Firm Heterogeneity, Credit Spreads, and Monetary Policy

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Motivation

- Financial frictions can shape the transmission of monetary policy to firms' borrowing and investment decisions.
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  - Strong: constrained firms invest/borrow more.
  - Weak/non-existent: unconstrained firms invest/borrow more.

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- Relative response of constrained vs. unconstrained firms to monetary policy ex ante ambiguous. Depends on strength of financial accelerator:
  - Strong: constrained firms invest/borrow more.
  - Weak/non-existent: unconstrained firms invest/borrow more.
- Quantitative relevance of credit channel is still an open question.

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- Why this disagreement?
  - Evidence so far based on differences in firm-level responses to monetary policy.
  - Focus on *quantities* (sales, investment, output,...) at *quarterly* (or even lower) frequency.

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  - Focus on *quantities* (sales, investment, output,...) at *quarterly* (or even lower) frequency.
- This paper:
  - Constructs a new, highly granular, daily bond-level data set to study the *high frequency* effects of monetary policy on firms' *credit spreads*.
  - More testable implications, more credible identification, more precise estimates.

What we do & Main findings

- **Daily firm-level event study** High frequency effects of monetary policy on credit spreads.
  - Surprise tightening in monetary policy leads to an aggregate increase in credit spreads.
  - Firms with high leverage are more responsive to monetary surprises.

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  - Persistent increase in spreads and contraction in volumes at aggregate level.
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- **Interpretation** Strong role for the financial accelerator and the credit view of monetary policy.

Literature

- **Credit view of monetary policy and financial accelerator**

  [Bernanke and Blinder (1992); Bernanke and Gertler (1989); Bernanke and Gertler (1995); Kashyap, Lamont and Stein (1994); Gertler and Gilchrist (1994); Kashyap and Stein (1995); Bernanke, Gertler, and Gilchrist (1999); Kashyap and Stein (2000), Gertler and Kiyotaki (2010); Gertler and Karadi (2011); Chari, Christiano and Kehoe (2013); Gertler and Karadi (2015)]

- **Heterogeneous impact of monetary policy across firms**

  * Focus on quantities (output, investment, employment): Crouzet and Mehrotra (2017); Ottonello and Winberry (2018); Cloyne, Ferreira, Fromel, Surico (2018); Bahaj, Foulis, Pinter, Surico (2018); Jeenas (2018).

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  * Focus on stock prices: Ippolito, Ozdagli and Perez-Orive (2018); Ozdagli (2018).
  * Focus on credit spreads: **This paper**!

Outline

[1] Model & Predictions

[2] Data sources

[3] Empirics

* High frequency event study
* Macro evidence

[4] Channels of transmission

A Simple Model

A stylized model of the credit channel

- Simple static framework to fix ideas based on Bernanke, Gertler, and Gilchrist (1999).

- Agents:
  - Many risk neutral entrepreneurs (firms).
  - Competitive risk neutral lender.

- Entrepreneurs differ in their level of net worth and have access to a risky project that requires funding.

- The relationship between lender and borrower is subject to agency costs a la Townsend (1979) (costly state verification)

Skip details

Environment

- Entrepreneur has access to a project with expected gross return $\mathbb{E}[\omega]R^k$.
  - Idiosyncratic shock $\omega \sim \log \mathcal{N}(1, \sigma^2)$ (private info)
  - Aggregate return to capital R^k is taken as given.

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- Project finance
  - Entrepreneur has limited net worth N (equity finance).
  - Capital expenditure QK is financed with a mix of net worth N and debt B:

$$QK = N + B.$$

  - Debt is supplied by risk neutral lender at rate R^L (more on this below).

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- Limited liability
  - If revenues cannot cover debt repayments (i.e., for bad realizations of ω), Entrepreneur goes bankrupt.

Environment (cont'd)

- Competitive risk neutral lender
  - Participation constraint $\Rightarrow$ Expected return on lending equals the gross funding cost R.
  - Offers a menu of loan contracts (R^L, B).
  - In case of bankruptcy, must pay a monitoring cost μ to observe entrepreneur returns and seize them.

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- Payoff structure:

	Entrepreneur's Payoff	Bank's payoff
$\omega R^k K \geq R^L B$	$\omega R^k K - R^L B$	$R^L B$
$\omega R^k K < R^L B$	0	$(1-\mu)\omega R^k K$

Entrepreneur's decision problem

- Entrepreneur's maximization of shareholder value:

$$V = \max_{K,B} \frac{1}{R} \mathbb{E} \left(\omega R^k QK - R^L B \right)^+$$

subject to lender's zero profit condition and balance sheet constraint:

$$\begin{aligned} RB &= \mathbb{I}_{\{\omega R^k QK \geq R^L B\}} R^L B + \mathbb{I}_{\{\omega R^k QK < R^L B\}} (1-\mu) \omega R^k QK \\ K &= N + B \end{aligned}$$

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- **Credit (capital) supply schedule**:

$$EFP \equiv \frac{R^k}{R} = f\left(\frac{QK}{N}\right) \quad f(1) = 1,\ f'(\cdot) > 0,\ f''(\cdot) > 0$$

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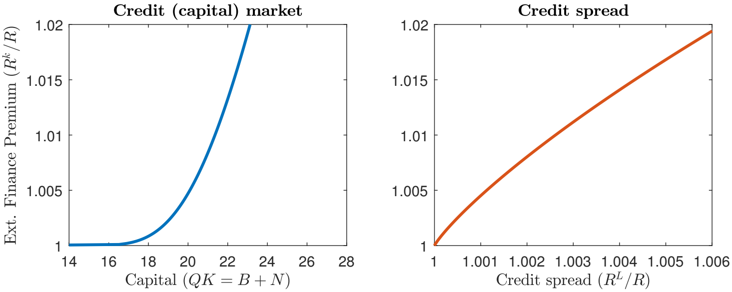
and credit spread

$$CS \equiv \frac{R^L}{R} = g\left(\frac{R^k}{R}\right) \qquad g(1) = 1,\ g'(\cdot) > 0,\ g''(\cdot) > 0$$

Credit (Capital) supply



- Supply curve is flat (with $EFP = 1$) when capital expenditures QK can be financed entirely with net worth N.
- When external finance B is necessary, the supply curve becomes upward sloping.

Credit (Capital) demand

- In general equilibrium, after (aggregate and idiosyncratic) shocks realize, Entrepreneur:
  - Rents capital in a competitive rental market for rental rate $z = MPK$.
  - Sells undepreciated capital $\omega K(1-\delta)$ at new price Q' after goods production.

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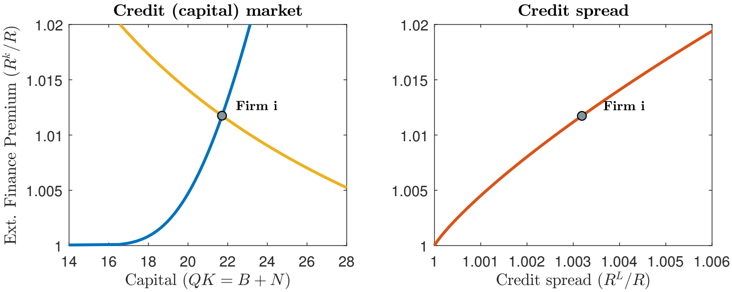
- **Credit (capital) demand schedule**

$$\frac{R^k}{R} = \frac{1}{R}\left(\alpha K_t^{\alpha-1} + \frac{Q'(1-\delta)}{Q}\right)$$

(rescaled by R)

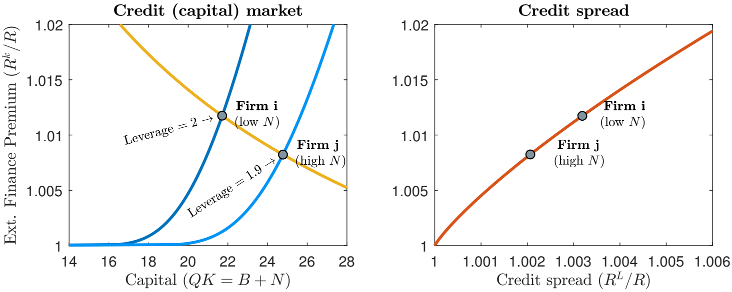
(assume fixed labor supply for simplicity, so that $MPK = \alpha K_t^{\alpha-1}$)

Credit (Capital) market equilibrium



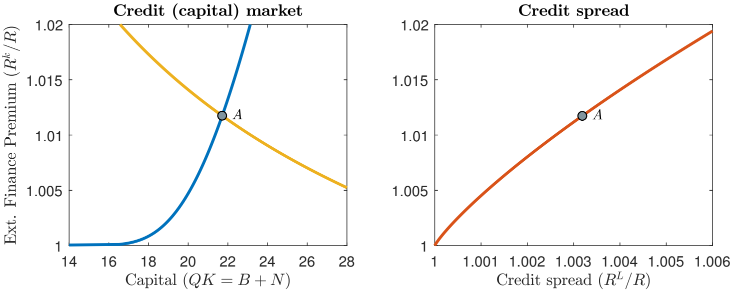
- Firm i has low net worth N and needs external finance for desired capital expenditure. Equilibrium lies in the region where $EFP > 1$.

