Corporate debt maturity matters for monetary policy

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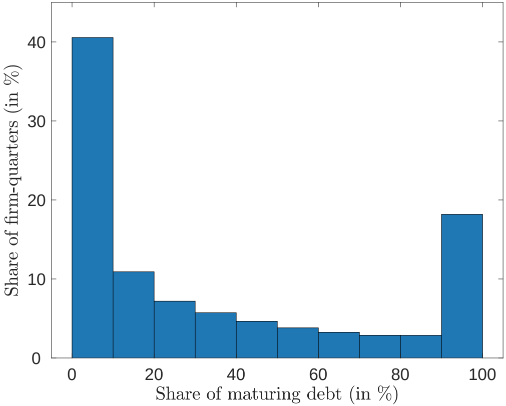
Motivation

Debt is the main source of external firm financing
but not all debt is created equal...



Share of maturing debt =

$$\frac{\text{debt maturing within next 12 months}}{\text{total firm debt}}$$

Research Question

Consider a change of **interest rates** by the central bank...

- **Small share of maturing debt**
- Investment response?

- **Large share of maturing debt**
- Investment response?

Debt Maturity and Monetary Policy

Roll-over risk:

Large share of maturing debt

$\Rightarrow$ high **roll-over** per period

$\Rightarrow$ high **pass-through** of interest rate changes to **cash flow**

$\Rightarrow$ should increase investment response!

Debt overhang:

Small share of maturing debt

$\Rightarrow$ long remaining **maturity**

$\Rightarrow$ **interest rate** and **inflation** have strong effect on **real** burden of **nominal** debt (Gomes-Jermann-Schmid *AER* 2016)

$\Rightarrow$ should increase investment response!

Main Results

Empirical analysis:

- Bond-level information
- Firm-level balance sheet data
- Monetary policy shocks

Result:

- Firm investment responds **more strongly** to monetary policy shocks when **share of maturing bonds** is **larger**

Main Results

Model:

- New Keynesian heterogeneous firm model
- financial frictions and **endogenous debt maturity**

Main Results

Results:

- Model matches **cross-sectional** patterns in firm size, age, **debt maturity**, leverage, credit spreads
- In line with empirical results, firms respond **more strongly** when **maturing bond share** is **larger**

Aggregate effects:

- Conventional (**ST** + **LT** interest rates) vs. Unconventional MP (only **LT** interest rate)
- Unconventional MP: **larger** effect on corporate debt maturity but **smaller** effect on output and inflation

Literature

- **Empirical evidence on debt maturity and financial crises:**
  Duchin Ozbas Sensoy 10, Almeida Campello Laranjeira Weisbenner 12, Benmelech Frydman Papanikolaou 19, Buera Karmakar 22, Kalemli-Ozcan Laeven Moreno 22, ...
- **Empirical evidence on monetary policy and firm heterogeneity:**
  Gertler Gilchrist 94, Ippolito Ozdagli Perez-Orive 18, Jeenas 19, Ottonello Winberry 20, Darmouni Giesecke Rodnyansky 21, Gurkaynak Karasoy-Can Lee 22, Cloyne Ferreira Froemel Surico 23, Anderson Cesa-Bianchi 24, ...
- **Heterogeneous firm models with financial frictions:**
  Bernanke Gertler Gilchrist 99, Cooley Quadrini 01, Khan Thomas 13, Gomes Jermann Schmid 16, Khan Senga Thomas 16, Crouzet 18, Arellano Bai Kehoe 19, Ottonello Winberry 20, ...

Outline

Outline

Data Set

- **Bond-level** information from **F**ixed **I**ncome **S**ecurities **D**atabase (FISD)
- **Firm-level** balance sheet data from Compustat

- Baseline sample:
  - Listed non-financial US firms with **outstanding bonds**
  - **35,000** firm-quarters from 1995Q2 to 2018Q3
  - **two thirds** of sales and fixed assets in Compustat
  - bonds account for 62% of debt in firm sample and 40% of debt in Compustat

Data Set: Maturing Bond Share

Key variable: **Maturing bond share** of firm i in **quarter** t

$$\mathcal{M}_{it} = \frac{\text{maturing bonds (in \$)}_{it}}{\text{total debt (in \$)}_{it-1}}$$

Distribution

Data Set: Monetary Policy Shocks

Looking for **causal** effects of MP:

- central bank **responds** to changes in economy
  $\Rightarrow$ large part of variation of interest rates **endogenous**
- isolate **surprise** component from **anticipated** changes
- **high frequency identification:**
  - 30 min window around FOMC announcement
  - price change of Federal Funds Futures
    (Gertler-Karadi *AEJ:Macro* 2015)

▸ Time series

Baseline Estimation

Panel local projections:

$$\log k_{it+h} - \log k_{it-1} = \delta_i^h + \delta_{st}^h + \beta_0^h \mathcal{M}_{it} + \beta_1^h \mathcal{M}_{it}\, \boldsymbol{\varepsilon_t^{\mathrm{MP}}} + \nu_{it+h}^h$$

Regress changes in firm-level **capital** k_{it} at forecast horizon h on...

- firm-fixed effect δ_i^h
- sector-time-fixed effect δ_{st}^h
- **maturing bonds share** $\mathcal{M}_{it}$
- **monetary policy shock** $\boldsymbol{\varepsilon_t^{\mathrm{MP}}}$

Key coefficient: β_1^h ...

Baseline Estimation

Panel local projections:

$$\log k_{it+h} - \log k_{it-1} = \delta_i^h + \delta_{st}^h + \beta_0^h \mathcal{M}_{it} + \beta_1^h \mathcal{M}_{it}\, \boldsymbol{\varepsilon}_{\boldsymbol{t}}^{\mathbf{MP}} + \nu_{it+h}^h$$

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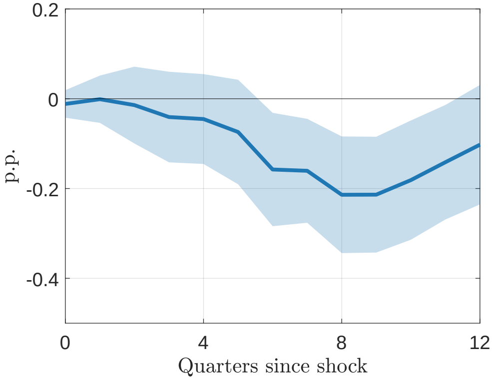
Key coefficient: β_1^h ...

