Debt Dilution and Firm Investment

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ADEMU Toulouse Summer School
Toulouse, June 20, 2017

Motivation

Big question: Do financial frictions matter for firm investment?

Standard models: *short-term debt* only

Empirically, most firm debt is *long-term debt*:

- for the average U.S. corporation, 67% of total debt does not mature within the next year

This paper:

- introduces *long-term debt* (and a maturity choice) into a standard model of firm financing and investment

Preview of Results

Main result:

- firms with previously issued outstanding debt do not internalize all costs from issuing additional debt
- they increase leverage and default risk

  $\Rightarrow$ **"Debt Dilution"**
- **debt dilution reduces investment and output**

We show this:

- analytically (2-period model)
- quantitatively (dynamic model)
- empirically (using firm-level Compustat data)

Preview of Results

Dynamic model:

- debt dilution is a **time-inconsistency problem**
- removing debt dilution is as beneficial as reducing corporate income tax by 5.3 percentage points

Policy options:

- upper limit to leverage
- upper limit to maturity choice
- different seniority structures

Literature

Debt dilution and sovereign default:

- e.g. Hatchondo and Martinez (2009, 2013), Arellano and Ramanarayanan (2012), Chatterjee and Eyigungor (2012, 2015), Hatchondo, Martinez, and Sosa-Padilla (2016), Aguiar, Amador, Hopenhayn, and Werning (2016)

Long-term debt and firm investment:

- e.g. Caggese and Perez (2015), Alfaro, Bloom, and Lin (2016), Gomes, Jermann and Schmid (2016)

Closest paper: Crouzet (2016)

- does not study the effect of debt dilution on investment
- model does not match empirical facts about debt maturity

Outline

Outline

2-period Model: Setup

2 periods: $t = 0, 1$

A firm owned by risk-neutral shareholders:

- earnings in $t = 1$:

$$f(k) - \delta k + \varepsilon k$$

- $f(k)$ concave $\Rightarrow$ diminishing returns
- capital k set in $t = 0$:
  - idiosyncratic earnings shock ε uncertain
  - $\mathbb{E}[\varepsilon] = 0$

2-period Model: Debt

Definition

Debt: A bond is a promise to pay one unit of the numéraire good together with a coupon payment c at the end of $t = 1$.

- firm can raise funds in $t = 0$ by selling a number Δ_b of new bonds at market price p
- total funds raised in $t = 0$ on the bond market: $p\Delta_b$

Assume that there is an *exogenous* amount b of bonds outstanding $\Rightarrow$ "Long-term" debt

- these bonds are otherwise identical to the one-period bonds sold in $t = 0$ and due in $t = 1$
- total stock of debt in $t = 1$: $b + \Delta_b \equiv \tilde{b}$

2-period Model: Debt & Capital

Firm chooses capital k in $t = 0$:

- firm sells new bonds and gets $\Delta_b p$
- shareholders inject equity e

$$k = e + p\,\Delta_b$$

Benefit of debt:

- total stock of debt in $t = 1$: $\tilde{b} = b + \Delta_b$
- coupon payments $\tilde{b}c$ are tax-deductible

Shareholder net worth q at the end of $t = 1$:

$$q = k - \tilde{b} + (1 - \tau)[f(k) - \delta k + \varepsilon k - c\tilde{b}]$$

- debt lowers tax payment by $\tau c \tilde{b}$

2-period Model: Limited Liability & Timing

Definition

Limited Liability: Shareholders are free to default in $t = 1$ and leave the firm to lenders for liquidation. A fraction ξ of firm assets is lost in this case.

Timing:

- t=0 Given b, the firm chooses k, e, and $\tilde{b} = b + \Delta_b$
- t=1 ε is realized.
  This determines net worth q.
  The firm decides whether to default.

