Estimating Dynamic Structural Models in Economics using Open Science Grid

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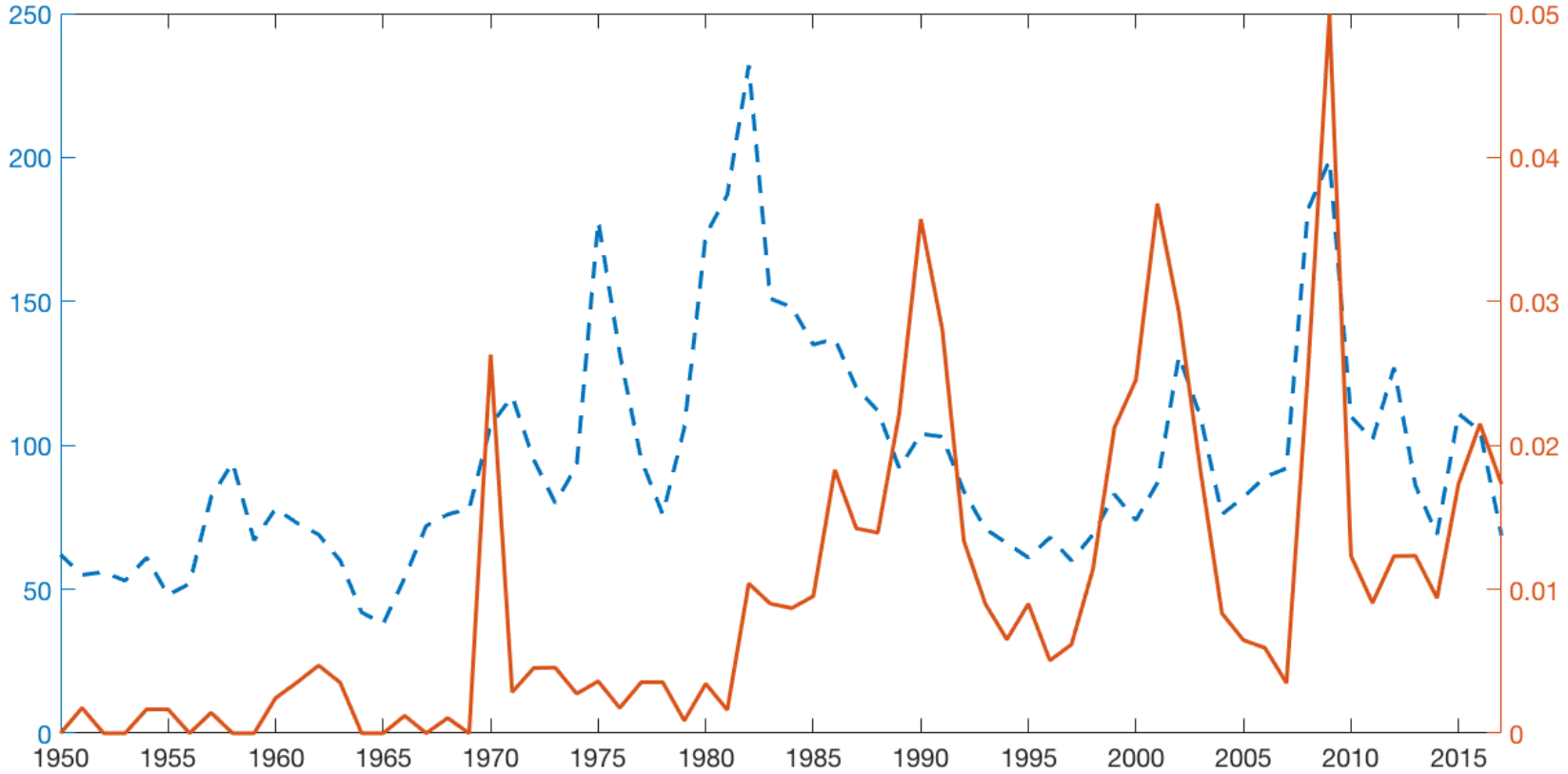
CU Boulder, Department of Economics