Baseline Estimation

Excess **capital response** associated to $\mathcal{M}_{it}$:

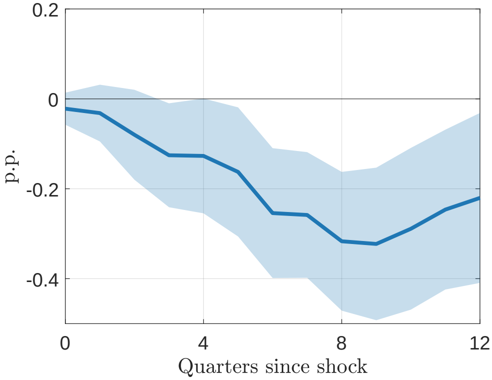


- **contractionary** 1-std MP shock ε_t^{MP}
- $\mathcal{M}_{it}$ is **1 std** higher
  $\Rightarrow$ 8 quarters later firm capital **0.2% smaller**
- about 30% of average capital response
- 95% confidence intervals

Av. Response

Estimation: Robustness

Excess **capital response** associated to $\mathcal{M}_{it} - \overline{\mathcal{M}}_i$:

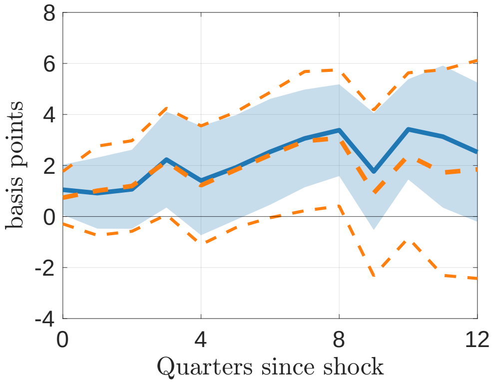


- substitute $\mathcal{M}_{it}$ by **within-firm deviation** from firm-specific mean: $\mathcal{M}_{it} - \overline{\mathcal{M}}_i$
- **controls**:
  - assets
  - age
  - leverage
  - asset liquidity
  - sales growth
  - average maturity

Details

Estimation: Credit spread on LHS

Excess **credit spread response** associated to $\mathcal{M}_{it}$:

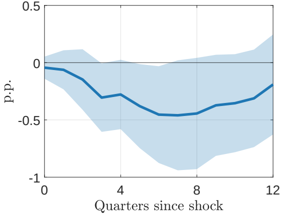


- **contractionary** 1-std MP shock ε_t^{MP}
- $\mathcal{M}_{it}$ is **1 std** higher
  $\Rightarrow$ 8 quarters later credit spread **3 bp higher**
- about 10% of average credit spread response
- **orange dashed**: within-firm deviation $\mathcal{M}_{it} - \overline{\mathcal{M}}_i$ and controls

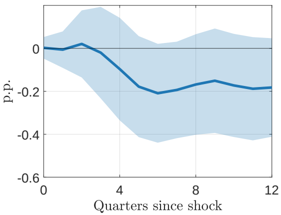
Time series Av. Response

Estimation: More LHS Variables

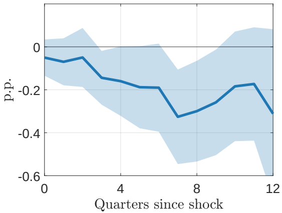
(a) Debt



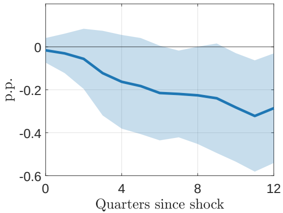
(b) Sales



(c) Employment



(d) Cost of goods sold



Estimation: More robustness

- Alternative MP shocks ▸ Link
- Alternative time samples ▸ Link
- Including non-bond-issuing firms ▸ Link
- Callable bonds and variable-coupon bonds ▸ Link
- Compustat maturing debt share ▸ Link
- Alternative denominators in $\mathcal{M}_{it}$ ▸ Link
- Non-linear specifications ▸ Link

Outline

Model

- New Keynesian model
- Heterogeneous firms
- Equity vs. debt
- **Endogenous debt maturity**

Model Setup

Firm problem:

Intermediate goods produced:

$$y_{it} = \boldsymbol{z_{it}} \left(k_{it}^{\psi} l_{it}^{1-\psi} \right)^{\zeta}$$

$\boldsymbol{z_{it}}$: **firm-specific productivity** k_{it}: capital l_{it}: labor

Firm earnings (before interest and taxes):

$$p_t y_{it} - w_t l_{it} + (\boldsymbol{\varepsilon_{it}} - \delta) Q_t k_{it} - f$$

p_t: price of intermediate goods w_t: wage $\boldsymbol{\varepsilon_{it}}$: **firm-specific capital quality shock**
δ: depreciation Q_t: price of capital goods f: fixed cost of production

Model Setup

Short-term debt:

	creditors	firm
$t:$	$\Rightarrow$	$P_{it}^S B_{it+1}^S$
$t+1:$	$\Leftarrow$	$(1+c)B_{it+1}^S$

Long-term debt:

	creditors	firm
$t:$	$\Rightarrow$	$P_{it}^L B_{it+1}^L$
$t+1:$	$\Leftarrow$	$(\gamma+c)B_{it+1}^L$
$t+2:$	$\Leftarrow$	$(1-\gamma)(\gamma+c)B_{it+1}^L$
$t+3:$	$\Leftarrow$	$(1-\gamma)^2(\gamma+c)B_{it+1}^L$
$t+4:$	$\Leftarrow$	$\ldots$

Model Setup

Cash-on-hand after production and payment of **debt** and **taxes**:

$$q_{it} = Q_t k_{it} - \frac{b_{it}^S}{\pi_t} - \frac{\gamma b_{it}^L}{\pi_t} + (1-\tau)\left[p_t y_{it} - w_t l_{it} + (\varepsilon_{it} - \delta) Q_t k_{it} - f - \frac{c(b_{it}^S + b_{it}^L)}{\pi_t}\right]$$

b_{it}^S: short-term debt (deflated by price level in $t-1$)
b_{it}^L: long-term debt (deflated by price level in $t-1$)
π_t: inflation τ: corporate income tax

Benefit of debt: c is tax deductible
Cost of debt: firm cannot commit to repaying $\Rightarrow$ default cost ξ

Model Setup

Next period's **capital** stock:

$$Q_t k_{it+1} = \underbrace{q_{it}}_{\text{Cash-on-hand}} + \underbrace{e_{it}}_{\text{Equity issuance}} + \underbrace{b^S_{it+1} p^S_{it}}_{\textbf{Short-term}\text{ debt issuance}} + \underbrace{\left(b^L_{it+1} - \frac{(1-\gamma) b^L_{it}}{\pi_t} \right) p^L_{it}}_{\textbf{Long-term}\text{ debt issuance}}$$

