The Impact of Adverse Selection on Misallocation of Capital and Finance

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Asia School of Business in collaboration of MIT Sloan

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Motivation

- Anecdotally, asym info is important *financial friction* which leads to misallocation but hard to quantify
- This paper focuses on asym info about firm's *persistent* productivity between informed borrower (firm) and uninformed creditors (bondholders)
- How large welfare loss created by asym info in corporate bond markets?

Two Ways to Alleviate Asym Info:

Debt Structure: International Comparison

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2. Debt substitution of costly monitored lending (e.g., bank loan)

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Debt Structure: International Comparison

- **Corporate bonds (∼70%)**
  - reputation building (Diamond 91)
    - ✓ dynamic learning (Bayesian updating of assessment) about firm's productivity from public info (e.g., financial disclosure)
- **Bank loans (∼30%)**
  - costly monitored lending (Diamond 84)
    - ✓ cost-advantage in collecting private info

Research Question

How much asym info about firm's productivity affects financing, investment, aggregate productivity, and consumer welfare?

Empirical Challenge:

Approach:

Research Question

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Empirical Challenge:

1. Full info set and investor's assessment about firm's productivity are unobservable for researcher
2. Assessment and financing are endogenous

Approach:

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Approach:

- Estimates corporate financing model under dynamic adverse selection (screening + signaling problems) consistent with data facts Data Facts
  - defaultable debts with heterogeneous firms (Hennessy and Whited 07)
  - integrates screening + signaling problems about firm's productivity (Chatterjee, Corbae, Dempsey, and Rios-Rull 20 for unsecured consumer credit market)

Summary

- **Estimation:** back out size of transitory "noise" to firm's choice from variance of leverage and probability of default
- **Mechanism:**
- **Counterfactual:**
- **Future Application:** *debt maturity*; *stock issue and buyback*; *and relationship banking*

Summary

- **Estimation:** back out size of transitory "noise" to firm's choice from variance of leverage and probability of default
- **Mechanism:**
  1. **Cross-subsidization** low (high) productivity firm overissues (underissues) corporate bonds and overinvests (underinvests) in capital compared to full info $\rightarrow$ capital misallocation ($\downarrow$ aggregate productivity)
  2. **Signaling** leverage and equity send positive signal to uninformed lenders $\rightarrow$ good reputation lowers interest rates of corporate bonds
- **Counterfactual:**

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- **Counterfactual:**
  1. symmetric info about firm's productivity
     - ✓ info improves aggregate productivity (TFP) $\uparrow 29\text{bps}$ and increases consumption $\uparrow 1.4\%$
     - ✓ bank debt / total debt $21\% \xrightarrow{\downarrow 6\%\text{points}} 15\%$
  2. taxation of debt forgiveness restores efficient allocation without changing info structure.
- **Future Application:** *debt maturity*; *stock issue and buyback*; *and relationship banking*

Thank You

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Selected Literature Review

1. Dynamic Adverse Selection in Unsecured Consumer Credit Markets
   Chatterjee, Corbae, Dempsey, and Rios-Rull 20 (hereafter CCDR).
2. Defaultable Bank Loan Markets
   Heterogeneous Firm: Cooley and Quadrini 01; Hennessy and Whited 07; Corbae and D'Erasmo 20.
3. Defaultable Corporate Bond and Bank Loan Markets
   Theory: **Diamond 91**; Rajan 92. **Macromodel:** De Fiore and Uhlig 15. **Heterogeneous Firm:** **Crouzet 17**; Xiao 19. **Borrowing Constraint:** Lian and Ma 20.
4. Dynamic Corporate Financing Model Under Asym Info
   Discrete Time: **Hennessy, Livdan, and Miranda 10**. **Continuous Time:** Morellec and Schurhoff 11.
5. Capital Misallocation and Financial Friction
   Gilchrist, Sim, and Zakrajšek 13; Whited and Zhao 20.

Contribution to Literature: this paper introduces dynamic learning in unmonitored corporate bonds and substitution for monitored bank loans in unified quantitative model

Roadmap

Introduction

Model

Equilibrium

Estimation/Validation

Counterfactual

Conclusion

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Environment

Basics:

- Time is discrete, infinite horizon, annual frequency
- Agents: (i) firm managers; (ii) financial intermediaries; and (iii) representative household
- Discrete choice model: amounts of debt and equity on discrete grids of points

Technology in Production:

- Production: $\exp(z)k^{\alpha_k}$, $\alpha_k \in (0,1)$ with fixed costs f, measured in units of output
  - where firm specific productivity $z \in \{z_L, z_H\}$ follows symmetric 2-state Markov process
  - and capital k
- Price of capital is 1
- Capital depreciates by rate δ

Environment (Cont'd)

Preference:

- Manager and financial intermediaries are risk-neutral
- No aggregate shocks $\rightarrow$ households risk aversion does not affect pricing
- Manager *effectively* receives per-period utility from

$$\underbrace{\text{equity payouts}}_{\text{shareholdings}} + (\text{transitory}) \text{ preference shocks}$$

- Preference shocks are unobservable
- Two types of preference shocks $(\varepsilon, \varepsilon_\Delta)$ Timing: 2 Sub-periods Timing: Diagram
  1. ε adds noise to balance sheet choice (debt outstanding b, debt type ϕ, next period equity e')
     where $\phi = \begin{cases} M & \text{for corporate bonds (Market debt)} \\ B & \text{for bank loans (Bank debt)} \end{cases}$
  2. ε_Δ adds noise to bankruptcy choice

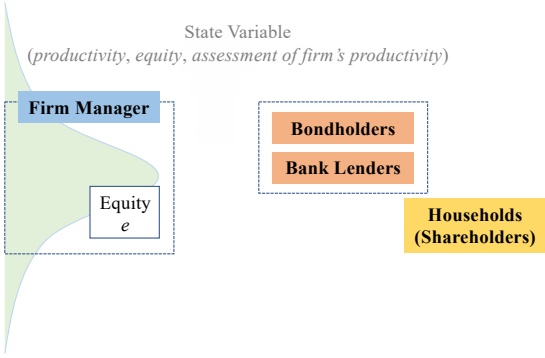
Preference Shocks

capture unobserved factors affecting firm's choice

- Discrete choice + preference shocks drawn from GEV dist $\rightarrow$ closed form solution (McFadden 73; Rust 87) Recursive Problem Conditional Value Function Simple Model
- Preference shocks help
  1. computation by smoothing value function Theory
  2. to eliminate off-the-equilibrium beliefs (=assessment of firm's productivity)
  3. to slow down dynamic learning about firm's productivity z
- *Transitory* preference shocks $(\varepsilon, \varepsilon_\Delta)$ hinder inference of *persistent* productivity z
- Micro-foundation to shocks: rational inattention (Matejka and Mckay 15)
  - info-processing to investigate payouts is costly (e.g., communication costs in board meeting)

Agents, Firm's Choice, and Flow of Funds

Equity Market | Role of Bank Loan



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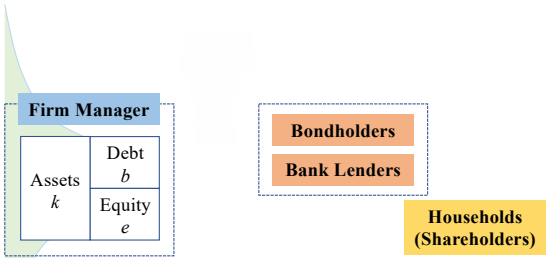

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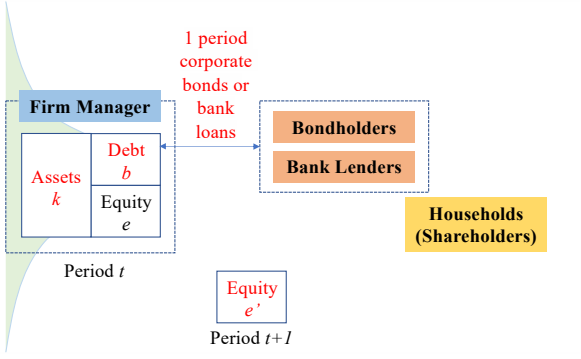