Credit (Capital) market equilibrium: Heterogeneity



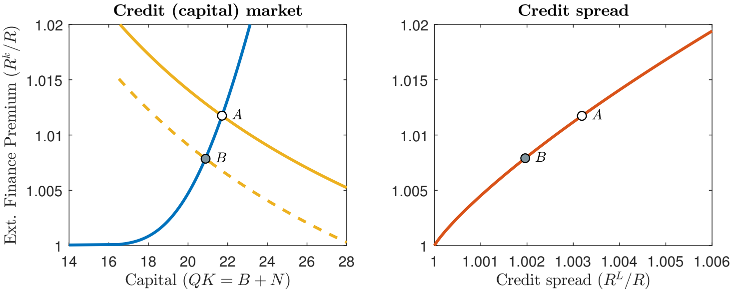
- Firm *j* has higher net worth *N* than firm *i*. Equilibrium lies where supply curve is less steep.
  - ✱ ↓ Borrowing (leverage) ⇒ ↓ Default probability ⇒ ↓ Credit spread.

Credit (Capital) market equilibrium



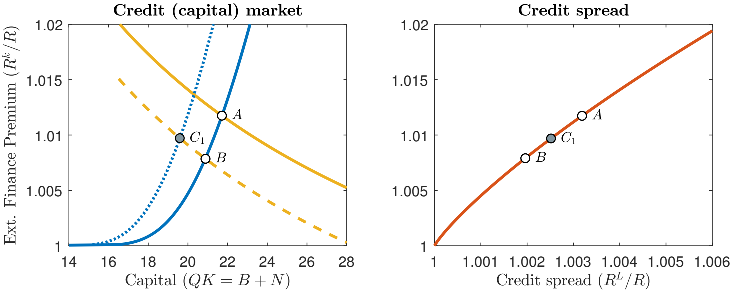
- **Next** Consider equilibrium (A) for a given firm. What are the implications of an unexpected monetary policy shock ($R \uparrow$)?

Monetary policy tightening: Credit demand



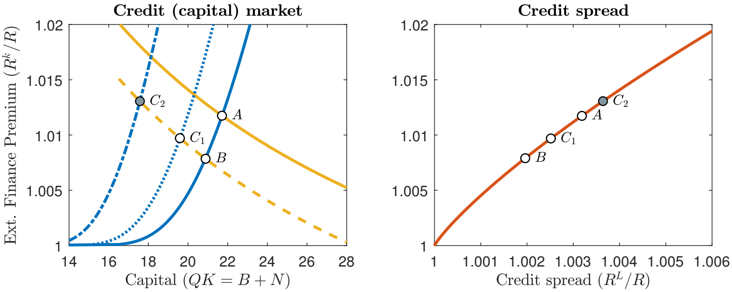
- Unanticipated mon. policy shock $(R\uparrow)$ depresses the demand for capital and its price (Q') $\Rightarrow$ Credit demand curve *shifts*.
- Lower discounted return on capital:
  - ✱ $\downarrow$ Borrowing (leverage) $\Rightarrow\downarrow$ Default probability $\Rightarrow\downarrow$ Credit spread.

Monetary policy tightening: The credit channel



- Fall in price of capital Q' induces a capital loss and reduces entrepreneurial net worth $N \Rightarrow$ Supply curve *shifts and tilts*.
- Lower net worth:
  - ∗ $\uparrow$ Default probability $\Rightarrow \uparrow$ Credit spread $\Rightarrow \downarrow$ Borrowing (leverage).

Monetary policy tightening: The credit channel



- Fall in price of capital Q' induces capital loss and reduces entrepreneurial net worth $N \Rightarrow$ Supply curve shifts *and tilts*.
- Strength of the credit channel is *a priori* ambiguous.
  - If the effect is strong enough, credit spreads eventually increase.

Model implications

- Aggregate response to a monetary policy tightening:
  - Credit spread response is ambiguous.
    - Strong financial accelerator: $\partial CS/\partial R > 0$.
    - Weak financial accelerator: $\partial CS/\partial R < 0$.
  - Borrowing falls ($\partial B/\partial R < 0$), irrespective of strength of financial accelerator.

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- Cross-sectional response to a monetary policy tightening (with strong financial accelerator):
  - The higher leverage, the stronger the increase in credit spread ($\partial CS/\partial R\partial L > 0$).
  - The higher leverage, the stronger the contraction in borrowing ($\partial B/\partial R\partial L < 0$).

  (because of tilting of $f(\cdot)$ & convexity of $f(\cdot)$ and $g(\cdot)$)

Data Sources

Exogenous variation in monetary policy

- High-frequency monetary policy surprises ϵ_t^m [Gurkaynak et al. (2005)].

- **Event study approach** Change in interest rate futures contracts (f), with a window of $a + b$ minutes around FOMC announcement time (t):

$$\epsilon_t^m = f_{t+a} - f_{t-b}$$

  where:

  * Window size: 30 minutes, $a = 20$ and $b = 10$.
  * Assumption: only monetary news affects ϵ_t^m in 30-minute window.

- Baseline: 9-month ahead Euro-Dollar futures (robust to using other contracts).

More info on MP surprises

Bond-level data

- Bond data from Bank of America Merrill Lynch (BAML) Global Index System.
  - Corporate bonds traded in the secondary market.
  - Constituents of Global Corporate Index (G0BC) and the Global High Yield Index (HW00).

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- Main variable of interest: Option Adjusted Spread (OAS). Two key features:
  [1] *Maturity matching*: Spreads are computed relative to a risk-free security that replicates the cash-flows of the corporate debt instrument.
  [2] *Option adjustment*: Most bonds are callable, OAS is adjusted for call optionality.

OAS Details

Bond-level data: Option adjusted spreads

- Sample period and coverage:
  - Sample period: Jan 1997 – Mar 2015.
  - Flow of new issuance (in 2014): 495 bn USD ($\sim 70\%$ of the market).
- Data treatment:
  - Drop if amount issued < 1 M$.
  - Drop if maturity < 1 and > 30 years.
  - Drop if spread > 2500 bps.
  - Focus on non-financial, senior, unsecured bonds issued in domestic currency.

Summary Statistics

Matching bond data with firm-level information

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  - Source: Center for Research in Security Prices (CRSP).
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- Balance sheets:
  - Match quarterly balance sheet data for listed firms within our bond panel.
  - Source: Compustat.
  - Variables: Totals assets, total debt, sales, cash flow, etc.

Final event study data set

- Merge all bond and firm information in an ‘event study’ data set around scheduled FOMC announcement days.
  - t is a monetary policy announcement date.
  - Download all available bond data at t.
  - Keep all bonds for which we could match equity price and balance sheet data.