Perfectly competitive **creditors**:

$$p^S_{it} = \mathbb{E} \frac{\beta u'(C_{t+1})}{u'(C_t)} \int_{\varepsilon_{it+1}} \left[(1 - \mathcal{D}_{it+1}) \frac{1+c}{\pi_{t+1}} + \mathcal{D}_{it+1} \frac{(1-\xi) \underline{q}_{it+1}}{b^S_{it+1} + b^L_{it+1}} \right] d\varphi(\varepsilon_{it+1})$$

$$p^L_{it} = \mathbb{E} \frac{\beta u'(C_{t+1})}{u'(C_t)} \int_{\varepsilon_{it+1}} \left[(1 - \mathcal{D}_{it+1}) \frac{\gamma + c + (1-\gamma) \mathbb{E}\, p^L_{it+1}}{\pi_{t+1}} \right.$$

$$\left. + \mathcal{D}_{it+1} \frac{(1-\xi) \underline{q}_{it+1}}{b^S_{it+1} + b^L_{it+1}} \right] d\varphi(\varepsilon_{it+1})$$

Model Setup

- convex cost of equity issuance
- convex cost of debt issuance $\Rightarrow$ **benefit** of long-term debt

What is the **cost** of long-term debt?

Model: Cost of long-term debt

Debt overhang:

sell **long-term debt**

at price p^L — default risk — default risk

t — $t+1$ — $t+2$

Model: Cost of long-term debt

Debt overhang:

Leverage =
debt / capital

⇓

default risk

Leverage =
debt / capital

⇓

default risk

sell **long-term debt**
at price p^L

t $\quad$ $t+1$ $\quad$ $t+2$

Model: Cost of long-term debt

Debt overhang:

sell **long-term debt** at price p^L

Leverage = debt / capital $\Downarrow$ default risk

Leverage = debt / capital $\Downarrow$ default risk

t — $t+1$ — $t+2$

Model: Cost of long-term debt

Debt overhang:

Leverage = debt / capital ⇓ default risk (at $t+1$)

Leverage = debt / capital ⇓ default risk (at $t+2$)

sell **long-term debt** at price p^L (at t)

t — $t+1$ — $t+2$

$\Rightarrow$ **cost** of long-term debt

Model: General Equilibrium

- Representative household: C_t and L_t
- Retail firms: Phillips curve $\Rightarrow p_t, \pi_t$
- Capital goods producers: $\Rightarrow Q_t$
- **Monetary policy:** Taylor rule

Endogenous **firm distribution** $\mu_t(q_{it}, b_{it}, z_{it+1})$:

- cash-on-hand q_{it}
- outstanding **long-term** debt b_{it}
- idiosyncratic firm-productivity z_{it+1}

Details Firm Problem

Outline

1. Introduction
2. Empirical Evidence
3. Model
4. Quantitative Analysis

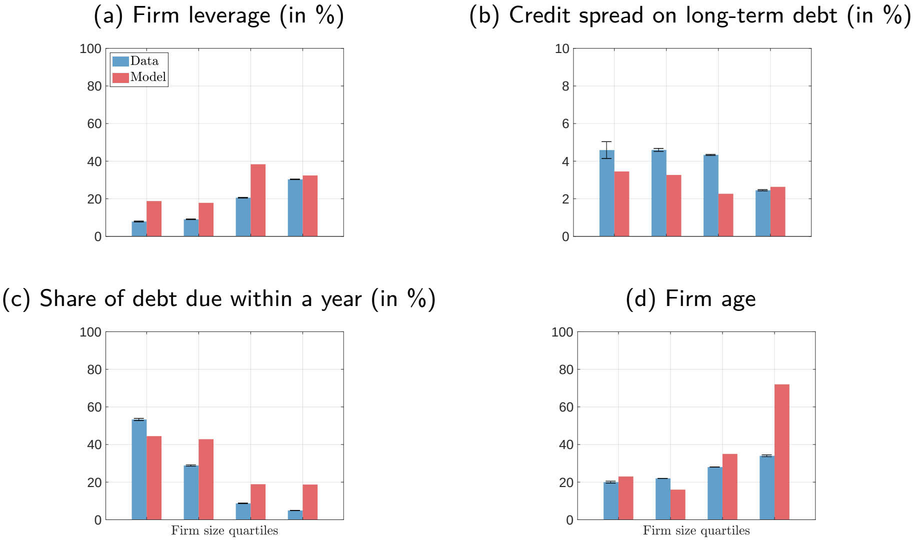
Model: Calibration

Important calibration targets:

Target	Data	Model
Mean firm leverage	34.4%	30.9%
Mean share of debt maturing within a year	30.5%	30.6%
Mean credit spread on long-term debt	3.1%	2.7%
Mean equity issuance / assets	11.4%	15.0%

▸ Full Calibration ▸ Solution method

Model: Cross-Section by Firm Size



Model: Cross-Section

- Choice of debt and capital affects **default risk**
- Part of **default costs** borne by existing **long-term creditors**

Long-term debt ↑ $\Rightarrow$ future debt ↑ future capital ↓

Model: Cross-Section

- Choice of debt and capital affects **default risk**
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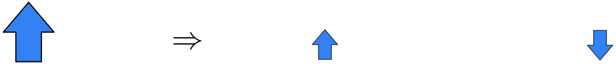
Long-term debt future debt future capital

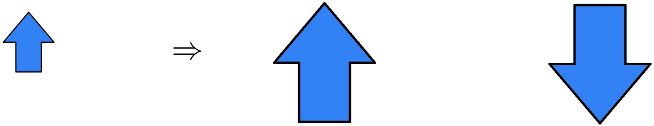


Small ex-ante **default risk**

Model: Cross-Section

- Choice of debt and capital affects **default risk**
- Part of **default costs** borne by existing **long-term creditors**

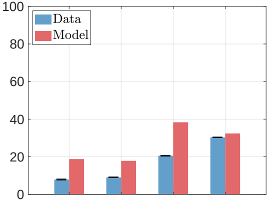
Long-term debt future debt future capital



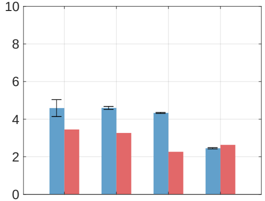
Large ex-ante **default risk**

Model: Cross-Section by Firm Size

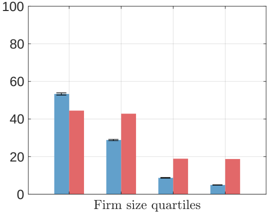
(a) Firm leverage (in %)