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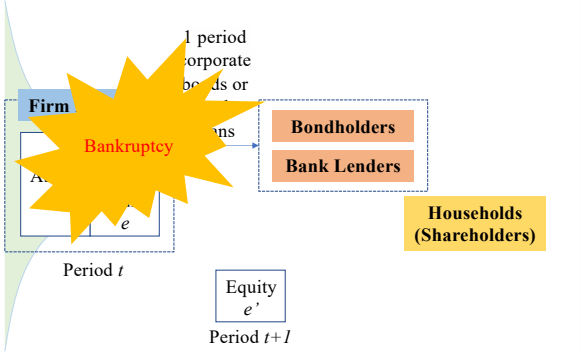

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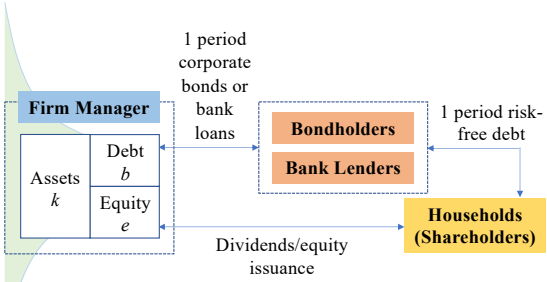

Technologies in Bank Loans and Corporate Bonds

Creditors (i.e., banks and bondholders) offer debt contract contingent on publicly observable characteristics (e.g., size of debt, leverage, assessment about firm's productivity)

1. **Asym info about persistent productivity z**
2. **Financial intermediation costs**
3. **Recovery at default (Ch. 11 reorganization)**

Corporate bond recovery at default depends on *privately informed* productivity z

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   - banks can charge different interest rates among firm's productivity z
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   - costs of banks $\mu_B >$ costs of bondholders μ_M
     - ✓ e.g., monitoring costs, compliance costs, regulatory burdens
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3. **Recovery at default (Ch. 11 reorganization)**
   - dispersed bondholders fail to coordinate Bankruptcy
   - cash-flow based debt in corporate bonds
   - asset based debt in bank loans
   - Lian and Ma 20 and EBITDA-multiple approach in practice

Corporate bond recovery at default depends on *privately informed* productivity z

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Evolution of Assessment of Firm's Productivity

follows Bayesian updating

1. Bondholders observe firm's state (equity (e), and assessment of firm's productivity (s)) and choice (size of borrowing (b), equity (e'), debt type (ϕ), and bankruptcy (Δ))
2. Bondholders Bayesian updates assessment of firm's productivity in next period (s') given (i) public info $\{e, s, b, \phi, e', \Delta\}$ and (ii) equilibrium policy functions How Firm Uses Reputation?

Corporate bond credit spreads depend on expectation of probability of default and recovery using probability weights ($\sim$ assessment of firm's productivity) Corporate Bond Pricing

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Data and Parameters

- Data for estimation: Compustat
- 12 parameters are selected outside model More
  - intermediation costs $\mu_B - \mu_M = 170\text{bps}$ (Schwert 20)
- Estimated 5 parameters $\{\alpha, \alpha_\Delta, f, f_{c11}, \lambda_1\}$ to U.S. data via Simulated Method of Moments More
  - var(debt to assets) and overall bankruptcy rates are informative to estimate variance of preference shocks $\{\alpha, \alpha_\Delta\}$
  - f_{c11} targets fraction of Ch. 11
- Linear external financing costs $\lambda_1 = 0.09$ is close to estimate in Hennessy and Whited 07
- Model is consistent with bank debt ratio, debt-to-EBITDA, spreads, PD, recovery rates, credit ratings in data Targeted and Untargeted Credit Losses Other Validations

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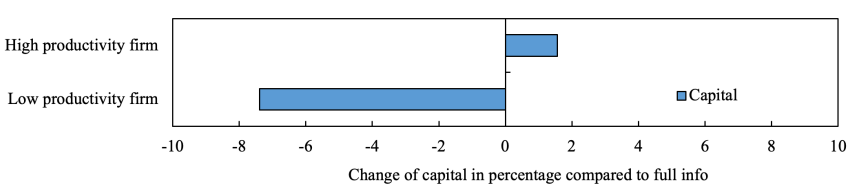
Info about Productivity Improves Efficiency

- Productivity z: private info (benchmark)$\rightarrow$ public info (counterfactual) Asym Info Model is Closet to Data
  - i.e., $q_M(\omega_M) \rightarrow q_M(\omega_M, z)$ where ω_M is observable firm characteristics
  - preference, technology, and parameters are unchanged

	Consumption	TFP	Aggregate bank debt ratio
Change (%)	1.35	0.29	-26.52

- Measured TFP and consumption increase, and less demand for bank loans in counterfactual Olley and Pakes Decomposition and Var(mpk)
- Private info induces low (high) type to overinvest (underinvest) $\rightarrow$ misallocation of capital



- Simpler model delivers different quantitative results Alternative Model

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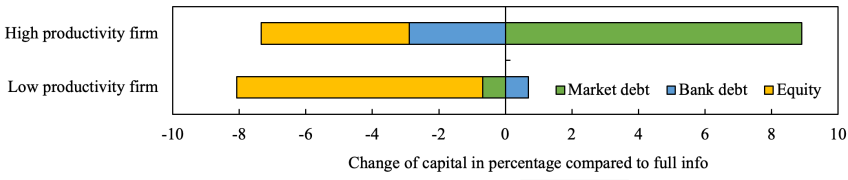

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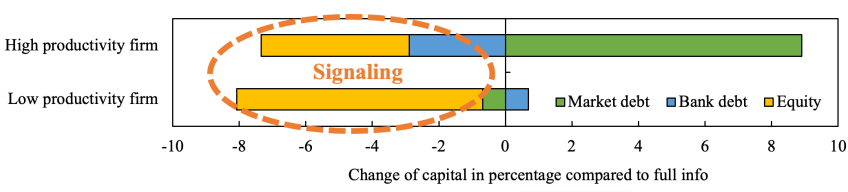

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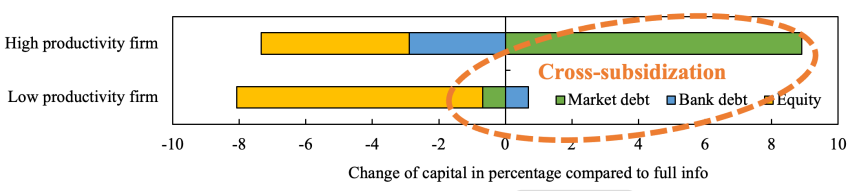

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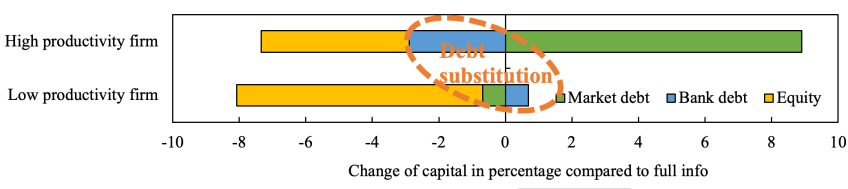

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Taxation of Cancellation of Debt (COD) Income

Return

Policy Recommendation:

- Taxation of debt forgiveness improves welfare without changing info structure Cancellation Of Debt

- Current US law exempts tax of COD in bankruptcy
  - COD=debt outstanding (b) - reduced debt repayment at default≥ 0
  - other things being equal, $\mathrm{COD}(z_L) > \mathrm{COD}(z_H)$ since $z_L < z_H$

	w/ asymmetric information			w/o asymmetric information		
	Benchmark	Counterfactual		Alternative benchmark	Counterfactual	
Panel A: Techonology						
Monitoring by bondholders				✓	✓	✓
Tax rate of COD (market debt)	0%	10%	10%	0%	10%	10%
Tax rate of COD (bank debt)	0%	0%	10%	0%	0%	10%
Panel B: Welfare and Capital Allocation						
Consumption	1.380	1.397	1.399	1.398	1.401	1.403
Change in % to benchmark	n.a.	**1.25**	**1.44**	n.a.	0.17	0.33
Output	12.81	12.82	12.82	12.77	12.75	12.75
Capital	45.03	45.04	45.02	44.60	44.48	44.47
Change in % to benchmark	n.a.	0.02	-0.04	n.a.	-0.27	-0.29
TFP	1.079	1.079	1.079	1.082	1.082	1.082
Change in % to benchmark	n.a.	0.06	0.07	n.a.	0.02	0.03
Panel C: Bankruptcy						
Bankruptcy prob. (Ch. 11) (%)	0.72	0.69	0.67	0.85	0.80	0.79
Bankruptcy prob. (Ch. 7) (%)	0.14	0.14	0.14	0.12	0.12	0.13

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Takeaways

What I Do:

- I develop quantitative model of reputation building

Main Mechanism:

Cross-subsidization in Corporate Bond Markets

⇓

Low (High) Productivity Firm Overinvests (Underinvests)

⇓

Capital Misallocation

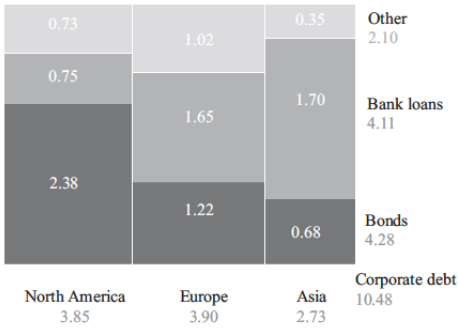
⇓

Welfare Loss

Policy Recommendation:

Taxation of Debt Forgiveness

Debt Structure: International Comparison



Reference: Becker and Josephson (2016). Debt outstanding of publicly traded debt in 37 countries (including US, UK, and Japan) by region in 2010.

