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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1. Reputation building in corporate bond markets
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**Debt Structure:**

- 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

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

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:
Appendix

## Research Question

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

### 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:

- 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:**
  1. Cross-subsidization: low (high) productivity firm overissues (underissues) corporate bonds and overinvests (underinvests) in capital compared to full info
  2. Signaling: leverage and equity send positive signal to uninformed lenders

- **Counterfactual:**
  1. symmetric info about firm’s productivity: ✓ info improves aggregate productivity (TFP) "29 bps and increases consumption" ✓ bank debt / total debt 21% # 6% 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
Summary

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- **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:**

- **Future Application:** debt maturity; stock issue and buyback; and relationship banking
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- **Mechanism:**
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- **Counterfactual:**
  1. symmetric info about firm’s productivity
     - ✓ info improves aggregate productivity (TFP) ↑ 29bps and increases consumption ↑ 1.4%
     - ✓ bank debt / total debt 21% ↓ 6%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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https://www.ikuotakei.com/
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
Roadmap

Introduction

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Conclusion
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 \( \delta \)
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
  
  \[
  \text{equity payouts} + (\text{transitory}) \text{ preference shocks} \]
  
  shareholdings

- Preference shocks are unobservable
- Two types of preference shocks $(\varepsilon, \varepsilon_\Delta)$
  1. $\varepsilon$ adds noise to balance sheet choice (debt outstanding $b$, debt type $\phi$, 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. $\varepsilon_\Delta$ 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)

- Preference shocks help
  1. computation by smoothing value function
  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

State Variable

(productivity, equity, assessment of firm’s productivity)

Firm Manager

Equity \( e \)

Bondholders

Bank Lenders

Households (Shareholders)
Agents, Firm’s Choice, and Flow of Funds

Firm Manager

| Assets $k$ | Debt $b$ | Equity $e$ |

Bondholders

Bank Lenders

Households (Shareholders)
Agents, Firm’s Choice, and Flow of Funds

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Agents, Firm’s Choice, and Flow of Funds

Firm Manager

Assets

$k$

Debt

$\text{Period } t$

Equity

$e$

1 period corporate bonds or bank loans

Bank Lenders

Bondholders

Households (Shareholders)

Equity

$e'$

Period $t+1$

Equity Market

Role of Bank Loan
Agents, Firm’s Choice, and Flow of Funds
Agents, Firm’s Choice, and Flow of Funds

1 period risk-free debt
Dividends/equity issuance
1 period corporate bonds or bank loans

Firm Manager

Assets

Debt

Equity

Bondholders

Bank Lenders

Households (Shareholders)
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 $\mu_M$
     - e.g., monitoring costs, compliance costs, regulatory burdens

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3. **Recovery at default (Ch. 11 reorganization)**
   - dispersed bondholders fail to coordinate
   - 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 $z$
Roadmap

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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 \( \phi \), and bankruptcy \( \Delta \))

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

Corporate bond credit spreads depend on expectation of probability of default and recovery using probability weights \( \sim \) assessment of firm’s productivity
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Data and Parameters

- Data for estimation: Compustat

- 12 parameters are selected outside model
  - intermediation costs $\mu_B - \mu_M = 170$ bps (Schwert 20)

- Estimated 5 parameters $\{\alpha, \alpha_\Delta, f, f_{c11}, \lambda_1\}$ to U.S. data via Simulated Method of Moments
  - $\text{var}(\text{debt to assets})$ 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
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Info about Productivity Improves Efficiency

- Productivity \( z \): private info (benchmark) → public info (counterfactual)
  - i.e., \( q_M(\omega_M) \rightarrow q_M(\omega_M, z) \) where \( \omega_M \) is observable firm characteristics
  - preference, technology, and parameters are unchanged

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- Measured TFP and consumption increase, and less demand for bank loans in counterfactual

- Private info induces low (high) type to overinvest (underinvest) → misallocation of capital

- Simpler model delivers different quantitative results
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![Bar chart showing change in capital for high and low productivity firms](chart.png)
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Taxation of Cancellation of Debt (COD) Income

Policy Recommendation:

▶ Taxation of debt forgiveness improves welfare without changing info structure

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

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<th>Panel A: Technology</th>
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<td>Tax rate of COD (market debt)</td>
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<td>Consumption</td>
<td>1.380 1.397 1.399</td>
<td>1.398 1.401 1.403</td>
</tr>
<tr>
<td>Change in % to benchmark</td>
<td>n.a. 1.25 1.44</td>
<td>n.a. 0.17 0.33</td>
</tr>
<tr>
<td>Output</td>
<td>12.81 12.82 12.82</td>
<td>12.77 12.75 12.75</td>
</tr>
<tr>
<td>Capital</td>
<td>45.03 45.04 45.02</td>
<td>44.60 44.48 44.47</td>
</tr>
<tr>
<td>Change in % to benchmark</td>
<td>n.a. 0.02 -0.04</td>
<td>n.a. -0.27 -0.29</td>
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<tr>
<td>TFP</td>
<td>1.079 1.079 1.079</td>
<td>1.082 1.082 1.082</td>
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<td>n.a. 0.06 0.07</td>
<td>n.a. 0.02 0.03</td>
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| 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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<td>Bankruptcy prob. (Ch. 11) (%)</td>
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<td>Bankruptcy prob. (Ch. 7) (%)</td>
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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

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.
Preference Shocks Affect Learning

No Shock

\[ \alpha \rightarrow \infty \]

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

Small Shocks

\[ \alpha = 4 \]

- Plotting pdf
  - 5-95 percentile, 10-90 percentile, and 25-75 percentile
  - modal choice (black solid lines)
Suppose I do not know firm’s type and observe firm’s choice (blue dots)
Try to guess firm’s type
Most likely to be $z_H$ (∼Bayesian inference) $\uparrow \Pr(z_H)$

Small preference shocks create small noise $\rightarrow$ inference is easier
Preference Shocks Affect Learning

Large Shocks

\[ \alpha = 1 \]

- Large preference shocks create large noise
- Inference is harder and depends on prior \( \uparrow \text{or} \downarrow \Pr(z_H) \)
  - 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)
Chapter 7 Liquidation

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

**Small Firm Files Ch. 7**

<table>
<thead>
<tr>
<th>Size Percentile</th>
<th>Probability of Bankruptcy</th>
<th>Fraction of Ch. 7</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Ch. 11 (%)</td>
<td>Ch. 7 (%)</td>
</tr>
<tr>
<td>Panel A: Internal Finance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25%</td>
<td>1.11</td>
<td>2.20</td>
</tr>
<tr>
<td>25%-50%</td>
<td>0.89</td>
<td>0.72</td>
</tr>
<tr>
<td>50-75%</td>
<td>0.68</td>
<td>0.26</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>0.45</td>
<td>0.15</td>
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<tr>
<td>Panel B: Total Assets</td>
<td></td>
<td></td>
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<tr>
<td>&lt;25%</td>
<td>0.65</td>
<td>0.51</td>
</tr>
<tr>
<td>25%-50%</td>
<td>1.21</td>
<td>0.83</td>
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<td>50-75%</td>
<td>0.93</td>
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<tr>
<td>&gt;75%</td>
<td>2.25</td>
<td>0.41</td>
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Birth and Death

Exiting

- Exogenous exiting at rate $\eta$ 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)
Timing: 2 Sub-periods

1. Balance sheet choice stage:
   - preference shocks $\varepsilon_{b,\phi,e'}$ of scale parameter $\alpha$
   - debt outstanding $b$; debt type $\phi \in \{\text{M(artketdebt)}, \text{B(ankdebt)}\}$; next period internal finance $e'$

2. Bankruptcy choice stage:
   - preference shocks $\varepsilon_{\Delta}$ of scale parameter $\alpha_{\Delta}$
   - 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 $(b, \phi, e'\Delta)$
Timing: Diagram

\[ W(e_t, z_t, s_t) \]

\((t)\) shock \hspace{1cm} \text{choose} \hspace{1cm} \epsilon_{b, \phi, e, t} \hspace{1cm} \text{funding and} \hspace{1cm} b_b \phi_b e_{t+1} \hspace{1cm} \text{savings} \hspace{1cm} \text{arrives} \hspace{1cm} W(e_t, z_t, s_t) \]

Balance sheets choice stage \hspace{1cm} Bankruptcy choice stage

2-stage discrete choice
Timing: Diagram

\[ W(e_t, z_t, s_t) \]
\[ V(e_t, z_t, b_t, \phi_t, e_{t+1}) \]

(t) shock \( \varepsilon_{b,\phi,e,t} \) arrives
choose funding and savings \( b_t, \phi_t, \varepsilon_{t+1} \)

(t+1) choose bankruptcy \( \Delta_t \)

Balance sheets choice stage

Bankruptcy choice stage

2-stage discrete choice
Timing: Diagram

\[ W(e_t, z_b, s_b) \quad V(e_t, z_b, b_b, \phi_b, e_{t+1}) \]

(t) shock choose funding and savings \( \epsilon_{b,\phi,e,t} \) arrives \( b_b, \phi_b, e_{t+1} \)

Balance sheets choice stage

Bankruptcy choice stage

2-stage discrete choice

\( \Delta_t \) debt bankruptcy settlement

\( (t+1) \)
The timing diagram illustrates the sequence of events in the model.

