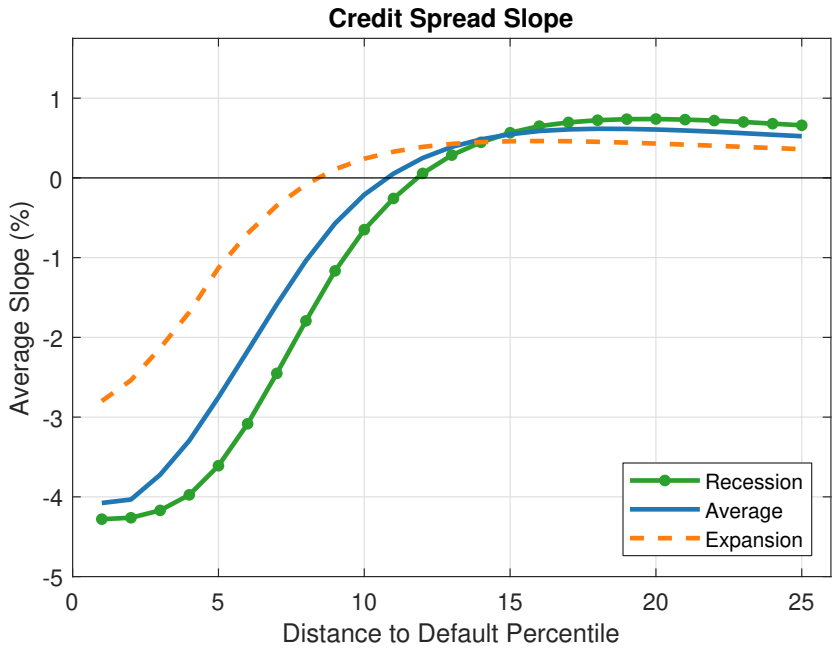




Term Structure Dynamics

Figure: **Credit Spreads Over the Business Cycle**



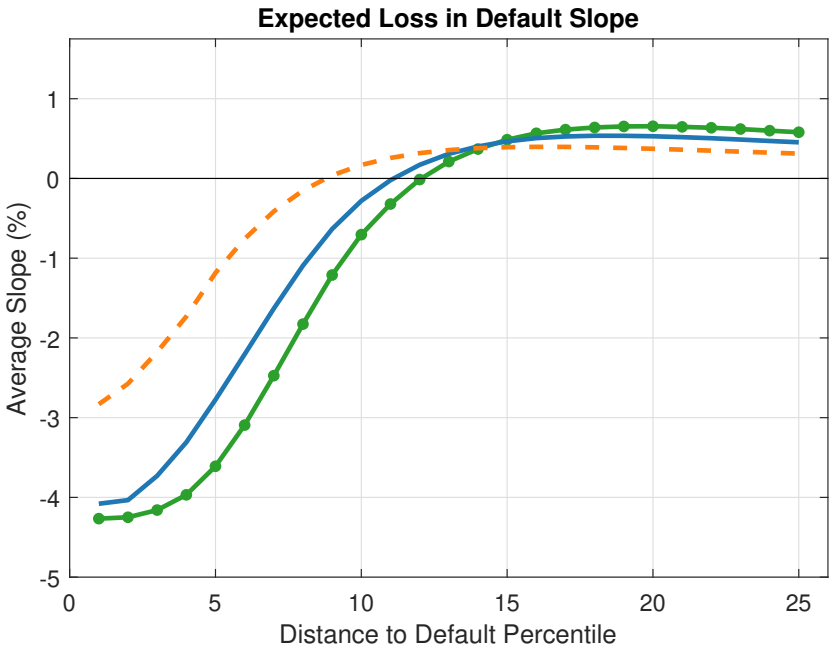


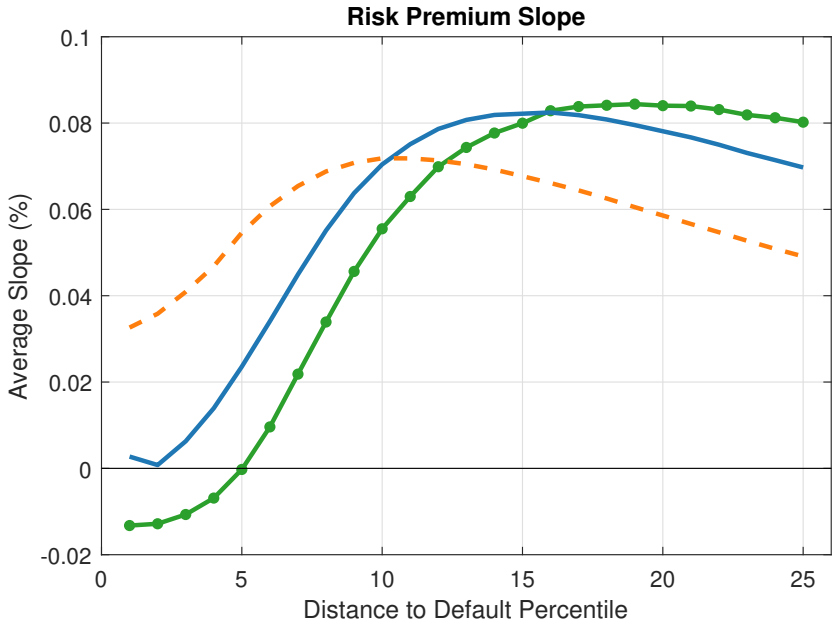
Observations:

- Term structure flips sign for the weakest firms
- Slope becomes increasingly negative, especially in recessions

Dynamics are Driven by Default Losses

Figure: **Credit Spreads Over the Business Cycle: Decomposition**





Counterfactuals

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Credit Spreads				
Credit Spread (1 Quarter)	0.40	0.52	0.41	2.23	0.61	0.40	0.40	0.40
Credit Spread (5 Years)	0.41	0.41	0.30	0.67	0.42	0.32	0.41	0.38
Credit Spread Slope	0.01	-0.11	-0.11	-1.54	-0.19	-0.08	0.00	-0.02
				Default and Recovery Rate				
Default Rate	1.24	1.80	1.04	5.78	1.58	0.81	1.23	1.18
Recovery in Default	0.47	0.52	0.37	0.29	0.43	0.49	0.58	0.46
Cyclicality, Default Rate	-0.76	-0.82	-0.75	-0.86	-0.76	-0.21	-0.76	-0.75
Cyclicality, Recovery Rate	0.75	0.83	0.74	0.78	0.74	0.41	0.47	0.74
				Firm Policies				
Leverage	26.61	22.03	35.52	79.20	37.86	28.65	26.40	27.06
Long-term Debt Share	94.43	41.60	96.00	86.29	73.74	95.82	94.11	94.26