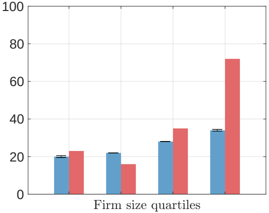
(b) Credit spread on long-term debt (in %)



(c) Share of debt due within a year (in %)



(d) Firm age



Model: Monetary Policy Shock

Monetary policy shock:

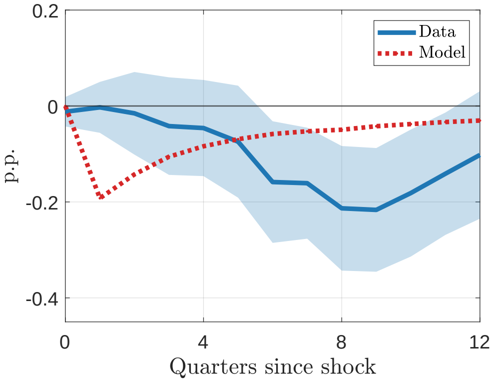
- persistent shock $\varepsilon_t^{\mathbf{MP}}$ to Taylor rule
- firms at different points of distribution $\mu_t(q_{it}, b_{it}, z_{it+1})$ respond **differently**
- role of $\mathcal{M}_{it}$?

  $\Rightarrow$ run same regressions as in empirical analysis on **simulated model data**

Aggegate response to MP shock

Model: Monetary Policy Shock

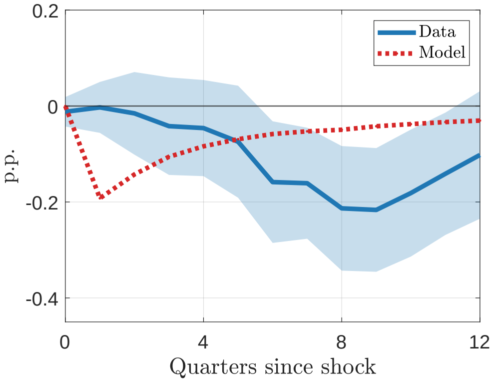
$$\log k_{it+h} - \log k_{it-1} = \ \dots \ + \beta_0^h \mathcal{M}_{it} + \beta_1^h \mathcal{M}_{it}\, \varepsilon_{\boldsymbol{t}}^{\mathbf{MP}} \ + \ \dots \ + \nu_{it+h}^h$$



Roll-over risk:

Model: Monetary Policy Shock

$$Q_t k_{it+1} = q_{it} + e_{it} + b^S_{it+1} p^S_{it} + \left(b^L_{it+1} - \frac{(1-\gamma) b^L_{it}}{\pi_t} \right) p^L_{it}$$

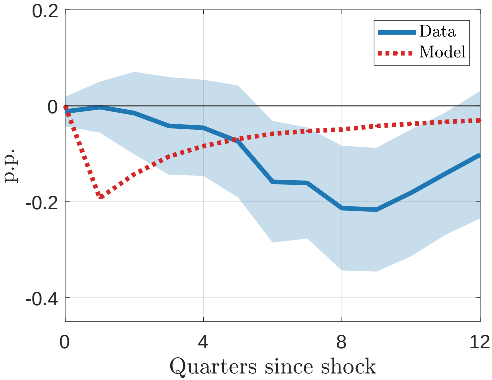


Roll-over risk:

- higher $\mathcal{M}_{it}$
  $\Rightarrow$ higher b^S_{it+1} and lower b^L_{it+1}
  $\Rightarrow$ more **roll-over**
- higher pass-through of p^S_{it} and p^L_{it} to cash flow

Model: Monetary Policy Shock

$$Q_t k_{it+1} = q_{it} + e_{it} + b^S_{it+1} p^S_{it} + \left(b^L_{it+1} - \frac{(1-\gamma) b^L_{it}}{\pi_t} \right) p^L_{it}$$



Debt overhang:

- higher **interest rate** and lower **inflation π_t** increase **debt overhang** for all firms
- effect on **capital** stronger for firms with higher ex-ante **default risk** with higher $\mathcal{M}_{it}$

More Quantitative Results

- Heterogeneous responses to MP shock ▸ Link
- Channel decomposition ▸ Link
- Exogenous variation in maturing bond share ▸ Link
- More LHS variables ▸ Link

Unconventional Monetary Policy

Conventional monetary policy:

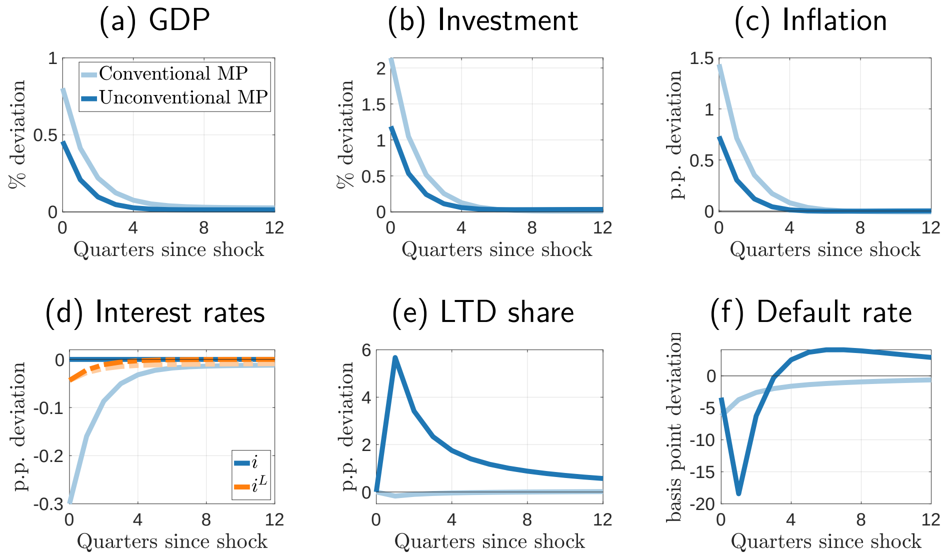
- shock to Taylor rule $\Rightarrow$ nominal **ST** interest rate
- expected time path of **ST** rates $\Rightarrow$ nominal **LT** interest rate

Unconventional monetary policy:

- shock to **LT** interest rate
- **ST** interest rate held constant

More Details

Unconventional Monetary Policy



Unconventional Monetary Policy

⇒ **dampened** aggregate effects of Unconventional MP on **output** and **inflation**

Two reasons:

1. Investment partly financed by **ST** debt ⇒ lowering only **LT** rates less effective
2. Strong endogenous reaction of **debt maturity**:
   - flatter yield curve
     ⇒ gradual and persistent build-up of **LT** debt
     ⇒ medium-term increase of default rate and **debt overhang**
     ⇒ dampened investment response

Outline

Conclusion

Question: Does **corporate debt maturity** matter for the effects of MP?