Return

Data Facts

1. Corporate bonds consist for 70% of non-financial corporate debt in US
2. Average firm issues corporate bonds is highly levered
3. Annual bankruptcy rates is 0.9%
   - Ch. 11 reorganization is 0.7% and Ch. 7 liquidation is 0.1%
4. Corporate bond recovery rates at default are highly dispersed
5. CFOs think *credit ratings* — expected Probability of Default (PD) — is one of most important determinant of debt financing

Source: Compustat, Graham and Harvey 10, Moody's, Flow of Funds.

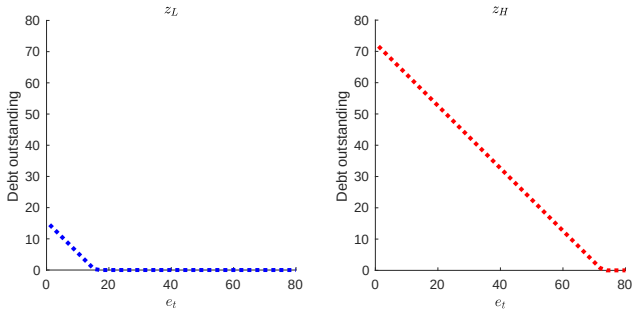
Return

Preference Shocks Affect Learning

Return

No Shock

$\alpha \to \infty$



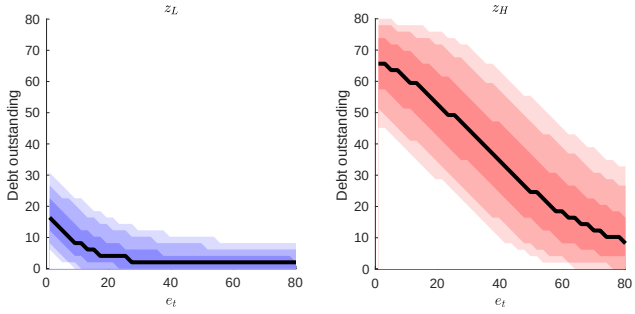
- Simple static model in Modigliani-Miller: firm solves optimal borrowing b given internal finance e
- Optimal capital: $k(z_L) < k(z_H) \to b(e, z) = k(z) - e$ if $k(z) < e$

Preference Shocks Affect Learning

Return

Small Shocks

$$\alpha = 4$$



- Plotting pdf
  - 5-95 percentile, 10-90 percentile, and 25-75 percentile
  - modal choice (black solid lines)

Preference Shocks Affect Learning

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Small Shocks

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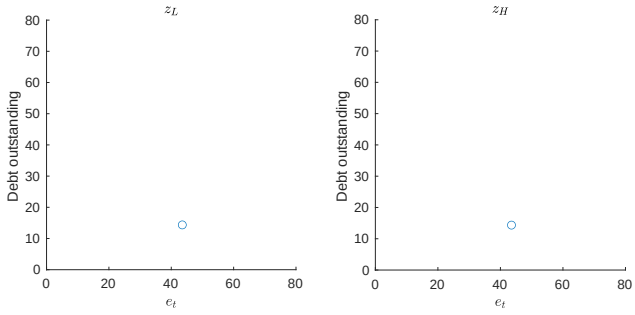

- Suppose I do not know firm's type and observe firm's choice (blue dots)
- Try to guess firm's type

Preference Shocks Affect Learning

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Small Shocks

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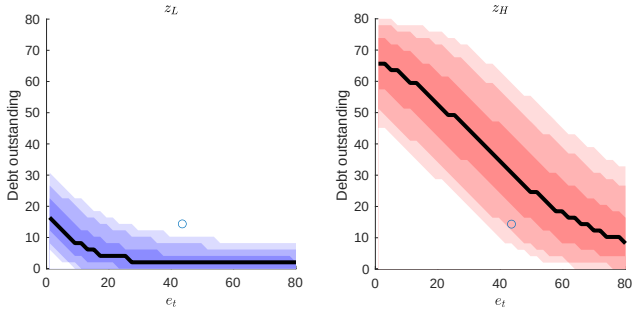

- Most likely to be z_H ($\sim$Bayesian inference) $\uparrow \Pr(z_H)$
- Small preference shocks create small noise $\rightarrow$ inference is easier

Preference Shocks Affect Learning

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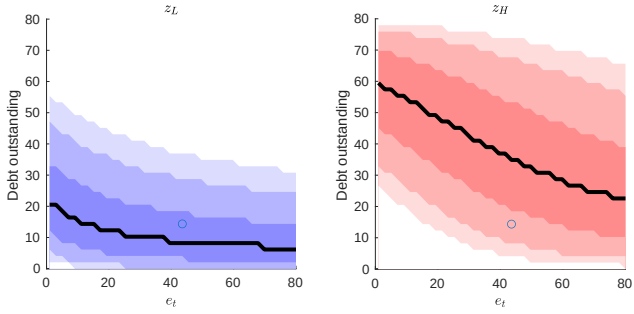
Large Shocks

$$\alpha = 1$$



- Large preference shocks create large noise
- Inference is harder and depends on prior $\uparrow$ or $\downarrow$ $\Pr(z_H)$
  - bondholders cannot distinguish whether action comes from z or preference shocks

Chapter 11 Reorganization

- Efficiency of liquidation of assets s_{c11}
- Debt repayment reflects coordination:
  1. (weak) bondholders receive cash flow $\max\{\exp(z)k^{\alpha_k} - f + s_{c11}(1-\delta)k - f_{c11}, 0\}$
  2. (strong) bank lenders receive liquidation value from take-it-or-leave-it offer (Crouzet 17; Xiao 19)

Return

Chapter 7 Liquidation

- Efficiency of liquidation of assets s_{c7}
- Debt repayment:
  - all type of debtors receive liquidation value $s_{c7}k$

Return

Bankruptcy by Size

Small Firm Files Ch. 7

	Probability of Bankruptcy				Fraction of Ch. 7 (%)	
	Ch. 11 (%)		Ch. 7 (%)			
Size Percentile	z_L	z_H	z_L	z_H	z_L	z_H
Panel A: Internal Finance						
<25%	1.11	2.20	0.57	0.00	33.83	0.00
25%-50%	0.89	0.72	0.12	0.00	12.31	0.00
50-75%	0.68	0.26	0.01	0.00	1.12	0.00
>75%	0.45	0.15	0.00	0.00	1.00	0.00
Panel B: Total Assets						
<25%	0.65	0.51	0.56	0.00	46.61	0.00
25%-50%	1.21	0.83	0.01	0.00	0.73	0.00
50-75%	0.93	0.65	0.00	0.00	0.49	0.00
>75%	2.25	0.41	0.00	0.00	0.00	0.00

Return

Birth and Death

Exiting

- Exogenous exiting at rate η with depreciation rate of value $1 - \chi$

Entry

- Entrants start from smallest internal finance
- Productivity is randomly drew from stationary distribution
- No track record (Diamond 89)

