Doubling Down on Debt: Limited Liability as a Financial Friction

Jesse Perla* Carolin Pflueger† Michal Szkup*

* UBC; † Chicago, Harris

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Motivation

- Financing investment with debt is often perceived as controversial
  - Debt may help overcome frictions in financial markets (e.g., Townsend (1979), Clementi and Hopenhayn (2006))
  - Debt may create inefficiencies (e.g. Jensen and Meckling (1979), Myers (1977), Vereshchagina and Hopenhayn (2009), Aguiar et al. (2019))
  - Capital structure is irrelevant in many baseline models (e.g. Modigliani and Miller (1958))
- Even more controversial are equity payouts financed with debt
  - Criticism of share buybacks & dividends by high leverage firms

Broader Literature

- Primarily in the spirit of micro-founding frictions in macro-finance **heterogenous** across productivity, debt, or leverage
  - e.g. Buera (2009), Khan and Thomas (2013), Moll (2014), Buera et al. (2015), Atkeson et al. (2017))
- Strong connections with (and differences from) sovereign default
  - e.g. Arellano and Ramanarayanan (2012), Chatterjee and Eyigungor (2013), Hatchondo et al. (2016), Aguiar et al. (2009)) and, especially, Aguiar et al. (2019)
- Complementary to literature on corporate finance, debt overhang, and "leverage racheting"
  - e.g. Parrino and Weisbach (1999), Diamond and He (2014), He and Milbradt (2016), Milbradt and Oehmke (2015), Brunnermeier and Oehmke (2013), Admati et al. (2018), DeMarzo (2019), DeMarzo and He (2020))

This Paper

- Goals of this paper:
  - Study distortions arising from limited liability and existing debt on **investment**
  - Investigate how these distortions are affected by **equity payouts**
- Simple model of firm investment (embeds Leland (1998) + intensive investment + intensive equity payouts)
  - A single firm protected by limited liability and facing default risk
  - Firm has non-trivial capital structure
  - Firm faces (one-shot/repeated) investment opportunities
- Only source of financial friction is **limited liability**
  - i.e. complete information, no theft, audited-financials, etc.
  - Clarity on ownership of all cashflows
- Empirical evidence on equity payouts & investment by leverage

Summary of Results

- Highly leveraged firms have incentives to further increase leverage
  - One-shot investment: **overinvestment** if any preexisting liabilities
  - Repeated investment: **overinvestment** by **high leverage** firms
  - Important forces for heterogeneity of financial frictions
- Financial friction: **double-selling cashflows in default**
  - Distinct from risk-shifting
  - Dilution of pre-existing liabilities (but not collateral claims)
  - Time-consistency: incentives to "double-sell" increase price of debt
- **Equity payouts** are efficient way to **dilute existing debt-holders**
  - One-shot: Mitigate inefficient overinvestment
  - Repeated: Under-investment for low-liability firms ($\uparrow$ prices)

Outline

1. Minimal model of one-shot investment opportunity
2. Analysis and characterization of new mechanism
3. Model with repeated investment opportunities
4. Suggestive empirical evidence (see paper)

MODEL WITH DEFAULTABLE DEBT

Model of a Firm Investment Decision

The firm has:

- State (Z, L) at point of one-shot investment opportunity
  - **Snapshot in time:** Source of pre-existing L doesn't matter
- Assets-in-place/productivity/capital, Z
  - Profits before debt service also Z, discounted at rate r
- Pre-existing liabilities with PV of promised payouts $L \geq 0$

Investment and Evolution of Z

- Assume operating profits, Z, follow Geometric Brownian Motion:

$$\mathrm{d}Z(t) = \sigma Z(t)\mathrm{d}\mathbb{W}(t)$$

- Enterprise value is expected present value, $EV(Z) = \frac{Z}{r}$
  - Careful with accounting of **claims** of all **cash flows**
- Invest in g such that $Z \to (1+g)Z$
  - Assume convex cost: $q(g)Z = \frac{\zeta}{2}g^2 Z$
- Let the **optimal investment choice** of the firm be $g(Z, L)$
- Upcoming repeated model
  - Arrival rate of opportunities, and (Z, L) a controlled jump-diffusion

Financing the Investment

- Assume firm can sell **defaultable consol bonds** with an embedded claim to the liquidation value of the firm for each bond
  - i.e. **secured** bond: L has claims in default at a fixed proportion
- Firm may use a mix of equity and debt financing
  - Proportion of $q(g)Z$ **financed by debt** is a chosen ψ
- Firm can make direct equity payouts to themselves, $M \in [0, \kappa Z]$, where $\kappa \geq 0$
  - Baseline is $\kappa = 0$, i.e. all financing must go into firm assets.
- Defaultable consol paying 1 until default, then liquidation claim

$$\underbrace{\mathbf{P}(\mathbf{Z}, \mathbf{L})}_{\textbf{Secured}} = \underbrace{\mathbf{P}^{\mathbf{J}}(\mathbf{Z}, \mathbf{L})}_{\textbf{Unsecured}} + \underbrace{\mathbf{P}^{\mathbf{B}}(\mathbf{Z}, \mathbf{L})}_{\textbf{Bankruptcy Claim}}$$