Empirically:

- Firms react more when **maturing bond share** is larger

Quantitative model:

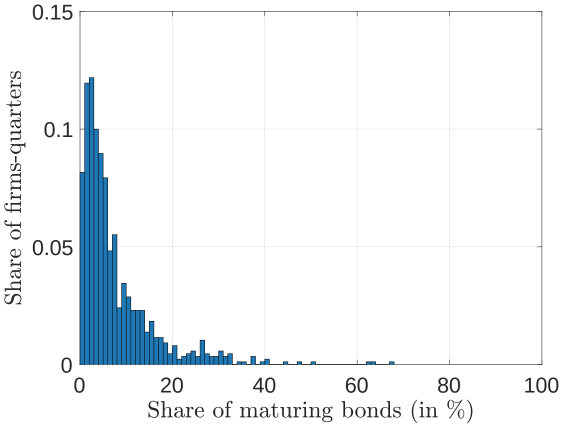
- **roll-over risk** and **debt overhang** together explain 90% of peak empirical estimate
- Unconventional MP (only **LT** rate) has **larger** effect on debt maturity but **smaller** effect on output and inflation than Conventional MP (**ST** + **LT** rate)

Conclusion

Thank you!

Appendix: Maturing Bond Share

- 6% of firm-quarters with $\mathcal{M}_{it} > 0$
- Histogram conditional on $\mathcal{M}_{it} > 0$:



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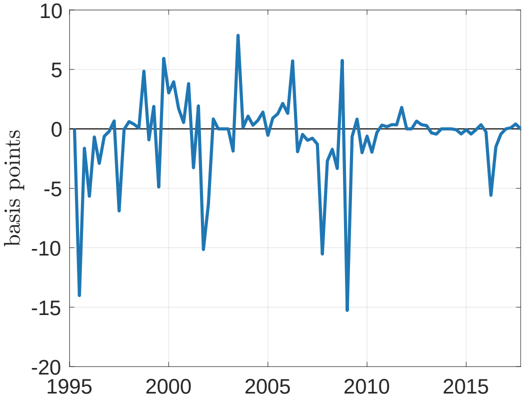
Appendix: Monetary Policy Shocks



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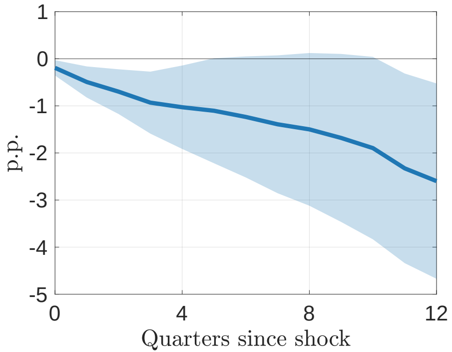
Appendix: Average Capital Response

$$\log k_{it+h} - \log k_{it-1} = \delta_i^h + \delta_{sq}^h + \alpha_1^h \boldsymbol{\varepsilon_t^{MP}} + \nu_{it+h}^h$$



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Appendix: Robustness Details

	$\Delta^{h+1} \log k_{it+h}$			
	$h=0$	$h=4$	$h=8$	$h=12$
$\mathcal{M}_{it}$	-0.0161	-0.129	-0.142	-0.0308
	(0.0237)	(0.0837)	(0.0856)	(0.107)
$\mathcal{M}_{it}$ × MP shock	-0.0221	-0.126*	-0.321***	-0.230**
	(0.0186)	(0.0658)	(0.0779)	(0.0942)
Assets	-0.694***	-5.301***	-10.04***	-15.56***
	(0.181)	(0.908)	(1.739)	(2.367)
Assets × MP shock	-0.0200	0.0612	-0.205	-0.658
	(0.0903)	(0.321)	(0.417)	(0.513)
Age × MP shock	-0.00197	0.0368	-0.104*	-0.165***
	(0.0203)	(0.0527)	(0.0547)	(0.0558)
Leverage	-0.284**	-2.304***	-3.330***	-4.198***
	(0.128)	(0.582)	(1.019)	(1.235)
Leverage × MP shock	-0.0367	-0.113	0.0699	0.339**
	(0.0453)	(0.268)	(0.286)	(0.151)
Liquidity	0.519***	1.230**	2.513***	2.972***
	(0.103)	(0.483)	(0.764)	(0.927)
Liquidity × MP shock	0.122**	-0.0768	0.0132	0.223
	(0.0606)	(0.170)	(0.263)	(0.338)
Sales growth	0.104	0.947***	0.821***	1.018***
	(0.0689)	(0.197)	(0.236)	(0.268)
Sales growth × MP shock	0.0461	-0.108	-0.264	-0.371**
	(0.0632)	(0.136)	(0.196)	(0.164)
Avg. bond maturity	-0.00592	-0.240	-0.396	-0.445
	(0.0486)	(0.271)	(0.438)	(0.564)
Avg. bond maturity × MP shock	0.0255	0.00266	0.00278	0.0175
	(0.0326)	(0.196)	(0.202)	(0.129)

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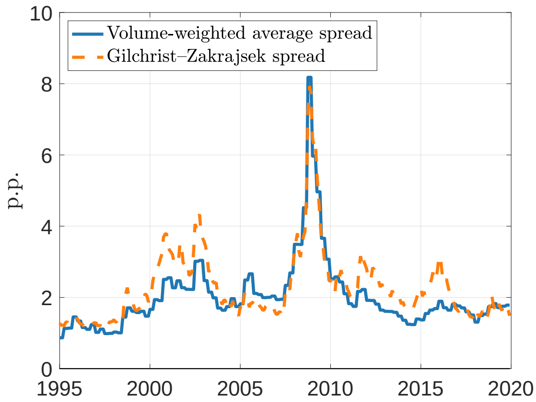
Appendix: Credit Spreads



