Capital Deaccumulation and the Large Persistent Effects of Financial Crises

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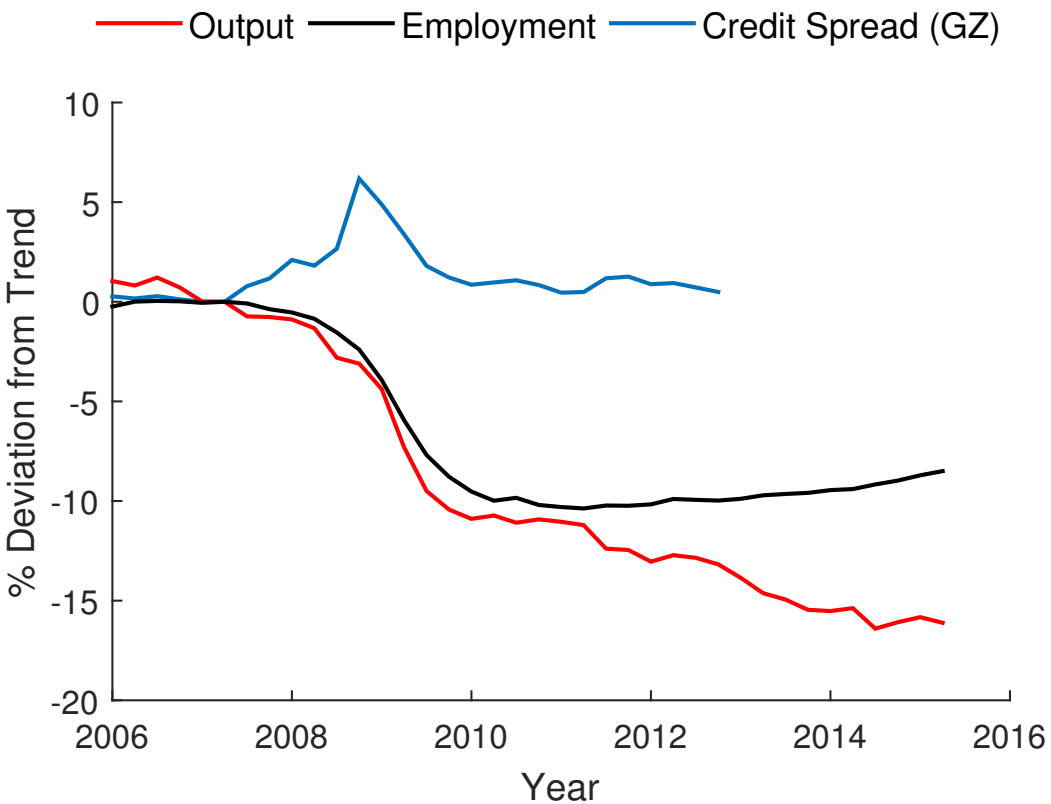
Motivating Questions

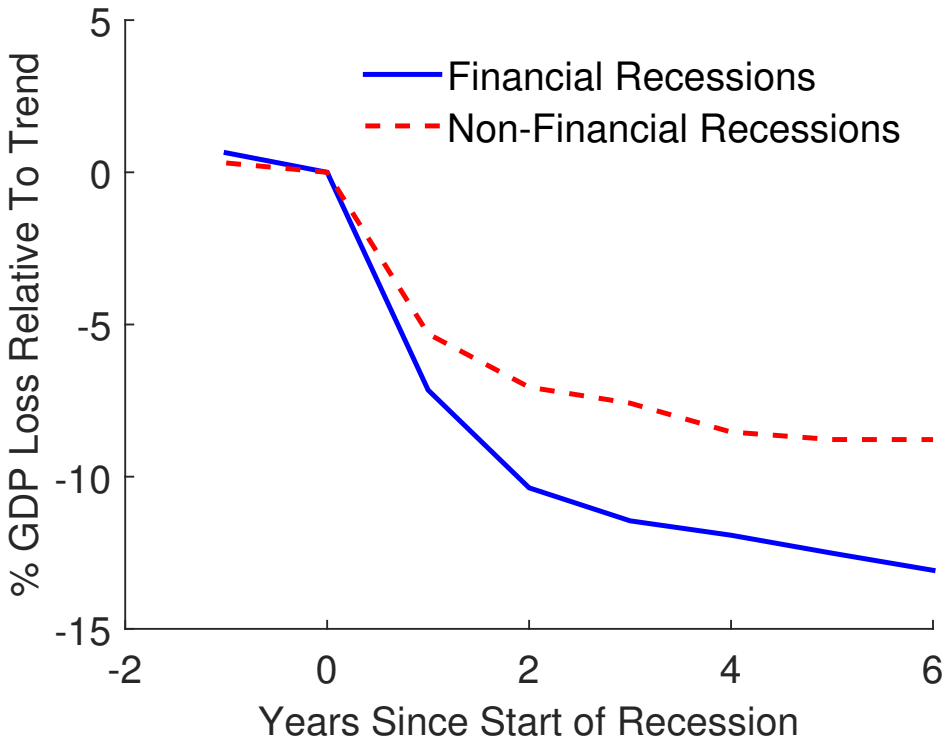
- Why are financial crises followed by persistent output drops?
- Could effect on investment and capital stock be important?