2-period Model: Firm Problem

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$t = 1$: **Default threshold** $\bar{\varepsilon}$: $\quad q = 0$

$$\Leftrightarrow \quad k - \tilde{b} + (1-\tau)[f(k) - \delta k + \bar{\varepsilon} k - c\tilde{b}] = 0$$

2-period Model: Firm Problem

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$$\Leftrightarrow \quad k - \tilde{b} + (1-\tau)[f(k) - \delta k + \bar{\varepsilon} k - c\tilde{b}] = 0$$

$t = 0$: **Firm problem** given b:

$$\max_{k, e, \Delta_b, \tilde{b}, \bar{\varepsilon}} \quad -e + \frac{1}{1+r} \int_{\bar{\varepsilon}}^{\infty} [k - \tilde{b} + (1-\tau)[f(k) - \delta k + \varepsilon k - c\tilde{b}]\ \varphi(\varepsilon)\, d\varepsilon$$

s.t.: $\quad \bar{\varepsilon}: \quad k - \tilde{b} + (1-\tau)[f(k) - \delta k + \bar{\varepsilon} k - c\tilde{b}] = 0$

$$k = e + p\,\Delta_b$$

$$\tilde{b} = b + \Delta_b$$

2-period Model: Creditors' Problem

We have assumed that fraction ξ of firm assets is lost in case of default

Here: $\xi = 1 \Rightarrow$ liquidation value of the firm is zero

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$t = 0$: Risk-neutral lenders break even on expectation:

$$p = \frac{1}{1+r} \left[1 - \Phi(\bar{\varepsilon})\right] (1 + c)$$

2-period Model: Equilibrium

$t = 0$: Firm maximizes shareholder value subject to creditors' break even condition:

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$$k = e + p\,(\tilde{b} - b)$$

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$$\text{s.t.:} \quad \overline{\varepsilon}: \quad k - \tilde{b} + (1-\tau)[f(k) - \delta k + \overline{\varepsilon} k - c\tilde{b}] = 0 \qquad \Rightarrow \tilde{b} = G(\bar{\varepsilon}, k)$$

$$k = e + p\,(\tilde{b} - b) \qquad \Rightarrow e = k - p\,(\tilde{b} - b)$$

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$$k = e + p(\tilde{b} - b) \qquad \Rightarrow e = k - p(\tilde{b} - b)$$

$$p = \frac{1}{1+r}[1 - \Phi(\overline{\varepsilon})](1+c) \qquad \Rightarrow p = H(\bar{\varepsilon})$$

$\Rightarrow$ This problem can be re-written in terms of k and $\bar{\varepsilon}$

2-period Model: Equilibrium

Simplification: $c = r$

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Consolidated problem in $t = 0$ given b:

$$\max_{k,\bar{\varepsilon}} \quad - e \qquad + \frac{1-\tau}{1+r}\, k \int_{\bar{\varepsilon}}^{\infty} [\varepsilon - \bar{\varepsilon}]\; \varphi(\varepsilon) d\varepsilon$$

2-period Model: Equilibrium

Simplification: $c = r$

Consolidated problem in $t = 0$ given b:

$$\max_{k,\bar{\varepsilon}} \quad \underbrace{-k + p\Delta_b}_{-e} \qquad + \frac{1-\tau}{1+r}\, k \int_{\bar{\varepsilon}}^{\infty} [\varepsilon - \bar{\varepsilon}]\ \varphi(\varepsilon) d\varepsilon$$

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Simplification: $c = r$

Consolidated problem in $t = 0$ given b:

$$\max_{k,\overline{\varepsilon}} \quad -k + \underbrace{[1 - \Phi(\overline{\varepsilon})]}_{p}\underbrace{(\tilde{b} - b)}_{\Delta_b} \qquad + \frac{1-\tau}{1+r}\, k \int_{\overline{\varepsilon}}^{\infty} [\varepsilon - \overline{\varepsilon}]\, \varphi(\varepsilon) d\varepsilon$$

2-period Model: Equilibrium

Simplification: $c = r$

Consolidated problem in $t = 0$ given b:

$$\max_{k,\overline{\varepsilon}} \quad -k + \underbrace{\left[1 - \Phi(\overline{\varepsilon})\right]}_{p} \underbrace{\left(G(\bar{\varepsilon}, k) - b\right)}_{\Delta_b} + \frac{1-\tau}{1+r}\, k \int_{\overline{\varepsilon}}^{\infty} \left[\varepsilon - \overline{\varepsilon}\right] \varphi(\varepsilon) d\varepsilon$$

