Financial Intermediation and Government Debt Default

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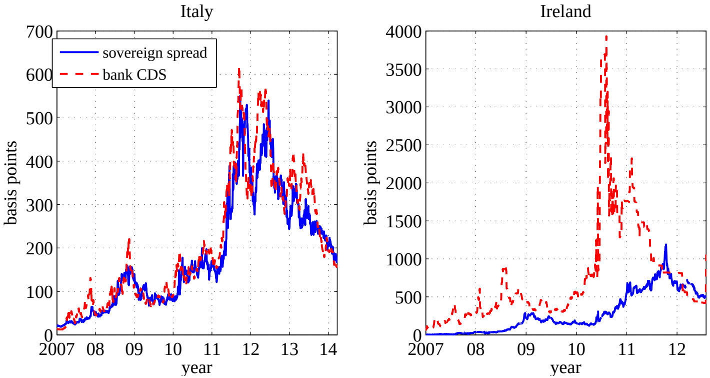
Motivation



Twin banking/sovereign-default crises:

- domestic costs of sovereign defaults through banking sector: Panizza, Sturzenegger and Zettelmeyer (2009)
- two-way risk spillover: sovereign default $\leftrightarrow$ banking crisis

WHAT WE DO

- Build a nonlinear model:
  - a conventional NK model with
  - financial intermediaries: Gertler and Karadi (2011)
  - fiscal and monetary policy
  - sovereign default: probability depends on debt level

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  - extended to include banking sector downsizing: Gertler and Kiyotaki (2013)

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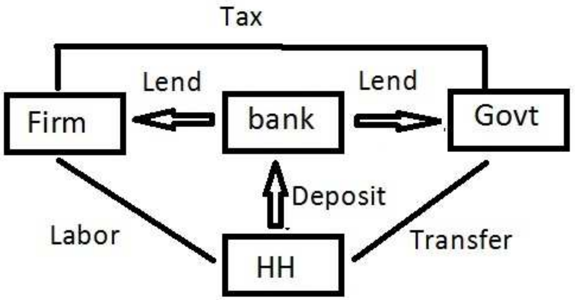
  - fiscal and monetary policy
  - sovereign default: probability depends on debt level
  - extended to include banking sector downsizing: Gertler and Kiyotaki (2013)
- Findings:
  - in the baseline case,
    - sovereign default can reduce investment by a substantial margin;
    - but if default doesn't materialize, sovereign risk premia itself has a small impact on the economy
  - if downsizings are possible,
    - even if default doesn't materialize, sovereign risk premia can have pronounced negative impact on the economy

Model Overview

- Financial friction:
  - occasionally binding credit constraint (agency problem)
  - banks lend to government and firms
- Sovereign default risk:
  - default can tighten up the credit constraint and spillover to firms



BANKS

Following Gertler and Karadi (2011),

- Bank's balance sheet,

$$
\begin{aligned}
N_{jt} + B_{jt} &= Q_t^k K_{jt} + Q_t^d D_{jt} \\
N_{jt+1} &= R_{t+1}^k Q_t^k K_{jt} + R_{t+1}^d Q_t^d D_{jt} - R_{t+1}^b B_{jt}
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- Bank's objective,

$$V_{jt} = \max \quad E_t \Lambda_{t,t+1} \left((1-\theta_{t+1}) N_{jt+1} + \theta_{t+1} V_{jt+1} \right)$$

  - a banker survives with prob. θ_t
  - $1-\theta_t$ new bankers with start-up funds from households

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- The evolution of aggregate net worth,

$$N_t = \underbrace{\theta_t \left(R_t^k Q_{t-1}^k K_{t-1} + R_t^d Q_{t-1}^d D_{t-1} - R_t^b B_{t-1} \right)}_{N_{et}} + \underbrace{\omega \left(Q_t^k K_{t-1} + Q_t^d D_{t-1} \right)}_{N_{nt}}$$

Banks

Agency problem (credit constraint),

$$V_{jt} \geq \lambda(Q_t^k K_{jt} + \eta Q_t^d D_{jt})$$

1. Interpretation: Gertler and Karadi (2011)
   - banks can divert λ of assets
   - depositors can liquidate banks and recover $1 - \lambda$ of assets
   - agency problem is less severe with government debt ($\eta < 1$)