US Great Recession



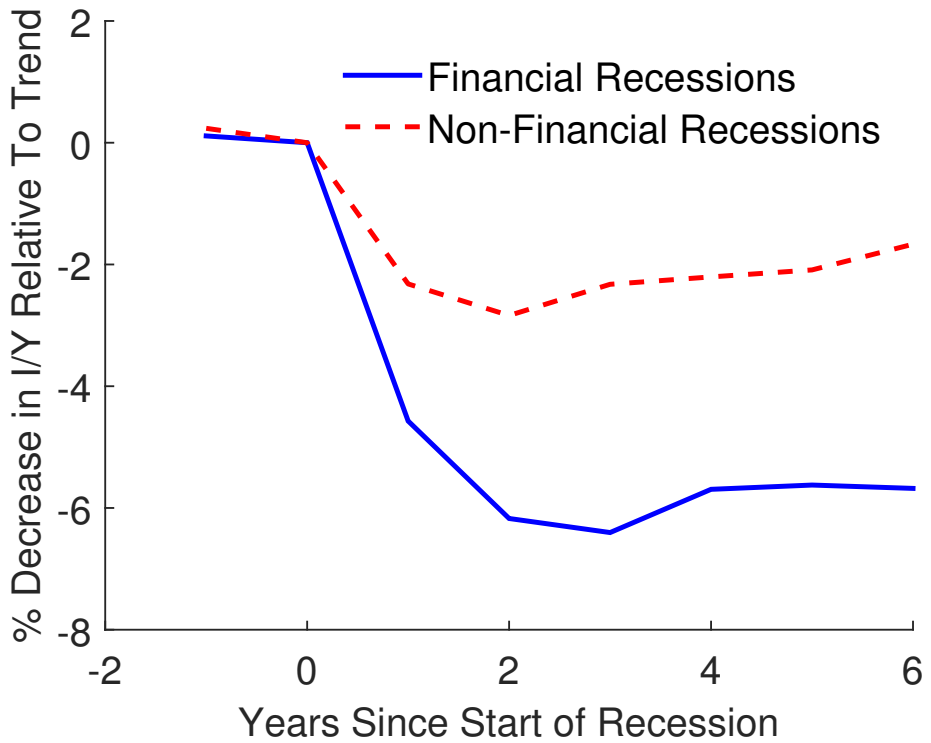
- Short-lived increase in credit spreads.
- Persistent slump in output and employment.

Financial Recessions Followed by Persistent Output Slumps



- Recessions in 40 OECD and Emerging Economies 1970-2014.
- Financial recessions occur within year of Reinhart & Rogoff (2009) banking crisis.

Financial Recessions Followed by Large Investment Drops



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The Puzzle

- Standard models do not generate large persistent effect.
- Reason: low depreciation of K means K fluctuates little. (Schwartzman, 2012; Bigio, 2012).

However...

- Some types of capital
  - Depreciate quickly.
  - May be crucial for production.
- Dynamics of these types of capital may really matter.

Equipment and Intangibles

- Intangibles includes e.g. advertising, R&D, software.
- Depreciate much faster than other capital ($\simeq$ 20% per year).
- So, stocks fluctuate a lot when investment varies.
  - For instance, fell three times as much as other capital (relative to trend) in Great Recession. more

Mechanism

- Dynamics of downturn:
  1. Financial shock $\Rightarrow$ hard for firms to borrow.
  2. Fall in investment.
  3. Rapid fall in stock of equipment and intangibles (high depreciation).
  4. Slump in output.
- Stock of equipment and intangibles replenished slowly after shock.
- With some wage rigidity, persistent slump in employment.

Preview of Main Results

- Financial shock $\Rightarrow$ drop in output and employment.
  - Ten years after shock hits:
    - Employment only recovered 64% from trough.
    - Output only recovered 19% from trough.
- Financial shocks matching credit spread after 2006:
  - Fall in output and employment $\simeq$ one third as large as recession.
  - No recovery 7 years later.

Literature

- **Persistent Effects of Financial Shocks:** Khan and Thomas (2010), Queralto (2013), and Ottonello (2014).
- **Disaggregating Capital:** Lopez and Olivella (2014).
- **Intangible Capital:** Corrado, Hulten and Sichel (2009, 2010), Eisfeldt and Papanikolaou (2014).

This Paper: High depreciation rate of equipment and intangibles means low investment in crises can lead to persistent slumps.

Model: Key Features

- Financial frictions (Bernanke, Gertler and Gilchrist, 1999).
- Two types of capital: structures and intangibles.
  Different depreciation rates.
- Endogenous wage rigidity.
  - Search and alternating offer bargaining (Hall and Milgrom, 2008).

Agents

- Entrepreneurs & Workers: live in large families and share consumption.
- Competitive Firms: Financial Intermediaries, Capital Producers.
- Family utility: $\sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma}(1-\nu N_t)^{\sigma}}{1-\sigma}$.

Agents

- **Entrepreneurs:** own structures, k_S and intangibles, k_I. Employ workers, n. Use to produce output.
- **Capital Producers:** transform output and period t structures and intangibles into period $t+1$ structures and intangibles.
- **Financial Intermediaries:** issue risk-free deposits to workers and lend to entrepreneurs.

Production Technology

- Each period entrepreneur draws i.i.d. shock ξ: $\xi \sim \ln \mathcal{N}$, mean $= 1$, s.d. $= \sigma_t$.

$$k_{S,t} = \xi \tilde{k}_{S,t}; k_{I,t} = \xi \tilde{k}_{I,t}$$

- Produces output according to:

$$y = Z\, \xi^{1-\alpha_S-\alpha_I}\, k_{S,t}^{\alpha_S}\, k_{I,t}^{\alpha_I}\, n_t^{1-\alpha_S-\alpha_I}$$

- Financial shock: σ_t evolves according to AR(1) process. Revealed one period in advance.