2-period Model: First Order Conditions

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Capital k:

$$\underbrace{-1}_{\text{Marginal cost of capital}} + \underbrace{[1 - \Phi(\bar{\varepsilon})]\frac{\partial G(\bar{\varepsilon}, k)}{\partial k}}_{\text{Marginal increase in value of debt}} + \underbrace{\frac{1-\tau}{1+r}\int_{\bar{\varepsilon}}^{\infty}[\varepsilon - \bar{\varepsilon}]\ \varphi(\varepsilon)\, d\varepsilon}_{\text{Marginal increase in expected dividend}} = 0$$

2-period Model: First Order Conditions

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Threshold value $\bar{\varepsilon}$:

$$[1-\Phi(\bar{\varepsilon})]\underbrace{(1-\tau)k\frac{\tau c}{1+(1-\tau)c}}_{\textit{Marginal tax benefit of } \bar{\varepsilon}} - \underbrace{\varphi(\bar{\varepsilon})(1+c)(\tilde{b}-b)}_{\substack{\textit{Marginal increase in}\\ \textit{expected costs of default}\\ \textbf{internalized by the firm}}} = 0$$

2-period Model: Debt Dilution

Choice of threshold value $\bar{\varepsilon}$:

- marginal increase in total expected costs of default

$$\varphi(\bar{\varepsilon})(1+c)\tilde{b}$$

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- firm disregards that by increasing $\bar{\varepsilon}$ it also reduces (*"dilutes"*) the value of previously issued bonds b

2-period Model: Debt Dilution

Proposition

The default rate $\Phi(\bar{\varepsilon})$ is increasing in b.

- the higher is b, the lower is the fraction of total default costs internalized by the firm

2-period Model: Debt Dilution

Proposition

For $b > \overline{b}$, capital k is falling in b.

$$\overline{b} = \frac{(1-\tau)k\left[\frac{f(k)}{k} - f'(k)\right]}{1+(1-\tau)c}.$$

For $b < \overline{b}$, capital k is increasing in b.

- the higher is b, the higher is $\bar{\varepsilon}$
- ambiguous effect of higher $\bar{\varepsilon}$ on capital:
  - lower effective tax rate $\Rightarrow$ higher capital
  - lower bond price $\Rightarrow$ higher cost of capital $\Rightarrow$ lower capital
- for $b > \overline{b}$, the second effect dominates

2-period Model: Debt Dilution

Proposition

If k is falling in b, leverage $\tilde{b}/k$ is increasing in b.

- if k is falling in b, higher $\bar{\varepsilon}$ implies higher debt $\tilde{b}$ and therefore higher leverage
- if k is increasing in b, this may or may not hold

Outline

Dynamic Model: Setup

Definition

Short-term Debt: In period t, the firm can sell a short-term bond. This is a promise to pay $1 + c$ in period $t + 1$.

t: firm receives $p^S \tilde{b}^S$

t+1: firms pays $(1 + c)\tilde{b}^S$

Dynamic Model: Setup

Definition

Long-term Debt: In period t, the firm can sell a long-term bond. A fraction γ of this bond matures each period. This is a promise to pay $\gamma + c$ in period $t+1$, $(1-\gamma)(\gamma + c)$ in period $t+2$, $(1-\gamma)^2(\gamma + c)$ in period $t+3$, etc. ...

t: firm receives $p^L \tilde{b}^L$

t+1: firms pays $(\gamma + c)\tilde{b}^L$

t+2: firms pays $(1-\gamma)(\gamma + c)\tilde{b}^L$

t+3: firms pays $(1-\gamma)^2(\gamma + c)\tilde{b}^L$

t+4: etc.