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   - banks can divert λ of assets
   - depositors can liquidate banks and recover $1 - \lambda$ of assets
   - agency problem is less severe with government debt ($\eta < 1$)
2. Alternative interpretation: capital requirement
   - the value of the bank must equal to or exceed a share λ of its assets
   - assume government debt has higher quality

BANKS

$$\begin{aligned}
V_{jt} &= \max E_t \Lambda_{t,t+1}\left((1-\theta_{t+1})N_{jt+1} + \theta_{t+1}V_{jt+1}\right) \\
s.t. & \quad V_{jt} \geq \lambda Q_t^k K_{jt} + \eta\lambda Q_t^d D_{jt} \quad \text{(with multiplier} \quad \mu_t) \\
& \quad N_{jt+1} = R_{t+1}^k Q_t^k K_{jt} + R_{t+1}^d Q_t^d D_{jt} - R_{t+1}^b B_{jt}
\end{aligned}$$

Let $V_{jt} = f_t N_{jt}$, then first-order conditions are,

$$\begin{aligned}
(K_{jt}) \qquad & E_t \beta \frac{u_c(t+1)}{u_c(t)}(1-\theta_{t+1}+\theta_{t+1}f_{t+1})(R_{t+1}^k - R_{t+1}^b) = \mu_t \lambda \\
(D_{jt}) \qquad & E_t \beta \frac{u_c(t+1)}{u_c(t)}(1-\theta_{t+1}+\theta_{t+1}f_{t+1})(R_{t+1}^d - R_{t+1}^b) = \eta\mu_t \lambda \\
(N_{jt}) \qquad & E_t \beta \frac{u_c(t+1)}{u_c(t)}(1-\theta_{t+1}+\theta_{t+1}f_{t+1})R_{t+1}^b + \mu_t f_t = f_t \\
(\mu_t) \qquad & \mu_t(f_t N_t - \lambda(Q_t^k k_t + \eta Q_t^d D_t)) = 0
\end{aligned}$$

Conventional model without banks: $\mu_t = 0, f_t = 1$

FIRMS, HOUSEHOLDS, AND MONETARY POLICY

- Firms:
  - Cobb-Douglas production
  - Capital producing firm: Tobin's Q
  - Rotemberg price adjustment cost: distortionary sales tax

$$(1-\epsilon)(1-\tau_t)+\epsilon P_{mt}-\psi\left(\frac{\pi_t}{\pi}-1\right)\frac{\pi_t}{\pi}+\beta\psi E_t\frac{u_c(t+1)}{u_c(t)}\left(\frac{\pi_{t+1}}{\pi}-1\right)\frac{\pi_{t+1}}{\pi}\frac{y_{t+1}}{y_t}=0$$

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- Households work, save, and receive transfers from bankers and government

$$\begin{aligned} \max \quad & E_0\sum_{t=0}^{\infty}\beta^t u\left(c_t, L_t\right) \\ s.t. \quad & c_t = w_t L_t + \Upsilon_t + R_t^b B_{t-1} - B_t + z_t \end{aligned}$$

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$$(1-\epsilon)(1-\tau_t)+\epsilon P_{mt}-\psi\left(\frac{\pi_t}{\pi}-1\right)\frac{\pi_t}{\pi}+\beta\psi E_t\frac{u_c(t+1)}{u_c(t)}\left(\frac{\pi_{t+1}}{\pi}-1\right)\frac{\pi_{t+1}}{\pi}\frac{y_{t+1}}{y_t}=0$$

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- Taylor rule:

$$\begin{aligned} \frac{i_t}{i} &= \left(\frac{\pi_t}{\pi}\right)^{k_\pi} \\ i_t &= R_{t+1}^b \pi_{t+1} \end{aligned}$$

returns on deposits aren't indexed to inflation

Fiscal Policy and Shocks

- Government budget constraint,

$$g + z_t - \tau_t y_t + \underbrace{(1-\Delta_t)(1-\rho_d+\rho_d(1+Q_t^d))\frac{D_{t-1}}{\pi_t}}_{R_t^d Q_{t-1}^d D_{t-1}} = Q_t^d D_t$$