- At time (t), shock $\epsilon_{b,\phi,e,t}$ arrives, and the firm chooses funding and savings $b_t, \phi_t, e_{t+1}$.
- Balance sheets choice stage.
- Bankruptcy choice stage.
- 2-stage discrete choice.

- At time (t+1), shock $\Delta_t$ arrives, the firm chooses bankruptcy settlement $\Delta_t$.
- Liquidation and exogenous exiting.
- Entry shock $\epsilon_{z,t+1}$ arrives.
Dynamic *Discrete* Choice Model

- Manager maximizes lifetime utility:

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

\[
V = \mathbb{E}_{\epsilon_{\Delta}} \left[ \max_{\hat{\Delta} \in \{0,1\}} \nu_{\hat{\Delta}} + \epsilon_{\hat{\Delta}} \right] \quad \text{(bankruptcy choice stage)}
\]

where \(\nu_{\Delta=1} = \max\{\nu_{c11}, \nu_{c7}\}\)

- \(\nu_{\Delta}\) 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 \(\{\epsilon_{b, \phi, e'}, \epsilon_{\Delta}\}\) are drawn from GEV distribution with *scale* parameters \(\{\alpha, \alpha_{\Delta}\}\)
Recursive Problem

Dynamic *Discrete* Choice Model

- Manager maximizes lifetime utility:

\[
W(e, z, s) = \frac{1}{\alpha} \ln \left( \sum_{b, \phi \in \{M, B\}, e'} \exp(\alpha V) \right)
\]

(balance sheet choice stage)

\[
V = \frac{1}{\alpha_\Delta} \ln \left( \sum_{\Delta \in \{0, 1\}} \exp(\alpha_\Delta v_{\Delta}) \right)
\]

(bankruptcy choice stage)

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

- \( v_{\Delta} \) 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

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

**Nonbankruptcy**

\[ v_{Δ=0} = \text{equity payout} - \text{external costs} + \text{continuation value} \]

\[ \text{equity payout} = \exp(z)k^{αk} - f + (1 - δ)k - \text{debt repayment} - e' \]  \hspace{1cm} (1)

**Ch. 11**

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

\[ \text{equity payout} = \exp(z)k^{αk} - f + sc_{c11}(1 - δ)k - fc_{c11} - \text{debt repayment} - e' \]  \hspace{1cm} (2)

**Ch. 7**

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

\[ \text{equity payout} = sc_{c7}k - \text{debt repayment} \]  \hspace{1cm} (3)
Value Function at Bankruptcy Choice Stage

Nonbankruptcy

\[ \nu_{\Delta=0} = \text{equity payout} - \text{external costs} + \text{continuation value} \]

\[ \text{equity payout} = \exp(z)k^{\alpha_k} - f + (1 - \delta)k - \text{debt repayment} - e' \]  

(1)

Ch. 11

\[ \nu_{c11} = \text{equity payout} - \text{external costs} + \text{continuation value} \]

\[ \text{equity payout} = \exp(z)k^{\alpha_k} - f + s_{c11}(1 - \delta)k - f_{c11} - \text{debt repayment} - e' \]  

(2)

Ch. 7

\[ \nu_{c7} = \text{equity payout} - \text{external costs} \]

\[ \text{equity payout} = s_{c7}k - \text{debt repayment} \]  

(3)

- **Continuation value** consists expectation of future \( W(e', z', s') \) over \( z' \) and \( s' \)
Manager’s Problem in Recursive Formula

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

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

$$W(e, z, s) = \mathbb{E}_{\epsilon, b, e'} \left[ \max_{b, e'} \mathbb{E}_{\epsilon} \left[ \max_{\Delta} \nu_{\Delta} + \epsilon_{\Delta} \right] \right] + \epsilon_{b, \phi, e'}$$

$$\Pi_{\Delta=0} = e^z(b + e)^{\alpha_k} + (1 - \delta)(b + e)$$

$$\Pi_{\Delta=1} = e^z(b + e)^{\alpha_k} + s_{c11}(1 - \delta)(b + e) - f_{c11}$$

$$\nu_{\Delta=0} = \Pi_{\Delta=0} - q_{M}^{-1}b - e' + q \sum_{z', s'} g_z g_s W(e', z', s')$$

$$\nu_{\Delta=1} = \Pi_{\Delta=1} - \min\{q_{M}^{-1}b, \max\{\Pi_{\Delta=1, 0}\}\} - e' + q \sum_{z', s'} g_z g_s W(e', z', s')$$