Dynamic Model: Setup

Definition

Floatation cost on the bond market:

$$\eta\,(\tilde{b}_t^S + |\tilde{b}_t^L - b_t|)$$

The firm pays η for each bond sold (and for each long-term bond repurchased)

Dynamic Model: Equilibrium

Dynamic Model: Equilibrium

Firm maximizes shareholder value subject to creditors' break even condition:

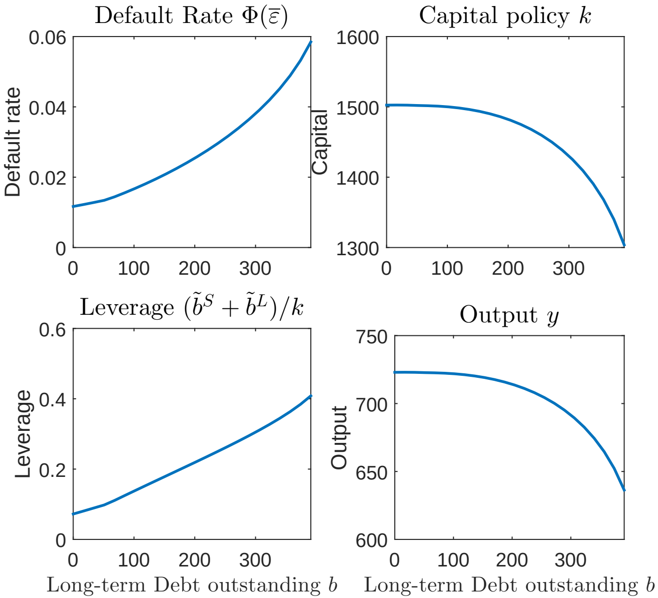
- firm cannot commit to future actions
- firm must take future firm policy as given
- time-consistent policy
- Markov Perfect equilibrium

▸ Equilibrium

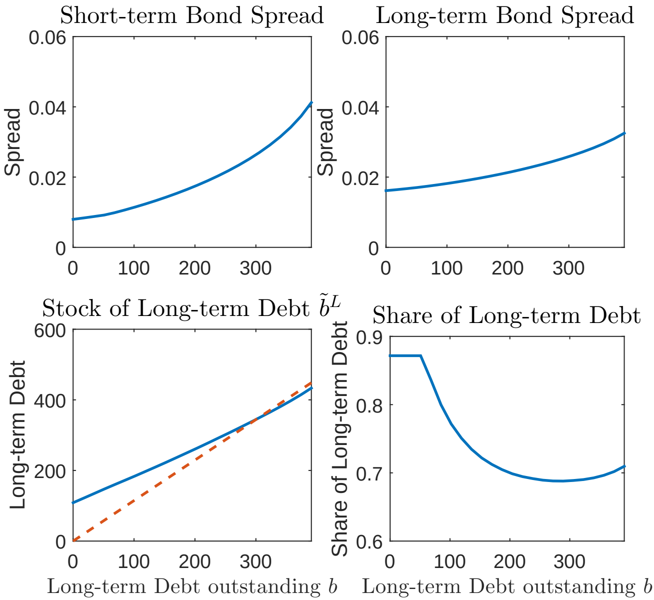
Dynamic Model: Parametrization

Variable	Description	Value	Target/Source
r	riskless rate	0.0309	
δ	depreciation	0.391	**Capital-output ratio** 2.07
γ	repayment rate	0.1283	**Long-term debt share** 67.4%
c	debt coupon	r	
τ	tax rate	0.3	*Hennessy and Whited (2005)*
σ_ε	st.dev. earnings	0.6275	**Leverage** 27.2%
α	decr. returns	0.9	*Blundell and Bond (2000)*
η	floatation cost	0.0109	*Altinkilic and Hansen (2000)*
ξ	default cost	0.62	**Credit spread** 2.30%

Dynamic Model: Policy Functions



Dynamic Model: Policy Functions



Distr.

Dynamic Model: Maturity Choice

Trade-off between short-term and long-term debt (LTD):

- LTD saves **floatation costs** on the bond market
- but LTD also creates **debt dilution** in the future
  $\Rightarrow$ higher default risk in the future

Higher future default risk hurts the firm:

- lower price of LTD sold today!
- default risk convex in b
- incentive to **reduce LTD** as b increases

Higher future default risk also hurts the holders of previously issued LTD b:

- higher b means less of the total cost of LTD is internalized by the firm!
- incentive to **increase LTD** as b increases

Outline

Empirical Analysis

One measure of debt dilution is the *OLD*-Share, the ratio of LTD outstanding b to total debt $\tilde{b}^S + \tilde{b}^L$:

$$OLD\text{-Share} = \frac{b}{\tilde{b}^S + \tilde{b}^L}$$

Theoretical prediction: the *OLD*-Share is...