  - long-term bond: share of $1-\rho_d$ matures, share of ρ_d receives coupon and is resold

$$R_t^d = (1-\Delta_t)\frac{1+\rho_d Q_t^d}{Q_{t-1}^d \pi_t}$$

  - government may default $\Delta_t \geq 0$
  - tax policy:

$$\frac{\tau_t}{\tau} = \left(\frac{(1-\Delta_t)D_{t-1}}{D}\right)^{\gamma_d}$$

  - transfers: exog shock follows AR(1)

Sovereign Default

Different approaches:

- Exogenous default: Bocola (2014)
  - default probability doesn't depend on the state of the economy
- Optimal default: Arellano (2008), Yue and Mendoza (2010)
- Fiscal limits: Bi (2012), Davig, Leeper and Walker (2010)

$$\Delta_t = \begin{cases} 0 & \text{if } D_{t-1} < D_t^* \\ \Delta & \text{if } D_{t-1} \geq D_t^* \end{cases}$$

$$p_{t-1} \equiv P(D_{t-1} \geq D_t^*) = \frac{\exp(\eta_1 + \eta_2 D_{t-1})}{1 + \exp(\eta_1 + \eta_2 D_{t-1})},$$

  - allow two-way spillover between sovereign and banking crises

Baseline vs. Extended Models

- Baseline case
  - θ_t is fixed at $\bar{\theta}$
- Extended case: financial sector downsizing
  - Survival rate increases with net worth and decreases with leverage (Gertler and Kiyotaki (2013))
  - Given $B_t = Q_t^k K_t + Q_t^d D_t - N_t$, it decreases with deposits

$$\theta_t = \frac{\exp(\eta_1^b - \eta_2^b B_{t-1})}{1 + \exp(\eta_1^b - \eta_2^b B_{t-1})}(\bar{\theta} - \theta_{min}) + \theta_{min}$$

  - The evolution of aggregate net worth,

$$N_t = \underbrace{\theta_t}_{\downarrow}(R_t^k Q_{t-1}^k K_{t-1} + R_t^d Q_{t-1}^d D_{t-1} - R_t^b B_{t-1}) + \underbrace{\omega(Q_t^k K_{t-1} + Q_t^d D_{t-1})}_{\downarrow}$$

Extended Model: Bank Run

- Simplified version of bank runs in Gertler and Kiyotaki (2013)
  - At each period, banks that receive a ‘bank-run’ signal have to exit.
  - The signal is random for individual banks ....
  - ... but at aggregate, the probability of runs depends on the balance sheet of the aggregate banking sector.
  - State-dependent survival rate
- Capture the downsizing of financial sector in crises

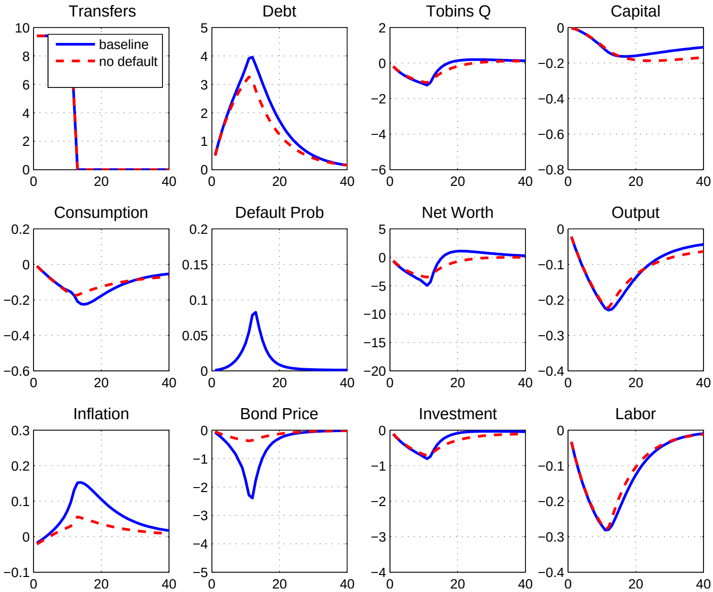
Method and Calibration

- Use policy function iteration to solve the nonlinear model
  - the state space $\mathbf{S}_t = \{D_{t-1}, K_{t-1}, B_{t-1}, i_{t-1}, \epsilon_t^z\}$
  - iterate on the decision rules f_i^L, f_i^π, f_i^D, f_i^{pm}, f_i^f until converge
- Calibration (preliminary):
  - fiscal limit distribution close to steady state (within 10%)
  - small haircut (0.08)