Investment Adjustment Costs

- Entrepreneurs cannot store capital from one period to next.
  $\Rightarrow$ Each period sell to capital producer at prices $q_{S,t}$, $q_{I,t}$.
- Capital producer tranforms $K_{S,t}$ into $K_{S,t+1}$ according to:

$$K_{S,t+1} = (1-\delta_S)K_{S,t} + I_{S,t} - \kappa_1 \left(\frac{I_{S,t}}{I_{S,t-1}} - 1\right)^2 I_{S,t} - \kappa_2 \left(\frac{I_{S,t}}{K_{S,t}} - \frac{I_S^\star}{K_S^\star}\right)^2 \frac{K_S^\star}{I_S^\star} K_{S,t}$$

- Transform $K_{I,t}$ into $K_{I,t+1}$ similarly.
- Sell capital back to entrepreneurs at prices $\tilde{q}_{S,t}$, $\tilde{q}_{I,t}$.
  - Capital producers maximize profits.

Labor Market Frictions

- Workers are employed or unemployed.
- Employed workers are matched with entrepreneurs.
  - Bargain over wages.
  - At end of period fraction δ_N separate.
- Unemployed workers search for jobs.
- Cobb Douglas matching function: $M_t = A_M^{1-\psi}(v_t)^{1-\psi}(1-N_t)^{\psi}$.
- Entrepreneurs must pay h_0 to post vacancies and pay h_1 to hire.

Wage Bargaining

- Bargaining based on Hall and Milgrom (2008) generates stickier wages and large employment response.
- Wages set according to:

$$0 = (1 - e^{-\rho}) \left[\frac{\mathcal{V}_N}{1 - \vartheta} - \frac{\mathcal{W} - \mathcal{U}}{\vartheta} \right] + e^{-\rho} \left[\frac{y + \gamma - w}{1 - \vartheta} - \frac{w - \underline{u}}{\vartheta} \right]$$

- Wage 'rigidity' depends on:
  - ρ : risk of separation during bargaining.
  - γ: cost to entrepreneur of preparing offers.

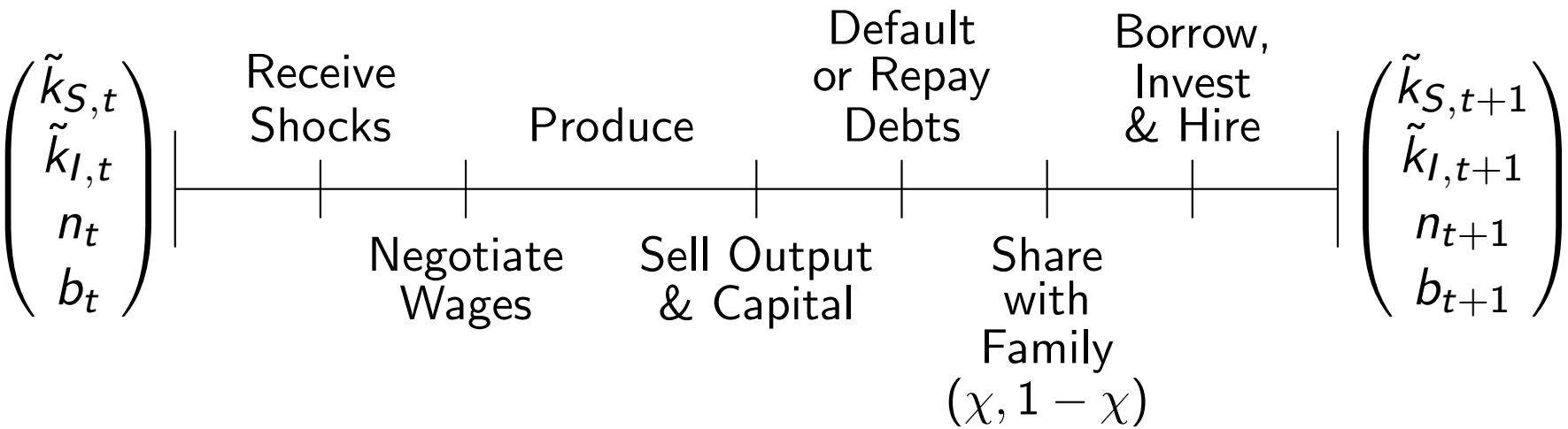
Financial Frictions

- At end of each period, entrepreneur may invest in capital and hire new workers.
  - Pays hiring cost h_t, and capital prices $\tilde{q}_{S,t}$, $\tilde{q}_{I,t}$.
- May fund this by borrowing from financial intermediaries.
- Repays next period by selling capital, output and/or equity.
- If draws $\xi_{t+1} < \overline{\xi}_{t+1}$, too little net worth at $t+1$ to repay debts.
  $\Rightarrow$ Defaults: financial intermediary confiscates assets and sells them.

Financial Frictions

- Financial intermediaries face losses if entrepreneur defaults.
- Additionally, financial intermediaries must pay monitoring cost in event of default.
  - Fraction μ of value of entrepreneur's assets.
- Financial intermediaries break-even on average.
  - Lend to entrepreneurs at credit spread Υ_t above risk-free rate.

One Period in Life of Entrepreneur



Entrepreneur's Problem

Entrepreneurs choose $\tilde{k}_{S,t+1}, \tilde{k}_{I,t+1}, n_{t+1}, b_{t+1}$ to maximize expected discounted flow of dividends to family subject to:

1. $x_{t+1} = \max\{0; y_{t+1} - w_{t+1}n_{t+1} + q_{S,t+1}k_{S,t+1} + q_{I,t+1}k_{I,t+1} + h_{t+1}n_{t+1} - b_{t+1}\}$
2. $b_{t+1} = [\tilde{q}_{S,t}\tilde{k}_{S,t+1} + \tilde{q}_{I,t}\tilde{k}_{I,t+1} + h_t n_{t+1} - x_t](1 + r_t)(1 + \Upsilon_t)$
3. $k_{S,t+1}, k_{I,t+1}, y_{t+1}, w_{t+1}$ depend on ξ_{t+1} shock.
4. Υ_t satisfies bank break-even constraint.