- ... **positively** correlated with leverage and default risk
- ... **negatively** correlated with capital

Empirical Analysis

Empirical test:

- firm-level data from Compustat 1984-2014
- Moody's Default & Recovery Database 1988-2014
- excluding financial firms and utilities

Convert the panel into a **cross-section** of firms: for firm j we use...

- **average** of firm j's *OLD-Share* in year t, $t+1$, $t+2$, ...
- **average** of firm j's *leverage* in year t, $t+1$, $t+2$, ...
- etc.

Empirical Results: Leverage

OLS (Industry FE)	Leverage	Leverage	Leverage (low Z-score)	Leverage (high Z-score)
OLD-Share		**0.0470*****	**0.0654****	**0.0222***
		(3.83)	(3.31)	(2.12)
Tobin's q	0.0273***	0.0278***	0.0456***	0.0148
	(6.42)	(6.64)	(7.46)	(1.70)
Profitability	-0.171***	-0.172***	-0.0796**	-0.0291
	(-8.20)	(-8.43)	(-2.77)	(-0.76)
Tangibility	0.253***	0.243***	0.282***	0.118***
	(6.59)	(6.19)	(5.47)	(4.01)
Firm age	-0.00413***	-0.00411***	-0.00323***	-0.00280***
	(-7.66)	(-7.75)	(-3.38)	(-5.60)
log Sales	0.0146***	0.0121***	0.0112**	0.0156***
	(7.51)	(6.30)	(3.04)	(6.81)
adj. R^2	0.2524	0.2557	0.2344	0.3025
N	5118	5115	2556	2559

Empirical Results: Default

Logit (Industry FE)	Default	Default	Default (low Z-score)	Default (high Z-score)
OLD-Share		**0.529***	**0.830****	**-0.345**
		(2.14)	(2.76)	(-0.66)
Leverage	3.989***	3.922***	3.421***	3.470***
	(11.55)	(11.45)	(8.04)	(4.65)
Tobin's q	-1.237***	-1.238***	-1.026***	-1.112***
	(-6.29)	(-6.30)	(-4.29)	(-3.52)
Profitability	-1.407***	-1.528***	-0.861*	-4.906***
	(-4.04)	(-4.53)	(-2.27)	(-5.10)
Firm age	0.00323	0.00408	0.0107	0.0150
	(0.35)	(0.43)	(0.89)	(0.85)
log Sales	0.429***	0.410***	0.421***	0.379***
	(11.25)	(10.39)	(9.67)	(4.67)
Pseudo R^2	0.2096	0.2114	0.2377	0.1638
N	5118	5115	2556	2559

Empirical Results: Asset Growth

OLS (Industry FE)	Δ log Assets	Δ log Assets	Δ log Assets (low Z-score)	Δ log Assets (high Z-score)
OLD-Share		**-0.0697***** (-7.43)	**-0.0868***** (-4.91)	**-0.0524***** (-4.58)
Leverage	-0.0810*** (-5.23)	-0.0725*** (-4.75)	-0.0264 (-1.47)	-0.0442 (-1.52)
Tobin's q	0.0339*** (6.46)	0.0342*** (6.56)	0.0251*** (3.40)	0.0401*** (3.98)
Profitability	0.183*** (7.65)	0.189*** (8.00)	0.148*** (4.92)	0.184** (2.74)
Firm age	-0.00646*** (-9.18)	-0.00638*** (-9.07)	-0.00675*** (-6.64)	-0.00640*** (-6.92)
log Sales	0.00556** (2.73)	0.00871*** (4.47)	0.01000** (3.14)	0.00435 (1.88)
adj. R^2	0.0830	0.0964	0.0299	0.1425
N	5116	5114	2555	2559

Outline

Policy / Governance

Necessary conditions for debt dilution:

- debt is risky
- firm can borrow before previously issued debt matures
- more than one lender
- less than full-commitment

These conditions are very general $\Rightarrow$ Policy / Governance options...