SIMULATIONS

- Cost of sovereign risk premia/default
  - Baseline vs. no-default model
  - Extended (with downsizing) vs. baseline vs. no-default model
- Two-way risk spillovers

Cost of Sovereign Risk Premia



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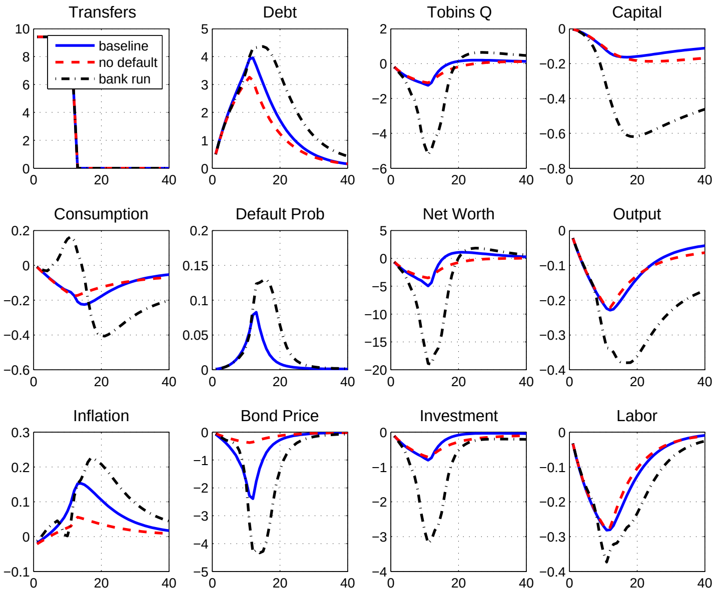

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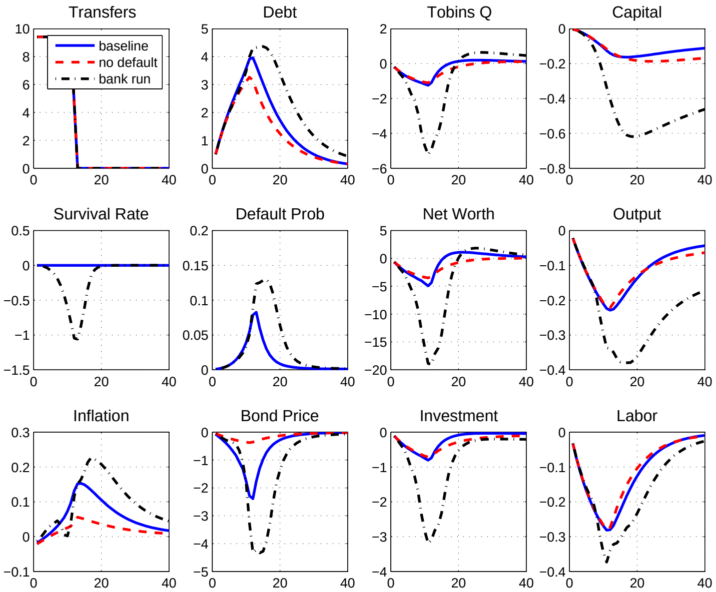
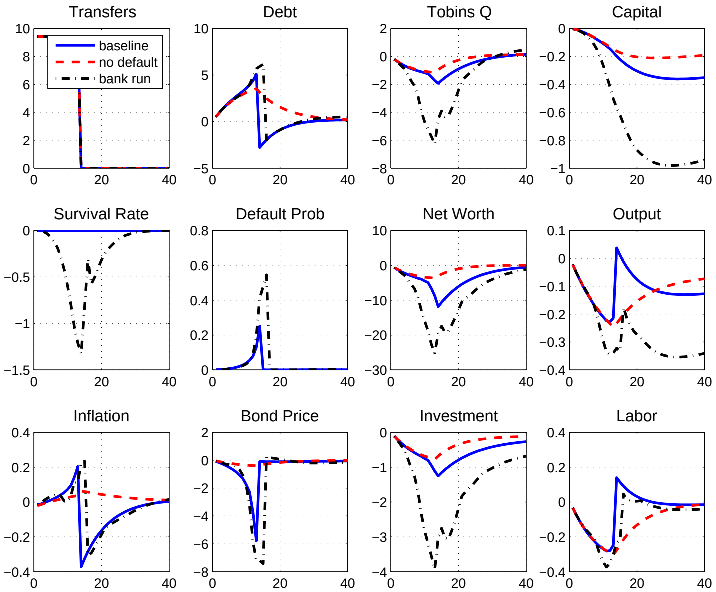