Worker Optimization

- Worker value functions satisfy

$$\mathcal{W}_t = w_t\, u'(C_t) + (1-\delta_N)\, E_t[m_{t+1}\mathcal{W}_{t+1}] + \delta_N\, E_t[m_{t+1}\mathcal{U}_{t+1}]$$

$$\mathcal{U}_t = -u'(N_t) + f_t\, E_t[m_{t+1}\mathcal{W}_{t+1}] + (1-f_t)\, E_t[m_{t+1}\mathcal{U}_{t+1}]$$

- Consumption satisfies Euler equation

$$u'(C_t) = \beta(1+r_t)u'(C_{t+1})$$

Calibration: Capital

- Intangibles in model = equipment and intangibles in data.
- Corrado and Hulten (2010) consider broad definition of intangible investment (including software, R&D, advertising and marketing).
- Find (for 1995-2007) that intangibles represent:
  - 33.9% of business capital.
  - 55% of business investment.
- I calibrate $\alpha_S, \alpha_I, \delta_S, \delta_I$ to match NIPA and C&H estimates.

Calibration: Key Parameters

Parameter	Value used	Target moment
δ_I	0.049	Private Equipment & Intangible I/Y
δ_S	0.011	Private Structural I/Y
α_I	0.38	Private Labor Share
α_S	0.15	Structural/Total Capital
h_0	0.019	Hiring Costs/Wage
h_1	0.31	Training Costs/Wage
ν	0.18	40% of Wage
κ_1	1.2	Based on Christiano & Davis (2006)
κ_2	0.7	Based on Christiano & Davis (2006)
μ	0.51	Average Credit Spread
σ_σ	0.28	St. Dev. Spread
ρ_σ	0.84	Autocorrelation, Spread

Estimation of Wage Bargaining Parameters

- Bayesian Estimation. Assume $C, N, \frac{y}{N}$ follow vector $AR(2)$ process. Use to infer values of $\mathcal{V}, \mathcal{W}, \mathcal{U}$.
- Assume wages measured with i.i.d. error.
- Estimate parameters ρ and γ of vector $AR(2)$ and wage bargaining equation.
  - New hire wage series of Haefke, Sonntag & Van Rens (2013).
  - Other variables from NIPA and BEA.
  - Loose priors.

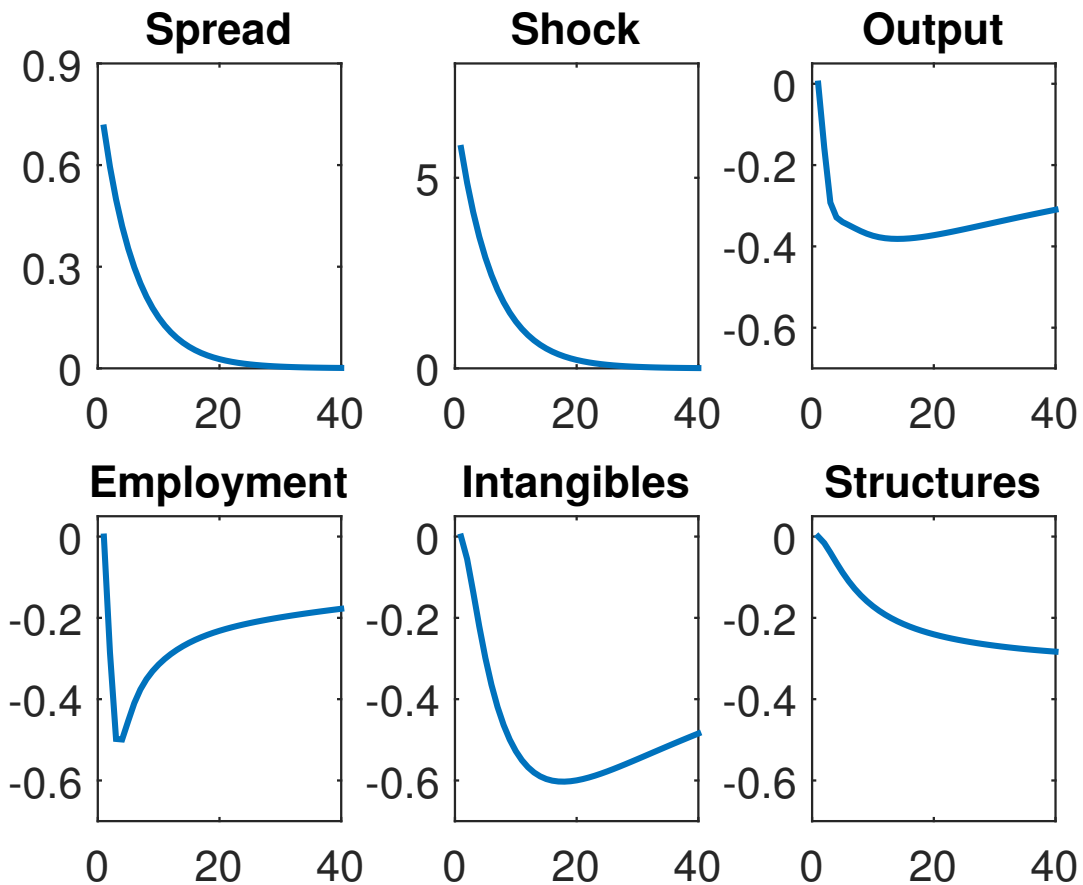
Estimation of Wage Bargaining Parameters: Results

Data supports much more rigid wages than Nash bargaining.