In this table, we compare model solutions under different parameter sets. Model (1) is the baseline. Model (2) is a model where we set the end of period capital stock of the firm to a constant value. Model (3) sets $\gamma_0 = 0$ and $\gamma_1 = 0$, such that investors are risk-neutral. Model (4) removes equity issuance costs ($\phi = 0$), model (5) debt issuance costs ($\xi_S = \xi_L = 0$). Model (6) removes counter-cyclical volatility. Model (7) removes counter-cyclical recovery rates. Model (8) sets $\gamma_1 = 0$, such that risk aversion is constant over the business cycle.

Outline

Conclusion

- Recent crises have highlighted the importance of understanding the impact on disruptions in credit markets on firms.

- In our study, we examine how credit markets evolve across the term structure for heterogeneous firms:
  - The slope of credit spreads becomes increasingly negative for the most vulnerable firms, i.e. those with low net worth and/or high leverage.
  - Short-term spreads become sensitive to aggregate news during recessions, reducing the ability of firms to smooth out liquidity shocks.

- We construct a novel, dynamic model of firm behavior that captures these facts, with aggregate risk, multiple debt maturities, and endogenous investment.

- Among other findings, we show that a weak firm's need for cash, and its inability to invest in rollover crises, leads to a disinvestment-default spiral.