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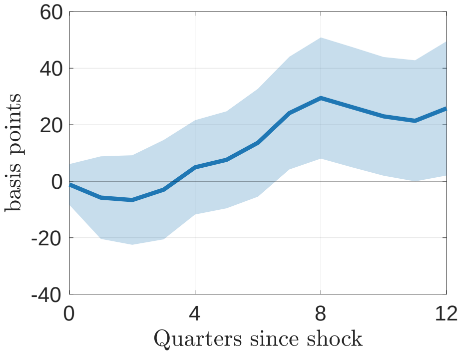
Appendix: Average Credit Spread Response

$$\text{Spread}_{it+h} - \text{Spread}_{it-1} = \delta_i^h + \delta_{sq}^h + \alpha_1^h \boldsymbol{\varepsilon}_{\boldsymbol{t}}^{\mathbf{MP}} + \nu_{it+h}^h$$



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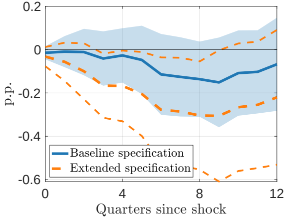
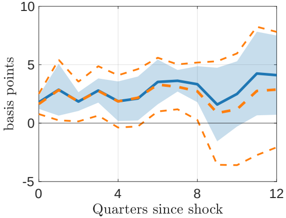
Appendix: Alternative MP shocks

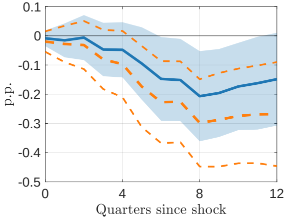
(a) Capital: Miranda-Agrippino Ricco



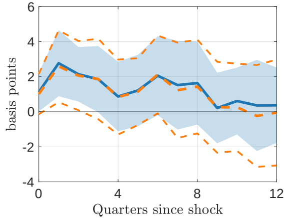
(c) Spread: Miranda-Agrippino Ricco



(c) Capital: Bauer Swanson



(d) Spread: Bauer Swanson



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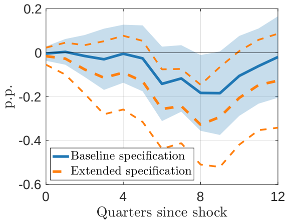
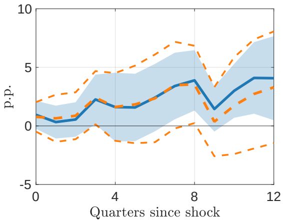
Appendix: Alternative Time Samples

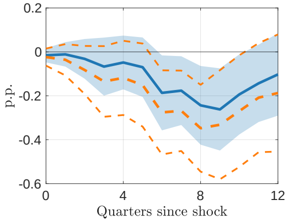
(a) Capital: Pre-Great Recession



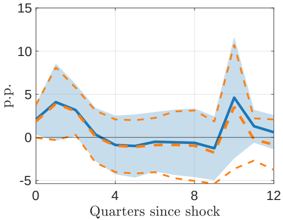
(b) Spread: Pre-Great Recession



(b) Capital: Exclude Great Recession



(d) Spread: No Great Recession dummies



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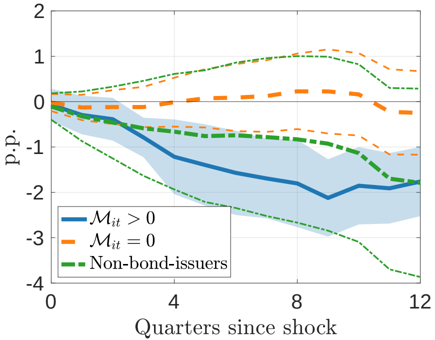
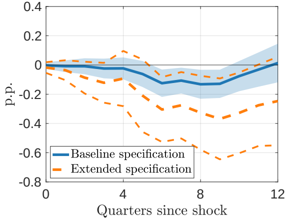
Appendix: Including Non-bond-issuing Firms

$$\begin{aligned}\Delta^{h+1}\log k_{it+h} =&\beta^h_{\mathcal{M}>0,0}\mathbb{1}\{\mathcal{M}_{it}>0\}+\beta^h_{\mathcal{M}=0,0}\mathbb{1}\{\mathcal{M}_{it}=0\}\\ &+\beta^h_{\mathcal{M}>0,1}\mathbb{1}\{\mathcal{M}_{it}>0\}\varepsilon^{mp}_t+\beta^h_{\mathcal{M}=0,1}\mathbb{1}\{\mathcal{M}_{it}=0\}\varepsilon^{mp}_t\\ &+\beta^h_{non\text{-}issuer,1}\{Non\text{-}bond\text{-}issuer_i\}\varepsilon^{mp}_t+\Gamma Z_{it}+\gamma^h_1\Delta gdp_{t-1}+\delta^h_i+\delta^h_{st}+\nu^h_{it+h}\end{aligned}$$

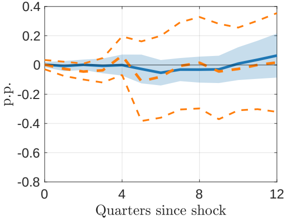


Appendix: Callable Bonds and Variable-coupon Bonds

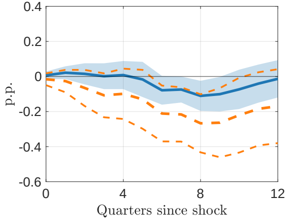
(a) Callable and non-callable



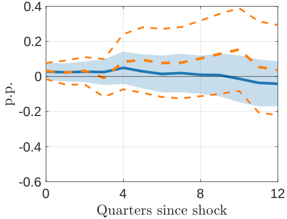
(b) Only callable



(c) Variable and fixed coupon



(d) Only variable coupon



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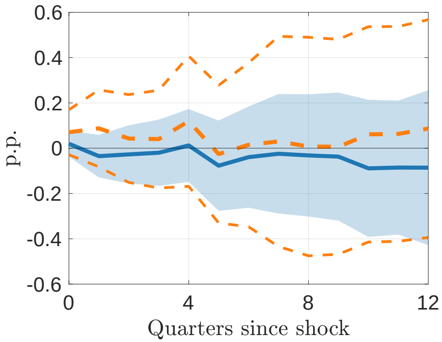
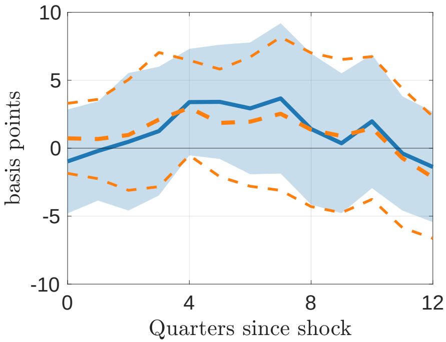
Appendix: Compustat Maturing Debt Share