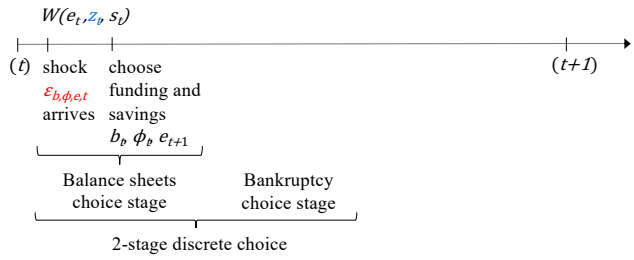
Return

Timing: 2 Sub-periods

1. **Balance sheet choice stage:**
   - preference shocks $\varepsilon_{b,\phi,e'}$ of scale parameter α
   - debt outstanding b; debt type $\phi \in \{\mathrm{M}(\text{artketdebt}), \mathrm{B}(\text{ankdebt})\}$; next period internal finance e'
2. **Bankruptcy choice stage:**
   - preference shocks ε_{Δ} of scale parameter α_{Δ}
   - bankruptcy $\Delta \in \{0(\text{no bankruptcy}), 1(\text{bankruptcy})\}$
   - choose bankruptcy chapters
   - debt settlement, exit, and entry
   - Bayesian learning of s' from public info $(b, \phi, e'\Delta)$

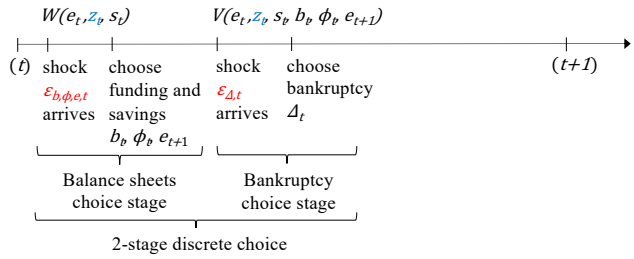
Return

Timing: Diagram



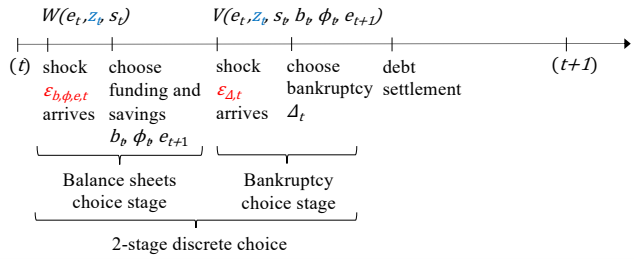
Return

Timing: Diagram



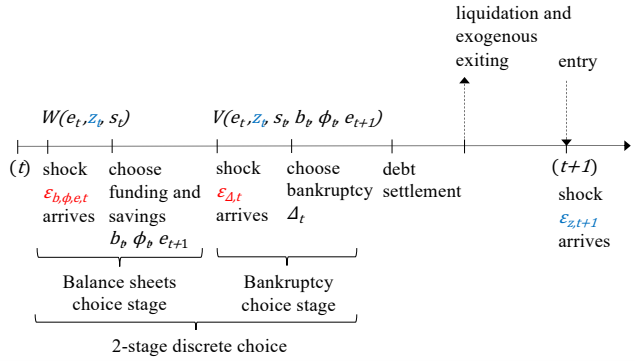
Return

Timing: Diagram



Return

Timing: Diagram



Return

Recursive Problem

Return

Dynamic *Discrete* Choice Model

- Manager maximizes lifetime utility:

$$W(e,z,s) = \mathbb{E}_{\varepsilon_{b,\phi,e'}}\left[\max_{b,\phi\in\{M,B\},e'} V + \varepsilon_{b,\phi,e'}\right] \qquad \text{(balance sheet choice stage)}$$

$$V = \mathbb{E}_{\varepsilon_\Delta}\left[\max_{\hat{\Delta}\in\{0,1\}} v_{\hat{\Delta}} + \varepsilon_{\hat{\Delta}}\right] \qquad \text{(bankruptcy choice stage)}$$

where $v_{\Delta=1} = \max\{v_{c11}, v_{c7}\}$

- v_Δ is value function at bankruptcy choice stage conditional on $\{e, z, s, b, \phi, e'\}$
- Internal finance e and debt outstanding b lie on *discrete* grids
- Action specific preference shocks $\{\varepsilon_{b,\phi,e'}, \varepsilon_\Delta\}$are drawn from GEV distribution with scale parameters $\{\alpha, \alpha_\Delta\}$

Recursive Problem

Return

Dynamic *Discrete* Choice Model

- Manager maximizes lifetime utility:

$$W(e,z,s) = \frac{1}{\alpha} \ln \left(\sum_{b,\phi \in \{M,B\},e'} \exp(\alpha V) \right) \qquad \text{(balance sheet choice stage)}$$

$$V = \frac{1}{\alpha_\Delta} \ln \left(\sum_{\hat{\Delta} \in \{0,1\}} \exp(\alpha_\Delta v_{\hat{\Delta}}) \right) \qquad \text{(bankruptcy choice stage)}$$

where $v_{\Delta=1} = \max\{v_{c11}, v_{c7}\}$

- v_Δ is value function at bankruptcy choice stage conditional on $\{e, z, s, b, \phi, e'\}$
- Internal finance e and debt outstanding b lie on *discrete* grids
- Action specific preference shocks $\{\varepsilon_{b,\phi,e'}, \varepsilon_\Delta\}$are drawn from GEV distribution with scale parameters $\{\alpha, \alpha_\Delta\}$
- Closed form solution (McFadden 73; Rust 87)

Value Function at Bankruptcy Choice Stage

Return

Nonbankruptcy

$$v_{\Delta=0} = \text{equity payout} - \text{external costs} + \text{continuation value}$$

Ch. 11

$$v_{c11} = \text{equity payout} - \text{external costs} + \text{continuation value}$$

Ch. 7

$$v_{c7} = \text{equity payout} - \text{external costs}$$

Value Function at Bankruptcy Choice Stage

Return

Nonbankruptcy

$$
\begin{aligned}
v_{\Delta=0} &= \text{equity payout} - \text{external costs} + \text{continuation value} \\
\text{equity payout} &= \exp(z)k^{\alpha_k} - f + (1-\delta)k - \text{debt repayment} - e' \qquad (1)
\end{aligned}
$$

Ch. 11

$$
\begin{aligned}
v_{c11} &= \text{equity payout} - \text{external costs} + \text{continuation value} \\
\text{equity payout} &= \exp(z)k^{\alpha_k} - f + s_{c11}(1-\delta)k - f_{c11} - \text{debt repayment} - e' \qquad (2)
\end{aligned}
$$

Ch. 7

$$
\begin{aligned}
v_{c7} &= \text{equity payout} - \text{external costs} \\
\text{equity payout} &= s_{c7}k - \text{debt repayment} \qquad (3)
\end{aligned}
$$

Value Function at Bankruptcy Choice Stage Return

Nonbankruptcy

$$
\begin{aligned}
v_{\Delta=0} &= \text{equity payout} - \text{external costs} + \text{continuation value} \\
\text{equity payout} &= \exp(z)k^{\alpha_k} - f + (1-\delta)k - \text{debt repayment} - e' \qquad (1)
\end{aligned}
$$

Ch. 11

$$
\begin{aligned}
v_{c11} &= \text{equity payout} - \text{external costs} + \text{continuation value} \\
\text{equity payout} &= \exp(z)k^{\alpha_k} - f + s_{c11}(1-\delta)k - f_{c11} - \text{debt repayment} - e' \qquad (2)
\end{aligned}
$$

Ch. 7

$$
\begin{aligned}
v_{c7} &= \text{equity payout} - \text{external costs} \\
\text{equity payout} &= s_{c7}k - \text{debt repayment} \qquad (3)
\end{aligned}
$$

- Continuation value consists expectation of future $W(e', z', s')$ over z' and s'