Summary of Parameters and Decisions

- Only **two** essential parameters (+ one scale)
  - r: **risk-free interest rate**
  - σ: **volatility of operating profits**
  - $q(\cdot)$: convex cost, assume quadratic $q(g) \equiv \frac{\zeta g^2}{2}$
    - ζ is a largely an uninteresting scale parameter
- Decisions of equity holders
  - Continuous **default** choice comparing PV of liabilities to PV of profits

$$\max \{\mathbf{0}, \mathbf{V}(\mathbf{Z}, \mathbf{L})\}$$

  - Choose **investment size**, g, **debt financing** proportion $\psi \in \Psi$, **equity payouts** M
- Decisions of new debt holders
  - **Pricing** of new debt when financing
  - Given equity holders investment, default decisions, equity payouts
- Passive old debt holders
  - No stand taken on prices for original L

Investment Choice Summary

Equity holders take the equilibrium budget constraint $\Phi(\cdot) = 0$ as given, and solve

$$V^*(Z, L) = \max_{\substack{g \geq 0 \\ \psi \in [0,1] \\ 0 \leq M \leq \kappa Z}} \left\{ \overbrace{V(\underbrace{(1+g)Z}_{=\hat{Z}}, \hat{L})}^{\text{Post-Investment Equity}} - \overbrace{(1-\psi)q(g)Z}^{\text{Equity Financed}} + \overbrace{M}^{\text{Payouts}} \right\} \quad (1)$$

$$\text{s.t. } \underbrace{\Phi(\hat{L}, Z, L, g, \psi, M) = 0}_{\text{Equilibrium Budget Constraint}} \quad (2)$$

- The post investment liabilities, $\hat{L}(\cdot)$ come from pricing of new debt, as embedded in $\Phi(\cdot) = 0$
- Induces a $(Z, L) \to (\hat{Z}, \hat{L})$ jump

First Best

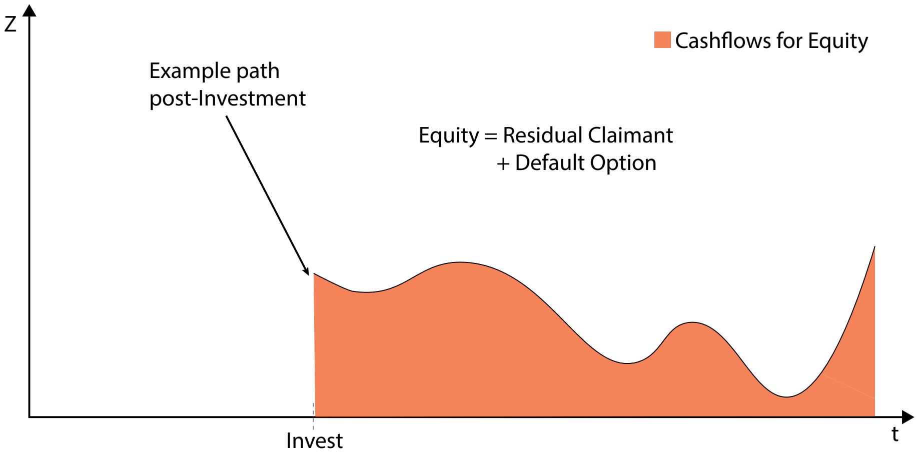
Definition (First-Best Investment)

We define the first-best undistorted investment, g^u, as investment that maximizes the net present value of the firm. That is,

$$g^u(Z) \equiv \arg\max_g \left\{ \overbrace{V((1+g)Z, 0)}^{\text{Post-Investment Equity}} - \overbrace{q(g)Z}^{\text{Equity Financed}} \right\} \tag{3}$$

i.e. equity holders have no debt and deep pockets

Example Cashflow, All Equity



- All cashflows are fairly priced
- Consider example path, valuations are expected PDV
- Would Modigliani-Miller hold? (i.e. capital structure non distorting)

Post-Investment Problem

- Firm with (Z, L) has an optimal stopping problem,

$$rV(Z,L) = Z - rL + \frac{\sigma^2}{2} Z^2 \boldsymbol{\partial}_{ZZ} V(Z,L)$$
$$V(\underline{Z}(L), L) = 0$$
$$\boldsymbol{\partial}_Z V(\underline{Z}(L), L) = 0$$

- The solution is a **default decision rule** $\underline{Z}(L)$
- Equity holders optimally walk away when they reach negative equity
  - i.e., $V(Z, L) \leq 0$ when $Z \leq \bar{Z}(L)$

Default Decision and Equity Value

Proposition (Continuation Value and Default Choice)