Parameter	Prior Type	Prior Mean	Prior Stand. Dev.	Post. Mode	Post. Stand. Dev.
$\log(\rho)$	Normal	$\log(0.5)$	3	$\log(0.0215)$	0.37
$\frac{\gamma}{y}$	Beta	0.6	0.3	0.51	0.125

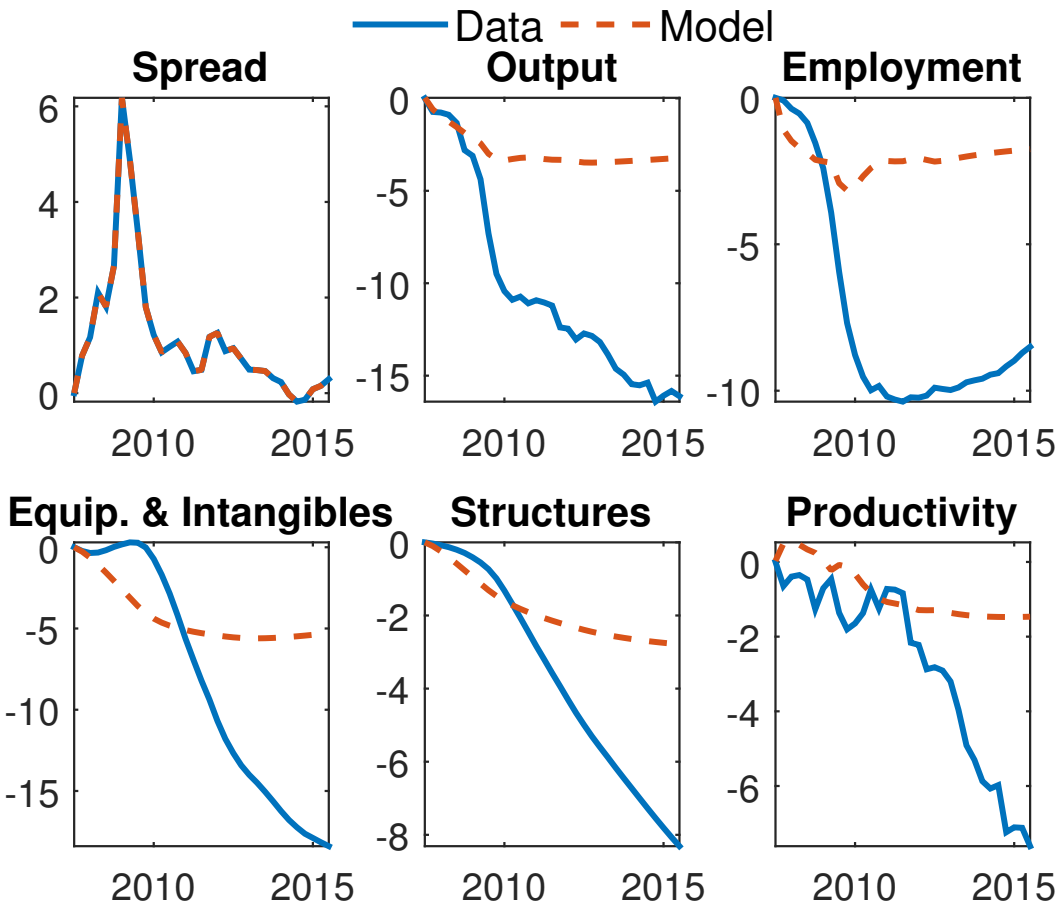
Impulse Response to Financial Shock

One standard deviation financial shock.