Cost of Sovereign Risk Premia

Without default materializing, sovereign risk premia

- has a small impact on the economy in the baseline model through the standard financial accelerator channel
- but is stagflationary and has pronounced negative impact on the economy in the bank run model
  - lower net worth by 15%, triple the reduction in capital, double the output loss

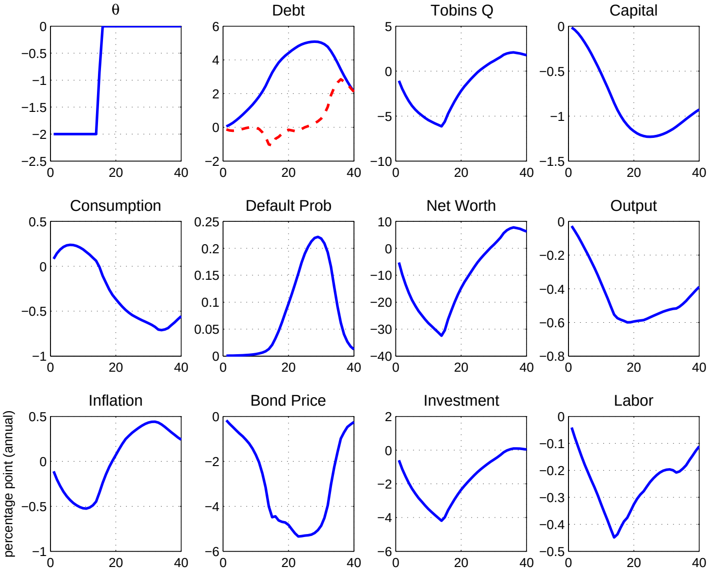
Cost of Sovereign Default



SIMULATIONS

- Cost of sovereign risk premia/default
- Two-way risk spillovers
  - Banking risk $\rightarrow$ government:
    - exogenous θ_t: AR(1) process
    - lower bank survival rate (θ_t) reduces bank net worth

BASELINE MODEL IRFS: (BANKS → SOVEREIGN)



To Conclude

- Findings: sovereign default/risk premia
  - has a small impact on the economy through the standard financial accelerator channel
  - but has pronounced negative impact if downsizings are possible
- Work in progress:
  - capital requirement depends on the riskiness of government bond

$$V_{jt} \geq \lambda(Q_t^k K_{jt} + \eta(?) Q_t^d D_{jt})$$

  - default scheme: government considers sovereign default costs through banking sector
  - endogenize the financial sector downsizing