Conference

HOW Meeting 2019 - Jefferson Lab

Corporate Default Rates and Credit Spreads



What we do in our Project

- Paper: *Financial Development, Default Rates and Credit Spreads*
- Document disconnect between default rates and credit spreads
- Rationalize it with a theory of **financial development**
  - Firms increase their leverage: **Default rates go up**
  - Firms operate at a more efficient scale: recovery rates goes up
  - As a result **Credit spreads barely move**
- Heterogenous agents' model quantitatively account for
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  - number of trends that have interested public firms during the last decades.

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- Study how changes in the environment θ affect the macroeconomy
- **How**: Heterogeneous Agents Model
  - Agents do the best they can (*Optimization*)
  - We aggregate agent decisions to get equilibrium outcomes
  - Find θ for which equilibrium outcomes closer to the data (*Optimization*)
  - Perform policy experiment
- **Computational challenges**:
  - Determining agents' decisions (*Optimization* - Inner Loop)
  - Estimating the structural parameters (*Optimization* - Outer Loop)

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The Inner Loop

Determining Agents' Decisions

Determining agents' decisions

- Agents do the best they can ▸ Our problem

$$V(\underline{s}) = \max_{s' \in \Gamma(\underline{s})} F(\underline{s}, s') + \beta \cdot \int_{\underline{s}'} V(\underline{s}') Q(\mathrm{d}s', s)$$

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- More in general

$$V(\cdot) = \mathbf{T}V(\cdot)$$

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- More in general

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- **Solution**: Value Function Iteration (VFI)

$$V^i(\cdot) = \mathbf{T}^i V^0(\cdot)$$

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- **Solution**: Value Function Iteration (VFI)

$$V^i(\underline{s}) = \mathbf{T}^i V^0(\underline{s})$$

- Guess V^0

$$\underbrace{V^1(k, z)}_{\text{New Guess}} = \max_{k' \in K} \; F(k, z, k') + \beta \cdot \int_{z'} \underbrace{V^0(k', z')}_{\text{Guess}} Q(z', z') \mathrm{d}z'$$

- Get new Guess V^1

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- **Solution**: Value Function Iteration (VFI)

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- Guess V^1

$$\underbrace{V^2(k, z)}_{\text{New Guess}} = \max_{k' \in K} \; F(k, z, k') + \beta \cdot \int_{z'} \underbrace{V^1(k', z')}_{\text{Guess}} Q(z', z') \mathrm{d}z'$$

- Get new Guess V^2

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- Guess V^{i-1}

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- Get new Guess V^i

- Repeat $V^i = TV^{i-1}$ till when $||V^i - V^{i-1}|| < \epsilon$

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- **Computational Challenges:**
  - **Peak-finding Algorithm**
  - **Value Function Iteration**

Closing the Model

Given a particular economy θ:

- Agents do the best they can (**Fixed Point Algorithm**):
  - Firms maximize dividends (given banks' interest rates)
  - Banks choose interest rates on loans (given firms' behavior)

(Other pieces of the puzzle: Entrants, Firms' Invariant Distribution)

- We aggregate agent decisions to get equilibrium outcomes $m^{\text{Model}}(\theta)$
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The Outer Loop

Estimating the structural parameters θ

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Table: Calibrated Parameters

Parameter	Description	Target	Data	Model
$\zeta = 0.35$	Borrowing Costs	Avg Leverage	0.24	0.25
$\sigma_e = 0.20$	Uncertainty	Std Leverage	0.31	0.34
$\xi = 110.4$	Uncertainty 2	Default Rate	0.32%	0.36%
$k_e = 8.5$	Capital Entrants	Investment Rate	0.63%	0.54%
$\gamma = 0.09$	Equity Issuance	Share Dividends	83%	82%