$s_{c11}$: 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)
- Business terminates
- Liquidation value of assets $s_{c7}k$

### Chapter 11 Reorganization
- Business continues (value depreciates by $\pi$)
- 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
Equity issuance is very costly in data

- Linear costs of equity financing $\lambda_1$ (Gomes 01)
  - financial frictions in reduced form
(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)
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:

\[ \Pr(z = z_H) = \frac{\Gamma(e, z_H, \Pr(z = z_H))}{\sum_{\hat{z} \in \{z_L, z_H\}} \Gamma(e, \hat{z}, \Pr(z = z_H))} \]

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

<table>
<thead>
<tr>
<th>Description</th>
<th>Notation</th>
<th>Value</th>
<th>S.E.</th>
<th>Target/Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Parameters Calibrated Outside the Model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital elasticity of profits</td>
<td>$\alpha_k$</td>
<td>0.650</td>
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<td>Standard setting</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$\delta$</td>
<td>0.150</td>
<td></td>
<td>Standard setting</td>
</tr>
<tr>
<td>Persistency of productivity</td>
<td>$\rho$</td>
<td>0.700</td>
<td></td>
<td>İmrohoroğlu and Tüzel (2014)</td>
</tr>
<tr>
<td>Std. dev. of productivity shock</td>
<td>$\sigma$</td>
<td>0.270</td>
<td></td>
<td>İmrohoroğlu and Tüzel (2014)</td>
</tr>
<tr>
<td>Risk-free rate</td>
<td>$\tau_f$</td>
<td>0.040</td>
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<td>T-Bill rate</td>
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<tr>
<td>Exogenous exiting rate</td>
<td>$\eta$</td>
<td>0.008</td>
<td></td>
<td>Exiting rate</td>
</tr>
<tr>
<td>Market intermediation costs</td>
<td>$\mu_M$</td>
<td>0.006</td>
<td></td>
<td>AAA Corporate bond spread</td>
</tr>
<tr>
<td>Bank intermediation costs</td>
<td>$\mu_B - \mu_M$</td>
<td>0.017</td>
<td></td>
<td>Schwert (2020)</td>
</tr>
<tr>
<td>Liquidation efficiency (exiting)</td>
<td>$\chi$</td>
<td>0.500</td>
<td></td>
<td>Crouzet (2017)</td>
</tr>
<tr>
<td>Liquidation efficiency (Ch. 7)</td>
<td>$s_{c7}$</td>
<td>0.380</td>
<td></td>
<td>Bris et al. (2006)</td>
</tr>
<tr>
<td>Reorganization efficiency</td>
<td>$s_{c11}$</td>
<td>0.869</td>
<td></td>
<td>Bris et al. (2006)</td>
</tr>
<tr>
<td>Loss of continuation value</td>
<td>$\pi$</td>
<td>0.300</td>
<td></td>
<td>Lang and Stulz (1992)</td>
</tr>
<tr>
<td><strong>Panel B: Parameters Estimated Inside the Model</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extreme value scale parameter</td>
<td>$\alpha$</td>
<td>2.251</td>
<td>(0.300)</td>
<td>Variance of debt to assets</td>
</tr>
<tr>
<td>Extreme value scale parameter</td>
<td>$\alpha_{\Delta}$</td>
<td>0.102</td>
<td>(0.015)</td>
<td>Bankruptcy rate (Ch. 11+Ch. 7)</td>
</tr>
<tr>
<td>Fixed costs for production</td>
<td>$f$</td>
<td>4.099</td>
<td>(0.298)</td>
<td>Equity issuance/assets</td>
</tr>
<tr>
<td>Fixed costs for Ch. 11</td>
<td>$f_{c11}$</td>
<td>28.698</td>
<td>(4.468)</td>
<td>Bankruptcy rate (Ch. 11)</td>
</tr>
<tr>
<td>Linear external financing costs</td>
<td>$\lambda_1$</td>
<td>0.092</td>
<td>(0.021)</td>
<td>Variance of dividends to assets</td>
</tr>
</tbody>
</table>
Model Matches (Targeted and Untargeted) Moments