The normalized equity value with $\ell \equiv L/Z$ is,

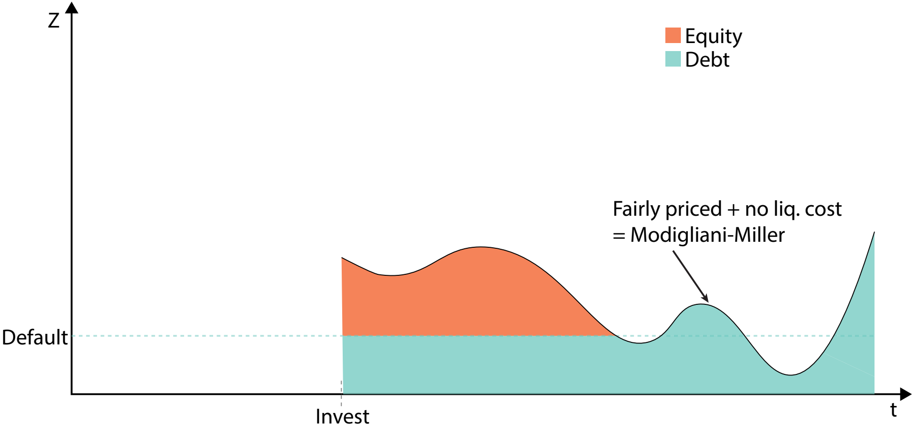
$$\frac{V(Z,L)}{Z} = \frac{1}{r} - \ell + \overbrace{\ell \underbrace{\frac{\chi}{\eta+1}\ell^{\eta}}_{\equiv s(\ell)}}^{\text{Option Value}}$$

η and χ functions of r and σ. And

$$\frac{Z}{\underline{Z}(L)} = \frac{\eta+1}{\eta}\frac{1}{r\ell}$$

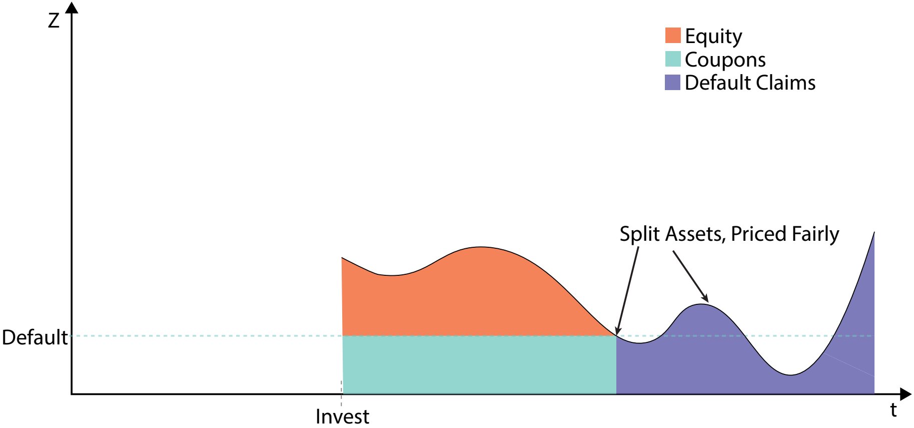
Random stopping-time: $T = \inf\{T \geq 0 | Z(t) = \underline{Z}\}$.

Would Modigliani-Miller Hold?



- Note: $\frac{Z}{\underline{Z}(L)} = \frac{\eta+1}{\eta} c$ with $c \equiv 1/(r\ell)$ is the interest coverage ratio
- Default decision: when coverage $= \eta/(1+\eta) \approx 1$ for small σ
- Reminder: one (fairly priced) Z path, agents use EPDV

Decoupling Liabilities from Default Claims



- Default claims could be sold by firm directly, or stripped by claimant
- Even if in the same asset, valuable to separate for intuition

Pricing Debt

- Define new leverage $\hat{\ell} \equiv \hat{L}/((1+g)Z)$, normalized $m \equiv M/Z$
- Price of debt given default decisions (with $P(Z,L) \equiv \frac{p(Z,L)}{r}$))

$$P(Z,L) = \underbrace{\mathbb{E}_T\left[\int_0^T e^{-r\tau}\mathrm{d}\tau\right]}_{\substack{\text{PDV of promised coupons}\\ = P^U(Z,L)}} + \underbrace{\mathbb{E}_T\left[e^{-rT}\frac{V((1-\theta)\underline{Z}(L),0)}{rL}\right]}_{\substack{\text{PDV of claims in bankruptcy}\\ = P^B(Z,L)}}$$

- Pricing new debt to finance investment in g

$$\underbrace{m}_{\substack{\text{Equity}\\ \text{Payouts}}} + \underbrace{\psi q(g)}_{\substack{\text{Debt}\\ \text{Financed}}} = \underbrace{p(\hat{\ell})}_{\substack{\text{Price of}\\ \text{New Debt}}} \times \underbrace{\left((1+g)\hat{\ell} - \ell\right)}_{\substack{\text{Amount of}\\ \text{Debt Issued}}}$$