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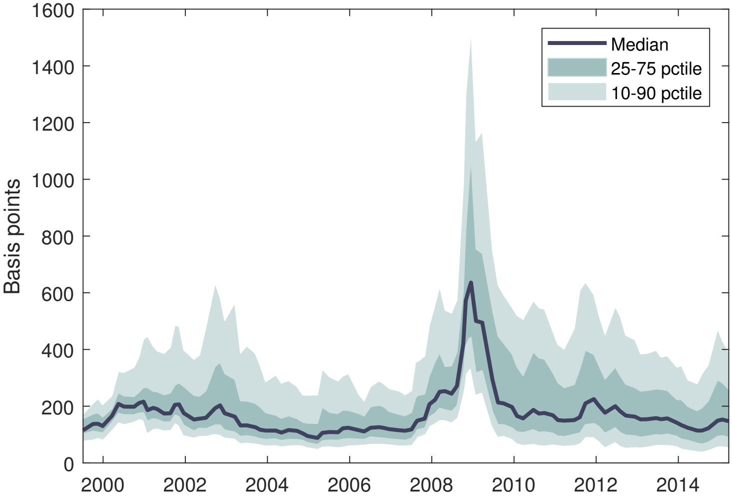
- Resulting data set
  - Sample period: Jan 1999 – Mar 2015.
  - No. of FOMC announcements: 127
  - No. of bonds: $7,081$.
  - No. of companies: $1,009$.
  - No. of observations: $191,635$.

Final data set: Corporate bond spreads



Empirics

High frequency event study

Methodology: Preliminaries

- Event study panel OLS specification:

$$\Delta s_{it} = \alpha_i + \beta \epsilon_t^m + e_{it}$$

where:

  * Δs_{it}: change in spread of bond i on FOMC announcement day.
  * ϵ_t^m: monetary policy surprise on FOMC announcement day.
  * β (rescaled): response of spreads to a monetary surprise that increases the 1-year T-bill by 25 bps.

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  where:

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  * ϵ_t^m: monetary policy surprise on FOMC announcement day.
  * β (rescaled): response of spreads to a monetary surprise that increases the 1-year T-bill by 25 bps.

- Note: Consider a 5-day change in spreads ($s_{i,t+5} - s_{i,t-1}$).
  * Corporate bond markets are less liquid than equities or government bonds [Gertler and Karadi (2015)].

Credit spreads response to monetary policy surprises

Dep. Variable: spread (Δs_i)	(1)
Source	BAML
MP surprise (ϵ^m)	19.86***
	(1.33)
R-squared	0.004
Obs.	191,635

- Positive aggregate response of credit spreads to monetary policy surprises $\Rightarrow$ Consistent with strong role for financial accelerator.
- Result quantitatively in line with VAR analysis in Gertler and Karadi (2015).

Additional results

Understanding aggregate results: Firm Heterogeneity

- Does monetary policy work in a heterogeneous fashion across firms?
- We focus on leverage as our main measure of firm balance sheet position.
  - Theoretically linked to the cost of external finance and borrowing/investment decisions.

Understanding aggregate results: Firm Heterogeneity

- Does monetary policy work in a heterogeneous fashion across firms?
- We focus on leverage as our main measure of firm balance sheet position.
  - Theoretically linked to the cost of external finance and borrowing/investment decisions.
- Notation:
  - $\Delta s_{ij,t}$: change in the spread of bond i, issued by firm j, on FOMC announcement day t.
  - L_{jt}: firm j's leverage in the quarter that belongs to day t, computed as:

$$L_{jt} = \frac{\text{Total Debt}_{jt}}{\text{Assets}_{jt}}$$

More on leverage definition

Heterogeneity in the data

	Low Leverage (below median)				
	Mean	SD	P25	Median	P75
Firm Total Assets ($M)	53,313	65,223	10,242	29,086	62,772
Firm Age (years)	36	13	25	41	48
Firm Credit Rating			A2	BBB1	BBB2
Firm Hadlock-Pearce Constraint	-4.2	0.4	-4.5	-4.4	-3.9
Bond Spread (basis points)	185	179	91	138	215
Bond Amount Issued ($M)	622	491	300	500	750
Total Observations	95,687				

	High Leverage (above median)				
	Mean	SD	P25	Median	P75
Firm Total Assets ($M)	27,388	42,231	6,827	15,772	34,701
Firm Age (years)	32	16	17	34	47
Firm Credit Rating			BBB1	BBB2	BB2
Firm Hadlock-Pearce Constraint	-4.2	0.4	-4.5	-4.3	-3.8
Bond Spread (basis points)	286	280	119	200	362
Bond Amount Issued ($M)	537	466	300	400	600
Total Observations	96,169				

Continuous leverage interaction

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta\epsilon_t^m + \gamma\left(\epsilon_t^m L_{j,t-1}\right) + \delta L_{j,t-1} + e_{ij,t}$.
- L_j is the (standardized) leverage of firm j.

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- L_j is the (standardized) leverage of firm j.

Dep. Variable: spread (Δs_{ij})	(1)	(2)
	Baseline	Leverage continuous
MP surprise (ϵ^m)	19.86***	19.74***
	(2.56)	(2.58)
MP surprise x Lev. ($\epsilon^m \times L_j$)		10.90***
		(2.80)
R-squared	0.041	0.053
Observations	191,409	191,409

Leverage quartile dummies

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_1 \left(\epsilon_t^m \ell_{j,t-1}^1\right) + ... + \beta_4 \left(\epsilon_t^m \ell_{j,t-1}^4\right) + e_{ij,t}$
- $\ell_j^k = 1$ when leverage of firm j's leverage is in the k^{th} quartile of the leverage distribution (and zero otherwise).

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Dep. Variable: spread (Δs_{ij})	(1)	(2)
	Baseline	Leverage quartile
MP surprise (ϵ^m)	19.86***	
	(2.56)	
MP surprise x Lev. Q1 ($\epsilon^m \times \ell_j^1$)		3.95
		(3.06)
MP surprise x Lev. Q2 ($\epsilon^m \times \ell_j^2$)		21.59***
		(4.26)
MP surprise x Lev. Q3 ($\epsilon^m \times \ell_j^3$)		17.97***
		(5.65)
MP surprise x Lev. Q4 ($\epsilon^m \times \ell_j^4$)		35.51***
		(6.16)
R-squared	0.041	0.042
Observations	191,409	191,409

High leverage dummy

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_1 \left(\epsilon_t^m \ell_{j,t-1}^{Low} \right) + \beta_2 \left(\epsilon_t^m \ell_{j,t-1}^{High} \right) + e_{ij,t}$.
- $\ell_{j,t-1}^{High} = 1$ when firm j's leverage lies in quartile $k > 1$ of the leverage distribution (and zero otherwise). $\ell_{j,t-1}^{Low} = 1$ when $k = 1$.

High leverage dummy

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_1 \left(\epsilon_t^m \ell_{j,t-1}^{Low} \right) + \beta_2 \left(\epsilon_t^m \ell_{j,t-1}^{High} \right) + e_{ij,t}$.
- $\ell_{j,t-1}^{High} = 1$ when firm j's leverage lies in quartile $k > 1$ of the leverage distribution (and zero otherwise). $\ell_{j,t-1}^{Low} = 1$ when $k = 1$.

Dep. Variable: spread (Δs_{ij})	(1)	(2)
	Baseline	High Leverage
MP surprise (ϵ^m)	19.86***	
	(2.56)	
MP surprise x Low Lev. ($\epsilon^m \times \ell_j^{Low}$)		3.97
		(3.05)
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)		24.75***
		(3.20)
R-squared	0.041	0.042
Observations	191,409	191,409

Robustness #1: Sectoral differences

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_{s,t} + \gamma \left(\epsilon_t^m \ell_{j,t-1}^{High} \right) + \delta \ell_{j,t-1}^{High} + e_{ij,t}$.
- Leverage might be correlated with sectors.
- Add time-industry (3-digit level) fixed effects ($\beta_{s,t}$).

Robustness #1: Sectoral differences

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_{s,t} + \gamma \left(\epsilon_t^m \ell_{j,t-1}^{High} \right) + \delta \ell_{j,t-1}^{High} + e_{ij,t}$.
- Leverage might be correlated with sectors.
- Add time-industry (3-digit level) fixed effects ($\beta_{s,t}$).

Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)
	Time-Sector FE	Time-Sector FE & Controls	Time-Sector FE & Two-way clust.
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)	19.98***	19.19***	19.98**
	(4.55)	(4.66)	(7.96)
R-squared	0.198	0.192	0.198
Observations	191,403	179,551	191,403

Robustness #2: Omitted variables

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_{s,t} + \gamma \left(\epsilon_t^m \ell_{j,t-1}^{High} \right) + \delta \ell_{j,t-1}^{High} + \Gamma \mathbf{X}_{jt} + e_{ij,t}$.
- Add firm specific controls $\mathbf{X}_{jt}$.
- $\mathbf{X}_{jt}$ includes size, age, credit ratings, sales growth.

Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)
	Time-Sector FE	Time-Sector FE & Controls	Time-Sector FE & Two-way clust.
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)	19.98***	19.19***	19.98**
	(4.55)	(4.66)	(7.96)
R-squared	0.198	0.192	0.198
Observations	191,403	179,551	191,403

Robustness #3: Double clustering

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_{s,t} + \gamma \left(\epsilon_t^m \ell_{j,t-1}^{High} \right) + \delta \ell_{j,t-1}^{High} + e_{ij,t}$.
- Allow for both cross-sectional and temporal dependence in the residuals.
- Cluster standard errors by firm-time.

Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)
	Time-Sector FE	Time-Sector FE & Controls	Time-Sector FE & Two-way clust.
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)	19.98***	19.19***	19.98**
	(4.55)	(4.66)	(7.96)
R-squared	0.198	0.192	0.198
Observations	191,403	179,551	191,403

Robustness #4: Within firm leverage

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_{s,t} + \gamma \left(\epsilon_t^m \tilde{\ell}_{j,t-1}^{High} \right) + \delta \tilde{\ell}_{j,t-1}^{High} + e_{ij,t}$.
- Control for permanent differences in leverage $\Rightarrow$ Compute *within-firm* variation in leverage.
- $\tilde{\ell}_{j_{j,t-1}}^{High}$ is now based on demeaned firm leverage.

Robustness #4: Within firm leverage

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- Control for permanent differences in leverage $\Rightarrow$ Compute *within-firm* variation in leverage.
- $\tilde{\ell}_{j_{j,t-1}}^{High}$ is now based on demeaned firm leverage.

Dep. Variable: spread (Δs_{ij})	(4)	(5)	(6)
	Time-Sector FE & Within Leverage	Time-Sector FE & IV	Time-Sector FE & Pre-crisis
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)			8.94***
			(2.59)
MP surprise x High Lev. ($\epsilon^m \times \tilde{\ell}_j^{High}$)	15.26***		
	(4.62)		
1yr Rate x High Lev. ($\epsilon^m \times \ell_j^{High}$)		19.21***	
		(4.43)	
R-squared	0.197	0.192	0.228
Observations	191,403	191,403	49,243

Robustness #5: Instrumental variable

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_{s,t} + \gamma \left(\Delta i_t \ell_{j,t-1}^{High} \right) + \delta \ell_{j,t-1}^{High} + e_{ij,t}$.
- Allow for noise in the monetary policy surprise $\Rightarrow$ Instrumental variable estimation.
- One-year rate (Δi_t) instrumented with ϵ_t^m.

Dep. Variable: spread (Δs_{ij})	(4)	(5)	(6)
	Time-Sector FE & Within Leverage	Time-Sector FE & IV	Time-Sector FE & Pre-crisis
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)			8.94***
			(2.59)
MP surprise x High Lev. ($\epsilon^m \times \tilde{\ell}_j^{High}$)	15.26***		
	(4.62)		
1yr Rate x High Lev. ($\epsilon^m \times \ell_j^{High}$)		19.21***	
		(4.43)	
R-squared	0.197	0.192	0.228
Observations	191,403	191,403	49,243

Robustness #6: Pre-crisis

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_{s,t} + \gamma \left(\epsilon_t^m \ell_{j,t-1}^{High} \right) + \delta \ell_{j,t-1}^{High} + \Gamma \mathbf{X}_{jt} + e_{ij,t}$.
- Pre-crisis sample $\Rightarrow$ Drop observations from January 2008

Dep. Variable: spread (Δs_{ij})	(4)	(5)	(6)
	Time-Sector FE & Within Leverage	Time-Sector FE & IV	Time-Sector FE & Pre-crisis
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)			8.94***
			(2.59)
MP surprise x High Lev. ($\epsilon^m \times \tilde{\ell}_j^{High}$)	15.26***		
	(4.62)		
1yr Rate x High Lev. ($\epsilon^m \times \ell_j^{High}$)		19.21***	
		(4.43)	
R-squared	0.197	0.192	0.228
Observations	191,403	191,403	49,243

Robustness #7: Double Sorting

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_{s,t} + \gamma\left(\epsilon_t^m \ell_{j,t-1}^{High}\right) + \delta\left(\epsilon_t^m z_{j,t-1}^{High}\right) + \Gamma \mathbf{X}_{jt} + e_{ij,t}$.
- Double sort by other firms characteristics $Z_{j,t-1}$.

Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)	(5)
	Leverage	Size	Sales Growth	Credit Rating	Time since IPO
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)	19.98***	19.51***	20.25***	14.52***	19.69***
	(4.55)	(4.60)	(4.56)	(4.73)	(4.57)
MP surprise x Size ($\epsilon^m \times z_i^{High}$)		3.74			
		(6.04)			
MP surprise x Sales growth ($\epsilon^m \times z_i^{High}$)			-7.61*		
			(4.57)		
MP surprise x Credit rating ($\epsilon^m \times z_i^{High}$)				-22.35***	
				(6.42)	
MP surprise x Age ($\epsilon^m \times z_i^{High}$)					14.32**
					(5.84)
R-squared	0.1975	0.1976	0.1978	0.1985	0.1976
Observations	191,403	191,403	191,095	191,403	191,403

Empirics

Quarterly local projections

Macro evidence: Real effects and persistence at business cycle frequency

- Focus so far: *high frequency* response of credit spreads.
  - Better identification, more precise estimates.

- **Concern** Estimated impact of monetary policy on spreads could be driven by transitory adjustment in prices (e.g., liquidity/trading frictions).

Macro evidence: Real effects and persistence at business cycle frequency

- Focus so far: *high frequency* response of credit spreads.
  - Better identification, more precise estimates.

- **Concern** Estimated impact of monetary policy on spreads could be driven by transitory adjustment in prices (e.g., liquidity/trading frictions).

- Additional questions:
  - Are the effects of monetary policy persistent?
  - Does monetary policy also affect credit volumes?
  - Are the cross-sectional patterns consistent with the high frequency evidence?

Bond issuance by leverage quartiles

- BAML data set also includes information on bond issuances.
  - Notation: $B_{ij,t}$ is the dollar amount associated with bond i, issued by firm j, on day t.

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Bond issuance by leverage quartiles

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  - Notation: $B_{ij,t}$ is the dollar amount associated with bond i, issued by firm j, on day t.
- But issuances at individual firm level are rare.
  - Avg. number of bonds issued per firm over 1997-2015 period is ~ 7 (lots of zeros).
- Compute *aggregate* series of real bond issuance by leverage quartile and quarter. Namely:
  1. Sort firms into leverage quartiles $k = 1, 2, 3, 4$.
  2. Sum issuances of firms belonging to a given leverage quartile k within a quarter τ:
  $$B_{k\tau} = \sum_t \sum_j B_{ij,t} \quad \text{for all } j \in k \text{ and } t \in \tau.$$
  3. Deflate with CPI index.

The impact of monetary policy on firms' borrowing

[1] **Aggregate impact**. Simple panel local projection ($k = 1, ..., 4$) of bond issuance on monetary policy:

$$B_{k,\tau+h} = \alpha_k + \beta^h \epsilon^m_\tau + \text{lags} + \text{controls} + e_{k,\tau+h}.$$

The impact of monetary policy on firms' borrowing

[1] **Aggregate impact.** Simple panel local projection ($k = 1, ..., 4$) of bond issuance on monetary policy:

$$B_{k,\tau+h} = \alpha_k + \beta^h \epsilon_\tau^m + \text{lags} + \text{controls} + e_{k,\tau+h}.$$

[2] **Relative impact on 'High leverage' firms.** Define a 'high leverage' dummy:

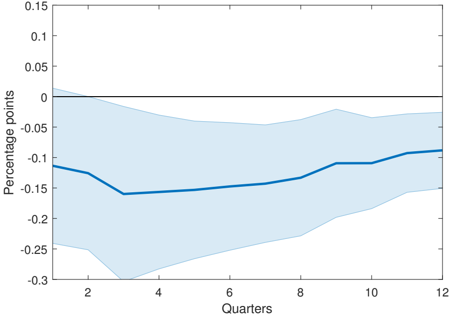
$$\ell_k^{High} = 1 \quad \text{for } k > 1.$$