Estimating the Structural Parameters

$$\theta^* = \underset{\theta \in \Theta}{\text{argmin}}\ L\left(m^{\text{Model}}(\theta)\,,\, m^{\text{Data}} \right)$$

- **Problem 1**: Computing $m^{\text{Model}}(\theta)$ takes time
  - Estimating Bellman Equation via Value Function Iteration
- **Problem 2**: Loss Function
  - Local Minima may not be Global Minima
  - **Solution:** Global Search
- **Problem 3**: The Parameter Space: Θ

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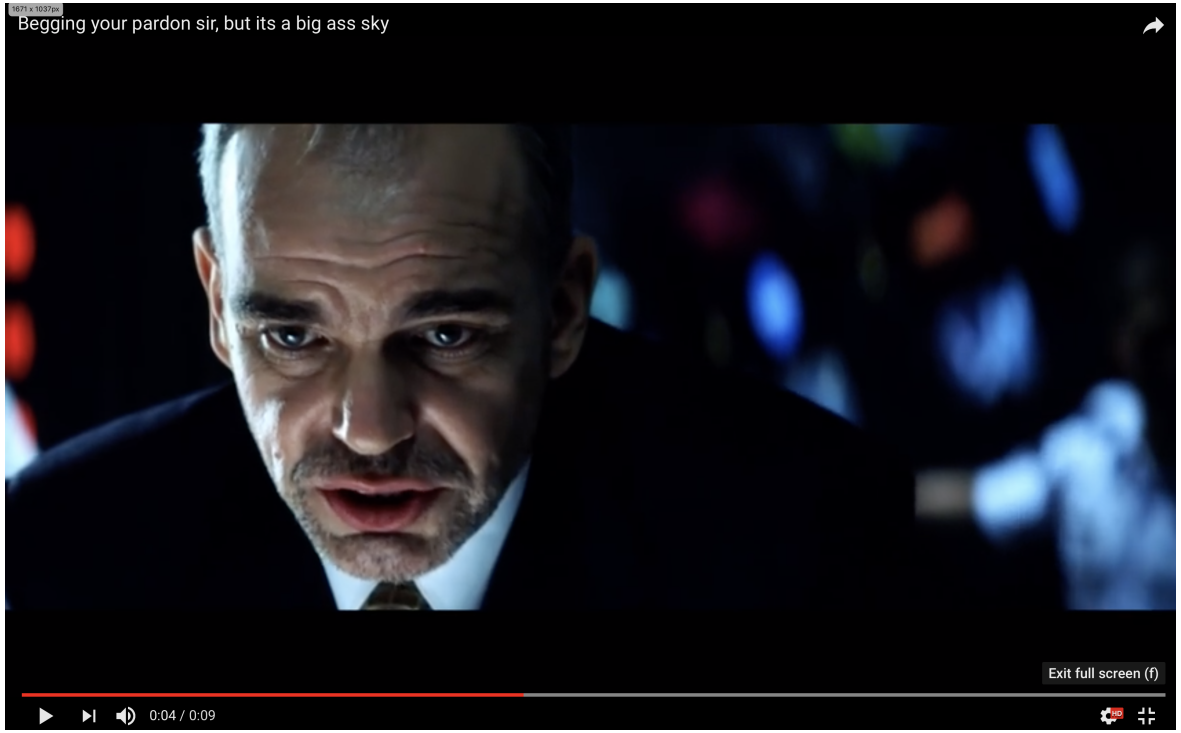
Armageddon (1998)



Well, our object collison **budget's** about a million dollars a year.
That allows us to track about 3% of the sky, and
begging your pardon sir, but it's a big-aXX sky.