- Provides an implicit function for the $\Phi(\cdot) = 0$

Prices and Spreads

Proposition (Price of a Defaultable Consol)

For a firm with state $\ell = L/Z$ with only defaultable consol bonds,

$$p(\ell) = 1 - \underbrace{s(\ell)}_{\text{Spread}} = \underbrace{(1-(1+\eta))s(\ell)}_{\equiv p^U(\ell)} + \underbrace{\eta s(\ell)}_{\equiv p^B(\ell)}$$

- If ℓ is small, then $p(\ell) \approx 1$. i.e. interest rate $\approx$ risk-free rate
- $\uparrow \ell$ then $p^U(\ell) \downarrow$ and $p^B(\ell) \uparrow$
- But overall, $\uparrow \ell$, then $p(\ell) \downarrow$ and $s(\ell) \uparrow$.
- No coincidence: recall **option value of default** in $v(\ell)$ solution

$$v(\ell) = \frac{1}{r} - \ell + \overbrace{\ell \underbrace{\frac{\chi}{\eta+1}\ell^{\eta}}_{\equiv s(\ell)}}^{\text{Option Value}}$$

- But how can firm manipulate this term and benefit?

Firm Investment

The problem of a firm with $\ell \equiv L/Z$ is to choose $(g, \psi, \hat{\ell}, m)$ such that,

$$v^*(\ell) = \max_{\substack{g \geq 0 \\ \psi \in [0,1] \\ 0 \leq m \leq \kappa}} \left\{ \overbrace{(1+g)v(\hat{\ell})}^{\text{Post-Investment Equity}} - \overbrace{(1-\psi)q(g)}^{\text{Equity Financed}} + \overbrace{m}^{\text{Payouts}} \right\}$$

$$\text{s.t.} \quad \underbrace{p(\hat{\ell})}_{\text{Bond Price}} \underbrace{((1+g)\hat{\ell} - \ell)}_{\text{New Bonds}} = \underbrace{\psi q(g)}_{\text{Debt Financed}} + \underbrace{m}_{\text{Payouts}}$$

$$p(\hat{\ell}) \geq p^B(\hat{\ell})$$

The first-best investment solves

$$g^u \equiv \arg\max_g \left\{ \overbrace{(1+g)v(0)}^{\text{Post-Investment Equity}} - \overbrace{q(g)}^{\text{Equity Financed}} \right\}$$

ANALYSIS

Rewrite Equity Holder's Problem

$$v^*(\ell) = \max_{\substack{g,\hat{\ell}\geq 0 \\ \psi\in[0,1] \\ 0\leq m\leq\kappa}} \left\{ \overbrace{\frac{1+g}{r} - q(g)}^{\text{Undistorted}} - p(\hat{\ell})\ell \right\}$$

$$\text{s.t. } p(\hat{\ell})((1+g)\hat{\ell} - \ell) = \psi q(g) + m$$

$$p(\hat{\ell}) \geq p^B(\hat{\ell})$$

- The first-best investment, g^u, is the unique solution to $\frac{1}{r} - q'(g^u) = 0$
- Modigliani-Miller Theorem holds if $\ell = 0$
- If $\ell > 0$: $\hat{\ell} \downarrow$ decreases v^* since $p(\hat{\ell}) \downarrow$ in $\hat{\ell}$
- Symmetrically: incentive to increase $\hat{\ell}$ independent of investment
- Payoffs, m, not directly in objective. Must manipulate $\hat{\ell}$

First-order condition for Optimal Investment

$$\underbrace{\frac{1}{r}}_{\substack{\text{Marginal increase}\\\text{PV cashflows}}} - \underbrace{q'(g)}_{\substack{\text{Marginal cost}\\\text{of investment}}} - \underbrace{p'(\hat{\ell})\frac{\partial\hat{\ell}}{\partial g}\ell}_{\substack{\text{Distortion due}\\\text{to debt}}} = 0$$

If $\ell = 0$, no distortion. Otherwise, consider incentives at $g = g^u$,

- Since $p'(\cdot) < 0$, depends on sign of $\frac{\partial\hat{\ell}}{\partial g}$
- If financing with equity, $\frac{\partial\hat{\ell}}{\partial g} > 0$, i.e. need to deleverage
- If financing with debt, $\frac{\partial\hat{\ell}}{\partial g} < 0$
- Note: if they can increase $\hat{\ell}$ independent of g, distortion disappears!
  - Hints at separation into two problems using equity payoffs