<table>
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<td></td>
<td></td>
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<tr>
<td>Bankruptcy prob. (Ch. 11) (%)</td>
<td>0.72</td>
<td>0.72</td>
<td>Compustat</td>
</tr>
<tr>
<td>Bankruptcy prob. (Ch. 7) (%)</td>
<td>0.14</td>
<td>0.14</td>
<td>Compustat</td>
</tr>
<tr>
<td>Variance of debt-to-assets</td>
<td>0.06</td>
<td>0.07</td>
<td>Compustat</td>
</tr>
<tr>
<td>Variance of dividends/total assets</td>
<td>0.01</td>
<td>0.02</td>
<td>Compustat</td>
</tr>
<tr>
<td>Equity issuance /total assets</td>
<td>0.15</td>
<td>0.16</td>
<td>Compustat</td>
</tr>
<tr>
<td><strong>Panel B: Untarget Moments (Financial Ratios)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debit-to-EBITDA</td>
<td>2.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank debt ratio</td>
<td>0.33</td>
<td>[0.28, 0.43]</td>
<td>CM (2018)</td>
</tr>
<tr>
<td>Aggregate bank debt ratio</td>
<td>0.21</td>
<td>0.31</td>
<td>Flow of Funds</td>
</tr>
<tr>
<td>Debt-to-EBITDA</td>
<td>2.58</td>
<td></td>
<td></td>
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<tr>
<td>Dividends/total assets</td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spreads (Non-bankrupt) (bps)</td>
<td>174</td>
<td></td>
<td></td>
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<tr>
<td>Spreads (Ch. 11) (bps)</td>
<td>378</td>
<td></td>
<td></td>
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<tr>
<td>Spreads (Ch. 7) (bps)</td>
<td>227</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spreads of bank debt (bps)</td>
<td>269</td>
<td>[251, 301]</td>
<td>Strahan (1999)</td>
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Model does a good job matching targeted moments

# Model Matches (Targeted and Untargeted) Moments

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<td>Equity issuance /total assets</td>
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<td>Debt-to-assets</td>
<td>0.39</td>
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<td>[251, 301]</td>
<td>Strahan (1999)</td>
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- 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 $\mu_M$)

Model Captures (Untargeted) Credit Losses

<table>
<thead>
<tr>
<th>Description</th>
<th>Market Debt</th>
<th>Bank Debt</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Debt-to-assets</td>
<td>0.42</td>
<td>0.39</td>
<td>Compustat</td>
</tr>
<tr>
<td></td>
<td>0.32</td>
<td>0.21</td>
<td></td>
</tr>
</tbody>
</table>

Panel B: Bankruptcy Probabilities

Panel C: Recovery Rates

Panel D: Expected Recovery Rates

Model Captures (Untargeted) Credit Losses

- 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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<td>Debt-to-assets</td>
<td>0.42 0.39 0.32 0.21</td>
<td>0.42 0.39 0.32 0.21</td>
<td>Compustat</td>
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</table>

**Panel A: Leverage**

**Panel B: Bankruptcy Probabilities**

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<th>Description</th>
<th>Market Debt</th>
<th>Bank Debt</th>
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</thead>
<tbody>
<tr>
<td>Chapter 11 Reorganization (%)</td>
<td>0.76 0.61 0.64 0.74</td>
<td>0.76 0.61 0.64 0.74</td>
<td>Compustat</td>
</tr>
<tr>
<td>Chapter 7 Liquidation (%)</td>
<td>0.08 0.08 0.25 0.15</td>
<td>0.08 0.08 0.25 0.15</td>
<td>Compustat</td>
</tr>
<tr>
<td>Fraction of Chapter 11</td>
<td>0.90 0.88 0.72 0.83</td>
<td>0.90 0.88 0.72 0.83</td>
<td>Compustat</td>
</tr>
</tbody>
</table>

**Panel C: Recovery Rates**

**Panel D: Expected Recovery Rates**

### Model Captures (Untargeted) Credit Losses

- 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

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<tr>
<td></td>
<td>Model</td>
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<td></td>
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<tr>
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<td><strong>Panel C: Recovery Rates</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td><strong>0.32</strong></td>
<td><strong>0.45</strong></td>
<td><strong>0.64</strong></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.37</td>
<td>0.38</td>
<td>0.24</td>
</tr>
<tr>
<td>Interquartile range</td>
<td><strong>0.69</strong></td>
<td><strong>0.73</strong></td>
<td>0.43</td>
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<tr>
<td>10th percentile</td>
<td>0.00</td>
<td>0.00</td>
<td>0.38</td>
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<tr>
<td>90th percentile</td>
<td>0.88</td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td><strong>Panel D: Expected Recovery Rates</strong></td>
<td></td>
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<td></td>
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</tbody>
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Note: AK (2014) compute summary statistics from Moody’s Ultimate Recovery Database.
### Model Captures (Untargeted) Credit Losses