Estimate the differential impact of monetary policy on high leverage firms' bond issuance:

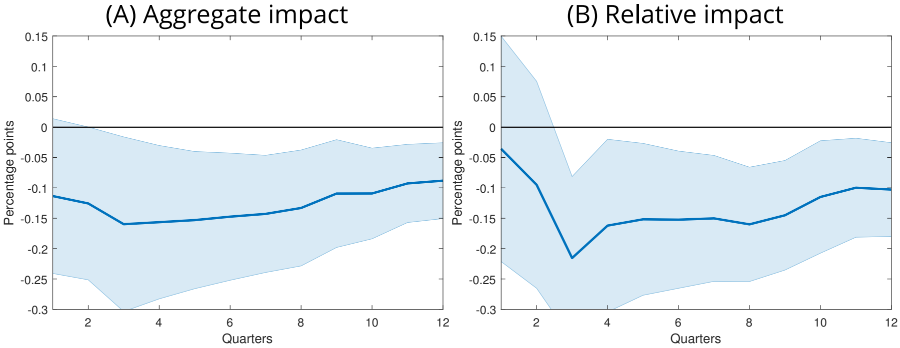
$$B_{k,\tau+h} = \alpha_k + \alpha_\tau + \beta^h \left(\ell_k^{High} \epsilon_\tau^m \right) + \text{lags} + \text{controls} + e_{k,\tau+h}.$$

A monetary policy tightening leads to a persistent contraction in credit volumes...

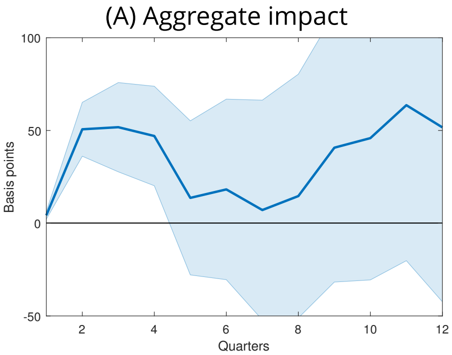
(A) Aggregate impact



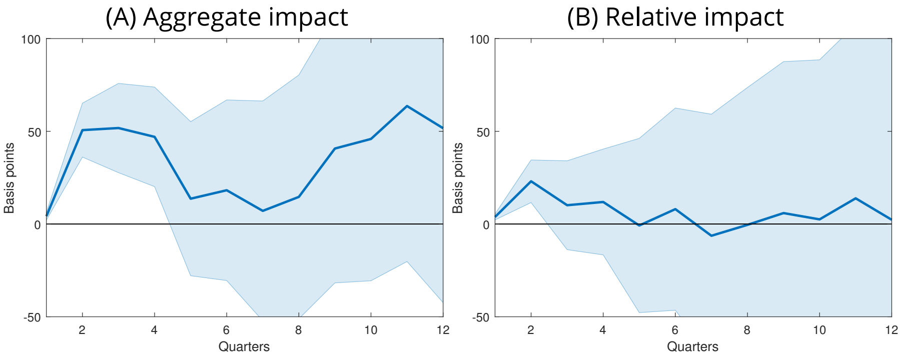
... and high leverage firms contract their borrowing by more than low leverage firms



Spreads also respond to monetary policy surprises in a persistent fashion...



...with high leverage firms experiencing a larger increase in spreads



Channels of Transmission

Expected Default & Risk Premium

Channels of transmission: Default risk vs. Risk premium

- Focus so far: response of *overall* credit spreads.
- **Concern** Estimated impact of monetary policy on spreads could be driven by a ‘frictionless’ default channel.

Channels of transmission: Default risk vs. Risk premium

- Focus so far: response of *overall* credit spreads.
- **Concern** Estimated impact of monetary policy on spreads could be driven by a 'frictionless' default channel.
- Follow Gilchrist and Zakrajšek (2012) and decompose credit spreads into two components:
  [1] A component that captures the systematic movements in firms' default risk.
  [2] A residual risk premium component (the excess bond premium).

Gilchrist and Zakrajšek (2012)'s approach: Overview

- Compute the 'distance to default' for each firm (DD_{jt}) [Merton (1974)].

Gilchrist and Zakrajšek (2012)'s approach: Overview

- Compute the 'distance to default' for each firm (DD_{jt}) [Merton (1974)].
- Regress corporate bond spreads on DD_{jt} and other bond/firm-specific characteristics ($X_{ij,t}$ and $Z_{j,t}$):

$$\log(1 + s_{ij,t}) = \alpha_i + \beta DD_{jt} + \Gamma X_{ij,t} + \Lambda Z_{jt} + \varepsilon_{ij,t}$$

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$$\log(1 + s_{ij,t}) = \alpha_i + \beta DD_{jt} + \Gamma X_{ij,t} + \Lambda Z_{jt} + \varepsilon_{ij,t}$$

- Fitted variation in spreads, $\hat{s}_{ij,t} = \exp(\hat{\alpha}_i + \hat{\beta} DD_{jt} + \hat{\Gamma} X_{ij,t} + \hat{\Lambda} Z_{jt} + \frac{\hat{\sigma}}{2})$, associated with default risk.

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- Residual variation in spreads, $\nu_{ij,t} = s_{ij,t} - \hat{s}_{ij,t}$, associated with risk premium.

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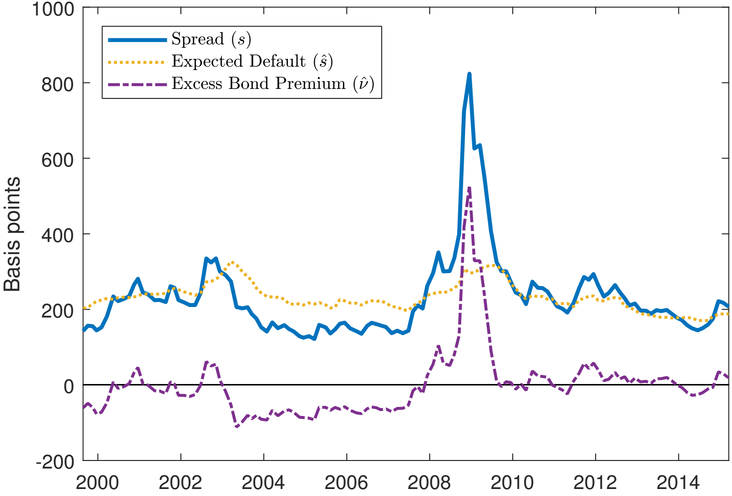
$$\log(1 + s_{ij,t}) = \alpha_i + \beta DD_{jt} + \Gamma X_{ij,t} + \Lambda Z_{jt} + \varepsilon_{ij,t}$$

- Fitted variation in spreads, $\hat{s}_{ij,t} = \exp(\hat{\alpha}_i + \hat{\beta} DD_{jt} + \hat{\Gamma} X_{ij,t} + \hat{\Lambda} Z_{jt} + \frac{\hat{\sigma}}{2})$, associated with default risk.
- Residual variation in spreads, $\nu_{ij,t} = s_{ij,t} - \hat{s}_{ij,t}$, associated with risk premium.
- [Excess Bond Premium (EBP) is defined as the average of the pricing error $\nu_{ij,t}$ across bonds for each time t.]

Details

Gilchrist and Zakrajšek (2012)'s decomposition



Comparison with GZ

Expected default and risk premium channels of monetary policy

- Consider Gilchrist and Zakrajšek (2012) corporate bond spreads decomposition:

$$\underbrace{s_{ij,t}}_{\text{Spread}} = \underbrace{\hat{s}_{ij,t}}_{\substack{\text{Expected}\\ \text{default}}} + \underbrace{\hat{\nu}_{ij,t}}_{\substack{\text{Risk}\\ \text{premium}}}$$

- Run baseline specification on both components:

$$\Delta\hat{s}_{ij,t} = \alpha_i + \beta\epsilon_t^m + e_{ij,t}$$
$$\Delta\hat{\nu}_{ij,t} = \alpha_i + \beta\epsilon_t^m + e_{ij,t}$$

- Then, consider leverage interaction.