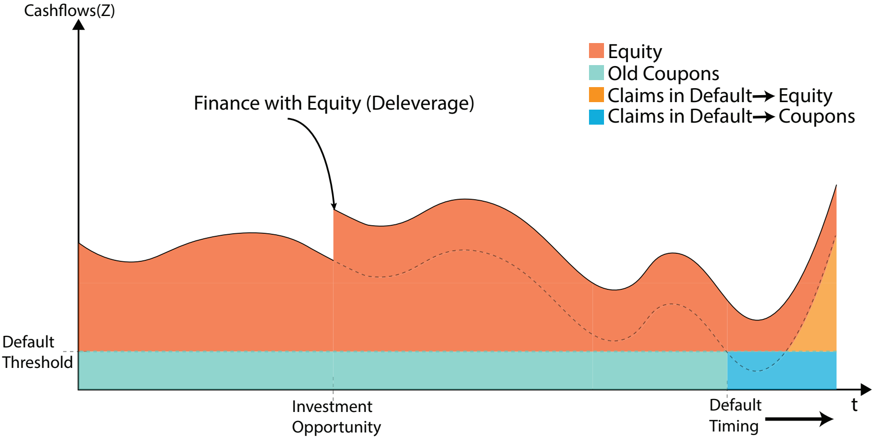
Characterizing Over/Under Investment

Proposition

Suppose that $\kappa = 0$ and denote by g^* equity holders' optimal investment.

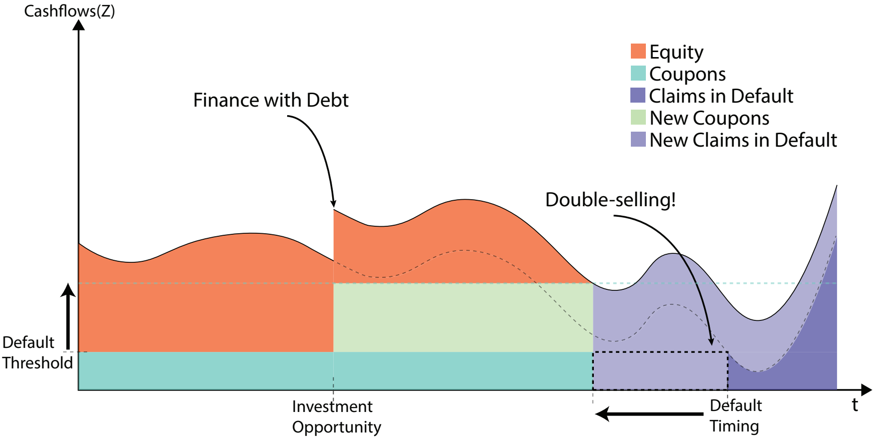
1. *If equity holders can only use equity financing then they underinvest, that is $g^* < g^u$.*
2. *If equity holders can choose financing optimally then*
   1. *They finance all their investment with debt*
   2. *They overinvest, that is $g^* > g^u$*

Equity Financing Decreases the Option Value of Default



- Deveraging: Same default threshold, pays coupons longer
- Converts old claims in default to coupons, but can't benefit

Debt Financing Dilutes Existing Claims to Coupons



- Due to increased leverage, dilutes existing debt holders and **double-selling** some of their promised coupon payments
- Converts old coupon claims to new default claims!
- Increased leveraged is a commitment to earlier default

Equity Payouts "Efficiently" Increase Leverage

Proposition

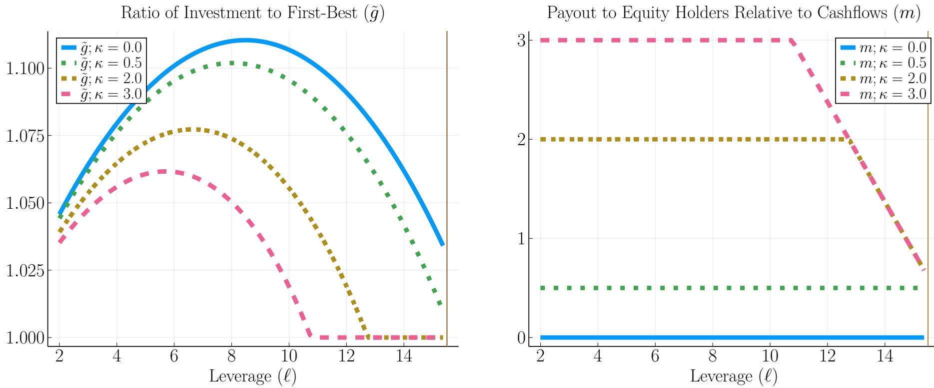
For g^*, m^*, ψ^* optimal choices, there exists $\underline{\kappa}$ such that

1. *If $\kappa < \underline{\kappa}$ then equity holders*
   1. *overinvest, that is $g^* > g^u$*
   2. *finance investment and equity payouts with debt, that is $\psi^* = 1$*
   3. *make payouts to the constraint, that is $m^* = \kappa$*
2. *If $\kappa \geq \underline{\kappa}$ then equity holders*
   1. *invest the first-best amount, that is $g^* = g^u$*
   2. *finance investment & equity payouts at least partially with debt*
   3. *make payouts to themselves $m^* < \kappa$*
   4. *are indifferent to defaulting/continuing after investment*

The threshold $\underline{\kappa}$ is $\downarrow$ in ℓ and r, and $\uparrow$ in σ.