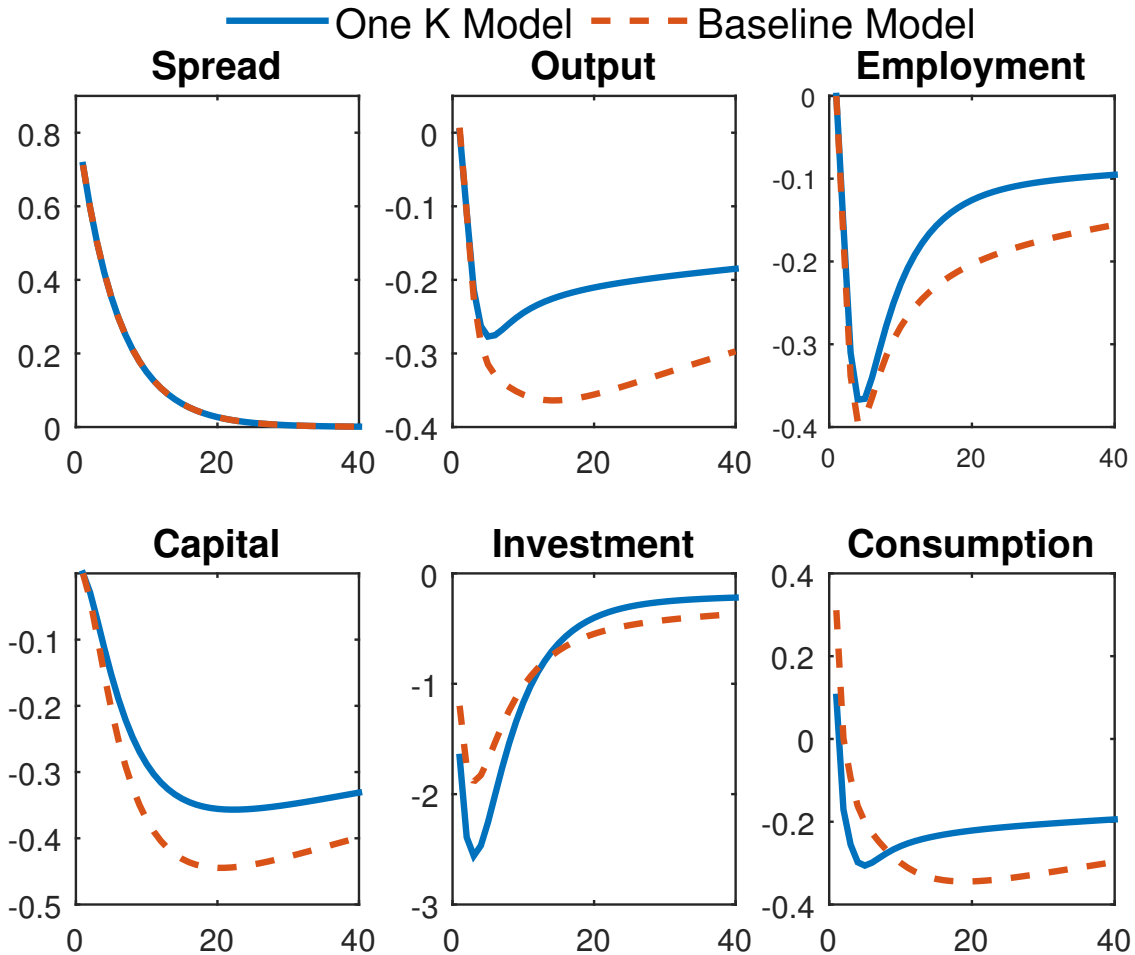


Comparison to Great Recession

Sequence of shocks to match credit spreads during Great Recession.