- upper limit to leverage
- upper limit to debt maturity
- seniority for short-term debt

Debt Covenants / Secured Debt

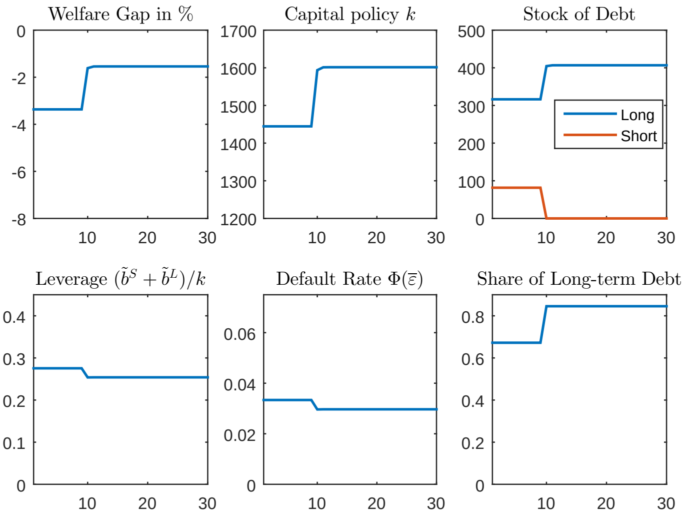
Policy: Welfare

Period welfare is value added:

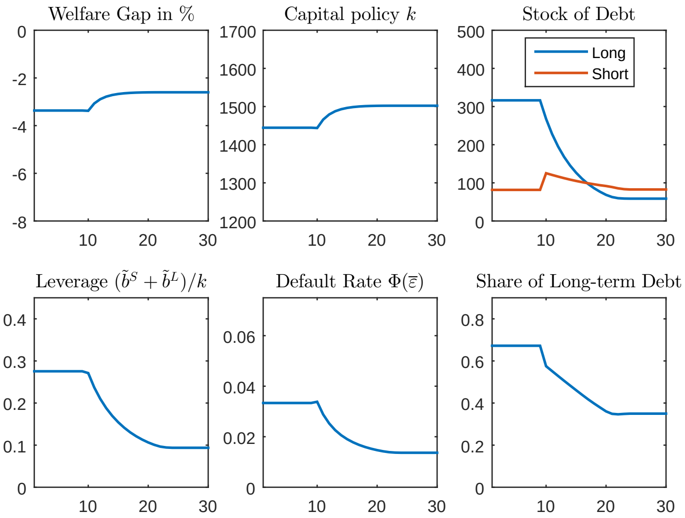
$$W = \int_0^1 \left[\, k(i)^\alpha - \delta k(i) - rk(i) \,\right] di$$

- assumption: taxes, earnings shocks, bankruptcy costs, floatation costs all purely redistributive
- financial frictions matter only because they distort capital

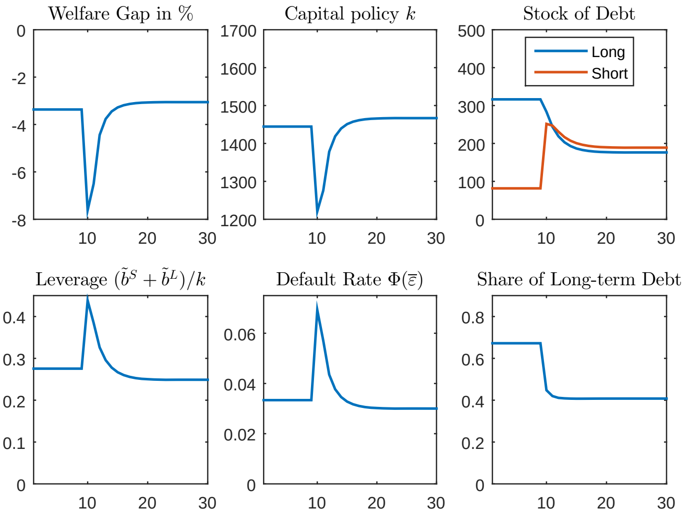
Policy: Leverage



Policy: Maturity



Policy: Seniority for Short-term Debt



Outline

Conclusion

Summary of results:

- we introduce *long-term debt* (and a maturity choice) into a standard model of firm financing and investment
- **debt dilution** increases default risk and leverage, and **reduces investment and output**

These results could matter for:

- **cyclical debt dilution** (companion paper!)
- **firm dynamics** in a model with more cross-sectional heterogeneity
- with nominal long-term debt, cyclical debt dilution creates a role for **monetary policy** even if prices are fully flexible, e.g. Gomes, Jermann and Schmid (2016)

Conclusion

Thank you!

Dynamic Model: Equilibrium

Firm maximizes shareholder value subject to creditors' break even condition:

$$
\begin{aligned}
V(b) = \max_{k,e',\tilde{b}^S,\tilde{b}^L,\bar{\varepsilon},p^S,p^L} & -e' \\
& + \frac{1}{1+r}\left[\int_{\bar{\varepsilon}}^{\infty}\left[q' + V((1-\gamma)\tilde{b}^L)\right]\varphi(\varepsilon)d\varepsilon + \Phi(\bar{\varepsilon})\, V(0)\right]
\end{aligned}
$$

$$
\text{s.t.:} \quad q' = k - \tilde{b}^S - \gamma\tilde{b}^L + (1-\tau)[k^\alpha - \delta k + \varepsilon k - c\tilde{b}^S - c\tilde{b}^L]
$$

$$
\bar{\varepsilon}: \qquad q' + V((1-\gamma)\tilde{b}^L) = V(0)
$$

$$
k = e' + p^S\tilde{b}^S + p^L(\tilde{b}^L - b) - \eta(\tilde{b}^S + |\tilde{b}^L - b|)
$$

$$
p^S = \frac{1}{1+r}\left[[1-\Phi(\bar{\varepsilon})]\,(1+c) + \Phi(\bar{\varepsilon})\,\frac{(1-\xi)\tilde{q}}{\tilde{b}^S + \tilde{b}^L}\right]
$$

$$
\begin{aligned}
p^L = \frac{1}{1+r}\Bigg[[1-\Phi(\bar{\varepsilon})]\Big(\gamma + c + (1-\gamma)\; p^L((1-\gamma)\tilde{b}^L)\Big) \\
+ \Phi(\bar{\varepsilon})\,\frac{(1-\xi)\tilde{q}}{\tilde{b}^S + \tilde{b}^L}\Bigg]
\end{aligned}
$$

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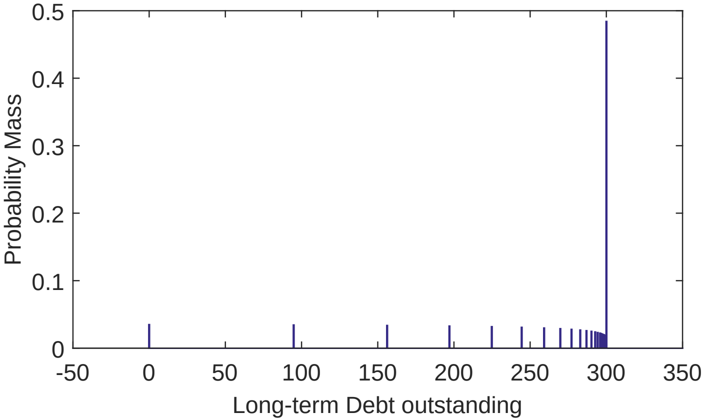
Dynamic Model: Firm Distribution



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Debt Covenants / Secured Debt

Maybe debt dilution is no problem in real life because firms have options to mitigate it:

- debt covenants
- secured debt

Empirical evidence:

- less than 20% of bonds outstanding have covenants which address debt dilution (e.g. leverage limits)
  - Nash, Netter and Poulsen (2003), Begley and Freedman (2004), Billett, King and Mauer (2007), Reisel (2014)
- in U.S. manufacturing, median share of secured debt is only 20% of total debt
  - Biguri (2016)

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