- **Separately** dilute existing coupons & maximize enterprise value
- Sell **new collateral claims** to maximized firm value— profiting on old-coupon cashflows through m and $g > g^*$ (if constrained by κ)

Investment Relative to First-Best for $\kappa \geq 0$



- Investment relative to first-best $\tilde{g} \equiv g/g^u$
- $\kappa = 0$ captures strict and $\kappa = 3.0$ lax constraints

MODEL WITH REPEATED INVESTMENT

Limited Liability with Repeated Investment

Limited liability is characterized by equity holders' **inability to commit** *to paying liabilities* **after firm default** *— with the exception of those liabilities that are directly secured by claims in liquidation.*

Arrival of Investment Opportunities

- Time-inconsistency suggests repeated version may be interesting
- Prices will reflect lack of ability to commit, and will distort asymmetrically
- Arrival rate $\lambda \geq 0$ of investments where $\lambda = 0$ nests one-shot
- Same problem of optimal investment time, given dynamic ℓ

$$v^*(\ell) = \max_{\substack{g \geq 0 \\ \psi \in [0,1] \\ 0 \leq m \leq \kappa}} \left\{ (1+g)v(\hat{\ell}) - (1-\psi)q(g) + m \right\}$$

$$\text{s.t. } p(\hat{\ell})((1+g)\hat{\ell} - \ell) = \psi q(g) + m$$

$$p(\hat{\ell}) \geq p^B(\hat{\ell})$$

- But now both $v(\cdot)$ and $p(\cdot)$ consider future investments

Evolution of Liabilities and Cash-Flows

- $\mathbb{N}(t)$ is a Poisson process with intensity $\lambda \geq 0$
- $g(Z(t^-), L(t^-))$ is the optimal investment choice
- $\hat{L}(Z(t^-), L(t^-))$ is the corresponding post-investment liabilities
- Cash-flows, Z, now follows a jump-diffusion

$$\mathrm{d}Z(t) = \sigma Z(t)\mathrm{d}\mathbb{W}(t) + g(t^-)d\mathbb{N}(t)$$

- Liabilities, L, follows a pure jump-process

$$\mathrm{d}L(t) = (\hat{L}(t^-) - L(t^-))\mathrm{d}\mathbb{N}(t),$$

- As before, can normalize to $\ell \equiv L/Z$

Proposition (Repeated Investment)

Solution: normalized equity value $v(\ell)$, *price* $p(\ell)$, *policies* $\{g(\ell), m(\ell), \psi(\ell), \hat{\ell}(\ell)\}$, *and default threshold,* $\bar{\ell}$ *such that*

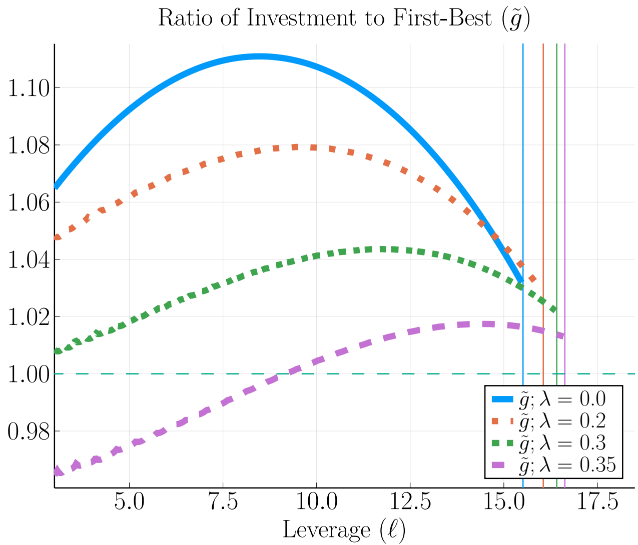
1. *Given* $v(\ell)$ *and* $p(\ell)$, *the policies* $\{g(\ell), m(\ell), \psi(\ell), \hat{\ell}(\ell)\}$ *solve the firm's investment problem*
2. *Given* $p(\ell)$ *and the policies,* $v(\ell)$ *solves differential variational inequality (DVI)*

$$0 = \min\{rv(\ell) - \frac{\sigma^2}{2}\ell^2 v''(\ell) - \lambda\left(v(\hat{\ell}(\ell)) - v(\ell)\right) - (1 - r\ell), v(\ell)\}$$

3. *Default threshold* $\bar{\ell}$ *is optimal, indifference point of the DVI*
4. *Given* $v(\ell)$ *and the policies,* $p(\ell)$ *solves*

$$rp(\ell) = r + \sigma^2 \ell p'(\ell) + \frac{\sigma^2}{2}\ell^2 p''(\ell) + \lambda\left(p(\hat{\ell}(\ell)) - p(\ell)\right)$$