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<tr>
<td></td>
<td>0.39</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td><strong>Panel B: Bankruptcy Probabilities</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Chapter 11 Reorganization (%)</td>
<td>0.76</td>
<td>0.64</td>
<td>Compustat</td>
</tr>
<tr>
<td></td>
<td>0.61</td>
<td>0.74</td>
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<tr>
<td>Chapter 7 Liquidation (%)</td>
<td>0.08</td>
<td>0.25</td>
<td>Compustat</td>
</tr>
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<td></td>
<td>0.08</td>
<td>0.15</td>
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<tr>
<td>Fraction of Chapter 11</td>
<td>0.90</td>
<td>0.72</td>
<td>Compustat</td>
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<tr>
<td></td>
<td>0.88</td>
<td>0.83</td>
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</tr>
<tr>
<td><strong>Panel C: Recovery Rates</strong></td>
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<tr>
<td>Mean</td>
<td>0.32</td>
<td>0.64</td>
<td>AK (2014)</td>
</tr>
<tr>
<td></td>
<td>0.45</td>
<td>0.75</td>
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</tr>
<tr>
<td>Standard deviation</td>
<td>0.37</td>
<td>0.24</td>
<td>AK (2014)</td>
</tr>
<tr>
<td></td>
<td>0.38</td>
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<td></td>
</tr>
<tr>
<td>Interquartile range</td>
<td>0.69</td>
<td>0.43</td>
<td>AK (2014)</td>
</tr>
<tr>
<td></td>
<td>0.73</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>10th percentile</td>
<td>0.00</td>
<td>0.38</td>
<td>AK (2014)</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>90th percentile</td>
<td>0.88</td>
<td>1.00</td>
<td>AK (2014)</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>1.00</td>
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<tr>
<td><strong>Panel D: Expected Recovery Rates</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean (lowest type score)</td>
<td>0.12</td>
<td>n.a.</td>
<td></td>
</tr>
<tr>
<td>Mean (highest type score)</td>
<td>0.86</td>
<td>n.a.</td>
<td></td>
</tr>
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</table>


- 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
- 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. 7 Dynamics
  - Ch. 11 Dynamics

- Expected PD and recovery rates at default by credit ratings
  - E[PD] and E[RR]
How Firm Uses Assessment of Firm’s Productivity as Signal?

Leverage ↑ and equity ↑

- Other signal? Bankruptcy and debt structure are less informative
- Signaling is not free: costs of bankruptcy; decreasing returns to scale; and costs of external equity issuance
How Firm Uses Assessment of Firm’s Productivity as Signal?

Leverage ↑ and equity ↑

Reputation (assessment of firm’s productivity) ↑

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

Reputation (assessment of firm’s productivity) ↑

Corporate bond interest rates ↓

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

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

Corporate bond markets: cross-subsidization

- 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 \( q^{-1}_M \): gross interest rate, \( \mu_M \): intermediation costs, \( q \): price of risk-free debt, PD: Probability of Default, RR: Recovery Rate at default, and Recovery: \( RR \times \text{Exposure At Default} \)

\[
(1 - E[PD])q^{-1}_M b + E[Recovery] - (1 + \mu_M)q^{-1} b = 0
\]

- debt repayment (no default)
- debt repayment (default)
- funding costs

profit

Bank Loan Pricing
Debt Pricing

Corporate bond markets: cross-subsidization

- 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, $\mu_M$: intermediation costs, $q$: price of risk-free debt, PD: Probability of Default, RR: Recovery Rate at default, and Recovery: $RR \times \text{Exposure At Default}$

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

$$E[\text{Recovery}] \approx E[PD] \times E[RR] \times q_M^{-1}b$$  \hspace{1cm} (5)

Exposure At Default
Debt Pricing

Corporate bond markets: cross-subsidization

- 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, $\mu_M$: intermediation costs, $q$: price of risk-free debt, PD: Probability of Default, RR: Recovery Rate at default, and Recovery: $RR \times \text{Exposure At Default}$

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

$$E[\text{Recovery}] \simeq E[PD] \times E[RR] \times \frac{q_M^{-1}b}{\text{Exposure At Default}}$$  \hspace{1cm} (5)

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

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

Corporate bond markets: cross-subsidization

- Competitive pricing from free entering in both debt markets $\rightarrow$ 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 $q^{-1}_M$: gross interest rate, $\mu_M$: intermediation costs, $q$: price of risk-free debt, PD: Probability of Default, RR: Recovery Rate at default, and Recovery: $RR \times \text{Exposure At Default}$

$$E[PD] \neq PD(z)$$
$$E[RR] \neq RR(z)$$

where $z \in \{z_L, z_H\}$ if $0 < s < 1$, $PD(z_H) \neq PD(z_L)$, and $RR(z_H) \neq RR(z_L)$
Debt Pricing (Cont’d)