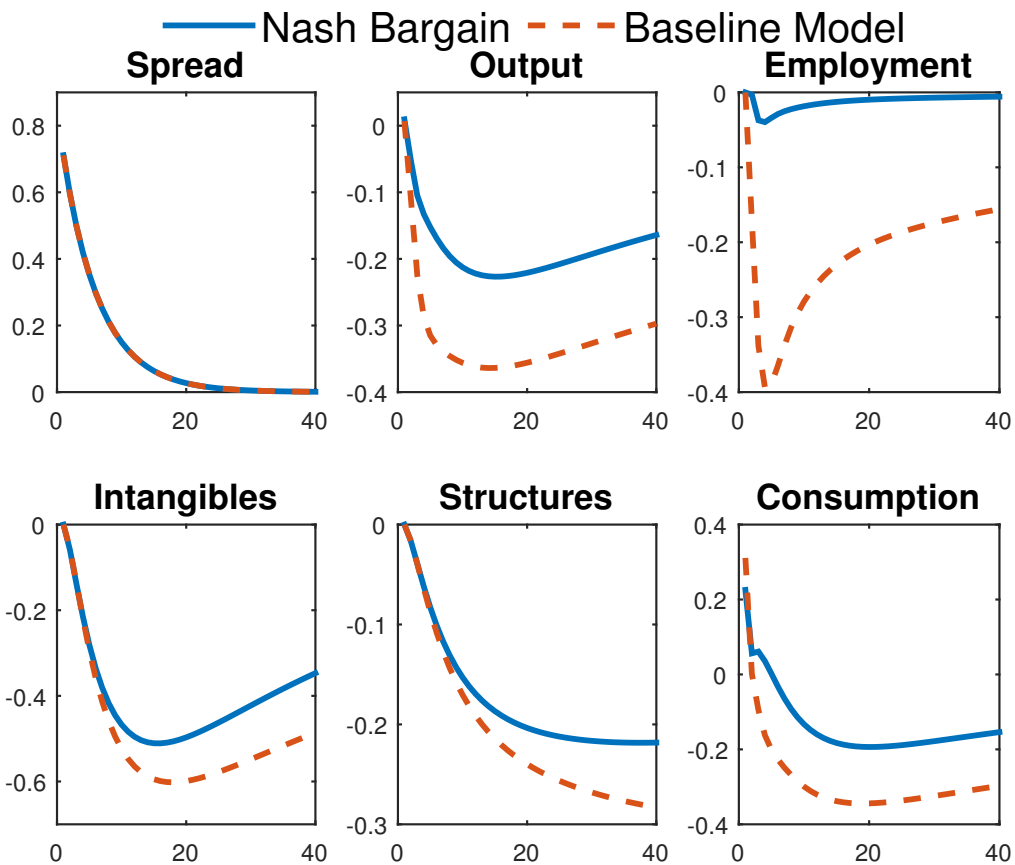


Results: One Type of Capital



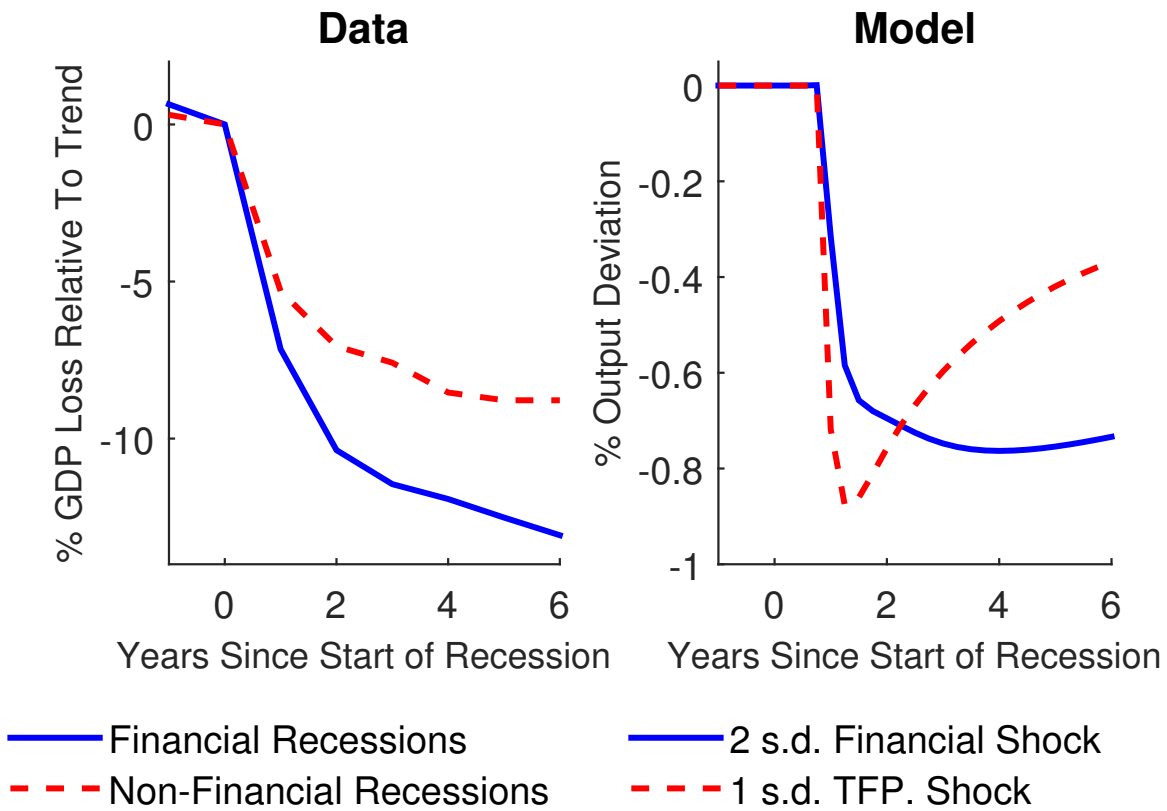
Baseline vs. model with one type of K and depreciation rate 6.8%.

Results: Nash Bargaining

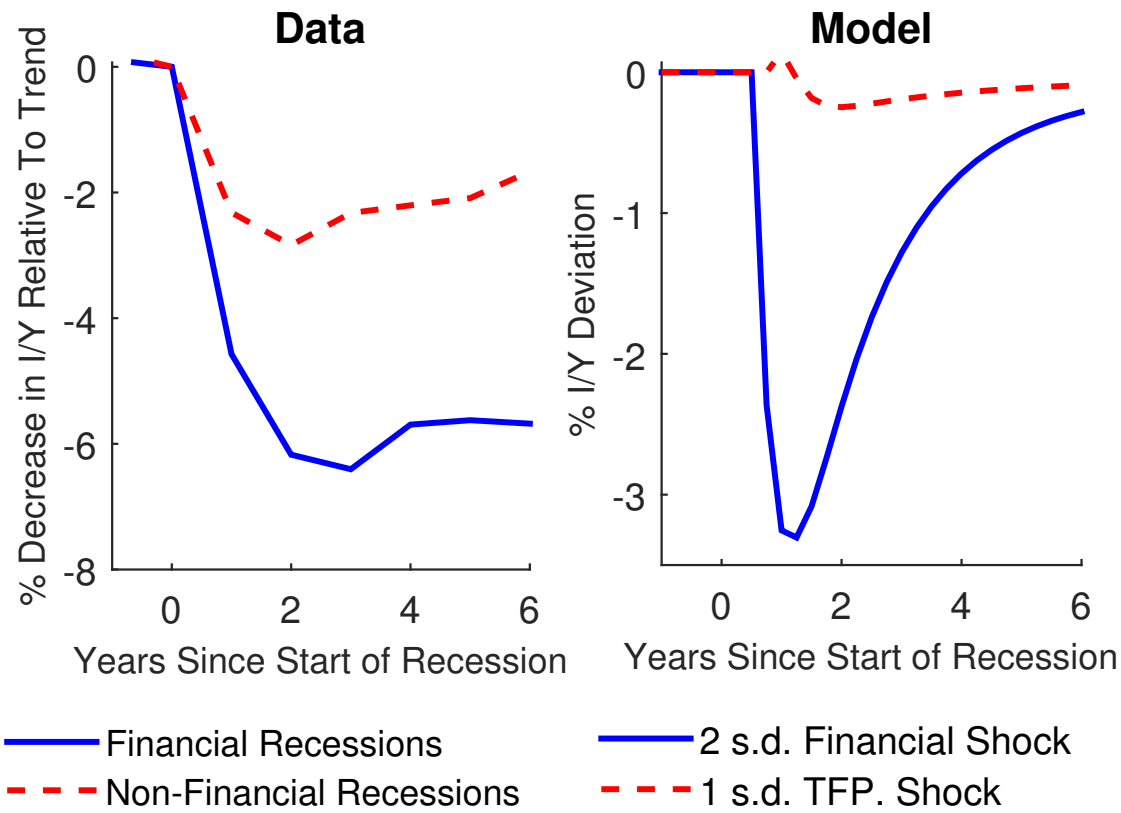


TFP vs. Financial Shocks

TFP shock parameters follow King & Rebelo (1999) & Michaillat (2014).