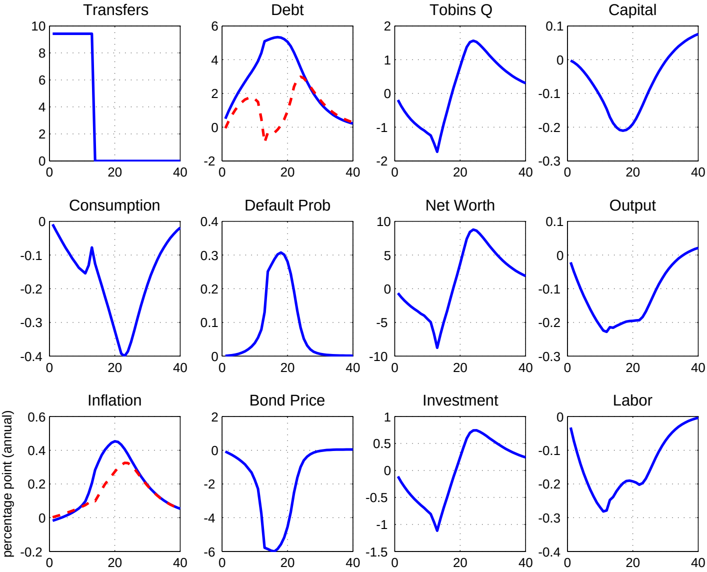
Future Work

- Extend to a small open economy
- Empirical evidence (joint with Nora Traum)
  - sovereign default/risk premia spillover across countries through banking sector channel

APPENDIX: SIMULATIONS

- Two-way risk spillovers
  - Sovereign risk ! banks: higher transfers (z_t) raise government debt and default probability
  - Banking risk ! government: lower bank survival rate ($_t$) reduces bank net worth
    - exogenous $_t$: AR(1) process

Baseline Model IRFs: (sovereign! banks)



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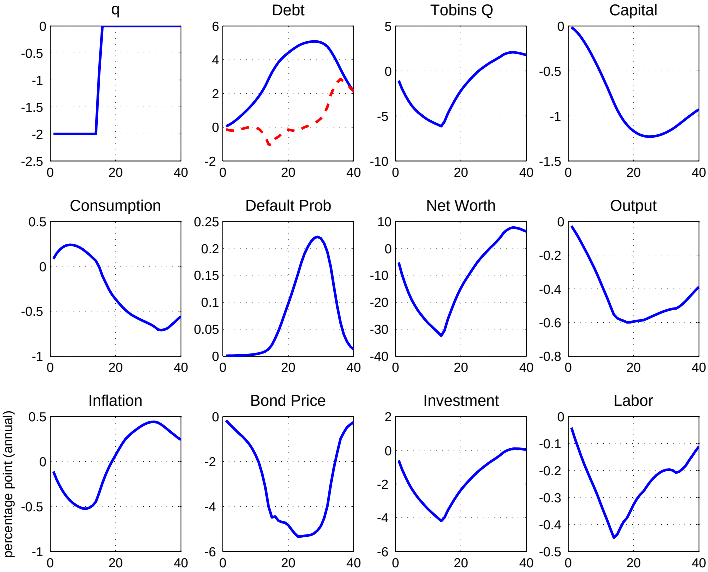
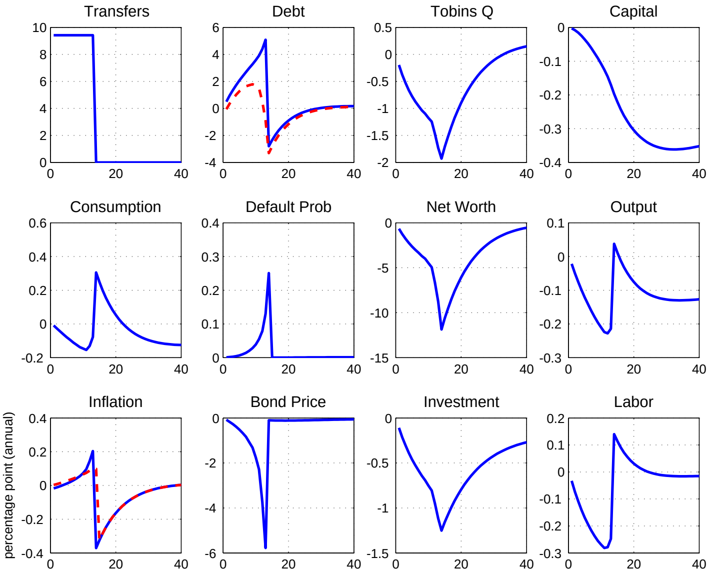