Manager's Problem in Recursive Formula

Return

Simple Model - Only Corporate Bonds, No Ch. 7, Zero Equity Issuance Costs

- Type score $s = \Pr(z = z_H)$

$$
\begin{aligned}
W(e,z,s) &= \mathbb{E}_{\varepsilon_{b,\phi,e'}}\left[\max_{b,e'} \mathbb{E}_{\varepsilon_\Delta}\left[\max_{\hat{\Delta}} v_{\hat{\Delta}} + \underbrace{\varepsilon_{\hat{\Delta}}}_{\text{pereference shocks}}\right] + \underbrace{\varepsilon_{b,\phi,e'}}_{\text{preference shocks}}\right] \\
\Pi_{\Delta=0} &= e^z(b+e)^{\alpha_k} + (1-\delta)(b+e) \\
\Pi_{\Delta=1} &= e^z(b+e)^{\alpha_k} + s_{c11}(1-\delta)(b+e) - f_{c11} \\
v_{\Delta=0} &= \Pi_{\Delta=0} - q_M^{-1} b - e' + q\sum_{z',s'} g_z g_s W(e',z',s') \\
v_{\Delta=1} &= \Pi_{\Delta=1} - \underbrace{\min\{q_M^{-1} b, \max\{\Pi_{\Delta=1}, 0\}\}}_{\text{debt repayment under Ch. 11}} - e' + q\sum_{z',s'} g_z g_s W(e',z',s')
\end{aligned}
$$

s_{c11}: liquidation efficiency (Ch. 11), f_{c11}: fixed costs for Ch. 11, q_M: market debt price, q: discount factor, g_z: transition prob of z, g_s: transition prob of type score

- g_s follows Bayes' rule given (i) public info and (ii) equilibrium policy functions

Bankruptcy

Chapter 7 Liquidation (Endogenous Exiting) More Birth and Death

- Business terminates
- Liquidation value of assets $s_{c7}k$

Chapter 11 Reorganization More

- Business continues (value depreciates by π)
- Reduce debt burden
  - borrower uses liquidation threat under Ch. 7 (take-it-or-leave-it offer) to bank lender
  - corporate bond recovery at default depends on cash flow
- Liquidation value of assets $s_{c11}k$
- Fixed costs $f_{c11} \rightarrow$ small firm files Ch. 7 More

Return

Financial Frictions in Equity Markets

- Equity issuance is very costly in data
- Linear costs of equity financing λ_1 (Gomes 01)
  - financial frictions in reduced form

Return

(Quantitative) Role of Bank Loan Markets

- Debt substitution mitigates reputation building
- Allows model estimation and validation (not every firms in Compustat universe issue corporate bonds in data)

Return

Theory

Existence

Theorem:

- *There exists a stationary recursive competitive equilibrium*

Sketch of proof: preference shocks eliminate off-the-equilibrium beliefs (CCDR 20)

Consistency of Firm Distribution and Assessment of Firm's Productivity

Proposition:

- *Stationary cross-sectional firm distribution satisfies:*

$$\underbrace{\Pr(z = z_H)}_{\text{assessment}} = \Gamma(e, z_H, \Pr(z = z_H))/ \underbrace{\sum_{\hat{z} \in \{z_L, z_H\}} \Gamma(e, \hat{z}, \Pr(z = z_H))}_{\text{fraction of high producitvity firm from stationary dist.}}$$

Sketch of proof: mathematical induction + rational agents such that (i) entrant's belief is consistent with ergodic distribution; (ii) belief updating is Bayesian where Γ: firm distribution

Return

Parameters

Description	Notation	Value	S.E.	Target/Reference
Panel A: Parameters Calibrated Outside the Model				
Capital elasticity of profits	α_k	0.650		Standard setting
Depreciation rate	δ	0.150		Standard setting
Persistency of productivity	ρ	0.700		İmrohoroğlu and Tüzel (2014)
Std. dev. of productivity shock	σ	0.270		İmrohoroğlu and Tüzel (2014)
Risk-free rate	r_f	0.040		T-Bill rate
Exogenous exiting rate	η	0.008		Exiting rate
Market intermediation costs	μ_M	0.006		AAA Corporate bond spread
Bank intermediation costs	$\mu_B - \mu_M$	0.017		Schwert (2020)
Liquidation efficiency (exiting)	χ	0.500		Crouzet (2017)
Liquidation efficiency (Ch. 7)	s_{c7}	0.380		Bris et al. (2006)
Reorganization efficiency	s_{c11}	0.869		Bris et al. (2006)
Loss of continuation value	π	0.300		Lang and Stulz (1992)
Panel B: Parameters Estimated Inside the Model				
Extreme value scale parameter	α	2.251	(0.300)	Variance of debt to assets
Extreme value scale parameter	α_Δ	0.102	(0.015)	Bankruptcy rate (Ch. 11+Ch. 7)
Fixed costs for production	f	4.099	(0.298)	Equity issuance/assets
Fixed costs for Ch. 11	f_{c11}	28.698	(4.468)	Bankruptcy rate (Ch. 11)
Linear external financing costs	λ_1	0.092	(0.021)	Variance of dividends to assets

Return

Model Matches (Targeted and Untargeted) Moments

Description	**Model**	**Data**	Source
Panel A: Target Moments			
Bankruptcy prob. (Ch. 11) (%)	0.72	0.72	Compustat
Bankruptcy prob. (Ch. 7) (%)	0.14	0.14	Compustat
Variance of debt-to-assets	0.06	0.07	Compustat
Variance of dividends/total assets	0.01	0.02	Compustat
Equity issuance /total assets	0.15	0.16	Compustat
Panel B: Untarget Moments (Financial Ratios)			

- Model does a good job matching targeted moments

Note: CM (2018) refers to Crouzet and Mehrotra (2018).

Return

Model Matches (Targeted and Untargeted) Moments

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Variance of debt-to-assets	0.06	0.07	Compustat
Variance of dividends/total assets	0.01	0.02	Compustat
Equity issuance /total assets	0.15	0.16	Compustat
Panel B: Untarget Moments (Financial Ratios)			
Debt-to-assets	0.39	0.24	Compustat
Bank debt ratio	0.33	[0.28, 0.43]	CM (2018)
Aggregate bank debt ratio	0.21	0.31	Flow of Funds
Debt-to-EBITDA	2.45	1.77	Compustat
Dividends/total assets	0.09	0.03	Compustat
Spreads (Non-bankrupt) (bps)	174	n.a.	n.a.
Spreads (Ch. 11) (bps)	378	n.a.	n.a.
Spreads (Ch. 7) (bps)	227	n.a.	n.a.
Spreads of bank debt (bps)	269	[251, 301]	Strahan (1999)

Note: CM (2018) refers to Crouzet and Mehrotra (2018).

Return

- Model does a good job matching targeted moments
- Model does a good job matching untargeted moments:
  - bank debt ratio (intermediation costs $\mu_B - \mu_M$)
  - debt-to-EBITDA (fixed costs f)
  - spreads of bank debt (intermediation costs μ_M)

Model Captures (Untargeted) Credit Losses

	Market Debt		Bank Debt		
Description	**Model**	**Data**	**Model**	**Data**	Source
Panel A: Leverage					
Debt-to-assets	**0.42**	**0.39**	**0.32**	**0.21**	Compustat
Panel B: Bankruptcy Probabilities					
Panel C: Recovery Rates					
Panel D: Expected Recovery Rates					

Note: AK (2014) compute summary statistics from Moody's Ultimate Recovery Database.
AK(2014) refers to Altman and Kalotay (2014).

- Split sample into bond and loan dependent firms
- Bond issuers are highly leveraged
  - intermediation costs

Return

Model Captures (Untargeted) Credit Losses

	Market Debt		Bank Debt		
Description	**Model**	**Data**	**Model**	**Data**	Source
Panel A: Leverage					
Debt-to-assets	0.42	0.39	0.32	0.21	Compustat
Panel B: Bankruptcy Probabilities					
Chapter 11 Reorganization (%)	0.76	0.61	0.64	0.74	Compustat
Chapter 7 Liquidation (%)	**0.08**	**0.08**	**0.25**	**0.15**	Compustat
Fraction of Chapter 11	0.90	0.88	0.72	0.83	Compustat
Panel C: Recovery Rates					
Panel D: Expected Recovery Rates					

- Split sample into bond and loan dependent firms
- Bond issuers are highly leveraged
  - intermediation costs
- Bank dependent firm files more Ch. 7 bankruptcy

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Return

Model Captures (Untargeted) Credit Losses

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Chapter 7 Liquidation (%)	0.08	0.08	0.25	0.15	Compustat
Fraction of Chapter 11	0.90	0.88	0.72	0.83	Compustat
Panel C: Recovery Rates					
Mean	**0.32**	**0.45**	**0.64**	**0.75**	AK (2014)
Standard deviation	0.37	0.38	0.24	0.33	AK (2014)
Interquartile range	**0.69**	**0.73**	0.43	0.51	AK (2014)
10th percentile	0.00	0.00	0.38	0.20	AK (2014)
90th percentile	0.88	1.00	1.00	1.00	AK (2014)
Panel D: Expected Recovery Rates					

Note: AK (2014) compute summary statistics from Moody's Ultimate Recovery Database. AK(2014) refers to Altman and Kalotay (2014).