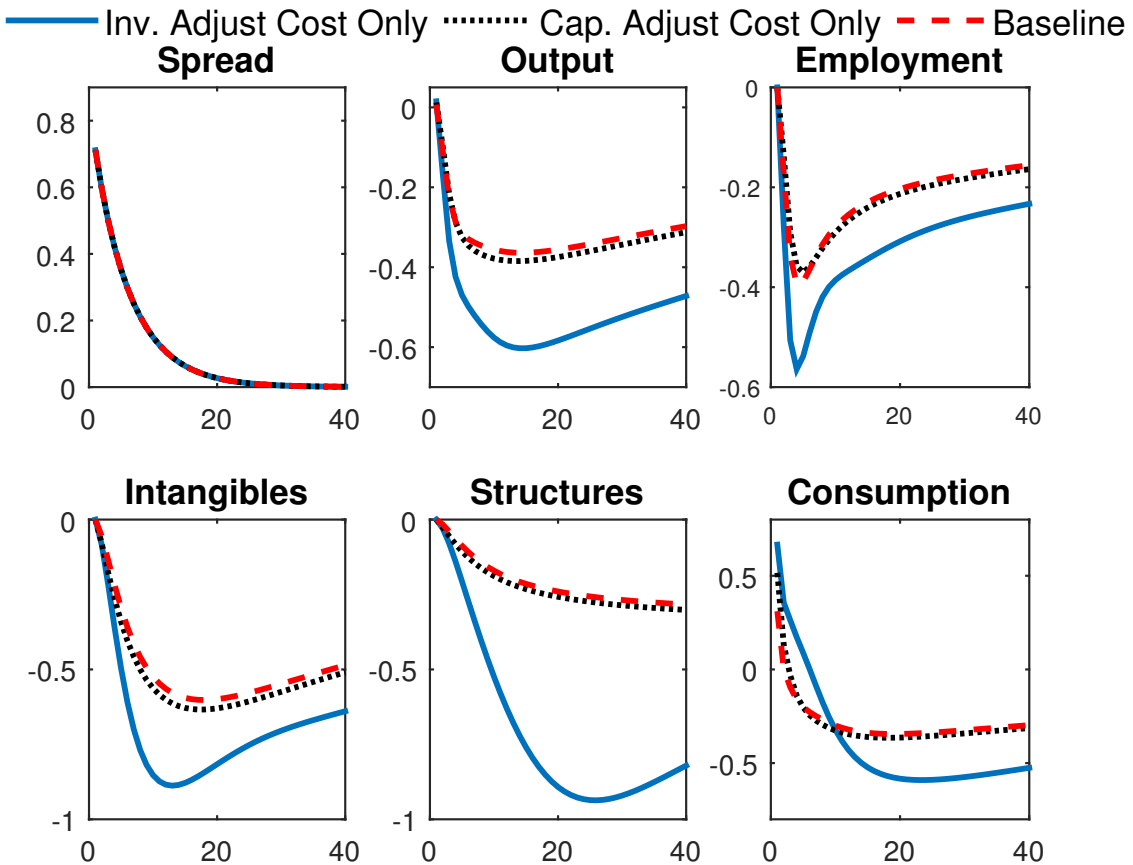
TFP vs. Financial Shocks: Investment



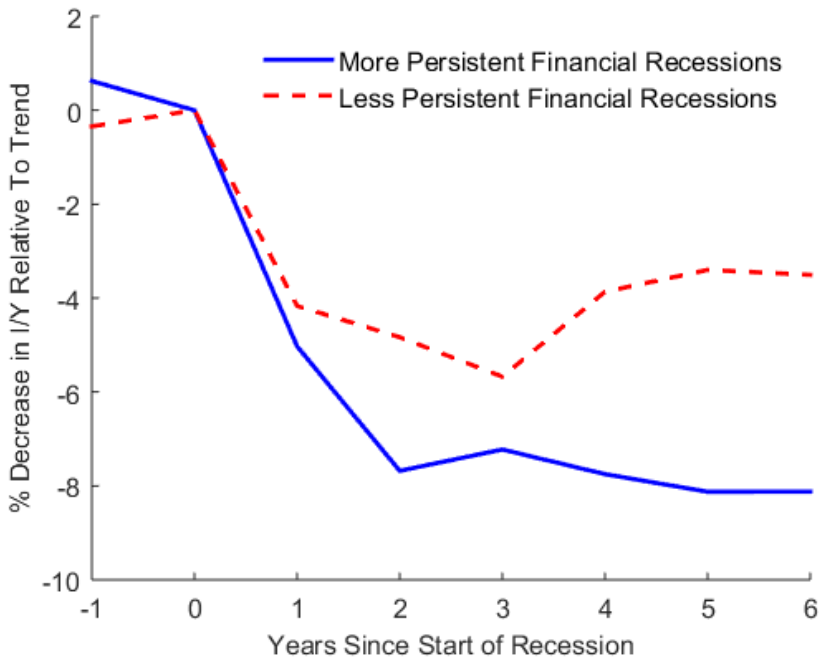
Conclusion

- Financial crises followed by:
  - Persistent output slumps.
  - Large investment drops.
  - More so than regular recessions.
- Dynamics of equipment and intangible capital help explain this.
  - Stocks of these can drop rapidly following financial shocks. (High depreciation rate).
  - This can generate persistent output slumps.
  - Can account for $\simeq$ one third of persistent slump after 2007.

Results: Reduced Adjustment Costs



I/Y Decrease: More Vs. Less Persistent Financial Recessions



- Recessions are 'More Persistent' if:

$$\min[YLoss_5; YLoss_6] > \max[YLoss_1; YLoss_2; YLoss_3]$$

Capital in the Great Recession