Bank loan markets: benefits of monitoring and costs of intermediation $\mu_B$

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

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

$$\text{Recovery}(z, \cdots) \simeq PD(z, \cdots) \times s_{c7}(e + b)$$

- 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
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
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, $\phi$, $e'$ and $\Delta$\}
- Simulated panel regressions to study determinants of type score $s'$:

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

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

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<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
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<tbody>
<tr>
<td><strong>Dependent variable:</strong></td>
<td><strong>Type score</strong> $s_t$</td>
<td><strong>Type score</strong> $s_t$</td>
<td><strong>Type score</strong> $s_t$</td>
<td><strong>Type score</strong> $s_t$</td>
</tr>
<tr>
<td><strong>Leverage</strong> $t-1$</td>
<td>$0.739^{***}$</td>
<td>$0.943^{***}$</td>
<td>$0.806^{***}$</td>
<td>(493.43)</td>
</tr>
<tr>
<td></td>
<td>(881.76)</td>
<td>(789.83)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ln(Internal finance)</strong> $t-1$</td>
<td>$0.212^{***}$</td>
<td>$0.306^{***}$</td>
<td>$0.191^{***}$</td>
<td>(325.37)</td>
</tr>
<tr>
<td></td>
<td>(716.11)</td>
<td>(386.23)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 11 bankruptcy</strong> $t-1$</td>
<td>$0.0283^{***}$</td>
<td>$0.0314^{***}$</td>
<td></td>
<td>(13.07)</td>
</tr>
<tr>
<td></td>
<td>(16.44)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Market funding ratio</strong> $t-1$</td>
<td>$0.00853^{***}$</td>
<td>$0.0000488$</td>
<td></td>
<td>(15.95)</td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ln(Firm age)</strong> $t-1$</td>
<td>$-0.00424^{***}$</td>
<td>$-0.0000297$</td>
<td></td>
<td>(-15.38)</td>
</tr>
<tr>
<td></td>
<td>(-0.12)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type score</strong> $s_{t-1}$</td>
<td></td>
<td></td>
<td></td>
<td>$0.346^{***}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(360.18)</td>
</tr>
<tr>
<td><strong>Number of observations</strong></td>
<td>475568</td>
<td>475568</td>
<td>475568</td>
<td>475568</td>
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<tr>
<td><strong>$R^2$</strong></td>
<td>0.339</td>
<td>0.182</td>
<td>0.696</td>
<td>0.762</td>
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<tr>
<td><strong>Fixed effects</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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</table>
Good (Bad) Type Score Reduces (Increases) Interest Rate
Firms with High Type Issue More Corporate Bonds
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) ✗
Asset Based Debt

Alternative Benchmark

- Corporate bond recovery: cash flow based → asset based

<table>
<thead>
<tr>
<th>Panel A: Technology</th>
<th>Data</th>
<th>Benchmark</th>
<th>Counterfactual</th>
<th>Alternative benchmark</th>
<th>Counterfactual</th>
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<tbody>
<tr>
<td>Monitoring by bondholders</td>
<td>✓</td>
<td>✓</td>
<td></td>
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<tr>
<td>Bond flexibility under Ch. 11</td>
<td>✓</td>
<td>✓</td>
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<table>
<thead>
<tr>
<th>Panel B: Capital Structure and Welfare</th>
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<tbody>
<tr>
<td>Debt</td>
</tr>
<tr>
<td>Debt (zL)</td>
</tr>
<tr>
<td>Debt (zH)</td>
</tr>
<tr>
<td>Equity</td>
</tr>
<tr>
<td>Equity (zL)</td>
</tr>
<tr>
<td>Equity (zH)</td>
</tr>
<tr>
<td>Aggregate bank debt ratio</td>
</tr>
<tr>
<td>Change in % compared to full info</td>
</tr>
<tr>
<td>Output</td>
</tr>
<tr>
<td>Change in % compared to full info</td>
</tr>
<tr>
<td>Capital</td>
</tr>
<tr>
<td>Change in % compared to full info</td>
</tr>
<tr>
<td>TFP</td>
</tr>
<tr>
<td>Change in % compared to full info</td>
</tr>
<tr>
<td>Panel C: Bankruptcy</td>
</tr>
<tr>
<td>Bankruptcy prob. (Ch. 11) (%)</td>
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<tr>
<td>Bankruptcy prob. (Ch. 7) (%)</td>
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<tr>
<th>Panel D: Market Debt Recovery Rates</th>
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<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Standard deviation</td>
</tr>
<tr>
<td>Interquartile range</td>
</tr>
<tr>
<td>10th percentile</td>
</tr>
<tr>
<td>90th percentile</td>
</tr>
</tbody>
</table>
Credit ratings is mapping of $E[PD]$ to 6 buckets (e.g., top 4% of safest bonds are categorized as “AAA/AA”)