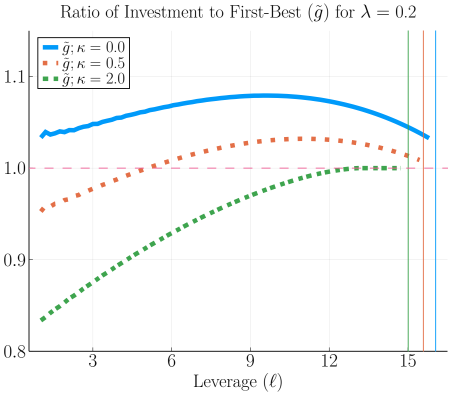
$$p(\bar{\ell}) = \frac{v(0)}{\bar{\ell}}$$

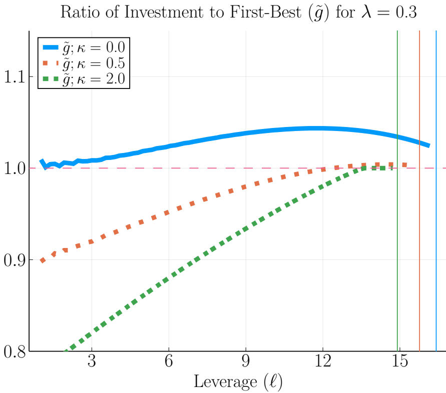


- Investment relative to first-best $\tilde{g} \equiv g/g^u$
- Vertical lines are $\bar{\ell}$ default threshold for each λ
- $\lambda = 0$ is one-shot, $\lambda = 0.3$ is baseline

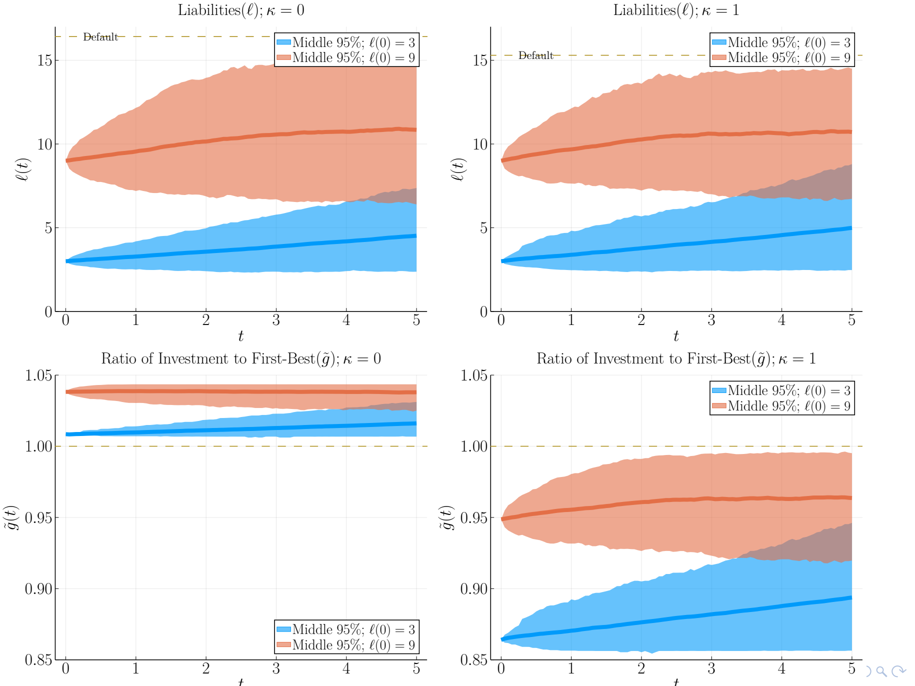
Dynamics of Leverage

- While this shows incentives to invest, it doesn't show dynamics
- Consider simulations for two different ℓ values over time
- Plot the distribution of various quantiles given optimal policy
- Consider whether $ell \nearrow$ over time? Probabilities of default for multiple κ





- $\kappa > 0$ still mitigates over-investment, but can cause under-investment
- $\kappa = 0$ no equity payouts, $\kappa = 2.0$ laxer constraint


Liabilities(ℓ); $\kappa = 0$
Default
Middle 95%; $\ell(0) = 3$
Middle 95%; $\ell(0) = 9$
$\ell(t)$
t
Liabilities(ℓ); $\kappa = 1$
Default
Middle 95%; $\ell(0) = 3$
Middle 95%; $\ell(0) = 9$
$\ell(t)$
t
Ratio of Investment to First-Best($\tilde{g}$); $\kappa = 0$
Middle 95%; $\ell(0) = 3$
Middle 95%; $\ell(0) = 9$
$\tilde{g}(t)$
t
Ratio of Investment to First-Best($\tilde{g}$); $\kappa = 1$
Middle 95%; $\ell(0) = 3$
Middle 95%; $\ell(0) = 9$
$\tilde{g}(t)$
t