(a) Capital



(b) Credit spreads



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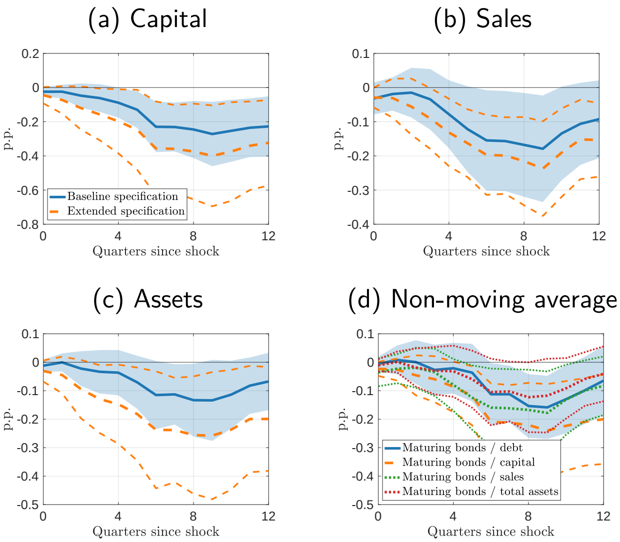
Appendix: Alternative Denominators in $\mathcal{M}_{it}$



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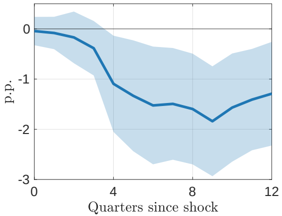
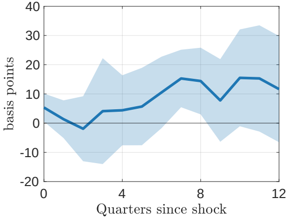
Appendix: Non-linear Specifications using Dummy Variables

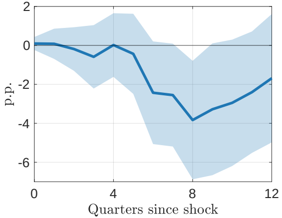
(a) Capital: $\mathcal{M}_{it} > 0$



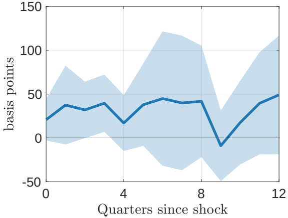
(b) Spread: $\mathcal{M}_{it} > 0$



(a) Capital: $\mathcal{M}_{it} > 15$



(b) Spread: $\mathcal{M}_{it} > 15$



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Appendix: Model Setup

$$V\left(q, b, z', S\right) = \max_{\phi(q,b,z',S)=\left\{k', e \geq \underline{e}, b^{S'}, b^{L'}\right\}} -e - G(e) - H\left(b^{S'}, b^{L'}, b/\pi\right)$$

$$+ \mathbb{E}\,\Lambda' \int_{\bar{\varepsilon}'}^{\infty} \left[(1-\kappa)\,V\left(q', b', z'', S'\right) + \kappa\left(q' - \frac{b'}{\pi'}\,g(q', b', z'', S')\right)\right]\varphi(\varepsilon')d\varepsilon'$$

subject to: $$q' = Q'k' - \frac{b^{S'}}{\pi'} - \frac{\gamma b^{L'}}{\pi'} + (1-\tau)\left[p'y' - w'l' + (\varepsilon' - \delta)Q'k' - f - \frac{c(b^{S'} + b^{L'})}{\pi'}\right]$$

$$y' = z'\left(k'^{\psi} l'^{1-\psi}\right)^{\zeta}, \quad \text{where:} \quad l' = \left(\zeta(1-\psi)p'z'k'^{\psi\zeta}/w'\right)^{\frac{1}{1-\zeta(1-\psi)}}$$

$$\bar{\varepsilon}' : \quad (1-\kappa)\,\hat{\mathbb{E}}\,V\left(q', b', z'', S'\right) + \kappa\left(q' - \frac{b'}{\pi'}\,\hat{\mathbb{E}}\,g(q', b', z'', S')\right) = 0$$

$$Q'k' = q + e + b^{S'}p^{S} + \left(b^{L'} - \frac{b}{\pi}\right)p^{L}$$

$$b' = (1-\gamma)b^{L'}$$

$$p^{S} = \mathbb{E}\,\Lambda'\left[[1 - \Phi(\bar{\varepsilon}')]\frac{1+c}{\pi'} + \frac{(1-\xi)}{b^{S'} + b^{L'}}\int_{-\infty}^{\bar{\varepsilon}'} \underline{q}'\ \varphi(\varepsilon')d\varepsilon'\right]$$

$$p^{L} = \mathbb{E}\,\Lambda'\left[\int_{\bar{\varepsilon}'}^{\infty} \frac{\gamma + c + (1-\gamma)\,g\left(q', b', z'', S'\right)}{\pi'}\varphi(\varepsilon')d\varepsilon' + \frac{(1-\xi)}{b^{S'} + b^{L'}}\int_{-\infty}^{\bar{\varepsilon}'} \underline{q}'\ \varphi(\varepsilon')d\varepsilon'\right]$$

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Appendix: Calibration 1

Table: Externally calibrated parameters

Parameter	Description	Value
β	preference parameter	0.99
c	debt coupon	$1/\beta - 1$
θ	inverse Frisch elasticity	0.5
ζ	production technology	0.75
ψ	production technology	0.33
δ	depreciation rate	0.025
γ	repayment rate long-term debt	0.05
τ	corporate income tax	0.4
ρ	demand elasticity retail goods	10
λ	price adjustment cost parameter	90
ϕ	capital goods technology	4
φ^{mp}	Taylor rule	1.25
ρ^{mp}	Taylor rule	0.5

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Appendix: Calibration 2

Table: Internally calibrated parameters

Parameter	Value	Target	Data	Model
ρ_z	0.988	Regression $\log(k)$ on age	0.022	0.024
$\bar{z}$	0.300	Std. of firm capital growth *(in %)*	16.8	15.0
$\sigma_{\varepsilon\|z\leq\mathbb{E}(z)}$	0.60	**Mean firm leverage** *(in %)*	34.4	30.9
$\sigma_{\varepsilon\|z>\mathbb{E}(z)}$	0.88	Regression leverage on age	0.196	0.225
ξ	0.54	**Mean credit spread on long-term debt** *(in %)*	3.1	2.7
η	0.0045	**Mean share of debt due within a year** *(in %)*	30.5	30.6
ν	0.0005	**Mean equity issuance / assets** *(in %)*	11.4	15.0
κ	0.0151	Firm exit rate *(in %)*	2.2	2.1
f	0.2606	Steady state value of firm entry	–	0

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Appendix: Solution Method

Reiter (2009):