Mean reversion in leverage and credit rating – which arise from productivity process and costly equity issuance
Dynamics

Model is also consistent with dynamics around Ch. 7
In real-world data:

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

<table>
<thead>
<tr>
<th>S&amp;P Credit Rating</th>
<th>Investment Grade</th>
<th>Speculative Grade</th>
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<tr>
<td></td>
<td>AAA/AA</td>
<td>A</td>
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<td>Panel A: Share (%)</td>
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<td>Model</td>
<td>4.00</td>
<td>15.00</td>
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<tr>
<td>Data</td>
<td>3.97</td>
<td>14.32</td>
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<td>Panel B: Bankruptcy and Default of Market Debt</td>
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<tr>
<td>Expected bankruptcy rates (%)</td>
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<tr>
<td>Model</td>
<td>0.08</td>
<td>0.15</td>
</tr>
<tr>
<td>Data</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>3 years</td>
<td>0.05</td>
<td>0.03</td>
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<td>Panel C: Expected Recovery Rates at Default of Market Debt</td>
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<tr>
<td>Expected recovery rates (%)</td>
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<tr>
<td>Model</td>
<td>Mean</td>
<td>Std. Dev.</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>0.01</td>
<td>0.03</td>
</tr>
</tbody>
</table>

- Distributions of PD and Recovery Rates in model are consistent with data
Asym Info (Benchmark) Model is Closer to Data

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

\[\begin{array}{cccccc}
0−10\% & 10−30\% & 30−50\% & 50−70\% & 70−90\% & 90−100\% \\
\hline
\text{LGD assessment (assigned score)} & 0 & 20 & 40 & 60 & 80 & 100 \\
\end{array}\]

Note: Data sample is from 2008 to 2010.

- Realized recovery rates $\neq$ expected recovery rates
TFP = Aggregate Capital^{\alpha k} / Aggregate Output

<table>
<thead>
<tr>
<th>Panel A: Technology</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>Monitoring on PD</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Monitoring on recovery at default</td>
<td>✓</td>
<td>✓</td>
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</tr>
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</tr>
<tr>
<td>Equity (zH)</td>
</tr>
<tr>
<td>Aggregate bank debt ratio</td>
</tr>
<tr>
<td>Consumption</td>
</tr>
<tr>
<td>Change in % compared to benchmark</td>
</tr>
<tr>
<td>Change in % compared to benchmark</td>
</tr>
<tr>
<td>Panel C: Allocation Efficiency</td>
</tr>
<tr>
<td>Change in % compared to benchmark</td>
</tr>
<tr>
<td>Change in % compared to benchmark</td>
</tr>
<tr>
<td>Avrg. output-weighted productivity</td>
</tr>
<tr>
<td>Avrg. productivity</td>
</tr>
<tr>
<td>Cov (productivity, output weights)</td>
</tr>
<tr>
<td>Variance of mlpk^2</td>
</tr>
<tr>
<td>Variance of productivity</td>
</tr>
<tr>
<td>Variance of log capital</td>
</tr>
<tr>
<td>Cov (z, capital)</td>
</tr>
</tbody>
</table>

| 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           |
Interaction of Financial Markets

<table>
<thead>
<tr>
<th></th>
<th>No bank debt</th>
<th>Zero external equity financing costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alternative benchmark</td>
<td>Counterfactual</td>
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<tr>
<td>Panel A: Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring by bondholders</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Panel B: Capital Structure and Welfare</td>
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<td></td>
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<tr>
<td>Debt</td>
<td>21.77</td>
<td>23.65</td>
</tr>
<tr>
<td>Equity</td>
<td>24.77</td>
<td>21.69</td>
</tr>
<tr>
<td>Consumption</td>
<td>1.476</td>
<td>1.482</td>
</tr>
<tr>
<td></td>
<td>n.a.</td>
<td>0.42</td>
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<tr>
<td>Output</td>
<td>13.11</td>
<td>12.94</td>
</tr>
<tr>
<td>Capital</td>
<td>46.54</td>
<td>45.34</td>
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<td></td>
<td>n.a.</td>
<td>-2.58</td>
</tr>
<tr>
<td>TFP</td>
<td>1.080</td>
<td>1.084</td>
</tr>
<tr>
<td></td>
<td>n.a.</td>
<td>0.36</td>
</tr>
</tbody>
</table>

- 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
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
Simpler Model Delivers Different Quantitative Results

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

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- break even intermediation costs +7bps