- Split sample into bond and loan dependent firms
- Bond issuers are highly leveraged
  - intermediation costs
- Bank dependent firm files more Ch. 7 bankruptcy
- *Realized* recovery rates
  - lower recovery on average in market debt
  - cash flow based debt is essential to match large heterogeneity in recovery rates Asset Based Debt

Return

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10th percentile	0.00	0.00	0.38	0.20	AK (2014)
90th percentile	0.88	1.00	1.00	1.00	AK (2014)
Panel D: Expected Recovery Rates					
Mean (lowest type score)	**0.12**	n.a.	n.a.	n.a.	
Mean (highest type score)	**0.86**	n.a.	n.a.	n.a.	

Note: AK (2014) compute summary statistics from Moody's Ultimate Recovery Database. AK(2014) refers to Altman and Kalotay (2014).

Return

- Split sample into bond and loan dependent firms
- Bond issuers are highly leveraged
  - intermediation costs
- Bank dependent firm files more Ch. 7 bankruptcy
- *Realized* recovery rates
  - lower recovery on average in market debt
  - cash flow based debt is essential to match large heterogeneity in recovery rates Asset Based Debt
- Type difference of corporate bond *expected* recovery rates is large (highest to lowest is 74%pts)

Other Validations

- Leverage and credit rating (=expected PD) dynamics before and after bankruptcy Ch. 11 Dynamics
Ch. 7 Dynamics
- Expected PD and recovery rates at default by credit ratings E[PD] and E[RR]

Return

How Firm Uses Assessment of Firm's Productivity as Signal?

Leverage ↑ and equity ↑

⇓

⇓

⇓

Simulated Panel | Exogenous Shock to Type Score | Market Debt Outstanding

- Other signal? Bankruptcy and debt structure are less informative Hypotheses of Signaling
- Signaling is not free: costs of bankruptcy; decreasing returns to scale; and costs of external equity issuance

Return

How Firm Uses Assessment of Firm's Productivity as Signal?

Leverage ↑ and equity ↑

⇓

Reputation (assessment of firm's productivity) ↑

⇓

⇓

Simulated Panel | Exogenous Shock to Type Score | Market Debt Outstanding

- Other signal? Bankruptcy and debt structure are less informative Hypotheses of Signaling
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Return

How Firm Uses Assessment of Firm's Productivity as Signal?

Leverage ↑ and equity ↑

⇓

Reputation (assessment of firm's productivity) ↑

⇓

Corporate bond interest rates ↓

⇓

Simulated Panel | Exogenous Shock to Type Score | Market Debt Outstanding

- Other signal? Bankruptcy and debt structure are less informative Hypotheses of Signaling
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Return

How Firm Uses Assessment of Firm's Productivity as Signal?

Leverage ↑ and equity ↑

⇓

Reputation (assessment of firm's productivity) ↑

⇓

Corporate bond interest rates ↓

⇓

Corporate bonds ↑

Simulated Panel Exogenous Shock to Type Score Market Debt Outstanding

- Other signal? Bankruptcy and debt structure are less informative Hypotheses of Signaling
- Signaling is not free: costs of bankruptcy; decreasing returns to scale; and costs of external equity issuance

Return

Debt Pricing

Corporate bond markets: cross-subsidization

Bank Loan Pricing

- Competitive pricing from free entering in both debt markets→zero profit
- One-period corporate bond price menu $q_M(e, s, b, e')$ is contingent on size of borrowing (b), equity (e, e'), and assessment of firm's productivity ($s \equiv \Pr(z = z_H)$)
  - where q_M^{-1}: gross interest rate, μ_M: intermediation costs, q: price of risk-free debt, PD: Probability of Default, RR: Recovery Rate at default, and Recovery: RR×Exposure At Default

$$\underbrace{(1 - E[\text{PD}])q_M^{-1}b}_{\text{debt repayment (no default)}} + \underbrace{E[\text{Recovery}]}_{\text{debt repayment (default)}} - \underbrace{(1+\mu_M)q^{-1}b}_{\text{funding costs}} = \underbrace{0}_{\text{profit}}$$

Debt Pricing

Corporate bond markets: cross-subsidization

Bank Loan Pricing

- Competitive pricing from free entering in both debt markets→zero profit
- One-period corporate bond price menu $q_M(e, s, b, e')$ is contingent on size of borrowing (b), equity (e, e'), and assessment of firm's productivity ($s \equiv \Pr(z = z_H)$)
  - where q_M^{-1}: gross interest rate, μ_M: intermediation costs, q: price of risk-free debt, PD: Probability of Default, RR: Recovery Rate at default, and Recovery: RR×Exposure At Default

$$q_M = \frac{(1 - E[\text{PD}])b}{(1 + \mu_M)q^{-1}b - E[\text{Recovery}]} \tag{4}$$

$$E[\text{Recovery}] \simeq E[\text{PD}] \times E[\text{RR}] \times \underbrace{q_M^{-1} b}_{\text{Exposure At Default}} \tag{5}$$

Debt Pricing

Corporate bond markets: cross-subsidization

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$$E[\mathrm{Recovery}] \simeq E[\mathrm{PD}] \times E[\mathrm{RR}] \times \underbrace{q_M^{-1} b}_{\text{Exposure At Default}} \tag{5}$$

$$E[\mathrm{PD}] = (1 - s) \times \mathrm{PD}(z_L, \cdots) + s \times \mathrm{PD}(z_H, \cdots)$$

$$E[\mathrm{RR}] = (1 - s) \times \mathrm{RR}(z_L, \cdots) + s \times \mathrm{RR}(z_H, \cdots)$$

Debt Pricing

Corporate bond markets: cross-subsidization

Bank Loan Pricing

- Competitive pricing from free entering in both debt markets→zero profit
- One-period corporate bond price menu $q_M(e, s, b, e')$ is contingent on size of borrowing (b), equity (e, e'), and assessment of firm's productivity ($s \equiv \Pr(z = z_H)$)
  - where q_M^{-1}: gross interest rate, μ_M: intermediation costs, q: price of risk-free debt, PD: Probability of Default, RR: Recovery Rate at default, and Recovery: RR×Exposure At Default

$$
\begin{aligned}
E[\mathrm{PD}] &\neq \mathrm{PD}(z) \\
E[\mathrm{RR}] &\neq \mathrm{RR}(z)
\end{aligned}
$$

where $z \in \{z_L, z_H\}$ if $0 < s < 1$, $\mathrm{PD}(z_H) \neq \mathrm{PD}(z_L)$, and $\mathrm{RR}(z_H) \neq \mathrm{RR}(z_L)$

Debt Pricing (Cont'd)

Bank loan markets: benefits of monitoring and costs of intermediation μ_B

- One-period bank loan price menu $q_B(e, z, s, b, \phi, e')$ is contingent on productivity (z)

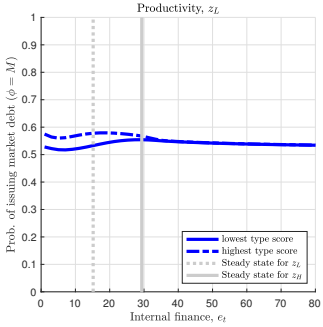
$$q_B(z, \cdots) = \frac{(1 - \mathrm{PD}(z, \cdots))b}{(1 + \mu_B)q^{-1}b - \mathrm{Recovery}(z, \cdots)} \tag{4}$$

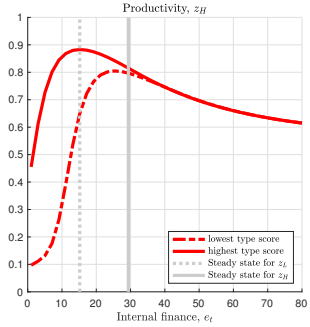
$$\mathrm{Recovery}(z, \cdots) \simeq \mathrm{PD}(z, \cdots) \times \underbrace{s_{c7}(e + b)}_{\text{liquidation value}} \tag{5}$$

- Debt types trade-offs: (i) monitoring; (ii) intermediation costs; (iii) recovery at default
- Who borrows from bank lenders? High productivity firm with low assessment of firm's productivity