Expected default & Risk premium

	(1)	(2)	(3)
Dep. Variable:	Spread (Δs)	Expected Default ($\Delta \hat{s}$)	Risk Premium ($\Delta \hat{\nu}$)
MP surprise (ϵ^m)	19.86***	6.48***	13.38***
	(2.56)	(0.90)	(2.63)
R-squared	0.041	0.053	0.038
Observations	191,409	191,409	191,409

- Monetary policy has a positive and statistically significant impact on expected default ($\hat{s}_{ij,t}$).
- But impact on risk premium ($\nu_{ij,t}$) is ~ 2 times larger than impact on expected default.

Expected default & Risk premium (cont'd)

- Larger coefficient on $\hat{\nu}_{ij,t}$ could simply reflect higher variance of risk premium ($\hat{\nu}_{ij,t}$) relative to expected default ($\hat{s}_{ij,t}$)
- Re-estimate same specifications after standardizing both series.

Expected default & Risk premium (cont'd)

- Larger coefficient on $\hat{\nu}_{ij,t}$ could simply reflect higher variance of risk premium ($\hat{\nu}_{ij,t}$) relative to expected default ($\hat{s}_{ij,t}$)
- Re-estimate same specifications after standardizing both series.

	(1)	(2)
Dep. Variable:	Expected Default, Standardized ($\Delta\hat{s}$)	Risk Premium, Standardized ($\Delta\hat{\nu}$)
MP surprise (ϵ^m)	0.47***	0.39***
	(0.06)	(0.08)
R-squared	0.053	0.038
Observations	191,409	191,409

- Response of $\hat{\nu}_{ij,t}$ not statistically different from response of $\hat{s}_{ij,t}$.

Expected default & Risk premium: Heterogeneity

- Time-sector fixed effects specification with continuous ($L_{j,t-1}$) and high leverage dummy ($\ell_{j,t-1}^{High}$) interactions.

	(1)	(2)	(3)	(4)
Dep. Variable:	Expected Default ($\Delta\hat{s}$)		Risk Premium ($\Delta\hat{\nu}$)	
	Leverage continuous	High Leverage	Leverage continuous	High Leverage
MP surpr. x Lev. ($\epsilon^m \times L_j$)	5.87***		7.64**	
	(1.77)		(3.02)	
MP surpr. x High Lev. ($\epsilon^m \times \ell_j^{High}$)		3.84***		16.14***
		(1.25)		(4.60)
R-squared	0.215	0.213	0.188	0.188
Observations	191,403	191,403	191,403	191,403

- High leverage firms are more responsive.

Concluding Remarks

Our main findings

- New evidence on the heterogeneous impact of monetary policy surprises on credit spreads and credit volumes at the bond level.

- Aggregate transmission of monetary policy to credit spreads is driven by:
  - Highly leveraged firms.
  - Risk premium (residual) component.

- Strong support for credit channel view of monetary policy transmission.

Firm Heterogeneity, Credit Spreads, and Monetary Policy

G. Anderson[1] A. Cesa-Bianchi[2]

[1]IMF
[2]Bank of England & CfM

Monetary policy and financial stability
ECB - December 18, 2018

Appendix

Monetary policy surprises (ED3)

- ED3 is the 3-quarter ahead euro-dollar futures rate.
- The euro-dollar futures price is given by 100 points minus the three-month London interbank offered rate for spot settlement on the third Wednesday of the contract month.
  - For example, a price quote of 97.45 implies a deposit rate of 2.55 percent per annum.
- Using euro-dollar futures instead of fed funds futures to capture future rate expectations is common because they are more liquid at longer horizons.
  - See Rigobon and Sack (2004) and Nakamura and Steinsson (2013) for the use of euro-dollar futures.
  - See Gurkaynak (2005) for a discussion of the liquidity of federal funds futures.

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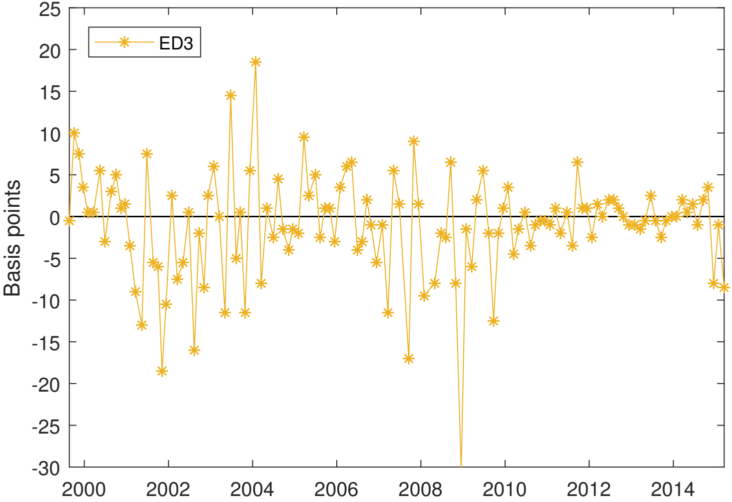
Monetary policy surprises – ED3



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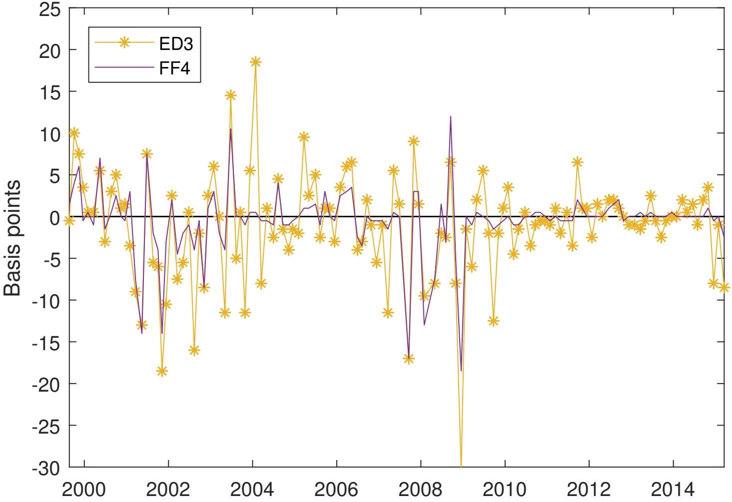
Monetary policy surprises – ED3 vs FF4



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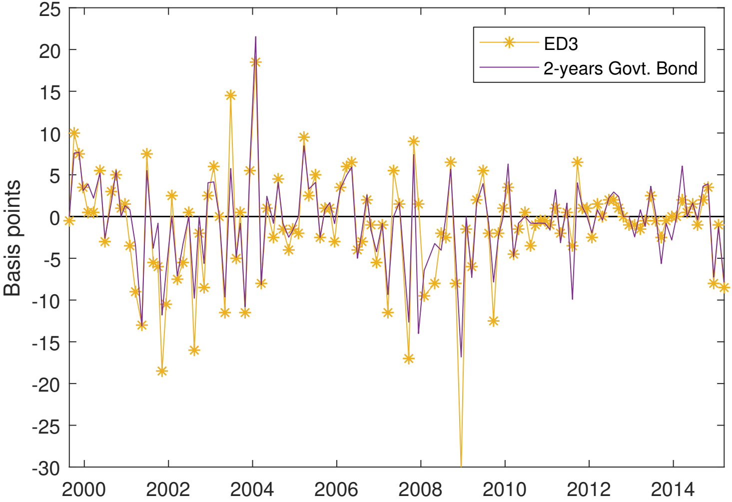
Monetary policy surprises – ED3 vs 2-year Govt. Bond



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Monetary policy surprises – ED3 vs other surprises: Statistics

- Average virtually zero (1 basis point)
- Roughly equal number of tightenings and loosenings
- High correlation with FF4 (pre-ZLB)

	ED3	FF4	R2Y	R5Y
Average	-1.07	-0.53	-0.01	0.00
St. Deviation	6.33	4.06	0.05	0.06
Skewness	-0.93	-1.63	-0.09	-0.38
Share of tightenings	44%	32%	39%	52%
Share of zeros	4%	25%	14%	3%
Share of loosenings	52%	43%	48%	45%
Corr(ED3,X), pre-ZLB		0.82	0.90	0.77
Corr(ED3,X), post-ZLB		0.68	0.86	0.68

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Monetary policy events: Unscheduled meetings

Date	*Announcement*
3rd January 2001	FOMC lowers federal funds rate by 50 basis points.
18th April 2001	FOMC lowers federal funds rate by 50 basis points.
10th August 2007	FOMC statement announcing provision of liquidity to facilitate orderly financial markets.
17th August 2007	FOMC statement on the deterioration of financial market conditions.
22nd January 2008	FOMC lowers federal funds rate by 75 basis points.
11th March 2008	FOMC increases and extends its swap lines with the ECB and Swiss National Bank.
8th October 2008	FOMC lowers federal funds rate by 50 basis points.
1st December 2008	Chairman Bernanke speech outlining the possibility of purchasing longer-term Treasury securities.