Baseline Model IRFs: Risk Premia

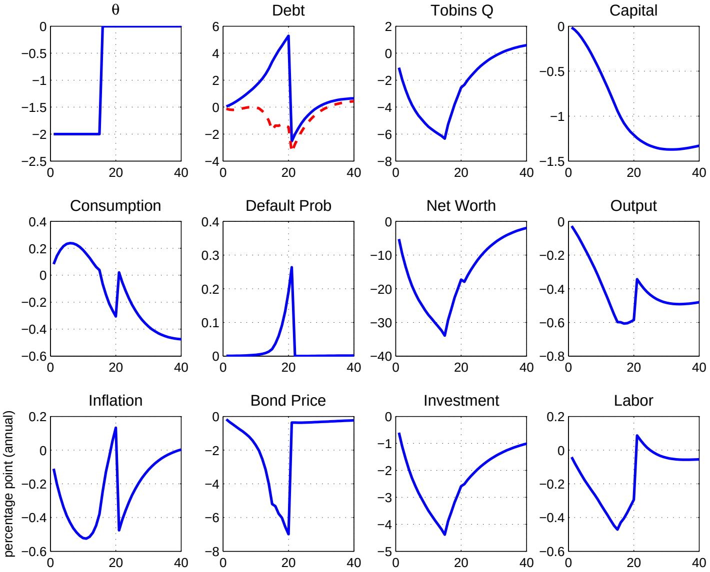
Sovereign risk without default occurring,

- Bank net worth & rm capital stock recover rapidly: risk prem ia raises net worth
- Sovereign risk premia is in ationary (due to higher taxes)
- Output recovers slowly

BASELINE MODEL IRFS: (SOVEREIGN! BANKS)



Baseline Model IRFs: (banks → sovereign)



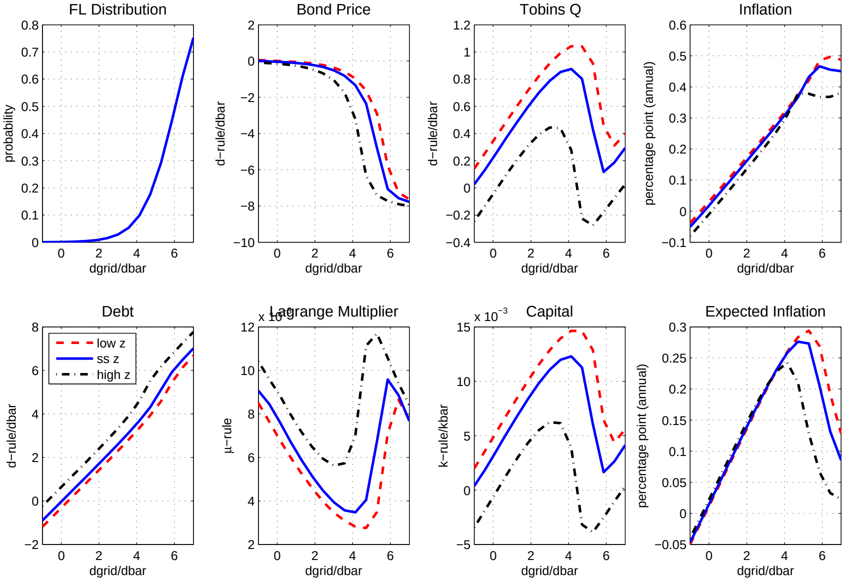
Baseline Model IRFs: Default

With sovereign default,

- Bank net worth recovers slowly $\rightarrow$ tighten up credit constraint $\rightarrow$ firm capital stock recover slowly
- Sovereign risk premia is inflationary, sovereign default is deflationary
- Rapid tax reduction $\rightarrow$ labor recovers rapidly
- Output recovers rapidly upon default (labor supply) but stays low in the long run (capital)

	parameters	
β	discount rate	0.995
μ^k	capital adjustment cost para	71.2
α	capital ratio	0.33
g/y	government spending-output ratio	0.15
z/y	government transfers-output ratio	0.1
$\frac{Q^d D}{4y}$	Annualised Govt Debt to GDP	0.49
π	steady-state inflation	1
ψ	price adjustment cost para	49.64
ϵ	substitution elasticity	4.167
κ_π	taylor coefficient	1.5
γ_d	tax response coefficient	1
$1/\zeta_l$	inverse of Frisch	0.276
ϵ^z	shock standard deviation	0.03
$R^k - R^b$	premium on bank loans	100 bpt (annual)
θ	banker survival rate	0.972
ϕ	leverage ratio	4
ρ_d	maturity of bonds	$1 - 1/8$
Δ	haircut	0.08