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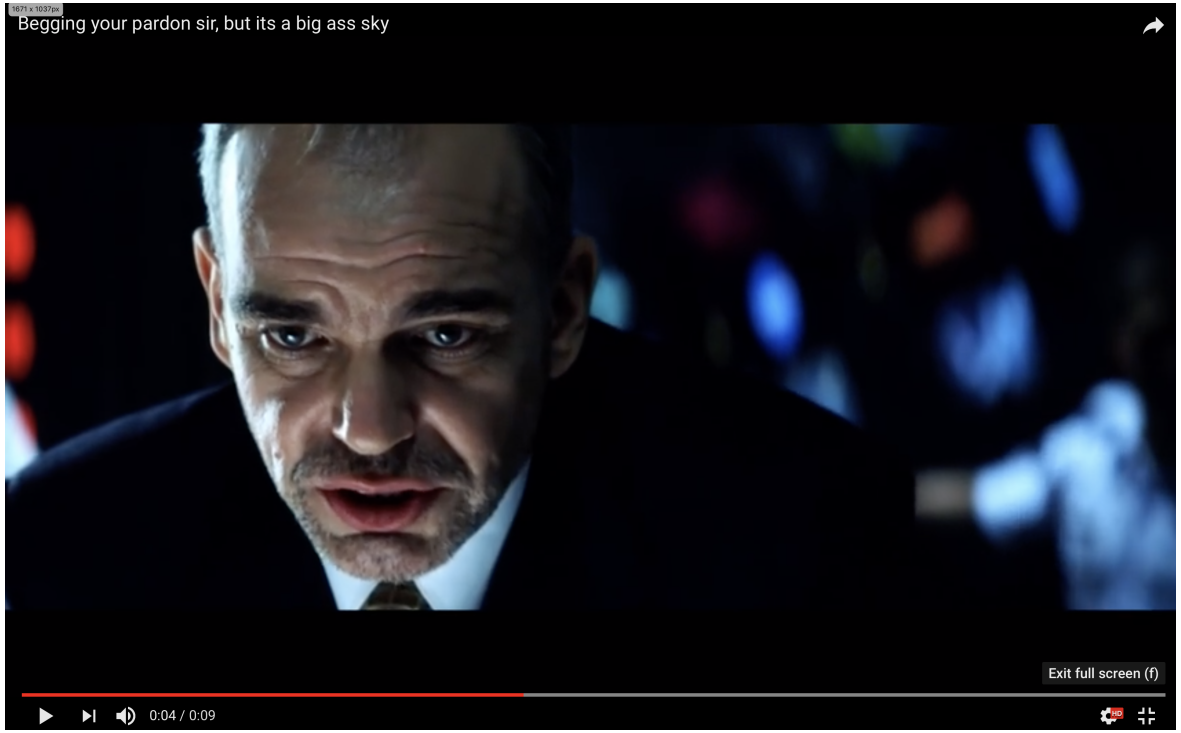

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- Amazon AWS
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Global Search over Parameter Space in OSG

- **Perfect Fit:** Model Economy θ
  - independent of each other
  - not memory intensive (<2GB)
  - run within 1-12 hours
  - portable (C++)
- DAGMan HTC Condor's workflow
  - **Easy to use**
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- **Opportunistic usage and sharing of resources (No SU)**

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Thanks!

Incumbents' Value Function

Back

$$V_i(\omega_i, z_i) = \max_{\phi_{D,i} \in \{0,1\}} (1 - \phi_{D,i}) V_i^c(\omega_i, z_i)$$

$$V_i^c(\omega_i, z_i) = \max_{d_i, k_i', l_i'} d_i + \beta \sum_{z_i'} \sum_{\xi_i'} \Gamma_{z_i, z_i'} \Gamma_{\xi_i'} V_i(\omega_i', z_i')$$

$$\text{s.t.} \quad \left(1 + \gamma \mathbb{I}_{\{d_i < 0\}}\right) d_i = \omega_i + l_i' - k_i'$$

$$\omega_i' = \pi_i' + (1 - \delta) k_i' - \left(\left[1 + r_i'\right] \mathbb{I}_{\{l_i' > 0\}} + \left[1 + r_F\right] \mathbb{I}_{\{l_i' < 0\}} \right) l_i'$$

$$\left(z_i, k_i', l_i', r_i'\right) \in H(z_i, k_i', l_i')$$