More info on MP surprises

BAML Option Adjusted Spread: Details

- Option-adjusted spread is the number of basis points that the fair value government spot curve is shifted in order to match the present value of discounted cash flows to the bond's price.
- For securities with embedded options (call, sink or put), a log normal short interest rate model is used to evaluate the present value of the securities potential cash flows. In this case, the OAS is equal to the number of basis points that the short interest rate tree must be shifted in order to match discounted cash flows to the bond's price.
- Fair value government spot yield curves are derived from a universe of bond prices using government Index constituents.
- More at https://www.theice.com/market-data/indices/fixed-income-indices.

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Bond-level data: Summary statistics

	Mean	Std. Deviation	Minimum	Median	Maximum
No. of Bonds per Firm/Month	3.8	4.5	1.0	2.0	57.0
Effective Yield (%)	5.3	3.0	0.1	5.2	39.6
Spread (%)	2.6	2.7	0.1	1.7	35.0
Coupon (%)	6.2	1.8	0.0	6.3	15.0
Amount Issued ($M)	570	478	25	450	15,000
Maturity at Issue (Years)	14.7	9.4	1.5	10.0	50.0
Time to Maturity (Years)	10.7	8.4	1.0	7.6	30.0
Effective Duration	6.7	3.8	0.0	5.9	19.3
Credit Rating (Composite)	-	-	D	BBB2	AAA
Callable (% of Observations)	51.4				

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Financial Constraint Index

- Follow Hadlock and Pierce (2010): show that firm size and age are very useful predictors of the severity of financial constraints
- Introduce a measure based solely on these two firm characteristics

$$\textit{HP index} = -0.548 \cdot \textit{Size} + 0.025 \cdot \textit{Size}^2 - 0.031 \cdot \textit{Age}$$

Firm-level variables definition

- Follow Ottonello and Winberry (2018)
- Leverage: Ratio of total debt (`dlcq+dlttq`) to total assets (`atq`).
- Net leverage: Subtract current assets (`actq`) net of other current liabilities (`lctq`) from debt liabilities to total assets.
  - Current assets consists of cash and other assets expected to be realized in cash within the next 12 months.
  - Current liabilities are those due within one year.
- Real Sales Growth: log-differences in sales (`saleq`) deflated using CPI.
- Size: Log of total assets (`atq`).

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Credit spreads response to monetary policy surprises

Dep. Variable: spread (Δs_i)	(1)	(2)	(3)	(4)
Source	BAML	BAML	Moody's	Moody's
	Bond-level	Weight. Av.	AAA	BAA
MP surprise (ϵ^m)	19.86***	19.46***	3.57	0.72
	(1.33)	(7.27)	(6.28)	(6.97)
R-squared	0.004	0.057	0.003	0.000
Obs.	191,635	121	123	123

- Strong response of credit spreads to monetary policy surprises.
- Larger and more statistically significant coefficient relative to off-the-shelf *aggregate* measures.

Additional results

OLS specification: Role of duration mismatch

	(1)	(2)	(3)	(4)
Source:	BAML	BAML - 10yr	BAML	BAML - 10yr
Dep. Variable:	Average	Average	Weigh. Av.	Weigh. Av.
MP surprise (ϵ^m)	14.69*	8.30	21.67***	15.39*
	(7.68)	(8.47)	(8.09)	(8.88)
R-squared	0.030	0.008	0.057	0.025
Obs.	121	121	121	121

- *BAML - 10yr* is constructed as BAML aggregate yield minus the 10 year govt. bond yield
- Coefficient is biased downward and standard error increases

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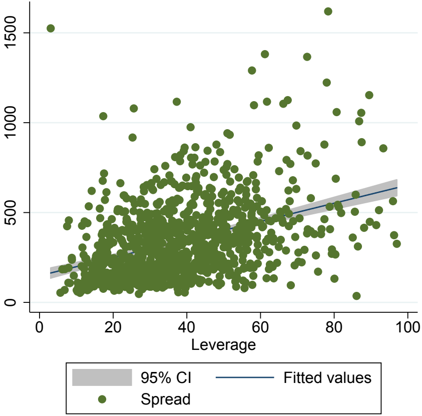
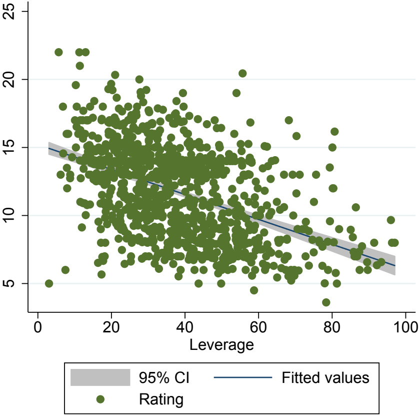
Leverage, Credit spreads, & Credit ratings

- In the data $Corr(Lev, Cred.Spread) > 0$, $Corr(Lev, Cred.Rating) < 0$.
- Supportive of the fact that heterogeneity in the data is driven by differences in net worth N, rather than monitoring costs μ or idiosyncratic variance σ.





Equity prices

Dep. Variable: spread (Δeq_j)	(1)	(2)	(3)	(4)
	Baseline	Leverage continuous	Leverage quartile	High Leverage
MP surprise (ϵ^m)	-6.33***	-6.32***		
	(0.31)	(0.31)		
MP surprise x Lev. ($\epsilon^m \times L_j$)		-0.93***		
		(0.36)		
MP surprise x Lev. Q1 ($\epsilon^m \times \ell_j^1$)			-6.67***	
			(0.54)	
MP surprise x Lev. Q2 ($\epsilon^m \times \ell_j^2$)			-4.29***	
			(0.53)	
MP surprise x Lev. Q3 ($\epsilon^m \times \ell_j^3$)			-6.37***	
			(0.67)	
MP surprise x Lev. Q4 ($\epsilon^m \times \ell_j^4$)			-8.16***	
			(0.80)	
MP surprise x Low Lev. ($\epsilon^m \times \ell_j^{Low}$)				-6.68***
				(0.54)
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)				-6.23***
				(0.39)
R-squared	0.0463	0.0465	0.0469	0.0463
Observations	191409	191409	191409	191409

Other characteristics: High Dummy Interaction

Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)
	Size	Sales Growth	Credit Rating	Age
MP surprise x Size ($\epsilon^m \times z_j^{High}$)	6.72			
	(5.94)			
MP surprise x Sales growth ($\epsilon^m \times z_j^{High}$)		-6.75		
		(4.65)		
MP surprise x Credit rating ($\epsilon^m \times z_j^{High}$)			-25.02***	
			(6.32)	
MP surprise x Age ($\epsilon^m \times z_j^{High}$)				16.08***
				(5.88)
R-squared	0.197	0.197	0.198	0.197
Observations	191,403	191,095	191,403	191,403

Other characteristics: Continuous Interaction

Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)
	Size	Sales Growth	Credit Rating	Age
MP surprise x Size ($\epsilon^m \times Z_j$)	1.16			
	(1.95)			
MP surprise x Sales growth ($\epsilon^m \times Z_j$)		1.64		
		(9.48)		
MP surprise x Credit rating ($\epsilon^m \times Z_j$)			-4.46***	
			(0.93)	
MP surprise x Age ($\epsilon^m \times Z_j$)				-0.54**
				(0.22)
R-squared	0.197	0.197	0.199	0.197
Observations	191,403	191,095	191,403	191,403

Double Sorting: Continuous Interaction)

- Specification: $\Delta s_{ij,t} = \alpha_i + \beta_{s,t} + \gamma\left(\epsilon_t^m L_{j,t-1}\right) + \delta\left(\epsilon_t^m Z_{j,t-1}\right) + \Gamma \mathbf{X}_{jt} + e_{ij,t}$.
- Double sort by other firms characteristics $Z_{j,t-1}$. Vector $\mathbf{X}_{jt}$ also includes $L_{j,t-1}$ and $Z_{j,t-1}$ as controls.

Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)	(5)
	Leverage	Size	Sales Growth	Credit Rating	Age
MP surprise x High Lev. ($\epsilon^m \times L_j$)	0.89***	0.99***	0.90***	0.59***	0.83***
	(0.17)	(0.17)	(0.17)	(0.19)	(0.18)
MP surprise x Size ($\epsilon^m \times Z_j$)		4.16**			
		(1.85)			
MP surprise x Sales growth ($\epsilon^m \times Z_j$)			2.87		
			(9.55)		
MP surprise x Credit rating ($\epsilon^m \times Z_j$)				-3.23***	
				(1.03)	
MP surprise x Age ($\epsilon^m \times Z_j$)					-0.35
					(0.22)
R-squared	0.198	0.199	0.199	0.200	0.199
Observations	191,403	191,403	191,095	191,403	191,403

Distance to default: The Merton-KMV framework

- Use Merton (1974) model to calculate firm-specific distance to default measures (DD_{jt}) $\Rightarrow$ Distance between the expected value of the firm and the default point.
  - Value of the firm (V) follows a geometric Brownian motion.
  - Firm has just issued a discount bond (D) maturing in T periods.
  - Distance-to-default (1-year horizon):

$$DD_{jt} = \frac{ln(V/D) + (\mu_V - 0.5\sigma_V^2)}{\sigma_V}$$

- Distance to default estimated using an iterative approach of the Merton-KMV Framework [Bharath and Shumway (2008)].

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Decomposing credit spreads: Pricing equation

- Empirical credit spread model:

$$\log(1 + s_{ij,t}) = \alpha_i + \beta DD_{jt} + \Gamma X_{ij,t} + \Lambda Z_{jt} + \varepsilon_{ij,t}$$

	Spread
Distance to default	-0.0596***
	(0.0002)
log(Age)	0.0145***
	(0.0006)
Log(Issuance)	0.0016
	(0.0010)
log(Duration)	0.2138***
	(0.0011)
log(Coupon)	0.3859***
	(0.0020)
R-squared	0.7175
Observations	618888

- Estimated by OLS with two-way clustered standard errors (firm and time) [Cameron et al (2011)].

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Decomposing Corporate Bond Spreads: Comparison with GZ

- Some small differences relative to Gilchrist and Zakrajsek (2012)'s approach
- Callable option-adjustment
  - *This paper*: adjustment is performed by BAML
  - *GZ*: yield curve factors for callable bonds
- Sample period
  - *This paper*: July 1999-March 2015
  - *GZ*: January 1970 to December 2012
- Number of time observations
  - *This paper*: Include bond spread observations on the day of monetary policy announcements, as well as the day before and 1 week after
  - *GZ*: end of the month observations

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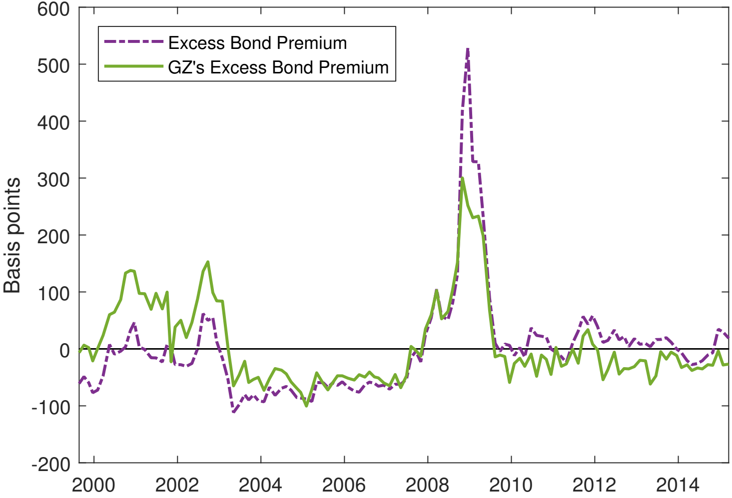
Excess Bond Premium: Comparison with GZ



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GZ’s adjustment for call optionality

- Large share of callable bonds in the sample
  - Movements in risk-free rates—by changing the value of embedded call options—have an independent effect on prices of callable bonds Duffee (1998)
  - Prices of callable bonds are more sensitive to uncertainty regarding the future course of interest rates
- Gilchrist and Zakrajšek (2012)’s approach: Credit spreads of callable bonds depend on
  - Level, slope, and curvature factors of the Treasury yield curve
  - Realized volatility of long-term interest rates

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Additional results

IV type regression		
	(1)	(2)
Dep. Variable:	One-year Rate (Δi_{1YR})	One-year Rate (Δi_{1YR})
MP surprise (ϵ^m)	0.43***	
	(0.01)	
MP surprise, Standardized ($\tilde{\epsilon}^m$)		2.32***
		(0.03)
R-squared	0.119	0.119
Observations	191,409	191,409

Additional results

All surprises: high Lev. & TSFE					
Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)	(5)
Shock:	FF4	FF6	MP4	ED2	ED4
MP surprise x High Lev. ($\epsilon^m \times \ell_j^{High}$)	28.10***	25.10***	25.32***	22.88***	17.18***
	(7.12)	(5.49)	(6.22)	(5.10)	(4.01)
R-squared	0.197	0.197	0.199	0.198	0.198
Observations	191,403	191,403	188,029	191,403	191,403

Additional results

All surprises					
Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)	(5)
FF4 surprise (ϵ^m)	32.61***				
	(3.96)				
FF6 surprise (ϵ^m)		27.83***			
		(3.03)			
MP4 surprise (ϵ^m)			31.10***		
			(3.49)		
ED2 surprise (ϵ^m)				26.58***	
				(2.85)	
ED4 surprise (ϵ^m)					14.49***
					(2.26)
R-squared	0.041	0.041	0.042	0.042	0.040
Observations	191,409	191,409	188,035	191,409	191,409

Additional results

All surprises (IV)					
Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)	(5)
Instrument:	FF4	FF6	MP4	ED2	ED4
1yr Rate (Δi_{1YR})	29.70***	31.93***	28.39***	45.90***	46.92***
	(3.57)	(3.43)	(3.18)	(4.90)	(7.23)
R-squared	0.012	0.009	0.015	-0.015	-0.017
Observations	191,409	191,409	188,035	191,409	191,409

Additional results

Target and path						
Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)	(5)	(6)
Instrument/Shock:	ED3	Target	Path	ED3	Target	Path
1yr Rate (Δi_{1YR})	46.59***	49.85***	0.40			
	(5.92)	(3.80)	(9.81)			
MP surprise (ϵ^m)				19.86***	31.58***	0.04
				(2.56)	(2.42)	(0.89)
R-squared	-0.054	-0.061	0.002	0.006	0.008	0.002
Observations	191,409	191,409	191,409	191,409	191,409	191,409

Additional results

Info surprises: JK						
Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)	(5)	(6)
Instrument/surprise:	ED3	ED3 MP	ED3 INFO	ED3	ED3 MP	ED3 INFO
1yr Rate (Δi_{1YR})	46.59***	89.30***	-58.18***			
	(5.92)	(6.65)	(13.84)			
MP surprise (ϵ^{m})				19.86***		
				(2.56)		
MP shock (ϵ^{MP})					132.47***	
					(9.36)	
Info shock (ϵ^{INFO})						-91.71***
						(21.33)
R-squared	-0.017	-0.134	-0.004	0.041	0.044	0.038
Observations	191,409	191,409	191,409	191,409	191,409	191,409

Additional results

Info surprises: MAR					
Dep. Variable: spread (Δs_{ij})	(1)	(2)	(3)	(4)	(5)
Instrument:	FF4	FF4BLP	FF4BLPO	FF4BLPO12	FF4BLPO12GBLAG
1yr Rate (Δi_{1YR})	30.16***	21.94***	1.89	13.56***	9.09***
	(3.64)	(3.04)	(3.37)	(2.29)	(2.12)
R-squared	0.011	0.026	0.047	0.037	0.041
Observations	77,874	77,874	77,874	77,874	77,874