APPENDIX: DECISION RULES (BASELINE)

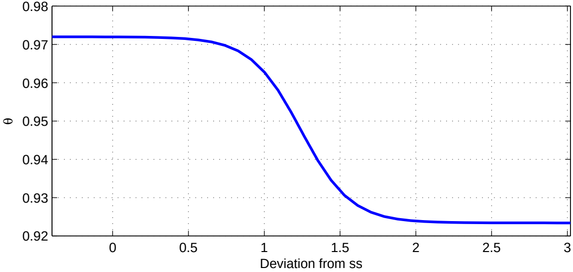


Appendix: Extended Model

- Assume survival rate increases with net worth and decreases with leverage (Gertler and Kiyotaki (2013))
- Given $B_t = Q_t^k K_t + Q_t^d D_t - N_t,$ it decreases with deposits

$$\theta_t = \frac{\exp(\eta_1^b - \eta_2^b B_{t-1})}{1 + \exp(\eta_1^b - \eta_2^b B_{t-1})}(\bar{\theta} - \theta_{min}) + \theta_{min}$$

- Calibration: $\Delta^b = 0, \theta_{min} = 0.95\bar{\theta}$



Each bank's objective becomes,

$$
\begin{aligned}
V_{jt} \quad &= \quad \max E_t \Lambda_{t,t+1} \left((1-\bar{\theta}) N_{jt+1}|_{nr} + (\bar{\theta} - \theta_{t+1}) N_{jt+1}|_{run} + \theta_{t+1} V_{jt+1} \right) \\
\text{with} \quad & \quad N_{jt+1}|_{nr} = R^k_{t+1} Q^k_t K_{jt} + R^d_{t+1} Q^d_t D_{jt} - R^b_{t+1} B_{jt} \\
& \quad N_{jt+1}|_{run} = R^k_{t+1} Q^k_t K_{jt} + R^d_{t+1} Q^d_t D_{jt} - R^b_{t+1}(1-\Delta^b_{t+1}) B_{jt}
\end{aligned}
$$

The first-order conditions are,

$$
E_t \beta \frac{u_c(t+1)}{u_c(t)} \left((1-\theta_{t+1}+\theta_{t+1} f_{t+1})(R^k_{t+1} - R^b_{t+1}) + (\bar{\theta} - \theta_{t+1}) \Delta^b_{t+1} R^b_{t+1} \right) = \mu_t \lambda
$$

$$
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$$

$$
E_t \beta \frac{u_c(t+1)}{u_c(t)} \left(1-\theta_{t+1}+\theta_{t+1} f_{t+1} - (\bar{\theta} - \theta_{t+1}) \Delta^b_{t+1} \right) R^b_{t+1} + \mu_t f_t = f_t
$$

Appendix: Nominal to Real Assets

Bank balance sheet:

$$
\begin{aligned}
&Q_t^k K_{jt} P_t + Q_t^d D_{jt}^n = N_{jt}^n + B_{jt}^n \\
\rightarrow\ &Q_t^k K_{jt} + Q_t^d D_{jt} = N_{jt} + B_{jt}
\end{aligned}
$$

The net worth evolves:

$$
\begin{aligned}
\frac{N_{jt+1}^n}{P_{t+1}} &= R_{t+1}^k Q_t^k K_{jt} + \frac{i_{t+1}^d}{\pi_{t+1}} Q_t^d \frac{D_{jt}^n}{P_t} - \frac{i_{t+1}}{\pi_{t+1}} \frac{B_{jt}^n}{P_t} \\
\rightarrow N_{jt+1} &= R_{t+1}^k Q_t^k K_{jt} + \underbrace{\frac{i_{t+1}^d}{\pi_{t+1}}}_{R_{t+1}^d} Q_t^d D_{jt} - \underbrace{\frac{i_{t+1}}{\pi_{t+1}}}_{R_{t+1}} B_{jt}
\end{aligned}
$$