1. **global** solution of **steady state**
   - idiosyncratic firm-level shocks z_{it} and ε_{it}
   - stationary firm distribution $\mu(q, b, z')$
   - computational challenge in models of risky long-term debt: p^L
   - value function iteration and interpolation
2. **perturbation** for **aggregate dynamics**
   - aggregate monetary policy shock
   - first-order linear approximation

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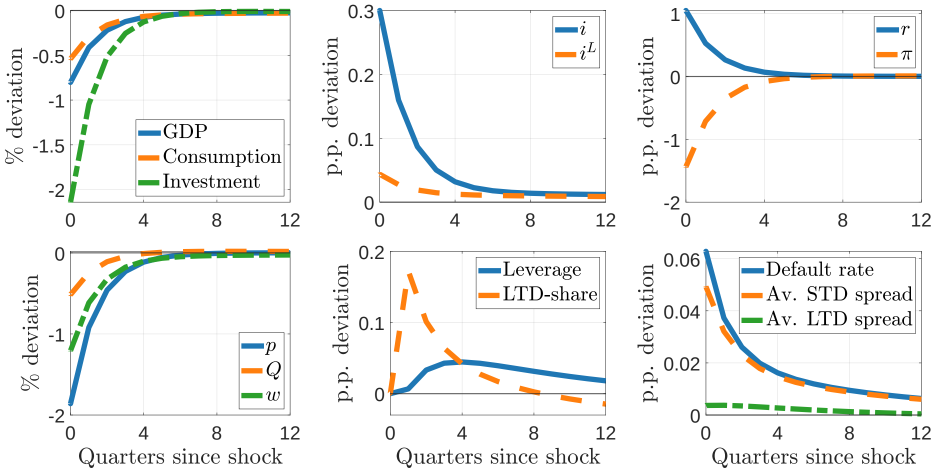
Appendix: Aggregate responses to MP shock



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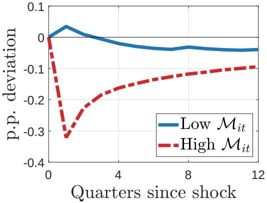
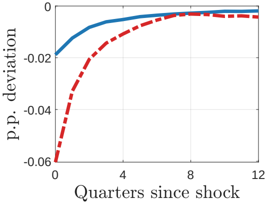
Appendix: Heterogeneous responses to MP shock

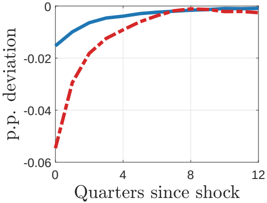
(a) Capital



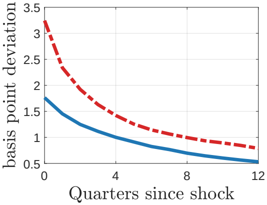
(b) Bond market revenue



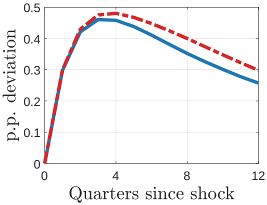
(c) Debt issuance



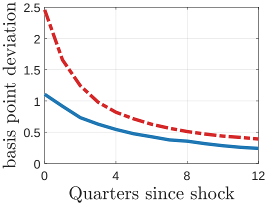
(d) Average credit spread



(e) Outstanding long-term debt



(f) Default rate



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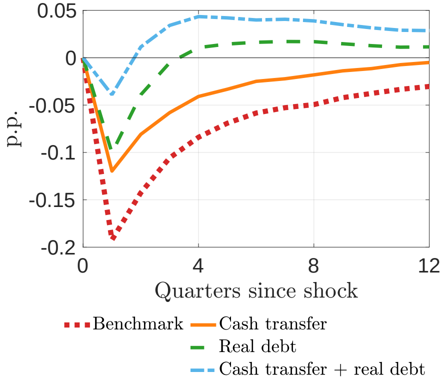
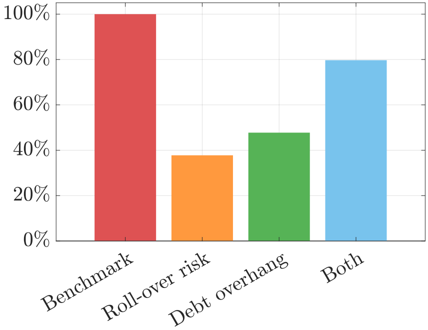
Appendix: Channel Decomposition

(a) Excess capital response



(b) Peak response



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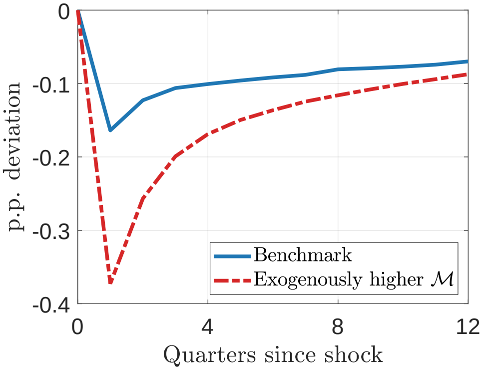
Appendix: Exogenous Variation in Maturing Bond Share

Average firm capital response:



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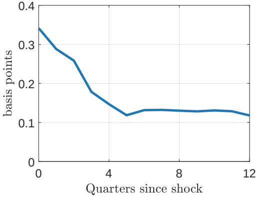
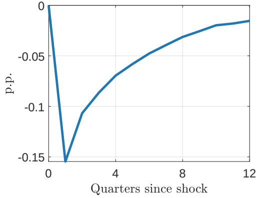
Appendix: More LHS Variables (Quantitative Model)

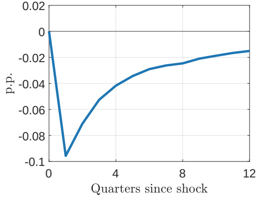
(a) Credit spread



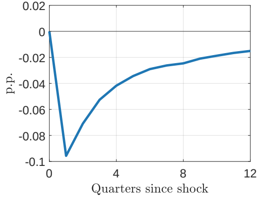
(b) Debt



(c) Sales



(d) Employment



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Appendix: Model Setup Unconventional MP

Stochastic discount factor $\Lambda^S_{t,t+1}$ prices:

- **short-term** debt

Stochastic discount factor $\Lambda^L_{t,t+1}$ prices:

- **long-term** debt
- equity

Segmented asset markets:

$$\Lambda^L_{t,t+1} = (1 + \eta^{ts}_t)\Lambda^S_{t,t+1}$$

$\Rightarrow$ persistent **term structure** shock η^{ts}_t

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