Return

Debt Structure Choice





- Type score = assessment of firm's productivity ($s \equiv \Pr(z = z_H)$)
- Corporate bonds are mostly cheaper for safer firms because intermediation costs are smaller
- When firm borrowers from banks?
  - small-sized firm because corporate bond recovery at default is low (interest rates are high)
  - low type score firm because it pays info rents
  - preference shocks

Return

Leverage and Equity Send Informative Signals s'

- Type score ($s = \Pr(z_H)$) updating follows Bayes rule
- s' is mapping from public info $\{e, s, b, \phi, e' \text{ and } \Delta\}$
- Simulated panel regressions to study determinants of type score s':

$$\begin{aligned} s_{i,t} &= \alpha_i + \beta_0 + \beta_1 \text{Leverage}_{i,t-1} + \beta_2 \ln(\text{Equity}_{i,t-1}) + \beta_3 \text{Bankruptcy}_{i,t-1} \\ &+ \beta_4 \text{Market funding ratio}_{i,t-1} + \beta_5 \ln(\text{Firm age}_{i,t-1}) + \beta_6 s_{i,t-1} + \varepsilon_{i,t} \end{aligned}$$

- Type score updating is mostly explained by leverage and equity: Regression
  - $+1\sigma$ leverage raises belief by 20%pts ($= \underbrace{0.81}_{\beta_1} \times 0.25$)
  - $+1\sigma$ equity raises belief by 11%pts ($= \underbrace{0.19}_{\beta_2} \times 0.60$)
  - typical reputation proxies are not good (i.e., bankruptcy, market funding ratio, firm age)

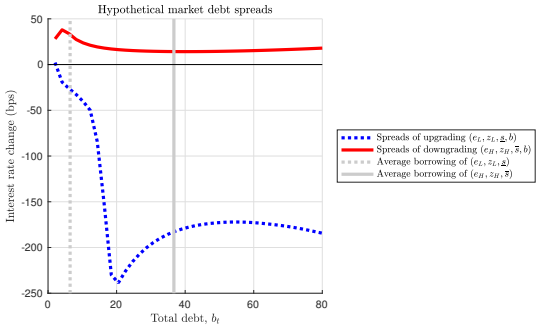
Return

Regressions

	Dependent variable: Type score s_t			
	(1)	(2)	(3)	(4)
Leverage$_{t-1}$	0.739***		0.943***	**0.806*** **
	(493.43)		(881.76)	(789.83)
ln(Internal finance$_{t-1}$)		0.212***	0.306***	**0.191*** **
		(325.37)	(716.11)	(386.23)
Chapter 11 bankruptcy$_{t-1}$			0.0283***	0.0314***
			(13.07)	(16.44)
Market funding ratio$_{t-1}$			0.00853***	0.0000488
			(15.95)	(0.10)
ln(Firm age$_{t-1}$)			-0.00424***	-0.0000297
			(-15.38)	(-0.12)
Type score s_{t-1}				0.346***
				(360.18)
Number of observations	475568	475568	475568	475568
R^2	0.339	0.182	0.696	0.762
Fixed effects	No	No	Yes	Yes

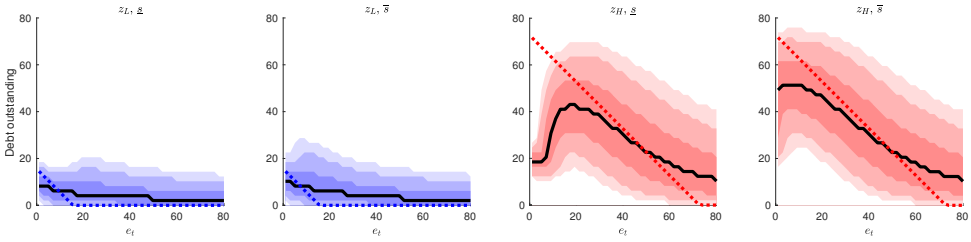
Return

Good (Bad) Type Score Reduces (Increases) Interest Rate



Return

Firms with High Type Issue More Corporate Bonds



Return

Signaling Theory in Corporate Finance

Signaling Alleviates Asym Info

Possibility (This Paper):

- Leverage (Ross 77; Hennessy, Livdan and Miranda 10) ✓
- Internal finance (Leland and Pyle 76) ✓
- Bankruptcy filing (Diamond 89, 91) ✗
- Debt structure (Houston and James 96) ✗
- Firm age (Datta, Iskandar-Datta, and Patel 99) ✗

Return

Asset Based Debt

Alternative Benchmark

- Corporate bond recovery: cash flow based → asset based

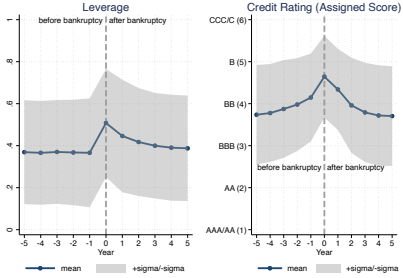
	Data	Benchmark	Counterfactual	Alternative benchmark	Counterfactual
		(i)	(ii)	(iii)	(iv)
Panel A: Techonology					
Monitoring by bondholders			✓		✓
Bond flexibility under Ch. 11				✓	✓
Panel B: Capital Structure and Welfare					
Debt	n.a.	20.80	22.74	18.04	18.36
Debt (zL)	n.a.	3.22	3.22	3.66	3.66
Debt (zH)	n.a.	17.58	19.52	14.37	14.69
Equity	n.a.	24.24	21.86	24.36	24.01
Equity (zL)	n.a.	9.52	8.57	8.98	8.85
Equity (zH)	n.a.	14.72	13.28	15.38	15.16
Aggregate bank debt ratio	0.31	0.21	0.15	0.24	0.22
Consumption	n.a.	1.380	1.398	1.281	1.283
Change in % compared to full info	n.a.	n.a.	1.35	n.a.	0.14
Output	n.a.	12.81	12.77	12.29	12.29
Capital	n.a.	45.03	44.60	42.40	42.37
Change in % compared to full info	n.a.	n.a.	-0.97	n.a.	-0.08
Capital (zL)	n.a.	12.74	11.80	12.65	12.51
Capital (zH)	n.a.	32.30	32.80	29.75	29.86
TFP	n.a.	1.079	1.082	1.076	1.077
Change in % compared to full info	n.a.	n.a.	0.29	n.a.	0.05
Panel C: Bankruptcy					
Bankruptcy prob. (Ch. 11) (%)	0.72	0.72	0.85	0.72	0.76
Bankruptcy prob. (Ch. 7) (%)	0.14	0.14	0.12	0.19	0.18
Panel D: Market Debt Recovery Rates					
Mean	0.45	0.32	0.36	0.62	0.61
Standard deviation	0.38	0.37	0.34	0.20	0.20
Interquartile range	0.73	0.69	0.66	0.27	0.24
10th percentile	0.00	0.00	0.00	0.41	0.41
90th percentile	1.00	0.88	0.81	1.00	0.98

Return

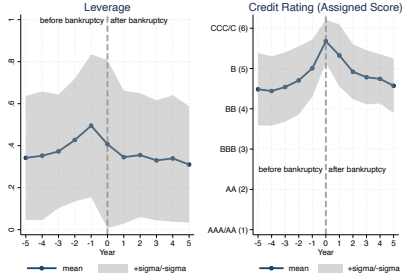
(Untarget) Model Dynamics Around Ch. 11 Are Close to Data

- Credit ratings is mapping of $E[\mathrm{PD}]$ to 6 buckets (e.g., top 4% of safest bonds are categorized as "AAA/AA")

Model



Data

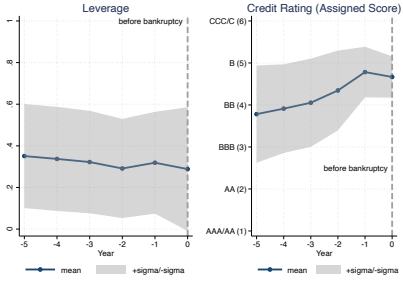


- Mean reversions in leverage and credit rating
  - which arise from productivity process and costly equity issuance

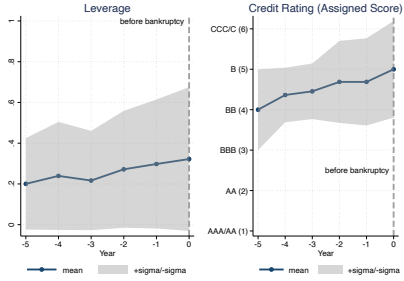
Return

Dynamics

Model



Data



- Model is also consistent with dynamics around Ch. 7

Return

E[PD] and E[RR] Conditional on Credit Rating

In real-world data:

- E[PD]=Historical Bankruptcy Rate
- E[Recovery Rate]=Recovery Rating
  - recovery ratings are only available for speculative grades

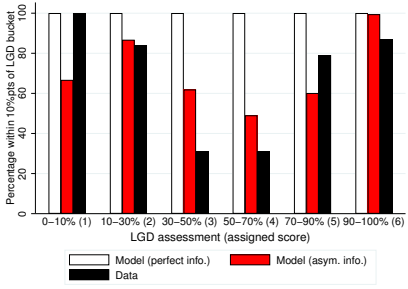
		S&P Credit Rating					
		Investment Grade			Speculative Grade		
		AAA/AA	A	BBB	BB	B	CCC/C
Panel A: Share (%)							
Model		4.00	15.00	24.00	27.00	27.00	3.00
Data		3.97	14.32	23.75	27.26	27.27	3.43
Panel B: Bankruptcy and Default of Market Debt							
Expected bankruptcy rates (%)							
Model		0.08	0.15	0.33	0.83	2.07	5.81
Historical annual bankruptcy rates (%)							
Data	1 year	0.00	0.00	0.07	0.12	0.57	14.13
	3 years	0.05	0.03	0.13	0.53	1.32	7.35
Panel C: Expected Recovery Rates at Default of Market Debt							
Model	Mean	1.00	0.98	0.85	0.39	0.25	0.26
	Std. Dev.	0.01	0.03	0.19	0.36	0.29	0.23
Data	Mean	n.a.	n.a.	n.a.	0.43	0.38	0.38
	Std. Dev.	n.a.	n.a.	n.a.	0.26	0.30	0.32
	Number of observations	n.a.	n.a.	n.a.	1150	728	248

- Distributions of PD and Recovery Rates in model are consistent with data

Return

Asym Info (Benchmark) Model is Closer to Data

- Moody's LGD assessment is $E[1 - \text{Recovery Rates}]$



Note: Data sample is from 2008 to 2010.

- Realized recovery rates≠expected recovery rates

Return

Misallocation

$$\text{TFP} = \text{Aggregate Capital}^{\alpha_k}/\text{Aggregate Output}$$

	Benchmark	Counterfactual		
		Perfect Monitoring	Partial Monitoring	
	(i)	(ii)	(iii)	(iv)
Panel A: Techonology				
Monitoring on PD		✓	✓	
Monitoring on recovery at default		✓		✓
Panel B: Capital Structure and Welfare				
Debt	20.80	22.74	22.38	21.13
Debt (zL)	3.22	3.22	3.22	3.19
Debt (zH)	17.58	19.52	19.16	17.95
Equity	24.24	21.86	22.36	23.66
Equity (zL)	9.52	8.57	8.78	9.32
Equity (zH)	14.72	13.28	13.59	14.34
Aggregate bank debt ratio	0.21	0.15	0.16	0.19
Consumption	1.380	1.398	1.404	1.389
Change in % compared to benchmark	n.a.	1.35	1.80	0.65
Output	12.81	12.77	12.79	12.78
Capital	45.03	44.60	44.74	44.79
Change in % compared to benchmark	n.a.	-0.97	-0.64	-0.54
Capital (zL)	12.74	11.80	12.00	12.50
Capital (zH)	32.30	32.80	32.74	32.29
Panel C: Allocation Efficiency				
TFP	1.079	1.082	1.081	1.079
Change in % compared to benchmark	n.a.	0.29	0.24	0.05
Avrg. output-weighted productivity	1.179	1.185	1.184	1.181
Avrg. productivity	1.037	1.037	1.037	1.037
Cov (productivity,output weights)	0.143	0.149	0.148	0.144
Variance of mpk×100	2.87	2.52	2.58	2.79
Variance of productivity	7.28	7.28	7.28	7.28
Variance of log capital	4.76	5.37	5.23	4.83
Cov (z,capital)	-9.18	-10.13	-9.93	-9.32
Panel D: Bankruptcy				
Bankruptcy prob. (Ch. 11) (%)	0.72	0.85	0.82	0.73
Bankruptcy prob. (Ch. 7) (%)	0.14	0.12	0.13	0.14

Return

Interaction of Financial Markets

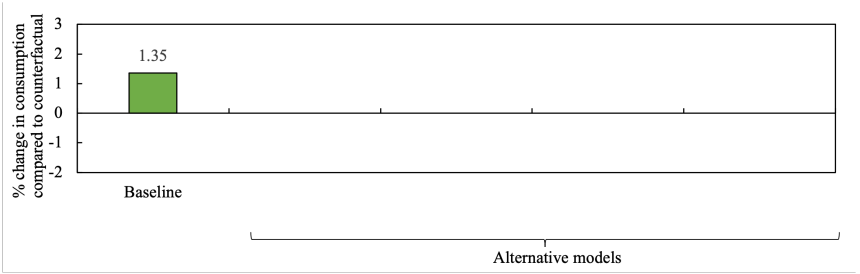
	No bank debt		Zero external equity financing costs	
	Alternative benchmark	Counterfactual	Alternative benchmark	Counterfactual
Panel A: Techonology				
Monitoring by bondholders		✓		✓
Panel B: Capital Structure and Welfare				
Debt	21.77	23.65	19.48	20.80
Equity	24.77	21.69	28.57	26.73
Consumption	1.476	1.482	1.857	1.843
Change in % to full info	n.a.	0.42	n.a.	-0.72
Output	13.11	12.94	13.32	13.25
Capital	46.54	45.34	48.05	47.53
Change in % to full info	n.a.	-2.58	n.a.	-1.09
TFP	1.080	1.084	1.075	1.077
Change in % to full info	n.a.	0.36	n.a.	0.18

- Substitution between corporate bonds and bank loans amplifies the change in consumption
  - improvement is less than 1/3 in model w/o bank debt
- More info might be inefficient in misspecified model w/o costly equity issuance

Return

Simpler Model Delivers Different Quantitative Results

No Bank Debt and Zero Equity Costs

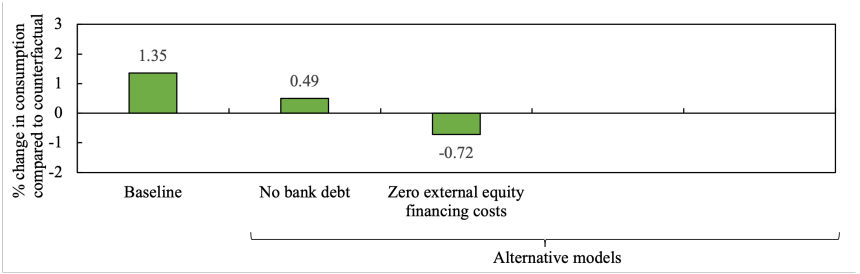


- How much economy is willing to pay for intermediation costs (e.g., monitoring costs)?
  - $\uparrow$ intermediation costs $\rightarrow \downarrow$ consumption
  - break even intermediation costs $+7$bps

Return

Simpler Model Delivers Different Quantitative Results

No Bank Debt and Zero Equity Costs



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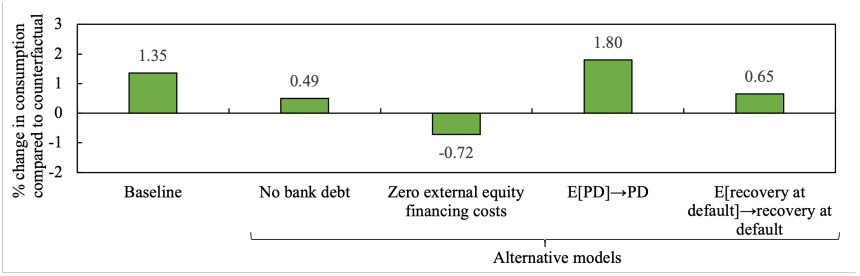
Return

Simpler Model Delivers Different Quantitative Results

No Bank Debt and Zero Equity Costs



- How much economy is willing to pay for intermediation costs (e.g., monitoring costs)?
  - ↑ intermediation costs → ↓ consumption
  - break even intermediation costs +7bps

Return