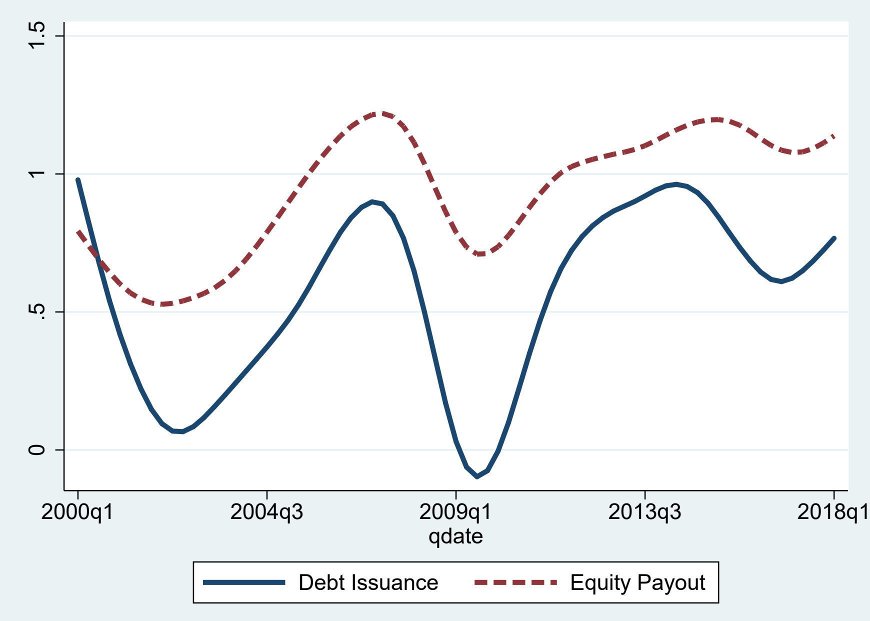
Conclusion

- Preexisting debt with new equity financing:
  - Sub-optimal investment by transferring cash-flows to old debt
- Strong incentives to increase leverage with preexisting debt
  - Leads to over-investment in a one-time investment model
  - When equity payouts are allowed, "efficient" leveraging mitigates over-leveraging.
- New financial friction induced by limited liability: **double-selling claims in default**
- The force remains in a repeated model
  - Repeated investment make debt more expensive *because* of this friction
  - The ease of dilution from equity payoffs makes them especially distortionary for low leverage firms
- Extensions in paper: seniority, bankruptcy costs, unsecured debt
- Policy Discussion in Paper: empirical evidence on equity payoffs/overinvestment consistent with the model

APPENDIX

EMPIRICAL EVIDENCE

Debt Issuance and Equity Payouts in the Data

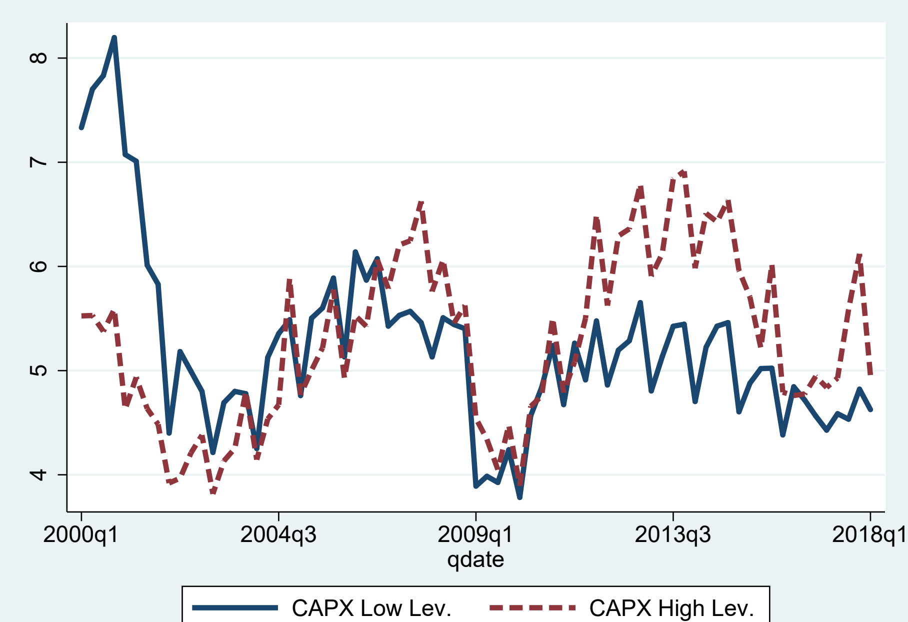


Positive Correlation Between Equity Payouts and Debt Issuance

Equity payout			
Delta Debt	0.04**	0.03**	0.04**
	(0.002)	(0.002)	(0.002)
No. Obs.	136697	136697	136697
Time FE	No	Yes	Yes
Firm FE	No	No	Yes

Regression equation: Equity payout$_{i,t} = b_0 + b_1$Delta Debt$_{i,t} + \varepsilon_{i,t}$. This table shows a panel regression of gross equity payouts onto the change in debt while controlling for time and firm fixed effects. The sample covers 2000Q1-2018Q1. Standard errors in parentheses are double-clustered by firm and quarter. * and ** denote statistical significance at the 5% and 1%-level.

Real Investment by Leverage in the Data



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